ICES WGNSSK REPORT 2014

ICES ADVISORY COMMITTEE

ICES CM 2014/ACOM:13

REF. ACOM

Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

30 April–7 May 2014

ICES HQ, Copenhagen, Denmark

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

Recommended format for purposes of citation:

ICES. 2015. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 30 April–7 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:13. 1493 pp.

For permission to reproduce material from this publication, please apply to the General Secretary.

The document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council.

© 2015 International Council for the Exploration of the Sea

Contents

Executive Summary **1**

1 General **3**

1.1 Terms of Reference 3

1.2 InterCatch 6

1.2.1 metier-based joined data call for WGNSSK and WGMIXFISH 6

1.2.2 Data raising and allocation to unsampled strata 7

1.3 General uncertainty considerations 10

1.4 IBTS survey Q1 in 2014 11

1.5 Internal auditing 11

1.6 Mixed Fisheries 12

1.7 Multi species considerations 12

1.8 Generic ToR on indicators (ToR f) 13

1.9 Recommendations from other groups 15

1.10 Special requests 19

1.11 References 19

2 Overview **20**

2.1 Introduction 20

2.2 Main management regulations 21

2.2.1 Landings obligation 21

2.2.2 Effort limitations 22

2.2.3 Stock-based management plans 23

2.2.4 Additional Technical measures 24

2.2.4.1 Minimum landing size 24

2.2.4.2 Minimum mesh size 24

2.2.4.3 Closed areas 25

2.3 Environmental considerations 26

2.4 Human consumption fisheries 27

2.4.1 Data 27

2.4.2 Summary of stock status and advice 28

2.4.2.1 Overall impressions 28

2.5 Industrial fisheries 32

2.6 Input from The ICES - FAO Working Group on Fishing Technology & Fish Behaviour (WGFTFB) 33

2.7 References: 36

3 *Nephrops* in Subareas IIIa **38**

3.1 General comments relating to all *Nephrops* stocks (IIIa and IV) 38

3.1.1 Introduction 38
3.1.2 A new approach for data poor *Nephrops* stocks 38
3.2 Nephrops stocks 39
3.3 *Nephrops* in Subarea IIIa 39
3.3.1 General 39
3.3.2 Data available from Skagerrak (FU3) and Kattegat (FU4) 40
3.3.3 Combined assessment (FU 3 & 4) 42
3.3.3.1 TV survey in IIIa 42
3.3.3.2 2013 Assessment. 43
3.3.4 Biological reference points 45
3.3.5 Quality of the assessment 45
3.3.6 Status of the Stock 46
3.3.7 Division IIIa *Nephrops* Management Considerations 46

4 *Nephrops* in Subareas IV 71

4.1 General comments relating to all *Nephrops* stocks 71
4.2 *Nephrops* in Subarea IV 71
4.2.1 The fishery in 2011 and 2012. 72
4.2.2 Data Available 72
4.2.3 Natural mortality, maturity at age and other biological parameters 73
4.2.4 Commercial catch-effort data and research vessel surveys 73
4.2.5 TV Survey in FU5 (Botney Gut / Silver Pit): 73
4.2.6 Status of stock 74
4.2.7 Management considerations for FU 5. 74
4.3 Farn Deeps (FU6) 75
4.3.1 Fishery in 2012 & 2013 75
4.3.2 ICES Advice in 2013 75
4.3.3 Assessment 75
4.3.4 Historical stock trends 79
4.3.5 MSY considerations 79
4.3.6 BRPs 81
4.3.7 Quality of assessment 82
4.3.8 Status of stock 82
4.3.9 Management considerations 83
4.4 Fladen Ground (FU7) 83
4.4.1 Ecosystem aspects 83
4.4.1.1 The Fishery in 2012 and 2013 83
4.4.2 ICES advice in 2013 84
4.4.3 Management 84
4.4.4 Assessment 84
4.4.5 Data available 85
4.4.6 Data analyses 87
4.4.7 Recruitment estimates 88
4.4.8 MSY considerations 88
4.4.9 Short-term forecasts 89
4.4.10 Biological Reference points 90

4.4.11 Quality of assessment 90
4.4.12 Management considerations 91
4.5 Firth of Forth (FU 8) 91
4.5.1 Ecosystem aspects 91
4.5.2 The Fishery in 2012 and 2013 91
4.5.3 Advice in 2013 92
4.5.4 Management 92
4.5.5 Assessment 92
4.5.6 Historical Stock trends 95
4.5.7 Recruitment estimates 96
4.5.8 MSY considerations 96
4.5.9 Short-term forecasts 96
4.5.10 Quality of assessment 98
4.5.11 Status of the stock 98
4.5.12 Management considerations 98
4.6 Moray Firth (FU 9) 98
4.6.1 Ecosystem aspects 98
4.6.2 The Fishery in 2012 and 2013 99
4.6.3 Advice in 2013 99
4.6.4 Management 100
4.6.5 Assessment 100
4.6.6 Historical Stock trends 103
4.6.7 Recruitment estimates 103
4.6.8 MSY considerations 103
4.6.9 Short-term forecasts 104
4.6.10 Quality of assessment 105
4.6.11 Status of the stock 105
4.6.12 Management considerations 105
4.7 Noup (FU 10) 106
4.7.1 Ecosystem aspects 106
4.7.2 The Fishery in 2012 and 2013 106
4.7.3 Advice in 2012 and 2013 106
4.7.4 Historical stock trends 107
4.7.5 Recruitment estimates 107
4.7.6 Short-term Forecasts 107
4.7.7 Status of the stock 107
4.7.8 Management considerations 107
4.8 Norwegian Deep (FU 32) 108
4.8.1 General 108
4.8.1.1 Ecosystem aspects. 108
4.8.1.2 Norwegian Deep (FU 32) fisheries 108
4.8.2 Advice in 2013 108
4.8.3 Management 109
4.8.4 Assessment 109
4.8.4.1 Data available 109
4.8.4.2 Data analysis 111
4.8.4.3 Historic stock trends 112
4.8.4.4 Recruitment estimates 112

4.8.4.5 Forecasts 112
4.8.4.6 Biological reference points 112
4.8.4.7 Quality of assessment 112
4.8.4.8 Status of stock 112
4.8.4.9 Management considerations 113
4.9 Off Horns Reef (FU 33) 114
4.9.1 Data available 114
4.9.2 Data analysis 115
4.9.2.1 Historic stock trends 115
4.10 Devil's Hole (FU 34) 115
4.10.1 Ecosystem aspects 115
4.10.2 The Fishery 116
4.10.3 Management 116
4.10.4 Assessment 116
4.10.5 Data available 116
4.10.6 Data analyses 118
4.10.7 Historical stock trends 119
4.10.8 Recruitment estimates 120
4.10.9 MSY considerations 120
4.10.10 Short-term Forecasts 120
4.10.11 Status of the stock 120
4.10.12 Management considerations 120

5 Norway Pout in ICES Subarea IV and Division IIIa (September 2014) ..... Error! Bookmark not defined.

5.1 Introduction: Update assessment ..... **Error! Bookmark not defined.**
5.2 General ..... **Error! Bookmark not defined.**
5.2.1 Ecosystem aspects ..... **Error! Bookmark not defined.**
5.2.2 Fisheries **Error! Bookmark not defined.**
5.2.3 ICES advice **Error! Bookmark not defined.**
5.2.4 Management up to 2014 ..... **Error! Bookmark not defined.**
5.3 Data available ..... **Error! Bookmark not defined.**
5.4 Catch at Age Data Analyses ..... **Error! Bookmark not defined.**
5.4.1 Final Assessment ..... **Error! Bookmark not defined.**
5.5 Historical stock trends ..... **Error! Bookmark not defined.**
5.6 Recruitment estimates ..... **Error! Bookmark not defined.**
5.7 Short-term prognoses ..... **Error! Bookmark not defined.**
5.8 Medium-term projections ..... **Error! Bookmark not defined.**
5.9 Biological reference points ..... **Error! Bookmark not defined.**
5.10 Quality of the assessment ..... **Error! Bookmark not defined.**
5.11 Status of the stock ..... **Error! Bookmark not defined.**
5.12 Management considerations ..... **Error! Bookmark not defined.**
5.12.1 Long term management strategies ..... **Error! Bookmark not defined.**
5.13 Other issues ..... **Error! Bookmark not defined.**
5.14 Sources: ..... **Error! Bookmark not defined.**

6 Plaice in Division VIId 258
6.1 General 258
6.1.1 Ecosystem aspects 258
6.1.2 Fisheries 258
6.1.3 ICES advices for previous years 259
6.1.4 Management 259
6.2 Data available 260
6.2.1 Catch 260
6.2.2 Age compositions 260
6.2.3 Weight at age 260
6.2.4 Maturity and natural mortality 260
6.2.5 Catch, effort and research vessel data 261
6.3 Data analyses 261
6.3.1 Reviews of last years assessment 261
6.3.2 Exploratory catch-at-age-based analyses 261
6.3.3 Exploratory survey-based analyses 262
6.3.4 Conclusions drawn from exploratory analyses 262
6.3.5 Final assessment 263
6.4 Historic Stock Trends 263
6.5 Biological reference points 264
6.6 Short-term forecasts 264
6.6.1 Recruitment estimates 264
6.6.2 Calculation of the VIId resident stock 264
6.6.3 Management options tested 265
6.7 Medium-term forecasts 265
6.8 Quality of the assessment 265
6.9 Status of the stock 265
6.10 Management considerations 266
6.11 Sources 266

7 Plaice in Skagerrak (IIIaN) 302
7.1 Ecosystem aspects 302
7.1.1 Fisheries 302
7.1.2 ICES Advice 303
7.1.3 Management 303
7.2 Data available 304
7.2.1 Catch 304
7.2.2 Weight at age 305
7.2.3 Maturity and natural mortality 305
7.2.4 Catch, effort and research vessel data 305
7.3 Data analyses 305
7.3.1 Catch-at-age matrix 305
7.3.2 Spatial information on catches 305
7.3.3 Survey series 306

7.4 Exploratory analysis 306
7.4.1 Final assessment 306
7.5 Historic Stock Trends 306
7.5.1 Stock perception from the North Sea fishers survey (FNSSS) 306
7.6 Recruitment estimates 307
7.7 Short-term forecasts 307
7.8 Medium-term forecasts - none 307
7.9 Biological reference points 307
7.10 Quality of the assessment 307
7.11 Status of the Stock 307
7.12 Management Considerations 307
7.13 References 309

8 Plaice in Subarea IV 331

8.1 General 331
8.1.1 Stock structure 331
8.1.2 Ecosystem considerations 331
8.1.3 Fisheries 332
8.1.4 ICES Advice 333
8.1.5 Management 334
8.2 Data available 334
8.2.1 Landings 334
8.2.2 Discards 334
8.2.3 Catch 335
8.2.4 Weight at age 335
8.2.5 Maturity and natural mortality 335
8.2.6 Catch, effort and survey data 335
8.2.7 InterCatch 336
8.3 Data analyses 336
8.3.1 Review of last year's assessment 336
8.3.2 Adaptations to the assessment in comparison to last year 338
8.3.3 Exploratory catch-at-age-based analyses 338
8.3.4 Final XSA results 340
8.3.5 Additional considerations regarding the final assessment 341
8.3.6 The Fishers' North Sea Stock Survey 342
8.4 Recruitment estimates 342
8.5 Short-term forecasts 343
8.6 Biological reference points 343
8.6.1 Precautionary approach reference points 343
8.6.2 F_{MSY} reference points 343
8.7 Quality of the assessment 344
8.8 Status of the Stock 345
8.9 Management Considerations 345

8.9.1 Multiannual plan 345
8.9.2 Technical measures 347
8.10 References 348

9 Sole in Sub-area VIId 419
9.1 General 419
9.1.1 Ecosystem aspects 419
9.1.2 Fisheries 419
9.1.3 ICES advice 419
9.1.4 Management 421
9.2 Data available 421
9.2.1 Catch 421
9.2.2 Age compositions 422
9.2.3 Weight at age 423
9.2.4 Maturity and natural mortality 423
9.2.5 Catch, effort and research vessel data 423
9.3 Data analyses 424
9.3.1 Reviews of last year's assessment 424
9.3.2 Exploratory catch at age analysis 424
9.3.3 Exploratory survey-based analyses 425
9.3.4 Final assessment 425
9.4 Historical Stock Trends 427
9.5 Recruitment estimates 427
9.6 Short term forecasts 427
9.7 Medium-term forecasts and Yield per recruit analyses 428
9.8 Biological reference points 428
9.9 Quality of the assessment 429
9.10 Status of the Stock 430
9.11 Management Considerations 430

10 Sole in Subarea IV 487
10.1 General 487
10.1.1 Ecosystem aspects 487
10.1.2 Fisheries 487
10.1.3 ICES Advice for 2014 487
10.2 Management 488
10.2.1 Catch 489
10.2.2 Age compositions 489
10.2.3 Weight at age 491
10.2.4 Maturity and natural mortality 491
10.2.5 Catch, effort and research vessel data 491
10.3 Data analyses 492
10.3.1 Exploratory catch-at-age based analysis 492
10.3.2 Exploratory single fleet analyses 492
10.3.3 Final assessment 492

10.3.4 Retrospective analyses and comparison with last years assessment 493
10.4 Historical Stock Trends 493
10.5 Recruitment estimates 494
10.6 Short-term forecasts 494
10.7 Medium-term forecasts 495
10.8 Biological reference points 495
10.9 Quality of the assessment 497
10.10 Status of the Stock 497
10.11 Management Considerations 497

11 Saithe in Subareas IV, VI and Division IIIa 548

11.1 General 548
11.1.1 Ecosystem aspects 548
11.1.2 Fisheries 548
11.1.3 ICES Advice of 2014 548
11.2 Management 549
11.3 Data available 549
11.3.1 Catch 549
11.3.2 Age compositions 549
11.3.3 Weight at age 550
11.3.4 Maturity and natural mortality 550
11.3.5 Catch, effort and research vessel data 550
11.4 Data analyses 550
11.4.1 Reviews of last year's assessment 551
11.4.2 Exploratory survey-based analyses 551
11.4.3 Exploratory catch-at-age-based analyses 551
11.4.4 Conclusions drawn from the exploratory analysis 552
11.4.5 SAM Assessment 552
11.4.6 Final assessment: XSA 553
11.5 Historic Stock Trends 553
11.6 Recruitment estimates 554
11.7 Short-term forecasts 554
11.8 Medium-term and long-term forecasts 554
11.9 Biological reference points 554
11.10 Estimation of F_{MSY} 555
11.11 Quality of the assessment and forecast 555
11.12 Status of the Stock 555
11.13 Management Considerations 555
11.13.1 Evaluation of the Management plan 556
11.14 References 556

12 Whiting in Subarea IV and Divisions VIId and IIIa 616

12.1 Whiting in Division IIIa 616
12.1.1 General 616
12.1.1.1 Stock definition 616
12.1.1.2 Ecosystem aspect 616
12.1.1.3 Fisheries 616
12.1.1.4 Data available 616
12.1.2 Data analyses 617
12.1.2.1 Exploratory survey-based analysis 617
12.1.2.2 Conclusions drawn from exploratory analysis 617
12.1.2.3 Advice 617
12.2 Whiting in Subarea IV and Divisions VIId 629
12.2.1 General 629
12.2.1.1 Stock definition 629
12.2.1.2 Ecosystem aspects 629
12.2.2 Fisheries 629
12.2.3 ICES advice 629
12.2.4 Management 630
12.2.5 Data available 631
12.2.5.1 Catch 631
12.2.5.2 Age compositions 632
12.2.5.3 Weight at age 632
12.2.5.4 Maturity and natural mortality 632
12.2.5.5 Research vessel data 633
12.2.6 Data analyses 633
12.2.6.1 Exploratory survey-based analyses 634
12.2.6.2 Exploratory catch-at-age-based analyses 635
12.2.6.3 Conclusions drawn from exploratory analyses 635
12.2.6.4 Final assessment 635
12.2.7 Historical stock trends 636
12.2.8 Recruitment estimates 636
12.2.9 Short-term forecasts 637
12.2.10 MSY estimation and medium-term forecasts 637
12.2.11 Biological reference points 637
12.2.12 Quality of the assessment 638
12.2.13 Status of the stock 639
12.2.14 Management considerations 639
12.3 References 640

13 Haddock in Subarea IV and Divisions IIIaW and VIa (North Sea, Skagerrak and West of Scotland) 703

13.1 General 703
13.1.1 Ecosystem aspects 703
13.1.2 Fisheries 703
13.1.3 ICES advice 704
13.1.4 Management 705
13.2 Data available 707
13.2.1 Catch 707
13.2.2 Age compositions 708
13.2.3 Weight at age 708
13.2.4 Maturity and natural mortality 708
13.2.5 Catch, effort and research vessel data 708
13.3 Data analyses 709
13.3.1 Exploratory catch-at-age-based analyses 709
13.3.2 Exploratory survey-based analyses 710
13.3.3 Conclusions drawn from exploratory analyses 710
13.3.4 Final assessment 711
13.4 Historical Stock Trends 712
13.5 Recruitment estimates 712
13.6 Short-term forecasts 713
13.7 MSY estimation and medium-term forecasts 714
13.8 Biological reference points 715
13.9 Quality of the assessment 715
13.10 Status of the Stock 715
13.11 Management Considerations 716
13.12 References 717

14 Cod 783

14.1 General 783
14.1.1 Stock definition 783
14.1.2 Ecosystem aspects 783
14.1.3 Fisheries 783
14.1.4 Management 785
14.2 Data available 788
14.2.1 Catch 788
14.2.2 Weight at age 791
14.2.3 Maturity and natural mortality 791
14.2.4 Catch, effort and research vessel data 791
14.3 Data analyses 793
14.3.1 Assessment audit 793
14.3.2 Exploratory survey-based analyses 793
14.3.3 Exploratory catch-at-age-based analyses 794
14.3.4 Final assessment 796
14.4 Historic Stock Trends 797
14.5 Recruitment estimates 797

14.6 MSY estimation 798
14.7 Short-term forecasts 798
14.8 Medium-term forecasts 800
14.9 Biological reference points 800
14.10 Quality of the assessment 801
14.11 Status of the Stock 803
14.12 Management Considerations 803
14.13 References 805

15 Pollack in the North Sea and Skagerrak (Subarea IV and Division IIIa) 862
15.1 General Biology 862
15.2 Stock identity and possible assessment areas 862
15.3 Management 862
15.4 Fisheries data 862
15.5 Survey data / recruit series 863
15.5.1 Biological sampling 863
15.5.2 Analysis of stock trends 863
15.5.3 Data requirements 863
15.6 References 864

16 Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat) 871
16.1 General 871
16.1.1 Biology and ecosystem aspects 871
16.1.2 Stock ID and possible assessment areas 871
16.1.3 Management regulations 871
16.2 Fisheries data 871
16.2.1 Historical landings 871
16.2.2 Inter Catch data 872
16.2.3 Discards 874
16.3 Survey data / recruit series 874
16.4 Biological sampling 874
16.5 Population biological parameters and other research 875
16.6 Analysis of stock trends / assessment 875
16.7 Data requirements 876
16.8 References 876

17 Striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern English Channel) and IIIa (Skagerrak–Kattegat) 888
17.1 General 888
17.1.1 Ecosystem aspects 888
17.1.2 Fisheries 888
17.1.3 ICES advice 888

17.1.4 Management 888
17.2 Data available 889
17.2.1 Catch 889
17.2.2 Age compositions 889
17.2.3 Survey data 890
17.3 CPUE (in number of individuals per hour) is derived from IBTS Q3 and presented in Figure 17.4.1.5.Data analyses 890
17.3.1 Exploratory survey-based analyses 890
17.3.2 Conclusions drawn from exploratory analyses 890
17.4 Sources: 890

18 Turbot in Subarea IV 900

18.1 General 900
18.1.1 Biology and ecosystem aspects 900
18.1.2 Fisheries 900
18.1.3 ICES advice for 2014 901
18.1.4 Management 901
18.2 Data used 901
18.2.1 Catch data 902
18.2.2 Survey data and commercial LPUE 903
18.2.3 Biological data 903
18.3 Stock assessment model 904
18.3.1 Model settings 904
18.3.2 Model diagnostics 905
18.4 Assessment model results 906
18.4.1 Status of the stock 906
18.4.2 Historic stock trends 906
18.4.3 Retrospective assessments 906
18.5 Biological reference points 907
18.6 Short-term forecast 908
18.7 Management considerations 908
18.7.1 Effort regulations 908
18.7.2 Technical measures 909
18.7.3 Combined TAC 909
18.8 Future work 909
18.9 References 910

19 Turbot in IIIa (Kattegat-Skagerrak) 942

19.1 General biology and historical trends 942
19.2 Stock identity and possible assessment areas 942
19.3 Management regulations 942
19.4 Fisheries data 943
19.5 Survey data, recruit series and analysis of stock trends 943
19.6 Biological sampling 943

19.7 Population biological parameters and other research 944
19.8 Data recommendations 944
19.9 References 944

20 Brill in Subarea IV, Subdivision IIIa and VIIde 955
20.1 General 955
20.1.1 Biology and ecosystem aspects 955
20.1.2 tock identity and possible assessment areas 955
20.1.3 Management regulations 956
20.2 Fisheries data 956
20.2.1 Landings 956
20.2.2 Discards 957
20.3 Survey data, recruit series 957
20.3.1 Survey Data 957
20.3.2 Commercial LPUE series 959
20.4 Biological sampling and population biology parameters 959
20.5 Analyses of stock trends and potential status indicators 960

21 Dab in Subarea IV (North Sea) and Division and IIIa (Skagerrak - Kattegat) 970
21.1 General 970
21.1.1 Biology and ecosystem aspects 970
21.1.1.1 Stock ID and possible assessment areas 970
21.1.2 Management regulations 970
21.2 Fisheries data 970
21.2.1 Historical landings 970
21.2.2 InterCatch 972
21.3 Survey data / recruit series 974
21.4 Analysis of stock trends / assessment 975
21.5 References 978

22 Flounder in Subarea IV (North Sea) and Division and IIIa (Skagerrak - Kattegat) 983
22.1 General 983
22.1.1 Biology and ecosystem aspects 983
22.1.2 Stock ID and possible assessment areas 983
22.1.3 Management regulations 983
22.2 Fisheries data 984
22.2.1 Historical landings 984
22.2.2 Inter Catch 985
22.3 Survey data / recruit series 987
22.4 Analysis of stock trends / assessment 988
22.5 References 991

23 Lemon sole in Subarea IV (North Sea) and Divisions IIIa (Skagerrak - Kattegat) and Division VIId (Eastern Channel) 996

23.1 General 996

23.1.1 Biology and ecosystem aspects 996

23.1.2 Stock ID and possible assessment areas 996

23.1.3 Management regulations 996

23.2 Fisheries data 996

23.2.1 Historical landings 996

23.2.2 Discards 998

23.3 Survey data / recruit series 998

23.4 Analysis of stock trends / assessment 999

23.5 References 1001

24 Witch flounder in Subarea IV, Division IIIa and VIId Error! Bookmark not defined.

Annex 1 List of Participants 1018

Annex 02 Update Forecasts and Assessments 1020

Annex 03 Stock Annexes Part 1 1062

Annex 03 Stock Annexes Part 2 1208

Annex 04 Recommendations 1440

Annex 5 Benchmark Planning and Data Problems by Stock 1442

Annex 06 Audit reports 1479

Annex 07 Joint WGNSSK and WGMIXFISH data call 1509

Annex 8 Working Documents 1542

Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met 30 April – 7 May 2014 at ICES Headquarters in Copenhagen, Denmark. There were 26 participants (four by correspondence) from 9 countries. The main terms of reference for the Working Group were: to update, quality check and report relevant data for the working group, to update and audit the assessment of the stocks, to produce a first draft of the advice on the fish stocks and fisheries under consideration, to prepare for benchmarks next year and to update the description of major regulatory changes and comment on the potential effects of such changes. Ecosystem changes have been analytically considered in the assessments for cod, haddock and whiting in the form of time varying natural mortalities estimated by the ICES Working Group on Multi Species Assessment Methods (WGSAM).

Working procedures

WGNSSK has to deal with an increasing number of data limited stocks formerly assessed by WGNEW. This did not prove to be an easy process as the knowledge transfer between groups is difficult and the workload increased because of the higher number of stocks.

The progress initiated in late 2011 on the quality of the data collection process were pursued in 2014. Notably, a number of improvements were brought to the InterCatch data raising process in the last years, both through technical improvements of the InterCatch procedures and interface, and through the development of a number of exploratory scripts allowing rapid data screening and visualisation. This has led to data raising procedures that were both smoother and better informed. As last year, data were requested through a joint DCF-based WGNSSK/WGMIXFISH/WGNEW data call, and the deadline for early data delivery were largely hold. In 2014 additional species were added to the data call to improve the availability of data for data limited stocks (e.g., dab, witch, flounder).

The principle analytical models used for the stock assessments were XSA and SAM.

In 2014, the North Sea haddock stock was benchmarked and haddock in IV and IIIaW was merged with haddock in VIa into one Northern Shelf haddock stock. The agreed setup was used by WGNSSK.

WGNSSK works in close cooperation with WGMIXFISH and assessment and forecast results are directly used by WGMIXFISH to produce mixed fisheries advice. Similar links are established between WGNSSK and WGSAM to allow for an effective exchange of data and knowledge regarding multi species assessments.

State of the Stocks

The overall perception of the demersal stocks in the North Sea is that fishing mortality has declined significantly for most stocks. This led to progressive improvements of abundance for a number of stocks, and even an outburst of North Sea plaice. However, recruitment has been poor in recent years for many stocks and especially gadoids still have low or decreasing abundance. The summary of stock status is as follows:

- Nephrops: abundance is globally decreasing compared to earlier years in the North Sea and Skagerrak but an increase was observed between 2012

and 2013 for some stocks (FU 8, 9). Harvest levels are considered sustainable in most cases.

- Norway Pout: The dynamic of the stock is highly variable from year to year, due to recruitment variability and a short life span. Recent stock size has increased significantly following the high recruitment in 2012 and is above MSY Bescapement. Fishing mortality has been lower than the natural mortality for this stock and has decreased in recent years to below the long-term average F (0.6)
- Cod in Subarea IV and Divisions IIIa and VIId: Fishing mortality declined from 2000 and is now estimated to be around 0.4, between Fpa and the FMSY proxy. SSB has increased from the historical low in 2006, and is now in the vicinity of Blim. Recruitment since 2000 has been poor.
- Haddock in area IV, IIIa and VIa: Fishing mortality has been below FMSY since 2008 and SSB has been above the MSY Btrigger since 2001. Recruitment is characterized by occasional large year classes, the last of which was the strong 1999 year class. Apart from the 2005 and 2009 year classes, which are around the long-term average, recent recruitment has been poor.
- Whiting in IV and VIId: SSB has declined in recent years and is close to the minimum value of the time-series, while fishing mortality has been declining over most of the time-series. The average level of recruitment has been low since 2003.
- Saithe in IIIa, IV and VI: Recruitment has been below average since 2006. Fishing mortality has fluctuated around FMSY since 1997. SSB has declined since 2005 and has been slightly below Bpa for the last 3 years.
- Plaice in IV: The stock is well within precautionary limits, has increased in the past ten years, and has reached a record-high level in 2014. Recruitment has been around the long-term average since the mid-2000's. In recent years, fishing mortality has been estimated below FMSY and below the target specified in the management plan.
- Sole in IV: SSB is increasing since 2007 and is estimated to be above Bpa in 2014. Fishing mortality has declined since 1995 and is estimated to be just above Fmsy in 2013.
- Plaice in VIId : Fishing mortality has declined since the mid-1990s and is presently among the lowest in the time-series. Spawning-stock biomass has increased since 2003 and is currently around the highest level.
- Sole in VIId : The spawning-stock biomass has fluctutated without trend and is above MSY Btrigger since 2002. Fishing mortality has always been above FMSY, and has been above Fpa since 2005. Recruitment has been fluctuating without trend. Recruitment in 2012 and 2013 are the lowest of the time series.
- Turbot in IV: Recruitment is variable around the long-term average. Since 2001 fishing mortality has declined. Spawning-stock biomass is at a low level, but has been gradually increasing in recent years.
- Most of the data limited stocks have a biennial advice and an evaluation of new data has not altered the perception of the stocks. Therefore, the advice is the same as last year. New advice was produced only for plaice in Skagerrak (-13% decrease in the survey index).

1 General

1.1 Terms of Reference

2011/2/ACOM13 The **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak** (WGNSSK), chaired by Alexander Kempf*, Germany, will meet at ICES Headquarters, 30 April – 7 May 2014 to:

a) Address generic ToRs for Regional and Species Working Groups (see Table below). The Norway pout assessments shall be developed by correspondence;

b) Assess the progress on the benchmark preparations and planning for 2015

The assessments will be carried out on the basis of the stock annex in National Laboratories, prior to the meeting. This will be coordinated as indicated in the Table below.

Material and data relevant for the meeting must be available to the group no later than 14 days prior to the starting date.

WGNSSK will report by 20 May 2014, and by 22 September 2014 (Norway pout) for the attention of ACOM. The group will report on the ACOM guidelines on reopening procedure of the advice before 14 October and will report on reopened advice before 29 October.

Fish Stock	Stock Name	Stock Coordinator	Assessment Coord. 1	Assessment Coord. 2	Advice
cod-347d	Cod in Subarea IV, Divison VIId & Division IIIa (Skagerrak)	UK(Scotland)	UK(England)	Denmark	Update
had-34	Haddock in Subarea IV (North Sea) and Division IIIa	UK(Scotland)	UK(Scotland)	UK(England)	Update
nep-5	Nephrops in Division IVbc (Botney Gut - Silver Pit, FU 5)	UK(England)	UK(England)	Denmark	Update
nep-6	Nephrops in Division IVb (Farn Deeps, FU 6)	UK(England)	UK(England)	Denmark	Update
nep-7	Nephrops in Division IVa (Fladen Ground, FU 7)	UK(Scotland)	UK(Scotland)	Denmark	Update
nep-8	Nephrops in Division IVb (Firth of Forth, FU8)	UK(Scotland)	UK(Scotland)	Denmark	Update
nep-9	Nephrops in Division IVa (Moray Firth, FU9)	UK(Scotland)	UK(Scotland)	Denmark	Update
nep-10	Nephrops in Division IVa (Noup, FU 10)	UK(Scotland)	UK(Scotland)	Denmark	Update
nep-32	Nephrops in Division IVa (Norwegian Deeps, FU 32)	Norway	Norway	Denmark	Update
nep-33	Nephrops in Division IVb (Off Horn Reef, FU 33)	Denmark	Denmark	Sweden	Update
nep-34	Nephrops in Division IVb (Devil's Hole, FU 34)	UK(Scotland)			Update
nep-iiia	Nephrops in Division IIIa (Skagerak Kattegat, FU 3,4)	Denmark	Denmark	Sweden	Update
nop-34	Norway Pout in Subarea IV and Division IIIa	Denmark	Denmark	Norway	Update

ple-eche	Plaice in Division VIId (Eastern Channel)	France	France	Belgium	Update
ple-skag	Plaice in Subdivision 20 (Skagerrak)	Denmark	Denmark	Sweden	Update
ple-nsea	Plaice Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Update
sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)	Norway	Norway	Germany	Update
sol-eche	Sole in Division VIId (Eastern Channel)	Belgium	Belgium	France	Update
sol-nsea	Sole in Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Update
whg-47d	Whiting Subarea IV (North Sea) & Division VIId (Eastern Channel)	UK(Scotland)	UK(Scotland)	UK(England)	Update
whg-kask	Whiting in Division IIIa (Skagerrak - Kattegat)	Sweden	Sweden	Denmark	Multiyear
bll-nsea	Brill in Subarea IV and Divisions IIIa and VIId,e	Belgium			Biennial 2nd year
fle-nsea	Flounder in Division IIIa and Subarea IV	Germany	The Netherlands		--,,--
lem-nsea	Lemon sole in Subarea IV and Divisions IIIa and VIId	United Kingdom			--,,--
wit-nsea	Witch in Subarea IV, Division IIIa and VIId	Sweden			--,,--
Tur-nsea	Turbot in Subarea IV	The Netherlands	The Netherlands		--,,--
Tur-kask	Turbot in Division IIIa	Denmark			Biennial 2nd year
mur-347d	Striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)	France			--,,--

For the following stocks, WGNSSK will finalise the draft text on ecosystem and fisheries information based on draft advice prepared by WGNEW

Fish Stock	Stock Name	Stock Coordinator	Assessment Coord. 1	Assessment Coord. 2	Advice
gug-347d	Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)	Germany			WGNEW
pol-nsea	Pollack in Subarea IV and Division IIIa	Norway			WGNEW

The generic ToRs applying to assessment Expert Groups were the following :

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGBIE, WGEEL, WGEF, WGHANSA, WGNEW and WGNAS.

The working group should focus on:

For the ecoregion:

a) Consider ecosystem overviews where available, and propose and possibly implement incorporation of ecosystem drivers in the basis for advice

b) For the ecoregion or fisheries considered by the working group, produce a brief report summarising for the stocks and fisheries where the item is relevant:

   i) Mixed fisheries overview and considerations;

   ii) Species interaction effects and ecosystem drivers;

   iii) Ecosystem effects of fisheries;

   iv) Effects of regulatory changes on the assessment or projections;

For all stocks:

c) If no stock annex is available this should be prepared prior to the meeting, based on the previous year's assessment and forecast method used for the advice, including analytical and data-limited methods

d) Audit the assessments and forecasts carried out for each stock under consideration by the Working Group and write a short report.

e) Propose specific actions to be taken to improve the quality and transmission of the data (including improvements in data collection).

f) Propose indicators of stock size (or of changes in stock size) that could be used to decide when an update assessment is required and suggest threshold % (or absolute) changes that the EG thinks should trigger an update assessment on a stock by stock basis.

g) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2016

h) Check the existing static parts of the popular advice and update as required.

i) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA (2008 report). The relevant groups will report on the AGCREFA 2008 procedure on reopening of the advice before 13 October and will report on reopened advice before 29 October.

j) Take into account new guidance on giving catch advice (ACOM, December 2013).

k) Update, quality check and report relevant data for the stock:

   1. Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets, either directly or, when relevant, through the regional database. Data should be provided to the data coordinators at deadlines specified in the ToRs of the individual groups. Data submitted after the deadlines can be incorporated in the assessments at the discretion of the Expert Group chair;

   2. Abundance survey results;

   3. Environmental drivers.

l) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database or, where relevant, the regional database.

For update advice stocks:

m) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing the generic introduction to the ICES advice (Section 1.2). If no change in the advice is needed, one page 'same advice as last year' should be drafted.

n) For each stock , when possible prior to the meeting:

i) Update the assessment using the method (analytical, forecast or trends indicators) as described in the stock annex.

ii) Produce a brief report of the work carried out regarding the stock, summarising for the stocks and fisheries where the item is relevant:

1. Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);
2. Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
3. Stock status and catch options for next year;
4. Historical performance of the assessment and brief description of quality issues with the assessment;
5. In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans. Describe the fleets that are involved in the fishery.

o) Review the outcomes of WKMSRREF2 for the specific stocks of the EG. Calculate reference points for stocks where the information exists but the calculations have not been done yet and resolve inconsistencies between MSY and precautionary reference points and if possible

For stocks with multiyear advice or biennial (2nd year) advice

p) In principle, there is no reason to update this advice. The advice should be drafted as a one page version referring to earlier advice. If a change in the advice (basis) is considered to be needed, this should be agreed by the working group on the first meeting day and communicated to the ACOM leadership. Agreement by the ACOM leadership will revert the stock to an update procedure.

1.2 InterCatch

1.2.1 metier-based joined data call for WGNSSK and WGMIXFISH

The InterCatch database has historically not been widely used by the WGNSSK. In 2009, only one stock was using InterCatch up to the final level, and slow improvements

were made in 2010-2011. 2012 represented a major change in the process of data collection. Following an initiative launched by ICES WGMIXFISH in August 2011, it had been decided to merge the data calls and data collection of both groups WGNSSK and WGMIXFISH, on the basis of 1) improving the availability of metier-based data and their consistency with the stock-based data used for single-stock assessment and 2) allowing WGMIXFISH to meet earlier and as such integrate the mixed-fisheries advice within the single-stocks advice sheets. In 2014 data limited stocks were included in the data call to improve the knowledge base for these stocks (see also Annex 7) . Under the landing obligation these stocks become more important and discard information is a prequisit to give catch advice and to carry out mixed fisheries scenarios under the landing obligation.

The principle of this joined data call was to define the minimum aggregation (metier) level that individual countries could deliver data following the requirements of the EU Data Collection Framework (DCF), and to use these as the basis for providing and subsequently raising data for all North Sea demersal stocks. ICES InterCatch database was chosen as the most appropriate tool to use until the planned Regional Data Bases are fully established and operational. Basic strata for the submission of catch and effort data were by country, quarter, area and metier.

In 2014, the procedure for data submission was largely the same as in 2013, only additional species were included in the species list. An official data call was issued by ICES, with a deadline for data delivery by 28th March. No major issues occurred at that stage, and only few data were delayed compared to this date.

However, data on sampling intensity and the quality of uploaded data are so far not an official part of the data call. This will be addressed in the data call for 2015.

1.2.2 Data raising and allocation to unsampled strata

Major changes occured in 2013 and 2014 with the raising of data within InterCatch. Different initiatives can be mentioned here.

1) Technical improvements in the InterCatch interface. 2012 was the first year where InerCatch was used so intensively and with so many strata (country * area* metier * quarter) to raise and allocate. The WGNSSK had then experienced that this procedure was tedious and lengthy, with many mouse clicks to perform for each step. WGNSSK had therefore suggested a number of technical improvements that would optimize the process stream and ease the workload. The ICES Secretariat made great effort in addressing these before the 2013 data call. This work proved very useful and efficient, and made the whole process much smoother and painless. The main improvements were as follows :

- Allocation Group Setup: Define a group of unsampled catch/strata for which each distribution will be calculated according to the (for the group) allocated sampled catches/strata
- Automatic allocation ‘same’ strata: Automatic find and allocate identic sampled strata’s just from other countries to unsampled catches/strata (with the identic strata)
- Discard Group setup: Define a group of raised discards for which each discard weight will be calculated according to the (for the group) selected landing-discard’s ratios
- CATON and age/length data overviews: All imported data are possible to examine in details

- Allocation overview for pivot Table/matrix: All unsampled strata are shown in the first column and all sampled strata are shown as the first row, then all the selected combinations are shown in the matrix.

Further improvements were:

2) Summary outputs and inspection of data before raising: the new features included in InterCatch allowed improved inspection and visualization of the data submitted by national data providers and a comparison with data from previous years. Various generic R scripts were developed by mainly L. Clarke (MSS) and Y. Vermard (IFREMER) mapping out the raw data, through e.g. quantification of the proportion of catches covered by sampling, identification of major gaps and outliers, plot of the age distribution and discards ratio of the various strata etc.

3) Raising procedures. Based on statistical principles discussed within WKPICS, RCMs, PGCCDBS and DC-MAP etc, the suggestions for the basis on which to proceed regarding raising of age distributions and discards ratio have been revisited. In 2012, the raising and allocating was based on finding similar strata from other countries, but this was judged not fully defendable in terms of statistical integrity. In 2013 and 2014, the underlying principles applied were thus:

a) main strata are supposed to be sampled. In essence one should expect that the largest share of catches should have age-based and discards information in InterCatch. Which means that there is indeed a great number of unsampled strata (as we saw this last year), but in reality they should represent only a minor part of the catches. Large strata without sampling information would need to be investigated further.

b) For the remaining unsampled part which should be small, it doesn't matter much how they are raised because that will only do a marginal difference at the end. And secondly, there is no sound basis for raising them.

c) Therefore, the suggestion was that by default, unsampled strata should be raised by all sampled strata, unless there is a good and informed reason for chosing differently after the data inspection process.

Ultimately, all these changes have triggered in-depth investigation and understanding of the data submitted, and are hopefully contributing to improved consistency and transparency in the assessment data. Some further improvements have nevertheless still be suggested, and in particular such as the flexibility to program the automatic matching and to set filters. InterCatch contains a feature for exact matches (in terms of métier, country, season, area) for automation, but a little more flexibility with this tool would help a lot, for example, by letting the user the selection of fields entering the exact match. Next to this it would be helpful if groups for raised discards and for the allocations from unsampled catches can be copied from previous years. The SOP could be shown directly together with the uploaded data to ease judegements on the quality of data used to raise unsampled metiers. Especially for by-catch species Intercatch must be able to deal with the situation that discards are reported together with zero landings in the future.

InterCatch summary data have been made available on the sharepoint for all stocks, and they will be investigated further during ICES WGMIXFISH.

By the end of the WG, the status of InterCatch use was as follows :

Stock	WG	WGYear	DataYear	Use of InterCatch	DataUsedInAssessment 1=Used	Comment
cod-347d	WGNSSK	2014	2012	Used as the only tool	1	Used as only tool since wgnssk 2012. Comparison in wgnssk 2013 report.
cod-347d	WGNSSK	2014	2013	Used as the only tool	1	Used as only tool since wgnssk 2012. Comparison in wgnssk 2013 report.
dab-nsea	WGNSSK	2014	2013	Used as the only tool	1	dab-nsea was for the first time included to the WGNSSK data call and therefore data were for the first time available in InterCatch. This year InterCatch was used to raise discards by metiers. Although, there were age reading data provided these were not used this year but they will be further analysed within the next year. Most of dab catches are discarded and discard raising will become more important with the implementation of the discard ban.
fle-nsea	WGNSSK	2014	2013	Used as the only tool	1	fle-nsea was included for the first time in the WGNSSK data call. Therefore, it was the first time Inter Catch could be used as raising tool for this stock. So far, Inter Catch was used for this stock to estimate the total catch. There is no analytical assessment for flounder. However, Inter Catch is a useful tool to estimate the total catch for this stock in the future. Not all countries provided information by metiers.
had-34	WGNSSK	2014	2013	Used as the only tool	1	Data collation for this subunit of the full Northern Shelf haddock stock (had-346a) was carried out using only InterCatch.
mur-347d	WGNSSK	2014	2013	Used as the only tool	0	No analytical assessment developped yet, Inter Catch was used for the first year in 2014. Very little age data provided this year
nep-10	WGNSSK	2014	2013	Used as the only tool	1	
nep-32	WGNSSK	2014	2013	Used in parallel with another tool, but InterCatch was only used for trial or partly raising	1	All data have been uploaded to Intercatch, but as the stock coordinator this year (spring 2014) worked from Cuba (slow net connection), files were also received directly from data submitters by e-mail. The Danish discards uploaded to Intercatch seemed unreliable and did not match the Danish lfd of cathces, they seemed to be too small. Danish discards were also received directly from Danish scientists (excel sheet) and these estimates seemed much more sensible. In the assessment the Danish discards in the excel sheet were used.
nep-33	WGNSSK	2014	2013	Used in parallel with another tool, but InterCatch was only used for trial or partly raising	1	
nep-3-4	WGNSSK	2014	2013	Used in parallel with another tool, but InterCatch was only used for trial or partly raising	1	
nep-5	WGNSSK	2014	2013	Used as the only tool	1	
nep-6	WGNSSK	2014	2013	Used as the only tool	1	
nep-7	WGNSSK	2014	2013	Used as the only tool	1	
nep-8	WGNSSK	2014	2013	Used as the only tool	1	Previously compared & showed < 1% difference.
nep-9	WGNSSK	2014	2013	Used as the only tool	1	Previously compared & differences < 1%
nop-34	WGNSSK	2014	2013	Used in parallel with another tool, but InterCatch was only used for trial or partly raising	0	The data provided to inter-catch by Denmark (and also for most recent year for Norway) are the same data as used in the assessment. As industrial catch raising is done differently by Denmark and Norway InterCatch is not used for raising of the industrial catches.
ple-eche	WGNSSK	2014	2013	Used as the only tool	1	
ple-nsea	WGNSSK	2014	2013	Used as the only tool	1	
ple-skag	WGNSSK	2014	2013	Used as the only tool	1	
sai-3a46	WGNSSK	2014	2013	Used as the only tool	1	
sol-eche	WGNSSK	2014	2013	Used as the only tool	1	
sol-nsea	WGNSSK	2014	2013	Used as the only tool	1	Though discard data is imported, discard is not used in the assessment. Therefore allocations are not set up for unsampled discards.
tur-kask	WGNSSK	2014	2013	Used as the only tool	1	
tur-nsea	WGNSSK	2014	2013	Used as the only tool	1	
whg-47d	WGNSSK	2014	2013	Used as the only tool	1	
whg-kask	WGNSSK	2014	2013	Used as the only tool	0	

1.3 General uncertainty considerations

Data or inputs used in this report are based on sampling or on census. Typical census data are landings data from saleslips representing total landing, while sampled data are random samples (design based) used to produce estimates of total, relative indices or to characterize composition (like catch at age). All sources of input may introduce error in estimates/calculations and is a limiting factor in the amount of information and/or interpretation of model results. The scientist at this working group are only responsible for a modest fraction of the input data used and are relying heavily on assumptions regarding their validity and quality. The information based on sampling will contain sampling errors (random errors due to the stochastic nature of such sampling) and estimates of sampling error are generally not used by this working group. Such errors will show up in residuals (residual plots are an important diagnostic in the report), but other sources of error will also show up in the same residuals and are not easily separated from random errors. Non random errors are either bias or model errors. Systematic bias over time is a particular concern and an example of such can be underreporting of catches which will compromise the validity of the model results as basis for advice. Model errors may represent the use of the "wrong" equations to describe relations, but will in this report typically be linked to assumptions regarding natural mortality, the relationship between survey indices and stock size (catchability) and exploitation pattern. Some assumptions are needed since the Baranov and catch equations does not have unique solutions (too many parameters to estimate).

Assessment working groups are in many ways end users of data and it would be preferable to have such information presented as point estimates together with estimates of uncertainty or confidence bands and with a description of potential sources of bias and qualitative remarks related to specific observations (bad weather may have had an influence, lack of sampling at a landing site etc.).

The working group appreciates the effort made by so many supporting hands involved in creating all information needed in fish stock assessment and is dependent on the quality of information being upheld over time. An assessment working group is where information from the commercial fishery is handled together with fishery independent information to create estimates of stock status and the impact of fishing.

Demersal trawl surveys are the most used source of fishery independent information in this working group (WGNSSK). A demersal trawl survey uses a standardized procedure of trawling to create samples from a fish population. The "population" in statistical terms is the population of possible trawl stations with trawl station being the primary sampling unit. The estimates of uncertainty from a demersal trawl survey is very much dependent on the number of samples (trawl stations) and far less on the size of the area surveyed and it seems that demersal trawl surveys on gadoid produces very similar estimates of uncertainty given the same number of trawl stations (ICES 1992) regardless of the size of the area. The relationship between sample size and precision can be illustrated using the following example: If a survey of 400 trawl stations produces an estimate (for a parameter of interest) with a corresponding relative standard error of 0.1 a reduction in survey effort to 100 trawl stations is likely to produce estimates with a relative standard error of 0.2 (divide the number of stations by 4 and the relative standard error is doubled). This is also likely to hold (at least as a rule of thumb) if one looks at results from a subarea of the original (400 station) area. When estimates of relative standard error approaches 0.3 will trends over time be very difficult to detect and with relative standard errors above 0.3 the estimator can only be used to detect sudden events.

1.4 IBTS survey Q1 in 2014

Nexto general uncertainty considerations, WGNSSK notes that bad weather conditions during the IBTS q1 survey led to a considerably lower number of hauls that could be conducted especially in the Northern part of the North Sea. Most of the ICES rectangles could be covered, however, often only with one instead of two hauls (Figure 1.4.1).

The lower number of hauls increases the uncertainty around survey indices (see general uncertainty considerations) what in turn increases the uncertainty especially for survivor estimates in the assessments. The 2014 IBTS Q1 survey index was used in the assessments of cod, haddock, Norway pout and whiting. For these stocks it was analysed whether the 2014 survey index values are outliers and whether there are unusal year effects. For haddock a strong year effect was visible and the 2014 data were downweighted in the assessment. For the other stocks no obvious outliers could be detected.

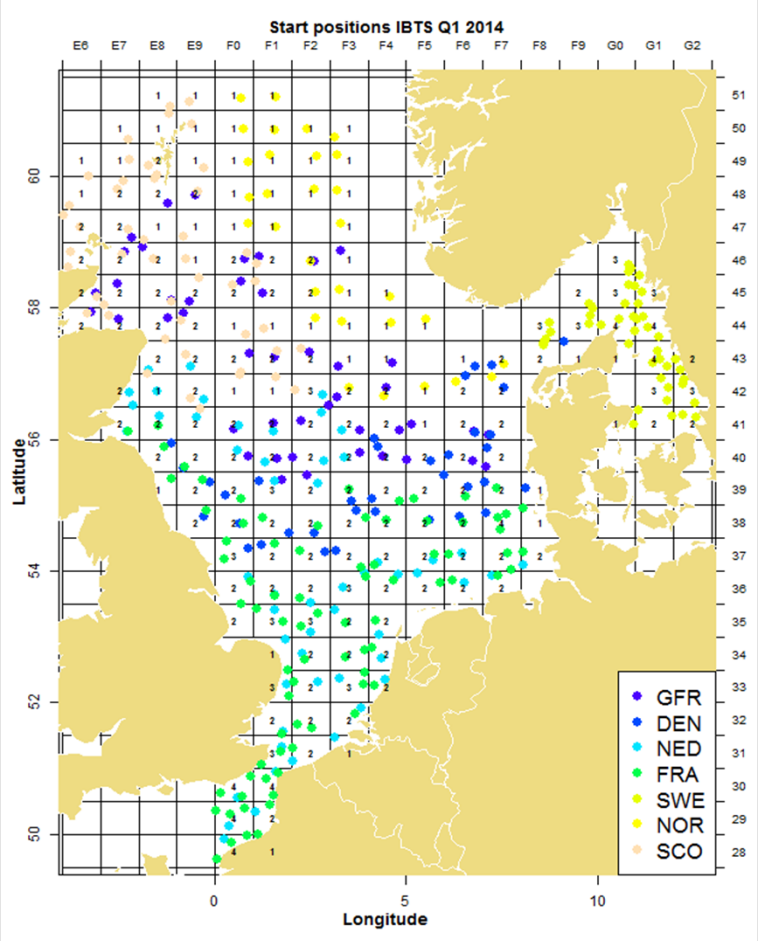


Figure 1.4.1: Hauls conducted during the 2014 IBTS Q1 survey

1.5 Internal auditing

Two years ago, ICES removed the external review process that had been in place for some years, and replaced it by an internal audit process within the Working Group itself. WGNSSK understands the motivations and reasoning behind this choice, and recognizes also that the process has certainly some merits and direct benefits such as increased participation and collaboration within the group across countries and stocks. However, WGNSSK wishes to underline that this audit is another heavy task pending on group members, and it was not possible to accomplish it during the 8-days meeting

itself. WGNSSK operates with seldom more than one scientist per stock (sometimes even one scientist for more than one stock), and there was simply not enough time to have assessments and reports finalized in time in order to carry their subsequent audit within the WG meeting. Audits had to be conducted by correspondence after the WG time, which is neither very efficient nor very motivating given the heavy workload most members usually operate with back in home institutes. WGNSSK recommends to explore alternative ways to strengthen the audit process (e.g., professional auditors as part of the ICES secretariat, external audit).

1.6 Mixed Fisheries

The mixed fisheries analyses have not been performed by WGNSSK over the last years. Instead, these are now being performed within the Working Group for Mixed Fisheries Advice for the North Sea (WGMIXFISH), which aims at evaluating the consistency of the ICES advice for the individual stocks in a mixed fisheries context, using the Fcube model (Ulrich *et al*., 2011).

The two groups have developed and issued a common data call since 2012, which greatly improved the quality and scheduling of data delivery. WGMIXFISH has met in late May 2014 in order to integrate mixed-fisheries advice for the North Sea into single stock advice.

It is therefore referred to ICES WGMIXFISH 2014 report for any further description of mixed-fisheries context.

However, the group discussed mixed fisheries issues under the landing obligation in an extra session. There is a potential problem with choke species in the North Sea. Target species as well as bycatch species can become choke species for certain fleet segments. One way to deal with the situation is to use ranges for F_{msy} instead of point estimates. Ranges can act as buffer and can minimize the discrepancies in available quotas for species in a mixed fishery. However, also this approach has only a limited potential to solve issues with choke species under the landing obligation. Objectives are needed to determine which F inside the range should be applied in certain situations (e.g., one species expoitated with F inside the range, another species wioth F outside the range; both species inside the range; both species outside the range)

The management of by-catch species (e.g., dab, lemon sole, turbot) by TAC further complicates the situation. If the TAC management for these species continues and Fmsy proxies will be implemented, theses species can become serious choke species. The interinstitutional task force on multi annual plans between the European parliament, the council and the Commission write in their agreement (EU 8529/14): "With regard to by-catch species, the Co-legislators will have to determine, taking account of the available scientific advice, whether these are sufficiently covered through the management measures according to MSY for the key species". Policy has to define what sustainable exploitation means for bycatch species and it has to be evaluated by science whether MSY tagets for target stocks are enough to ensure a sustainable exploitation of bycatch species.

1.7 Multi species considerations

ICES gave advice on multi species considerations for the North Sea in 2013 for the first time to start a dialogue between ICES and its stakeholders on this topic. Simulations were carried out with the stochastic multi species model SMS to analyse F_{msy} in a multi species context. The multi species considerations can be found under: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf

WGNSSK supports this step. However, the group also raised concerns about the data basis for the simulations (stomach data mainly from 1981 and 1991) and the high number of assumptions behind the model results.

Already in 2013 the group discussed the progress achieved under various initiatives such as ICES WGSAM (2011, 2012), ICES WKMTRADE (2012) and the EU project MYFISH. The group noted that a multispecies benchmark as in the Baltic may be needed where the North Sea SMS model and keyrun settings are reviewed by external experts before a final multi species advice can be given. Further it was concluded that even if final results are available, it will be difficult to agree on multi species reference points. There are many direct and indirect interactions between species, making it difficult to reach a single and robust best solution. Optimization scenarios carried out so far show that the result (target F) depends very much on the objectives (objective function) and SSB constraints used. The exact combination of species target F depends also on the weighting factors (e.g. price per kg when optimizing value) actually used for calculating these objectives. This makes the approach less robust for use in management. On a stakeholder workshop organized by ICES and MYFISH (ICES WKM-TRADE 2012) it has been agreed that when offering trade-offs, ICES can provide scenarios below F_{MSY} for the exploitation of some populations. This will allow a policy choice to be made within the limits defined and explained by ICES. F_{MSY} could thus be defined as a range, although the upper bound should not be seen as optimum solution for fisheries exploitation rates. F_{MSY} should be seen as the upper bound for the target F (WKM-TRADE 2012).

1.8 Generic ToR on indicators (ToR f)

The opinion of the group has not changed compared to last year and only a small paragraph on the experience in 2014 with data limited stocks has been added:

ToR f): ”Propose potential indicators of stock size (or changes in stock size) including threshold % (or absolute) changes that may trigger an update assessment.” The motivation for doing this is “ . . . the process of streamlining the advisory process from assessment EGs to the final advice in order to reduce the workload for the expert community.” The request covers both intermediate year reopening of advice as well as the potential to introduce a system of multiannual advice with a fallback position or “safeguarding” in form a reopening procedure. The working group would like to point out that time spent at the yearly assessment meetings represent only a modest fraction of the work related to collect and prepare the information needed in these meetings.

The approach and choice of threshold should relate to “risk and uncertainty” without being more specific, but it could be interpreted as a reopening of advice being more likely if the overall perception is a stock in poor conditions.

Additional background information was found in ICES 2008 and ICES 2012. The information given in the generic ToR for assessment working groups suggests using “indicators” together with predefined thresholds of the same to be used as criteria for reopening advice.

WGNSSK is of the opinion that “new information” is best assessed by using the information directly in an assessment model (update run), which is usually quick to produce once the necessary data have been put together.

The group considers that even for stocks where the surveys have usually a good correlation with the assessment result (such as e.g. haddock or Norway pout), the diagnostic

is more robust and precise when proceeding with the update run including all sources of information rather than when considering the surveys alone. The search for candidate indicators would look into aggregate survey indices and what relative change they represent in addition to information from the fishery where catch rates and overall effort change could be possible candidates. The relative importance of different sources of information is assessed in the traditional influence diagrams presented with most assessments (percentage Contribution to survivors' estimates in final XSA assessment) and will be a good starting point. It is likely that "noisy" assessments will have a much larger probability of being reopened with the inclusion of new information. This reveals a need to change the whole assessment and advisory process and could be related to the timing of the assessment itself or the quality of the input data.

The group points out that estimates of thresholds are likely to vary with time as the relative "importance" or contribution to the assessment itself will vary. This is likely to happen if sampling levels are changed and the corresponding time series will over time be given more or less weight (contribution) to the assessment. A similar effect will occur at the detection and corresponding correction of bias whether this is done external or internal to the assessment model.

Good estimates of thresholds to trigger reopening of advice (and assessment) would include annual simulations of new input and their effect on the assessment including likely scenarios for the intermediate year uptake and corresponding assumptions.

WGNSSK recommends that the actual extent of the problem is first investigated on historical assessment data, before deciding that this should be implemented in the future. A first starting point for a workshop looking into candidate indicators and thresholds is to see how much certain biomass estimates change from one assessment to the next and assess how big the need for such a procedure is. An obvious candidate is to compare predicted SSB at start of the TAC year with the last estimated SSB in the following year's assessment.

As an important point, WGNSSK underlines that since stock assessment and corresponding advice is an integrated part of most long term management plans, this represents a change to the management plan itself (or at least the implementation of it) that needs to be evaluated in the same way as management plans in general (Management Strategy Evaluations, MSE).

Any case by case MSE should look into the robustness in choice of indicator including the likelihood of triggering a reopening for the wrong reasons or missing out on a "needed" opening.

The question how these issues would appear if the advice was based on probabilistic forecasts was raised, but no conclusion was made. A precautionary advice based on estimated assessment uncertainty may be changed when uncertainty is reduced (because of new information) without the perception of stock status (point estimates) being changed.

In conclusion, WGNSSK considers that for most North Sea demersal stocks, the current procedure with analytical assessment is now well established and mature, with rapid update assessments and management plans tailored to these, and benchmarks process at regular intervals. WGNSSK considers that the workload in this process has already been greatly optimized compared to the recent history where working groups spent a lot of time fiddling with assessment settings and runs. WGNSSK considers therefore that reverting to indicators-based advice would requires a lot of additional work in the short term for evaluating robustness and management options in this new frame, and

that the future gains in time would be limited considering that most time is already spent collecting and preparing the data anyway.

The situation is different for data limited stocks (i.e. category 3 stocks). Survey indices are the main data source for these stocks and are therefore the basis to decide whether biennial or multiannual advice needs be reopened. Based on the experience this year, agreed criteria triggering the reopening of advice are lacking. Objective criteria are needed to determine when the perception of the stock status has changed to avoid subjective interpretations of survey time series. Thereby the uncertainty around survey estimates needs to be taken into account. By using survey index point estimates the chance is high that the reopening is based on noise in survey data (especially when applying the standard 2:3 rule from WKLIFE!). The group already suggested the use of smoother functions last year. However, WKLIFE didn't had the time to evaluate their applicability and to define standards for the smoothing functions so far.

1.9 Recommendations from other groups

WGNSSK received a recommendation from WGISDAA to *"…inform WGISDAA of priority stocks where improvments in survey information could be of benefit to the assessment proceedure. "* In addition, the IBTS working group inofficially asked for an overview on survey data used in the different assessments. As answer WGNSSK started to produce an overview on the usage of surveys and suggestions for improvement (Table 1.9.1). Further the chairs of the respective working groups will be directly contacted.

Table 1.9.1: Overview on survey usage and need for improvement

Stock	Surveys used in the assessment	Improvements needed? (coverage, sampling intensity, additional data (age readings, stomachs, environmental data etc…))	Length frequency is (planned to be) used in the index/assessment	Age readings are (planned to be) used for the index/assessment?	Maturity at length/age are (planned to be) used for the index/assessment?	Sex ratio is (planned to be) used for the index/assessment?	Age reading workshop needed in the next 1-2 years?	Comments
cod-347d	IBTS Q1, but IBTS Q3 remains a priority for inclusion (benchmark to investigate)	To be investigated for benchmark (but catchability issues related to change in fish distribution critical)	Yes (combined with ALKs)	Yes	Yes (may be considered for benchmark)	No	No	Urgent need to investigate catchability issues related to change in fish distribution. Assessment would benefit greatly from estimates of precision.
had-346a	IBTS q1 and q3	Link between the western waters survey and IBTS needed	Yes	Yes	Yes (for maturity ogive)	no	no	
nep-32	Norwegian annual shrimp survey covering FU 32 and FU 3: annual distribution maps	The catches of nephrops in the survey trawl are small and highly variable. Due to economic reasons it will not be possible to increase the number of trawl stations. Possibilities for creating a fishery independent biomass index will be explored						
nop-34	IBTS Q1, SGFS Q3, EGFS Q3, IBTS Q3	Coverage of spawning aggregations in Q1	No	Yes	No, but relevant	No, but relevant	Yes	
ple-eche	French GFS, UK BTS, old Int YFS	additional recruitment survey with a broad coverage	yes	yes	no	no	no	
ple-skag	IBTS Q1, IBTS Q3, BTS	Too few hauls in Skagerrak for reliable index	yes	yes	yes, tentatvely (used in Ulrich et al., 2013 stock structure paper)	not now	yes - possible difference in age reading between Dk (reading most catch otoliths) and SW	

Table 1.9.1 (cont.)

Stock	Surveys used in the assessment	Improvements needed? (coverage, sampling intensity, additional data (age readings, stomachs, environmental data etc…))	Length frequency is (planned to be) used in the index/assessment	Age readings are (planned to be) used for the index/assessment?	Maturity at length/age are (planned to be) used for the index/assessment?	Sex ratio is (planned to be) used for the index/assessment ?	Age reading workshop needed in the next 1-2 years?	Comments
ple-nsea	BTS-combined (ISIS+Tridens), SNS	None	-	Yes	Fixed ogive used.	No	No	The appropriateness of teh SNS survey was called into question. Changes in stock distribution are likely to have caused changes in catchability of the survey. This survey has low weighting in the assessment model and its use will be examined further at the next benchmark.
sai-3a46	IBTS Q3, NORACU	Current surveys do not cover the deeper areas and the nursery grounds. Poor coverage by surveys of the recruits. "Design" of NORACU needs drastic improvement as this "survey" does not have a proper survey design and lacks sampling for biological data/verification of the acoustic signal.	Yes	Yes	for maturity ogive	no	no	There is a breakdown in agreement between IBTS Q3 and NORACU; this breakdown needs to be closely examined in the IBP.
sol-eche	UK(E&W)-BTS ,UK(E&W)-YFS, and FR-YFS	additional recruitment survey with a broad coverage as the UK(E&W)-YFS was halted in 2006	yes	yes	for maturity ogive	no	?	
sol-nsea	BTS-ISIS, SNS	BTS data from area near the border with VIId would improve the assessment. The Belgian data for this area is in the process of being prepared.	-	Yes	Fixed ogive used.	No	No	It is hoped to have the Belgian BTS data ready in time for the sole benchmark in 2015. At present the assessment is supplimented with a commercial CPUE index.

Table 1.9.1 (cont.)

Stock	Surveys used in the assessment	Improvements needed? (coverage, sampling intensity, additional data (age readings, stomachs, environmental data etc…))	Length frequency is (planned to be) used in the index/assessment	Age readings are (planned to be) used for the index/assessment?	Maturity at length/age are (planned to be) used for the index/assessment?	Sex ratio is (planned to be) used for the index/assessment?	Age reading workshop needed in the next 1-2 years?	Comments
whg-47d	IBTS q1 and q3	none	yes	yes	Fixed ogive used.	no	?	
whg-kask	IBTS Q1 and IBTS Q3	Stock ID necessary, age reading improvements welcomed	Yes	Yes	No (data borrowed from IV)	No	Yes	Stock ID is the key issue here. Analysis of the historic stock development would also be useful.
bll-nsea	none	none of the existing surveys assumed to be representative for the stock						
dab-nsea	IBTS Q1	maturity data needed for better estimate of maturity ogive	Yes	Yes	Yes	Yes	Yes	
fle-nsea	IBTS Q1	maturity data needed for better estimate of maturity ogive	Yes	Yes	Yes	Yes	No	
lem-nsea	IBTS Q1	?	Yes	?	Yes	Yes	?	
wit-nsea	IBTS q1q3	Age reading coverage	yes	yes	yes	no	yes	
Tur-nsea	BTS-ISIS, SNS	A survey with broader coverage on the North Sea would improve the assessment.	-	Yes	Fixed ogive used.	No	No	The internal consistency of the indices used for turbot is poor. The assessment is supplimented with a commercial CPUE index.
Tur-kask	BITS	no catches of turbot in IBTS	yes	not now	not now	not now	no	
gug-347d	IBTS Q1	maturity data needed for better estimate of maturity ogive	Yes	not now	Yes	Yes	not now	

1.10 Special requests

Two EU-Norway requests dealing with North Sea demersal stocks have been issued in spring 2014 regarding the the cod advice from last year. Progresses on these requests have been noticed by WGNSSK, but all requests will be dealt with separately by other Review Group/Advice Drafting Group, and are therefore not presented further in this WGNSSK report.

1.11 References

ICES 1992. Report of the workshop on the analysis of trawl survey data. Woods Hole, 4.-9. June, 1992. C.M. 1992/D:6

ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA), 20–22 August 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:60. 30 pp.

ICES. 2012. Report of the Second Ad Hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA2), 23–24 May 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:35. 44 pp.

Ulrich, C., Reeves, S. A., Vermard, Y., Holmes, S. J., and Vanhee, W. 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. – ICES Journal of Marine Science, 68: 1535–1547.

ICES. 2012. Report of the Workshop on North Sea and Baltic Sea Multispecies Trade-offs (WKM-Trade), 9 October 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:71. 15 pp.

ICES. 2012. Report of the Working Group on Multispecies Assessment Methods (WGSAM) , 22-26 October 2012, Venice, Italy. ICES CM 2012/SSGSUE:10. 145 pp.

ICES WGMIXFISH 2014. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH-NS). 26. – 30. May Kopenhagen. ICES CM 2014/ACOM:xx.

2 Overview

2.1 Introduction

The demersal fisheries in the North Sea can be categorised as a) human consumption fisheries, and b) industrial fisheries which land the majority of their catch for reduction purposes. Demersal human consumption fisheries usually either target a mixture of roundfish species (cod, haddock, whiting), a mixture of flatfish species (plaice and sole) with a by-catch of roundfish and other flatfish (turbot, brill dab), or *Nephrops* with a bycatch of roundfish and flatfish. A fishery directed at saithe exists along the shelf edge.

The industrial fisheries which used to dominate the North Sea catch in weight have become much less prominent. Human consumption landings have steadily declined over the last 30 years, with an intermediate high in the early 80's. The landings of the industrial fisheries show the largest annual variations, resulting from variable recruitment and the short life span of the main target species. The total demersal landings from the North Sea reached over 2 million t in 1974, were around 1.5 million t in the 1990s and are currently around 600,000t, of which over half is industrial fisheries.

For some stocks, the North Sea assessment area may also cover other regions adjacent to ICES Subarea IV. Thus, combined assessments are made for cod including IIIaN (Skagerrak) and VIId, for haddock including VIa and IIIa, Norway pout including IIIa, for whiting including VIId, and for saithe including IIIa and VIa. The state of *Nephrops* stocks are evaluated on the basis of discrete Functional Units (FU) on which estimates of appropriate removals are founded. Quota management for *Nephrops* is still carried out at the Subarea and Division level, however.

The sandeel assessment has been moved to ICES HAWG and is therefore not presented anymore in WGNSSK report.

The analysis of biological interactions (predator-prey relationships) among species has been a central theme in ICES over the last 30 years, primary for the Baltic Sea and the North Sea. The 2011 North Sea key run performed by the multispecies group WGSAM represents the ultimate state of the art in terms of multispecies assessment, with the dynamic estimation of predation mortality. This has led to the publication of the first multispecies advice by ICES in 2013 (http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/2013/mult-NS.pdf) . The single-stock assessments and advice presented in this report are however not (yet) produced by the multispecies assessment model, but time variant values of natural mortalities estimated by multispecies assessments for cod, haddock, and whiting are incorporated in the assessments of these species. Flatfish are not part of the current multi species assessment and more work is needed to incorporate also information on flatfish in the multi species advice.

Gear types vary between fisheries. Human consumption fisheries use otter trawls, pair trawls, *Nephrops* trawls, seines, gill nets, or beam trawls, while industrial fisheries use small meshed otter trawls. Trends in reported effort in the major fleets fishing in the North Sea are described annually by the ICES WG on Mixed Fisheries Advice for the North Sea (ICES WGMIXFISH 2014), which meets straight after the WGNSSK. Both WG share a joint data call issued by ICES for fulfilling the data needs of both groups (Annex 6).

The data distinguish between two basic concepts, the Fleet (or fleet segment), and the Métier. Their definition has evolved with time, but the most recent official definitions

are those from the CEC's Data Collection Framework (DCF, Reg. (EC) No 949/2008), which we adopt here:

- ***A Fleet segment*** is a group of vessels with the same length class and predominant fishing gear during the year. Vessels may have different fishing activities during the reference period, but might be classified in only one fleet segment.
- ***A Métier*** is a group of fishing operations targeting a similar (assemblage of) species, using similar gear, during the same period of the year and/or within the same area and which are characterized by a similar exploitation pattern.

Fleets and métiers were defined to match with the available economic data and the cod long term management plan. In 2013 and 2014 WGMIXFISH included new stocks in its analyses (plaice and sole in the Eastern Channel as full analytical stocks; hake in the North Sea and plaice in Skagerrak as additional "lpue" stocks as well as turbot with an assessment indicative of trends, see WGMIXFISH 2013 and 2014 report). Ultimately, WGMIXFISH has identified 43 national demersal fleets (combination of country, main gear and vessel size category, plus an "others" OTH fleet) from nine countries. These fleets engage in one to four different métiers each, resulting in 118 demersal fisheries (country*fleet*métier*area) in the North Sea, Skagerrak and Eastern Channel.

ICES WGMIXFISH (2014) produces a number of synthetic Figures describing main trends, between 2003 and 2013, of effort and catches and landings by fleet and stock.

Overall nominal effort (kW-days) by EU demersal trawls, seines, beam trawls, gill/trammel nets, and longlines (all mesh sizes included) in the North Sea, Skagerrak, and Eastern Channel had been substantially reduced since the implementation of the two successive effort management plans in 2003 and 2008 (−38% between 2003 and 2013, −17% between 2008 and 2013). Following the introduction of days-at-sea regulations in 2003, there was a substantial switch from the larger mesh (>100 mm, TR1) gear to the smaller mesh (70–99 mm, TR2) gear. Subsequently, effort by TR1 has been relatively sTable, whereas effort in TR2 and in small-mesh beam trawl (80–120 mm, BT2) has shown a pronounced decline (0%, −52%, and −52%, respectively, between 2004 and 2013). Gill- and trammelnet fisheries have remained sTable (ICES WGMIXFISH 2014). Effort in large-meshed beam trawl (≥120 mm, BT1) has increased significantly in 2012 and 2013 after a decade of continuous decline. Nominal effort reported by Norway has increased since 2011 due to the generalization of electronic logbooks.

2.2 Main management regulations

The near-collapse of the North Sea cod stock in the beginning of the 2000s led to the introduction of effort restrictions alongside TACs as a management measure within EU fisheries. There has also been an increasing use of single-species multi-annual management plans, partly in relation to cod recovery, but also more generally. The management frames can be summarised as such:

2.2.1 Landings obligation

Fisheries in Norwegian waters have been subject to a landing obligation for cod and haddock from 1987 and for most species since 2009. A landing obligation for EU fisheries on demersal species in the North Sea is due to be implemented from 2016 in a phased approach with all quota stocks subject to the landings obligation from 2019 onwards. Detailed definitions of the landing obligation can be found in Article 15 of regulation 1380/2013.

There is a high probability that the implementation of the EU landing obligation with its complex definitions, exemptions and rules (e.g. de-minimis, high survival, 9% inter-species flexibility) has implications for the quality of monitoring of the catches and the quality of assessments of the stock status and exploitation rate. De-minimis exemptions and the 9% inter-species flexibility rule can lead to serious implications for stocks dependent on the interpretation of the respective paragraphs in the regulation (STECF 2014a, b). The possibility to use up to 9% of the quota of a target species for bycatch of any other species constitutes a major factor for uncertainty in future management as it is not possible to predict what will happen at least in the first years. Regional discard plans are currently under development (see Article 15 (5) and (6)) but the level of detail in these plans is still under discussion.

The landing obligation will mean a serious change and therefore exploitation patterns of fleets will most likely change in the future. Predictions of these changes are hardly possible what will lead to an increased uncertainty in short term forecasts until more information becomes available. Next to this there is a risk that the data basis deteriorates under the landing obligation because discarding becomes illegal and fishermen have a strong incentive to hide discards.

2.2.2 Effort limitations

For vessels registered in EU member states, effort restrictions in terms of days at sea were introduced in 2003 and subsequently revised annually. Initially days at sea allowances were defined by calendar month. From 2006 the limit was defined on an annual basis. The maximum number of days a fishing vessel could be absent from port varied according to gear type, mesh size (where applicable) and region. A complex system of 'special conditions' (SPECONs) developed upon request from the Member States, whereby vessels could qualify for extra days at sea if special conditions (specified in the Annexes) were met. Increasingly detailed micromanagement took place until 2008 (Ulrich et al., 2012). A detailed description of these categories as well as the corresponding days at sea can be found in STECF (2008).

In 2008 the system was radically redesigned. From 2009, a total effort limit (measured in kW days) is set and divided up between the various nation's fleet effort categories. The baselines assigned in 2009 were based on track record per fleet effort category averaged over 2004-2006 or 2005-2007 depending on national preference, and the effort ceilings were updated in 2010. After some reductions based on the cod management plan to support the recovery of the cod stock, an effort roll over was decided for 2013 and 2014.

The areas are Kattegat, the part of IIIa not covered by Skagerrak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone Via and EC waters of ICES zone Vb. The grouping of fishing gear concerned are: Bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≤ 100 mm) – TR2 (≤ 70 and < 100 mm) – TR3 (≤ 16 and < 32 mm); Beam trawl of mesh size: BT1 (≤ 120 mm) – BT2 (≤ 80 and < 120 mm); Gill nets excluding trammel nets: GN1; Trammel nets: GT1 and Longlines: LL1. The respective effort limitations per area per gear can be found in annex IIa and Appendix 1 to Annex IIa in the annual TAC and quota regulations (EC No 43/2009; EC No 23/2010; EC No 57/2011; EC No 44/2012, 40/2013).

Table 2.1.1 Maximum allowable fishing effort in kilo watt days in 2013 and 2014.

Geographical area: Skagerrak, that part of ICES division IIIa not covered by the Skagerrak and the Kattegat; ICES subarea IV and EU waters of ICES division IIa; ICES division VIId

Regulated gear	BE	DK	DE	ES	FR	IE	NL	SE	UK
TR1	895	3 385 928	954 390	1 409	533 451	157	257 266	172 064	6 185 460
TR2	193 676	2 841 906	357 193	0	6 496 811	10 976	748 027	604 071	5 127 906
TR3	0	2 545 009	257	0	101 316	0	36 617	1 024	8 482
BT1	1 427 574	1 157 265	29 271	0	0	0	999 808	0	1 739 759
BT2	5 401 395	79 212	1 375 400	0	1 202 818	0	28 307 876	0	6 116 437
GN	163 531	2 307 977	224 484	0	342 579	0	438 664	74 925	546 303
GT	0	224 124	467	0	4 338 315	0	0	48 968	14 004
LL	0	56 312	0	245	125 141	0	0	110 468	134 880

The STECF and ICES WGMIXFISH has performed annual monitoring of deployed effort trends since 2002.

Overall nominal effort (kW-days) by EU demersal trawls, seines, beam trawls, gill/trammel nets, and longlines (all mesh sizes included) in the North Sea, Skagerrak, and Eastern Channel had been substantially reduced since the implementation of the two successive effort management plans in 2003 and 2008 (−38% between 2003 and 2013, −17% between 2008 and 2013). Following the introduction of days-at-sea regulations in 2003, there was a substantial switch from the larger mesh (>100 mm, TR1) gear to the smaller mesh (70–99 mm, TR2) gear. Subsequently, effort by TR1 has been relatively sTable, whereas effort in TR2 and in small-mesh beam trawl (80–120 mm, BT2) has shown a pronounced decline (0%, −52%, and −52%, respectively, between 2004 and 2013). Gill- and trammelnet fisheries have remained sTable (ICES WGMIXFISH 2014). Effort in large-meshed beam trawl (≥120 mm, BT1) has increased significantly in 2012 and 2013 after a decade of continuous decline. Nominal effort reported by Norway has increased since 2011 due to the generalization of electronic logbooks.

In addition, a more detailed overview and analyses of the various measures implemented in the frame of the cod recovery plan can be found in the 2011 joint STECF/ICES evaluation of this plan (ICES WKROUNDMP 2011, Kraak et al., 2013)

2.2.3 Stock-based management plans

Cod, saithe, haddock, whiting, plaice and sole are now subject to multi-annual management plans (the latter two, being EU plans, not EU-Norway agreements). These plans all consist of harvest rules to derive annual TACs depending on the state of the stock relative to biomass reference points and target fishing mortality. The harvest rules also impose constraints on the annual percentage change in TAC. These plans have been discussed, evaluated and adopted on a stock-by-stock basis, involving different timing, procedures, stakeholders and scientists involved, disregarding mixed-fisheries interactions (ICES WGMIXFISH 2012). The technical basis of the individual management plans is detailed in the relevant stock section.

With the new CFP, the demand for mixed fisheries management plans covering all species caught in a fishery is increasing. However, so far only first drafts of hypothet-

ical multi species (fishery based) management plans have been designed. With the implementation of the landing obligation by 2016 for the North Sea demersal fisheries, problems caused by the management of mixed fisheries with single species plans become more and more evident.

2.2.4 Additional Technical measures

The national management measures with regard to the implementation of the available quota in the fisheries differ between species and countries. The industrial fisheries are subject to regulations for the by-catches of other species (e.g. herring, whiting, haddock, cod). Technical measures relevant to each stock are listed in each stock section. To these additional management measures belong real time closures or Fully Documented Fisheries (FDF).

2.2.4.1 Minimum landing size

"Undersized marine organisms must not be retained on board or be transhipped, landed, transported, stored, sold, displayed or offered for sale, but must be discarded immediately to the sea" (EC 850/98). Minimum landing sizes in the North Sea are the same as in all European waters (except in Skagerrak and Kattegat, where minimum sizes are slightly smaller for fin fish and larger for *Nephrops*). The value for demersal stocks is shown below. Minimum landing sizes are currently transformed into Minimum Conservation Reference Sizes (MCRS) that will be implemented with the landing obligation.

Species	MLS
Cod	35 cm
Haddock	30 cm
Saithe	35 cm
Whiting	27 cm
Sole	24 cm
Plaice	27 cm
Nephrops	25mm (carapace length) -40mm in IIIa and Norwegian Waters

2.2.4.2 Minimum mesh size

Regulations on mesh sizes are more complex than those on landing sizes, as they differ depending on gears used, target species and fishing areas. Many other accompanying measures are implemented simultaneously with mesh sizes. They include regulations on gear dimensions (e.g. number of meshes on the circumference), square-meshed panels, and netting material. The most relevant mesh size regulations of EC No 2056/2001 are presented below.

Towed nets excluding beam trawls

Since January 2002, the minimum mesh size for towed nets fishing for human consumption demersal species in the North Sea is 120 mm. There are however many derogations to this general rule, and the most important are given below:

- ***Nephrops* fishing.** It is possible to use a mesh size in range 70-99 mm, provided catches retained on board consist of at least 30% of *Nephrops*. However, the net needs to be equipped with a 80 mm square-meshed panel if a mesh size of 70-99 mm is to be used in the North Sea and if a mesh size of 90 mm is to be used in the Skagerrak and Kattegatt the codend has to be square meshed.

- **Saithe fishing.** It is possible to use a mesh size range of 110-119 mm, provided catches consist of at least 70% of saithe and less than 3% of cod. This exception however does not apply to Norwegian waters, where the minimum mesh size for all human consumption fishing is 120 mm. Since January 2002 Norwegian trawlers (human consumption) have had a minimum mesh size of 120 mm in EU-waters. However, since August 2004 they have been allowed to use down to 110 mm mesh size in EU-waters (but minimum mesh size is still 120 mm in Norwegian waters).
- **Fishing for other stocks.** It is possible to use a mesh size range of 100-119 mm, provided the net is equipped with a square-meshed panel of at least 90 mm mesh size and the catch composition retained on board consists of no more than 3 % of cod.
- **2002 exemption.** In 2002 only, it was possible to use a mesh size range of 110-119 mm, provided catches retained on board consist of at least 50% of a mixture of haddock, whiting, plaice sole, lemon sole, skates and anglerfish, and no more than 25% of cod.

Beam trawls

- **Northern North Sea.** It is prohibited to use any beam trawl of mesh size range 32 to 119 mm in that part of ICES Subarea IV to the north of 56° 00' N. However, it is permitted to use any beam trawl of mesh size range 100 to 119 mm within the area enclosed by the east coast of the United Kingdom between 55° 00' N and 56° 00' N and by straight lines sequentially joining the following geographical coordinates: a point on the east coast of the United Kingdom at 55° 00' N, 55° 00' N 05° 00' E, 56° 00' N 05° 00' E, a point on the east coast of the United Kingdom at 56° 00' N, provided that the catches taken within this area with such a fishing gear and retained on board consist of no more than 5 % of cod.
- **Southern North Sea.** It is possible to fish for sole south of 56° N with 80-99 mm meshes in the cod end, provided that at least 40 % of the catch is sole, and no more than 5 % of the catch is composed of cod, haddock and saithe.

Combined nets

It is prohibited to simultaneously carry on board beam trawls of more than two of the mesh size ranges 32 to 99 mm, 100 to 119 mm and equal to or greater than 120 mm.

Fixed gears

The minimum mesh size of fixed gears is of 140 mm when targeting cod, that is when the proportion of cod catches retained exceeds 30% of total catches.

2.2.4.3 Closed areas

Twelve mile zone

Beam trawling is not allowed in a 12 nm wide zone along the British coast, except for vessel having an engine power not exceeding 221 kW and an overall length of 24 m maximum. In the 12 mile zone extending from the French coast at 51°N to Hirtshals in Denmark trawling is not allowed to vessels over 8m overall length. However, otter trawling is allowed to vessels of maximum 221 kW and 24 m overall length, provided that catches of plaice and sole do not exceed 5% of the total catch. Beam trawling is only allowed to vessels included in a list that has been drawn up for the purposes. The number of vessels on this list is bound to a maximum, but the vessels on it may be replaced by other ones, provided that their engine power does not exceed 221 kW and

their overall length is 24 m maximum. Vessels on the list are allowed to fish within the twelve miles zone with beam trawls having an aggregate width of 9 m maximum. To this rule there is a further derogation for vessels having shrimping as their main occupation. Such vessels may be included in annually revised second list and are allowed to use beam trawls exceeding 9 m total width.

Plaice box

To reduce the discarding of plaice in the nursery grounds along the continental coast of the North Sea, an area between 53°N and 57°N has been closed to fishing for trawlers with engine power of more than 221 kw (300 hp) in the second and third quarter since 1989, and for the whole year since 1995. Beare *et al*. (2013) conducted a thorough analysis of the potential effect of the plaice box on the stock of plaice, and concluded that no significant effect, neither positive nor negative, could be related to the implementation of the plaice box.

Cod box

An emergency measure to enhance cod spawning in the North Sea was enforced in January 2001. The EU and Norway agreed on a temporary closure of the demersal fishery in the main spawning grounds from February 15 until 30 April 2001.

Sandeel box

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, ICES advised in 2000 for a closure of the sandeel fisheries in the Firth of Forth area east of Scotland. All commercial fishing was excluded, except for a maximum of 10 boat days in each of May and June for stock monitoring purposes. The closure was initially designated to last for three years but has been repeatedly extended and remains in force. The level of effort of the monitoring fishery was increased in 2006.

Cod protection area in the North Sea

The cod protection area defined in Council Regulation (EC) No 2287/2003 Annex IV was intended to enhance the TAC uptake of haddock in the North Sea while preventing cod by-catches. It regulated fishing of haddock of licensed vessels for a maximum of 3 months under the conditions that there was no fishing inside or transiting the cod protection area, that cod did not contribute more than 5 % to the total catch retained on board, that no transhipment of fish at sea occurred, that trawl gear of less than 100 mm mesh size was carried on board or deployed, and that a number of spe

Unilateral management

In addition to the EU-wide statutory regulations, some countries impose additional management schemes on their fleets. One example of this is the Scottish Conservation Credits scheme which encompasses technical regulation and temporary spatial closures in return for derogation from some EU effort controls. This scheme, and others like it are described in the stock sections to which they pertain.

2.3 Environmental considerations

WGNSSK welcomes the progress made to provide ecosysterm overviews. These overviews can play an important role to identify environmental factors influencing the current development of fish and shellfish stocks. However, the ecosystem overviews have so far not been agreed by ACOM. In addition, references to published papers are missing. References are needed to substantiate statements made in the ecosystem overviews. In addition, from these overviews it is still difficult to relate certain changes to

obsersavations made in the assessments. Therefore, the WG considers that although it is clear that the North Sea ecosystem is undergoing change and this will affect fish stocks, the causal mechanisms linking the environment with fish stock dynamics are not yet clearly-enough understood for such information to be used as part of fisheries management advice. To improve the situation ICES may provide a database with all available environmental data and indicators from the various working and study groups to make them available to the scientific community. The longer the time series and the higher the contrast in these time series, the more likely that causal relationships can be identified.

2.4 Human consumption fisheries

2.4.1 Data

Estimates of discarding rates provided by a number of countries through observer sampling programme were used in the assessments of various roundfi and flatfishsh as well as some *Nephrops* FUs in the North Sea, to raise landings to catch (see also section 01). This year for the first time also trials were made to raise the discards to landings for species so far not utilizing discard information in their assessments (e.g., sole in IV and VIId, dab, flounder, saithe). This has to be seen as preparation for the implementation of the landing obligation in 2016. Aim is to provide catch advice for all stocks from 2015 onwards.

In the EU, national sampling programs are defined and implemented as part of the Data Collection Framework (DCF). Other discard sampling programmes (e.g. industry self-sampling) have been in place in recent years and the data are increasingly entering the assessment process in some instances (e.g., plaice in IV, haddock). In general, some discarding occurs in most human-consumption fisheries, particularly when strong year classes are approaching the minimum landing size. As TACs have become more restrictive for some species (e.g. cod), an increase in discarding of markeTable fish (i.e. over minimum landing size) has been observed. In 2013, a landing obligation has been agreed between the EU Parliament and the Council of Ministers, as one of the most important aspects of the reform of the Common Fishery Policy (CFP), and this is going to have fundamental implications for the demersal fisheries and associated data collection program (see above).

For a number of years there had been indications that substantial under-reporting of roundfish and flatfish landings is likely to have occurred. It is suspected to have been particularly strong for cod during until 2006, and catches were expected to be much larger than the TAC. Since the middle of the 2000s, the WG had used an assessment method for North Sea cod (Section 14) which estimated unallocated removals, potentially due to to reporting problems, unrecorded discards, changes in natural mortality, or changes in survey catchability etc. In 2013, WGNSSK considered that the assumption of unallocated removals after 2006 could not be justified by any known factors (cf also ICES WKCOD 2011), and relaxed that assumption in the assessment.

Several research-vessel survey indices are available for most species, and were used both to calibrate population estimates from catch-at-age analyses, and in exploratory analyses based on survey data only. Commercial CPUE series were available for a number of fleets and stocks, but for various reasons few of them could be used for assessment purposes (although they are presented and discussed in full for each stock). The use of commercial CPUE indices has been phased out where possible.

Bycatches in the industrial fisheries were significant in the past for haddock, whiting and saithe, but these have reduced considerably in recent years.

2.4.2 Summary of stock status and advice

2.4.2.1 Overall impressions

The main impression in 2014 is that fishing mortality could be reduced significantly for many North Sea stocks of roundfish and flatfish. There are clearly decreasing trends in fishing mortality, to the point that natural mortality is increasingly becoming the dominant source of mortality for many species and/or age ranges (cf multispecies advice 2013). All stocks with agreed biomass reference points are above B_{lim}, only the SSB of cod and saithe is below B_{pa}. Many stocks are exploited around Fmsy levels. Exemptions are plaice and sole in VIId as well as turbot where F is still above F_{msy}. An important aspect is that recruitment still remains poor compared to historical average levels especially for gadoids. This leads to decreasing trends in SSB for haddock, saithe and whiting despite an exploitation around F_{msy} or even below. Also cod is revcovering more slowly than expected. Reduced recruitment of cod can be linked to the reduced parental stock size, but potentially also to the genetic erosion of some components of the populations, likely combined with an effect of a climatic phase and status of the food web which is unfavourable to recruitment. This indicates that recovery of the cod stock is still fragile and must not be jeopardised. It is important to maintain resilient stocks whose SSB builds on several year classes and to avoid local overfishing of local components or sub-populations. Very low recruitment was also observed for both sole stocks (IV and VIId) in 2012 and 2013. In contrast, the southern North Sea currently undergoes an outburst of the plaice stock with SSB values higher than ever observed in the assessment time series.

The overall abundance of the Nephrops stocks with TV-survey abundance estimates was decreasing until 2012, both for stocks with estimated high or low harvest rates. In 2013 some stocks (e.g., FU 8 and 9) showed again an increase in abundance.

WGNSSK has to deal with an increasing number of data limited fish stocks. Most of these stocks have a biennial advice and an evaluation of new data has not altered the perception of the stocks compared to last year. New advice was produced only for plaice in Skagerrak (-13% in TAC based on a decrease in the survey index)

Each year, ICES WGMIXFISH summarizes the main points of status and advice for the main stocks in its report, and this section is copied below (see also ICES WGMIXFISH 2014):

Fish stocks:

Species	Area	Stock status	Summary	Advice 2015
cod	Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa West (Skagerrak)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) Above target Precautionary approach (F_{pa},F_{lim}) Harvested sustainably Management plan (F_{MP}) Above target Stock size 2012 2013 2014 MSY ($B_{trigger}$) Below trigger Precautionary approach (B_{pa},B_{lim}) Reduced reproductive capacity Management plan (SSB_{MP}) Below trigger	Fishing mortality declined from 2000 and is now estimated to be around 0.4, between Fpa and the FMSY proxy. SSB has increased from the historical low in 2006, and is now in the vicinity of Blim. Recruitment since 2000 has been poor.	ICES advises on the basis of the **EU–Norway management plan** that catches in 2015 should be no more than 35 486 tonnes. If discard rates do not change from those in 2013, this implies landings of no more than 26 713 tonnes.
Haddock	Subarea IV (North Sea), Division IIIa West (Skagerrak) and Division VIa (West of Scotland)	Stock status F (Fishing Mortality) 2011 2012 2013 MSY (F_{MSY}) Appropriate Precautionary approach (F_{pa},F_{lim}) Not defined SSB (Spawning-Stock Biomass) 2012 2013 2014 MSY ($B_{trigger}$) Above trigger Precautionary approach (B_{pa},B_{lim}) Full reproductive capacity	Fishing mortality has been below FMSY since 2008 and SSB has been above the MSY Btrigger since 2001. Recruitment is characterized by occasional large year classes, the last of which was the strong 1999 year class. Apart from the 2005 and 2009 year classes, which are around the long-term average, recent recruitment has been poor.	ICES advises on the basis of the **MSY approach** that catches should be no more than 54 580 t for the whole assessment area. If rates of discards and industrial bycatch do not change from the average of the last three years (2011–2013), this implies human consumption landings of no more than 48 176 t.
Plaice	Subarea IV (North Sea)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) Appropriate Precautionary approach (F_{pa},F_{lim}) Harvested sustainably Management plan (F_{MP}) Below target Stock size 2012 2013 2014 MSY ($B_{trigger}$) Above trigger Precautionary approach (B_{pa},B_{lim}) Full reproductive capacity Management plan (SSB_{MP}) Above target	The stock is well within precautionary limits, has increased in the past ten years, and has reached a record-high level in 2014. Recruitment has been around the long-term average since the mid-2000's. In recent years, fishing mortality has been estimated below FMSY and below the target specified in the management plan.	ICES advises on the basis of stage two of the EU management plan (Council Regulation No. 676/2007) that catches should be no more than 179 301 t. If discard rates do not change from the average of the last three years (2011–2013), this implies landings of no more than 128 376 t.
Sole	Subarea IV (North Sea)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) Above target Precautionary approach (F_{pa},F_{lim}) Harvested sustainably Management plan (F_{MP}) Appropriate Stock size 2012 2013 2014 MSY ($B_{trigger}$) Above trigger Precautionary approach (B_{pa},B_{lim}) Full reproductive capacity Management plan (SSB_{MP}) Above target	SSB is increasing since 2007 and is estimated to be above Bpa in 2014. Fishing mortality has declined since 1995 and is estimated to be just above Fmsy in 2013.	ICES advises on the basis of the second stage of the EU management plan (Council Regulation No. 676/2007) but cannot quantify the resulting catches. The implied landings should be no more than 10 973 t.
Saithe	Subarea IV (North Sea), Division IIIa (Skagerrak), and Subarea VI (West of Scotland and Rockall)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) Appropriate Precautionary approach (F_{pa},F_{lim}) Harvested sustainably Management plan (F_{MP}) At limit Stock size 2012 2013 2014 MSY ($B_{trigger}$) Below trigger Precautionary approach (B_{pa},B_{lim}) Increased risk Management plan (SSB_{MP}) Below trigger	Recruitment has been below average since 2006. Fishing mortality has fluctuated around FMSY since 1997. SSB has declined since 2005 and has been slightly below Bpa for the last 3 years.	ICES advises on the basis of the **EU–Norway management plan**, that catches should be no more than 80 097 t. If discard rates do not change from the average of the last 2 years (2012-2013), this implies commercial landings of no more than 72 854 t.
Whiting	Subarea IV (North Sea) and Division VIId (Eastern Channel)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) Undefined Precautionary approach (F_{pa},F_{lim}) Undefined Stock size 2012 2013 2014 MSY ($B_{trigger}$) Undefined Precautionary approach (B_{pa},B_{lim}) Undefined Qualitative evaluation Below recent average	SSB has declined in recent years and is close to the minimum value of the time-series, while fishing mortality has been declining over most of the time-series. The average level of recruitment has been low since 2003.	ICES advises on the basis of the **EU–Norway management plan** that total catches should be no more than 28 317 tonnes. If rates of discards and industrial bycatch do not change from the average of the last three years (2011–2013), this implies human consumption landings of no more than 17 190 tonnes (13 678 tonnes in the North Sea and 3 512 tonnes in Division VIId). Management for Division VIId should be separated from the rest of Subarea VII.

Fish stocks (cont.)

Species	Area	Stock status	Summary	Advice 2015
Sole	Division VIId (Eastern Channel)	**Stock status** **Fishing pressure** 2011 2012 **2013** MSY (F_{MSY}) ✗ ✗ ✗ Above target Precautionary approach (F_{pa},F_{lim}) ○ ○ ○ Increased risk **Stock size** 2012 2013 **2014** MSY (B_{trigge}) ✓ ✓ ✓ Above trigger Precautionary approach (B_{pa},B_{lim}) ✓ ✓ ✓ Full reproductive capacity	The spawning-stock biomass has fluctutated without trend and is above MSY Btrigger since 2002. Fishing mortality has always been above FMSY, and has been above Fpa since 2005. Recruitment has been fluctuating without trend. Recruitment in 2012 and 2013 are the lowest of the time series.	ICES advises **on the basis of the MSY approach** but cannot quantify the resulting catches. The implied **landings should be no more than 1 931 t.**
Plaice	Division VIId (Eastern Channel)	**Stock status** **Fishing pressure** **2011–2013** MSY (F_{MSY}) ✗ Above target Precautionary approach (F_{pa},F_{lim}) ? Unknown **Stock size** **2011–2013** MSY (B_{trigge}) ? Unknown Precautionary approach (B_{pa},B_{lim}) ? Unknown Qualitative evaluation ↗ Increasing	Fishing mortality has declined since the mid-1990s and is presently among the lowest in the time-series. Spawning-stock biomass has increased since 2003 and is currently around the highest level.	ICES advises **on the basis of the data-limited approach** but cannot quantify the resulting catches. The implied **landings of plaice in Division VIId should be no more than 3279 tonnes.**
Turbot	Subarea IV (North Sea)	**Stock status** **Fishing pressure** 2011 2012 **2013** MSY (F_{MSY}) ✗ ✗ ✗ Above target Precautionary approach (F_{pa},F_{lim}) ? ? ? Unknown Qualitative evaluation ↘ ↘ ↘ Declining **Stock size** 2012 2013 **2014** MSY (B_{trigge}) ? ? ? Unknown Precautionary approach (B_{pa},B_{lim}) ? ? ? Unknown Qualitative evaluation → ↗ ↗ Increasing from low level	Recruitment is variable around the long-term average. The sudden increase in F in 2002 is because of a reduction of the minimum landing size in The Netherlands in 2001. Since then fishing mortality has declined. Spawning-stock biomass is at a low level, but has been gradually increasing in recent years.	ICES advises **on the basis of the data-limited approach** that **catches should be no more than 2406 t.** All catches are assumed to be landed. TACs may not be appropriate as a management tool for bycatch species. A combined TAC for turbot and brill may lead to overexploitation of one of the stocks. An increase in mesh size would lead to higher yield per recruit and reduction in the proportion of immature fish in the catches.

Nephrops stocks:

Species	Area	Stock status	Summary	Advice 2015
Nephrops	Botney Gut–Silver Pit (FU 5)	State of the stock Fishing pressure 2011–2013 MSY (F_{MSY}) ? Unknown Precautionary approach (F_{pa},F_{lim}) ? Unknown Qualitative evaluation ✓ Below possible reference points Stock size 2011–2013 MSY ($B_{trigger}$) ? Unknown Precautionary approach (B_{pa},B_{lim}) ? Unknown Qualitative evaluation ✓ Above poss. reference points	The state of this stock is unknown. Preliminary stock surveys (2010 and 2012) indicate relatively high density compared to neighbouring FUs, which compared to estimated landing numbers imply harvest rates considerably below those associated with MSY for other North Sea Nephrops stocks.	ICES advises on the basis of the **ICES approach for data-limited stocks** that catches should be no more than 1159 t. If discard rates do not change from the assumed rate of 25% (from FU 7), this implies **landings of no more than 1043 t.**
Nephrops	Farn Deeps (FU 6)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) ✗ ✗ ✗ Above Precautionary approach (F_{pa},F_{lim}) ? ? ? Undefined Stock size 2011 2012 2013 MSY (B_{trigge}) ✓ ✗ ✗ Below trigger Precautionary approach (B_{pa},B_{lim}) ? ? ? Undefined	The stock size has declined since 2005 and has been fluctuating near MSY Btrigger since 2007. Changes in survey methodology in 2007 make exact comparisons with the preceding series difficult, but the general trend is considered reliable.	ICES advises **on the basis of the MSY approach** ,and considering that no discard ban is in place in 2015, that **landings should be no more than 983 t**, assuming that discard rates do not change from the average of the last 3 years (2011-2013) and a fixed proportion of discards survive.
Nephrops	Fladen Ground (FU 7)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) ✓ ✓ ✓ Below target Precautionary approach (F_{pa},F_{lim}) ? ? ? Undefined Stock size 2011 2012 2013 MSY (B_{trigge}) ✓ ✗ ✓ Above trigger Precautionary approach (B_{pa},B_{lim}) ? ? ? Undefined	The stock size has declined from the highest observed value in 2008 and is just above the MSY Btrigger. The harvest rate has declined in recent years, and fell to approximately 3% in 2013 which is well below FMSY.	ICES advises on the basis of the MSY approach, that catches should be no more than 10 759 t. All catches are assumed to be landed. In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level. Should the
Nephrops	Firth of Forth (FU 8)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) ✗ ✗ ✓ Below target Precautionary approach (F_{pa},F_{lim}) ? ? ? Undefined Stock size 2011 2012 2013 MSY (B_{trigge}) ✓ ✓ ✓ Above trigger Precautionary approach (B_{pa},B_{lim}) ? ? ? Undefined	The stock size declined in 2008-2012 but has increased around 25% in 2013. The harvest rate decreased in 2013 to 15.6% and is now below FMSY.	ICES advises on the basis of the MSY approach, and considering that no discard ban is in place in 2015, that landings should be no more than 1769 t, assuming that discard rates do not change from the average of the last 3 years (2011-2013) and a fixed proportion of discards survive.
Nephrops	Moray Firth (FU 9)	Stock status Fishing pressure 2011 2012 2013 MSY (F_{MSY}) ✗ ✗ ✓ Below target Precautionary approach (F_{pa},F_{lim}) ? ? ? Undefined Stock size 2011 2012 2013 MSY (B_{trigge}) ✓ ✓ ✓ Above trigger Precautionary approach (B_{pa},B_{lim}) ? ? ? Undefined	The stock size declined in 2008-2012 but has increased around 25% in 2013. The harvest rate decreased in 2013 to 15.6% and is now below FMSY.	ICES advises on the basis of the MSY approach and considering that no discard ban is in place in 2015, that landings should be no more than 1185 t, assuming that discard rates do not change from the average of the last 3 years (2011-2013) and a fixed proportion of discards survive. In order to ensure the stock in this FU is exploited sustainably, management should be

Nephrops (cont.)

Species	Area	Stock status	Summary	Advice 2015
Nephrops	Noup (FU 10)	Stock status Fishing pressure: MSY (F_{MSY}) Unknown; Precautionary approach (F_{pa},F_{lim}) Unknown; Qualitative evaluation Below possible reference points Stock size: MSY ($B_{trigger}$) Unknown; Precautionary approach (B_{pa},B_{lim}) Unknown; Qualitative evaluation Unknown	The state of the stock is unknown. UWTV surveys in FU 10 have been conducted sporadically indicating the density is relatively low (0.1 Nephrops/m2). Landings in FU 10 are at a historical minimum suggesting harvest rates below those associated with MSY for other North Sea Nephrops stocks.	ICES advises on the basis of the ICES approach for data-limited stocks that catches should be no more than 33 t. If discard rates do not change from the assumed rate of 7.9% (from FU9), this implies landings of no more than 32 t. To protect the stock in this functional unit (FU), management should be implemented at the functional
Nephrops	Norwegian Deep (FU 32)	State of the stock Fishing pressure: MSY (F_{MSY}) Unknown; Precautionary approach (F_{pa},F_{lim}) Unknown; Qualitative evaluation below poss refpoints Stock size: MSY ($B_{trigger}$) Unknown; Precautionary approach (B_{pa},B_{lim}) Unknown; Qualitative evaluation stableUnknown	The state of this stock is unknown. Based on the assumed low density (based on lowest observed density at FU7, Fladen Ground), harvest rates are considered low for this stock.	ICES advises on the basis of the data-limited approach but cannot quantify the resulting catches. The implied landings should be no more than 625 t. For the stock in this functional unit (FU), management is implemented at the functional unit level.
Nephrops	Horn's Reef (FU 33)	State of the stock Fishing pressure: MSY (F_{MSY}) Unknown; Precautionary approach (F_{pa},F_{lim}) Unknown Stock size: MSY ($B_{trigger}$) Unknown; Precautionary approach (B_{pa},B_{lim}) Unknown; Qualitative evaluation Increasing	The state of this stock is unknown. Based on the assumed low density (based on lowest observed density at FU7, Fladen Ground), harvest rates are considered low for this stock.	ICES advises on the basis of the data-limited approach, but cannot quantify the resulting catches. The implied landings should be no more than 1136 t. In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level.
Nephrops	Devil's Hole (FU 34)	Stock status Fishing pressure: MSY (F_{MSY}) Unknown; Precautionary approach (F_{pa},F_{lim}) Unknown; Qualitative evaluation Below possible reference points Stock size: MSY ($B_{trigger}$) Unknown; Precautionary approach (B_{pa},B_{lim}) Unknown; Qualitative evaluation Declining	The state of the stock is unknown. The mean survey density indicates the stock is declining. No survey information is available for 2013.	ICES advises on the basis of the ICES approach for data-limited stocks that catches should be no more than 410 t. If discard rates do not change from the recent average (2008-2011), this implies landings of no more than 383 t. To protect the stock in this functional unit (FU), management should be implemented at the functional unit level.
Nephrops	Division IIIa	Stock status Fishing pressure: 2012 2013 2014 MSY (F_{MSY}) Appropriate Precautionary approach (F_{pa},F_{lim}) Undefined Stock size: 2013 2014 2015 MSY ($B_{trigger}$) Unknown Precautionary approach (B_{pa},B_{lim}) Unknown Qualitative evaluation Increasing	Estimates of absolute abundance, available for 2011, 2012 and 2013 from an underwater TV (UWTV) survey for the whole area are considered to be stable. The estimated harvest ratios suggest that the stock is exploited sustainably.	ICES advises on the basis of the MSY approach that catches in 2015 should be no more than 10290 tonnes in 2015. If total discard rates do not change from the average of the last three years (2011–2013), this implies total landings of no more than 5318 tonnes. Note that this figure includes discards expected to survive the discarding process – assumed to be 25% of the total number discarded for this stock.

2.5 Industrial fisheries

The Norway Pout assessment was benchmarked in 2012 through an inter-benchmark protocol (IBPNPOUT), resulting in changes in biological parameters (growth, maturity and natural mortality), but the general perception of the stock hasn't changed significantly. Fishery has fluctuated considerably in recent years with full or partial closures in 2005, 2006, 2007 and 2011. The stock is largely driven by natural process, particularly recruitment. Stock size has increased following the very high recruitment in 2012 and is well above MSY $B_{escapement}$ in 2014. Fishing mortality has been lower than the natural

mortality for this stock and has decreased in recent years to below the long-term average F (0.6). Recruitment in 2013 is below the long term average.

2.6 Input from The ICES – FAO Working Group on Fishing Technology & Fish Behaviour (WGFTFB)

The WGFTFB provides fishery development information specific to the various assessment Expert Groups every second year, based on annual questionnaires to a number of FTFB members (ICES 2012, WGFTFB). The information specific to WGNSSK in 2013 is reported below.

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial CPUE estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the North Sea, Skagerrak and Kattegat.

It should be noted that the information contained in this report does not cover fully all fleets engaged in North Sea fisheries; information was obtained from Scotland, France, Netherlands, Belgium, Sweden, Denmark and Norway.

Fleet dynamics

- It is now apparent that within the Netherlands, driven primarily by the cost of fuel, there is huge demand to use the pulse trawl and the number of vessels applying to fish under the 5% derogation far exceeds the number of licences available. Vessels not using the pulse trawl in the Netherlands are finding it increasingly difficult to get financial support from banks on economical (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively). A total of 42 licences have been given out by the Dutch Ministry for pulse trawling. The majority of these licences are for flatfish beam trawls although 2-3 vessels are involved in trials to test the Belgium "HOVERCRAN" system. (Netherlands: Implications: Switch from beam trawling to pulse trawling).
- Measures to reduce fuel costs in the Dutch fleet have been continuing since 2008 from 35% (now 50 M€) to 25% in 2009 due to adaptations in gear and operation. Reports show that the use of the SumWing can save up to 300 tonnes of fuel per year per boat (Loa = 40 m), and with the pulse trawl up to 800-1000 tonnes annually. Up to 78 Dutch beam trawlers now used the SumWing with 28 of these using the Pulse/Wing trawl. A further 12 Dutch registered vessels in the UK, 2 in Germany and 5 in Belgium are also using the Sum Wing with 3 of these using the dual Pulse/Wing. (Netherlands: Implications: Switch to more fuel efficient gear).
- The use of the SumWing, Pulse Trawl and Pulse/Wing beam trawls are reported to have resulted in a shift in grounds in ICES Area IV, and also add fishing time, due to faster hauling speed. This is not well documented but may result in increased a change in effort patters and increased fishing time (Netherlands: Implications: Improved fuel efficiency).
- A recent analysis carried out in the Netherlands has measured the relative changes in catching efficiency between the pulse trawl and the standard beam trawl in numbers caught per hour. This analysis has shown a reduction in catching efficiency for plaice of around 25-30%; for sole 20-25% with

a reduction in discards of 55-60% and a reduction in benthos of 35-40-%. (Netherlands: Implications: Changes in catching efficiency).

- There are a smaller number of vessels in Belgium, Germany and the UK (Dutch owned) using the pulse trawl. However, the derogation only allows it to be used in the south of the North Sea and this has hindered the uptake of the gear in Belgium as they have only a limited sole quota in this area. (Belgium: Implications: Lower uptake of pulse trawl).
- The shift to Danish/Scottish seining has continued in a number of countries. This is driven by high fuel prices: There are now around 16 Dutch vessels operating in the North and the South North Sea, while there are around 12 French vessels now converted to Danish seining. (France: Implications: Shift from trawling to Seining).
- At least two Dutch beam trawlers have been converted into dual purpose vessels with the capability of fishing with twin-rigs and beam trawls. The idea is to increase the fishing opportunities for these vessels and allow them to switch between fisheries at different time of the year. (Netherlands: Implications: Dual purpose fishing vessels).
- In Norway there has not been any removal of fishing effort through decommissioning but the number of vessels has reduced due to movement of quota from newer and bigger vessels. In particular the medium and larger sized seine net fleets are being renewed. Altogether 3-4 new large whitefish trawlers, 4-5 pursers, 7-9 large seine netters and a large number of coastal vessels have entered the fleet over the period 2010-2012. While not measured it is likely that capacity and effort have increased. (Norway: Implications: Increases in fishing effort).

Technology Creep

- As reported the use of the SumWing and Pulse trawl are widespread now in the Netherlands. This is driven by high fuel costs with reported savings ranging from 10-50% from a combination fo the gear and lower towing speeds. (Netherlands: Implications: Improved fuel efficiency).
- Since 2010 one large Belgium beam trawler is now using the energy-efficient SumWing as a replacement for standard beam trawl gear. In addition some 25 other beam trawlers are using the SumWing seasonally. Additional there is growing interest in using the electric pulse trawl amongst the Belgium beam trawl fleet al.though none of them are using as yet as they are awaiting authorisation to do so from the EU. These changes are driven by high fuel prices. (Belgium: Implications: Changes in gear type).
- There have been continued efforts by many countries to reduce fuel costs through the use of more energy efficient gears. Modifications tested include hydrodynamic/low impact trawl doors, dynex warps, low drag twines and reductions in the size of trawls used. In addition there have been changes in fishing operations through slower steaming to and from grounds, fishing closer to home ports and other fuel saving measures. The actual impacts on fishing effort are difficult to predict but this is likely to be a continuing trend. However, as a result of one project in France (EFFICHALUT) an energy efficient trawl has been developed and is now being used by 15 whitefish trawls. The anticipated annual savings from these 15 vessels is estimated at €800,000 per year. (Multiple countries: Implications: Improved energy efficiency)

- IMR continues to cooperate with a commercial partner (Scantrol AS) on development of a camera-based system to identify and measure individual fish inside a trawl. Preliminary results indicate lengths estimated using the camera system are within 5-10% of manually measured lengths. The system has the potential to be a useful tool to verify size and species stratification by depth during acoustic surveys. A new, more compact, system capable of operating at up to 2000 m depth is being readied for field trials in May and software development to further automate image analysis is underway. (Norway: Implications: New acoustic survey tool).

Technical Conservation Measures

- The Dutch government closed the Botany Gut in December 2011 and 2011 for three months to all trawling to protect cod. The Nephrops fishermen have looked for an exemption from this closure on the basis of low cod impact although observer data suggest catches of 2-5/hour Pilot studies will be carried out in 2012 to test selective gears to reduce cod catches. (Netherlands: Implications: Reduction of cod catches).
- At the Dutch Shipyard, Maaskant are developing an on board separator system to sort out debris and benthic organisms before they affect the catch. The objective of this system is to improve the survival rate of discarded flatfish. Trials will be carried out during 2012 and 2013. (Netherlands: Implications: Improved survival of discarded fish).
- In Sweden the use of rigid sorting grids has continued to increase in the Skagerrak and Kattegat. In Skagerrak the use of sorting grid has increased from 50 % 2009 to 53 % 2010 of total TR2 effort. The TR2 effort is by far the most important gear category in both Skagerrak and Kattegat constituting 80-90 % of total effort. Almost 100 % have opted to use this device due primarily to national legislation allocating 50% of the total Nephrops quota to grid vessels (Sweden: Implications: Widespread use of sorting grid).
- Extensive testing has been carried out in the North Sea by the UK (Scotland) with a new design of trawl called the Flip-flap netting grid (FFG) which has been developed by a Scottish netmaker for reducing cod catches in the Nephrops fishery. The results show a large and significant decrease in the number of the three main whitefish spcies retained by the FFG gear. The reductions by weight of cod, haddock and whiting were 73, 67 and 82% respectively. There are indications that will be introduced as a regulated gear across the Scottish fleet during 2012. (UK (Scotland): Implications: Widespread use of selective gear)
- Trials with sorting grids in the Norway pout fishery were completed in 2011, with further tests of flexible grid designs. In 2011 grids with a 40mm bar spacing were made mandatory for Norwegian vessels on the basis of these and earlier trials for blue whiting and Norway pout in the Barents Sea. From mid-2013 all vessels with have to use in these small mesh fisheries in the Norwegian Economic Zone in the North Sea. (Norway: Implications: Mandatory use of sorting grids).
- Experiments from the North Sea carried out by Denmark during 2011have indicated that 50% of Nephrops above MLS are lost through the codend in nominal 120 mm codends used in the North Sea indicated a general increase in mesh size is not applicable in this fishery. (Denamrk: Implications: Loss of markeTable catch)

- In July 2011 Denmark introduced a mandatory regulation requiring the use of the SELTRA trawl in the demersal fisheries in the Kattegat. This selective device comprises a 180mm square mesh panel or 270mm diamond mesh panel contained in a 4 panel section laced 4m from the codend. This on the basis of trials with this device which showed very good reductions in cod catches. The L50 for the 180mm panel is around 64cm. (Denamrk: Implications: Mandatory introduction of a selective gear)

Ecosystem effects

- The large scale uptake of the pulse trawl has resulted in reduced ecosystem impacts on benthos and also a reduction in discards. A large scale monitoring programme is currently being undertaken to fully assess these reductions (Netherlands: Implications: Reduced ecosystem impacts in the southern North Sea).
- Several Dutch beam trawlers are testing a new T-Line concept using pins instead of chains to chase fish out of the seabed. The initial trials carried out in December 2011 were not particular successful as the pins had a tendency to break off and catches of sole were low but a new version will be tested later in 2012. The objective of this design is to reduce fuel and impact on the seabed. (Netherlands: Implications: Lower ecosystem impact of beam trawls).
- Uptake of the Swedish cod and haddock quotas in the Skagerrak have been high in the first two quarters of 2012 (between 55-70%) raising fears that the fisheries will be closed early in the year leading to discarding (Sweden: Implications: Potential discard problem).

Development of New Fisheries

- Two Dutch vessels have converted to potting for crab due to high fuel prices and low returns from other fishing methods. No other details are reported (Netherlands: Implications: Testing of new fisheries).
- The fishery for greater weever (*Trachinus draco*) in the Kattegat seen during 2010 and 2011 as continued. This fishery has developed as a consequence of low catches of *Nephrops* and cod during the first quarter of the year. The weever is also one of few species that are without limiting quotas and few regulations attached to it in the Kattegat. (Sweden: Implications: development of new fishery).

2.7 References:

Beare, D., Rijnsdorp, A. D., Blæsbjerg, M., Damm, U., Egekvist, J., Fock, H., .. Verweij, M. (2013). Evaluating the effect of fishery closures: lessons learnt from the Plaice Box. Journal of Sea Research, 84, 49-60.

ICES WKCOD 2011. Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011). ICES CM 2011/ACOM:51.

ICES WGMIXFISH 2013. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH). 20. - 24. May Kopenhagen. ICES CM 2013/ACOM: 22.

ICES WGMIXFISH 2014. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH-NS). 26. – 30. May Kopenhagen. ICES CM 2014/ACOM:xx.

Kraak, Sarah B.; Bailey, Nick; Cardinale, Massimiliano; Darby, Chris; De Oliveira, José A.; Eero, Margit; Graham, Norman; Holmes, Steven; Jakobsen, Tore; Kempf, Alexander; Kirkegaard,

Eskild; Powell, John; Scott, Robert D.; Simmonds, E. John; Ulrich, Clara; Vanhee, Willy; Vinther, Morten. 2013.Lessons for fisheries management from the EU cod recovery plan. Marine policy. 37. 200-213.

STECF 2014a. Landing Obligation in EU Fisheries - part II (STECF-14-01). ISBN 978-92-79-36219-4.

STECF 2014b. Landing Obligations in EU Fisheries - part 3 (STECF-14-06). ISBN 978-92-79-37840-9.

Ulrich, C., et al., 2012. Challenges and opportunities for fleet- and métier-based approaches for fisheries management under the European Common Fishery Policy, Ocean & Coastal Management 70, 38-47.

3 *Nephrops* in Subareas IIIa

3.1 General comments relating to all *Nephrops* stocks (IIIa and IV)

3.1.1 Introduction

Nephrops stocks have previously been identified by WGNEPH on the basis of their population distribution and characteristics, and established as separate Functional Units. The Functional Units (FU) are defined by the groupings of ICES statistical rectangles given in Table 3.1.1 and illustrated in Figure 3.1.1. The statistical rectangles making up each FU encompass the distribution of mud sediment on which *Nephrops* live. There are two FUs in Division IIIa and nine FUs in Subarea IV. At the 2010 WG, it was noted that a significant and increasing proportion of *Nephrops* landings were being taken outside the previously defined FUs in Subarea IV. This has led to the introduction of a new FU (FU 34) covering the Devil's Hole. Additional catches of *Nephrops* are also taken from smaller, isolated pockets of mud distributed throughout the ICES divisions (e.g. off the east coast of Scotland at Arbroath). Management of *Nephrops* currently operates at the ICES Subarea/Division level.

Functional Units were previously aggregated by WGNEPH into a series of nominal Management Areas (MA) intended to provide a pragmatic solution for more localised management. In 2008 the Working Group agreed that this process had served no useful purpose and should be discontinued.

MSY estimation for *Nephrops* stocks is complicated by the absence of an age-based analytical assessment. The process for determining suiTable F_{msy} proxies for *Nephrops* stocks can be found in Section 3.3.4.

3.1.2 A new approach for data poor *Nephrops* stocks

The WKLIFE considered the following *Nephrops* stocks: FU 5 (Botney Gut - Silver Pit), 10 (Noup), 32 (Norwegian Deep), and 33 (Off Horns Reef). All four stocks were considered to belong to category 6 (data-limited stocks) including stocks for which only landings data are available. The working group agrees with this classification. WKLIFE considered the available data for these stocks. An L50 value (Length at 50% maturity) exists for *Nephrops* in FU 5, otherwise there is no information on growth parameters or maturity. The newly established functional unit 34 (Devil's Hole) is also a category 6 data poor stock.

According to WKLIFE, SPR and F_{SPR} reference points have been identified as proxies for SSB_{MSY} and F_{MSY} respectively. These reference points could be used to inform risk assessment approaches applied to category 6 and 7 stocks and can be calculated on the basis of life-history information and knowledge of selection patterns. Life-history traits (LHTs) should be compiled by stock experts in the relevant assessment working groups. LHTs are available from a number of sources including Fish-Base, literature not (yet) accounted in FishBase, grey literature, and recent estimates based on DCF data collection.

Last year the working group introduced a different approach to previous years in order to provide an estimated guidance of the biomass in FUs 5, 10, 32, 33, and 34 and consider different harvest ratios. Using FU area (calculated from information on the extension of suiTable habitat and/or extent of *Nephrops* fisheries), mean discard percentage

from all years of data, and mean weight in catches, Tables of harvest ratios were calculated for each of the five data poor functional units, using a range of landings (100 t to maximum landings observed for each stock) and densities (0.05-0.8 animals m-2). The density range come from the North Sea/Skagerrak stocks for which UWTV surveys exist. For each data poor FU, the mean and maximum of the landings time series is marked in the Table. Harvest ratios larger than 10 % are marked red. For each stock the most likely densities are considered based on information from neighbouring FUs.

This approach enables the working group to consider the sustainability of historic landings as well as present a guidance to landings within safe biological limits.

3.2 Nephrops stocks

The presentation of data and assessments relating to the Divisions IIIa and IV FUs can be found in Sections 3 and 4, respectively.

Overall landings for Divisions IIIa and IV reported to the WG are summarised by Functional Unit in Table 3.1.2.

3.3 *Nephrops* in Subarea IIIa

3.3.1 General

At present there are two functional units in Division IIIa: Skagerrak (FU 3) and Kattegat (FU 4). This separation was based on observed variable differences between Skagerrak and Kattegat regarding size composition in catches in the 1980s and 1990s. However, the distribution of *Nephrops* is almost continuous from southern Kattegat into Skagerrak, and the exchange of recruits between the southern and northern areas is very likely. With the longer data series now available, it seems the differences in size composition between the two areas are more likely to be random or caused by factors from fishing operations. The assessment is therefore conducted on *Nephrops* in IIIa as one stock.

Ecosystem aspects

Nephrops live in burrows in suiTable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder (in the burrows) (Loo *et al*., 1993). This ability may contribute to maintaining a high production of this species in IIIa, due to increased organic production. *Nephrops* have recently been found to have a high prevalence of plastics which may have implications for the health of the stock (Murry and Cowie, 2011).

Severe depletion in oxygen content in the water can force the animals out of their burrows, thus temporarily increasing the trawl catchability of this species during such environmental changes (Bagge *et al*. 1979). An especially severe case was observed in the end of the 1980s in the southern part of IIIa in late summer, where unusually high catch rates of *Nephrops* were observed. The increasing amount of dead specimens in the catches led to the conclusion of severe oxygen deficiency in especially the southern part of IIIa (Kattegat) in late 1988 (Bagge *et al*., 1990).

No information is available on the extent to which larval mixing occurs between *Nephrops* stocks, but the similarity in stock indicator trends between FU 3 and 4 for both Denmark and Sweden indicates that recruitment has been similar in both areas. These observations suggest they may be related to environmental influences.

ICES Advice

The most recent advice for *Nephrops* in IIIa was given in 2013. ICES concluded that:

'Estimates of absolute abundance, available for 2011 and 2012 from an underwater TV (UWTV) survey for the whole area, showed a 30% decrease. The landings per unit effort suggest an increase in biomass over the full time-series. The estimated harvest ratios of 5.0% (2011) and 8.2% (2012) from these UWTV surveys together with the fishery indices (effort and lpue) suggest that the stock is exploited sustainably.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area IIIa was decreased from 5200 tonnes in 2013 to 5019 t in 2014. The minimum landings size for *Nephrops* in area IIIa is still 40mm carapace length. This relative high MLS for IIIa compared to *Nephrops* stocks in the North Sea (25mm) maintained strictly following advice from the industry. However, this leads to a high discard ratio (discards/ discards+landings) and at present 67% of the catch (in number) in IIIa consists of undersized individuals (Figure 3.2.1.1). It is expected that ongoing experimental work on improving gear selectivity will further reduce the amount discarded. The European Union and Norway have agreed that a discard ban will be implemented in EU waters from the 1st January 2015. The discard ban will be applicable to *Nephrops* from the 1st January 2016. New technical measures have also been agreed upon and have been implemented since the 1st February 2013.

Swedish gear regulations since 2004 imply that it is mandatory to use a 35 mm species selective grid together with an 8 m full square-mesh codend of 70 mm and extension piece when trawling for *Nephrops* in Swedish national waters. Additionally, the Danish gear regulations since 2011 imply a mandatory use of either the grid or the use of the SELTRA trawl which compromise a 90mm codend with either a square-mesh panel (180 mm in the Kattegat and 140 mm in the Skagerrak) or 270mm diamond mesh panel. In Article 11 in the cod recovery plan, member states may apply for unlimited number of days when using the species selective grid trawl.

3.3.2 Data available from Skagerrak (FU3) and Kattegat (FU4)

Landings

Division IIIa includes FU 3 and 4, which are assessed together. Total *Nephrops* landings by FU and country are shown in Table 3.2.1.2 and Table 3.2.1.3.

FU 3 is primarily exploited by Denmark, Sweden and Norway. Denmark and Sweden dominate this fishery, with 61 % and 36 % by weight of the landings in 2013, respectively. Landings by the Swedish creel fishery represented 13-18 % of the total Swedish *Nephrops* landings from the Skagerrak in the period 1991 to 2002. Since 2002 creel catches have been steadily increasing and in 2013 accounted for 37% of Swedish landings (Table 3.2.2.1). In the early 1980s, total *Nephrops* landings from the Skagerrak increased from around 1000 t to just over 2670 t. Since then they have been fluctuating around a mean of 2500 t (Figure 3.2.2.1).

Both Denmark and Sweden have *Nephrops* directed fisheries in the FU 4 (Kattegat). In 2013, Denmark accounted for about 77 % of total landings in FU4, while Sweden took 23 % (Table 3.2.2.5). Minor landings have been taken by Germany (< 1%).

After a decline in the observed landings in 1994, total *Nephrops* landings from the Kattegat increased again until 1998 and have fluctuated around 1500 t. However, since 2006 the landings have increased and were in 2010 the highest on record over the 50 year period (Figure 3.2.2.4). Since 2010, landings have fluctuated around 1600 t.

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991-2013. Of these, the Swedish data series can be considered as being the most complete, since sampling took place regularly throughout the time period and usually covered the whole year. Trends in mean size in catch and landings for Skagerrak are shown in Figure 3.2.2.2 and Table 3.2.2.4. Mean sizes for both landings and discards are fluctuating without trend.

For Kattegat, size distributions of both the landings and discards are available from Sweden for 1990-2013, and from Denmark for 1992-2013. The at-sea-sampling intensity has generally increased since 1999. The Danish sampling intensity was low in 2007 and 2008, but was normalized in 2009 to 2013. Information on mean size is shown in Figure 3.2.2.5 and Table 3.2.2.8. Notice, that except for small mean sizes from 1993 to 1996 all categories have been fluctuating without trend the last 18 years.

In earlier years, the Swedish discard samples were obtained by agreement with selected fishermen, and this might have tempted fishermen to bias the samples. However, the reliability of the catch samplings was cross-checked by special discard sampling projects in both the Skagerrak and the Kattegat. In recent years, the Swedish *Nephrops* sampling has been carried out by onboard observers in both Skagerrak and Kattegat. In 1991, a biological sampling programme of the Danish *Nephrops* fishery was started on board fishing vessels in order to also cover the discards in this fishery. Due to its high cost and the lack of manpower, Danish sampling intensity in the early years was in general not satisfactory, and seasonal variations were not often adequately covered. The Norwegian *Nephrops* fishery is small and has not been sampled.

Natural mortality, maturity at age and other biological parameters

In previous analytical assessments (when Length Cohort Analyses were performed, see e.g. WGNEPH, 2003), natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females. Discard survival was assumed to be 0.25 for both males and females (after Gueguen & Charuau, 1975, Redant & Polet, 1994, and Wileman *et al*. 1999).

Growth parameters are as follows:

Males:	$L\infty$ = 73mm CL, k = 0.138.
Immature females:	$L\infty$ = 73mm CL, k = 0.138.
Mature females:	$L\infty$ = 65mm CL, k = 0.10, Size at 50% maturity = 29mm CL.

Growth parameters for males were taken from Ulmestrand and Eggert (2001) and female growth parameters have been assumed to be similar to those of Scottish *Nephrops* stocks.

Data on size at maturity for males and females were presented at the ICES Workshop on *Nephrops* Stocks in January 2006 (ICES WKNEPH, 2006).

Catch and effort data – FU3

Effort data for the Swedish fleet are available from logbooks for 1978-2013 (Figure 3.2.2.1 and Table 3.2.2.2). During the period 1998 to 2005, twin trawlers shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in LPUE during this period (Table 3.2.2.2). Since 2005, LPUE for twin trawls has increased. The LPUE for single trawls has shown and increasing trend throughout the entire time series. The long term trend in LPUEs is similar in the Swedish and Danish fisheries (Figure 3.2.2.1).

Total Swedish trawl effort shows a decreasing trend since 1992 and has been fluctuating without trend since 2003. From 2007 onwards, total Swedish trawl effort has been estimated from LPUEs from the single trawl with a grid (targeting only *Nephrops*).

Danish effort Figureures for the Skagerrak (Table 3.2.2.3 and Figure 3.2.2.1) were estimated from logbook data. For the whole period, it is assumed that effort is exerted mainly by vessels using twin trawls. The overall trend in effort for the Danish fleet is similar to that in the Swedish fishery. After having been at a relatively low level in 1994-98, effort increased again in the next four years, followed by a decrease to a relatively low level in 2007 to 2013. Also the trend in LPUE is similar to that in the Swedish single trawl fishery, however with a much more marked increase in the Danish LPUE for 2007 and 2008. This high LPUE level is likely to be a consequence of the national (Danish) management system introduced in 2007.

It has not been possible to explicitly incorporate 'technological creeping' in a further evaluation of the Danish effort data. However, since 2000 the Danish logbook data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/LPUE, e.g. vessel size (Figure 3.2.2.3).

Catch and effort data – FU4

Swedish total effort, converted to single trawl effort, has been relatively sTable over the period 1978-90. Effort increased from 1990 to 1993, followed by a decrease to 1996. During the last 20 years effort has remained relatively sTable, except for 2007 and 2008 where effort increased. (Figures 3.2.2.4 and Table 3.2.2.6). Figures for total Danish effort are based on logbook records since 1987. Danish effort increased from 1995 to 2001, decreased from 2002 to 2007 and has been fluctuating without trend since (Figure 3.2.2.4 and Table 3.2.2.7).

Since 2000 the Danish logbook data have been standardised to account for changes in fishing power due to changes in the physical characters of the *Nephrops* fleet. The data have been analysed in various ways to elucidate the effect of factors likely to influence the effort/LPUE, e.g. vessel size (Figure 3.2.2.6).

3.3.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

This stock was not audited in 2013.

3.3.3.1 TV survey in IIIa

In 2008 and 2009, an exploratory UWTV survey was carried out by Denmark. In 2010, the TV survey was expanded covering the main *Nephrops* grounds in the western part of Skagerrak (subarea 1) and Northern part of Kattegat (subarea 2). Since 2011, the TV survey has been carried out in collaboration between Denmark and Sweden and covers the main *Nephrops* fishing grounds in IIIa (subarea 1-6). However, important parts of the assumed distributional range of *Nephrops* were still not covered in 2013. The survey is still developing and improved spatial coverage is expected for 2014. Figure 3.2.3.4 presents the distribution of stations with valid density estimates from 2008 to 2013. A similar survey design has been for applied for both national surveys; A fixed grid with random stratified stations.

In order to estimate the total population numbers, the density estimates have to be raised from the survey areas to total area of the population distribution. VMS information is currently the best available proxy to estimate the *Nephrops* stock distribution in IIIa. VMS data from the Swedish and Danish fishery from 2010 were used and are

described in more detailed in ICES (2011). The area estimates for each subarea are defined in Table 3.2.3.1. Burrow counting and identification follows the standard protocols defined by WGNEPS.

Abundance indices from UWTV surveys

The number of valid stations conducted in the UWTV survey in IIIa divided into subareas Figure 3.2.3.2 is shown in Table 3.2.3.1 and Figure 3.2.3.4.

In WK*NEPH (*2009) a number of bias sources were highlighted relating to the "counted" density from the TV surveys. These bias sources are not easily estimated and are largely based on expert opinion. For the *Nephrops* stock in IIIa it is assumed that the largest source of perceived bias is the "edge effect", due to the relative large sizes of the burrow systems. The cumulative bias correction factor estimated for IIIa was set to be 1.1, meaning that the TV survey is likely to overestimate *Nephrops* abundance by 10 %.

FU	Area	Edge effect	Detection rate	Species identification	Occupancy	Cumulative bias
3 and 4	Skagerrak and Kattegat (IIIa)	1.3	0.75	1.05	1	1.1

3.3.3.2 2013 Assessment.

The assessment of the state of the *Nephrops* stock in IIIa is based on the UWTV survey from 2013 as well as trends in total combined (Denmark and Sweden) LPUE, and discards (numbers) as a proxy for recruitment during the period 1990-2013.

Combined relative effort declined slightly over the period 1990 to 2013 (Figure 3.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level in the recent 6 years (Figure 3.2.4.2). This high level may be attributed to the change in the Danish management system (Individual Transferable Quotas) in 2007. Technical creep, changes in targeting behaviour, stock size and catchability may also be responsible for some of this increase. High LPUEs attribuTable to sudden changes in catchability (caused by e.g. poor oxygen conditions) are known to occur but are generally of short duration.

Since the abundance of small *Nephrops* (typically discards of specimens below minimum landing size) may also be regarded as an index of recruitment, they can be used to further explain the current developments in the stock. The large amounts of discards in the periods 1993-95 and 1999-2000 reflect strong recruitment during these years (Figure 3.2.4.3). The high levels of discards in 1993-95 are believed to have significantly contributed to the high LPUE in 1998-99. The high amount of discards observed in 2007, 2008 and 2009 would then indicate high recruitment in these years.

MSY consideration (TV-survey)

There are no precautionary reference points defined for *Nephrops*. Under the ICES MSY framework, exploitation rates which are likely to generate high long-term yields (and low probability of stock overfishing) have been explored and proposed for Division IIIa. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{MSY} directly and hence proxies for F_{MSY} are determined. WGNSSK (2010) developed a framework for proposing F_{MSY} proxies for the various *Nephrops* stocks based upon their biological

and historical characteristics, and is described in section 1 of that report. Three candidates for F_{MSY} are $F_{0.1}$, $F_{35\%SpR}$ and F_{MAX}. There may be strong differences in relative exploitation rates between the sexes in many stocks. To account for this, values for each of the candidates have been determined for males, females and the two sexes combined. An appropriate F_{MSY} candidate has been selected according to the perception of stock resilience, factors affecting recruitment, population density, knowledge of biological parameters and the nature of the fishery (relative exploitation of the sexes and historical Harvest Rate vs stock status).

A decision-making framework based on the Table below was used in the selection of preliminary stock-specific F_{MSY} proxies (ICES, 2010a). These proxies may be modified following further data exploration and analysis. The combined sex F_{MSY} proxy should be considered appropriate if the resulting percentage of virgin spawner-per-recruit for males or females does not fall below 20%. When this does happen a more conservative sex-specific F_{MSY} proxy should be picked instead of the combined proxy.

		Burrow density (average burrows m−2)		
		Low	Medium	High
		<0.3	0.3-0.8	>0.8
Observed harvest rate or landings compared to stock status	> Fmax	F35%SPR	Fmax	Fmax
	Fmax - F0.1	F0.1	F35%SPR	Fmax
	< F0.1	F0.1	F0.1	F35%SPR
	Unknown	F0.1	F35%SPR	F35%SPR
Stock size estimates	Variable	F0.1	F0.1	F35%
	STable	F0.1	F35%SPR	Fmax
Knowledge of biological parameters	Poor	F0.1	F0.1	F35%SPR
	Good	F35%SPR	F35%SPR	Fmax
Fishery history	STable spatially and temporally	F35%SPR	F35%SPR	Fmax
	Sporadic	F0.1	F0.1	F35%SPR
	Developing	F0.1	F35%SPR	F35%SPR

The absolute burrow density in Division IIIa is medium (0.3-0.8/m2), the observed harvest ratio is between F0.1 and Fmax and historically the fishery is sTable both spatially and temporally. This means that $F_{35\%\ SpR}$ may be selected as a proxy for F_{MSY}. $F_{35\%\ SpR}$ is unusually higher than F_{max} for this stock due to the very high discarding ratios observed in the fishery, therefore it is recommended to use F_{MAX}. For 2015 this corresponds to a TAC of 5318 tonnes. Under a landings obligation it may well be necessary to recalculate a harvest rate associated with F_{MSY} as total catches would be subjected to 100% mortality (current discard survival is estimated to be 25 %).

Harvest ratio as proxy for F_{MSY} for IIIa from length cohort analysis 2011 (2008-2010):

	Male	**Female**	**Combined**
Fmax	6.8 %	10.0 %	7.9 %
F0.1	4.9 %	7.6 %	5.6 %

F35%SpR	8.1 %	12.9 %	10.5 %

The harvest ratios ((landings + dead discards)/total stock biomass) equivalent to F_{msy} proxies are based on yield-per-recruit analyses from length cohort analyses. These analyses utilise average length frequency data taken over the 3 year period (2008-2010). All F_{MSY} proxy harvest rate values are considered preliminary and may be modified following further data exploration and analysis.

Basis	Total catches*	Landings	Dead discards**	Surviving discards**	Harvest rate
	L+DD+SD	L	DD	SD	for L+DD
	6513	3366	2360	787	5.0
F0.1	7294	3770	2643	881	5.6
F2013 (UWTV)	7555	3904	2738	913	5.8
Fmax	10290	5318	3729	1243	7.9
	11723	6059	4248	1416	9.0
F35%SpR	13677	7068	4956	1652	10.5
	15630	8078	5664	1888	12.0

Weights in tonnes.

* Total catches are the landings including dead and surviving discards.

** Total discard rate is assumed to be 67.2% of the catches (by number, average of last three years, 2011–2013), discard survival is assumed to be 25% (WKNEPH; ICES, 2009).

A summary of the results from the TV survey 2013 is presented in Table 3.2.3.1. The estimated bias corrected abundance index was 0.296 resulting in a total biomass of 108 thousand tonnes (2914 million individuals). Total removals (landings + dead discards) were estimated to 6768 tonnes resulting in a harvest rate of 5.8%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased by 50 % since 2002 and is currently at a low level while LPUE shows an increasing trend and is at a long term high level in recent years (Figures 3.2.4.1 and 3.2.4.2). Mean sizes are fluctuating without trend. There are no signs of overexploitation in IIIa.

The conclusion from this indicator based assessment is that the stock is exploited sustainably.

3.3.4 Biological reference points

No biological reference points are used for this stock.

3.3.5 Quality of the assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling in this fishery has been conducted on a quarterly basis for Danish and Swedish *Nephrops* trawlers since 1990, and is considered to represent the fishery adequately.

The UWTV survey 2013 was conducted in all 6 defined subareas in IIIa. A correction factor of 1.1 for estimated bias was used. A total weighted mean density was estimated based on density estimates from each sub-area and weighted by the size of each sub-area. The estimated F_{msy} proxies for this stock provide a relatively low Harvest Ratio

which may be a result of the high discards ratios (52% in weight) which occur due to the high minimum landing size (40 mm). These removals do not increase the yield from the stock.

The Danish lpue data used as indicators for stock development have been standardised regarding engine size. However, LPUE is also influenced by changes in catchability due to sudden changes in the environmental conditions or/and changes in selectivity, gear efficiency or a change in targeting behaviour due to the cod management plan in IIIa. Also the changes in management systems (indicated by the broken red line in Figure 3.2.4.2), which occurred in 2007 in Denmark, caused a general increase in LPUE. In IIIa, fluctuations in catches of small *Nephrops* are used as indicators of recruitment (Figure 3.2.4.3).

3.3.6 Status of the Stock

The *Nephrops* stock in Division IIIa was assessed with an UWTV survey for the third year (all 6 subareas) and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory (Figure 3.3.6.1).

The 2013 Harvest Ratio was estimated to be relatively low (5.8% from UWTV survey) implying the stock appears to be exploited sustainably.

The analysis of commercial LPUE and effort data indicate that LPUE shows an increasing trend while effort shows a decreasing trend and the WG concludes that current levels of exploitation appear to be sustainable.

3.3.7 Division IIIa *Nephrops* Management Considerations

The observed trends in effort, LPUE and discards are similar for FU 3 and FU 4. Our present knowledge on the biological characteristics of the *Nephrops* stocks in these two areas does not indicate obvious differences, and therefore the two FUs are treated as one single 'stock' in the assessment.

The UWTV- survey in IIIa suggests that the harvest ratio of the stock is relatively low and the stock is exploited at a sustainable level.

The combined logbook recorded effort has decreased since 2002 and is currently at a low level while LPUE has increased and is at a relatively high level in the last seven years (Figures 3.2.4.1 and 3.2.4.2). Mean sizes are fluctuating without trend (Figures 3.2.2.2 and 3.2.2.5). There are no signs of overexploitation in IIIa.

Given the apparent stability of the stock, the WG concludes that current levels of exploitation appear to be sustainable.

The WG encourages the work on size selectivity in *Nephrops* trawls to reduce the large amount of discarded undersized *Nephrops* in IIIa.

Mixed fishery aspects

Cod and sole are significant by-catch species in these fisheries in IIIa, and even if data on catches, including discards, of the by-catch gradually become available, they have not yet been used in the management. The WG has for many years recommended the use of species selective grids in the fisheries targeting *Nephrops* as legislated for Swedish national waters. New technical measures (Swedish grid and SELTRA trawl) have recently been agreed upon for the *Nephrops* directed fishery and have been implemented since the 1st February 2013. The European Union and Norway have also agreed that a discard ban will be implemented in EU waters from the 1st January 2015. The discard ban will be applicable to *Nephrops* from the 1st January 2016.

Table 3.1.1. Definition of *Nephrops* Functional Units in IIIa and IV in terms of ICES statistical rectangles.

FU no.	Name	ICES area	Statistical rectangles
3	Skagerrak	IIIaN	47G0; 46F9-G1; 45F8-G1; 44F7-G0; 43F8-F9
4	Kattegat	IIIaS	44G1; 42-43 G0-G2; 41G1-G2
5	Botney Gut - Silver Pit	IVb,c	36-37 F1-F4; 35F2-F3
6	Farn Deeps	IVb	38-40 E8-E9; 37E9
7	Fladen Ground	IVa	44-49 E9-F1; 45-46E8
8	Firth of Forth	IVb	40-41E7; 41E6
9	Moray Firth	IVa	44-45 E6-E7; 44E8
10	Noup	IVa	47E6
32	Norwegian Deep	lVa	44-52 F2-F6; 43F5-F7
33	Off Horn Reef	lVb	39-41F5; 39-41F6
34	Devil's Hole	IVb	41-43 F0-F1

Table 3.1.2 Summary of *Nephrops* landings from the ICES area, by Functional Unit.

Year	FU 3	FU 4	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981	992	1728		1073	372	1007	1416	36				76	3980
1982	1470	1828		2524	421	1195	1119	19				157	5437
1983	2205	1472		2078	693	1724	941	15				101	5551
1984	2675	2036		1479	646	2134	1169	111				88	5628
1985	2191	1798		2027	1147	1968	2081	22				139	7386
1986	2018	1807		2015	1543	2263	2143	68				204	8236
1987	2441	1605		2191	1695	1675	1992	44				195	7791
1988	2363	1364		2495	1575	2529	1959	76				364	8995
1989	2564	1313		3098	2299	1888	2576	84		16		233	10176
1990	2866	1475		2498	2540	1931	2037	217		47		222	9442
1991	2924	1304	862	2063	4223	1405	1520	196		69	83	560	15055
1992	1893	1012	612	1473	3363	1756	1591	188		75	106	401	12290
1993	2288	924	721	3030	3492	2368	1809	376	339	160	44	434	15942
1994	1981	893	503	3683	4568	1850	1537	495	755	137	129	703	17107
1995	2429	998	869	2569	6419	1762	1279	280	489	164	132	844	18142
1996	2695	1285	679	2483	5210	1687	1451	344	952	77	128	808	17679
1997	2612	1594	1149	2189	6170	2193	1447	317	760	276	99	662	19369
1998	3248	1808	1111	2177	5136	2144	1032	256	836	358	88	694	18791
1999	3194	1755	1244	2391	6518	2207	1009	278	1119	738	202	988	21428
2000	2894	1816	1121	2178	5570	1785	1539	274	1084	610597	184	900	19760
2001	2282	1774	1443	2574	5542	1527	1401	177	1190	791	271	1268	19971
2002	2977	1471	1231	1954	7245	1340	1132	403	1170	861	343	1383	21153
2003	2126	1641	1144	2245	6294	1127	1080	336	1089	929	675	1390	19400
2004	2312	1653	1070	2153	8730	1657	1333	228	922	1268	488	1224	22552
2005	2546	1488	1099	3094	10684	1989	1605	165	1089	1050	378	1120	25931
2006	2392	1280	974	4903	10791	2458	1805	133	1028	1288	448	1249	28299
2007	2771	1741	1294	2966	11911	2651	1843	153	755	1467	717	1637	29190
2008	2851	2025	963	1218	11573	2450	1515	172	675	1096	937	1673	27226
2009	3004	1842	728	2703	13327	2663	1067	87	477	1163	1305	2367	29429
2010	2938	2185	959	1443	12968	1950	1063	39	407	806	865	709***	25970
2011	2511	1475	1053	2070	7559	1889	1391	68	395	1191	432	1166****	20034
2012	2212	1860	1240	2460	4415	2129	866	13	310	1084	597	608	17704
2013*	2147	1613	1050	2982	2959	1501	655	15		946	121		

*** Provisional**

**** Devil's Hole landings only separated from 2011.**

***** 695t in IV and 14t in IIIa**

******IV only**

Table 3.2.1.2. - Division IIIa: Total *Nephrops* landings (tonnes) by Functional Unit, 1991-2013.

Year	FU 3	FU 4	Total
1991	2924	1304	4228
1992	1893	1012	2905
1993	2288	924	3212
1994	1981	893	2874
1995	2429	998	3427
1996	2695	1285	3980
1997	2612	1594	4206
1998	3248	1808	5056
1999	3194	1755	4949
2000	2894	1816	4710
2001	2282	1774	4056
2002	2977	1471	4448
2003	2126	1641	3767
2004	2312	1653	3965
2005	2546	1488	4034
2006	2392	1280	3672
2007	2771	1741	4512
2008	2851	2025	4876
2009	3004	1842	4846
2010	2938	2185	5123
2011	2511	1475	3986
2012	2536	1893	4429
2013	2147	1613	3760

Table 3.2.1.3. - Division IIIa: Total *Nephrops* landings (tonnes) by country, 1991-2013.

Year	Denmark	Norway	Sweden	Germany	Total landings	Total Disc.	Total Catch
1991	2824	185	1219		4228	5183	9411
1992	2052	104	749		2905	2523	5428
1993	2250	103	859		3212	8493	11705
1994	2049	62	763		2874	6450	9324
1995	2419	90	918		3427	4464	7891
1996	2844	102	1034		3980	2148	6128
1997	2959	117	1130		4206	3469	7675
1998	3541	184	1319	12	5056	1944	7000
1999	3486	214	1243	6	4949	4108	9057
2000	3325	181	1197	7	4710	5664	10374
2001	2880	138	1037	1	4056	3767	7823
2002	3293	116	1032	7	4448	4311	8760
2003	2757	99	898	13	3767	2208	5975
2004	2955	95	903	12	3965	2532	6497
2005	2901	83	1048	2	4034	3014	7048
2006	2432	91	1143	6	3672	2926	6598
2007	2887	145	1467	13	4512	6524	11036
2008	3174	158	1509	19	4860	4746	9606
2009	3372	128	1331	15	4846	6129	10975
2010	3721	124	1249	29	5123	3548	8671
2011	2937	87	945	17	3986	2847	6833
2012	2970	104	1355	0	4429	4771	9200
2013	2550	73	1134	3	3760	4010	7770

Table 3.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991-2013.

Year	Denmark	Norway			Sweden			Germany	Total
		Trawl	Creel	Sub-total	Trawl	Creel	Sub-total		
1991	1639	185	0	185	949	151	1100	0	2924
1992	1151	104	0	104	524	114	638	0	1893
1993	1485	101	2	103	577	123	700	0	2288
1994	1298	62	0	62	531	90	621	0	1981
1995	1569	90	0	90	659	111	770	0	2429
1996	1772	102	0	102	708	113	821	0	2695
1997	1687	117	0	117	690	118	808	0	2612
1998	2055	184	0	184	864	145	1009	0	3248
1999	2070	214	0	214	793	117	910	0	3194
2000	1877	181	0	181	689	147	836	0	2894
2001	1416	125	13	138	594	134	728	0	2282
2002	2053	99	17	116	658	150	808	0	2977
2003	1421	90	9	99	471	135	606	0	2126
2004	1595	85	10	95	449	173	622	0	2312
2005	1727	71	12	83	538	198	736	0	2546
2006	1516	80	11	91	583	201	784	0	2391
2007	1664	127	18	145	709	253	962	0	2771
2008	1745	124	34	158	675	273	948	0	2851
2009	2012	101	27	128	605	260	864	0	3004
2010	1981	105	20	125	563	266	829	4	2938
2011	1801	74	12	87	432	188	621	2	2510
2012	1516	80	24	104	592	324	916	0	2536
2013	1309	57	16	73	484	279	763	0	2146

Table 3.2.2.2. *Nephrops* Skagerrak (FU 3): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991-2013. (*Include only *Nephrops* trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	676	401	71.4	9.5	5.6
1992	360	231	73.7	4.9	3.1
1993	614	279	72.6	8.4	3.8
1994	441	246	60.1	7.3	4.1
1995	501	336	60.8	7.8	5.2
1996	754	488	51.1	14.8	9.6
1997	643	437	44.4	14.4	9.8
1998	794	557	49.7	16.0	11.2
1999	605	386	34.5	17.5	9.3
2000	486	329	32.7	14.9	10.9
2001	446	236	26.2	17.0	10.4
2002	503	301	29.4	17.1	8.8
2003	310	254	21.5	13.9	11.4
2004*	474	257	20.1	23.6	13.4
2005*	760	339	29.7	25.6	12.7
2006*	839	401	37.5	22.4	12.2
2007*	894	314	24.1	37.0	13.0
2008*	605	264	20.0	30.3	13.2
2009*	482	285	19.6	24.5	14.5
2010*	476	286	20.7	23.0	13.8
2011*	334	198	16.8	19.9	11.8
2012*	542	238	16.0	33.8	14.9
2013*	251	137	11.3	22.2	12.1

Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	740	439	39.5	18.7	11.1
1992	370	238	34.1	10.9	7.0
1993	568	258	35.9	15.8	7.2
1994	444	248	34.1	13.1	7.3
1995	403	270	32.9	12.2	8.2
1996	187	121	13.0	14.4	9.3
1997	219	149	17.5	12.5	8.5
1998	254	178	16.7	15.2	10.6
1999	382	244	27.6	13.8	8.8
2000	349	237	31.3	11.1	10.1
2001	470	249	33.7	14.0	7.4
2002	392	244	33.3	11.8	7.1
2003	168	138	22.5	7.5	6.1
2004	217	118	21.7	10.0	5.4
2005	263	117	22.1	11.9	5.3

2006	253	121	19.6	12.9	6.2
2007*	248	87	5.4	45.6	16.0
2008*	139	61	3.4	41.3	18.0
2009*	211	125	7.1	29.5	17.5
2010*	165	99	5.9	27.8	16.7
2011*	202	120	7.7	26.3	15.6
2012*	544	239	12.9	42.2	18.6
2013*	423	231	13.8	30.7	16.8

Table 3.2.2.3. *Nephrops* Skagerrak (FU 3): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991-2013.

Year	kW days	Days at sea	Fishing days	LPUE
1991	6272817	23695	21854	75
1992	4797327	18565	16891	68
1993	4151784	15274	13615	109
1994	3532464	13253	11667	111
1995	3453419	13344	11964	131
1996	3699633	13871	12740	139
1997	3512641	13455	12328	137
1998	3641085	13073	11917	172
1999	4312598	14816	13445	154
2000	4574172	15530	14040	134
2001	4074471	13565	11925	119
2002	4798320	16791	14489	142
2003	3609840	11884	10717	133
2004	4008783	13401	11993	133
2005	3762911	12571	11183	154
2006	3298814	10829	9732	156
2007	2424173	8026	7295	228
2008	2332056	8016	7300	239
2009	2549895	8814	8058	250
2010	2668904	9027	8338	238
2011	2666680	9767	8912	202
2012	2181133	8321	7547	201
2013	1737339	6769	6372	205

Table 3.2.2.4. - Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991-2013.

	Catches					
	Undersized		Full sized		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.2	30.9	41.2	42.7	30.9	29.8
1992	33.3	32.3	43.3	44.7	33.3	32.2
1993	33.0	31.5	42.0	43.6	33.0	31.5
1994	31.7	29.6	41.7	43.6	31.7	29.6
1995	30.0	28.5	41.6	41.3	32.9	29.8
1996	33.2	31.9	42.9	44.0	37.6	37.0
1997	35.8	34.5	44.6	44.1	39.8	39.1
1998	34.8	34.4	46.1	43.9	40.7	37.3
1999	34.6	33.9	44.9	43.8	39.3	36.1
2000	30.6	30.5	45.6	45.0	32.5	34.1
2001	33.6	33.6	45.5	43.6	37.3	36.4
2002	33.9	33.7	44.0	42.5	37.2	37.3
2003	33.5	32.6	43.2	43.4	38.0	36.7
2004	34.3	33.4	44.6	45.2	38.7	36.6
2005	33.5	32.4	43.7	43.0	36.4	35.3
2006	33.2	32.9	44.7	42.7	37.1	36.1
2007	32.6	31.9	44.4	42.4	34.9	33.5
2008	33.6	32.3	44.0	42.7	36.5	34.5
2009	35.0	33.8	45.3	42.8	39.8	35.9
2010	34.2	33.8	46.2	44.8	38.9	36.6
2011	33.8	33.1	44.5	43.3	38.4	36.5
2012	34.8	34.1	44.2	42.5	38.2	36.2
2013	35.1	34.8	45.0	42.9	38.6	36.9

Table 3.2.2.5. ***Nephrops*** **Kattegat (FU 4): Landings (tonnes) by country, 1991-2013.**

		Sweden				
Year	**Denmark**	Trawl	Creel	**Sub-total**	**Germany**	**Total**
1991	1185	119	0	119	0	1304
1992	901	111	0	111	0	1012
1993	765	159	0	159	0	924
1994	751	142	0	142	0	893
1995	850	148	0	148	0	998
1996	1072	213	0	213	0	1285
1997	1272	319	3	322	0	1594
1998	1486	306	4	310	12	1808
1999	1416	329	4	333	6	1755
2000	1448	357	4	361	7	1816
2001	1464	304	6	309	1	1774
2002	1240	219	5	224	7	1471
2003	1336	287	5	292	13	1641
2004	1360	270	11	281	12	1653
2005	1175	303	8	311	2	1488
2006	916	347	11	358	6	1280
2007	1223	491	15	505	13	1741
2008	1429	561	16	577	19	2025
2009	1360	450	16	467	15	1842
2010	1740	403	17	420	25	2185
2011	1136	308	16	324	15	1475
2012	1454	406	33	439	0	1893
2013	1241	341	27	368	3	1612

Table 3.2.2.6. - Kattegat (FU 4): Catches and landings (tonnes), effort ('000 hours trawling), CPUE and LPUE (kg/hour trawling) of Swedish *Nephrops* trawlers, 1991-2013 (*Include only *Nephrops* trawls with grid and square mesh codend).

Single trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	66	39	10.3	6.4	3.7
1992	44	28	11.6	3.8	2.4
1993	128	58	14.9	8.6	3.9
1994	95	53	16.2	5.7	3.2
1995	79	53	9.6	7.8	5.5
1996	207	134	13.7	15.1	9.8
1997	269	183	18.0	15.0	10.2
1998	181	127	13.1	13.8	9.7
1999	146	93	8.1	17.9	11.4
2000	114	77	8.5	13.4	9.1
2001	117	62	7.6	15.4	8.2
2002	42	25	3.7	11.2	6.7
2003	49	40	4.6	10.7	8.7
2004	70	44	4.3	16.2	10.1
2005	147	100	12.3	11.9	8.1
2006	234	154	15.1	15.5	10.2
2007*	107	51	4.1	25.7	12.3
2008*	121	57	4.4	27.6	13.0
2009*	157	81	5.1	30.9	16.1
2010*	181	102	7.6	23.8	13.4
2011*	75	45	3.8	20.0	12.0
2012*	80	45	3.4	23.5	13.3
2013*	44	26	2.3	19.5	11.6
Twin trawl					
Year	Catches	Landings	Effort	CPUE	LPUE
1991	93	55	8.8	10.6	6.2
1992	101	65	14.2	7.1	4.6
1993	187	85	17.8	10.6	4.8
1994	138	77	14.2	9.7	5.4
1995	125	84	11.0	12.2	7.7
1996	97	63	7.5	13.0	8.4
1997	183	124	12.7	14.3	9.7
1998	215	151	15.0	14.4	10.1
1999	306	195	20.1	15.2	9.7
2000	330	224	24.5	13.5	9.1
2001	353	187	25.1	14.1	7.4
2002	256	153	23.2	11.0	6.6
2003	222	181	24.8	8.9	7.3
2004	253	158	16.5	15.4	9.6
2005	198	135	15.3	12.9	8.8
2006	183	121	12.7	14.4	9.5

2007*	112	54	3.6	30.9	14.8
2008*	164	78	4.8	34.1	16.1
2009*	309	161	11.0	28.2	14.6
2010*	297	167	9.2	32.2	18.1
2011*	266	159	9.7	27.3	16.3
2012*	406	231	12.4	32.8	18.6
2013*	354	210	15.0	23.7	14.0

Table 3.2.2.7. *Nephrops* Kattegat (FU 4): Logbook recorded effort (kW days, Days at sea, and fishing days) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991-2013.

Year	kW days	Days at sea	Fishing days	LPUE
1991	4074212	22533.7	16923.5	70
1992	3587105	19828.91	14449	62
1993	2744914	15120.28	10682.5	72
1994	2408095	13723.39	11086	68
1995	2282190	12859.75	10244.5	83
1996	2654978	14675.99	11831	91
1997	2785958	14337.53	11571	110
1998	2918412	15153.38	12383	120
1999	3359469	16623.11	13600.5	104
2000	3632346	18280.59	14660.5	99
2001	3803086	18688.65	15293.5	96
2002	3236501	16496.57	13332.5	93
2003	3141247	15267.19	12582	106
2004	2933114	14237.21	11324.5	120
2005	2452042	11810.59	9335	126
2006	2147461	10430.58	8467	108
2007	2022910	9883.15	7896.5	155
2008	2147785	10536.89	8468.5	169
2009	2219200	11119.6	8726.333	156
2010	2438736	12054.94	9706.833	179
2011	2009220	10284.09	8099	140
2012	2287683	11777.01	9826.333	148
2013	2218508	11653.01	9261	134

Table 3.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991-2013. Since 2005 based on combined Danish and Swedish data.

	Catches					
	Discards		Landings		All	
Year	Males	Females	Males	Females	Males	Females
1991	30.7	31.1	42.4	42.5	32.5	32.9
1992	33.0	30.3	44.4	43.2	36.7	34.9
1993	30.5	29.3	42.3	43.1	31.3	30.1
1994	29.7	28.3	40.8	40.2	31.2	28.9
1995	30.8	30.5	42.4	42.0	33.7	33.2
1996	32.7	31.3	42.0	44.0	36.7	37.3
1997	33.6	33.2	45.0	44.5	37.1	35.0
1998	34.2	33.2	45.6	44.1	41.3	36.8
1999	32.9	33.8	45.3	40.9	37.8	34.9
2000	35.1	35.2	45.7	42.1	40.4	36.9
2001	32.2	33.0	44.1	41.9	35.9	36.5
2002	34.4	33.3	44.4	43.8	37.2	36.2
2003	33.0	33.2	43.5	42.2	37.1	36.0
2004	34.7	34.2	45.1	43.2	39.9	37.5
2005	33.5	33.9	45.8	43.1	38.7	38.7
2006	33.2	33.6	45.1	42.8	37.9	37.4
2007	33.9	33.2	44.8	43.5	37.2	35.5
2008	32.6	32.4	44.0	43.9	37.5	35.9
2009	33.8	33.1	44.7	44.1	36.8	35.2
2010	34.6	33.8	45.9	44.5	39.8	36.9
2011	33.7	32.9	44.7	43.3	38.1	35.5
2012	33.8	33.2	44.3	42.9	37.1	35.7
2013	34.4	34.6	44.8	42.9	38.0	36.5

Table 3.2.3.1. Summary output of the TV-survey in IIIa from 2013.

Subarea	Area (km2)	Number of stations	Absolute mean density	95% Confidence interval	Population numbers (mill.)	Population estimates (tonnes)
1	3079	59	0.178	0.045	547	20223
2	1982	57	0.136	0.053	270	10003
3	2462	9	0.360	0.204	886	32796
4	676	5	0.442	0.170	299	11055
5	670	8	0.616	0.365	413	15274
6	973	19	0.512	0.332	499	18450
Total	9842	157	0.296		2914	107801

Mean weight (2011-2013)	37.0	Harvest rate	0.058
Removals 2013 (landings + dead discards**)	169*		

*** In millions**

****The survival rate of discard is estimate to be 25% (Wileman *et al.* 1999)**

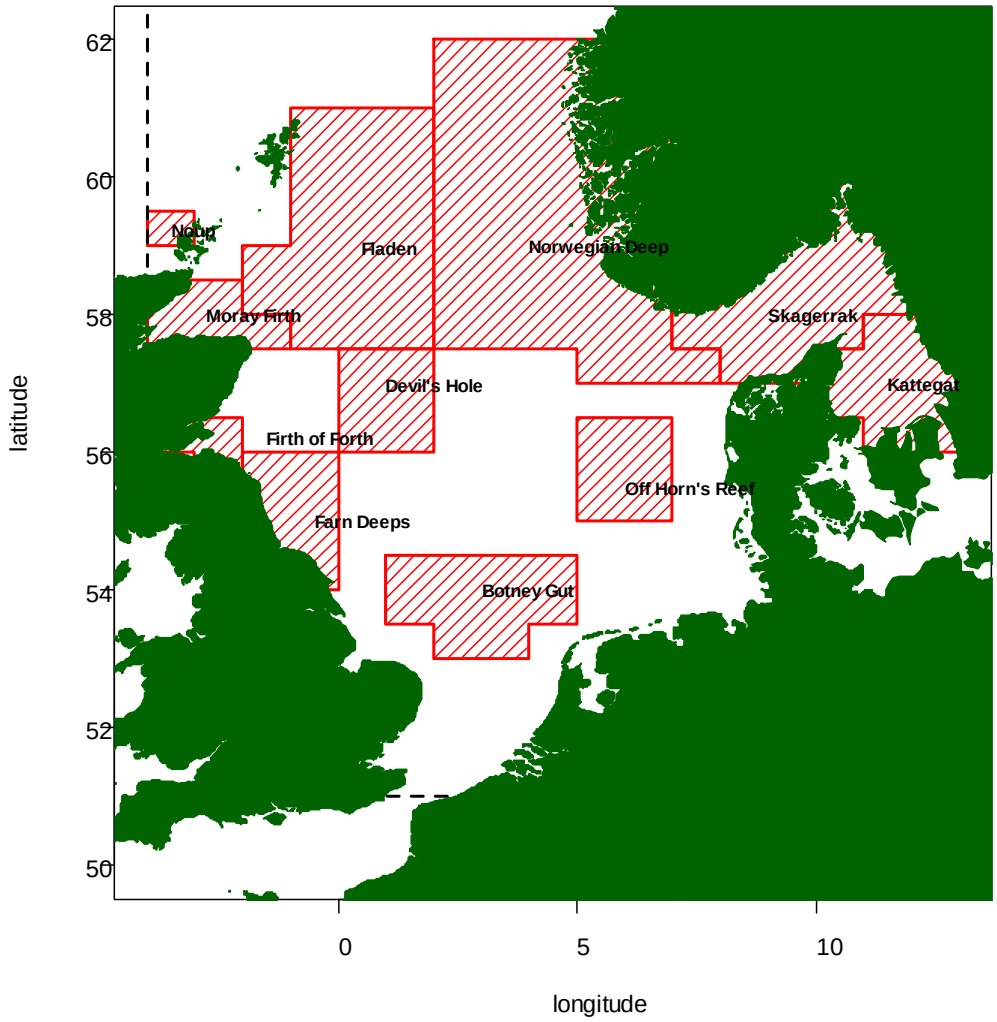


Figure 3.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

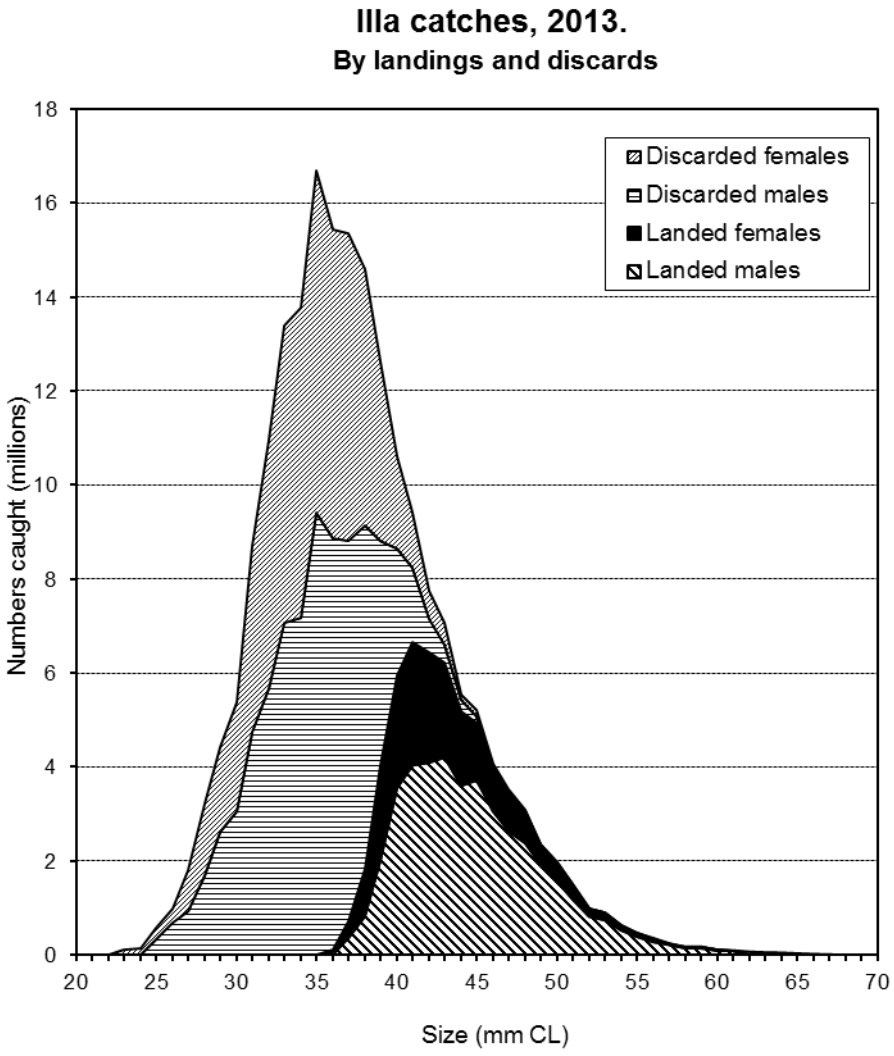


Figure 3.2.1.1. Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2013.

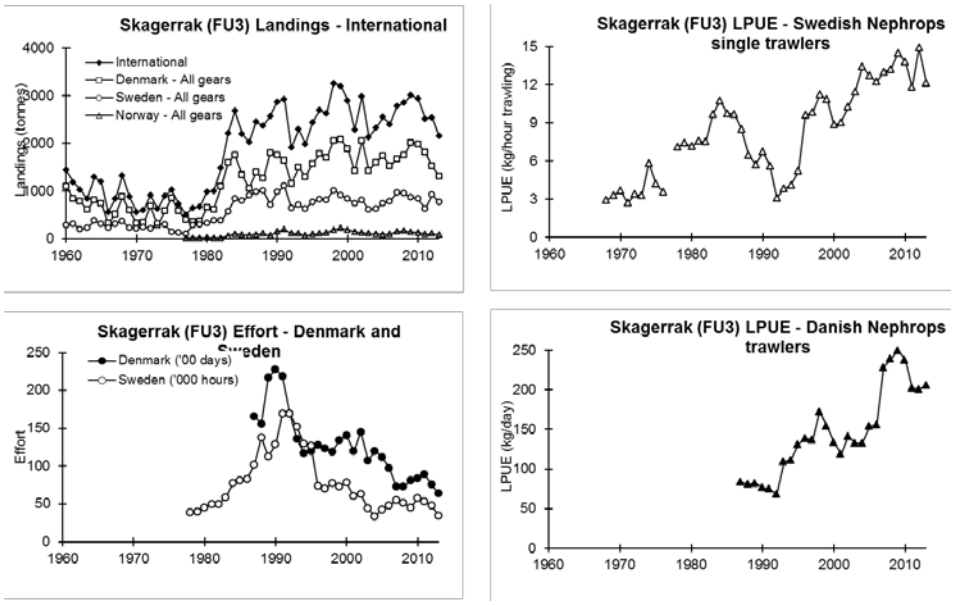


Figure 3.2.2.1. ***Nephrops*** **Skagerrak (FU 3): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.**

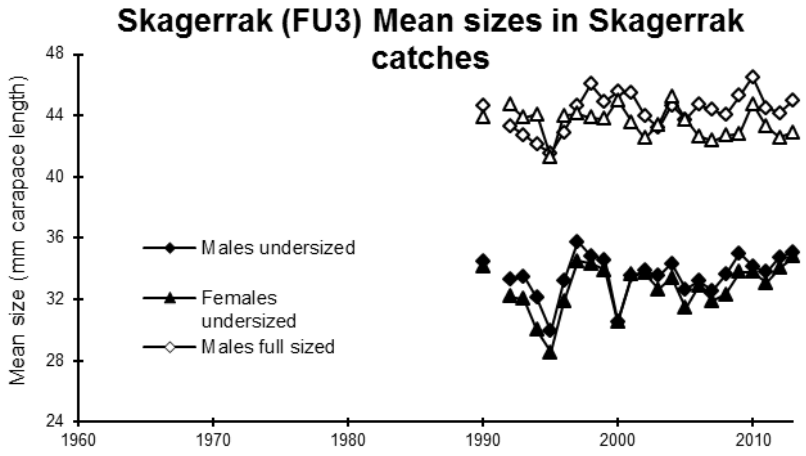


Figure 3.2.2.2. ***Nephrops*** **in FU 3. Mean sizes in the catches.**

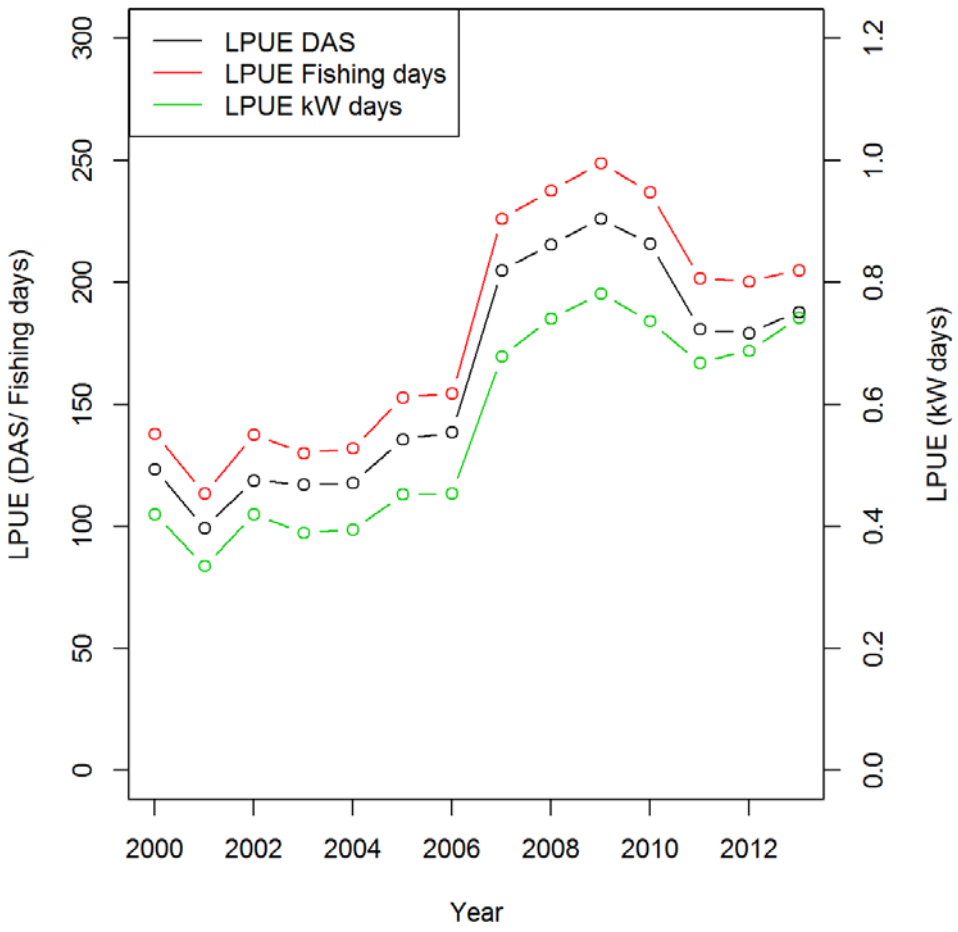


Figure 3.2.2.3. ***Nephrops*** **in FU 3. Danish LPUE trends.**

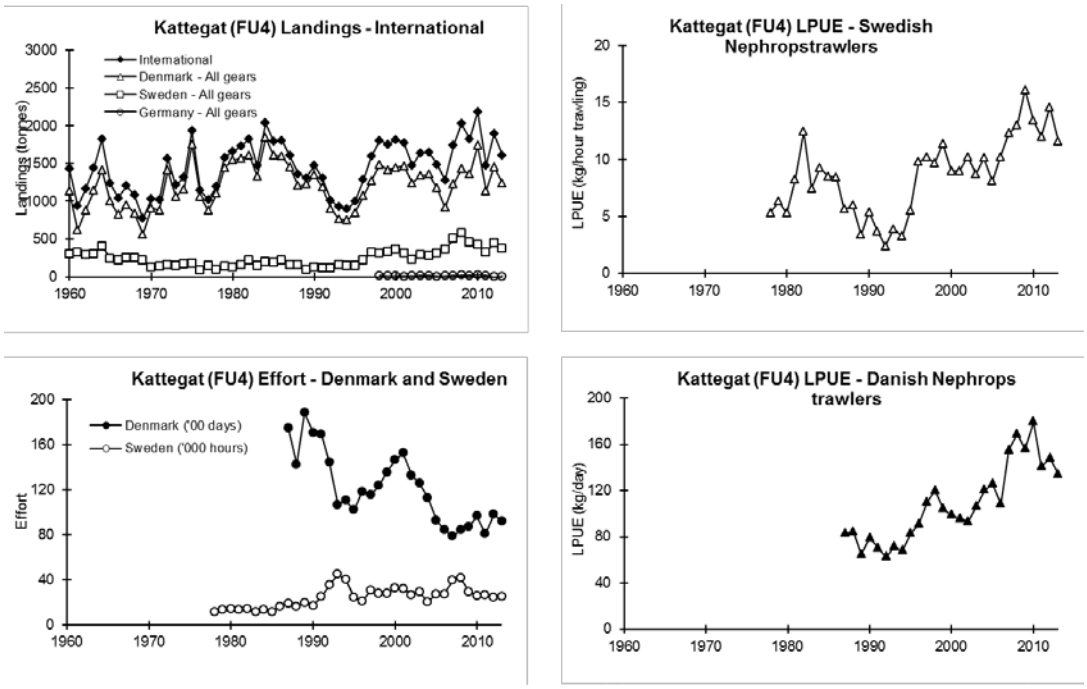


Figure 3.2.2.4. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.**

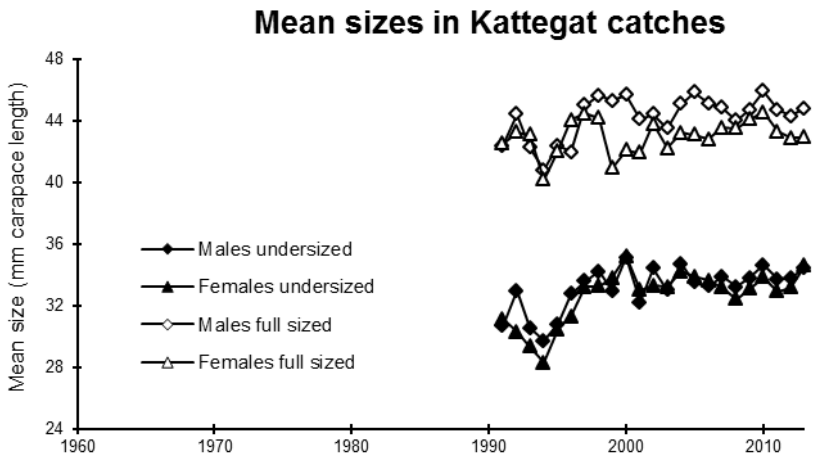


Figure 3.2.2.5. ***Nephrops*** **in FU 4. Mean sizes in the catches.**

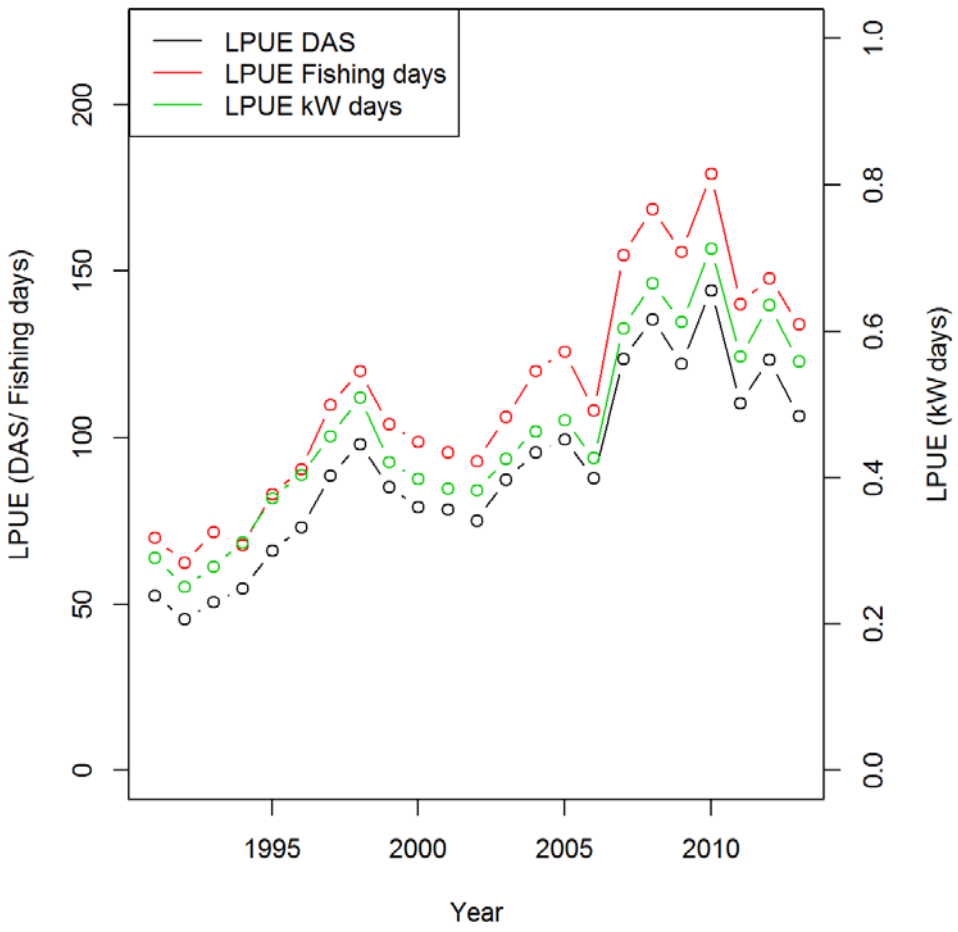


Figure 3.2.2.6. ***Nephrops*** **in FU 4. Danish LPUE trends.**

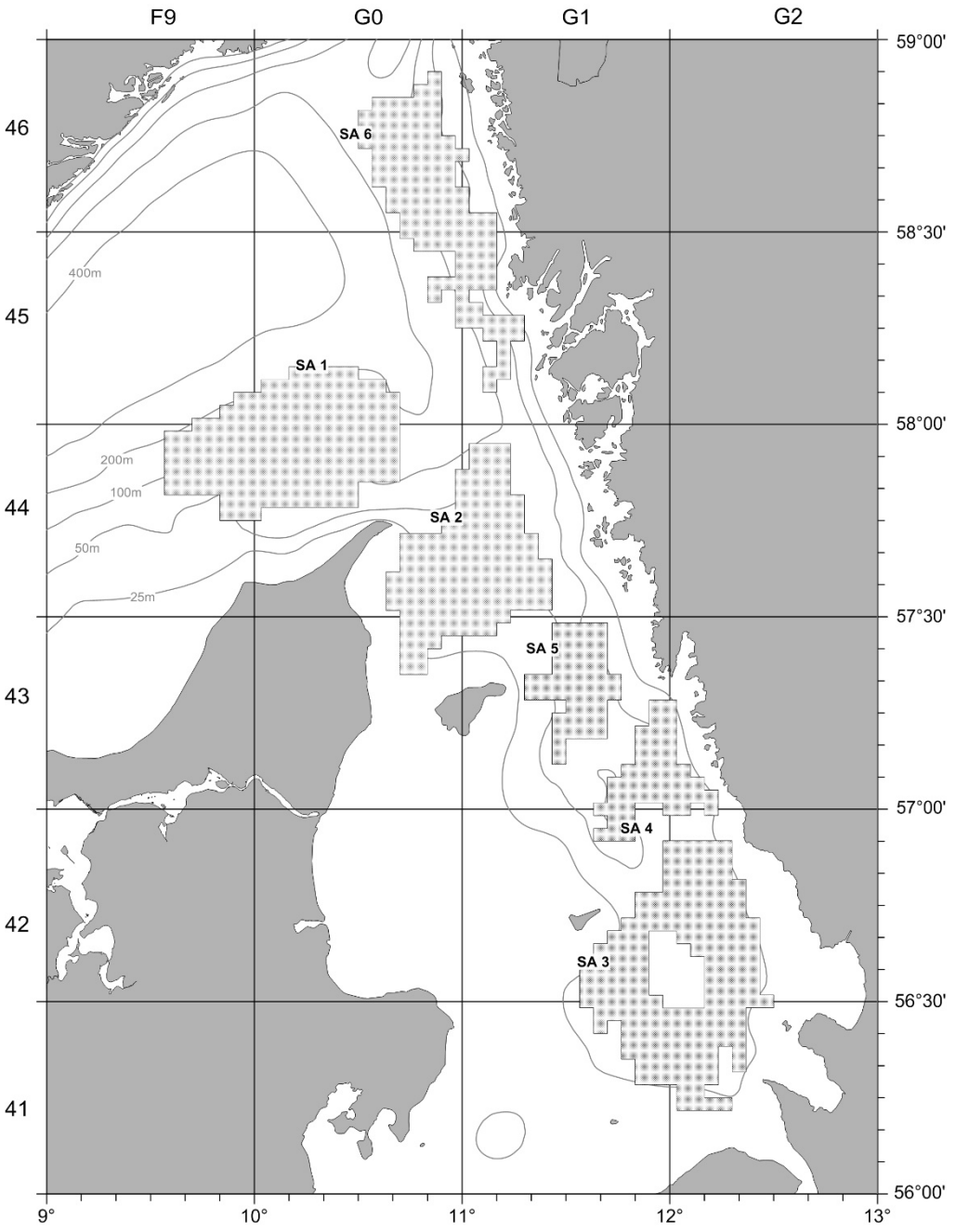


Figure 3.2.3.2. The defined sub areas of the *Nephrops* stock in IIIa.

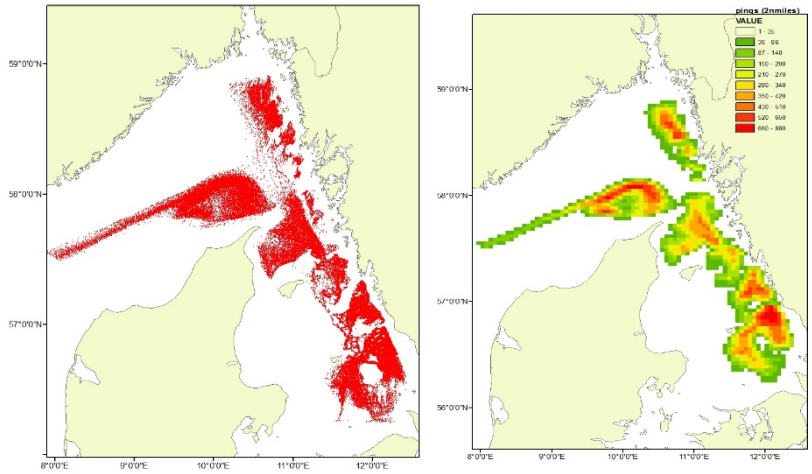


Figure 3.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010. Left map shows VMS pings and the right map shows density of VMS pings.

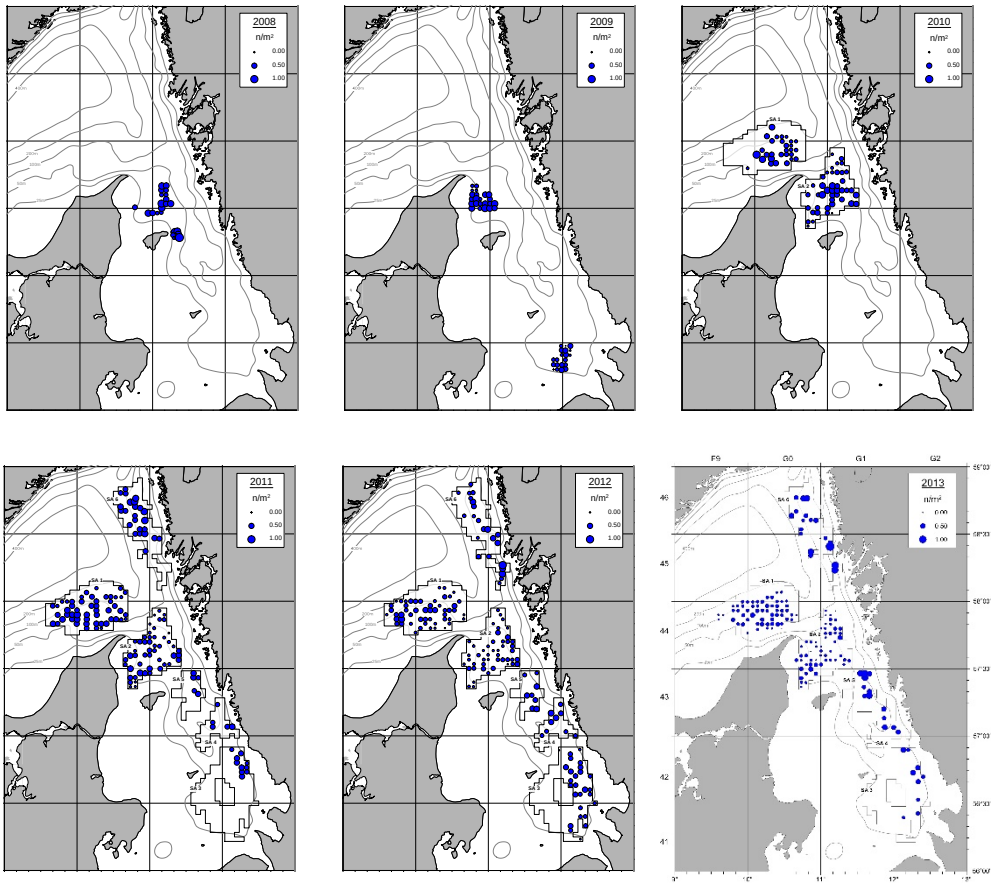


Figure 3.2.3.4. Sampling locations and *Nephrops* burrow density in the UWTV survey in the Skagerrak and Kattegat (FU 3 and 4) in 2008 (26 stations, Denmark only), 2009 (47 stations, Denmark only), 2010 (72 stations, Denmark only), 2011 (146 stations), 2012 (166 stations), and 2013 (157 stations).

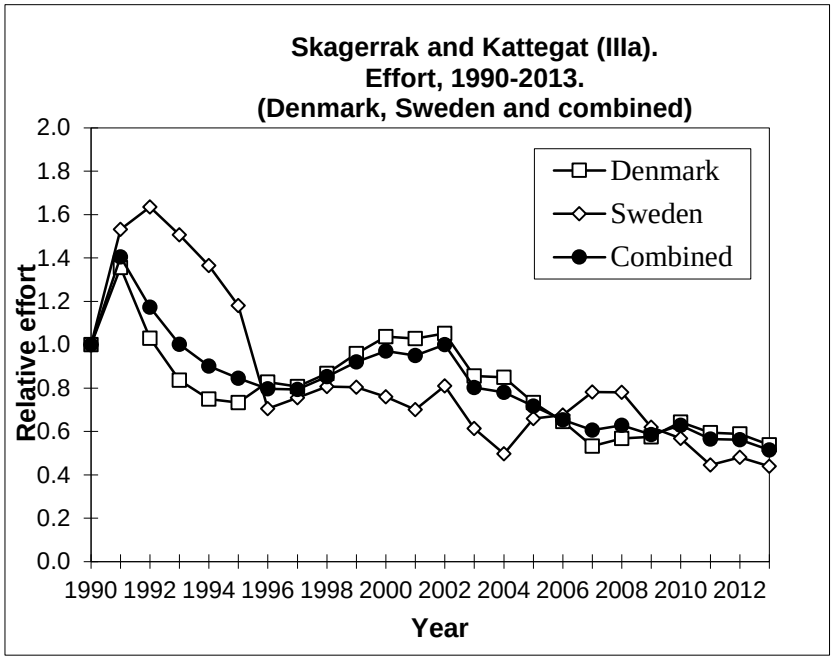


Figure 3.2.4.1 ***Nephrops*** **in Area IIIa. Combined Effort for FU 3&4**

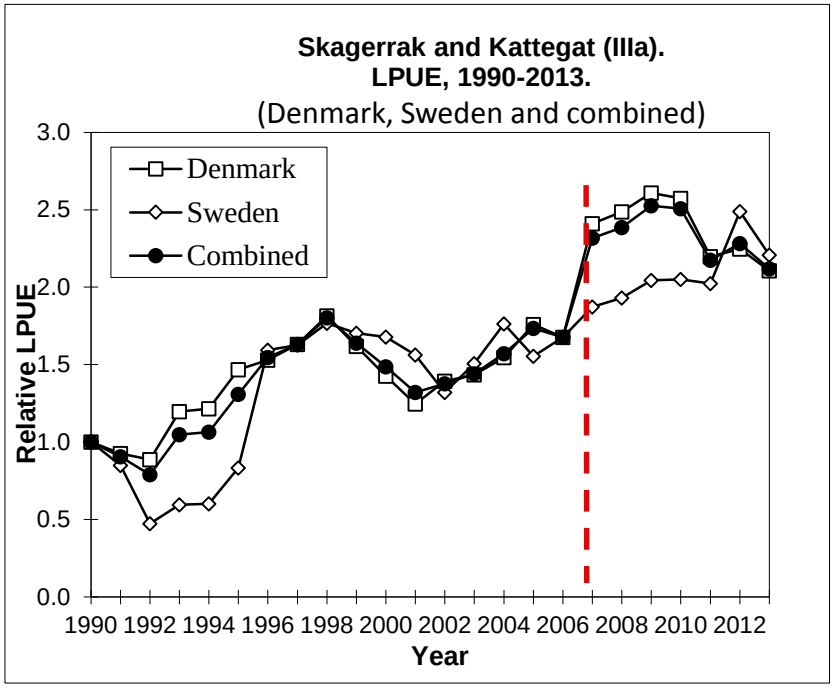


Figure 3.2.4.2 ***Nephrops*** **in Area IIIa. Combined LPUE for FU 3&4. Red dotted line shows the year before the shift in Danish management system.**

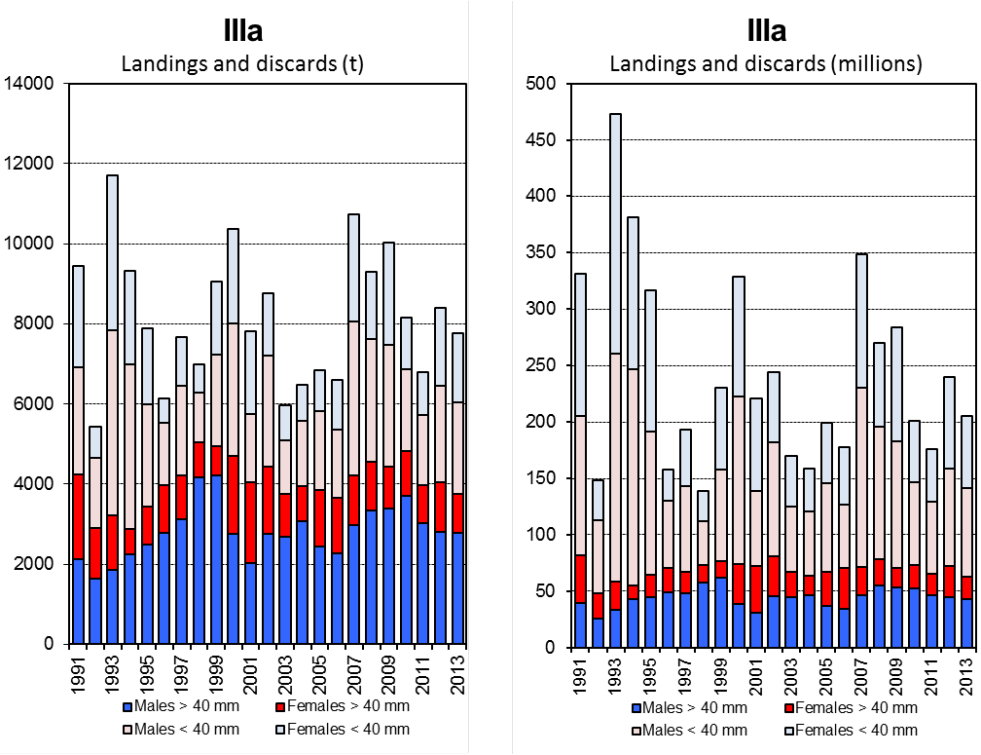


Figure 3.2.4.3 *Nephrops* in IIIa FUs 3&4. Catch by sex and size category in numbers and biomass.

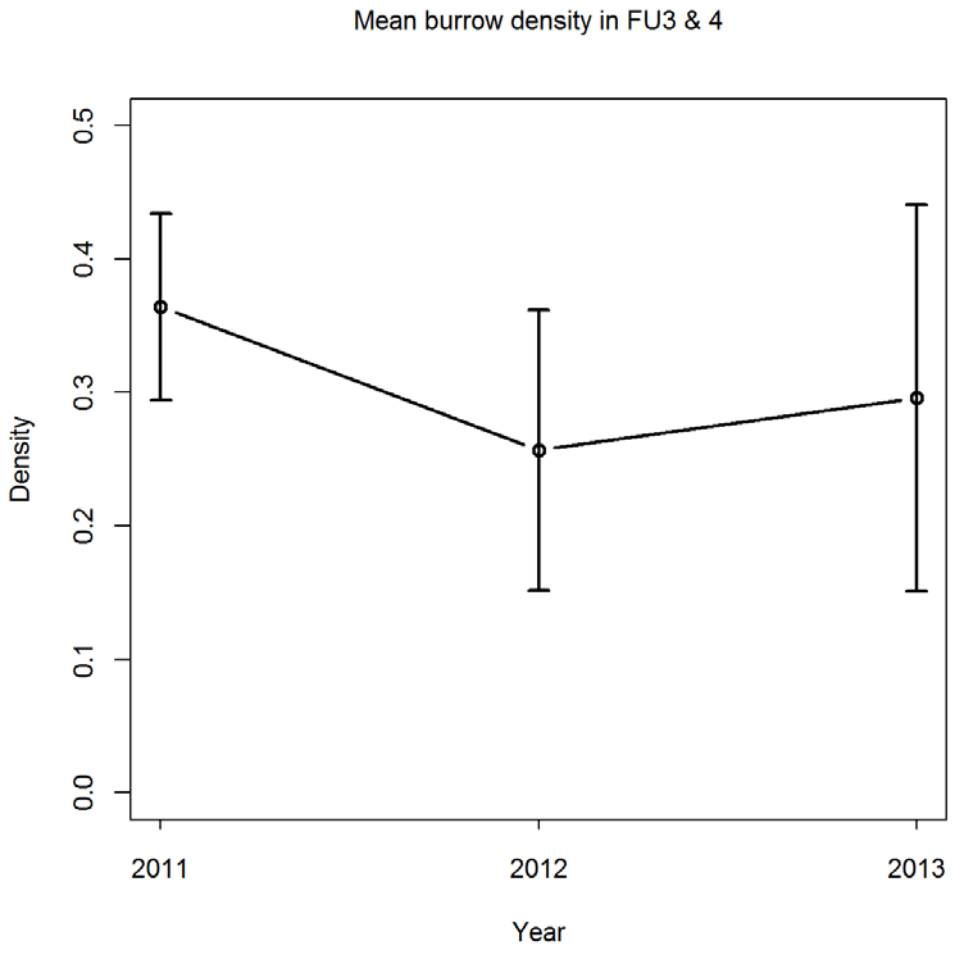


Figure 3.3.6.1. Mean burrow density in IIIa by year. Error bars indicate the 95 % confidence intervals.

4 *Nephrops* in Subareas IV

4.1 General comments relating to all *Nephrops* stocks

See section 3.1

4.2 *Nephrops* in Subarea IV

Division IV contains nine FUs 5, 6, 7, 8, 9, 10, 32, 33 and 34. Management is applied at the scale of ICES Division through the use of a TAC and an effort regime. FU34 (The Devil's Hole) is a new functional unit designated by SGNepS (2010).

Management at ICES Subarea Level

The 2012 EC TAC for *Nephrops* in ICES Subarea IIa and IV was 21929 tonnes in EC waters (plus 1200 tonnes in Norwegian waters). For 2013, this was reduced to 17350 tonnes in EC waters and 1000 tonnes in Norwegian waters. In 2014, there has been a further reduction to 15499 tonnes in EC waters, and an additional 1000 TAC for EU vessels in Norwegian waters.

The minimum landings size (MLS) for *Nephrops* in Subarea IV (EC) is 25 mm carapace length. Denmark, Sweden and Norway apply a national MLS of 40 mm.

Days-at-sea regulations and recently introduced effort allocation schemes (kW*day) have reduced opportunities for directed whitefish fishing. STECF 2010 stated that the overall effort (kW*days) by demersal trawls, seines and beam trawls shows a substantial reduction since 2002. However, there have also been substantial changes in the usage of the different mesh size categories by the demersal trawls. In particular there has been a sharp reduction in usage of gears with a mesh size of between 100 mm and 119 mm (targeting whitefish), but only a gradual decline in the effort of *Nephrops* vessels (TR2).

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops,* the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70-99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double.

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90 mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller that 100 mm in the North Sea south of 57°30'N.

Official catch statistics for Subarea IV are presented in Table 3.3.1. The preliminary officially reported landings in 2013 are around 10,500 tonnes, representing a decline of over 50% from the peak observed in 2009 (24,500t). The decline has been almost entirely from within the UK which typically represents 80% of the landings. Overall quota uptake for 2013 was 62%.

Table 3.1.2 shows landings by FU as reported to the WG. It also shows that a small but significant proportion of the landings from Subarea IV come from outside the defined

Nephrops FUs. This value increased to nearly 10 % of the total in 2009 and as a response, a new Functional Unit at the Devil's Hole (FU 34) was designated in 2011. The trends observed in the 2012 Fishers' North Sea stock survey for *Nephrops* are discussed in the Quality of Assessment sections for each FU but there was no update to this survey in 2013.

Botney Gut (FU5)

4.2.1 The fishery in 2011 and 2012.

Over the last 15 years the national composition of the fleet fishing this FU has changed with Belgium reducing its landings and the UK increasing. In 2012 the UK and Netherlands continued to dominate the fishery taking ~80% of the landings from this area whilst in 2013 the UK landings were significantly reduced. There was no reported fishery by Danish vessels in 2012 for the first time since 1994 and activity in 2013 was minimal (1 tonne).

Nephrops in FU5 are caught by trawling, there is no creeling in the area.

4.2.2 Data Available

Landings

Landings by country for FU 5, including Belgium, Denmark, Netherlands, Germany and UK are available since 1991 (Table 4.3.1). Landings increased from ~800t in the early 1990s to ~1200t in the early 2000s, peaking at ~1400t in 2001. There then followed a period of general decline to a low in 2009 but landings have subsequently recovered and in 2013 were 1050t, around the 10 year average. Between 1991 and 1995, the Belgian fleet took more than 75% of the international *Nephrops* landings from this FU, but since then, the Belgian landings have declined drastically, and since 2006 there has been no directed Belgian *Nephrops* fishery by Belgian operated vessels. Some Belgian owned vessels operating as Dutch vessels have a directed fishery and trebled the landings between 2009 and 2013. Danish landings have been at very low levels in recent years with effectively a cessation of operations from 2012. In the most recent years UK and Netherlands have accounted for most of the landings from this FU.

No discard data are provided for FU5, although the Dutch discards self-sampling programme does collect data in this FU. It was hoped that these data would have been available for the 2013 and 2014 assessments but unfortunately were not. Discard data were available for the Belgian *Nephrops* fleet for the period 2002 – 2005 but in the absence of a directed fishery since 2006, there have been no data collection from the Belgian *Nephrops* landings.

Length compositions

Length compositions in the Dutch landings are available from 2003 to 2012 (Figure 4.3.1). Data for 2013 were not considered of sufficient quality for inclusion due to a large SOP error (SOP=sum of products, the sum of number landed at length * weight at length should be close to the total landing biomass) . Both mean sizes of males and females show an increasing trend over time (Table 4.3.2), although the intensity of sampling is fairly low in FU 5 and as a result samples may not be fully representative of actual removals. From 2005 to 2009 the average numbers measured are >10000 individuals a year, while between 2010 and 2012 the sampling measurements dropped to around 2500-3000 individuals. Sampling intensity in 2011 and 2012 was particularly low in the third quarter which is the main period of the fishery.

4.2.3 Natural mortality, maturity at age and other biological parameters

No analytical assessment has been performed this year.

In previous analytical assessments (see e.g. WGNEPH, 2003), natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females. Discard survival was assumed to be 0.25 for both males and females (after Gueguen & Charuau, 1975, and Redant & Polet, 1994).

Growth parameters are as follows:

Males: $L\infty$ = 62mm CL, k = 0.165.

Immature females: $L\infty$ = 62mm CL, k = 0.165.

Mature females: $L\infty$ = 60mm CL, k = 0.080, Size at 50% maturity = 27mm CL.

Growth parameters have been assumed to be similar to those of Scottish *Nephrops* stocks with similar overall size distributions of the landings (see e.g. WGNEPH, 2003). Female size at 50% maturity was taken from Redant (1994).

4.2.4 Commercial catch-effort data and research vessel surveys

Effort and LPUE Figures are available for Belgian directed fisheries from 1997, the Dutch fleet (all vessels catching *Nephrops*) since 2000, Danish bottom trawlers with mesh size > 70 mm (since 1996) and English vessels using *Nephrops* gears since 2000, Table 4.3.3 and Figure 4.3.2.

The effort of the Belgian *Nephrops* fleet decreased between 1997 and 2005 after which it has fluctuated without trend.

The effort of the Dutch fleet (all trips recording catches of *Nephrops*) peaked in 2001 and has been in general decline since then.

anish effort has been negligible since 2007 and there was no activity at all by Danish vessels in 2012 and only one vessel operating in 2013. The spikes in LPUE for Danish vessels in 2008 may reflect either some misreporting or sudden increasing efficiency due to the FKA agreement for fishing industry described in Section 3.2.1.2. The sharp spike in LPUE for 2011 remains unexplained.

ffort by English vessels targeting *Nephrops* (targeting being classed as trips where *Nephrops* comprise >=25% of landings by biomass) in FU5 is variable being at a high level between 2005-2009 but has since declined to a low level. Since 2008, a few (1-3) vessels towing quad-trawls have been present in the fleet taking between 11% and 43% of the landings. Changes to the composition of the English fleet in terms of both numbers of vessels and the gear they deploy means that the LPUE series is considered unreliable as an index of abundance. LPUE (Kg per hr fishing) of English vessels is high compared to Belgian vessels in the past (table 4.3.3) and is considerably higher than observed in FU6. Twin-rigged vessels generally have higher LPUE than single rigged vessels, particularly in 2010. (Figure 4.3.3)

4.2.5 TV Survey in FU5 (Botney Gut / Silver Pit):

There were no new surveys in this FU since the last assessment in 2013. Details of the 2010 and 2012 surveys are given in the WGNSSK report from 2013.

Intercatch

FU5 data were available from Intercatch for all nationalities for 2011, 2012 and 2013. Quarterly landings by metier were available for all countries fishing the functional unit. Length composition data were not available for 2013 as the sample rate was considered insufficient to raise the distributions.

4.2.6 Status of stock

The status of this stock is uncertain although there are no consistent signals that this stock is suffering from over-exploitation. The lack of reliable of length information on this stock in recent years means that there is no information regarding incoming recruitment and the selectivity of the Dutch fleet is such that even with better sampling levels, a recruitment signal is unlikely to be obtained through commercial data. There is considerable contradiction in the LPUE signals over the past 10 years and changes in the fleet compositions make them too unreliable as indicators of stock abundance.

Following the procedure outlined in section 3.1.2, an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in this functional unit. The discard rate of 25% was taken from FU6, the mean landing weight from the Dutch landings sampling programme and the mean discard landing weight from FU7. The 2012 survey shows that density is relatively high on this ground at 0.7 burrows per metre squared. 10 year average landings of 1043 at this density equates to a harvest rate of around 2.5%, which is well below any proxy for Fmsy used on other grounds. There is considerable uncertainty in the initial TV estimate, but the table below shows that even if the density were over-estimated by a factor of 2, the harvest rate would still be below 10% at the level of average landings.

	FU5 : Botney Gut					1,850	Area (km2)	45	land wt		25%	percentage discards
								15	disc wt			
				Density								
Basis	Catch	**landings**	**discards**	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	579	521.5	58	16.7%	8.4%	4.2%	2.8%	2.1%	1.7%	1.4%	1.2%	1.0%
Average	1159	1043	116	33.4%	16.7%	8.4%	5.6%	4.2%	3.3%	2.8%	2.4%	2.1%
Maximum	1600	1440	160	46.1%	23.1%	11.5%	7.7%	5.8%	4.6%	3.8%	3.3%	2.9%
											Latest TV survey * preliminary	

	FU5 : Botney Gut			1,850	Area (km2)	45	mean weight (g)			25%	percentage discards
		Density									
Basis	**landings**	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	
0.5 * Average	545	17.5%	8.7%	4.4%	2.9%	2.2%	1.7%	1.5%	1.2%	1.1%	
Average	1090	34.9%	17.5%	8.7%	5.8%	4.4%	3.5%	2.9%	2.5%	2.2%	
Maximum	1440	46.1%	23.1%	11.5%	7.7%	5.8%	4.6%	3.8%	3.3%	2.9%	
									Latest TV survey * preliminary		

4.2.7 Management considerations for FU 5.

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock, considering the recent trend in LPUE and technological creep of the gear, the exploitation of this stock should monitored closely.

4.3 Farn Deeps (FU6)

4.3.1 Fishery in 2012 & 2013

ince the beginning of the time-series, the UK fleet has accounted for virtually all landings from the Farn Deeps (Table 4.4.1). Landings increased from 2460t in 2012 to 2982 in 2013, the highest value since 2006. (Figure 4.4.1). The introduction of the buyers and sellers legislation in 2006 means direct comparison with previous years should be viewed with caution because the suspected resulting improvement in reporting levels will have created a discontinuity in the data. Directed effort (i.e. days fishing by vessels fishing with *Nephrops* gears) in 2013 rose slightly from the 2012 level and has generally fluctuated without trend since the late 1990s (although again the change in legislation in 2006 complicates the interpretation of any trends). Effort trends in terms of KW hours are further complicated by changes in the gears used, particularly the use of multi-rig fishing gears which generally have a higher fishing power. The proportion of landings by single rig gears fell between 2004 and 2009 but rose again in 2013. Multi-rigged gears (triple and quad) are only used occasionally on this ground and none were recorded in 2013 (Figure 4.4.2). Note that due to a review of the effort data, the series presented in this report is substantially different to the previous Figures. It transpires that the Figures given in previous reports were for all functional units rather than being specific to FU6.

Historically the fishery has been prosecuted by a combination of local English boats (smaller vessels undertaking day-trips) and larger vessels from Scotland with occasional influxes of effort by Northern Irish vessels. The total number of vessels in the fishery had been decreasing since 2007 but has increased in 2012 and 2013 (Figure 4.4.3). Much of this increase comes from larger Scottish boats, likely to be a response of vessels moving away from reduced catch rates in FU7s.

The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2013 data comprise the end of the 2012-2013 fishery and the start of the 2013-2014 fishery. The quarterly patterns of directed effort by English vessels (Figure 4.4.7) was less skewed in 2013 due to a lower proportion of effort in the first quarter.

4.3.2 ICES Advice in 2013

The last assessment of *Nephrops* in FU6 was in 2013.

The basis for advice in 2013 was the "Transition to an **MSY approach** with caution at low stock size". This corresponded to landings of less than 1026 t .

ICES also advised "*To protect the stock in this Functional Unit, management should be implemented at the Functional Unit level*".

The transition was required because the stock was assessed to be below the proxy for MSY $B_{trigger}$.

Management is at the ICES Subarea level as described at the beginning of Section 3.3.

4.3.3 Assessment

Review of the 2013 assessment

"There was no review of the 2013 assessment.

Data available

Catch, effort and research vessel data

Three types of sampling occur on this stock, landings sampling, catch sampling and discard sampling providing information on size distribution and sex ratio. The sampling intensity is considered to be generally good although concerns regarding the sampling levels of tail (as opposed to whole) landings has resulted in the catch and landings distributions being estimated from the monthly catch samples, supplemented by the discard sampling. The use of landings sampling where the tailed portion of the catch is under-represented would upwardly bias the estimate of landing lengths.

Discards

The procedure used to estimate discards changed in 2002. The methods are described in detail in the Stock Annex. Discarding practice varies considerably between vessels in any given period but there is no significant trend in the computed discard ogives (Figure 4.4.4) hence the use of a fixed discard ogive on the catch length distributions since 2002. The Benchmark meeting in 2013 concluded that the historical assumption of 0% discard survival was no longer applicable as a significant proportion of catch sorting now takes place at sea. For day-boats, the first haul of the day will generally be sorted on the fishing grounds whilst the second haul will be sorted whilst steaming back to port (and therefore passing over habitat unsuitable for Nephrops. Discarding practice for multi-day boats will generally result in discards returning to suitable sediment. The conclusion was therefore that although the full 25% survival assumed in other FUs was not likely to be applicable a 15% survival rate was a reasonable estimate for this FU.

There is a clear change in length frequencies around 2007 with much lower contributions from the smaller (discarded) size classes (Figure 4.4.7). This may reflect an improvement in selectivity by the fleet or alternatively a decrease in recruitment levels. There is a decrease in the overall level of TV survey around the same time indicating that this change in length distribution may at least partly reflect a reduction in the level of recruitment.

A bi-modal length frequency distribution for landed females has been present since 2009 and becomes more pronounced. This could be the result of a large year class, but a similar phenomenon is not observed in the male part of the population, in fact the mean size in the males decreased in 2012 and 2013. The mean annual increment of the female second mode is only around 2mm whereas interannual growth would be expected to be more and therefore year class strength is unlikely to be the cause of this feature. Females have been the dominant portion of the catches during since the first quarter of 2012 (Figure 4.4.5). The predominance of large females in the catches means they were foraging for food on the surface at a time when they would have been expected to be brooding eggs within their burrows. There is therefore considerable concern that this stock is likely to be suffering from reduced recruitment and will continue to do so for at least the next two years (assuming that recruits enter the fishery between age 2 and 3).

Effort and LPUE

Directed effort fell from a very high level in the mid 1990s to a low point in 1999 from which it generally increased until 2006. Directed effort has fluctuated without trend between 2008-2012. (Figure 4.4.7)

Between 1998 and 2006, overall directed LPUE had fluctuated around 33kg per hour but fell in 2007 and has since fluctuated around a mean of 23kg per hour. (Table 4.4.2 & Figure 4.4.1). This apparent change in LPUE coincides with the introduction of the

buyers and sellers legislation in 2006 and is not considered a reliable indicator of a dramatic decrease in stock abundance. LPUE since 2007 is considered more reliably reported but the time series is too short and variable to be informative. LPUE differs markedly between gear types (Figure 4.4.6) with the multi-rigged gears typically outperforming the single rig gears by a factor of 2, but there is a reasonable degree of similarity in the interannual variability between the different gears. The direction of change in LPUE for 2013 varied by gear, with unspecified and single otter trawls increasing whilst twin trawls appear to decrease. The use of LPUE as an index of stock abundance for Nephrops is confounded by changes in availibility of Nephrops to fishing gears depending upon environemental factors such as tide and light levels, plus changes to emergence behaviour induced by mating and predator avoidance. There is a general level of agreement between LPUE for the different gears and a decline in stock abundance from around 2004 to 2009. The rise in LPUE for non-specified trawlers in 2012 and 2013 is more likely to reflect a change in targeting behaviour than an increase in stock abundnace.

Traditionally, males tend to predominate the landings, averaging about 70% (range 64%-79%) by biomass in the period 1992-2005. Towards the end of the fishing season (February-March) there is usually an increase in female availability as mature females emerge from their burrows having released their eggs. There has been a marked change in the seasonal pattern of sex-ratio for Farn Deeps *Nephrops* since the winter of 2005. Prior to this the ratios were generally smooth with small (~10%) seasonal fluctuations, but since then the fishery has observed very large swings, with whole years being dominated by landings of females (2006, 2010, 2012 and 2013, Figure 4.4.5)

irected effort is generally highest in the 1st and 4th quarter of the year in this fishery (Figure 4.4.7) with landings correspondingly highest in these quarters. Effort in 2013 was less skewed than normal with a relatively low level of effort in the first quarter. Female LPUE in the fourth quarters of 2000, 2006, 2009, 2001 and 2013 have been higher than one might expect given that they are supposed to have reduced availability due to egg-brooding.

Analysis of individual vessel records indicates an increase in directed *Nephrops* fishing since around 2000. Restrictions on both quota and effort for directed finfish fishing over the last eight years will have restricted the more casual effort on *Nephrops*. Further research is needed to better define directed fishing effort and thereby improve on this series.

UWTV

Underwater TV surveys of the Farn Deeps grounds have been conducted at least once in each year from 1996 onwards. Initially there were two surveys, one in the autumn preceding the fishery and one in the spring immediately after the fishery, however only the autumn survey has continued. In 2013 the UWTV survey of the Farn Deeps was carried out in June for operational reasons. The potential change in survey timing was presented to the Benchmark meeting in 2013 and a report of the discussions is contained within the report of that group (ICES 2013). The following points were considered.

- There is practically no targeted *Nephrops* fishing between May and September; therefore there is minimal scope for fishery induced changes in stock abundance between the new survey time and the previous October timing.
- There are no migrations of animals to consider, *Nephrops* are on (or rather in) the ground all year round. What affects their availability to the fishery is their emergence behaviour, which does not affect the ability to count the burrows.
- The only factor which may affect the burrow density between June and September is any seasonality in the creation of new burrow complexes by juveniles. There are no data regarding the timing of burrow creation with which to make an informed judgement as to whether this is likely to be an important effect.

The Benchmark group concluded therefore that the FU 6 TV series should continue to be regarded as a single series and that where possible work should be undertaken to investigate if the survey timing change was likely to have affected results.

A time series of indices is given in Figure 4.4.9 and table 4.4.5. The procedure used to work up the TV survey has been changed in 2011. The original survey design was a random-stratified design where the ground was split into regular boxes with stations randomly placed within. At a later stage additional stations were inserted into areas of high density to better define them, however this was not accounted for in the process of estimating overall abundance and therefore the higher density of stations in high-density *Nephrops* areas will have biased the estimate upwards. In addition, the distance covered by the TV sledge was determined by assuming a straight-line between the start and finish positions of the vessel. Since 2007, GPS logging of the position of the vessel and the sledge (via a Hi-Pap beacon) at short intervals (~5 seconds) has enabled a considerably more robust estimate of viewed distance to be made. The abundance estimate is now made using a geostatistical procedure in which the spatial position of the burrow density estimates are first fitted by a semi-variogram model and then a 3D surface of burrow density is created using Kriging on a 500m*500m grid. Uncertainty estimation of the overall abundance estimate is performed by bootstrapping the counts, re-fitting the semi-variogram and re-estimating the surface. Uncertainty estimates are typically 2%, much lower than the previous estimates which ignored spatial structure to a large degree. Figure 4.4.10 shows the final maps along with the abundance estimates. The TV survey in 2009 was hampered by a period of poor weather and low visibility which coincided with the surveying of the areas traditionally associated with the highest densities (fishing vessels were working this area at the time of survey and consequently disturbing the sediment). The spatial pattern of burrow density is similar through time with the highest density ground running along the eastern edge of the mud-patch.

Intercatch

All data for 2012 were entered onto Intercatch. Landings data by fleet were provided by Scotland, England and the Netherlands, whilst England provided length distributions for landings and discards by fleet where available.

Discard ratios for all unsampled fleets were raised on the combined annual data from England. Quarterly length distributions were imported for England which represetned 90% of the landings. Consequently, length frequencies for the remaining metiers were generated from the pooled data (i.e. irrespective of metier or quarter) for both landing and discard components.

Natural mortality, maturity at age and other biological parameters

iological parameter values are included in the Stock Annex which was updated at the 2013 benchmark.

Exploratory analyses of RV data

A comprehensive review of the use of underwater TV surveys for *Nephrops* stock assessment was undertaken by WKNeph (ICES 2009). This covered the range of potential biases resulting from factors including edge effects, species mis-identification, burrow occupancy. Cumulative bias-correction factors were estimated for each FU and for FU6 the bias correction factor is 1.2 meaning that the raw counts from the TV survey are likely to overestimate densities of *Nephrops* by 20%. The correction factor is therefore applied to the raw counts to arrive at the absolute abundance index. Estimates of absolute burrow density total abundance estimates (with confidence estimates) are given in Table 3.3.2.4.

Final Assessment

he estimated abundance in 2013 was 706 million individuals (95% confidence interval of ±18 million), significantly below the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2013 was 21.8%, nearly three times the MSY proxy level of 8.1%.

he stock therefore remains in a vulnerable state. The dominance of large females in the landings again for the 2012-2013 fishery suggests that they had not successfully mated and therefore there remains the potential for poor recruitment for 2014 and 2015 (recruits to the fishery are estimated to be ~ 2-3 years old)

4.3.4 Historical stock trends.

The time series of TV surveys is 13 consecutive years although the new geostatistical method has only been applied retrospectively to 2007. Whilst there is expected to have been a small over-estimation of abundance using the previous technique it is likely that the reduction in stock abundance observed between the two periods of estimation procedure is real.

Estimates of historical harvest ratio (the proportion of the stock which is removed) range from 6.1% to 25.5% (Table 4.4.5). The harvest ratio jumped from around 12% in 2004-2005 to 25.5% in 2006 when the new reporting legislation came in. The harvest rate has only been below the MSY level once in 12 years.

4.3.5 MSY considerations

Considerations for setting Harvest Ratios associated with proxies for F_{msy} for *Nephrops* are described in ICES, WGNSSK, 2010, section 1.

- Average density in the stock is at a medium level, above the level of the FU 7 but below that of FU 8.
- Density has varied through time but does not appear to undergo large scale interannual fluctuations. Spatially there is a good degree of consistency in the pattern of high and low density between the years.
- Estimated growth rates are at a moderate level although the data supporting them are quite old. Natural mortality estimates are standard.
- The fishery in the Farn Deeps is a winter fishery (October – March) with typically male dominated catches. The intra-annual pattern of sex ratios in the catches has changed in 2006 and 2009 possibly due to sperm limitation leading to more mature but unfertilised females being available to the fishery. This may lead to reduced recruitment to the fishery.
- Although the time series of observed harvest rates is relatively short, there has been a fair degree of fluctuation (7-25%). The observed harvest rate is, of course, confounded by the change in reporting levels considered to have occurred around 2006. The average harvest rate since 2006 is 15.7% which is above the most recent estimate of F_{max} for males.

The following table shows the mean F, implied harvest rate and resulting spawner per recruit values (expressed as a percentage of virgin) for the range of F_{msy} proxies suggested for *Nephrops* stocks. These values were last recalculated in 2013 using a length cohort analysis model (SCA, see ICES, WKNep 2009) on the combined length frequencies for 2010-2012. The model fit to the data (Figure 3.3.2.11) is reasonable but the increasing bi-modality of the length frequency observed in the females over the past 4 years does violate model assumptions and the model under-predicts the landings of larger females.

		Fbar 20–40mm		Harvest Rate	% Virgin Spawner per Recruit	
		Female	Male		Female	Male
F0.1	Comb	0.09	0.09	8.7%	47.52%	32.11%
F0.1	Female	0.16	0.16	14.0%	32.63%	18.26%
F0.1	Male	0.07	0.07	7.1%	53.02%	38.50%
F35%	Comb	0.12	0.12	11.1%	39.98%	24.50%
F35%	Female	0.17	0.17	15.2%	34.82%	16.64%
F35%	Male	0.16	0.16	8.1%	57.17%	34.88%
Fmax	Comb	0.17	0.17	15.3%	34.58%	16.48%
Fmax	Female	0.29	0.29	21.6%	22.22%	9.47%
Fmax	Male	0.12	0.12	11.6%	44.70%	23.73%

The default Harvest Rate suggested for *Nephrops* is the combined sex F35%SpR. The effects of sperm limitation appear to have been a factor in the recent development of this stock. There are signs that this stock may be in a period of lower productivity and so a harvest rate which gives greater protection to the spawning potential of males would be advisable. The group therefore recommends moving the F_{msy} proxy to the harvest rate equivalent to F35% on males for this stock (8.1%).

WGNSSK suggests the absolute abundance index from the TV survey as observed in 2007 (i.e. the first year when the stock was considered to be depleted in the recent series) should become a proxy for $B_{trigger}$ ($B_{trigger}$ = 858 million).

Short term forecasts.

Catch and landing predictions for 2015 are given in the text table below. This assumes that the absolute abundance estimate made in June 2013 is relevant to the stock status for 2015. Discard rates and mean weight in the landings are the mean of 2011-2013. The ICES MSY approach dictates that where the stock status is below the trigger point, the maximum advised fishing rate should be the MSY rate adjusted by the ratio of the current stock status to the Btrigger level. For 2015 this gives

$HR_{2015} = HR_{MSY}$ (8.12%) * Abundnace 2013 (706) / Btrigger (858) = 7.1%

The harvest rates show refer to the landings and dead discard components only. If the surviving discards were also to die at capture (e.g. under a landings obligation) then the inflicted harvest rate would be higher.

The provision of total catch advice is complicated by the fact that some discards go back live. The calculation of MSY-compliant harvest rates includes provision for these live discards, however a land-all policy would mean that all individuals will die. At present it is not possible to determine how fishers might change their fishing practices in response to a landings obligation, but if practices do not substantially change then it will be necessary to revise the MSY harvest rate to account for the shift to 100% mortality.

	Harvest ratio	Catch	Landings	Dead Discards	Surviving Discards
F0.1Male	7%	1175	1032	120	23
MSY_Approach	7%	1199	1053	123	23
F35%Male	16%	2686	2359	275	52
F0.1Comb	9%	1511	1327	155	29
	10%	1678	1474	172	33
F35%Comb	12%	2014	1769	206	39
FmaxMale	12%	2014	1769	206	39
F0.1Female	16%	2686	2359	275	52
F35%Female	17%	2853	2506	292	55
FmaxComb	17%	2853	2506	292	55
Fcurrent	16%	2766	2429	283	54
FmaxFemale	29%	4867	4275	498	94

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the male or combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in male or combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the male or combined YPR.

4.3.6 BRPs

Suggestions for proxies of biological reference points are shown in the catch option table.

4.3.7 Quality of assessment

Changes to the legislation regarding the reporting of catches in 2006 means that the levels of reported landings from this point forward are considered to better reflect the true landings and hence effort input into this fishery. This does mean that comparison of LPUE with previous years is inadvisable and the independence of the final assessment from these data is likely to continue for some time.

The length and sex compositions arising from the land-based catch sampling programme are considered to be representative of the fishery. Estimates of discarded and retained length frequencies arising from the discard sampling programme are also considered robust since 2002.

The TV survey in this area has a high density of survey stations compared to other TV surveys and the abundance estimates are generally considered robust. There is greater uncertainty in the index for 2009 due to the absence of stations in the higher density areas which may result in an over-estimate of the magnitude of the decline for this year.

The spatial distribution of the 2013 survey results continues the pattern observed in other years, although at a lower overall level. The spine of high density on the western edge of the ground remains a regular feature. The main features of the survey series are peaks in abundance 2001 and 2005, with reasonably constant series since 2007.

The only harvest rate observed to be below the MSY level was in 2008, the mean harvest rate of 15.2% is almost double the MSY level.

The most recent North Sea Stock Survey was carried out in 2012 and the following paragraph relates to comparisons between the North Sea Stock Survey and the 2013 assessment of FU6 Nephrops. The NSSS area which relates to this Functional Unit is area 4. Comparing this survey to the 2010 survey shows strong consistency in the impression of stock size and abundance. Interestingly there appears to be a split in the industry in both years in relation to abundance in both years, with part saying "less", part saying "more" but very few saying "same" and this pattern appears to be unique to area 4. The perception of the fishery being composed of "all sizes" is captured by the sampling data showing a broadening range of sizes. There is some consistency between the overall abundance track and the scientific survey in that the Stock Survey trajectory for area 4 is considerably flatter than in other areas (contrasting well with the scientific perception that the Farn Deeps stock has declined and is relatively stable. Overall participation in the survey dropped for *Nephrops* with 46 respondents in 2012 compared to 74 in 2011.

Without suitable controls on the movement of effort between Functional Units there is nothing to prevent the effort in 2012 continuing to inflict fishing mortality above the F35%SprR level and indeed above the level of F_{max}. Prior to the introduction of “Buyers and Sellers” legislation in 2006 reporting rates are considered to have been low and hence the estimated Harvest Ratios prior to 2006 are also likely to have been underestimated.

4.3.8 Status of stock

The 2013 TV survey indicates the stock continues to be in a depleted state, below the level of MSY $B_{trigger}$ with harvest rates well in excess of the MSY advised rate. There are no indications of strong recruitments coming into the stock and the continued increase in large females appearing in the catches suggests that the situation may continue to deteriorate.

4.3.9 Management considerations

The WG, ACFM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level and management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Decreases in abundance in other FUs (i.e. Firth of Forth and the Fladen grounds) may raise the risk of higher effort being deployed in this FU. The high cost of fuel combined with the relative coastal proximity of this ground makes fishing this Functional Unit a relatively attractive proposition and additional fishing effort would be inadvisable given the current low level of the stock.

4.4 Fladen Ground (FU7)

4.4.1 Ecosystem aspects

The Fladen Ground (Functional Unit 7) is located towards the centre of the Northern North Sea off the east coast of Scotland (Figure 3.1.1.). This region is characterised by an extensive area of mud and muddy sand, and hydrographic conditions include a large scale seasonal gyre which develops in the late spring over a dome of colder water.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Within the Fladen Ground FU these substrates are distributed more or less continuously over a very large area (approx. 30000km^2). Figure 4.5.5 shows the distribution of sediment in the area. Sandy mud and muddy sand are the dominant sediment types, with patches of mud in the south west area of the FU. Numerous fish species occur in in the same area as *Nephrops* with demersal fish more prevalent in the northern area. In the softest areas of mud, *Pandalus borealis* is also found.

4.4.1.1 The Fishery in 2012 and 2013

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (2946 tonnes in 2013), with England taking 8 tonnes and Denmark only 5 tonnes (Table 4.5.1).

In 2012-2013, over 100 vessels participated in the Fladen fishery at various times throughout the year. Catch consisted of *Nephrops*, haddock, whiting, cod, anglerfish and megrim. The majority of these (approximately 70%) are Scottish vessels fishing out of and landing to Fraserburgh. A number of vessels have installed freezer capabilities to enable longer trips, but the average trip is ~ seven days. The fishery is seasonal and the fleet nomadic, moving between Fladen, Moray Firth, Firth of Forth and Farn Deeps according with the time of the year and catch rates. The majority of vessels typically use 80/90 mm mesh although recently (due to pressures in gear sizes) some have switched to 100 mm mesh, as they can target both *Nephrops* and fish.

Fishing has been extremely poor in 2012 and 2013. As a result, in 2012 many vessels moved to the west coast of Scotland to fish the North Minch. This had serious implications on the effort allocations for the North Minch and led to the Scottish Government intervening with measures in order to prevent the premature closure of the fishery. In 2013 the number of boats targeting *Nephrops* in the west coast of Scotland was reduced significantly as the days at sea allocation was based on activity between 2009-11 and therefore adjusted the opportunity available to North Sea vessels significantly.

In the first half of 2013 the Scottish boats working at Fladen struggled to catch sufficient *Nephrops* during their trips to make the fishery viable. This resulted in landings over this period being dramatically less than has been experienced in recent years. Normally the fishery recovers in the spring but in 2013 this did not happen until later into the summer/autumn. Vessels explored wide areas of the Fladen grounds but found the situation to be quite widespread. When catches were recorded, the catch rates were relatively high but for the fleet as a whole and shellfish processors the low volumes of *Nephrops* landed were a problem. The situation became so difficult that a hardship fund was set up by Government to assist vessels and a further response by many boats was to seek work as support vessels in the oil industry or to turn to targeting whitefish. In response to the poor fishery in Fladen, several vessels moved again in 2013 to other areas in the North Sea where catches were reported to be better such as the Farn Deeps (FU 6), Firth of Forth (FU 8) and Moray Firth (FU 10).

4.4.2 ICES advice in 2013

The last assessment of *Nephrops* in FU7 was in 2013.

"*ICES advises on the basis of the MSY approach that landings in 2014 should be no more than 8959 tonnes. If total discard rates do not change from the average of the last 3 years (2010–2012), this implies total catches of no more than 9059 tonnes. Note that this Figure includes discards expected to survive the discarding process – assumed to be 25% of the total number discarded for this stock.*

In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level. Should the catch in this FU be lower that advised, the difference should not be transferred to other FUs.".

4.4.3 Management

Total Allowable Catch (TAC) management is at the ICES Subarea level. Most *Nephrops* vessels operate TR2 gear (>=70 and <100mm) and are subject to the effort regulations of the cod recovery plan. In Scotland the Conservation Credits scheme is in operation and various technical measures apply to *Nephrops* vessels (as described in section 3.4).

4.4.4 Assessment

Comments from the audit report reviewers of the 2013 assessment

The assessment report and advice was well written, and fully documented. To be consistent with the numbering defined in the draft section, this section should be labelled 4.x. Section 04 being Nephrops in Subarea IV. It was easy to follow and interpret. Tables and Figures are adequately referred in the text but must be relabeled based on the new section of Nephrops IV

The strong increasing trend in mean weight-at-age needs attention, as it is important information on the population dynamics and ecological conditions of the stock. This strong increase in mean weight-at-age and decreasing in LPUE of the Scottish fleet are in line with the TV abundance estimated from the survey and the decline of the stock since 2008. The possible causal mechanisms including reduced recruitment are well covered in the report. Possible reduction in recruitment is mentioned in the draft "supporting information" of the advice as a cause for large mean size, but should also be pointed out as a plausible cause for the observed reduction in LPUE.

The methodology for computing the TAC for landing all policy should be described in the report (or stock annex). We could not find it and the numbers are not directly understandable from the tables.

The review group concluded that the assessment had been performed correctly."

Approach in 2014

The assessment of *Nephrops* in 2014 is based on examining trends in the UWTV survey data (1992-2013) and utilising an extensive series of commercial fishery data and follows the process defined by the benchmark WG 2009. The assessment approach is further described in the stock annex.

The provision of advice in 2014 followed the process of 2013, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{msy} for *Nephrops* are described in the WGNSSK 2010 report.

4.4.5 Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with small contributions from Denmark and England, and are presented in Table 4.5.1 and Figure 4.5.1. Total international landings (as reported to the WG) in 2013 were 2959 tonnes (over 1400 tonnes lower than the 2012 total), consisting mostly of Scottish landings with only 13 tonnes landed by other countries.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas, particularly Fladen. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to 2013 and only annual summaries are available.

Trends in Scottish effort and LPUE are shown in Figure 4.5.1 and Table 4.5.2. Effort has been relatively stable from 2002 to 2010 but fell in the last three years because of poor fishing and part the fleet relocating to the west coast of Scotland, mostly in the first half of 2012. LPUE has gradually increased since 2000 to a peak of over 620 kg/day in 2009. It has fallen since then until 2012 remaining approximately the same in 2013. Danish LPUE data are presented in Table 4.5.3. Effort has decreased over the time series (1991-2013) whilst LPUE has gradually increased to a high in 2009 followed by a decrease in the last four years.

Males consistently make the largest contribution to the landings and this was the same in 2013 (Figure 4.5.2). This is likely to be due to the varying seasonal pattern in the fishery and associated relative catchability (due to different burrow emergence behaviour) of male and female *Nephrops*. This is confirmed by the quarterly landings as shown in Figure 4.5.2. In 2012 and 2013 the landings were much lower in the second and third quarters of the year, periods when females would be expected to be more available for capture.

Discarding of undersized and unwanted *Nephrops* has occurred in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 2000. The discarding rate average (2000-2013) is approximately 9% by number in this FU. In the last six years discard rates have dropped below the long term average and in 2011-2013 no discards were recorded in the observer trips conducted. This reduced discard rate appears to be due to a change in the discard pattern with greater numbers of small individuals being retained and could also signal reduced recruitment and a tendency towards the use of larger mesh gears (see below on length compositions).

It is likely that some *Nephrops* survive the discarding process. An estimate of 25 % survival is assumed for this FU in order to calculate removals (landings + dead discards) from the population.

Intercatch

Scottish data for 2013 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2014 WG and output length compositions were obtained in formats suitable for running the assessment.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch data analysis are not presently possible for this species, examination of length compositions can provide a preliminary indication of exploitation effects.

Figure 4.5.3 shows a series of annual length frequency distributions for the period 2000 to 2013. Catch (removals) length compositions are shown for each sex with the mean catch and landings lengths shown in relation to MLS (25 mm) and 35 mm. In both sexes the mean sizes have been generally stable over time except for the last three years where a noticeable shift in the length distribution and an increase in the mean size has been observed in both males and females.

Figure 4.5.1 and Table 4.5.4 show the series of mean sizes of larger *Nephrops* (>35 mm) in the landings. This parameter might be expected to reduce in size if overexploitation were taking place but there is no evidence of this. The mean size of smaller animals (<35 mm) in the catch is also fairly stable through time until 2010 when an increase is noticeable which may be associated with lower recruitments. In 2011-2013 the landings mean size increased but discarding stopped, this may signal a period of reduced recruitment but could possibly reflect the increasing use of more selective gears. Quantitative information on trends in gear changes is not currently available. A further difficulty in the interpretation of these size observations is that the ground extends over a wide area and the distributional pattern of fleet activity is known to vary over time. This may lead to exploitation of sub-areas within the ground, where size compositions may be slightly different.

Mean weights in the landings through time (1990-2013) are shown in Figure 4.5.4 and Table 4.5.5. The variability in mean size is greater in Fladen (and Devil's Hole) than in other areas. In 2011 the mean weight increased and 2012 is the highest value in the time series for Fladen. The mean weight in landings for 2013 was 34.9 g.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

Underwater TV (UWTV) surveys using a stratified random design are available for FU 7 since 1992 (missing survey in 1996). UWTV surveys of *Nephrops* burrow density and distribution reduces the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 4.5.6. On average, approximately 65 stations have been considered valid each year (71 stations in 2013). Data are raised to a stock area of 28153 km^2 based on the stratification (by sediment type). General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in more detail in the Stock Annex.

Previous review groups have noted that the UWTV survey did not cover the stock distribution. The survey stations are randomly distributed within strata and therefore the actual location of the survey stations varies from year to year and in some years, particular regions of the main part of the ground may not be surveyed. There is an additional small patch of mud to the north of the ground which it is not possible to survey (due to time constraints and distance to survey ground) and therefore the estimated absolute abundance is likely to be slightly underestimated by the UWTV survey.

4.4.6 Data analyses

Exploratory analyses of survey data

Table 4.5.7 shows the basic analysis (corrected to absolute values) for the three most recent UWTV surveys conducted in FU 7. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground has a range of mud types from soft silty clays to coarser sandy muds (<40% silt and clay) and the latter predominates. Most of the variance in the survey is associated with the coarse sediment which surrounds the main centres of abundance.

Figure 4.5.5 shows the distribution of stations in recent UWTV surveys (2008-2013), with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground. Table 4.5.6 and Figure 4.5.6 show the time series estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates.

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009). A number of potential biases were highlighted including those due to edge effects, species burrow mis-identification and burrow occupancy. The cumulative bias correction factor estimated for FU7 was 1.35 meaning that the raw UWTV survey is likely to overestimate *Nephrops* abundance by 35 %. In order to convert the raw UWTV survey abundance to an absolute abundance the raw data are divided by 1.35.

Final assessment

The UWTV survey is again presented as the best available information on the Fladen *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey and it therefore only provides information on abundance over the area of the survey.

The 2013 UWTV survey data shows that the abundance is still at a low level although it has increased 5% from the 2012 estimate and is now above the biomass trigger.

Historical Stock trends

The UWTV survey estimates of abundance for *Nephrops* in the Fladen suggest that the population has fluctuated over the 20 year period of the surveys. From 1997 to 2008 the abundance has generally increased and reached a peak of 7360 million individuals in 2008. Since 2008 the abundance has fallen and the absolute abundance in 2013 is estimated to be 2902 million individuals (Table 4.5.8).

Table 4.5.8 also shows the estimated harvest ratios from 2003-2013. These range from 4-10% over this period and are all below $F_{0.1}$. It is unlikely that prior to 2006, the estimated harvest ratios are representative of actual harvest ratios due to under-reporting of landings.

In addition to the discard rate, Table 4.5.8 shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.4.7 Recruitment estimates

Recruitment estimates from surveys are not available for this FU. However, the increase in mean size of small animals <35 mm (i.e. a lower proportion of small animals in this component of the catch) observed in recent years may be indicative of lower recent recruitment.

4.4.8 MSY considerations

A number of potential F_{msy} proxies were obtained from the per-recruit analysis for *Nephrops* as documented in the WGNSSK 2010 report. The analysis was updated in 2011 using 2008-10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery and since previous estimates were derived several years before. An update was not performed this year. The complete range of the per-recruit F_{msy} proxies is given in the table below and the process for choosing an appropriate F_{msy} proxy is described in WGNSSK 2010 report.

		Fbar(20–40 mm)			SPR (%)		
WGNSSK 2011		M	F	HR (%)	M	F	T
F0.1	M	0.14	0.09	9.5	40.3	47.6	43.3
	F	0.19	0.12	12.1	32.6	40.0	35.7
	T	0.16	0.10	10.3	37.8	45.2	40.9
Fmax	M	0.28	0.18	16.2	23.6	30.8	26.5
	F	0.49	0.32	24.1	13.5	19.5	16.0
	T	0.33	0.21	18.5	20.0	26.9	22.8
F35%SpR	M	0.18	0.11	11.4	34.5	41.9	37.6
	F	0.24	0.15	14.4	27.1	34.5	30.1
	T	0.20	0.13	12.4	31.7	39.1	34.8

* M = males, F = females , T = combined

The reduction in discard rate results in $F_{0.1}$ and F_{max} occurring at a higher level of fishing mortality and higher harvest rate in the new analysis (maximising yield-per-recruit NOT catch). See the stock annex for previously estimated values used at WGNSSK 201). The small reduction in $F_{35\%SpR}$ harvest rates appears to be the result of a small change in the estimated selection pattern.

For this FU, the absolute density observed on the UWTV survey is low (average of just over 0.2 m^{-2}) suggesting the stock may have low productivity. In addition, the expansion of the fishery in this area is a relatively recent phenomenon and as a result the population has not been well-studied and biological parameters are considered particularly uncertain. Furthermore, historical harvest ratios in this FU have been below that equivalent to fishing at $F_{0.1}$. For these reasons, it is suggested that a more conservative proxy is chosen for F_{msy} such as $F_{0.1(T)}$.

The F_{msy} proxy harvest ratio is 10.3 %

The $B_{trigger}$ point for this FU (lowest observed absolute UWTV abundance, 1992-2010) is calculated as 2767 million individuals.

4.4.9 Short-term forecasts

A landings prediction for 2015 was made for the Fladen Ground (FU7) using the approach agreed at the Benchmark Workshop in 2009 and outlined in the introductory section of the 2010 WGNSSK report. The table below shows landings predictions at various harvest ratios, including a selection of those equivalents to the per-recruit reference points and the harvest ratio in 2013. The landings prediction is calculated following the procedure outlined in the stock annex (section: short term projections). Recently, to account for the future implementation of the land all policy, the projected amount of discards has been added to the catch options table. The discard component is split between discards expecting to die and those surviving (assumed to be 25%). Discards (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings under a landings obligation (Total Catches = Landings + Dead Discards + Surviving Discards). Given that the discard rate for Fladen in 2011-2013 is 0%, the projected landings and catches are estimated the same for 2015. The landings prediction for 2015 at the F_{msy} proxy harvest ratio is 10759 tonnes.

The inputs to the landings forecast were as follows:

Survey abundance (2013) = 2902 million

Mean weight in landings (2011-2013) = 35.99 g

Dead discard rate (by number) = 0% (average 2011-2013)

Absolute correction factor = 1.35.

$F_{(2011\text{-}2013)}$ = Average F2011-2013= 4.7 %

Harvest ratio F_{2013} = **3.1 %**

Basis	Total Catches*	Landings	Dead Discards**	Surviving Discards**	Harvest Rate
	L+DD+SD	L	DD	SD	for L+DD
MSY approach	10759	10759	0	0	10.3
F2013	3238	3238	0	0	3.1
F2011-2013	4909	4909	0	0	4.7
F35SpR	12952	12952	0	0	12.4
FMAX	19324	19324	0	0	18.5

Weights in tonnes

*** Total catches are the landings including dead and surviving discards.**

**** Discards were estimated to be zero in 2011-2013.**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

4.4.10 Biological Reference points

Biological reference points have not been defined for this stock.

4.4.11 Quality of assessment

The TV surveys results show that the abundance has fallen in recent years, but not to the extent that would cause such a loss of fishing opportunity as observed especially in 2013. It is necessary to consider the biology of *Nephrops* (and indeed other crustaceans using cryptic, or burrow orientated behaviours) that are only available to trawling when they emerge from burrows. One explanation for the low emergence in 2013 (and to some extent in 2012) is that bottom temperatures appear to have been unusually low and for longer. Other environmental variables such as light levels, strength of tides are also known to exert an effect in the emergency behaviour of *Nephrops*. The recent low landings in Fladen may be the result of a complex interplay of factors combined with reduced average densities in the population as confirmed by the recent TV survey results.

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 2000, and is considered to represent the fishery adequately.

The quality of landings (and catch) data is likely to have improved in recent years following the implementation of 'the registration of buyers and sellers' legislation in the UK in 2006, but because of concerns over the accuracy of earlier years, the final assessment adopted is independent of official statistics.

Underwater TV surveys have been conducted for this stock since 1992, with a continuous annual series available since 1997. The number of valid stations in the survey has remained relatively stable throughout the time period. Confidence intervals are relatively small.

The UWTV survey is conducted over the main part of the ground, representing an area of around 28 200 km^2 of suitable mud substrate (the largest ground in Europe). The Fladen Functional Unit contains several patches of mud to the north of the ground which are fished, bringing the overall area of substrate to 30 633 km^2. This area is not surveyed but would add to the abundance estimate. The absolute abundance estimate for this ground is therefore likely to be underestimated by the current methodology.

The Fishers' North Sea stock survey suggests that moderate or high amounts of recruits were apparent in Area 1 (which Fladen FU lies largely within) in 2011 compared to 2009. The time series of perceived abundance in Area 1 increases up to 2011. Opinion on discards appears to be split fairly evenly between lower, higher and no change. There are no Fishers' North Sea survey data available for 2013.

Status of the stock

The 2013 UWTV survey data presented at this meeting show that abundance has increased 5% from last year and is now just above the biomass trigger abundance value. The stable mean sizes in the length compositions of catches (of individuals >35mm CL) over a long period of time suggests that the stock is being exploited sustainably. The increase in mean length of smaller individuals in the catch in recent years may be indicative of lower recruitment. The estimated harvest ratio in 2013 (removals/UWTV abundance) was 3.1% and is considerable lower than Fmsy.

4.4.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level and management at the Functional Unit level could provide controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Nephrops fisheries have a bycatch of cod. In 2005, high abundance of 0 group cod was recorded in Scottish surveys near to this ground. This year class of cod has subsequently contributed to slightly improved cod stock biomass and efforts are being made to avoid the capture of cod so that the stock can build further. The Scottish industry operates under the Conservation Credits Scheme and is implementing improved selectivity measures in gears which target *Nephrops* and real time closures with a view to reducing unwanted by-catch of cod and other species.

4.5 Firth of Forth (FU 8)

4.5.1 Ecosystem aspects

The Firth of Forth Functional Unit 8 is located in the south-west of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 3.1.1.). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to seaward, narrowing towards the coast with river basins draining into the area. Sandy mud and muddy sand deposits are widespread throughout the area covering an area of 915 km^2, the coarsest muds being found offshore beyond the May Island.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 4.6.4 shows the distribution of sediment in the area. There is some evidence of *Nephrops* larval drift from grounds to the south of the area but most larvae appear to be produced locally and the population is characterised by high density and generally small size. Although this area was historically important for fish catches, this area has now declined and *Nephrops* is the main commercial species. The recruits of numerous demersal fish species occasionally aggregate in the area and small pelagics (sprat and juvenile herring) are seasonally abundant. Important seabird colonies occur in the area and the 'Wee Bankie' gravel area, important for sandeels is located further offshore to the north and east of the Firth.

4.5.2 The Fishery in 2012 and 2013

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 4.6.1). In 2012 around 30 vessels worked regularly in the Firth of Forth and there were no vessel changes in 2013. Most vessels are under 12m in length with about 10 in 12-15m category and a few above 15m. The overall number of boats operating varies seasonally as vessels move around the UK in response to varying catch rates. Days at sea regulations affect opportunities for

diversification. In 2012 and 2013 rather more large boats moved into the area in response to lower catch rates at the Fladen Ground and on the west coast of Scotland. Catches were generally reported as good and the market demand was for larger, higher quality *Nephrops*. In spring between March and May some boats moved to the Minches in the West coast while during the winter months, a number of vessels shifted down to the Farn Deeps fishery. The predominant trawl gear mesh sizes are 80mm and 95mm. Only 5 local vessels fished with twin rig gears in 2012/2013. The fishery continues to be characterised by catches of small *Nephrops* which often leads to higher discard rates than in other east coast Functional Units. There was a small squid fishery in the summer of 2012. There is also a small amount of landings by creel vessels in this area (57 tonnes in 2013) although typically the main target species of these vessels are crabs and lobsters.

Further general information on the fishery can be found in the Stock Annex.

4.5.3 Advice in 2013

The ICES conclusions in 2013 in relation to State of the Stock were as follows:

"*The stock remains above MSY Btrigger but has declined since 2008. The harvest rate remains above FMSY.*"

The ICES advice in 2013 (for 2014) (Single-stock exploitation boundaries) was as follows:

MSY approach

"*ICES advises on the basis of the transition to the MSY approach that landings in 2014 should be no more than 1417 tonnes. If total discard rates do not change from the average of the last 3 years (2010–2012), this implies total catches of no more than 1646 tonnes. Note that this Figure includes discards expected to survive the discarding process – assumed to be 25% of the total number discarded for this stock."*

"In order to ensure the stock in this FU is exploited sustainably, management should be implemented at the functional unit level."

4.5.4 Management

Management is at the ICES Subarea level as described at the beginning of Section 4.2.

4.5.5 Assessment

Comments from the audit report reviewers of the 2013 assessment

"*The assessment report and advice was well written, and fully documented. To be consistent with the numbering defined in the draft section, this section should be labeled4.x. Section 04 being Nephrops in Subarea IV. It was easy to follow and interpret. Tables and Figures are adequately referred in the text but must be relabeled based on the new section of Nephrops IV. The methodology for computing the TAC for landing all policy should be described in the report (or stock annex). We could not find it and the numbers are not directly understandable from the tables.*

The review group concluded that the assessment had been performed correctly."

Approach in 2014

The assessment in 2014 is based on a combination of examining trends in fishery indicators and underwater TV using an extensive data series for the Firth of Forth Ground FU 8. The assessment of *Nephrops* through the use of the UWTV survey data and other

commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice is based on a development of the process defined by the benchmark WG(2009). Section 1.*** outlines the WG approach to integrate WKFRAME recommendations in the provision of F_{MSY} proxies for *Nephrops*. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involving collaboration between WGNSSK and WGCSE. The TV based assessments derive predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 4.6.1 and Figure 4.6.1,. Most of the landings are made by trawlers with creels accounting for just under 4%. Reported landings rose by over 200 tonnes between 2011 and 2012 followed by significant drop in 2013 to 1501 tonnes. The value for 2009 of over 2,600 tonnes was the highest in the available time series whilst the 2013 landings are below the long term average (2134 tonnes).

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the 4 main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and LPUE are shown in Figure 4.6.1 and Table 4.6.2 . Effort has shown a gradual decline over the time period. Some of this is recently attributable to the EU effort management regime although, as part of the Scottish conservation credits scheme, *Nephrops* vessels have been eligible for effort 'buy-backs'. LPUE rose in the early 2000s and since 2006 has stabilised at a relatively high level.

Males consistently make the largest contribution to the landings (Figure 4.6.2), although the sex ratio does vary and in 2011 more females in the catches moved the ratio closer to 1:1. This situation continued in 2012 and 2013. The proportion of females in the landings has increased in other years too (for example 2008). This may be due to the change in seasonal effort distribution with greatest effort in the 3rd quarter in 2008 when females are likely to be more available to the fishery (compared with a more evenly distributed seasonal effort pattern in 2007 – Figure 4.6.2).

Discarding of undersized and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Historically, discard rates have been higher in this stock than the more northerly North Sea FUs for which Scottish discard estimates are also available. This could arise from the fact that the use of larger meshed nets is not so prevalent in this fishery (80 mm is more common) and in addition, the population appears to consist of smaller individuals due to slower growth. Discarding rates in this FU have varied between 19% and 55 % of the catch by number (2004 -2013 average 33 %). In the last five years, discard rates appear to have dropped to below this value (28 % on average by number). This appears

to be due to increased retention of *Nephrops* rather than an absence of small *Nephrops* from the catches.

It is likely that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed in order to calculate removals (landings + dead discards) from the population.

Intercatch

Scottish data for 2013 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2014 WG and output length compositions obtained in formats suitable for running the assessment.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed annual catch data analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 4.6.3 shows a series of annual length frequency distributions for the period 2000 to 2013. Size information on catches (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35mm shows no evidence of reductions in relative numbers of larger animals.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35 mm) in the landings shown in Figure 4.6.1 and Table 4.6.3. This parameter might be expected to reduce in size if overexploitation were taking place but over the last 20 years has in fact been quite stable. The mean size in the catch in the < 35 mm category (Figure 4.6.1) also shows no particular trend although it has rised very slightly in the period 2009-2012 showing a small decrease in 2013.

Mean weight in the landings is shown in Figure 4.5.4 and Table 4.5.5 and this also shows no systematic changes over the time series.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

TV surveys using a stratified random design are available for FU 8 since 1993 (missing surveys in 1995 and 1997). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 4.6.4. On average, about 43 stations have been considered valid each year. In 2013, there were 51 valid stations. Abundance data are raised to a stock area of 915 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

A further non-surveyed area of sediment (Lunan Bay) exists just north of the Firth of Forth FU. There is a small *Nephrops* fishery in this area (off Arbroath), but the area is only surveyed on an irregular basis and therefore is not included in any estimates of

abundance. The WG wishes to emphasise that this area is out-with the Firth of Forth functional unit, is considered as part of the 'other' North Sea *Nephrops* area and hence not further considered in this section.

Data analyses

Exploratory analyses of survey data

Table 4.6.5 shows the basic analysis for the three most recent TV surveys conducted in FU 8. The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand. Depending on the year, high variance in the survey is associated with different strata and there is no clear distributional or sedimentary pattern in this area. Densities observed in this FU are typically higher than those of the more northerly FUs in the North Sea.

Figure 4.6.4 shows the distribution of stations in TV surveys, with the size of the symbol reflecting the *Nephrops* burrow density. Abundance is currently higher towards the eastern parts of the ground and around the Isle of May. Table 4.6.4 and Figure 4.6.5 show the time series of estimated abundance for the TV surveys, with 95% confidence intervals on annual estimates. The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009). A number of potential issues were highlighted including those arising from edge effects, species burrow mis-identification and burrow occupancy. To take account of these effects, a cumulative correction factor of 1.18 was estimated for FU 8 and this is applied to raw counts in order to derive the absolute abundance.

Final assessment

The underwater TV survey is again presented as the best available information on the Firth of Forth *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey, and it therefore only provides information on abundance over the area of the survey.

The stock has declined in size from 2008 to 2012 when it was at the highest point in the series and increased 28 % in 2013. The stock remains close to the average abundance and is above the biomass trigger. The UWTV abundance was relatively high in the period 2003 to 2010. The value calculated for 2013 is close to the 2007-2010 abundance and is similar to that recorded in 2004. The TV survey information, taken together with information showing stable mean sizes, suggest that the stock is sustainable at the current harvest rate. The calculated harvest ratio in 2013 (dead removals/TV abundance) is below F_{max}. The mean size of individuals < 35 mm in the catch show no strong trend in recent years.

4.5.6 Historical Stock trends

The TV survey estimate of abundance for *Nephrops* in the Firth of Forth suggests that the population decreased between 1993 and 1998 and then began a steady increase up to 2003. Abundance is estimated to have fluctuated without trend in the years since then. The abundance estimates from 2003-2013 (the period over which the survey estimates have been revised) is shown in Table 4.6.6. The stock is currently estimated to consist of 668 million individuals.

Table 4.6.6 also shows the estimated harvest ratios over this period. These range from 12-27 % over this period. (Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation). The estimated harvest rate in 2013 is 15.6 % which is now below the estimated value at F_{max} (16.3 %).

In addition to the discard rate, Table 4.6.6 also shows the dead discard rate (av 11-13 used in the catch options table) which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.5.7 Recruitment estimates

Survey recruitment estimates are not available for this stock.

4.5.8 MSY considerations

A number of potential F_{msy} proxies are obtained from the per-recruit analysis for *Nephrops* and these are discussed further in Section 2 of this report. The most recent analysis (in 2011) used 2008-10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery. The biological parameters used in the analysis can be found in the Stock Annex. The complete range of the per-recruit F_{msy} proxies is given in the table below and the process for choosing an appropriate F_{msy} proxy is described in Section 2.

		Fbar(20–40 mm)			SPR (%)		
WGNSSK 2011		M	F	HR (%)	M	F	T
F0.1	M	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29.0
	T	0.17	0.07	9.4	34.6	56.6	43.9
Fmax	M	0.25	0.11	12.7	25.3	46.8	34.4
	F	0.64	0.28	26.7	9.1	22.9	14.9
	T	0.34	0.14	16.3	18.8	38.5	27.1
F35%SpR	M	0.17	0.07	9.4	34.6	56.6	43.9
	F	0.39	0.17	18.3	16.0	34.5	23.9
	T	0.25	0.11	12.7	25.3	46.8	34.4

For this FU, the absolute density observed in the UWTV survey is relatively high (average of ~ 0.8 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) has been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that the sexes combined $F_{max(T)}$ is chosen as the F_{msy} proxy.

The F_{msy} proxy harvest ratio is 16.3 %.

The $B_{trigger}$ point for this FU (lowest observed absolute UWTV abundance) is calculated as 292 million individuals.

4.5.9 Short-term forecasts

A landings prediction for 2015 was made for the Firth of Forth (FU8) using the approach agreed at the Benchmark Workshop and outlined in the introductory section to

this chapter (Section 3.1). The table below shows landings predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed in Section 2 of this report and the harvest ratio in 2013 using the input parameters agreed at WKNEPH (ICES 2009). The landings prediction is calculated following the procedure outlined in the stock annex (section: short term projections). Recently, to account for the future implementation of the land all policy, the projected amount of discards has been added to the catch options table. The discard component is split between discards expecting to die and those surviving (assumed to be 25%). Discards (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings under a landings obligation (Total Catches = Landings + Dead Discards + Surviving Discards). The landings prediction for 2015 at the F_{msy} proxy harvest ratio is 1769 tonnes. In previous years, a F_{msy} transition stage harvest ratio was applied but this is no longer needed because i) F_{2013} is below F_{msy} and ii) the MSY policy aims to adjust fishing mortalities to the levels corresponding to MSY by 2015. The inputs to the landings forecast were as follows:

Survey abundance (2013) = 668 million

Mean weight in landings (2011-13) = 20.24 g

Mean weight in discards (2011-13) = 9.83 g

Dead discard rate (by number, average 2011-13) = 19.7 %

$F_{(2011-2013)}$ = Average F2011-2013= 20.8 %

arvest ratio F_{2013} = **15.6 %**

Basis	Total Catches*	Landings	Dead Discards**	Surviving Discards**	Harvest Rate
	L+DD+SD	L	DD	SD	for L+DD
MSY approach	2050	1769	211	70	16.3
F0.1	1183	1020	122	41	9.4
F35SpR	1598	1378	165	55	12.7
F2013	1962	1693	202	67	15.6
F2011-2013	2616	2257	269	90	20.8

*** Total catches are the landings including dead and surviving discards**

**** Total discard rate is assumed to be 24.7% of the catches (in number, last 3 years average, 2011-2013), discard survival is assumed 25% (ICES, 2009).**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

A discussion of F_{msy} reference points for *Nephrops* is provided in Section 3.1.

Biological Reference points

Biological reference points have not been defined for this stock.

4.5.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately.

There are concerns over the accuracy of historical landings (pre 2006) due to misreporting and because of this the final assessment adopted is independent of officially reported data.

UWTV surveys have been conducted for this stock since 1993, with a continual annual series available since 1998.

The Fishers' North Sea Stock survey does not include specific information for the Firth of Forth. Area 3 shows a perception of decreased abundance over the period 2007 - 2012, but this covers the Firth of Forth and parts of the Devil's Hole in addition to the Moray Firth. There are no Fishers' North Sea survey data available for 2013.

4.5.11 Status of the stock

The stock has declined in size since 2008 when it was at the highest point in the series but remains close to the average abundance and is above the biomass trigger. The UWTV abundance was relatively high in the period 2003 to 2010. The value calculated for 2013 is about the same abundance to that recorded in 2010. The TV survey information, taken together with information showing stable mean sizes, suggests that the stock is sustainable at the current harvest rate. The calculated harvest ratio in 2013 (dead removals/TV abundance) is below F_{msy}.

4.5.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

Nephrops discard rates in this Functional Unit are relatively high in comparison to other Functional Units and there is a need to reduce these and to improve the exploitation pattern. An additional reason for suggesting improved selectivity in this area relates to bycatch. It is important that efforts are made to ensure that other fish are not taken as unwanted bycatch in this fishery which mainly uses 80mm mesh. Larger square mesh panels and new, more selective TR2 gears implemented as part of the Scottish Conservation Credits scheme should help to improve the exploitation pattern for some species such as haddock and whiting and small cod.

Although the persistently high estimated harvest rates do not appear to have adversely affected the stock, they are estimated to be equivalent to fishing at a rate greater than F_{msy} (except in 2013) and therefore it would be unwise to allow effort to increase in this FU.

4.6 Moray Firth (FU 9)

4.6.1 Ecosystem aspects

The Moray Firth Functional Unit is located in the east of the Northern North Sea and is an inshore ground just off the east coast of Scotland (Figure 3.1.1). In common with other firths around the Scottish coast, the area is characterised by a wide entrance to

seaward, narrowing towards the coast with river basins draining into the area. Muddy sand deposits are the most widespread sediment, particularly towards the outer areas of the Firth, with smaller areas of sandy mud. Overall the ground covers an area of 2195km^2. In the inner parts of the Firth the sediment is more patchy and there are several areas of sand and of gravel.

Owing to its burrowing behaviour, the distribution of *Nephrops* is restricted to areas of mud, sandy mud and muddy sand. Figure 4.7.4 shows the distribution of sediment in the area. It is thought that most larvae are produced locally although some drift from the Fladen may occur. The population is characterised by medium densities of *Nephrops*. Although this area was historically important for fish catches, this area has now declined and *Nephrops* is the main commercial species with squid catches important in some years. The recruits of numerous demersal fish species occasionally aggregate in the area and small pelagics (sprat and juvenile herring) are seasonally abundant. The area is important for marine mammals (seals and cetaceans).

4.6.2 The Fishery in 2012 and 2013

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 4.7.1). Vessels targeting this fishery typically conduct day trips from the nearby ports along the Moray Firth coast. Around 15-20 local vessels (all single riggers) regularly fish in Moray Firth area, mostly out of Burghead. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. In recent years, shortages of *Nephrops* at the Fladen led to more vessels from Fraserburgh and Peterhead to visit the Moray Firth. These larger twin riggers fished mainly in the outer areas of the Firth but have recently moved to the inner Firth, causing friction with the local fleet.

In the end of 2012, a new voluntary code of conduct for *Nephrops* trawlers (Moray Firth Prawn Agreement) has been agreed amongst fishermen for the Inner Moray Firth so as to protect the viability of smaller vessels based in the area. The agreement proposes that an area in the most westerly part of the Moray Firth be reserved for vessels under 300HP with a further small area reserved for vessels under 400HP. In 2013 it has been reported that the majority of visiting vessels have been following the voluntary code of conduct.

Nephrops creeling in the Moray Firth is not common (only 7 tonnes in 2013) as grounds are in open water and gear conflicts with trawl vessels are likely to happen. A squid fishery usually takes place in the Moray Firth in the late summer, starting in the Southern Trench when squid moves inshore. The majority of the local *Nephrops* fleet participated in the squid fishery between August and early October 2013. Further general information on the fishery can be found in the Stock Annex.

4.6.3 Advice in 2013

The ICES advice for 2014 was as follows:

"*ICES advises on the basis of the MSY approach that landings in 2014 should be no more than 739 tonnes. If total discard rates do not change from the average of the last 3 years (2010–2012), this implies total catches of no more than 796 tonnes. Note that this Figure includes discards expected to survive the discarding process – assumed to be 25% of the total number discarded for this stock.*

To protect the stock in this functional unit (FU), management should be implemented at the functional unit level."

4.6.4 Management

Management is at the ICES Subarea level as described at the beginning of Section 4.2.

4.6.5 Assessment

Comments from the audit report reviewers of the 2013 assessment

The assessment report and advice was well written, and fully documented. To be consistant with the numbering defined in the draft section, this section should be labelled 4.x. Section 04 being Nephrops in Subarea IV. It was easy to follow and interpret. Tables and Figures are adequately referred in the text but must be relabeled based on the new section of Nephrops IV. This stock appears to be showing no signs of over-exploitation, however the 2011 and 2012 harvest ratio were greater than Fmsy proxy. The methodology for computing the TAC for landing all policy should be described in the report (or stock annex). We could not find it and the numbers are not directly understandable from the tables."

Approach in 2014

The assessment in 2014 is based on a combination of examining trends in fishery indicators and UWTV using an extensive data series for the Moray Firth FU 9. The assessment of *Nephrops* through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG 2009 and described in the stock annex.

The provision of advice in 2014 followed the process of 2013, and attempts to incorporate decisions taken at WKFRAME (2010) for the provision of MSY advice. The approach was developed based on inter-sessional work carried out by participants of the benchmark and involved collaboration between WGNSSK and WGCSE. The UWTV based assessments have derived predicted landings by applying a harvest rate approach to populations described in terms of length compositions from the trawl component of the fishery. Considerations for setting Harvest Ratios (HR) associated with proxies for F_{msy} for *Nephrops* are described in the WGNSSK 2010 report.

Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with very small contributions from England, and are presented in Table 4.7.1. Total landings (as reported to the WG) in 2013 for Scotland were 652 tonnes (25% lower than 2012) and England only landed 3 tonnes. Landings in recent years (post 2006) are more reliable due to the introduction of 'buyers and sellers' legislation. The long term landings trends are shown in Figure 4.7.1.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and LPUE are shown in Figure 4.7.1 and Table 4.7.2. Effort has shown a gradual decline over the time period (2000-2013). Some of this is attributable

to the EU effort management regime although *Nephrops* vessels have generally been allocated exemptions. LPUE rose in the early 2000s and since 2006 it has stabilised and fluctuated at a higher level.

Males generally make the largest contribution to the landings (Figure 4.7.2), although in 2011 the proportion of females is higher than in the recent past, in 2012 and 2013 males dominate again. The high contribution of females appears to be due to a much higher proportion of the fishery taking place in the third quarter when females are more available. This observation has been made a number of times before in the Moray Firth (particularly for example in 1994 when female catches exceeded those of males). Increased female catchability has also been associated with stocks which are in a poor state (females may remain more active as they have been unable to mate due to lack of males in the population). This problem usually manifests itself at times of the year when females would normally be reduced in the catches. This is not the case here.

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 1990. Discarding rates in this FU appear to be highly variable with rates over the time series of between 3 and 33 % of the catch by number. In 2013 the observed rate by number was at its lowest level, approximately 3% by number. Discards rates were generally higher in the past and now appear to be generally lower but with occasional high annual levels which may be associated with occasional high recruitments (e.g. 2004).

It is likely that some *Nephrops* survive the discarding process, an estimate of 25% survival is assumed in order to calculate removals (landings + dead discards) from the population.

Intercatch

Scottish data for 2013 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2014 WG and output length compositions were obtained in formats suitable for running the assessment.

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 4.7.3 shows a series of annual length frequency distributions for the period 2000 to 2013. Catch (removals) are shown for each sex with the mean catch and landings lengths shown in relation to MLS and 35mm. There is little evidence of change in the mean size of either sex over time and examination of the tails of the distributions above 35mm shows no evidence of reductions in relative numbers of larger animals. Occasional large year classes can be observed in these length frequency data (2002 and 2004). This is consistent with the occasional high discard rates observed for this FU.

The observation of relatively stable length compositions is further confirmed in the series of mean sizes of larger *Nephrops* (>35mm) in the landings shown in Figure 4.7.1 and Table 4.7.3. This parameter might be expected to reduce in size if overexploitation were taking place, but it appears to be stable throughout the time series.

Mean weight in the landings is shown in Figure 4.5.4 and Table 4.5.5 and this also shows no systematic changes over the time series.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

Research vessel data

Underwater TV (UWTV) surveys of *Nephrops* burrow number and distribution reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

The numbers of valid stations used in the final analysis in each year are shown in Table 4.7.4. On average, 40 stations have been considered valid each year, 55 stations were sampled in 2013. Abundance data are raised to a stock area of 2195 km^2. General analysis methods for UWTV survey data are similar for each of the Scottish surveys, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 4.7.5 shows the basic analysis for the three most recent UWTV surveys conducted in FU 9 (2011-2013). The table includes estimates of abundance and variability in each of the strata adopted in the stratified random approach. The ground is predominantly of coarser muddy sand and typically, most off the variance in the survey is associated with a patchy area of this sediment to the west of the FU. The densities typically observed in this FU are lower than those observed in FU 8.

Figure 4.7.4 shows the distribution of stations in UWTV surveys (2008-2013), with the size of the symbol reflecting the *Nephrops* burrow density. The abundance appears to be highest at the western and eastern ends of the FU, with lower densities in the more central area. Table 4.7.4 and Figure 4.7.5 show the time series of estimated abundance for the UWTV surveys, with 95% confidence intervals on annual estimates. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009). A number of potential biases were highlighted including those due to edge effects, species burrow mis-identification and burrow occupancy. The cumulative bias correction factor estimated for FU 9 was 1.21 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 21 %. In order to convert the raw UWTV survey abundance to an absolute abundance the raw data are divided by 1.21.

Final assessment

The UWTV survey is again presented as the best available information on the Moray Firth *Nephrops* stock. This survey provides a fishery independent estimate of *Nephrops* abundance. At present it is not possible to extract any length or age structure information from the survey and it therefore only provides information on abundance over the area of the survey.

The perception of the state of the stock is that there has been a gradual decline in abundance since since 2007 (from 531 million to 299 million individuals in 2012) but in 2013 the abundance increased over 50% to 469 million. The abundance is above the biomass trigger of 262 million individuals.

The mean size of individuals > 35 mm (males and females) remains relatively stable.

4.6.6 Historical Stock trends

The UWTV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased between 1997 and 2005 but has gradually fallen since then (with the exception of 2007 and 2013). The abundance estimates from 2003-2013 are shown in Table 4.7.6.

Table 4.7.6 also shows the estimated harvest ratios over this period. These range from 7-20 % over the period 2003-2013. Estimated harvest ratios prior to 2006 may not be representative of actual harvest ratios due to under-reporting of landings before the introduction of 'Buyers and Sellers' legislation. The estimated harvest rate has fallen in recent years from 19% in 2011 to approximately 6 % in 2013 and is now below the F_{msy} proxy value of 11.8 %.

In addition to the discard rate, Table 4.7.6 also shows the dead discard rate (average 2011-2013 used in the catch options table) which is calculated as the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.6.7 Recruitment estimates

Survey recruitment estimates are not available for this stock, although the length frequency distributions and highly variable discard rates suggest that this FU may be characterised by occasional large year classes.

4.6.8 MSY considerations

A number of potential F_{msy} proxies were obtained from the per-recruit analysis for *Nephrops* as documented in the WGNSSK 2010 report. The analysis was updated in 2011 using 2008-10 catch-at-length data, to account for the apparent changes in the discard pattern in this fishery and since previous estimates were derived several years before. An update was not performed this year. The complete range of the per-recruit F_{msy} proxies is given in the table below and the process for choosing an appropriate F_{msy} proxy is described in WGNSSK 2010 report.

		Fbar(20–40 mm)			SPR (%)		
		M	F	HR (%)	M	F	T
F0.1	M	0.13	0.07	7.16	42.35	61.48	49.89
	F	0.24	0.12	11.61	27.45	47.01	35.16
	T	0.14	0.07	7.84	39.46	58.93	47.13
Fmax	M	0.26	0.13	12.31	25.80	45.16	33.42
	F	0.68	0.36	23.82	11.42	25.16	16.83
	T	0.34	0.18	14.92	20.79	39.10	28.01
F35%SpR	M	0.17	0.09	9.11	34.69	54.48	42.48
	F	0.41	0.22	17.12	17.62	34.83	24.40
	T	0.24	0.13	11.79	27.02	46.53	34.71

The changes in the selection and discard patterns, and relative availability of females as estimated by the LCA result in slight decreases in the estimated MSY harvest ratio proxies compared to those calculated previously. (See stock annex for previously calculated values used at WGNSSK 2010).

Moderate absolute densities are generally observed on the UWTV survey of this FU. Harvest ratios (which are likely to have been underestimated prior to 2006) appear to have been above $F_{35\%SPR}$ and in addition there is a long time series of relatively stable

landings (average reported landings ~ 1500 tonnes, above those predicted by currently fishing at $F_{35\%SPR}$). For these reasons, it is suggested that $F_{35\%SPR(T)}$ is used as the F_{msy} proxy.

The F_{msy} proxy harvest ratio is 11.8 %.

The $B_{trigger}$ point for this FU (lowest observed UWTV abundance) is calculated as 262 million individuals.

4.6.9 Short-term forecasts

A landings prediction for 2015 was made for the Moray Firth (FU9) using the approach agreed at the Benchmark Workshop. The table below shows landings predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points and the average harvest ratio (2011-2013). The landings prediction is calculated following the procedure outlined in the stock annex (section: short term projections). Recently, to account for the future implementation of the land all policy, the projected amount of discards has been added to the catch options table. The discard component is split between discards expecting to die and those surviving (assumed to be 25%). Discards (by number) are calculated using data from the on-board observer sampling programme. This value is multiplied by the mean weight in discards to obtain the projected discard weight. A column is also included to show expected landings under a landings obligation (Total Catches = Landings + Dead Discards + Surviving Discards). The landings prediction for 2015 at the F_{msy} proxy harvest ratio is 1185 tonnes. The inputs to the landings forecast were as follows:

Survey abundance (2013) = 469 million

Mean weight in landings (2011-2013) = 23.25 g

Mean weight in discards (2011-13) = 10.35 g

Dead discard rate (by number, average 2011-2013) = 7.9 %

SAbsolute correction factor = 1.21

$F_{(2011-2013)}$ = Average F2011-2013= 12.8 %

Harvest ratio F_{2013} = **5.8 %**

Basis	Total Catches*	Landings	Dead Discards**	Surviving Discards**	Harvest Rate
	L+DD+SD	L	DD	SD	for L+DD
MSY approach	1245	1185	45	15	11.8
F2013	612	583	22	7	5.8
F0.1	824	784	30	10	7.8
F2011-2013	1351	1286	49	16	12.8
FMAX	1573	1497	57	19	14.9

Weights in tonnes

*** Total catches are the landings including dead and surviving discards**

**** Total discard rate is assumed to be 10.1% of the catches (in number, last 3 years average, 2011-2013), discard survival is assumed 25% (ICES, 2009).**

$F_{0.1(T)}$: Harvest ratio equivalent to fishing at a level associated with 10 % of the slope at the origin on the combined sex YPR curve.

$F_{35\%SPR(T)}$: Harvest ratio equivalent to fishing at a rate which results in combined SPR equal to 35% of the unfished level.

$F_{max\ (T)}$: Harvest ratio equivalent to fishing at a rate which maximises the combined YPR.

A discussion of F_{msy} reference points for *Nephrops* is provided in Section 3.1.

Biological Reference points

Biological reference points have not been defined for this stock.

4.6.10 Quality of assessment

The length and sex composition of the landings data is considered to be well sampled. Discard sampling has been conducted on a quarterly basis for Scottish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately.

There are concerns over the accuracy of landings (pre 2006) and effort data and because of this the final assessment adopted is independent of official statistics.

UWTV surveys have been conducted for this stock since 1993, with a continual annual series available since 1996. The number of valid stations in the survey has remained relatively stable throughout the time period.

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. Area 3 covers the Moray Firth, Firth of Forth and areas of the Devil's Hole and there appears to be some inconsistencies between the report in 2011 and 2012. In 2011 the report documented a perceived increase in the *Nephrops* abundance in this area since 2008; however the 2012 report appears to show a perceived decrease since 2008. There are no Fishers' North Sea survey data available for 2013.

4.6.11 Status of the stock

The evidence from the UWTV survey suggests that following a continuous decrease from 2007 to 2012 the abundance increased over 50% in 2013 . There is no evidence from the mean size information to suggest overexploitation of the FU. The harvest ratio (removals/UWTV abundance) for 2013 (5.8%) was lower than 2012 (13.7%) and is now below F_{msy} (11.8%).

4.6.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

There is a by-catch of other species in the Moray Firth area. It is important that efforts are made to ensure that unwanted by-catch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted bycatches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The estimated harvest rates have generally been greater than F_{msy} and because the abundance (as estimated by the UWTV survey) appears to have declined in recent years (2005-2012), it would be unwise to allow effort to increase in this FU.

4.7 Noup (FU 10)

4.7.1 Ecosystem aspects

The Noup is a small area of muddy sand located to the west of Orkney. The area is exposed to the open Atlantic to the west and strong tidal currents occur in the area. The surrounding coarser grounds are important edible crab fishing areas and fish populations (mixed demersal species) are important in the locality.

4.7.2 The Fishery in 2012 and 2013

The Noup currently supports a relatively small fishery. Few vessels fished this area regularly and currently there is no targeted fishery for *Nephrops* in Noup. In recent years, boats from Scrabster landing *Nephrops* use 120 mm mesh twin rigs (targeting whitefish). *Nephrops* boats from Orkney spend most of the year fishing in the Moray Firth (FU 9). Landings from Noup have decreased steadily since 2002 and in 2013 only 15 tonnes of *Nephrops* were landed (Table.4.8.1). Further general information on the fishery can be found in the Stock Annex.

4.7.3 Advice in 2012 and 2013

The advice provided in 2012 was biennial and valid for 2013 and 2014.

The 2012 advice for this stock is biennial and valid for 2013 and 2014 (see ICES, 2012): Based on the ICES approach for data-limited stocks, ICES advises that landings should be no more than 50 tonnes."

"To protect the stock in this functional unit (FU), management should be implemented at the functional unit level."

Data available

Commercial catch and effort data

Landings from this fishery are reported only from Scotland and are presented in Table 4.8.1 and Figure 4.8.1. Total landings (as reported to the WG) in 2013 were only 15 tonnes, an increase of 2 tonnes from the previous year which was the lowest landing reported in the time series (1997-2013). *Nephrops* are almost exclusively landed by 'non-*Nephrops*' vessels. This supports the anecdotal information received from the fishing industry that this area is rarely fished by *Nephrops* vessels due to the high catch rates of whitefish in the area.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort. At the present time, these revised data cover the period 2000 to the present and only annual summaries are available.

Trends in Scottish effort and LPUE are shown in Figure 4.8.1 and Table 4.8.2. Effort has declined over the time period and is more marked than on other *Nephrops* grounds owing to the dominance of trawlers targeting demersal fish in the area. Demersal vessels have been more directly impacted by effort reductions. LPUE decreased in 2012

but increased slightly in 2013. Interpretation of this index is difficult since the vessels are not targeting *Nephrops*.

Length compositions

Levels of market sampling are low and discard sampling is not available. Mean sizes in the landings in previous years are shown in Figure 4.8.1 and Table 4.8.3. In 2013 only three sampling trips took place covering quarters 2 and 4.

Natural mortality, maturity at age and other biological parameters

No data available.

Research vessel data

An underwater TV (UWTV) survey of this FU has been conducted sporadically (1994, 1999, 2006 and 2007). A density distribution map of these surveys is shown in Figure 4.8.2 and results shown in Table 4.8.4.

Data analyses

No assessment has been presented in 2014.

4.7.4 Historical stock trends

Recent landings for this FU have been low, approximately 13 tonnes in 2012 and 15 tonnes in 2013.

No UWTV survey has been conducted in this FU in recent years.

4.7.5 Recruitment estimates

There are no recruitment estimates for this FU.

4.7.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.7.7 Status of the stock

The current state of the stock is unknown.

4.7.8 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

The Noup area supports a mixed fishery in which *Nephrops* are taken mainly by demersal trawlers targeting fish. It is important that efforts are made to ensure that unwanted by-catch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted by-catches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES, 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (WKNEPH, 2013). Following the procedure outlined (section 3.1.2), the spatial extent of the *Nephrops* grounds were estimated (based on BGS sediment maps) to provide a likely envelope for the total abundance of

Nephrops in FU 10 (see table below). UWTV survey information on the mean density of *Nephrops* (0.11 *Nephrops*/m², rounded to 0.1 in the table below), from the most recent UWTV survey (2007), was used together with discard percentages, and mean weights taken from FU 9 (Moray Firth). In 2014 the table was updated to include the latest range of values for the calculation of the average landings and catch advice based on the discard levels previously observed. Landings of 50 tonnes (advice given in 2012 for 2013 and 2014) result in a harvest ratio of 5.7% which is below the range of harvest ratios observed for other North Sea functional units (8-16%) and therefore considered precautionary. The proposed advice for 2015 and 2016 is 50 tonnes. In line with the advice for other stocks, discard (survival assumed to be 0%, mean weight in discards estimated from Moray Firth, 2011-2013) and total catch weight expected under the land all policy were added to the table.

Basis	Catches	Landings	Discards	Range of potential densities (Nephrops per m2)							
				0.05	0.1	0.15	0.2	0.3	0.4	0.6	0.8
Recent average (2011-2013)	33	32	1	7.3%	3.7%	2.4%	1.8%	1.2%	0.9%	0.6 %	0.5 %
SALY (Advice for 2013-2014)	52	50	2	11.4 %	5.7%	3.8%	2.9%	1.9%	1.4%	1.0 %	0.7 %
0.5 * Average	56	54	2	12.3 %	6.2%	4.1%	3.1%	2.1%	1.5%	1.0 %	0.8 %
	72	69	3	15.8 %	7.9%	5.3%	3.9%	2.6%	2.0%	1.3 %	1.0 %
Average (2004-2013)	111	107	4	24.4 %	12.2 %	8.1%	6.1%	4.1%	3.1%	2.0 %	1.5 %
Maximum	415	400	15	91.3 %	45.7 %	30.4 %	22.8 %	15.2 %	11.4 %	7.6 %	5.7 %

Area: 409 km²

Mean weight in landings: 23.25 g (from Moray Firth, 2011-2013)

Mean weight in discards: 10.35 g (from Moray Firth, 2011-2013)

Discard rate: 7.9% (from Moray Firth, 2011-2013). Discard survival assumed to be 0%

SAbsolute correction factor = 1.35 (from Fladen)

4.8 Norwegian Deep (FU 32)

4.8.1 General

4.8.1.1 Ecosystem aspects.

See stock annex (section A.3).

4.8.1.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2).

4.8.2 Advice in 2013

Advice for Nephrops was biennial for 2012 and 2013.

In 2012 ICES noted for this stock that:

- "Perceptions of this stock (FU 32) are based on Danish LPUE data. The overall trend in these LPUE Figures does not indicate any decline in stock abundance."
- "However, the effect of technological creep on the effective effort of the fishery is not known."
- "Recent trends in overall size distribution in the catches also indicate that the *Nephrops* stock in FU 32 is not over-exploited. The WG concludes that the level of exploitation on this stock is sustainable."
- "The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 2 %), even in the years of maximum landings."

4.8.3 Management

An overview of the management of *Nephrops* in FU 32 is given in the stock annex (section A.2). The EU fisheries in FU 32 take place mainly in the Norwegian zone of the North Sea. The EU fisheries are managed by a separate TAC for this area. For 2008 the agreed TAC for EU vessels was 1300 t, and for 2009-2012 it has been 1200 t. In 2013 the TAC was reduced to 1000 t, following the ICES advice. In 2014 the TAC was also 1000 t. The EU quota of *Nephrops* in Norwegian waters (area 04-N) is mainly allocated to Denmark (app. 95 %) with a small fraction of app. 5 % to UK. There is no quota restriction currently for the Norwegian fishery. It is not prohibited to discard *Nephrops* in FU 32.

4.8.4 Assessment

4.8.4.1 Data available

Landings data for the 2014 assessment (all fleets in 2013) have been uploaded using InterCatch.

Catch

Dutch landings from FU 32 were incorporated into the report for the first time in 2010. International landings from the Norwegian Deep increased from less than 20 t in the mid-1980s to 1190 t in 2001 (Table 4.9.1, Figure 4.9.1). Since then landings have declined due to a reduction of Danish landings, and total landings in 2013 amounted to only 191t, the lowest Figure since 1992. The decreased Danish landings can be explained by increasing fuel costs, fewer vessels, and *Nephrops* landings now occurring mainly as a bycatch in mixed fisheries. Danish vessels used to take 80-90 % of the total landings, but since 2008 this percentage has decreased to 65-75 %. Norwegian landings have decreased since 2009.

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Table 4.9.1). Danish discards are low due to the legislated 120 mm mesh size. The discard ratio (discard as percentage of catch) was high in 2004-2005 (around 25 %), but decreased to 10-17 % in the years 2006-2012. In 2013 estimated Danish discards were 68 tons, and the discard ratio increased to 35%. There are no Norwegian discard data.

Length composition

The average size of *Nephrops* in Danish landings showed a general decreasing trend for both males and females in the period 2000-2006 (Figure 4.9.1). The increase in mean size in landings from 2007 to 2012 coincides with a sharp decrease in landings and may imply a lower exploitation pressure in recent years. However, the mean size of both males and females in the Danish landings decreased from 2012 to 2013. This decline is

due to 1) landing of undersized (< MLS of 40 mm CL) *Nephrops* in 2013, and 2) a smaller proportion of large *Nephrops* in the landings in 2013 compared with 2012. One possible explanation for the decrease in the number of large *Nephrops* could be that the declining Danish fishery in 2013 contracted into an area with small *Nephrops*, possibly in the southern part of FU 32. The mean sizes of males and females in the 2013 landings of respectively 44 and 43 mm CL are similar to mean sizes in Skagerrak landings (FU 3) (Figure 3.2.2.2). The average sizes in the Danish catches have shown a similar trend as the average sizes in the landings. The Norwegian time series of mean size in catches also shows an increasing trend from 2006 until present for females, while for males, the mean size is fluctuating without trend. This could be due to limited Norwegian catch sampling in 2012. Unfortunately the Norwegian coast guard provided no catch samples in CL in 2013. The increasing mean size in the Danish catches from 2007 to 2012 (Figure 4.9.1) may indicate lower recruitment, or larger individuals in the population. Mean sizes of individuals < MLS are more informative than mean sizes in catches when considering recruitment, and will be presented at the 2015 WG meeting.

The length frequency distributions in the Danish catches from years 2007, 2010 and 2012 had a greater proportion of large specimens compared with former years (Figure 4.9.2).The 2013 length frequency distribution, on the other hand, had a relatively smaller proportion of large specimens, as noted above, as well as a reduced proportion of smaller specimens. In general, there are few individuals below the MLS of 40 mm due to the legislated 120 mm mesh size. The size distributions of catches from Norwegian coast guard inspections of Danish and Norwegian trawlers do not show any conspicuous annual changes (Figure 4.9.3). Danish and Norwegian length frequency distributions in catches have been compared for 2006, 2007 and 2012 where data exist from both countries (Figure 4.9.4). Trends are similar.

Natural mortality, maturity at age and other biological parameters

No data are available at present. Data from the Norwegian shrimp survey covering FU 32 were considered by the 2013 benchmark (WKNEPH 2013) for estimation of maturity at length. However, annual catches in the survey are too small for estimation of annual maturity values. Possibilities for obtaining maturity data and length-weight relationships from the Danish at-sea-sampling programme will be considered.

Catch, effort and research vessel data

Effort and LPUE Figures for the period 1989-2013 are available from Danish logbooks (Table 4.9.2, Figure 4.9.1). In 2013, the Danish effort index was changed to kW days (formerly fishing days) (see stock annex, section B.4), as kW days account for temporal differences in vessel size. For 2013 onwards, days at sea, fishing days as well as kW days will be presented (Table 4.9.2). The time series of fishing days (earlier years' effort index) was updated. The new Danish LPUE index based on kW days shows a decreasing trend as opposed to the former LPUE index based on fishing days which fluctuated without trend around a mean level of approximately 200 kg day^{-1} (Figure 4.9.1). As kW days is a more representative effort index, the new LPUE index is a more representative index of catch rate. However, due to changes in the management regime, changes in the LPUE index do not necessarily imply stock size changes (see below).

In the beginning of the 1990s vessel size increased in the Danish fleet fishing in FU 32. This increase, and more directed fisheries for *Nephrops* in areas with previously low exploitation levels are probably partly responsible for the observed increase in the Danish LPUE in those years (Table 4.9.2, Figure 4.9.1). The Norwegian mesh size legislation was changed in 2002 (see stock annex, section A.2). The introduction of the larger mesh size of 120 mm may explain the decrease in LPUE (catch rate) from 1999 to 2001 with

the subsequent stabilizing at a lower level relative to the late 1990s. However, the lower LPUE may also reflect a stock decrease as Danish landings in 1999 increased to >1000 tons and remained at this level until 2006. In 2007 individual vessel quotas were introduced in the Danish fishery. This resulted in the vessels buying up a lot of fish quotas and shifting their effort to fin fish rather than *Nephrops*. To get good catches of *Nephrops* vessels need to target this species by fishing at dusk/dawn when the animals are out of their burrows, as opposed to fin fish fisheries where good catches can be obtained around the clock. From 2012 to 2013 the Danish LPUE decreased by approximately 40 %. As noted above, it is possible that the Danish fishery has contracted into areas south in FU 32 (due to fuel costs) with locally high fishing mortality explaining both the decreased mean sizes in landings as well as the decreased LPUE in 2013. The low LPUE in 2013 may therefore not be representative for the whole stock in FU 32. Environmental changes resulting in lower *Nephrops* densities cannot be ruled out, however, such changes do not explain the lower mean sizes.

The Danish effort increased from 2004 to 2006, but showed a strong decline in 2007 and has since continued decreasing. It has not been possible to incorporate 'technological creep' in the evaluation of the effort data. However, the use of twin trawls has been widespread for many years.

In 2013, the WG suggested that the Danish LPUE could be a candidate for an indicator of stock size which could potentially be used to determine when an assessment update was required, where a value outside the observed range of LPUE values of 160-240 kg/day in the years 1994-2012 should trigger an update. This corresponded to an approximately 20 % increase/decrease from the mean LPUE of 207 kg/day (1994-2012). However, due to the declining trend of the new LPUE index (catch rate) and uncertainties regarding the representativeness of this index with stock size due to changes in the fishery, namely the increase in minimum mesh size (2002) and change of management regime (2007), it is presently difficult to determine whether an updated assessment is required.

The information on *Nephrops* in Norwegian logbooks is deficient. Logbook catches from FU 32 constituted 17 to 59 % of trawl landings in 2000-2013. The 2013 benchmark (WKNEPH 2013) analysed the Norwegian LPUE Figures from bottom and shrimp trawls. The data from bottom trawls and shrimp trawls prior to 2010 are considered unsuitable for LPUE analyses (see stock annex, section B.4). With the introduction of Norwegian electronic logbooks, compulsory for all vessels ≥ 15 m length in 2011, two new time series from respectively bottom and shrimp trawls (single and twin) are established from 2011 onwards. However, as a large portion of the Norwegian fleet landing *Nephrops* in FU 32 consists of vessels < 15 m, especially north of 60 °N, the Norwegian logbook data available for analyses will continue to be limited.

The Norwegian annual shrimp survey shows that *Nephrops* is distributed in areas deeper than 100 m in FU 32 (Figure 4.9.5). Survey data in 2014 only covered the northern part of FU 32 due to bad weather. There were fewer stations with catches of *Nephrops* in this area of the Norwegian Deep in 2014 compared with former years.

4.8.4.2 Data analysis

Review of last year's assessment

"The required work towards answering the TORs for this stock has been done.

The report is clear, referring to the annex for more details. The annex provides good background information.

Some minor changes/elaborations are required, as noted above. "

The minor changes related

Exploratory analysis of catch data

There was no age based analysis carried out

Exploratory analysis of survey data

Catches of *Nephrops* from the annual Norwegian shrimp trawl survey (back to 1997) are small and variable. The benchmark in 2013 (WKNEPH 2013) suggested that although small, these catches should be explored with the aim of establishing a biomass index time series for *Nephrops* in FU 32. This work has not yet been carried out.

Final assessment

No age based numerical assessment is presented for this stock. The state of the stock was judged on the basis of basic fishery data.

4.8.4.3 Historic stock trends

The increase in mean size in catches and landings from 2006 to 2012 in females and from 2005 to 2012 in males could indicate both a slight decrease in recruitment and/or a lower exploitation pressure in recent years. This increase coincides well with the decreasing landings in the same time period. The decline in mean sizes from 2012 to 2013 may not be representative of the whole stock (see above). The introduction of a new effort index (kW days) in 2013 resulted in a stepwise declining trend in the new LPUE index, from the mid 1990s until present.

4.8.4.4 Recruitment estimates

There are no recruitment estimates for this stock.

4.8.4.5 Forecasts

There were no forecasts for this stock.

4.8.4.6 Biological reference points

No reference points are defined for this stock.

4.8.4.7 Quality of assessment

The data available for this stock remains limited.

4.8.4.8 Status of stock

The perceptions of this stock (FU 32) are based on Danish landings and effort data as well as mean sizes (CL) in landings and catches. A new Danish effort index which accounts for temporal differences in vessel size was introduced in 2013 (kW days as opposed to former fishing days). The effect of technological creep on the effective effort of the fishery is still not known. The new Danish LPUE index shows a stepwise declining trend from the mid 1990s until present. However, it is not possible to determine whether this decrease in LPUE is due to changes in management or whether the decrease to some extent also reflects stock changes. The present international landings from the stock are very small and it therefore seems likely that the drop in LPUE from 2012 to 2013 is due to changes in fishery patterns rather than stock size changes. New Norwegian LPUE time series are still very short, but will complement Danish data in

years to come. Trends in mean size in landings and catches, and overall size distribution in the catches have for many years indicated that the *Nephrops* stock in FU 32 is not over-exploited. The large drop from 2012 to 2013 in mean sizes in landings and catches may also be explained by changes in fishery patterns. The low mean sizes in landings in 2013 are due both to landings of undersized *Nephrops* as well as a smaller proportion of larger animals in 2013 compared with 2012.

The WG concludes that the available data give a non-conclusive perception of stock status. However, recent low landings imply low fishing mortality. The average annual landings over the last ten years are 625 t (2004-2013), while the short-term average landings are 356 t (2009-2013). The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 1 %), even in years when landings were highest.

4.8.4.9 Management considerations

For 2006-2008 the agreed TAC for EU vessels was 1300 t. This decreased to 1200 t in 2009-2012 and 1000 t in 2013-2014. The WG notes, however, that there is no TAC for the Norwegian vessels fishing in FU 32.

The Danish at-sea-sampling programme provided a satisfactory number of observer trips in 2013. However, not all quarters were sampled. Possibilities for obtaining biological data from the at-sea-sampling programme should be explored. Danish VMS data should be explored in order to determine interannual variation in the spatial extent of the fishery. Norwegian sampling of catches by the Norwegian coast guard should be improved. The sampling has been satisfactory in some years, but not in others. The main problems are that individuals are often measured by total length (whole cm) and sample weights are not collected, not allowing calculation of catches by length. Furthermore, the discard and landings components are not sampled separately, thus not allowing for estimation of discards. The total length and CL measurements from the coast guard may probably be combined to provide a larger data source for the annual Norwegian length frequency distributions of catches, as these are now presented by length intervals. The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks, compulsory for all vessels ≥ 15 m length, which provides consistent data for part of the fleet from 2011 onwards.

Following the procedure outlined in section 3.1.2, the spatial extent of the *Nephrops* grounds was estimated to provide a likely envelope for the total abundance of *Nephrops* in FU 32 (see table below). UWTV-survey information on the mean density of *Nephrops* (minimum value of 0.2 animals/m^2), from the neighbouring functional unit (FU 7 Fladen Ground), was used together with the mean discard percentage in Danish catches in 2003-2013 (19 %) and mean weight of *Nephrops* in the Danish catches in 2013 (41 g). The area of the *Nephrops* ground in FU 32 was estimated using information on the spatial distribution of the Norwegian and Danish fisheries, as well as suitable sediment. The biomass estimates imply very low harvest ratios in FU 32 (≤ 1 %), even in former years with high landings (1000-1200 t).

Based on the ICES approach for data-limited stocks, ICES advises that catches in 2015 and 2016 should be no more than 734 t implying landings of no more than 624t.

			FU 32: Norwegian Deep			55,500 Area (km2)		41 mean weight (g)				19% discards
								Density				
	discards	landings	catches	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.5 * Average	68	313	367	0.4%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	136	625	734	0.8%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
Maximum	363	1190	1452	1.5%	0.8%	0.4%	0.3%	0.2%	0.2%	0.1%	0.1%	0.1%
					min. Fladen density							

4.9 Off Horns Reef (FU 33)

4.9.1 Data available

Catch

The landings from FU 33 were marginal for many years. However, from 1997 to 2004, Danish landings increased considerably, from 274 to 1,097 t. Denmark dominated the fishery during this period. Since 2004, Danish landings have gradually decreased and in 2013 were 310 t. The other countries reporting landings from the area are Belgium, Netherlands, Germany and the UK. Dutch landings show an increasing trend from the start of the time series until 2007 when landings were almost 500 t. Since 2007, Dutch landings show a slightly decreasing trend and in 2013 were 304 t. Belgium and German landings having increased throughout the time period and were around 150 t respectively in 2013. UK landings were highest in 2009 (170 t) and have since decreased dramatically in 2012 and 2013. In 2007, total landings were the highest on record (1467 t). Since 2007, total landings have shown a decreasing trend, and were 946 t in 2013 (Table 4.10.1 and Figure 4.10.1).

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 to 2013 are shown in Figure 4.10.2. Notice, that except for 2005 and 2011 they are rather similar. Figure 4.10.1 shows the development of the mean size of *Nephrops* in catches. The drop in the mean CL in the catches in 2005 and 2013 reflects an increase in numbers at around 30 mm CL and could indicate a large recruitment in these years, see also Figure 4.10.1

In the period 2001-2005, and in 2009-2013 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples do not cover all quarters.

Natural mortality, maturity at age and other biological parameters

No data available

Catch and effort data

Table 4.10.2 and Figure 4.10.1 show the development in Danish effort and LPUE. Notice that the 10-fold increase in fishing effort from 1996 to 2004 seems to correspond to the increase in landings during the same period and the LPUE was relatively stable. After 2004 the Danish effort decreased markedly, and since 2009 has remained stable at around 300 000 kW days. Dutch effort data are available from 2005-2013 and shows an increasing trend since 2007, where it has been around 1 300 000 kW days in the most recent 2 years. The Danish LPUE shows an increasing trend during the whole period, and in 2012 and 2013 were the highest on record (~1.3 kg/ kW day). This increase in LPUE could reflect an increase in gear efficiency (technological creep) or in fishers' ability to exploit the stock. LPUE from the Netherlands increased from 0.3 kg/kW day in 2005 to around 0.7 kg/kW day in 2007, and has since fallen to below 0.3 kg/kW day in 2013.

4.9.2 Data analysis

Audit of the 2013 assessment (FU33) states "The required work towards answering the TORs for this stock has been done. The report is clear, but lacks information about ecosystem considerations. A stock annex should be produced for this FU".

Exploratory analyses of catch data

No catch at age analysis has been carried out for this stock.

Exploratory analyses of survey

No survey data were available

4.9.2.1 Historic stock trends

The available data do not provide any clear signals on stock development:

Danish effort began decreasing after 2004. Since then, the LPUE has steadily increased, except for 2010 when LPUE declined slightly. Last year, new data from the Netherlands became available for the last nine years, and shows a more stable effort. LPUE has slightly decreased for Denmark and the Netherlands in 2013.

The size distribution in the 2013 catches is similar to those in 2001-04 and 2009-2010. The smaller individuals in the 2005 and 2011 catches could reflect a high recruitment in these years. The decrease in mean size could indicate either high recruitment or a decline in the stock, reflected by fewer large individuals. However, there are no recruitment estimates for this FU.

Forecasts: Forecasts were not performed.

Biological reference points: There are no reference points defined for this stock.

Perceptions of the stock are based on Danish and Dutch LPUE data and trends in size composition in Danish catches. As stated above, comparing the size distribution in the 2005 and 2011 catches with those in other years could indicate high recruitment in 2005 and 2011.

Management considerations for FU 33.

The North Sea TAC is not thought to be restrictive for the fleets exploiting this stock. Considering the recent trend in LPUE and the technological creep of the gear, the exploitation of this stock should be monitored closely.

4.10 Devil's Hole (FU 34)

The Devil's Hole was designated as a functional unit in 2010, after recommendation from SGNEPS because of increasing landings in the area. Advice was first provided for this functional unit in 2012 using the data limited approach.

4.10.1 Ecosystem aspects

The area consists of a number of narrow trenches (up to 2 km wide) running in a north-south direction, with an average length of 20-30 km. These trenches fall across six ICES statistical rectangles: 41-43F0 and 41-43F1, which are used to define this functional unit. The British Geological Survey (BGS) sediment map (showing sediments suitable for *Nephrops*) of the area is shown in Figure 4.11.1 and suggests that there is one large, and several smaller areas of muddy sand (10 – 50 % silt and clay).

4.10.2 The Fishery

The fishery in this area is prosecuted largely by Scottish vessels operating out of ports in the northeast of Scotland, but occasionally making landings into northeast England. The fleet consists of large *Nephrops* trawlers which have the capability of operating in such offshore areas. Around five vessels operate out of Peterhead with another 12 from Fraserburgh regularly visiting the areas. These vessels also fish the Fladen on a regular basis and visit the other more inshore functional units in times of poor weather or poor *Nephrops* catch rates in the offshore areas. During 2012, a number of Fladen vessels moved into the area from time to time. In 2013 the effort in FU 34 decreased as the poor fishery in Fladen continued and fewer boats were reported to be operating in the *Nephrops* offshore grounds.

Advice in 2012 and 2013

Advice provided in 2012 was biennial for 2013 and 2014.

The 2012 advice for this stock is biennial and valid for 2013 and 2014 (see ICES, 2012): Based on the ICES approach for data-limited stocks, ICES advises that landings should be no more than 600 tonnes.

"To protect the stock in this functional unit (FU), management should be implemented at the functional unit level."

4.10.3 Management

Total Allowable Catch (TAC) management is at the ICES Subarea level.

4.10.4 Assessment

Data are presented which in future may form the basis for an assessment. A benchmark was carried out for this functional unit in 2013 (WKNEPH 2013) which advised to continue with the data limited approach at present with the aim of moving to a full underwater TV (UWTV) assessment in the near future.

4.10.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 1991-2013 are presented in Table 4.11.1 and a time series of landings (2000-2013) is also shown in Figure 4.11.2. Landings gradually increased from 378 tonnes in 2005 to approximately 1305 tonnes in 2009. Landings declined in 2010 and 2011, increased again slightly in 2012 and declined sharply in 2013 to 121 tonnes.

In previous years, concerns were expressed over the reliability of the effort Figures provided for Scottish *Nephrops* trawlers; effort Figures were unrealistically low in some areas. Investigation of the issue revealed a problem in the MSS Marine Laboratory database, where only the effort expended in the first statistical rectangle visited by a vessel during a trip was being output. This did not affect landings. An extraction of days absent effort data by the Marine Scotland data unit in Edinburgh covering the four main trawl gears landing *Nephrops* into Scotland produced higher Figures which capture all the effort.

Trends in Scottish effort and LPUE are shown in Figure 4.11.3 and Table 4.11.2. Effort has fluctuated over the time period and declined from 2003 to 2006 and then increased until 2009 before falling again. The decrease may partly be explained as a result of re-

ductions in available effort imposed by the effort management regime and partly because this ground is more remote than a number of other *Nephrops* grounds and costs of steaming to and from the ground are likely to be high. LPUE showed an increasing trend from 2003 to 2009 followed by a slight drop in 2011 and has remained stable in the last couple of years.

Length compositions

Levels of both market and discard sampling are low and in 2012 and 2013 there were no samples taken. Sampled data are only available from the Scottish fleet. Mean sizes in the catch and landings for 2006 to 2011 are shown Table 4.11.3. Sampling has not been conducted in all quarters, so there is potential bias in these results.

Natural mortality, maturity at age and other biological parameters

No specific data are available for this functional unit, but there may be potential to adapt parameters from other functional units which have apparently similar biological characteristics.

Research vessel data

Marine Scotland Science (MSS) have carried out UWTV surveys of the Devil's Hole area opportunistically over the past 10 years. Since 2009, VMS data have been used to define the location of the survey stations. It is not known how station locations were selected on the earlier surveys in this area. It was not possible to survey FU 34 in 2013 but it is expected that this FU will be visited in the 2014 UWTV survey.

4.10.6 Data analyses

A density distribution map of these surveys is shown in Figure 4.11.4 with the size of the symbol reflecting the *Nephrops* burrow density. Table 4.11.4 and Figure 4.11.5 show the time series of mean burrow densities and 95 % confidence intervals.

The use of the UWTV surveys for *Nephrops* in the provision of advice was extensively reviewed by WKNEPH (ICES, 2009). The first step in obtaining an estimate of absolute abundance is to raise the density estimates using an estimate of the area of stock distribution.

For functional units 7-9, the area of BGS suitable sediment is used to raise the density to total abundance. At the Devil's Hole this area is calculated as just over 4000 km^2. Previous work presented in Campbell et al. (2009) has shown BGS maps to be inaccurate in some areas. At the Devil's Hole, differences were found between BGS sediment types and actual sediment composition obtained by particle size analysis of sediment samples from MSS surveys. (SGNEPS report, ICES 2010). Given the apparent narrowness of some of the trenches in the area, one potential explanation for the mismatch is that the original BGS sediment samples on which maps are based were taken at too coarse a resolution to pick out the narrow patches of mud.

Given these uncertainties in spatial distribution, the spatial extent of the fishery was further investigated at the latest benchmark (WKNEPH, 2013). Figure 4.11.6 shows the BGS map overlaid with vessel monitoring system (VMS) data from Scottish *Nephrops* vessels from 2007-2011. It is evident that not all of the 'muddy sand' area is being fished. It is not clear whether this is due to an absence of *Nephrops* or just very low densities over much of the larger patch of BGS defined 'muddy sand'. In addition there are areas of high VMS density which fall outwith the BGS mud sediments, further suggesting that the BGS map of this area may be incomplete.

The VMS data revealed that the fished area varies quite significantly between years. However, given that the spatial extent of suitable habitat for *Nephrops* is likely to remain stable from year to year, the benchmark Workshop (2013) agreed that the entire data set (all years) should be considered in the calculation of the area of spatial extent. A number of different approaches were investigated which made use of all the VMS data:

- area of polygons estimated from alpha convex hull analysis of combined (2007-2011) data
- average of annual area estimates
- area of intersecting annual polygons
- area of union of annual polygons

The alpha convex hull analysis of the combined data set resulted in a much increased area estimate (and potentially overestimated) of over 2500 km^2 and included much of the area in the northeast where the VMS points are too sparsely distributed to be included in the convex hull analysis conducted on an annual basis. The increased density of points resulting from the amalgamation of years of data means that this area (northeast) is no longer excluded due to low intensity of points by the alpha convex hull method with α=0.01. The area of the intersecting annual polygons is relatively low resulting from the large number of relatively small mud patches which are not consistently fished from year to year. An alternative approach (agreed by WKNEPH) making use of the full set of VMS data is to use the union of the estimated annual polygons. The resulting set of polygons is shown in Figure 4.11.7.

Year	Area (km2)
2007	1060
2008	1130
2009	1283
2010	980
2011	664
average	1023
union	1753
intersect	457

While considering the fished area, a number of additional areas of fishing activity were identified to the south of the previously defined area – in statistical rectangles 39F0 and 40F0. These contribute only a small amount in terms of total area (~100 km^2) and landings and are therefore currently not included in the spatial extent of the stock.

The spatial extent across rectangles 41-43F0-F1 is estimated as 1753 km^2.

4.10.7 Historical stock trends

Scottish landings from this area have risen substantially over the last ten years but fell in more recent years. Estimates of mean density in the stock have declined from 2009 to 2012, but remain slightly higher than in 2003, although this may be due to the change is survey sampling design, with a greater proportion of stations in the western trenches since 2009, producing the high densities.

4.10.8 Recruitment estimates

There are no recruitment estimates for this FU.

4.10.9 MSY considerations

ohort analysis, and therefore Fmsy proxy harvest rates have not been calculated for this functional unit.

4.10.10 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.10.11 Status of the stock

The current state of the stock is unknown.

4.10.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. Management at the Functional Unit level could provide the controls to ensure that catch opportunities and effort were compatible and in line with the scale of the resource.

There is a by-catch of other species in the Devil's Hole area. It is important that efforts are made to ensure that unwanted by-catch is kept to a minimum in this fishery. Current efforts to reduce discards and unwanted by-catches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The advice guidance and category classification for data-limited stocks (DLS) was addressed at WKLIFE2 (ICES, 2012). The methodology for DLS *Nephrops* stocks is further described in the 2013 Benchmark report (WKNEPH, 2013). Following the procedure outlined (section 3.1.2), an estimate of the total *Nephrops* grounds was used to give a likely envelope for the total abundance of *Nephrops* in the FU 34 (see text table below). UWTV survey information on the mean density of *Nephrops* (0.13 *Nephrops*/m^2, rounded to 0.15 in the table below),from the most recent UWTV survey (2012), was used together with the mean weight (average 2007-2010) and discard percentage (average 2008-2011). The 2012 survey shows that density is relatively low at 0.13 *Nephrops*/m^2. The advice for 2013 and 2014 was based on the recent average landings and recommended landings were of no more than 600 tonnes. In 2014 the table was updated to include the latest range of values for the calculation of the average landings and catch advice based on the discard levels previously observed. Landings of 600 tonnes (advice given in 2012 for 2013 and 2014) result in harvest ratio of 8.2%. To reduce the potential harvest ratio to a more precautionary level, a value of 383 tonnes based on the recent landings average (2011-2013) was proposed. This would equate to a harvest ratio of 5.3% which is below the range of harvest ratios observed for other North Sea functional units (8-16%). The proposed advice for 2015 and 2016 is 383 tonnes. In line with the advice for other stocks, discard (survival assumed to be 0%, mean weight in discards estimated from Fladen, 2008-2010) and total catch weight expected under the land all policy were added to the table.

	Catches	landings	Discards	Density (Nephrops per m2)							
Basis				0.05	0.1	0.15	0.2	0.3	0.4	0.6	0.8

0.5 * Average	337	315	22	13.0 %	6.5%	4.3%	3.2%	2.2 %	1.6 %	1.1 %	0.8 %
Recent average (2011-2013)	410	383	27	15.8 %	7.9%	5.3%	3.9%	2.6 %	2.0 %	1.3 %	1.0 %
-20%*2012 advice	513	480	33	19.8 %	9.9%	6.6%	4.9%	3.3 %	2.5 %	1.6 %	1.2 %
-15%*2012 advice	546	510	36	21.0 %	10.5 %	7.0%	5.3%	3.5 %	2.6 %	1.8 %	1.3 %
	615	575	40	23.7 %	11.9 %	7.9%	5.9%	4.0 %	3.0 %	2.0 %	1.5 %
SALY (Advice for 2013-2014)	642	600	42	24.7 %	12.4 %	8.2%	6.2%	4.1 %	3.1 %	2.1 %	1.5 %
Average (2004-2013)	673	629	44	25.9 %	13.0 %	8.6%	6.5%	4.3 %	3.2 %	2.2 %	1.6 %
Maximum	1396	1305	91	53.8 %	26.9 %	17.9 %	13.5 %	9.0 %	6.7 %	4.5 %	3.4 %

Area: 1753 km^2

Mean weight in landings: 31.76 g (2007-2010, from WKNEPH, 2013)

Mean weight in discards: 14.94 g (2008-2010, from Fladen)

Discard rate: 12.9% (2008-2011, from WKNEPH, 2013). Discard survival assumed to be 0%

SAbsolute correction factor = 1.40 (WKNEPH, 2013)

Table 4.2.1. Nominal landings (tonnes) of *Nephrops* in Sub-area IV, 1984 – 2013, as officially reported to ICES.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Belgium	638	679	344	437	500	574	610	427	384	418	304	410	185	311	238
Denmark	7	50	323	479	409	508	743	880	581	691	1128	1182	1315	1309	1440
Faeroe Islands	-	-	-	0	0	0	0	0	0	1	3	12	0	1	1
France	-	-	-	7	0	0	0	0	0	0	0	0	0	0	0
Germany	.	.	.	0	0	0	0	2	2	16	24	16	69	64	58
Germany (Fed. Rep.)	5	4	5	1	2	1	2	0	0	0	0	0	0	627	
Netherlands	-	-	-	0	0	0	9	3	134	131	159	254	423	64	6945
Norway	1	1	1	2	17	17	46	117	125	107	171	74	83	1	93
Sweden	-	1	-	0	0	0	0	4	0	1	1	1	0		3
UK (Eng + Wales + NI)	.	.	.	0	0	2938	2332	1955	1451	2983	3613	2530	2462	2206	2094
UK (Eng + Wales)	1477	2052	2002	2173	2397	0	0	0	0	0	0	0	-	-	8980
UK (Scotland)	4158	5369	6190	5304	6527	7065	6871	7501	6898	8250	8850	10018	8981	10466	13602
UK	-	-	-	-	-	-	-	-	-	-	-	-	-		
Total	6286	8156	8865	8403	9852	11103	10613	10889	9575	12598	14253	14497	13518	15049	13602

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	350	252	283	284	229	213	180	214	205	200	265	115	295	374
Denmark	1963	1747	1935	2154	2128	2244	2339	2024	1408	1078	875	603	828	728
Faeroe Islands	1	0	-	-	-	-	-	-	-	-	-	-		
France	0	0	-	-	-	-	-	-	-	-	-	+		+
Germany	104	79	140	125	50	50	109	288	602	266	410	373	552	385
Netherlands	662	572	851	966	940	918	1019	982	1147	737	882	701	1012	1024
Norway	144	147	115	130	100	93	132	96	99	143	139	123	70	75
Sweden	4	37	26	14	1	1	3	1	5	26	2	1	1	1

UK (Eng + Wales + NI)	2431	2210	2691	1964	2295	2241	3236	4937	3295	1679	3437	-		
UK (Scotland)	10715	9834	9681	11045	10094	12912	10565	16165	17930	17960	18587	-		
UK	-	-	-	-	-	-		-	-	-	-	18941	14190	10976
Total	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20857	16948	13541

	2013
Belgium	287
Denmark	387
Faeroe Islands	0
France	0
Germany	425
Netherlands	911
Norway	62
Sweden	0
UK (Eng + Wales + NI)	-
UK (Scotland)	-
UK	8605
Total	10677

* **Landings data for 2013 are preliminary.**

Table 3.1.2 Summary of *Nephrops* landings from the ICES area, by Functional Unit , 1991-2008.

Year	FU 5	FU 6	FU 7	FU 8	FU 9	FU 10	FU 32	FU 33	FU 34	Other **	Total
1981		1073	373	1006	1416	36				76	3980
1982		2524	422	1195	1120	19				157	5437
1983		2078	693	1724	940	15				101	5551
1984		1479	646	2134	1170	111				88	5628
1985		2027	1148	1969	2081	22				139	7386
1986		2015	1543	2263	2143	68				204	8236
1987		2191	1696	1674	1991	44				195	7791
1988		2495	1573	2528	1959	76				364	8995
1989		3098	2299	1886	2576	84				233	10176
1990		2498	2537	1930	2038	217				222	9442
1991	862	2063	4223	1404	1519	196				560	10827
1992	612	1473	3363	1757	1591	188				401	9385
1993	721	3030	3493	2369	1808	376	339	160		434	12730
1994	503	3683	4569	1850	1538	495	755	137		703	14233
1995	869	2569	6440	1763	1297	280	489	164		844	14715
1996	679	2483	5217	1688	1451	344	952	77		808	13699
1997	1149	2189	6171	2194	1446	316	760	276		662	15163
1998	1111	2177	5136	2145	1032	254	836	350		694	13735
1999	1244	2391	6521	2205	1008	279	1119	724		988	16479
2000	1121	2178	5569	1785	1541	275	1084	597		900	15050
2001	1443	2574	5541	1528	1403	177	1190	791		1268	15915
2002	1231	1954	7247	1340	1118	401	1170	861		1383	16705
2003	1144	2245	6294	1126	1079	337	1089	929		1390	15633
2004	1070	2153	8729	1658	1335	228	922	1268		1224	18587
2005	1099	3094	10685	1990	1605	165	1089	1050		1120	21897
2006	974	4903	10791	2458	1803	133	11033	1288		1249	24627
2007	1294	2966	11910	2652	1842	155	755	1467		1637	24678
2008	963	1218	12240	2450	1514	173	675	1444		1673	22350
2009	728	2703	13327	2662	1067	89	477	1163		2367	24583
2010	959	1443	12825	1871	1032	38	407	806	757	709****	20847
2011	1053	2070	7558	1888	1391	69	395	1191	433	1166*****	17214
2012	1240	2460	4369	2091	860	13	310	1084	597	608****	13632
2013*	1050	2982	2959	1501	655	15	191	946	121	409	10829

*** Provisional**

**** Includes IIIa.**

*****Devil's Hole landings only separated from 2011.**

***** *695t in IV and 14t in IIIa**

******IV only**

Table 4.3.1 *Nephrops* in FU 5. Nominal Landings (tonnes) of *Nephrops*, 1991-2010, as reported to the WG.

	Belgium	Denmark	Netherlands	Germany	UK	Total**
1991	682	176	na		4	862
1992	571	22	na		19	612
1993	694	20	na		7	721
1994	494	0	na		9	503
1995	641	77	148		3	869
1996	266	41	317		55	679
1997	486	67	540		56	1149
1998	372	88	584	39	28	1111
1999	436	53	538	59	158	1244
2000	366	83	402	52	218	1121
2001	353	145	553	114	278	1443
2002	281	94	617	88	151	1231
2003	265	36	661	24	158	1144
2004	171	39	646	16	198	1070
2005	109	87	654	51	198	1099
2006	77	24	444	99	330	974
2007	75	3	464	201	551	1294
2008	49	29	268	108	509	963
2009	52	3	288	98	287	728
2010	48	5	354	140	411	959
2011	60	18	480	145	350	1053
2012	129	0	497	121	493	1240
2013	142	1	447	168	292	1050

*** provisional na = not available**

**** Totals for 1991-94 exclusive of landings by the Netherlands**

Table 4.3.2. *Nephrops* in FU5. Mean length (mm) by sex in landings from Dutch sampling.

	Mean length (mm)	
Year	Females	Males
2003	38.43	38.43
2004	37.68	39.21
2005	36.85	37.47
2006	37.33	37.85
2007	38.05	38.9
2008	38.71	39.81
2009	38.18	39.91
2010	41.1	41.1
2011	41.2	41.1
2012	39.7	40.8
2013	na	na

Table 4.3.3 *Nephrops* in FU5. Landings, effort and LPUE for directed fisheries.

	Belgium (1)			Netherlands (2)			Denmark (3)			England		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
	tons	000 hrs	kg/hour	tons	days at sea	kg/day	tons	days at sea	kg/day	tons	Hrs Fished	Kg/hr
1991												
1992												
1993												
1994												
1995												
1996							34	132	261			
1997	486	57.6	8.4				24	59	412			
1998	372	66.3	5.6				78	174	447			
1999	436	44.0	9.9				44	107	408			
2000	366	47.8	7.7	402	7936	50.7	76	247	306	43	1416	30.5
2001	353	38.3	9.2	553	9797	56.5	78	283	275	73	2349	31.2
2002	281	32.3	8.7	617	8999	68.6	47	200	237	7	360	20.4
2003	265	34.6	7.7	661	9043	73.1	33	132	247	21	509	42.2
2004	171	22.8	7.5	646	8676	74.5	36	149	242	14	249	57.8
2005	109	13.4	8.1	654	7950	82.3	87	297	291	59	1193	49.4
2006	77	8.5	9.1	444	6784	65.4	24	66	366	171	3320	51.4
2007	75	10.8	6.9	464	6859	67.6	3	13	254	176	2494	70.5
2008	49	9.0	5.4	268	4976	53.9	29	41	777	239	3787	63.1
2009	52	10.8	4.8	288	5909	48.7	3	9	324	139	2337	59.6
2010	48	7.8	6.1	354	5735	61.7	5	14	366	135	1576	86

2011	60	11.0	5.5	480	5811	82.6	18	13	1362	75	980	77
2012	129	13.9	9.3	497	5244	94.8	no data	no data	no data	81	971	83
2013	142	12.1	11.7	447	4886	91.5	1	7.5	133	18	399	46
*** provisional na = not available**												
(1) Vessels directed towards Nephrops at least 10 months per year												
(2) All vessels operating in FU 5, regardless of directedness towards Nephrops												
(3) Logbook records from vessels operating in FU 5, with mesh size >=70 mm with Nephrops in catches												

Table 4.4.1 *Nephrops* in FU 6. Nominal Landings (tonnes) of *Nephrops*, 1981-2010, as reported to the WG.

Year	UK England & N. Ireland	UK Scotland	Sub total	Other countries**	Total
1981	1006	67	1073	0	1073
1982	2443	81	2524	0	2524
1983	2073	5	2078	0	2078
1984	1471	8	1479	0	1479
1985	2009	18	2027	0	2027
1986	1987	28	2015	0	2015
1987	2158	33	2191	0	2191
1988	2390	105	2495	0	2495
1989	2930	168	3098	0	3098
1990	2306	192	2498	0	2498
1991	1884	179	2063	0	2063
1992	1403	60	1463	10	1473
1993	2941	89	3030	0	3030
1994	3530	153	3683	0	3683
1995	2478	90	2568	1	2569
1996	2386	96	2482	1	2483
1997	2109	80	2189	0	2189
1998	2029	147	2176	1	2177
1999	2197	194	2391	0	2391
2000	1947	231	2178	0	2178
2001	2319	255	2574	0	2574
2002	1739	215	1954	0	1954
2003	2031	214	2245	0	2245
2004	1952	201	2153	0	2153
2005	2936	158	3094	0	3094
2006	4430	434	4864	39	4903
2007	2525	437	2962	4	2966
2008	976	244	1220	0	1220
2009	2299	414	2713	0	2713
2010	1258	185	1443	0	1443
2011	1806	250	2056	14	2070
2012	2177	256	2433	27	2460
2013*	2666	305	2971	11	2982

*** provisional na = not available**

**** Other countries includes Ne, Be and Dk**

Table 4.4.2: *Nephrops* in FU 6: Landings and effort by English vessels targeting *Nephrops*.

Year	Landings (tonnes)	Effort (000 hrs)	LPUE (Kg per hr)
1994	2449	90.882	26.9
1995	1790	60.078	29.8
1996	1830	54.996	33.3
1997	1580	46.016	34.3
1998	1124	29.931	37.6
1999	1294	40.048	32.3
2000	1070	30.484	35.1
2001	1100	39.093	28.1
2002	1054	33.193	31.7
2003	1376	45.072	30.5
2004	1208	36.945	32.7
2005	1586	43.704	36.3
2006	1944	55.054	35.3
2007	1093	51.12	21.4
2008	644	37.595	17.1
2009	1194	42.537	28.1
2010	795	44.71	17.8
2011	967	38.259	25.3
2012	1057	39.841	26.5
2013 *	1107	45.493	24.3
* provisional			

Table 4.4.3 *Nephrops* in FU 6: Mean sizes in catches and landings by sex.

	Catches		Landings	
Year	Males	Females	Males	Females
1985	30.1	28.5	35.4	33.8
1986	31.7	30.2	35.3	33.7
1987	28.6	27	35.3	33.3
1988	28.7	27.3	35	33.9
1989	29	28.2	32.4	31.9
1990	27.1	27.4	31.8	31.3
1991	28.9	27.1	33.5	33.1
1992	30.8	29	33	31.9
1993	32.1	28.7	33.4	30.1
1994	30.5	27.7	33.8	30.5
1995	28.4	27.4	33.8	31.6
1996	29.8	28.2	34.5	32.1
1997	29.9	29.6	33.5	32.1
1998	30	28.9	34.9	33.7
1999	29.6	27.5	35.1	33.6
2000	27.2	26.8	31.1	31.3
2001	26.2	26.3	30.6	31.3
2002	28.0	26.9	30.9	30.0
2003	29.0	27.1	31.7	30.6
2004	29.2	27.0	32.3	30.6
2005	29.7	29.4	32.1	32.2
2006	29.0	30.3	31.4	32.4
2007	31.3	30.7	33.3	32.6
2008	31.5	31.1	33.5	33.3
2009	30.0	31.0	32.1	33.3
2010	31.2	31.4	32.8	33.2
2011	32.0	31.6	33.7	33.6
2012	30.8	32.0	33.2	34.5
2013*	29.6	32.4	32.0	35.3

*** provisional**

na = not available

Table 4.4.4 *Nephrops* in FU 6: Results of the UWTV survey.

Year	Stations	Season	Mean density	Absolute Abundance	95% confidence interval	Method
			burrows/m²	millions	millions	
1997	87	Autumn	0.46	1500	125	Box
1998	91	Autumn	0.33	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.56	1685	67	Box
2002	37	Autumn	0.33	1048	112	Box
2003	73	Autumn	0.33	1085	90	Box
2004	76	Autumn	0.43	1377	101	Box
2005	105	Autumn	0.49	1657	148	Box
2006	105	Autumn*	0.37	1244	114	Box
2007	105	Autumn*	0.28	858	23	Geostatistics
2008	95	Autumn*	0.31	987	39	Geostatistics
2009	76	Autumn*	0.22	682	38	Geostatistics
2010	95	Autumn*	0.25	785	21	Geostatistics
2011	97	Autumn*	0.28	878	17	Geostatistics
2012	97	Autumn*	0.24	758	13	Geostatistics
2013	110	Summer	0.23	706	18	Geostatistics

Table 4.4.5 *Nephrops* in FU 6: Historical harvest rate determination.

Year	TV abundance index	Landings (t)	Discard rate	Mean Weight Landings(g)	Mean Weight Discards (g)	N removed	Observed Harvest Rate
2001	1685	2574	66.60%	20.67	9.62	373	22.1%
2002	1048	1953	46.10%	20.00	9.50	181	17.3%
2003	1085	2245	42.10%	21.89	9.56	177	16.3%
2004	1377	2152	41.70%	23.14	9.22	160	11.6%
2005	1657	3094	34.50%	23.58	10.32	200	12.1%
2006	1244	4858	31.30%	22.53	10.58	314	25.2%
2007	858	2966	25.00%	24.95	10.89	159	18.5%
2008	987	1213	24.90%	26.63	10.97	61	6.1%
2009	682	2711	29.30%	24.45	10.54	157	23.0%
2010	785	1443	23.00%	25.18	11.74	74	9.5%
2011	878	2072	22.60%	27.05	11.02	99	11.3%
2012	758	2457	27.42%	27.30	10.16	124	16.4%
2013	706	2982	29.80%	27.60	9.80	154	21.8%

Table 4.5.1 *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981-2013, as reported to the WG.

	UK Scotland					Other	Total
	Nephrops	Other	Creel	Sub-total	Denmark	countries	
Year	trawl	trawl				*	
1981	304	68	0	372	0	0	372
1982	381	40	0	421	0	0	421
1983	588	105	0	693	0	0	693
1984	552	94	0	646	0	0	646
1985	1020	120	0	1140	7	0	1147
1986	1401	92	0	1493	50	0	1543
1987	1023	349	0	1372	323	0	1695
1988	1309	185	0	1494	81	0	1575
1989	1724	410	0	2134	165	0	2299
1990	1703	598	0	2301	236	3	2540
1991	3021	772	0	3793	424	6	4223
1992	1809	1164	0	2973	359	31	3363
1993	2031	1234	0	3265	224	3	3492
1994	1816	2356	0	4172	390	6	4568
1995	3568	2389	19	5976	439	4	6419
1996	2338	2578	7	4923	286	1	5210
1997	2712	3221	0	5933	235	2	6170
1998	2290	2673	0	4963	173	0	5136
1999	2860	3546	0	6406	96	16	6518
2000	2916	2546	0	5462	103	5	5570
2001	3540	1936	0	5476	64	2	5542
2002	4511	2546	0	7057	173	15	7245
2003	4175	2033	0	6208	82	4	6294
2004	7274	1319	1	8594	136	0	8730
2005	8849	1508	5	10362	321	1	10684
2006	9470	1026	1	10497	283	11	10791
2007	11055	734	0	11789	119	3	11911
2008	11432	666	0	12098	133	8	12239
2009	12688	499	0	13187	130	10	13327
2010	12544	288	0	12832	124	12	12968
2011	7367	128	0	7495	64	<0.5	7559
2012	4257	81	0	4338	75	2	4415
2013*	2745	201	0	2946	5	8	2959

*** provisional na = not available**

****Other countries includes Belgium, Norway and UK England**

Table 4.5.2 *Nephrops*, Fladen (FU 7): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2013.

Year	Landings	Effort	LPUE
2000	5462	35.4	154.3
2001	5476	28.6	191.5
2002	7057	28.6	246.7
2003	6208	22.0	282.2
2004	8593	21.6	397.8
2005	10357	23.6	438.9
2006	10496	22.8	460.4
2007	11789	21.6	545.8
2008	12098	22.9	528.3
2009	13187	21.2	622.0
2010	12832	21.0	611.0
2011	7495	15.3	489.9
2012	4338	12.0	361.5
2013*	2946	11.9	247.6

Table 4.5.3 *Nephrops*, Fladen (FU 7): Logbook recorded effort (kW days) and LPUE (kg/kW day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, and estimated total effort by Danish trawlers, 1991-2013.

	Logbook data	
Year	Effort	LPUE
1991	2576957	0.165
1992	2110696	0.170
1993	852161	0.263
1994	1068924	0.365
1995	745766	0.589
1996	564297	0.507
1997	285987	0.822
1998	242403	0.714
1999	173983	0.552
2000	280850	0.367
2001	287911	0.222
2002	512686	0.337
2003	187095	0.438
2004	271227	0.501
2005	430272	0.746
2006	499202	0.567
2007	160590	0.741
2008	106969	1.243
2009	93746	1.387
2010	174121	0.712

2011	65646	0.975
2012	125835	0.596
2013	123745	0.040

Table 4.5.4 *Nephrops*, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1993-2013.

	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
Year	Males	Females	Males	Females	Males	Females
1993	na	na	30.4	29.6	38.7	38.2
1994	na	na	30.0	28.9	39.2	37.8
1995	na	na	30.6	29.8	39.9	38.1
1996	na	na	30.4	29.1	40.6	38.8
1997	na	na	30.2	29.1	40.9	38.8
1998	na	na	30.8	29.4	40.7	38.3
1999	na	na	30.9	29.6	40.5	38.5
2000	30.7	30.1	31.2	30.5	41.3	38.7
2001	30.1	29.4	30.7	29.7	39.6	38.0
2002	30.6	30.0	31.3	30.7	39.5	38.3
2003	30.9	29.8	31.2	30.1	40.0	38.1
2004	30.8	29.9	31.1	30.2	40.1	38.7
2005	30.9	30.0	31.2	30.1	40.1	38.2
2006	30.3	29.7	30.8	30.0	40.7	38.2
2007	29.8	29.2	30.4	29.5	40.8	38.8
2008	29.7	28.6	29.8	28.7	41.8	39.1
2009	30.7	29.5	31.2	29.9	39.7	38.7
2010	30.4	29.0	30.5	29.0	39.8	38.4
2011	31.7	29.6	31.7	29.6	41.2	38.6
2012	31.9	30.6	31.9	30.6	41.8	38.5
2013	31.4	30.2	31.4	30.2	42.2	39.0

na = not available

Table 4.5.5 *Nephrops*, FUs 7-9 and 34 (Fladen, Firth of Forth, Moray Firth and Devil's Hole. Mean weight (g) in the landings.

Year	Fladen	Firth of Forth	Moray Firth	Devil's Hole	Noup
1990	31.59	20.29	20.05	na	na
1991	26.50	20.03	18.53	na	na
1992	29.61	20.96	23.49	na	na
1993	25.38	24.30	23.42	na	na
1994	23.72	19.51	22.25	na	na
1995	27.51	19.55	20.59	na	na
1996	29.82	20.81	21.40	na	na
1997	32.08	18.87	20.43	na	23.94
1998	31.37	18.23	20.47	na	20.58
1999	30.55	20.05	21.79	na	21.23
2000	36.35	21.83	25.44	na	30.81
2001	25.10	21.22	24.18	na	25.30
2002	27.93	19.62	27.68	na	27.95
2003	30.15	22.31	23.32	na	20.05
2004	30.98	22.45	27.57	na	28.98
2005	29.05	22.33	23.84	na	24.13
2006	29.25	21.43	22.34	22.93	25.97
2007	26.63	20.97	23.04	26.27	25.58
2008	28.18	17.23	25.29	30.08	33.18
2009	28.20	19.41	23.46	39.62	49.38
2010	26.38	19.76	26.94	31.08	51.93
2011	36.17	19.75	21.63	42.05	45.73
2012	36.91	21.66	23.16	na	34.48
2013	34.90	19.30	24.95	na	43.56
Mean (11-13)	35.99	20.24	23.25	31.76*	-

*** Mean weight for Devil's Hole based on 2007-2010 range (WKNEPH, 2013)**

na = not available

Table 4.5.6. *Nephrops*, Fladen (FU 7): Results of the 1992-2013 TV surveys (not bias-adjusted).

		Abundance	Mean density	95% confidence interval
Year	Stations	millions	burrows/m2	millions
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996	No survey			
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	336

Table 4.5.7. *Nephrops*, Fladen Ground (FU 7):Summary of TV results for most recent 3 years (2011-2013) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.

Stratum (ranges of % silt clay)	Area (km2)	Number of Stations	Mean burrow density (no./m2)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2011 TV survey							
>80	3248	11	0.196	0.001	639	1369	0.021
55<80	4967	16	0.173	0.008	862	12607	0.198
40<55	4304	11	0.149	0.011	641	18344	0.288
<40	15634	35	0.079	0.004	1241	31481	0.493
Total	28153	73			3382	63801	1
2012 TV survey							
>80	3248	10	0.201	0.004	654	3817	0.074
55<80	4967	14	0.129	0.004	641	7704	0.149
40<55	4304	13	0.112	0.009	481	12390	0.239
<40	15634	33	0.062	0.004	972	27841	0.538
Total	28153	70			2748	51753	1
2013 TV survey							
>80	3248	9	0.183	0.001	593	1867	0.049
55<80	4967	14	0.166	0.007	823	11739	0.309
40<55	4304	15	0.115	0.005	493	5982	0.158
<40	15634	33	0.064	0.002	993	18347	0.484
Total	28153	71			2902	37934	1

Table 4.5.8 *Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2013.

year	Adjusted abundance (millions)	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard
2003	5547	4.1	209	24	226	6294	349	10.1	30.15	14.83	7.8
2004	5725	5.4	282	34	307	8730	506	10.6	30.98	15.06	8.2
2005	4325	9.3	368	46	403	10684	823	11.2	29.05	17.74	8.6
2006	4862	8.4	369	54	409	10791	798	12.7	29.25	14.87	9.8
2007	7017	7	447	55	488	11911	747	10.9	26.63	13.67	8.4
2008	7360	6.1	434	18	448	12239	257	3.9	28.18	14.54	3
2009	5457	9.4	473	51	511	13327	707	9.7	28.2	13.85	7.5
2010	5224	9.9	492	34	517	12968	560	6.5	26.38	16.44	4.9
2011	3382	6.2	209	0	209	7559	0	0	36.17	NA	0
2012	2748	4.7	128	0	128	4415	0	0	36.91	NA	0
2013	2902	3.1	89	0	89	2959	0	0	34.9	NA	0

Table 4.6.1 *Nephrops*, Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981-2013, as reported to the WG.

Year	UK Scotland				UK	
	Nephrops trawl	Other trawl	Creel	Sub-total	(E, W & NI)	Total **
1981	947	60	0	1007	0	1007
1982	1138	57	0	1195	0	1195
1983	1681	43	0	1724	0	1724
1984	2078	56	0	2134	0	2134
1985	1907	61	0	1968	0	1968
1986	2204	59	0	2263	0	2263
1987	1583	90	2	1675	0	1675
1988	2455	74	0	2529	0	2529
1989	1834	53	0	1887	1	1888
1990	1900	30	0	1930	1	1931
1991	1362	43	0	1405	0	1405
1992	1715	41	0	1756	0	1756
1993	2349	17	0	2366	2	2368
1994	1827	17	0	1844	6	1850
1995	1707	53	0	1760	2	1762
1996	1621	66	0	1687	0	1687
1997	2136	55	0	2191	2	2193
1998	2105	37	0	2142	2	2144
1999	2193	10	1	2204	3	2207
2000	1775	9	0	1784	1	1785
2001	1484	34	0	1518	9	1527
2002	1302	31	1	1334	6	1340
2003	1116	8	0	1124	3	1127
2004	1650	4	0	1654	3	1657
2005	1974	0	4	1978	11	1989
2006	2438	3	12	2453	5	2458
2007	2627	10	7	2644	7	2651
2008	2435	2	8	2445	5	2450
2009	2620	8	26	2654	9	2663
2010	1923	5	13	1941	9	1950
2011	1789	6	89	1884	5	1889
2012	1944	17	126	2087	42	2129
2013*	1429	3	57	1489	12	1501

* provisional na = not available

** There are no landings by other countries from this FU

Table 4.6.2 *Nephrops*, Firth of Forth (FU 8): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2013

Year	Landings	Effort	LPUE
2000	1784	10.5	169.8
2001	1518	11.5	131.8
2002	1333	10.4	128.2
2003	1124	8.3	135.8
2004	1654	9.5	174.0
2005	1974	7.7	256.2
2006	2441	6.2	395.4
2007	2637	6.4	411.5
2008	2437	6.4	378.4
2009	2628	5.9	449.0
2010	1928	5.1	381.5
2011	1795	4.6	389.0
2012	1961	5.1	387.7
2013*	1432	4.0	358.0

*** provisional na = not available**

Table 4.6.3 *Nephrops*, Firth of Forth (FU 8): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1981-2013

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31.0	39.7	38.7
1982	na	na	30.4	30.1	40.0	39.1
1983	na	na	31.1	30.8	40.2	38.7
1984	na	na	30.3	29.7	39.4	38.4
1985	na	na	30.6	29.9	39.4	38.2
1986	na	na	29.7	29.2	39.1	38.5
1987	na	na	29.9	29.6	39.1	38.2
1988	na	na	28.5	28.5	39.1	39.0
1989	na	na	29.2	28.9	38.7	38.9
1990	28.3	27.2	29.8	28.6	38.3	38.8
1991	28.7	27.5	29.8	28.7	38.3	38.7
1992	29.5	27.9	30.2	28.7	38.1	38.7
1993	28.7	28.0	30.3	29.5	39.0	38.6
1994	25.7	25.1	29.1	28.5	38.8	37.8
1995	27.9	27.1	29.4	28.9	38.7	37.9
1996	28.0	27.4	29.8	28.8	38.6	38.6
1997	27.2	27.0	29.2	28.7	38.8	38.2
1998	27.7	26.4	29.0	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38.0	37.9

2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011	28.6	27.5	30.0	28.3	38.8	38.2
2012	28.4	28.0	30.4	29.3	39.0	38.1
2013	28.3	27.4	29.6	28.8	38.8	37.9
	na = not available					

Table 4.6.4. ***Nephrops*****, Firth of Forth (FU 8): Results of the 1993-2013 TV surveys. Bias ajusted**

Year	Stations	Mean Density burrows/m²	Abundance millions	95% conf interval millions
1993	37	0.61	555	142
1994	30	0.49	448	78
1995	no survey			
1996	27	0.41	375	88
1997	no survey			
1998	32	0.32	292	81
1999	49	0.51	463	78
2000	53	0.48	443	70
2001	46	0.46	419	79
2002	41	0.56	508	119
2003	36	0.84	767	138
2004	37	0.69	630	141
2005	54	0.78	710	143
2006	43	0.91	827	125
2007	49	0.76	692	132
2008	38	0.97	881	297
2009	45	0.80	732	142
2010	39	0.75	682	147
2011	45	0.58	533	87
2012	66	0.57	522	64
2013	51	0.73	668	125

Table 4.6.5. ***Nephrops*****, Firth of Forth (FU 8):Summary of TV results for most recent 3 years (2009-2013) showing strata surveyed, numbers of stations in each strata, and bias adjusted, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum	Area (km²)	Number of Stations	Mean burrow density (no./m²)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2011 TV survey							
M & SM	170	7	0.319	0.063	54	260	0.116
MS(west)	139	9	0.430	0.108	59	231	0.103
MS(mid)	211	10	0.653	0.064	137	281	0.125
MS(east)	395	19	0.714	0.180	282	1475	0.656
Total	915	45			533	2247	1
2012 TV survey							
M & SM	170	16	0.454	0.125	77	225	0.185
MS(west)	139	9	0.180	0.039	25	83	0.068

MS(mid)	211	17	0.671	0.114	142	299	0.245
MS(east)	395	24	0.705	0.094	279	614	0.502
Total	915	66			522	1222	1
2013 TV survey							
M & SM	170	10	0.477	0.342	81	992	0.213
MS(west)	139	8	0.568	0.214	79	518	0.111
MS(mid)	211	12	1.051	0.381	221	1409	0.302
MS(east)	395	21	0.725	0.235	286	1744	0.374
Total	915	51			668	4663	1

Table 4.6.6 *Nephrops*, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2013.

year	Adjusted abundance (millions)	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard
2003	767	12.4	51	59	95	1127	546	53.9	22.31	9.25	46.7
2004	630	16.4	74	40	103	1657	406	34.9	22.45	10.25	28.7
2005	710	19.4	89	65	138	1989	602	42.1	22.33	9.28	35.3
2006	827	26.7	115	142	221	2458	1510	55.2	21.43	10.67	48.1
2007	692	22.9	126	43	159	2651	614	25.3	20.97	14.34	20.3
2008	881	21.1	142	58	186	2450	796	29.1	17.23	13.65	23.5
2009	732	26	137	71	190	2663	573	34.1	19.41	8.09	27.9
2010	682	19.2	99	43	131	1950	407	30.2	19.76	9.55	24.5
2011	533	22.1	100	24	118	1889	231	19.5	19.75	9.56	15.3
2012	522	24.6	100	38	129	2129	379	27.2	21.66	10.1	21.9
2013	668	15.6	81	31	104	1501	301	27.4	19.3	9.82	22

Table 4.7.1 *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981-2013, as reported to the WG.

	UK Scotland				UK*	
Year		Other			England	
	Nephrops trawl	trawl	Creel	Sub-total		Total **
1981	1299	117	0	1416	0	1416
1982	1033	86	0	1119	0	1119
1983	850	91	0	941	0	941
1984	960	209	0	1169	0	1169
1985	1908	173	0	2081	0	2081
1986	1932	211	0	2143	0	2143
1987	1724	268	0	1992	0	1992
1988	1637	322	0	1959	0	1959
1989	2102	474	0	2576	0	2576
1990	1698	339	0	2037	0	2037

1991	1285	235	0	1520	0	1520
1992	1285	306	0	1591	0	1591
1993	1505	304	0	1809	0	1809
1994	1179	358	0	1537	0	1537
1995	967	312	0	1279	0	1279
1996	1084	364	1	1449	2	1451
1997	1103	343	0	1446	1	1447
1998	739	289	4	1032	0	1032
1999	813	194	2	1009	0	1009
2000	1341	196	2	1539	0	1539
2001	1186	213	2	1401	0	1401
2002	883	247	2	1132	0	1132
2003	873	196	11	1080	0	1080
2004	1222	103	8	1333	0	1333
2005	1526	64	12	1602	3	1605
2006	1751	42	11	1804	1	1805
2007	1818	17	6	1841	2	1843
2008	1444	68	3	1515	0	1515
2009	1033	31	2	1066	1	1067
2010	1026	28	9	1063	0	1063
2011	1358	23	9	1390	1	1391
2012	834	24	8	866	0	866
2013*	611	34	7	652	3	655
*** provisional na = not available**						
**** No landings by non UK countries from this FU**						

Table 4.7.2 *Nephrops*, Moray Firth (FU 9): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2013.

Year	Landings	Effort	LPUE
2000	1537	7.9	194.6
2001	1399	7.2	194.3
2002	1130	7.5	150.7
2003	1069	5.9	181.2
2004	1325	6.2	213.7
2005	1590	4.8	331.3
2006	1793	4.6	389.8
2007	1835	4.8	382.3
2008	1512	4.3	351.6
2009	1064	3.5	304.0
2010	1054	3.6	292.8
2011	1381	3.9	354.1
2012	858	3.1	276.8
2013*	645	3.0	215.0

Table 4.7.3 *Nephrops*, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1991-2013.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	30.5	28.2	39.1	37.7
1982	na	na	30.2	29.0	40.0	37.9
1983	na	na	29.9	29.1	40.6	38.3
1984	na	na	29.7	29.3	39.4	38.1
1985	na	na	28.9	28.7	38.7	37.8
1986	na	na	28.7	27.8	39.1	38.4
1987	na	na	29.0	28.3	39.4	38.6
1988	na	na	29.1	28.7	38.9	38.4
1989	na	na	29.8	28.8	40.1	39.4
1990	28.0	27.5	30.3	29.1	38.4	38.7
1991	28.3	27.4	30.1	28.6	38.2	38.2
1992	29.4	28.6	31.0	30.5	38.3	38.0
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31.0	39.4	37.5
1995	25.8	25.0	29.9	29.3	39.1	38.0
1996	29.3	28.4	30.6	29.7	38.5	38.0
1997	28.5	27.9	29.5	28.9	38.8	38.2
1998	28.7	28.2	30.1	29.3	38.8	38.2
1999	29.5	28.8	30.4	29.7	38.9	37.6
2000	29.8	29.1	31.5	30.6	39.2	38.3

2001	30.0	29.2	30.9	30.2	39.5	37.9
2002	27.2	27.0	31.2	30.9	41.0	38.7
2003	29.3	29.2	30.3	30.1	39.8	38.0
2004	29.3	28.4	31.3	30.8	39.0	39.2
2005	30.0	28.7	31.0	29.6	39.2	38.5
2006	29.7	28.9	30.6	29.6	39.3	38.6
2007	30.1	28.8	30.3	29.0	39.4	38.6
2008	29.3	27.7	30.2	28.2	39.8	40.2
2009	29.7	28.9	30.7	29.3	39.6	38.5
2010	29.7	29.1	31.1	30.5	40.0	38.9
2011	28.6	28.4	29.4	29.0	39.5	38.4
2012	29.5	29.1	30.5	29.9	39.2	38.5
2013	30.7	29.3	30.9	29.5	39.6	38.4
			na = not available			

Table 4.7.4 *Nephrops*, Moray Firth (FU 9): Results of the 1993-2013 TV surveys. Bias adjusted.

		Mean density	Abundance	95% confidence interval
Year	**Stations**	burrows/m²	millions	millions
1993	31	0.16	345	78
1994	29	0.32	702	176
1995	no survey			
1996	27	0.21	465	90
1997	34	0.12	262	55
1998	31	0.15	323	95
1999	52	0.18	400	87
2000	44	0.17	386	98
2001	45	0.16	345	112
2002	31	0.24	521	121
2003	32	0.33	730	314
2004	42	0.29	626	186
2005	42	0.40	869	198
2006	50	0.21	445	124
2007	40	0.24	531	156
2008	45	0.21	481	151
2009	50	0.19	415	140
2010	43	0.18	406	116
2011	37	0.17	372	160
2012	44	0.14	299	90
2013	55	0.21	469	106

Table 4.7.5 *Nephrops*, Moray Firth (FU 9):Summary of TV results for most recent 3 years (2011-2013) showing strata surveyed, numbers of stations in each strata, bias adjusted, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.

Stratum	Area (km^2)	Number of Stations	Mean burrow density ($no./m^2$)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2011 TV survey							
M & SM	169	2	0.09	0.00	15	5	0.001
MS(west)	682	8	0.32	0.12	220	7268	0.933
MS(mid)	698	12	0.08	0.00	56	145	0.019
MS(east)	646	15	0.13	0.01	82	374	0.048
Total	2195	37			373	7793	1
2012 TV survey							
M & SM	169	3	0.37	0.03	62	321	0.131
MS(west)	682	18	0.11	0.04	74	1009	0.412
MS(mid)	698	11	0.13	0.01	93	638	0.26
MS(east)	646	12	0.11	0.01	71	482	0.197
Total	2195	44			299	2450	1
2013 TV survey							
M & SM	169	3	0.22	0.06	37	580	0.17
MS(west)	682	18	0.22	0.06	148	1576	0.463
MS(mid)	698	18	0.23	0.01	160	300	0.088
MS(east)	646	16	0.19	0.04	124	950	0.279
Total	2195	55			469	3406	1

Table 4.7.6 *Nephrops*, Moray Firth (FU 9): Adjusted TV survey abundance, landings, discard rate (proportion by number), dead discard rate (proportion by number) and estimated harvest ratio 2003-2013.

Year	Adjusted abundance (millions)	Harvest ratio	Landings numbers	Discards numbers	Removals numbers	Landings (tonnes)	Discards (tonnes)	Discard rate	Mean weight in	Mean weight in	Dead discard
2003	730	7.1	46	7	52	1080	70	13.7	23.32	9.51	10.6
2004	626	10.5	48	23	66	1333	272	32.6	27.57	11.62	26.6
2005	869	8.8	67	12	76	1605	122	15	23.84	10.31	11.7
2006	445	20.1	81	12	90	1805	117	12.8	22.34	9.86	9.9
2007	531	16	80	7	85	1843	95	7.9	23.04	13.95	6
2008	481	13.7	60	8	66	1515	74	11.4	25.29	9.6	8.8
2009	415	11.6	45	4	48	1067	33	7.6	23.46	8.72	5.8
2010	406	11.5	39	10	47	1063	104	19.8	26.94	10.63	15.7
2011	372	18.9	63	10	70	1391	102	13.9	21.63	10.12	10.8
2012	299	13.7	37	6	41	866	54	13.2	23.16	9.72	10.3
2013	469	5.8	26	1	27	655	10	3.3	24.95	11.21	2.5

Table 4.8.1 *Nephrops*, Noup (FU 10), Nominal Landings (tonnes) of *Nephrops*, 1981-2013, as reported to the WG.

Year	Nephrops Trawl	Other trawl	Creel	Sub Total	Other UK	Total
1981	12	23	0	35	0	35
1982	12	7	0	19	0	19
1983	10	6	0	16	0	16
1984	76	35	0	111	0	111
1985	1	21	0	22	0	22
1986	45	22	0	67	0	67
1987	13	32	0	45	0	45
1988	23	53	0	76	0	76
1989	24	60	0	84	0	84
1990	101	117	0	218	0	218
1991	111	86	0	197	0	197
1992	58	130	0	188	0	188
1993	200	176	0	376	0	376
1994	307	187	0	494	0	494
1995	163	116	0	279	0	279
1996	181	164	0	345	0	345
1997	185	131	1	317	0	317
1998	184	72	0	256	0	256
1999	211	67	0	278	0	278
2000	196	78	0	274	0	274
2001	88	89	0	177	0	177
2002	246	157	0	403	0	403

2003	258	78	0	336	0	336
2004	174	54	0	228	0	228
2005	81	84	0	165	0	165
2006	44	89	0	133	0	133
2007	46	107	0	153	0	153
2008	74	98	0	172	0	172
2009	24	63	0	87	0	87
2010	4	35	0	39	0	39
2011	27	41	0	68	0	68
2012	2	11	0	13	0	13
2013*	4	11	0	15	0	15
* provisional						

Table 4.8.2 *Nephrops*, Noup (FU 10): landings (tonnes), effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2013.

Year	Landings	Effort	LPUE
2000	274	1.6	169
2001	177	1.4	128
2002	403	2.0	198
2003	336	1.4	234
2004	228	0.9	254
2005	165	0.7	226
2006	133	0.6	217
2007	153	0.6	259
2008	172	0.7	231
2009	87	0.9	100
2010	39	0.8	48
2011	68	0.8	88
2012	13	0.6	23
2013*	15	0.5	30
* provisional na = not available			

Table 4.8.3 *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997-2013. No females in samples in 2010.

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
1997	29.7	28.3	40.4	38.2
1998	30.4	29.8	38.8	38.6
1999	30.4	30.1	39.2	37.8
2000	31.8	30.1	38.2	39.1
2001	31.4	29.5	38.7	37.9
2002	30.8	29.9	39.7	38.5
2003	29.3	30.4	39.9	38.5
2004	31.4	30.0	40.2	38.8
2005	31.0	29.3	39.3	38.4
2006	30.8	30.2	40.4	38.7
2007	30.7	29.4	40.2	38.7
2008	31.9	30.6	40.3	39.3
2009	33.2	33.2	42.6	42.7
2010	33.3	na	42.6	na
2011	32.8	32.7	43.3	40.1
2012	32.4	31.8	40.7	40.1
2013	34.0	32.4	43.7	39.7
	na = not available			

Table 4.8.4 *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006 & 2007 TV surveys (adjusted for [Fladen's] bias=1.35). No surveys since then.

		Mean density		95% confidence interval
			Abundance	
Year	Stations	burrows/m²	millions	millions
1994	10	0.47	185	67
1995	no survey			
1996	no survey			
1997	no survey			
1998	no survey			
1999	10	0.22	89	31
2000	no survey			
2001	no survey			
2002	no survey			
2003	no survey			
2004	no survey			
2005	2	poor visibility, limited survey - see text		
2006	7	0.13	55	35
2007	9	0.11	44	19

Table 4.9.1 *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993-2012

		Danish discards		Norway							
Year	Denmark	dead	live	Trawl	Creel	Sub-total	Sweden	UK	Netherlands	Total	TAC
1993	220			102	1	103		16		339	
1994	584			161	0	161		10		755	
1995	418			68	1	69		2		489	
1996	868			73	1	74		10		952	
1997	689			56	8	64		7		760	
1998	743			88	1	89		4		836	
1999	972			119	15	134		13		1119	
2000	871			143	0	143	37	34		1085	
2001	1026			72	13	85	26	53		1190	
2002	1043			42	21	63	13	52		1171	
2003	996	145	48	68	11	79	1	14		1090	
2004	835	200	67	72	8	80	1	6		922	1000
2005	979	272	91	89	13	102	2	6		1089	1000
2006	939	126	42	62	19	81	1	7	5	1033	1300
2007	652	64	21	77	20	97	5	1		755	1300
2008	505			112	30	142	24	4		675	1300
2009	331	29	10	107	31	138	2	6		477	1200
2010	282	36	12	82	41	123	1	1		407	1200

2011	322			29	40	69	1	3	395	1200
2012	234	35	12	25	50	75	1	0	310	1200
2013 *	128	51	17	18	45	63	0	0	191	1000
2014										1000
* provisional										

Table 4.9.2 *Nephrops* Norwegian Deep (FU 32): Danish effort (days) and LPUE, 1993-2012

Year	kW days ('1000)	Days at sea	Fishing days	LPUE
1993	957	2170	1681	230
1994	1473	3632	2836	396
1995	1037	2527	1986	403
1996	1794	4130	3336	484
1997	2008	4242	3486	343
1998	1527	3380	2759	487
1999	2316	4779	3850	420
2000	2688	5127	4196	324
2001	3642	6657	5709	282
2002	3230	5950	5026	323
2003	3535	6357	5466	282
2004	2491	4377	3755	335
2005	2806	5121	4383	349
2006	3059	5330	4586	307
2007	1793	3069	2577	364
2008	1590	2523	2125	318
2009	1361	2178	1806	243
2010	1153	1908	1616	244
2011	1152	1863	1543	280
2012	908	1475	1285	258
2013	842	1421	1282	152

Table 4.10.1 *Nephrops* in FU 33. (Off Horns Reef) Landings (tonnes) by country, 1993-2013.

	Belgium	Denmark	Germany	Netherl.	UK	Total **
1993	0	159		na	1	160
1994	0	137		na	0	137
1995	3	158		3	1	164
1996	1	74		2	0	77
1997	0	274		2	0	276
1998	4	333	8	12	1	350
1999	22	683	14	12	6	724
2000	13	537	12	39	9	597
2001	52	667	11	61	+	791
2002	21	772	13	51	4	861
2003	15	842	4	67	1	929
2004	37	1097	24	109	1	1268
2005	16	803	31	191	9	1050
2006	97	710	151	314	15	1288
2007	118	610	201	496	42	1467
2008	130	362	160	386	58	1096
2009	121	231	150	491	170	1163
2010	56	180	206	295	69	806
2011	163	396	202	403	28	1191
2012	181	394	132	376	2	1084
2013*	156	310	174	304	2	946
* provisional na = not available						
** Totals for 1993-94 exclusive of landings by the Netherlands						

Table 4.10.2 *Nephrops* in FU 33. (Off Horns Reef): Logbook recorded effort (days fishing) and LPUE (kg/day) for bottom trawlers catching *Nephrops* with codend mesh sizes of 70 mm or above, 1991-2013.

Year	kW days	Days at sea	Fishing days	LPUE*
1991	620639.3	1426	1134	0.11
1992	544059.5	1404	1084	0.14
1993	637661.5	1469	1164	0.25
1994	388775.7	1001	783	0.35
1995	380403.8	1082	824	0.42
1996	224435.5	674	522	0.33
1997	496749.6	1465	1140	0.55
1998	773518	2319	1787	0.43
1999	1250181	3606	2871	0.55
2000	1066842	3287	2543	0.50
2001	1283157	3918	3117	0.52
2002	1642288	4637	3611	0.47
2003	1617254	4774	3841	0.52
2004	1914258	5653	4431	0.57

2005	1094058	3311	2654	0.73
2006	966177.6	2712	2153	0.73
2007	786120.6	2006	1575	0.78
2008	445526.7	926	723	0.81
2009	274715.9	647	547	0.84
2010	255069.1	541	435	0.71
2011	346294.2	760	608	1.14
2012	299679	707	595	1.31
2013	238522.8	560	493	1.30
*kg/ kW days				

Table 4.11.1. *Nephrops*, Devil's Hole (FU 34). Nominal landings (tonnes) of *Nephrops* 1986-2013 as reported to the WG for 2012. Scottish data only from 1986 to 2009.

	UK Scotland							
Year	Nephrops trawl	Other trawl	Creel	Sub-total	UK (E, W & NI)	Denmark	Netherlands	Total
1986	20	3	0	23				23
1987	2	3	0	5				5
1988	1	1	0	2				2
1989	15	13	0	28				28
1990	20	6	0	26				26
1991	64	21	0	85				85
1992	78	28	0	106				106
1993	23	21	0	44				44
1994	79	50	0	129				129
1995	37	95	0	132				132
1996	40	89	0	129				129
1997	30	70	0	100				100
1998	15	73	0	88				88
1999	80	122	0	202				202
2000	89	95	0	184				184
2001	159	112	0	271				271
2002	240	103	0	343				343
2003	518	157	0	675				675
2004	398	90	0	488				488
2005	253	125	0	378				378
2006	359	89	0	448				448
2007	649	68	0	717				717
2008	844	93	0	937				937
2009	1297	8	0	1305				1305
2010	816	22	0	838	25	1	1	865
2011	406	16	0	422	6	4		432
2012	546	4	0	550	37	10		597
2013*	92	15	0	107	11	3		121
* provisional								
Landings for other countries previous to 2010 are currently unavailable								

Table 4.11.2 *Nephrops*, Devils Hole (FU 34): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2013.

Year	Landings	Effort	LPUE
2000	184	3391	54
2001	271	3142	86
2002	343	2022	170
2003	675	2614	258
2004	488	1551	315
2005	378	1545	245
2006	448	1440	311
2007	717	1824	393
2008	937	1673	560
2009	1305	1921	679
2010	838	1465	572
2011	422	1041	405
2012	550	1255	438

Year	Landings	Effort	LPUE
2000	184	3.4	54.1
2001	271	3.1	87.4
2002	343	2.0	171.5
2003	675	2.6	259.6
2004	488	1.6	305.0
2005	378	1.5	252.0
2006	448	1.4	320.0
2007	717	1.8	398.3
2008	937	1.7	551.2
2009	1305	1.9	686.8
2010	838	1.5	558.7
2011	422	1.0	422.0
2012	550	1.3	423.1
2013*	107	0.4	267.5

* provisional na = not available

Table 4.11.3. *Nephrops*, Devil's Hole (FU 34). Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 2006-2011. Samples not available in 2012 and 2013.

	Landings			
	< 35 mm CL		=> 35 mm CL	
Year	Males	Females	Males	Females
2006	29.7	29.8	39.7	38.1
2007	30.4	28.7	40.5	39.2
2008	31	30.5	40.3	39.6

2009	31.7	31.1	41.3	40.6
2010	32.1	29.7	39.1	38.8
2011	31.7	30.7	43.7	40.4
2012	na	na	na	na
2013	na	na	na	na
	na = not available			

Table 4.11.4. ***Nephrops*****, Devil's Hole (FU 34). Results of the 2003, 2005 and 2009-12 surveys (adjusted for bias=1.40).**

		Mean	95%
		density	confidence
			interval
Year	Stations	burrows/m²	burrows/m²
2003	20	0.09	0.02
2004	no survey		
2005	29	0.09	0.04
2006	no survey		
2007	no survey		
2008	no survey		
2009	14	0.26	0.12
2010	20	0.23	0.08
2011	15	0.19	0.09
2012	16	0.13	0.06

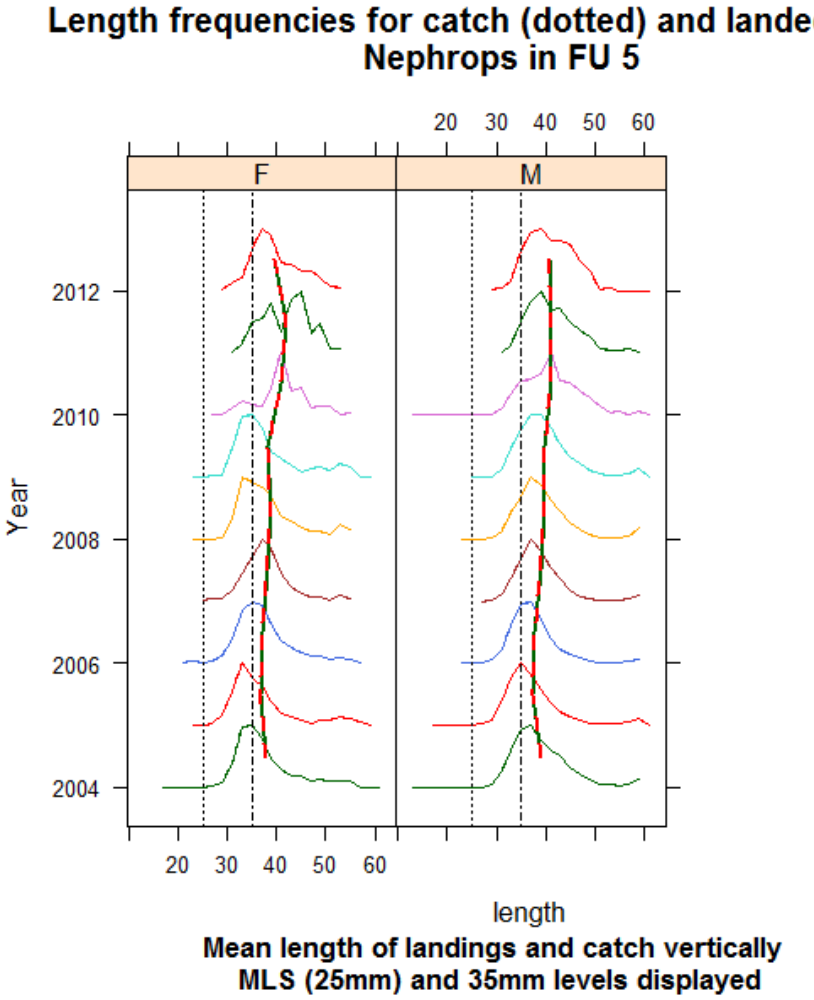


Figure 4.3.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2003 to 2011. For 2003 the length distribution is given by sex combined.

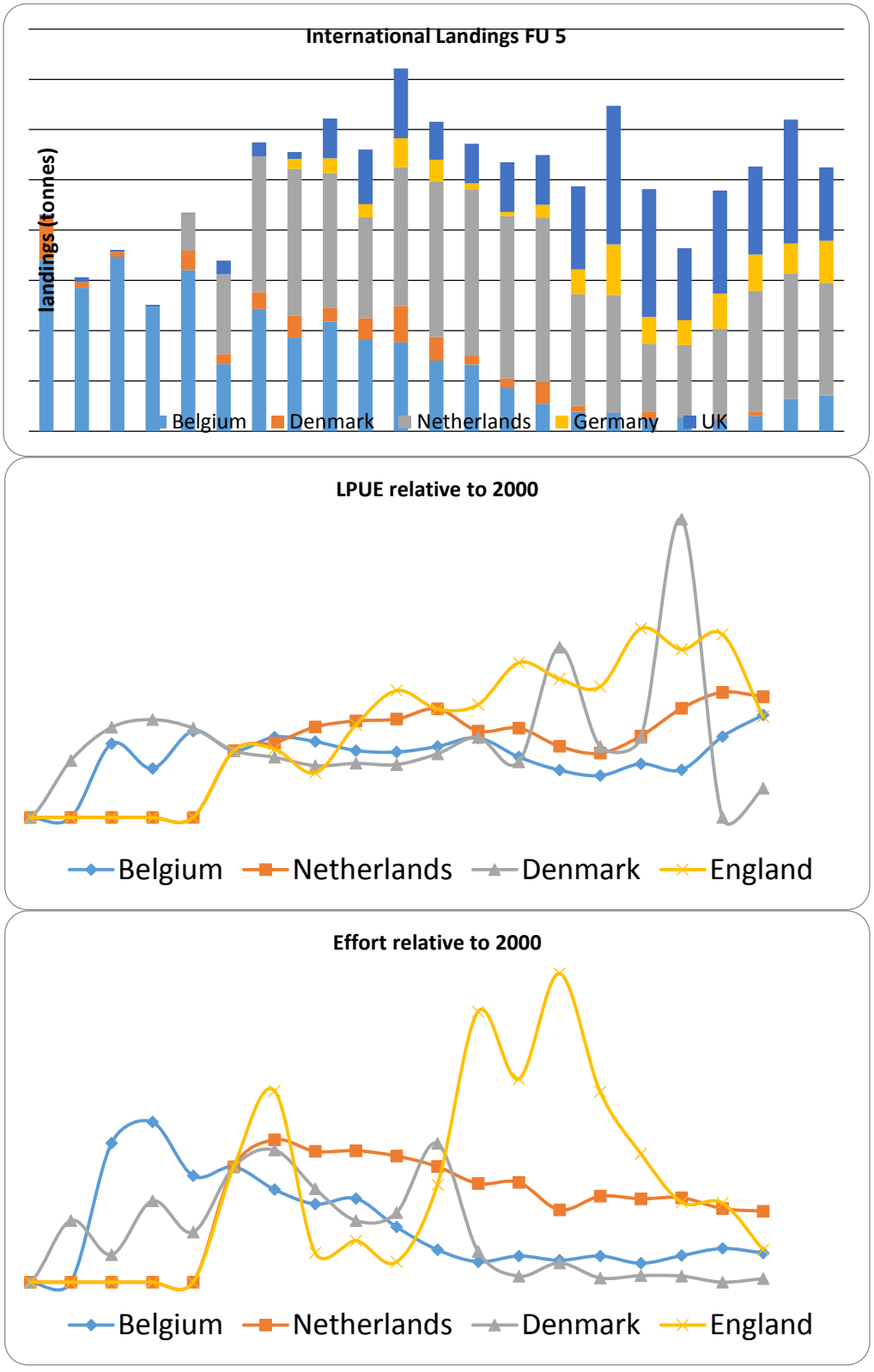


Figure 4.3.2 - FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUEs.

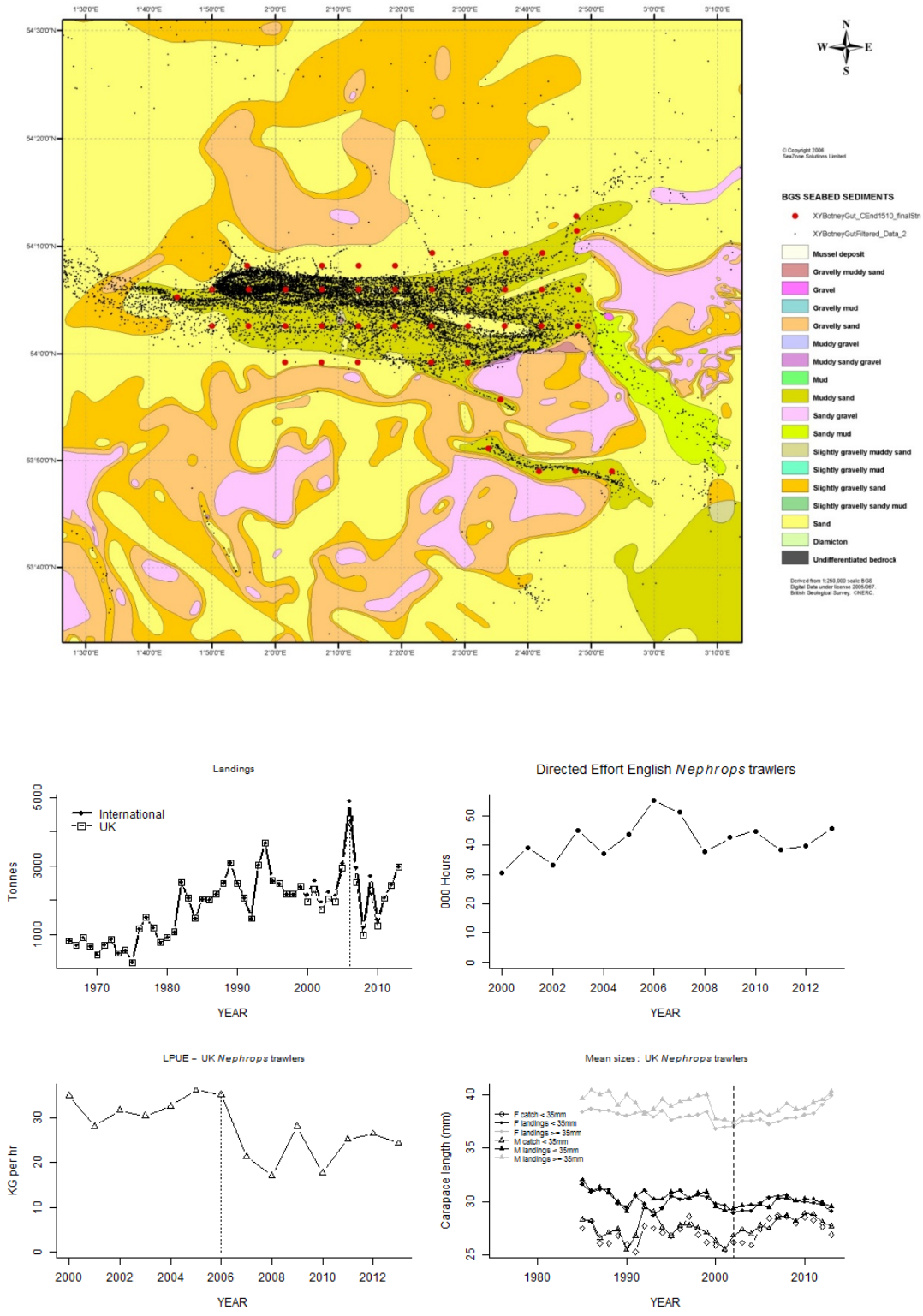


Figure 4.4.1 *Nephrops* in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.

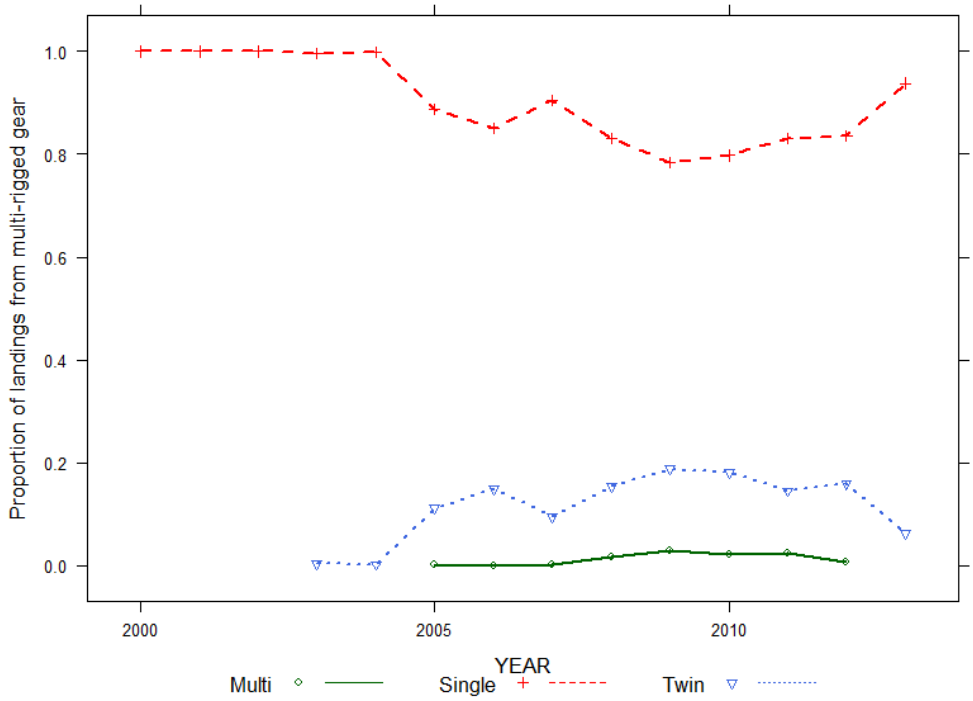


Figure 4.4.2 ***Nephrops*** **in FU6. Proportion of landings from different gear types.**

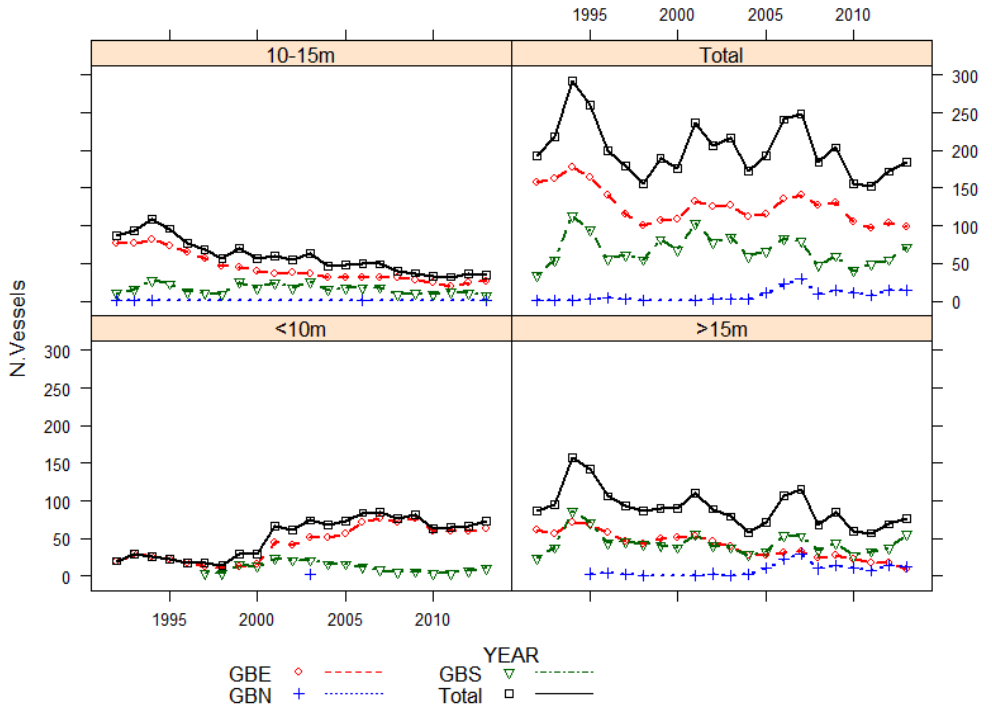


Figure 4.4.3 ***Nephrops*** **in FU6, Number of participating vessels (from UK) by vessel size category.**

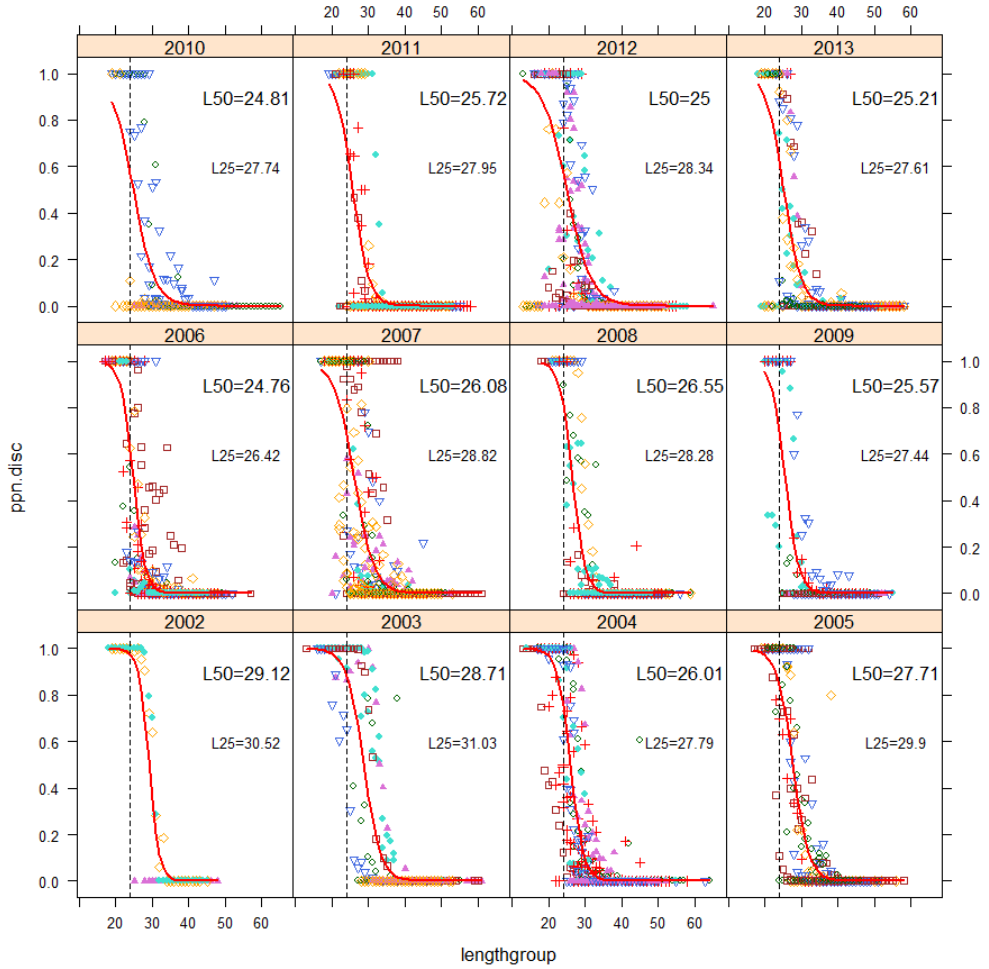


Figure 4.4.4 ***Nephrops*** **in FU6, annual discard ogives. The different point shapes represent different sampling trips within any year.**

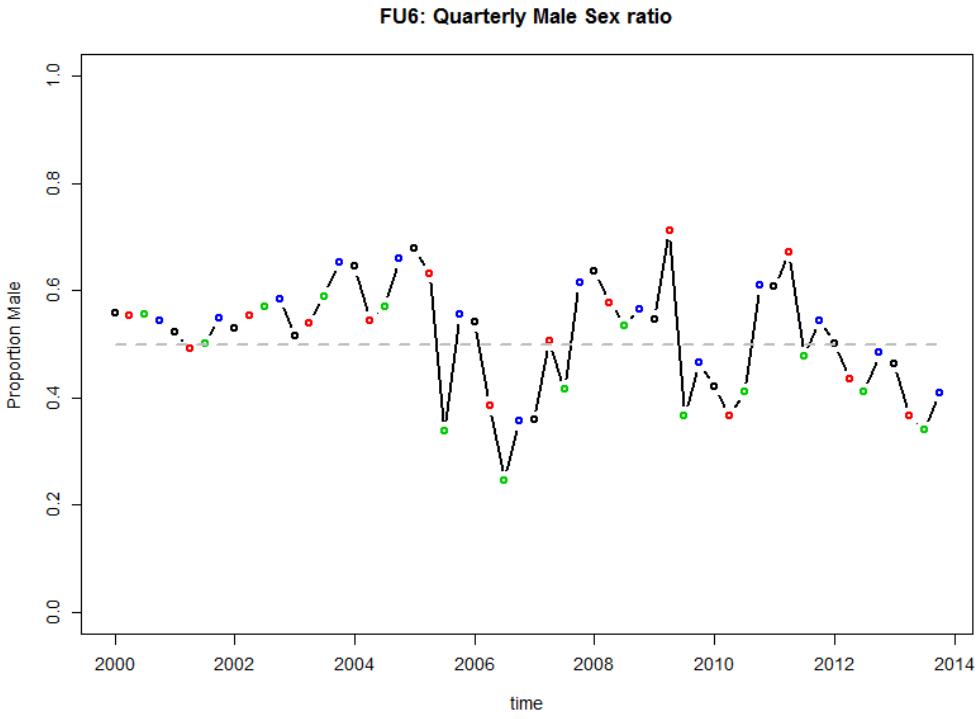


Figure 4.4.5 *Nephrops* **in FU6: Quarterly sex ratio in the catches.**

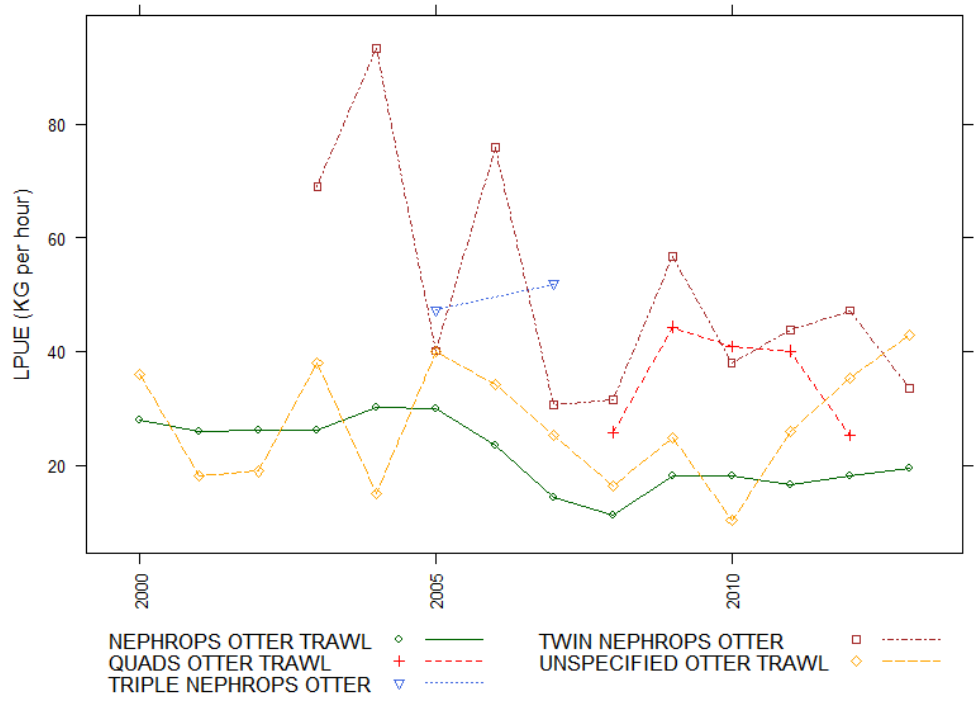


Figure 4.4.6 *Nephrops* **in FU6: LPUE for directed English trawlers by gear type.**

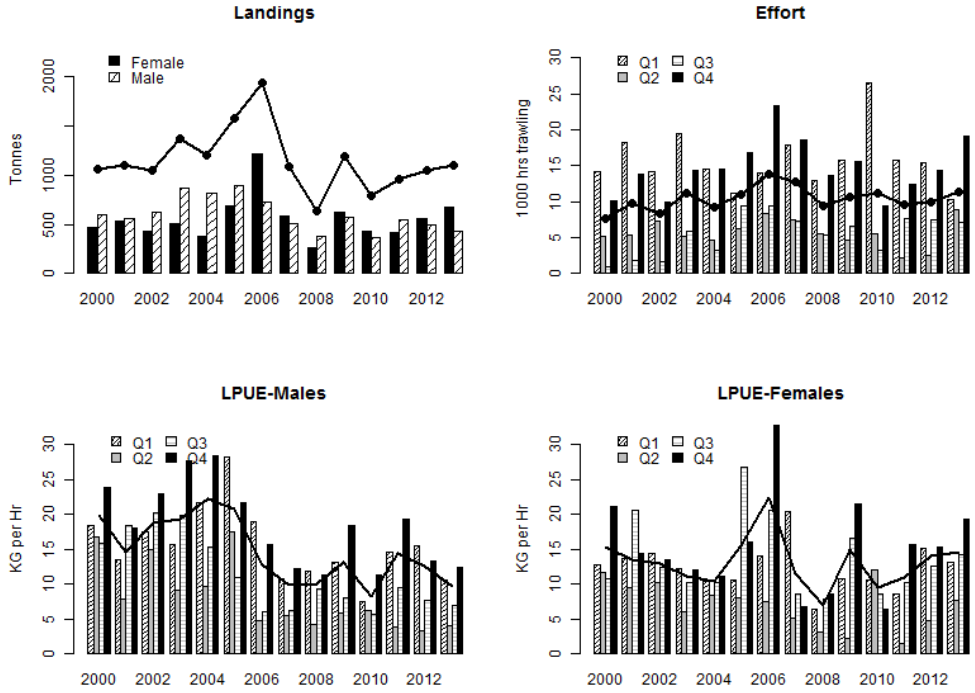


Figure 4.4.7 ***Nephrops*** **in FU6: LPUE by sex and quarter.**

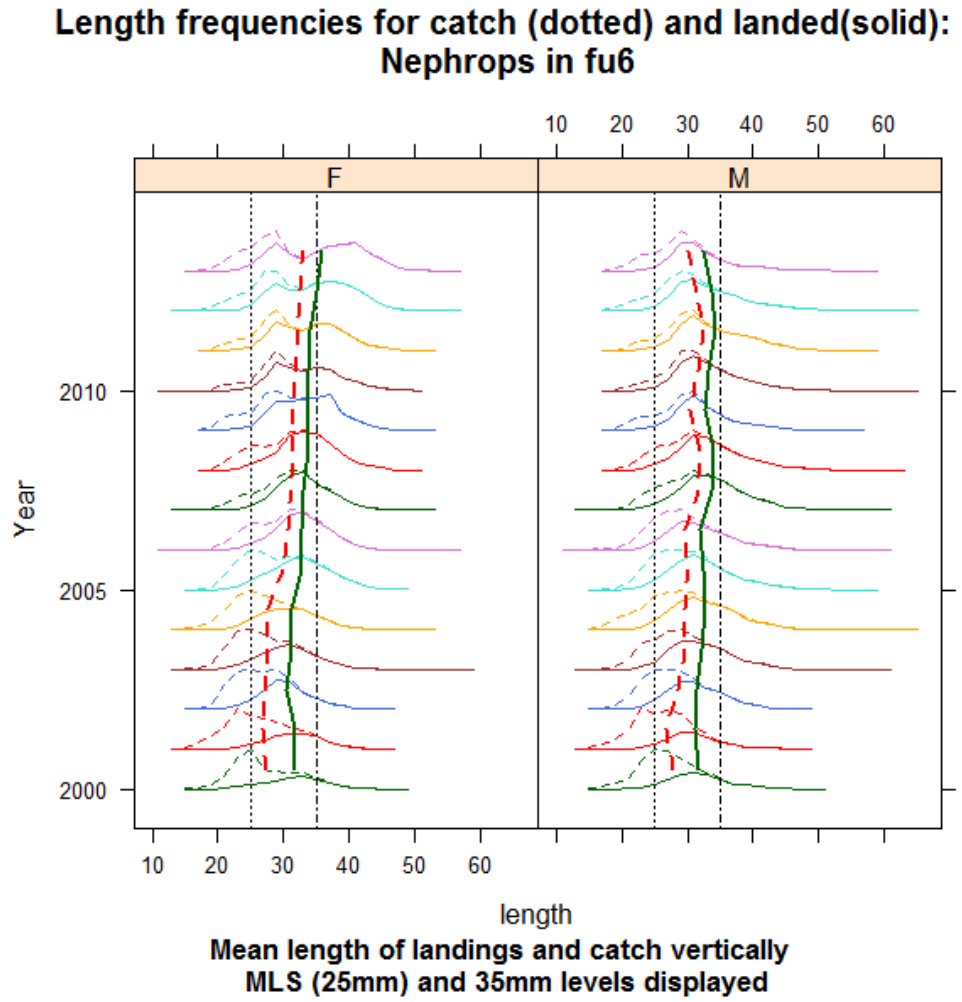


Figure 4.4.8 *Nephrops* **in FU6: Annual length frequencies for landings and discards.**

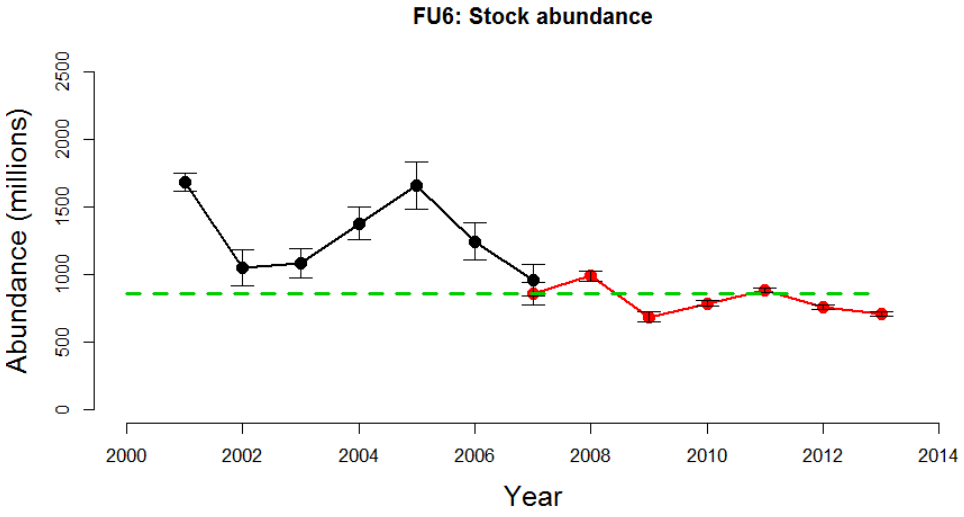


Figure 4.4.9 *Nephrops* **in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the Geostatsistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.**

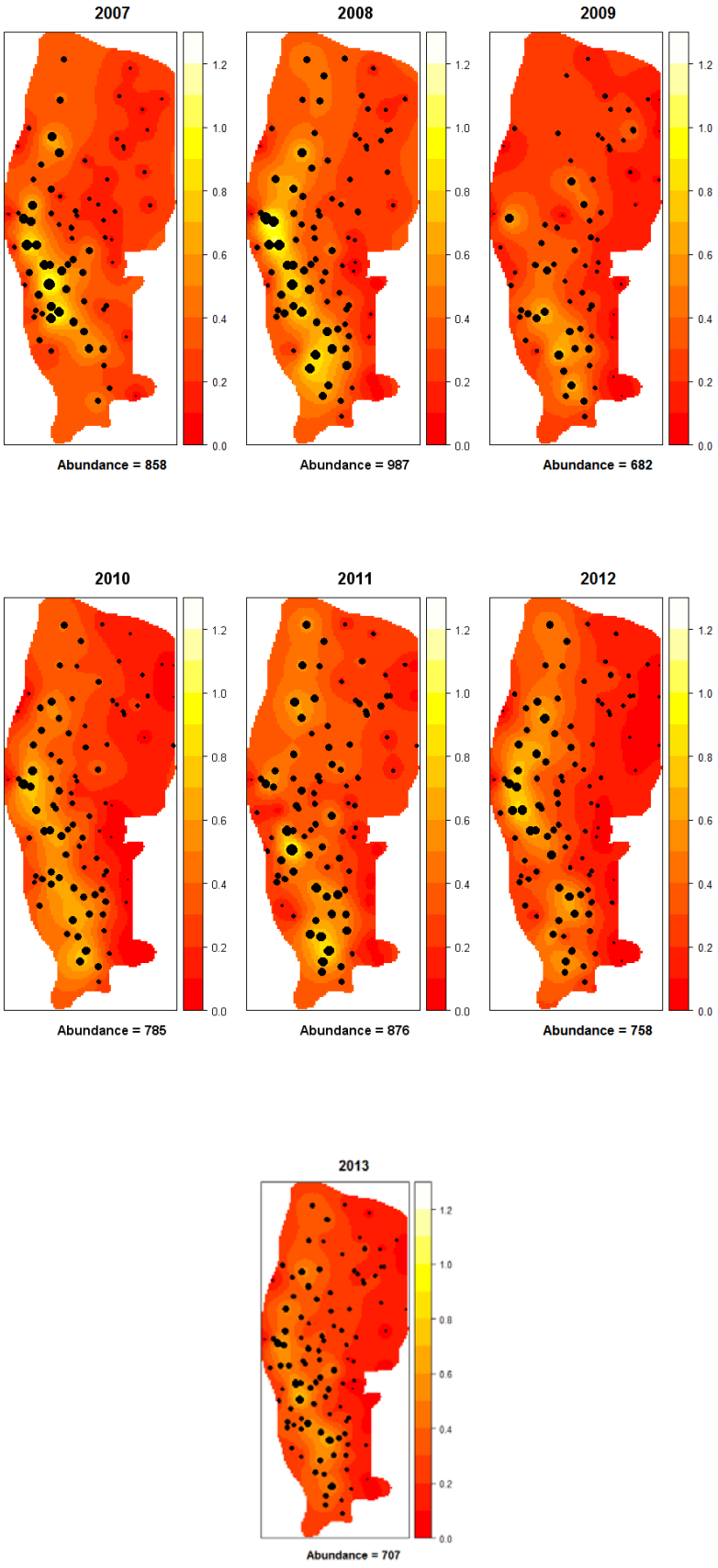


Figure 4.4.10 *Nephrops* **in FU6: Results of the UWTV survey.**

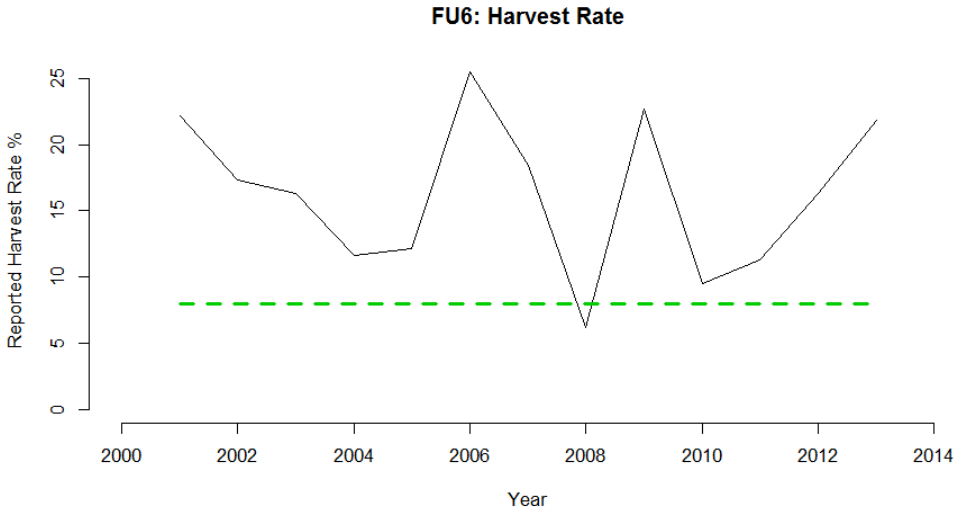


Figure 4.4.11 *Nephrops* in FU6: Observed harvest ratio (removals divided by abundance estimate).

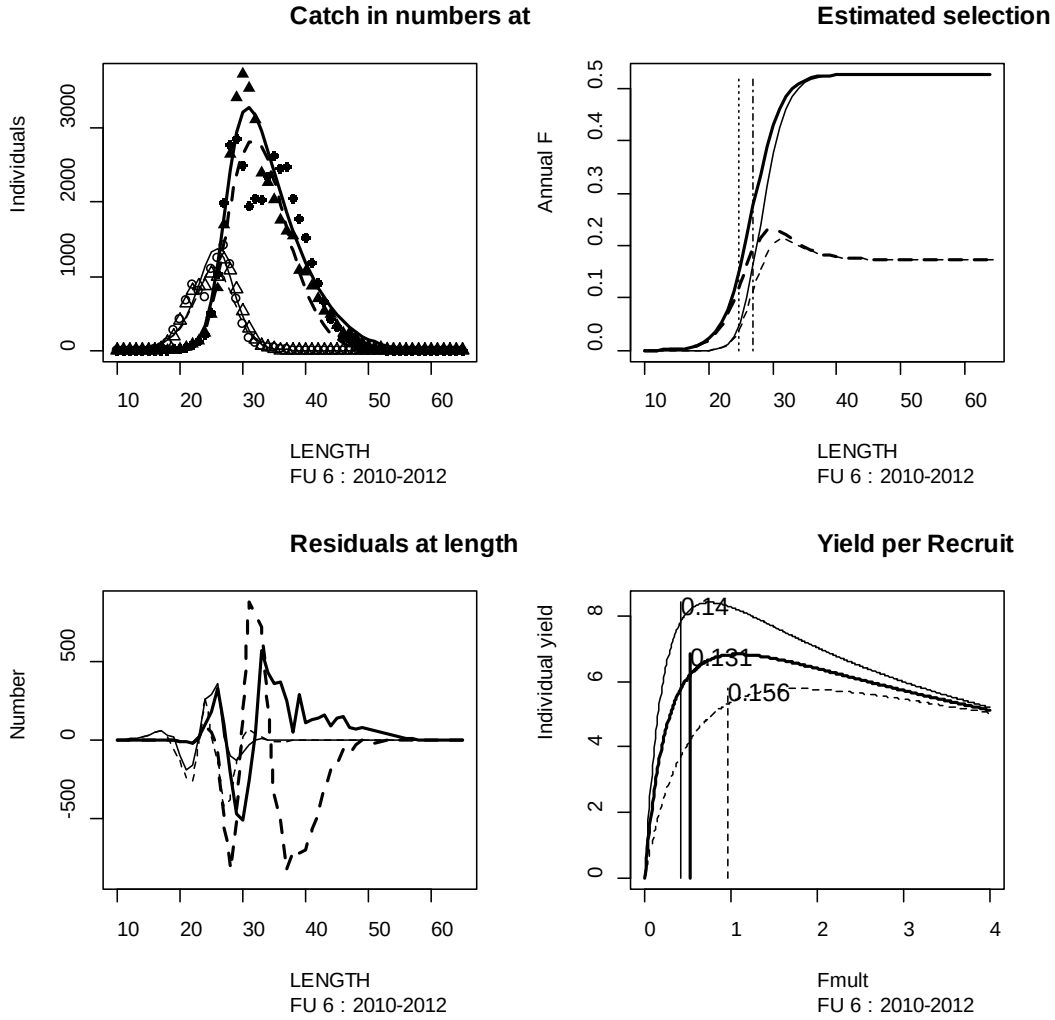


Figure 4.4.12 ***Nephrops*** **in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards and landings, top right gives the fishing mortality at length with the vertical lines representing length at 25% selection and 50% selection. Bottom left shows residual numbers (observed – expected) at length. The bottom right gives the Yield Per recruit against fishing mortality, the thick solid line gives the combined value and vertical lines represent $F_{0.1}$ for the three curves.**

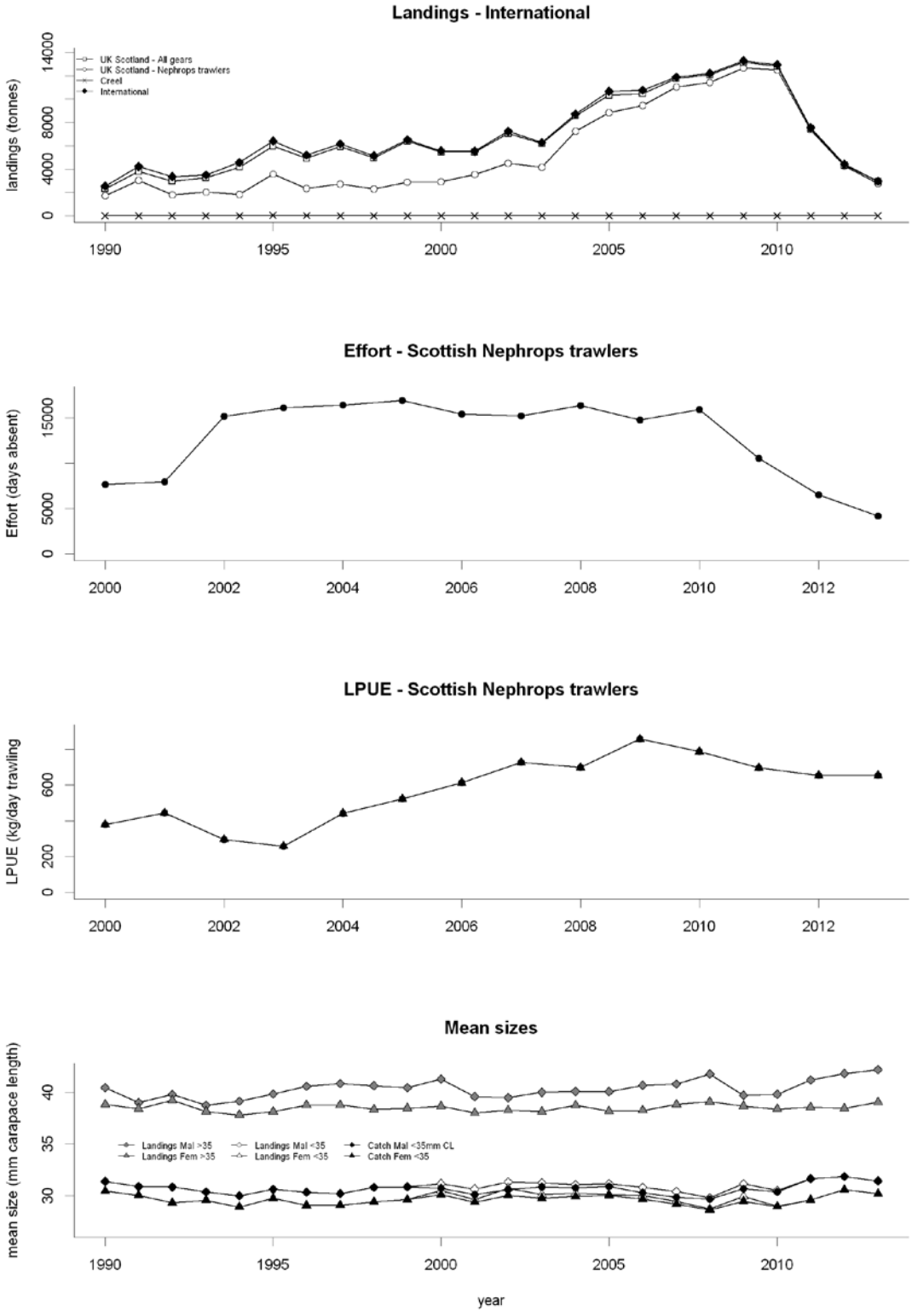
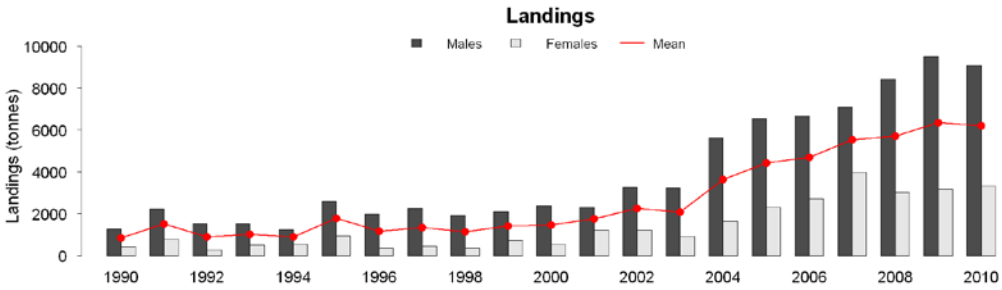
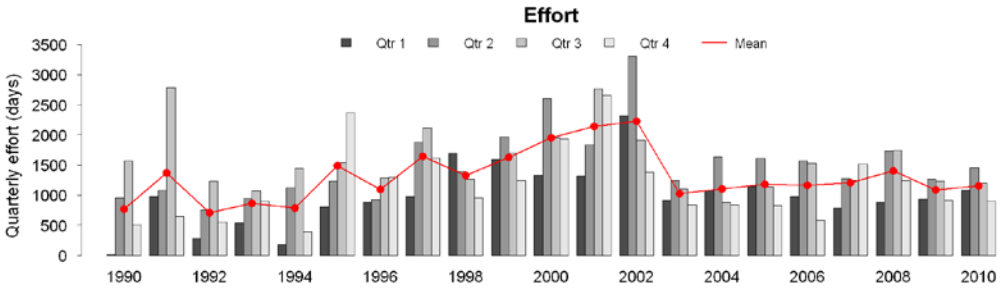


Figure 4.5.1 *Nephrops*, **Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2013.**


Landings
Males
Females
Mean
Landings (tonnes)
10000
8000
6000
4000
2000
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010


Effort
Qtr 1
Qtr 2
Qtr 3
Qtr 4
Mean
Quarterly effort (days)
3500
3000
2500
2000
1500
1000
500
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

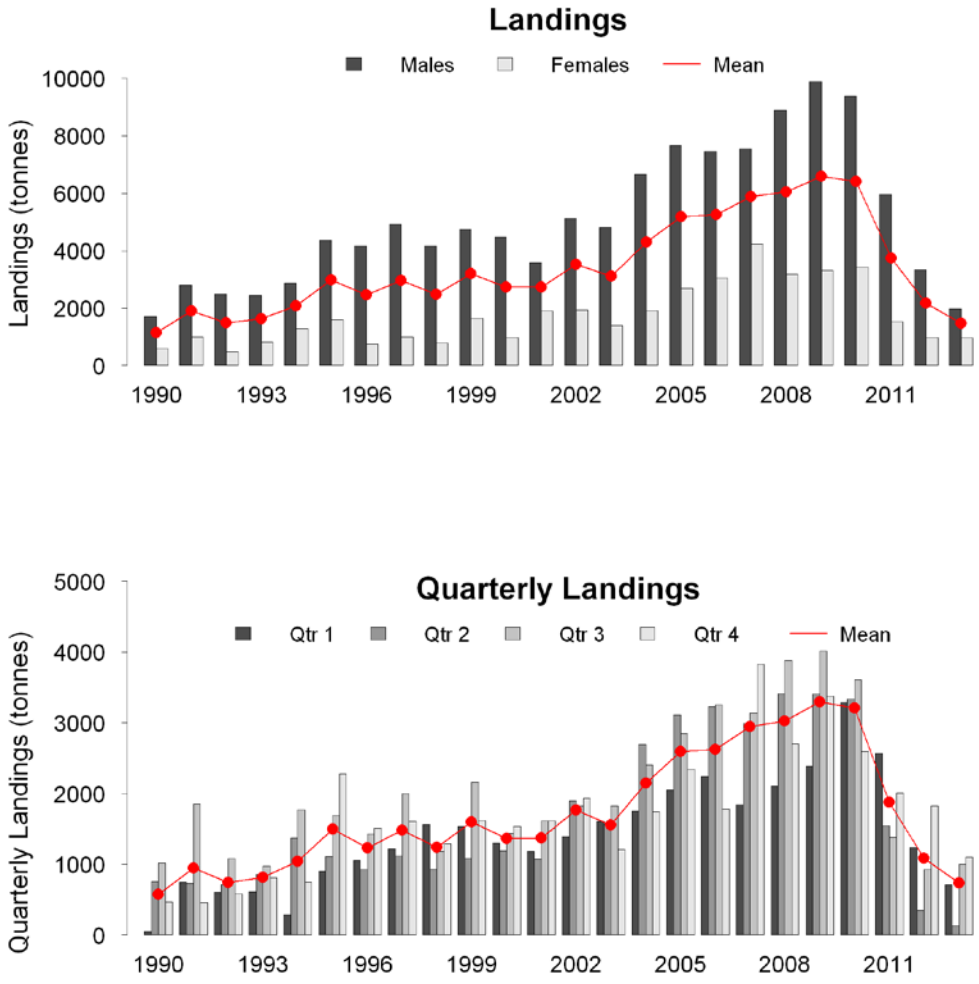


Figure 4.5.2 ***Nephrops*****, Fladen (FU 7), Landings by sex and effort by quarter from Scottish** ***Nephrops*** **trawlers.**

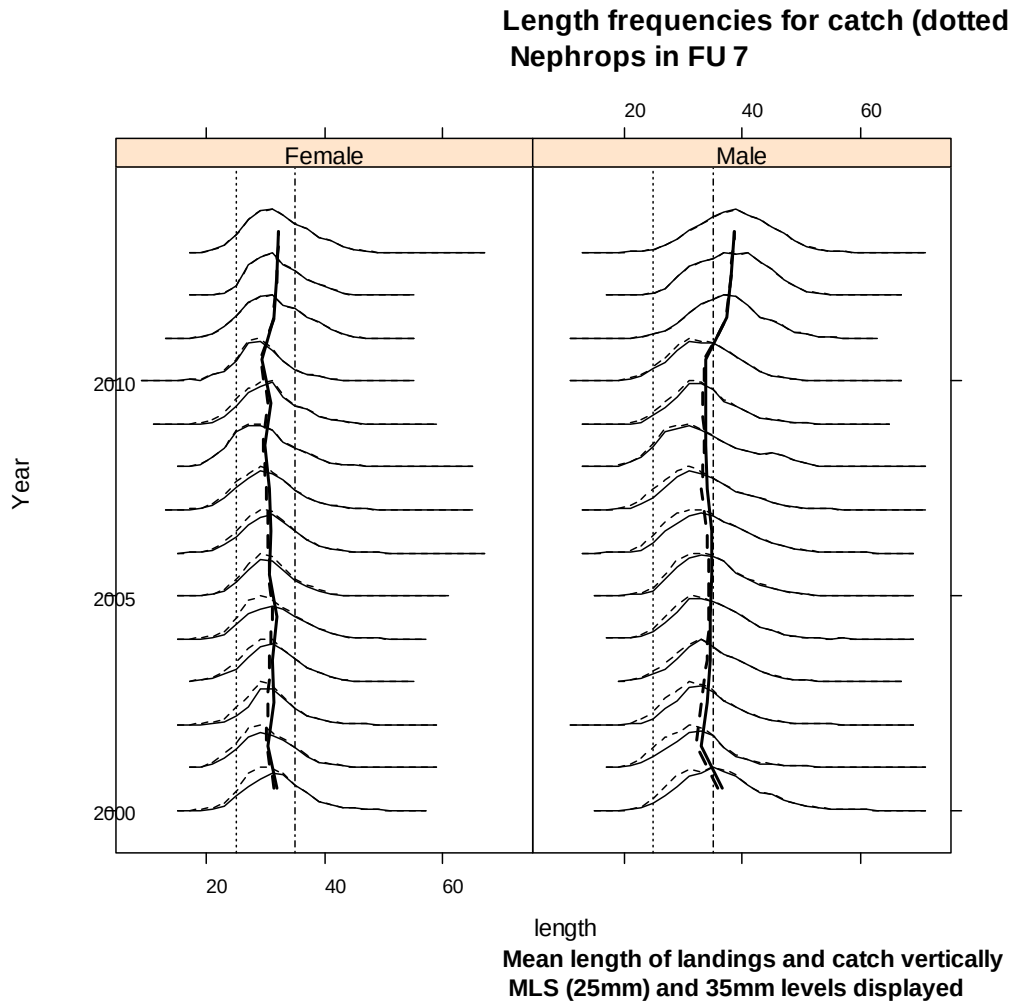
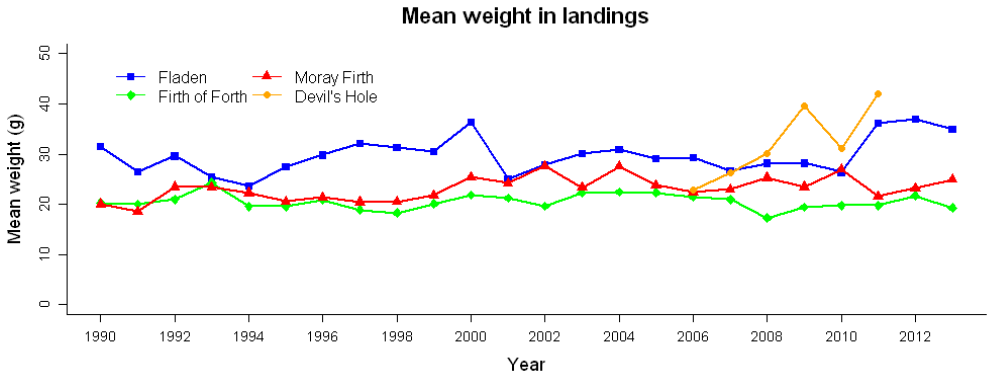
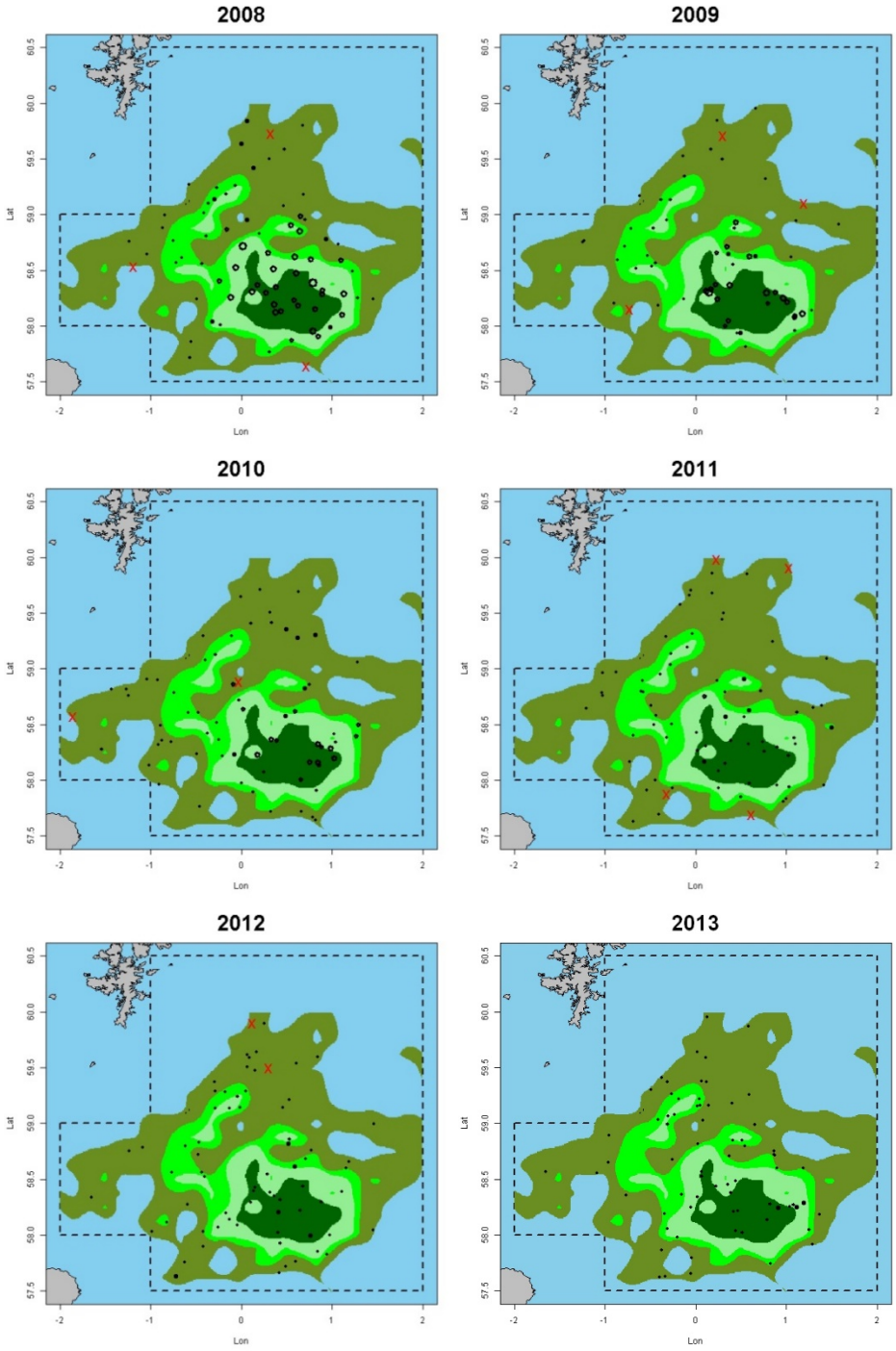


Figure4.5.3 *Nephrops* Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2013 (top). Mean sizes of catch and landings are displayed vertically.



4.5.4 *Nephrops*, (FUs 7-9 and 34, Fladen, Firth of Forth, Moray Firth and Devil's Hole). Individual mean weight (g) in the landings from 1990-2013 (Scottish market sampling data). FU 34 data only available for 2006-2011.


2008
2009
2010
2011
2012
2013
Lat
Lon

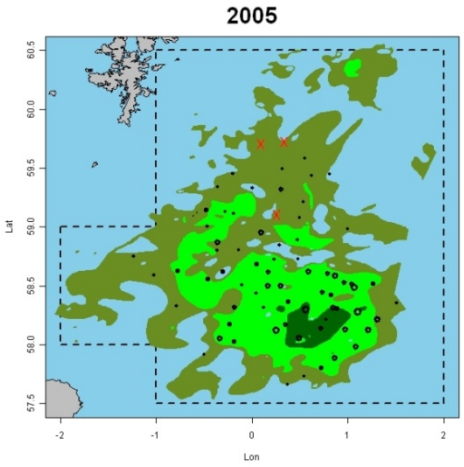


Figure 4.5.5 *Nephrops*, **Fladen (FU 7). TV survey distribution and relative density (2008-2013). Green and brown areas represent areas of suitable sediment for Nephrops. Density proportional to circle radius. Red crosses represent zero observations.**

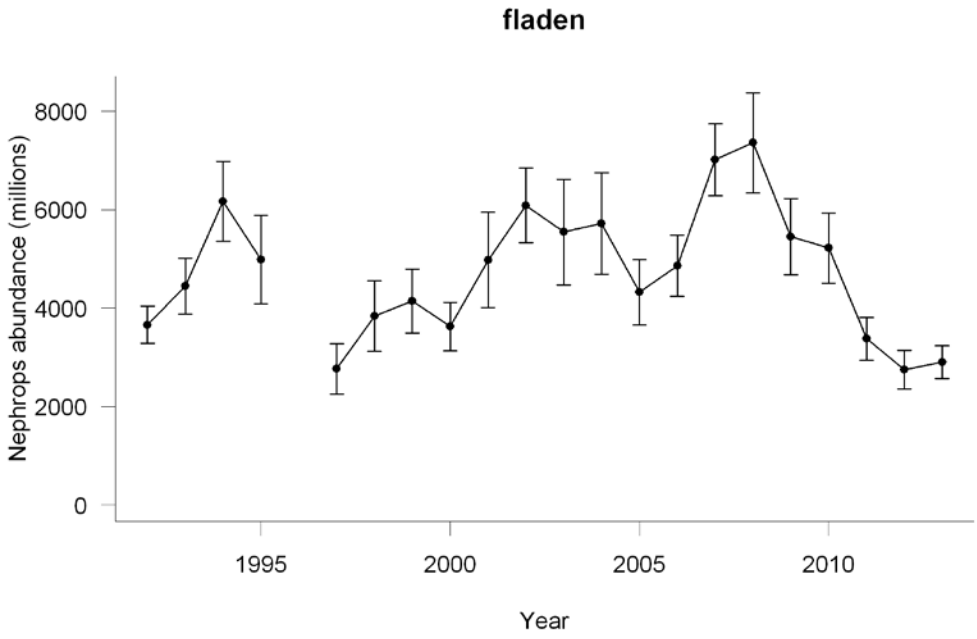


Figure 4.5.6 *Nephrops*, **Fladen (FU 7), Time series of TV survey abundance estimates (bias corrected), with 95% confidence intervals, 1992 – 2013.**

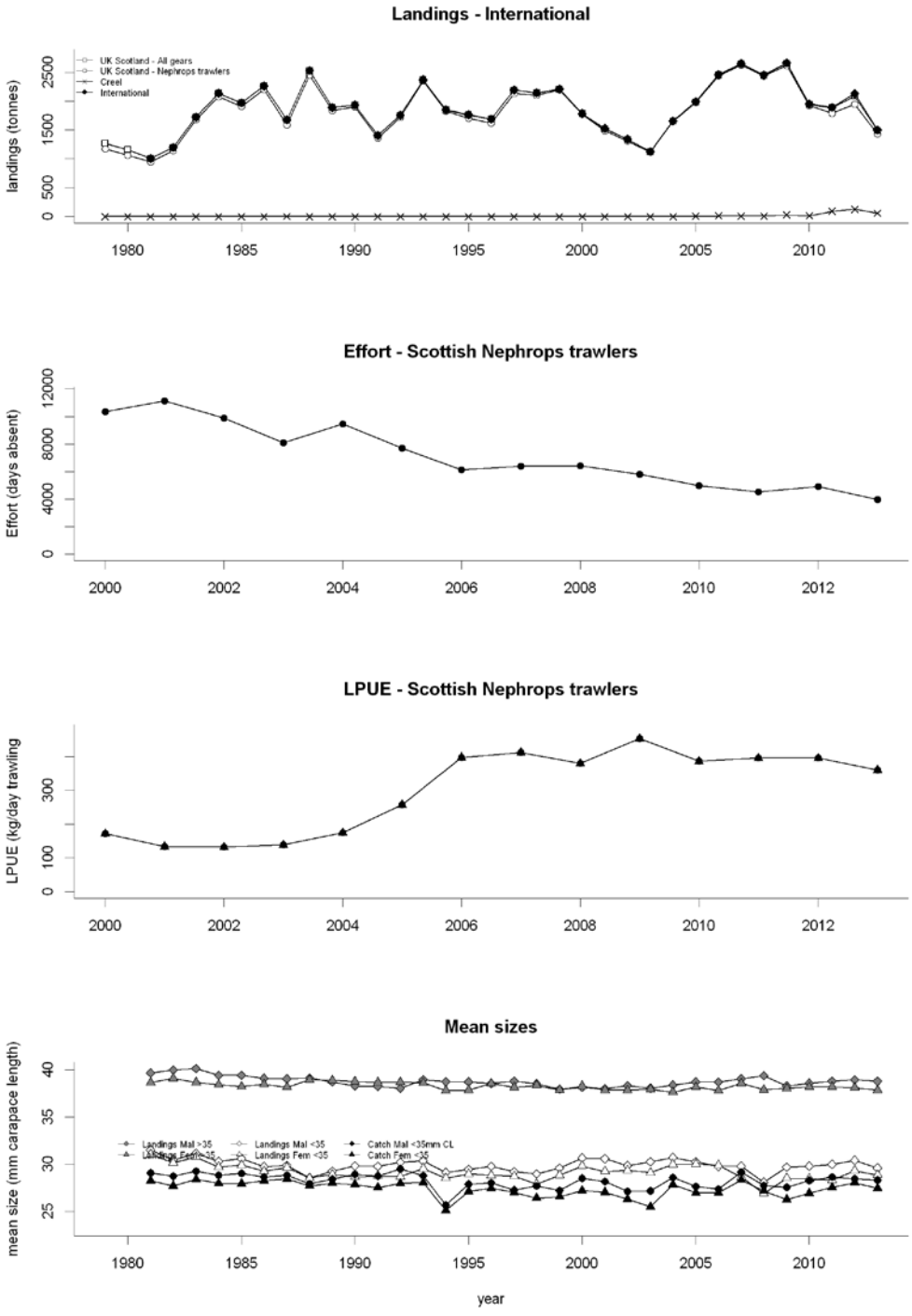


Figure 4.6.1 ***Nephrops*****, Firth of Forth (FU 8), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2013.**

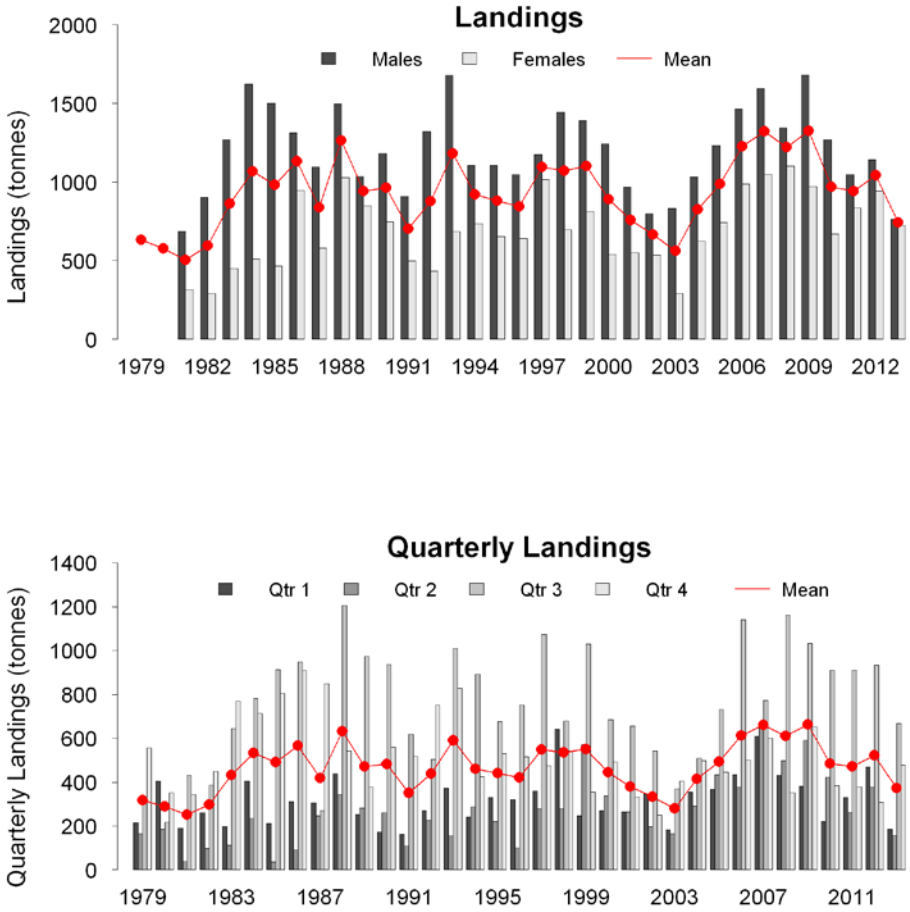


Figure 4.6.2 ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

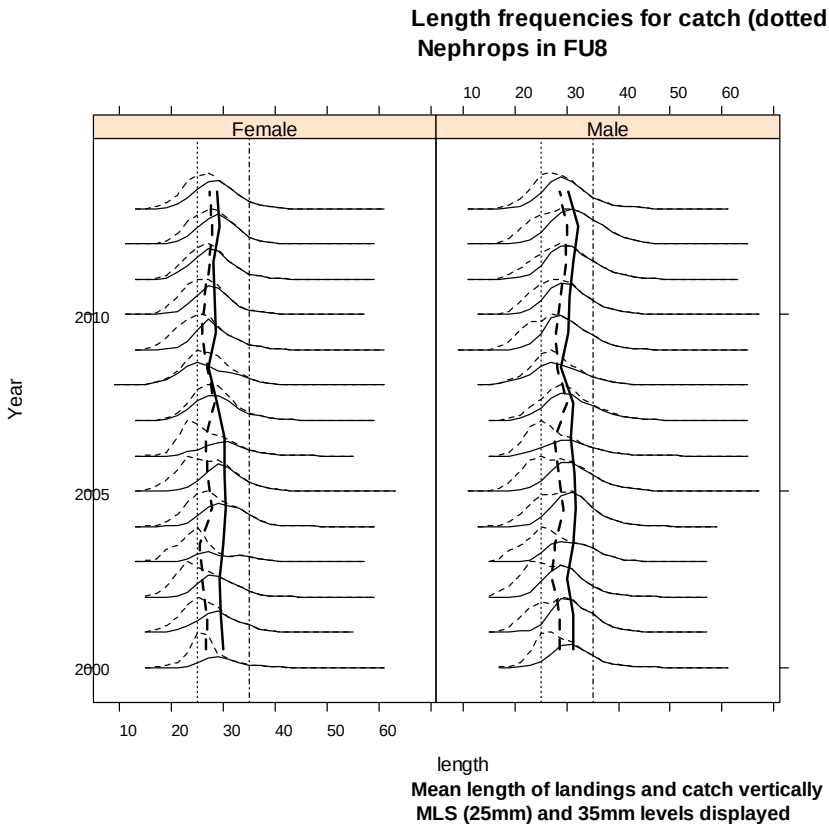


Figure 4.6.3 *Nephrops* Firth of Forth (FU 8) Length composition of catch of males (right) and females left from 2000 (bottom) to 2013 (top). Mean sizes of catch and landings are displayed vertically.

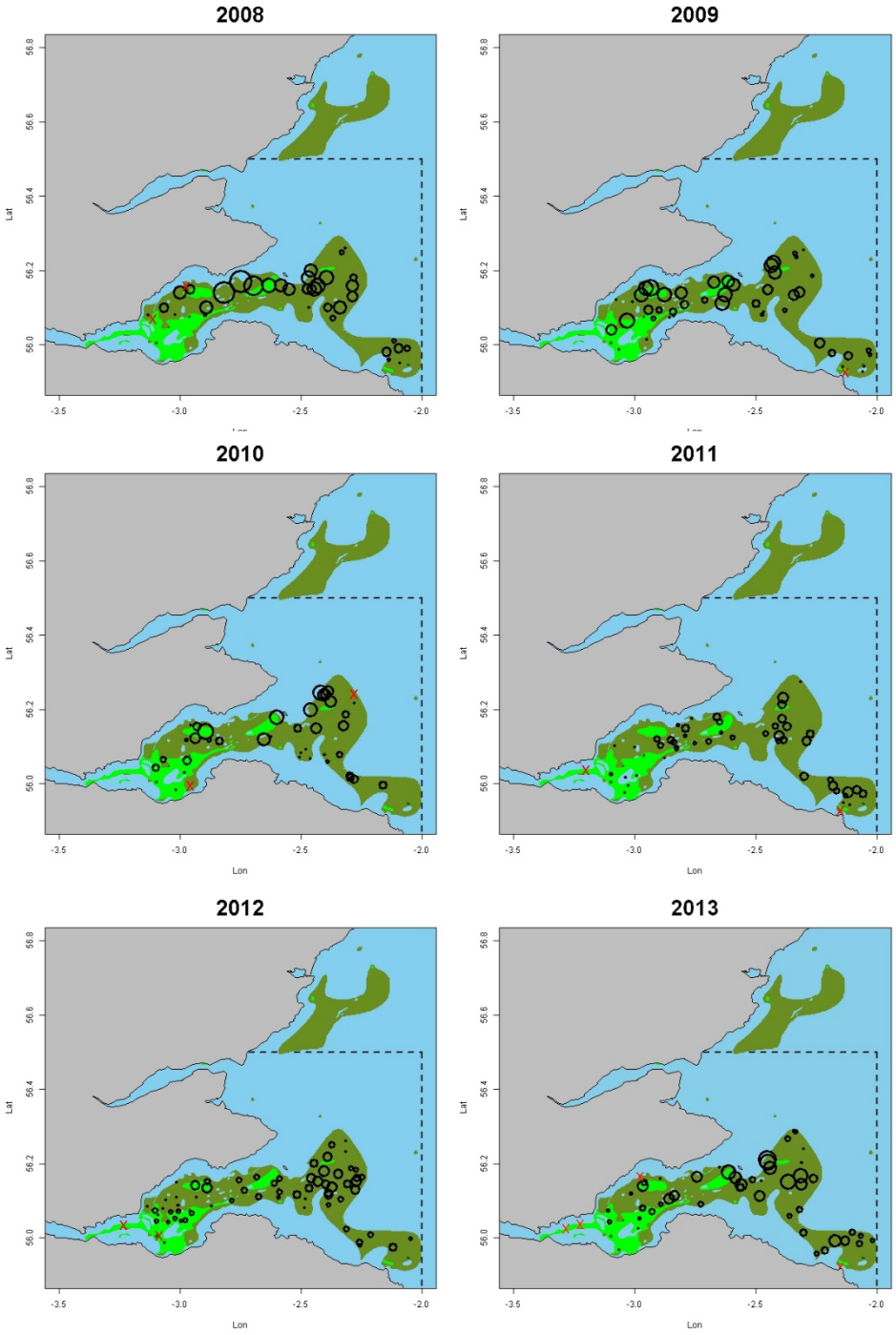


Figure 4.6.4 *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density (2008-2013). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

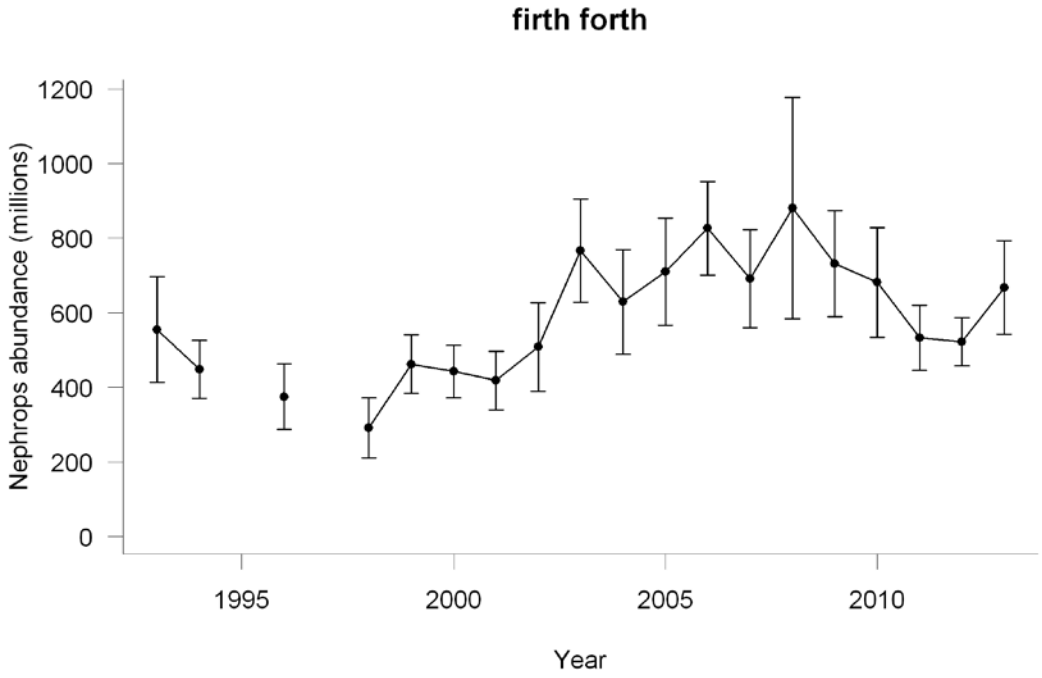


Figure 4.6.5 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates (bias corrected), with 95% confidence intervals, 1993 – 2013.**

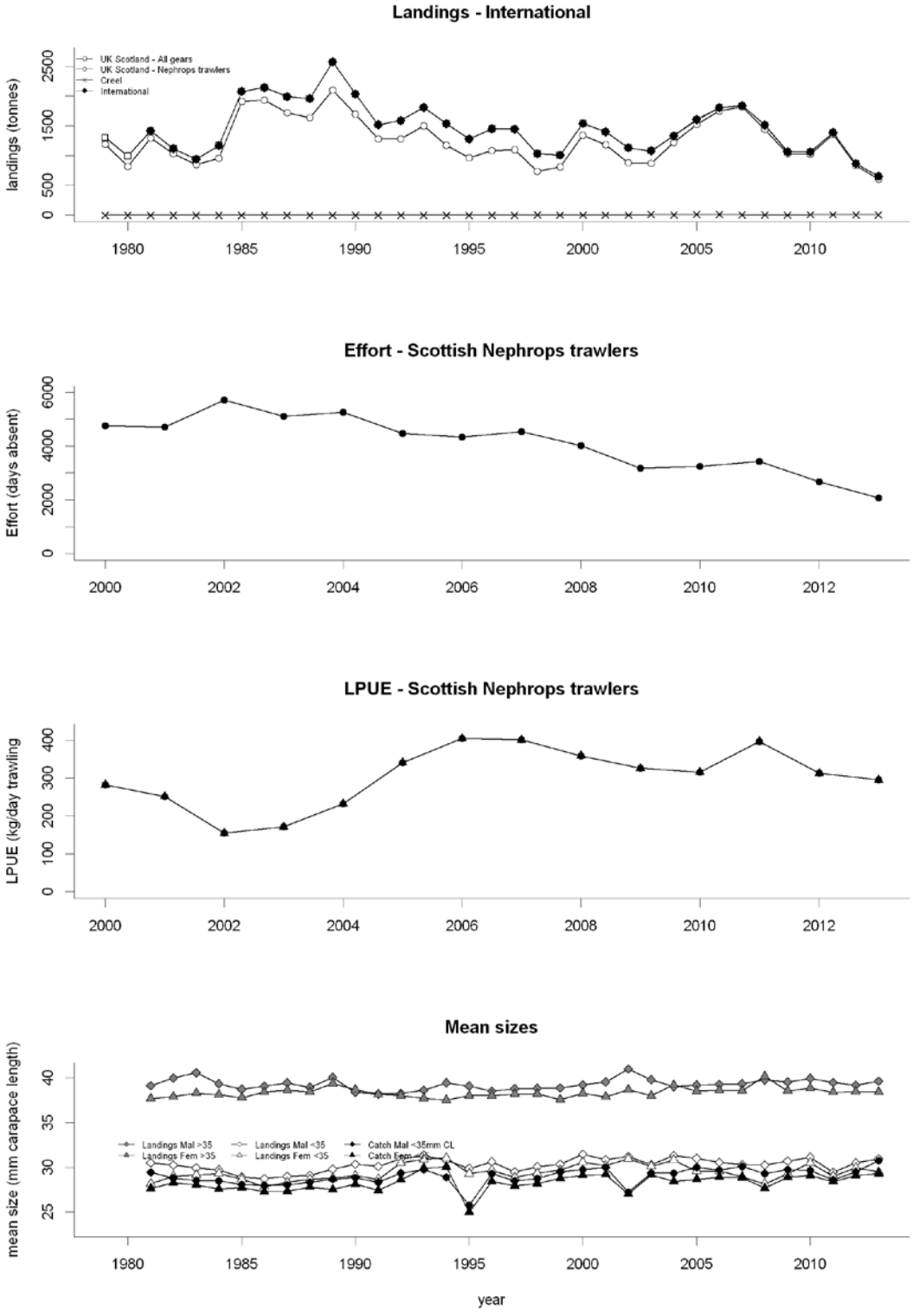


Figure 4.7.1 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2013.**

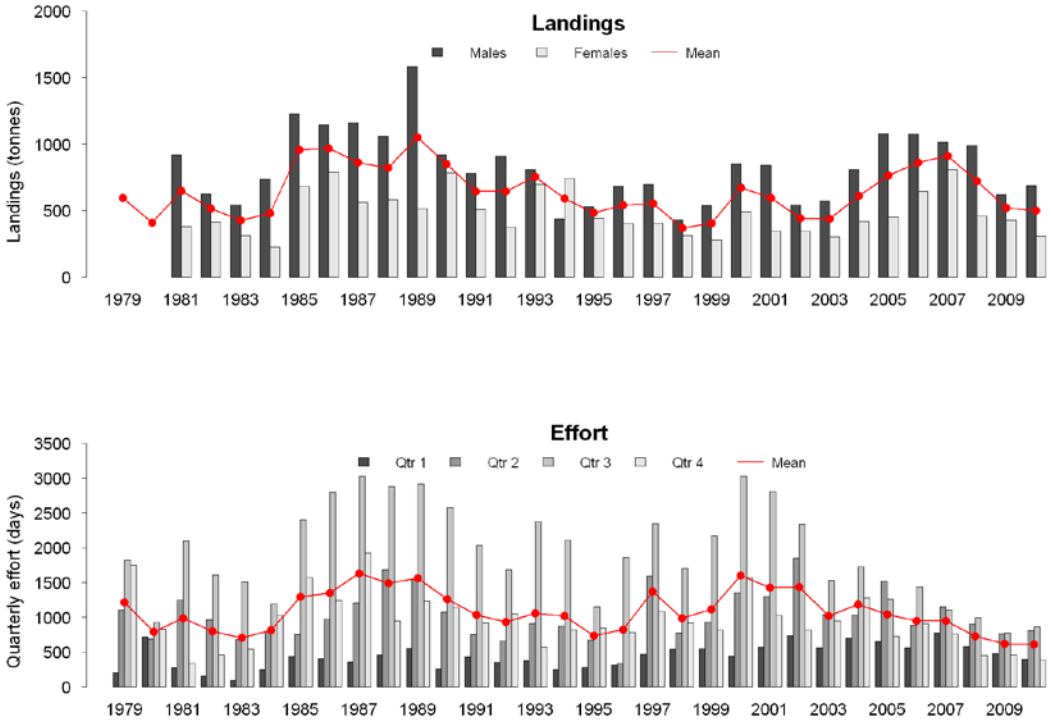


Figure 4.7.2 ***Nephrops*****, Moray Firth (FU 9), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

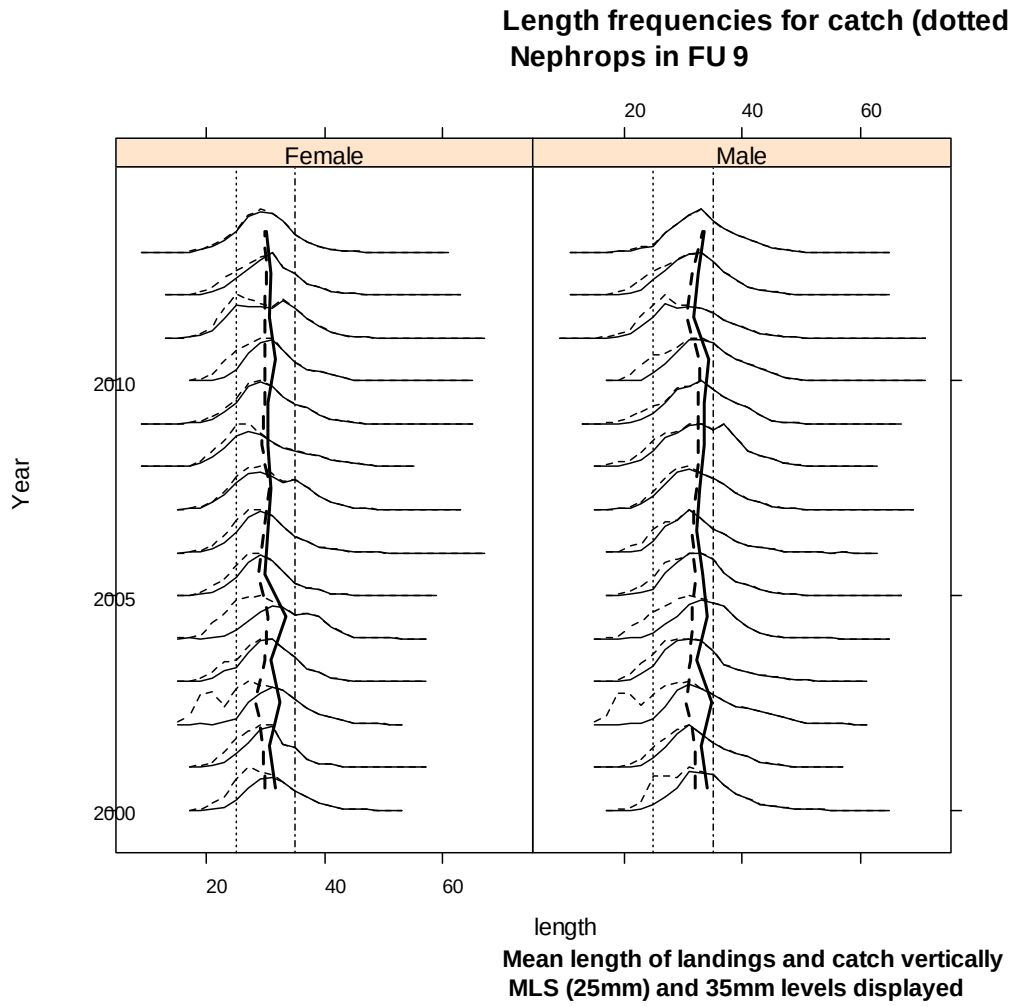


Figure 4.7.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2013 (top). Mean sizes of catch and landings are displayed vertically.**

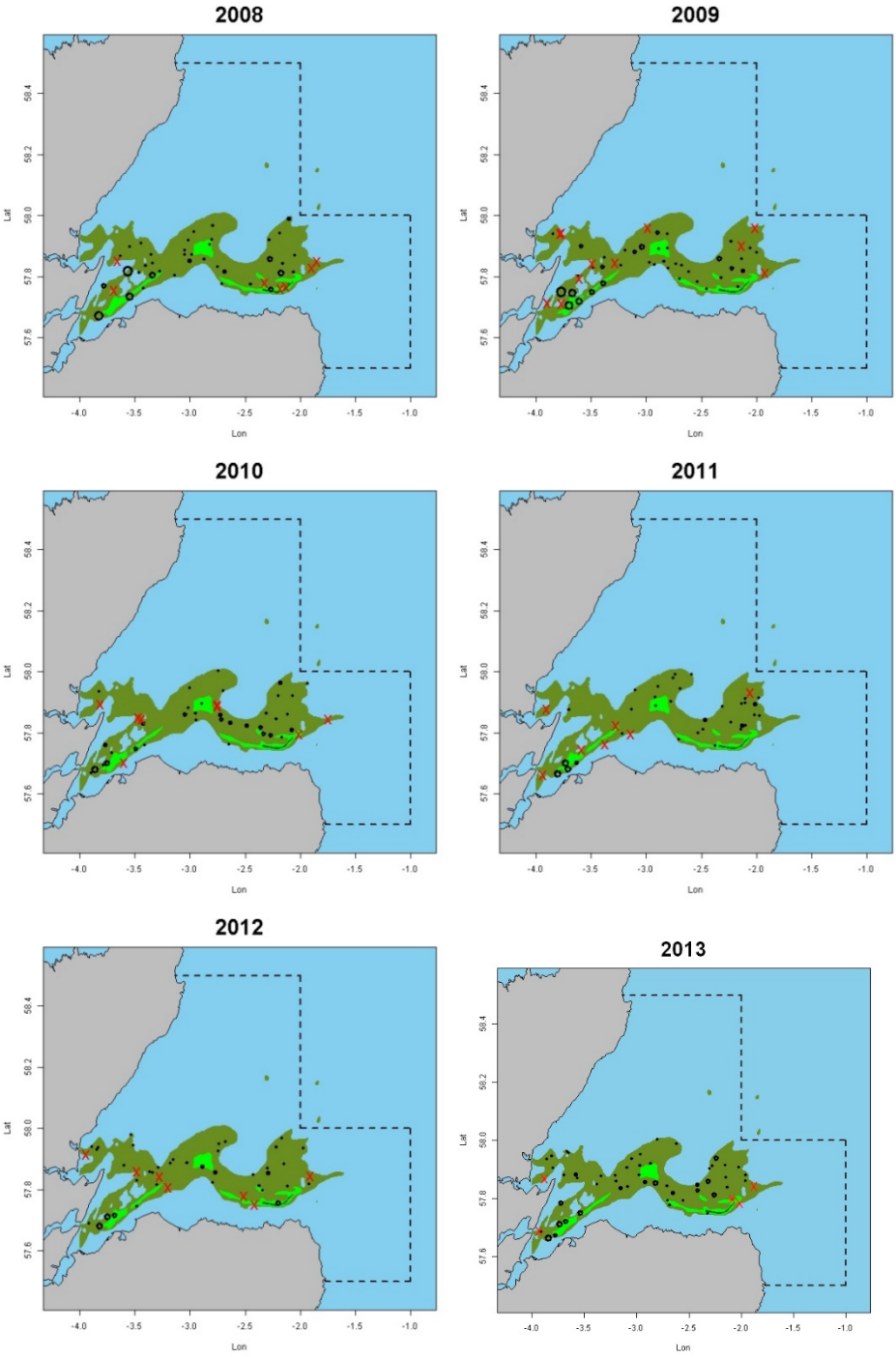


Figure4.7.4 *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2008-2013). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

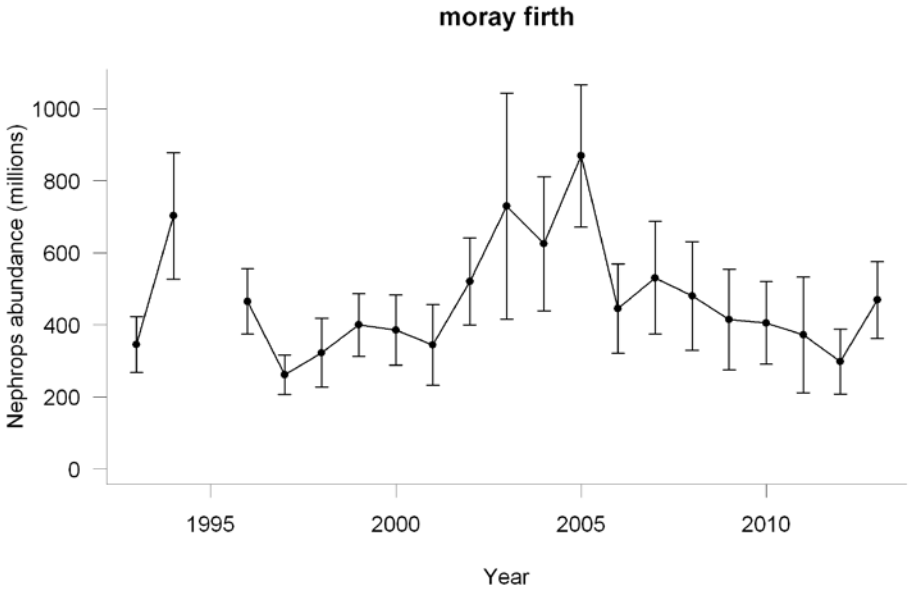


Figure 4.7.5 ***Nephrops*****, Moray Firth (FU 9), Time series of TV survey abundance estimates (bias corrected), with 95% confidence intervals, 1993 – 2013.**

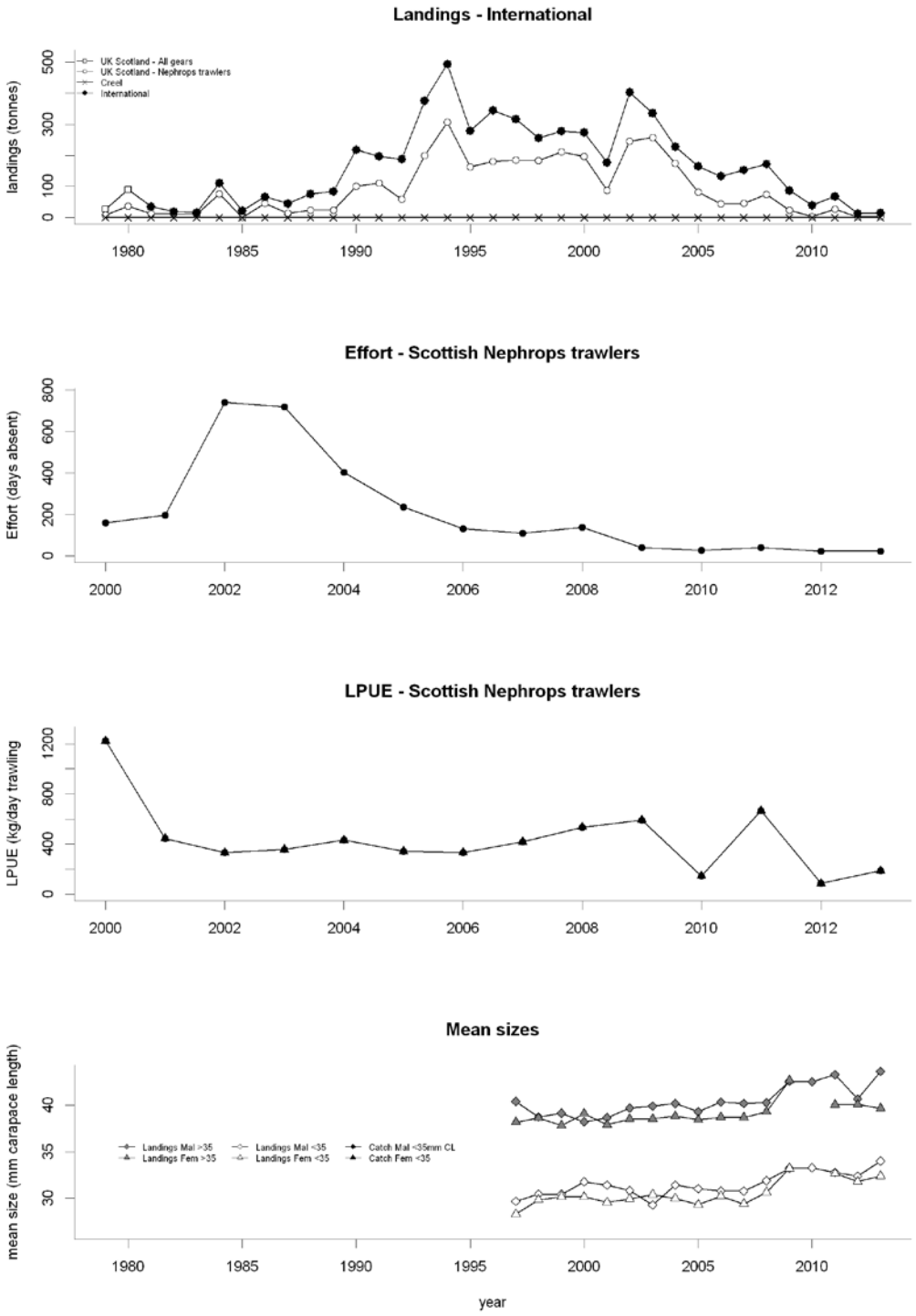


Figure 4.8.1 ***Nephrops*****, Noup (FU 10), Long term landings, effort, LPUE and mean sizes (no females in samples in 2010).**

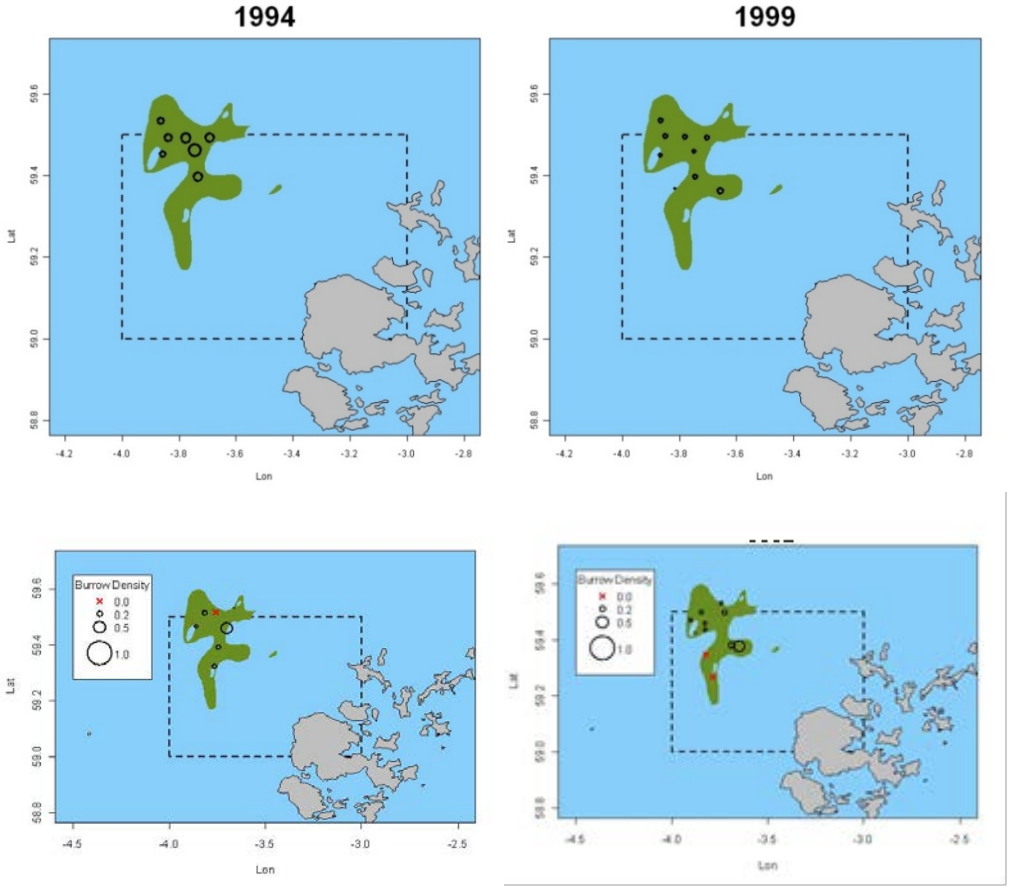


Figure 4.8.2 *Nephrops*, **Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007). Green and brown areas represent areas of suitable sediment for** *Nephrops*. **Density proportional to circle radius. Red crosses represent zero observations.**

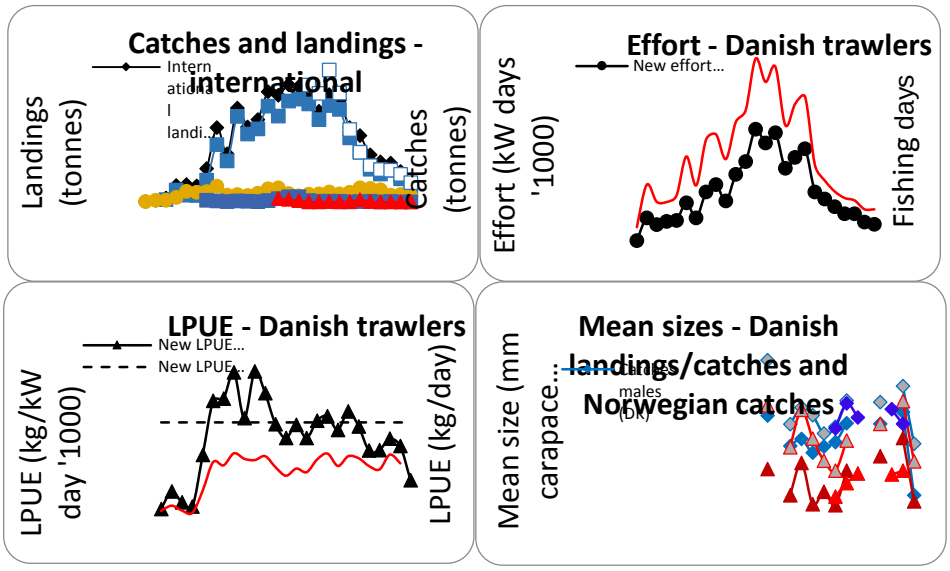


Figure 4.9.1 *Nephrops* **in FU 32 (Norwegian Deep): Landings, effort, LPUE and mean size.**

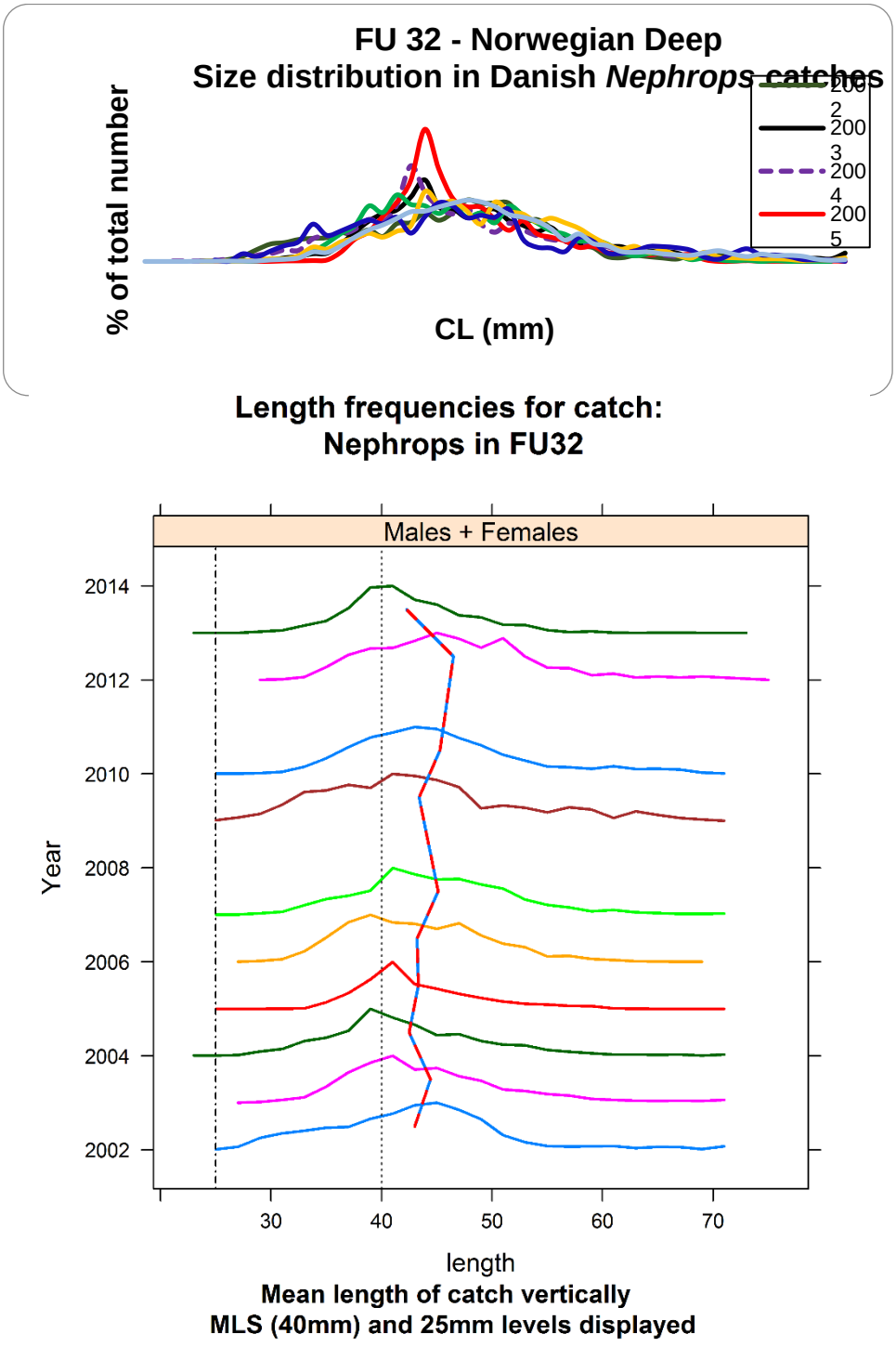


Figure 4.9.2 Nephrops in FU 32 (Norwegian Deep): Size distribution in Danish catches.

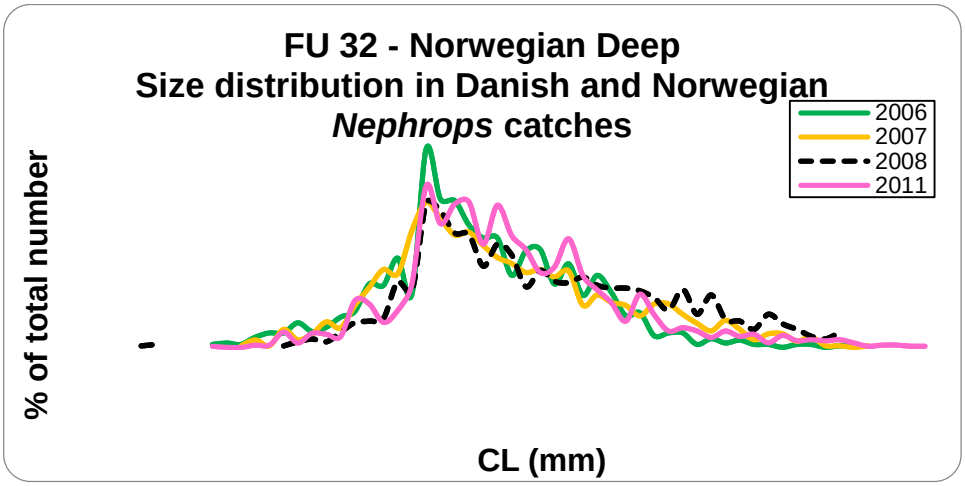


Figure 4.9.3, Nephrops in FU 32 (Norwegian Deep): Size distribution of Danish and Norwegian catches. Data from the Norwegian coast guard.

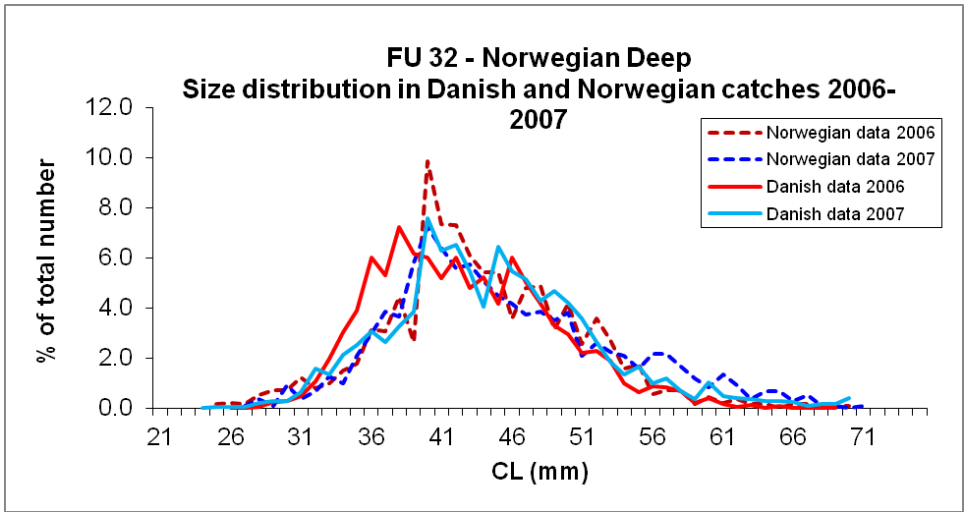
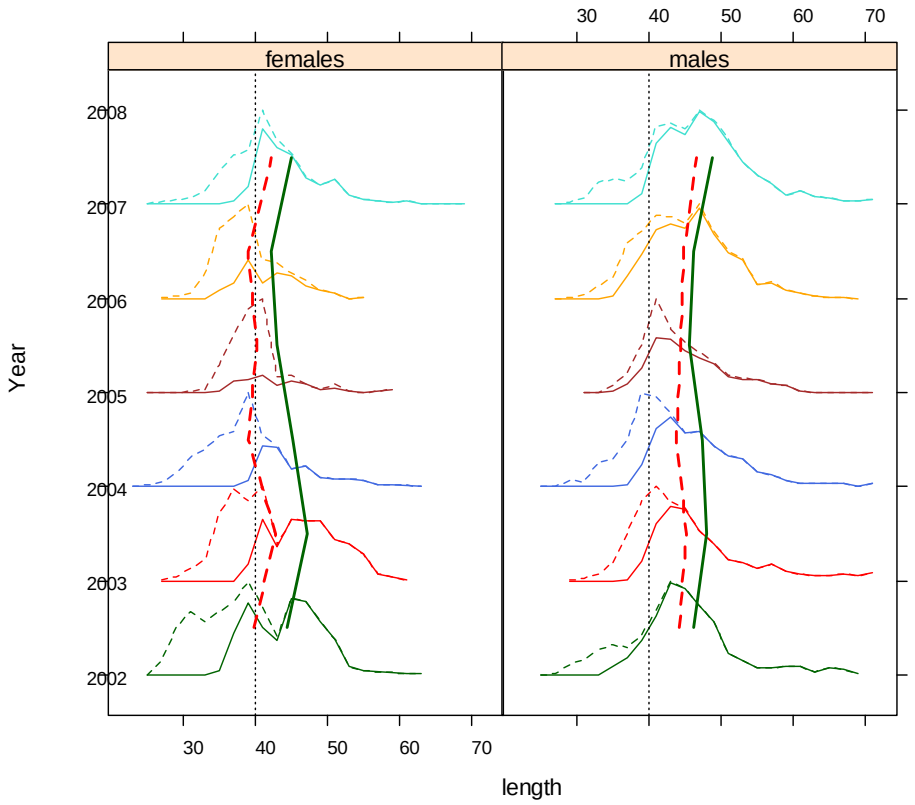


Figure 4.9.4, Nephrops in FU 32 (Norwegian Deep): Comparison of size distribution in catches (2006-2007) from Danish and Norwegian data sources.

**Length frequencies for catch (dotted
Nephrops in FU 32**



**Mean length of landings and catch vertically
MLS (40mm) indicated**

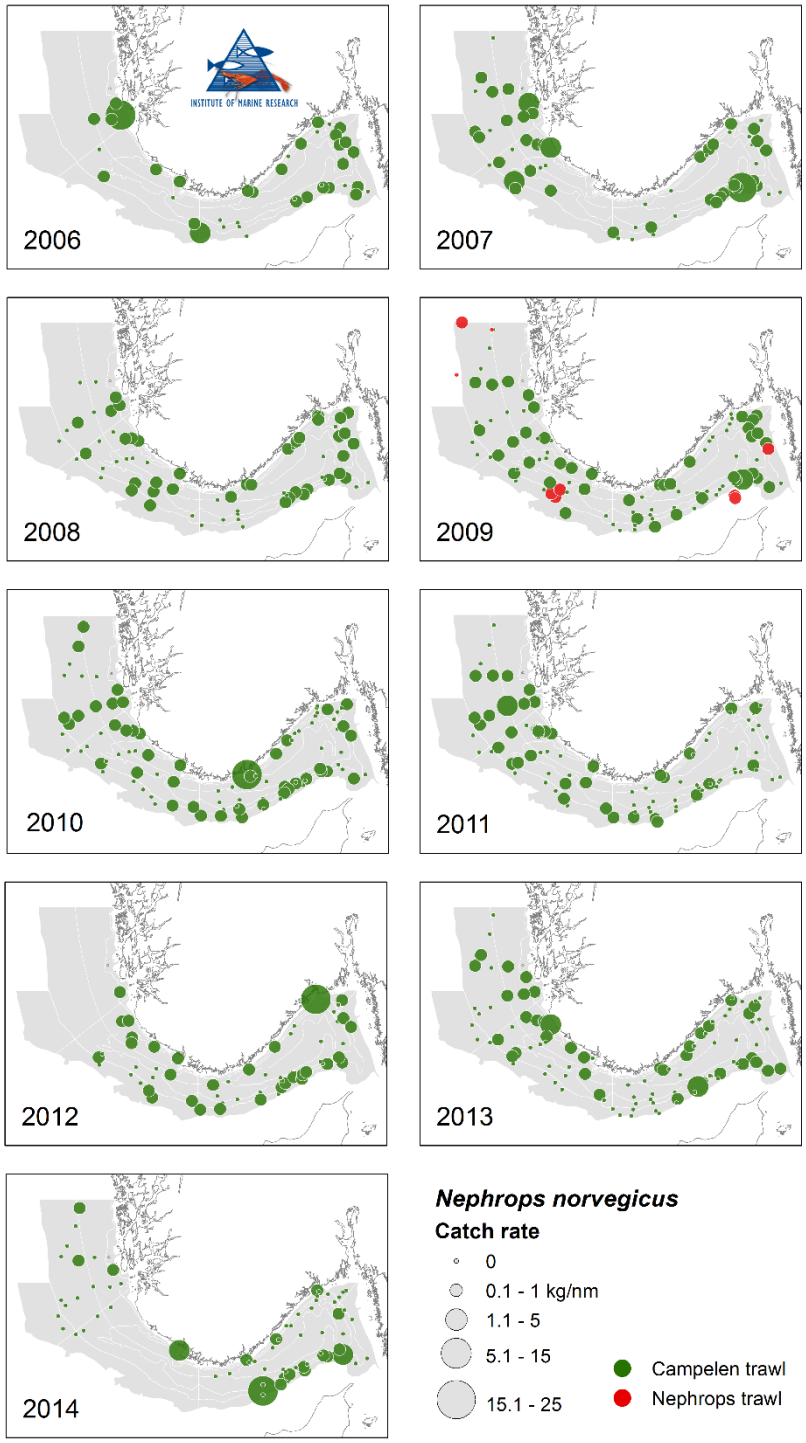


Figure4.9.5 *Nephrops* in FU 32 (Norwegian Deep): Distrobution of *Nephrops* in Norwegian surveys

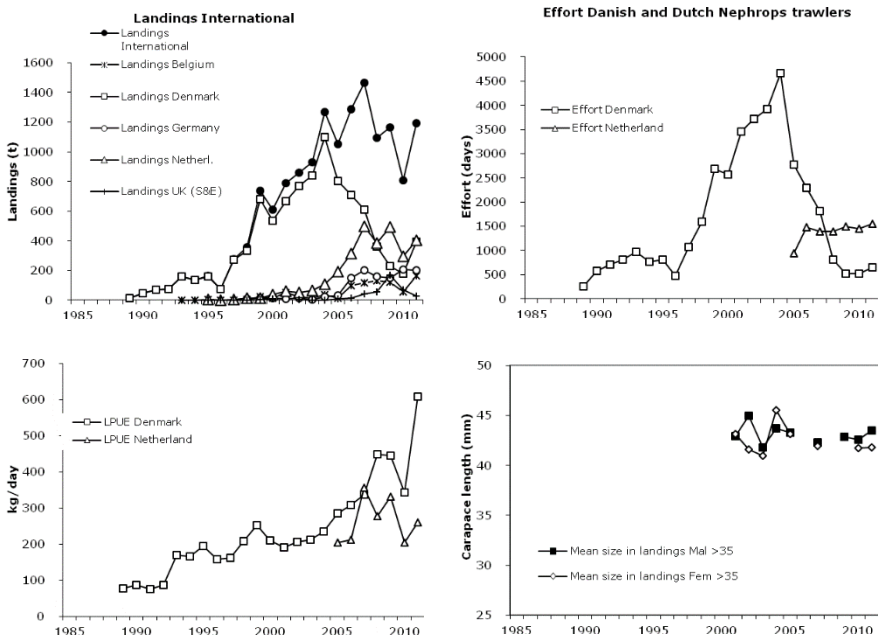


Figure 4.10.1 ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

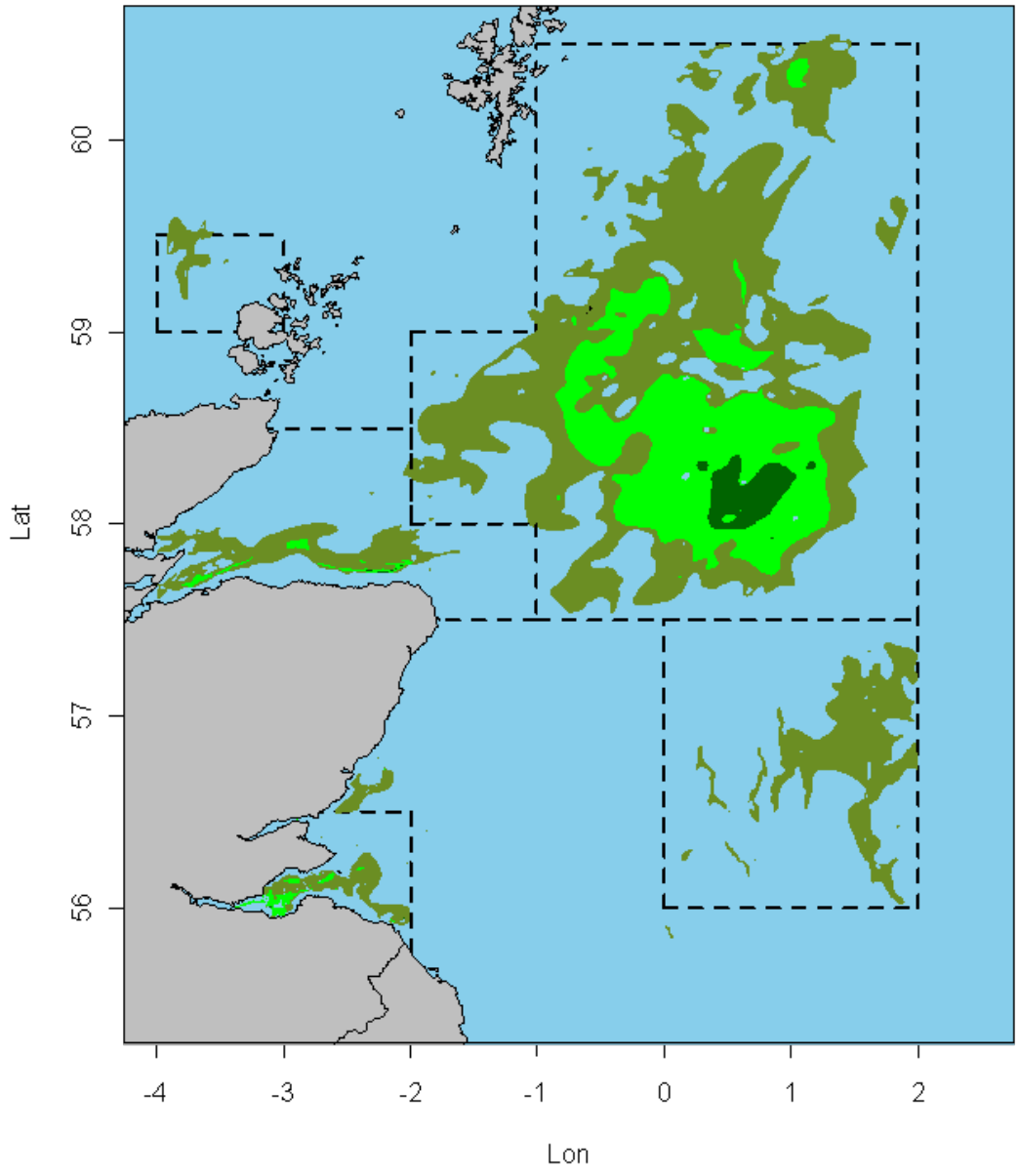


Figure 4.11.1. ***Nephrops*****, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for** ***Nephrops*** **in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**

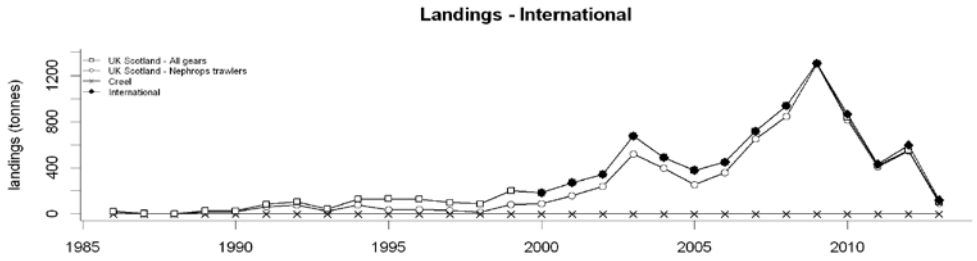


Figure 4.11.2. Nephrops, Devil's Hole (FU 34). Landings from 1986 to 2013.

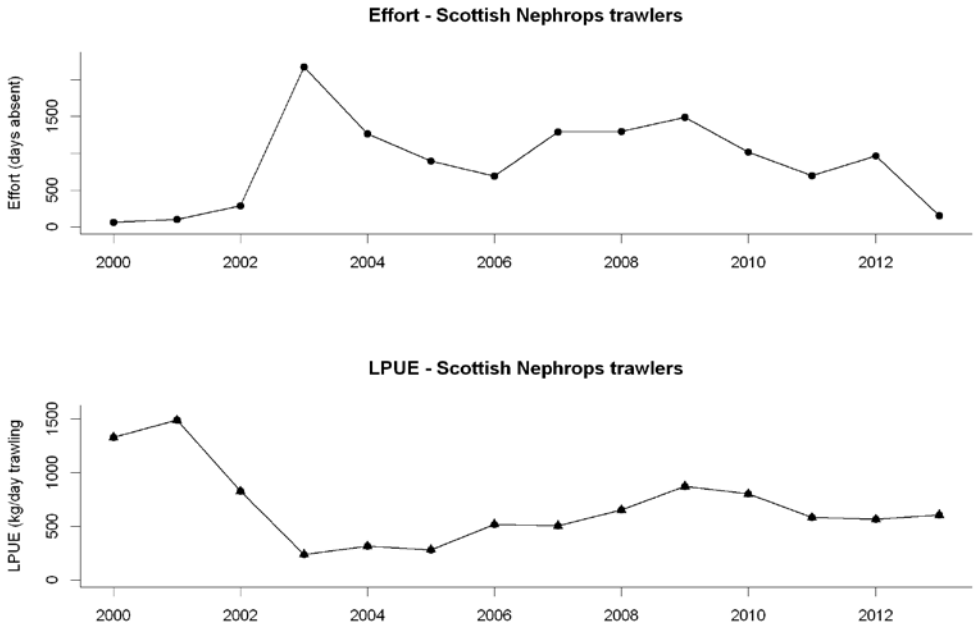


Figure 4.11.3. *Nephrops*, Devil's Hole (FU 34). Effort (days) and LPUE (kg/day) by Scottish trawlers (2000-2013).

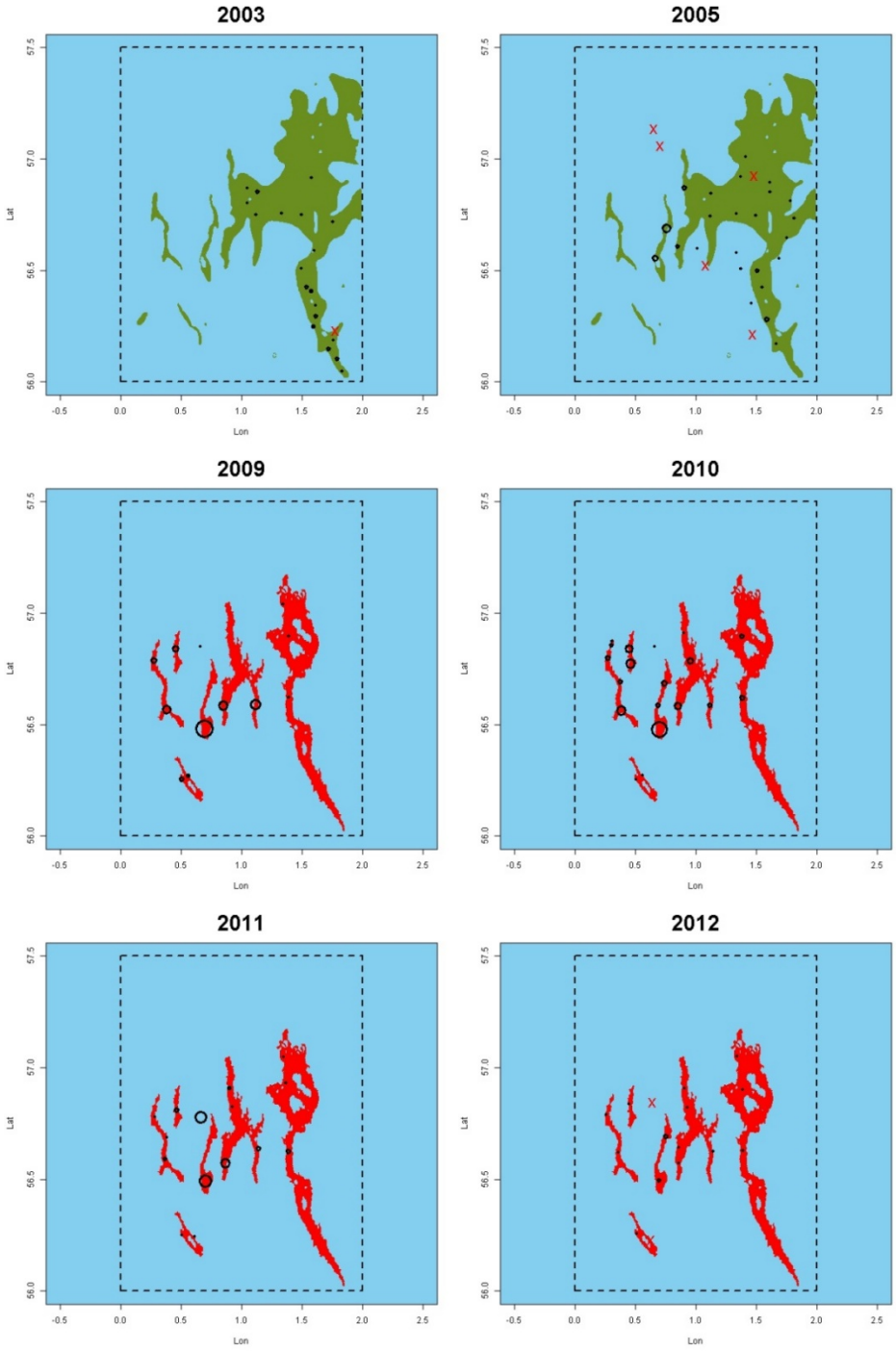


Figure 4.11.4. *Nephrops*, Devil's Hole (FU 34). UWTV survey distribution and relative density (2003, 2005, 2009-2012). Olive areas indicate areas of suitable sediment for *Nephrops*. 2009 - 2012 survey station locations generated from vessel monitoring system (VMS) data. 2003 and 2005 show BGS maps, 2009-2012 show VMS inferred suitable *Nephrops* sediment (WKNEPH, 2013). Density proportional to circle radius.

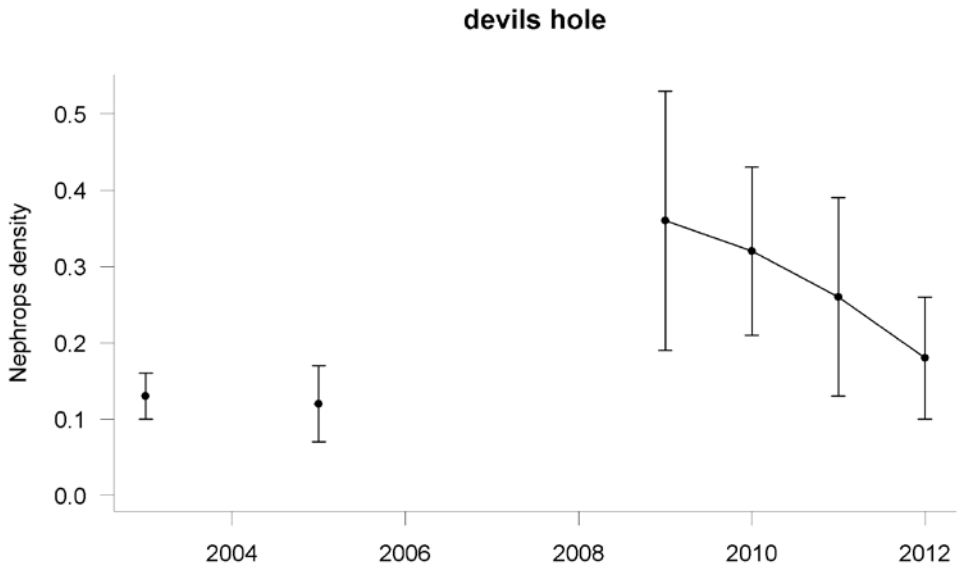


Figure 4.11.5. ***Nephrops*****, Devil's Hole (FU 34). Time series of UWTV survey density estimates (not bias adjusted), with 95 % confidence intervals, 2003, 2005, 2009-12.**

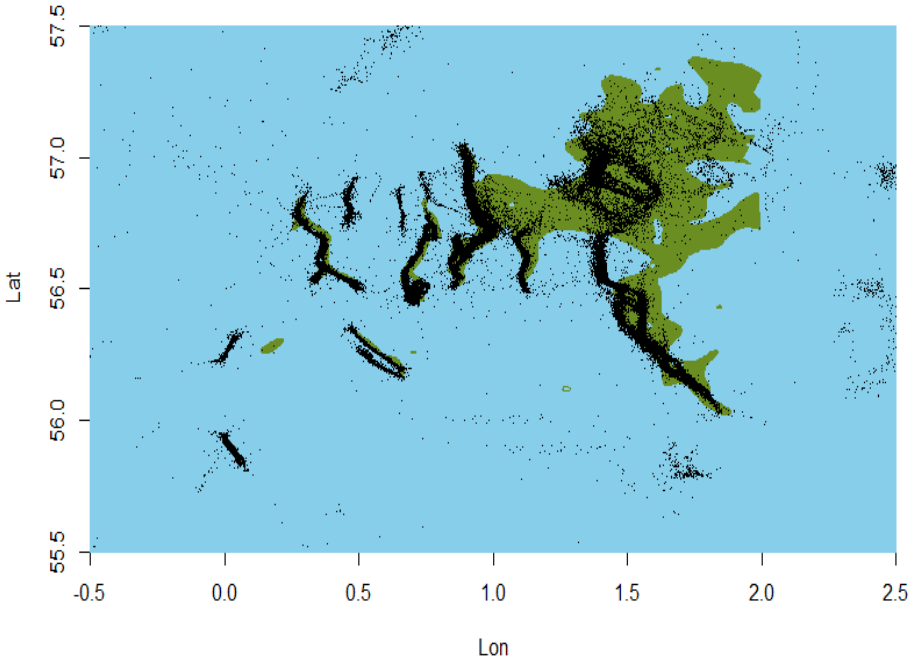


Figure 4.11.6. ***Nephrops*****, Devil's Hole (FU 34). Comparison of BGS sediment map with VMS data from Scottish trawlers (2007-2011) filtered for** ***Nephrops*** **landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.**

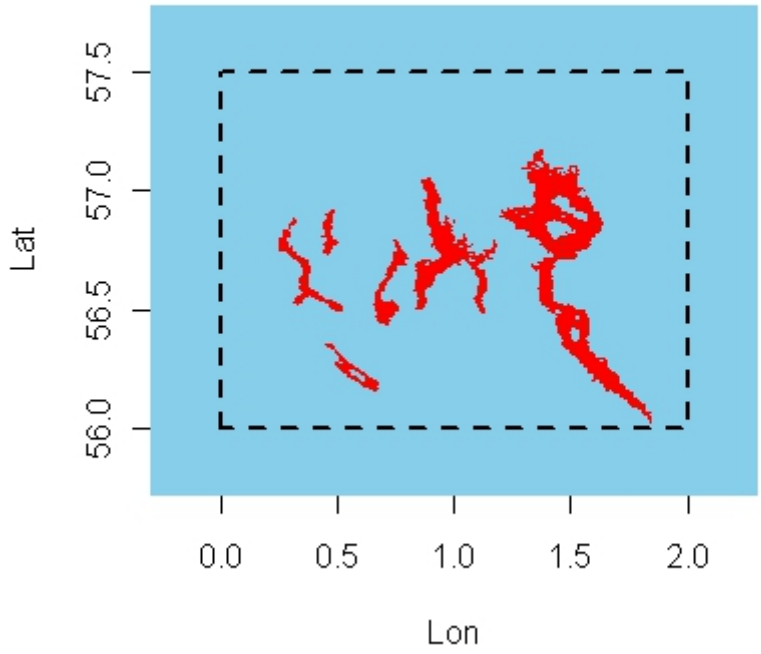


Figure 4.11.7. ***Nephrops*****, Devil's Hole (FU 34). Union of 2007-2011 annual VMS polygons (from alpha convex hull) with VMS data filtered for** ***Nephrops*** **landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.**

5 Norway Pout in ICES Subarea IV and Division IIIa (May 2014)

Introduction: Update and inter-benchmark assessment

The May 2014 assessment of Norway pout in the North Sea and Skagerrak is an update assessment from the May and September 2013 assessments, which are up-date assessments of the 2004 and 2006 benchmark assessments, with respect to use of the same assessment model, tuning fleets and assessment parameter settings, and the Inter-benchmark assessment in spring 2012 (ICES IBPNorwayPout, ICES 2012c) with respect to the population dynamic parameter settings for natural mortality, maturity at age and mean weight at age. The previous settings in the assessment were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The new settings according to the inter-benchmark (from May 2012 onwards) include constant quarterly and yearly natural mortality, but with varying M by age, 20% maturity for the 1-group, and slightly changed levels of constant mean weight at ages in the stock which have been calculated from long term averages of mean weight at age in the catch. These parameters have impact on the predictions and estimates of the SSB because the stock consists of very few year classes. The assessment is a "real time" monitoring (and management) run up to 1st April 2014, and includes new information from second half year 2013 and 1st quarter 2014.

Furthermore, a within year short term prognosis (Forecast) up to 1st January 2015 is given for the stock based on the up-date assessment.

5.1 General

5.1.1 Ecosystem aspects

Norway pout is a short-lived species and most likely a one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and total stock biomass (TSB) rapidly because of the short life span of the species (Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a, 2002b). Furthermore, 20% of age 1 is estimated mature and is included in the SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year influences the SSB in the following year. Also, Norway pout is to a limited extent exploited from age 0. Only limited knowledge is available on the influence of environmental factors, such as temperature, on the recruitment. On this basis Norway pout should be managed as a short-lived species.

Stock definition: Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen *et al.*, 2012, Lambert *et al*,, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt 1968; Sparholt *et al.*, 2002b). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al.*, 2009).

Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al* (2009) show that the maturity rate for the 1-group is close to 20% in average (var-

ying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), gave no evidence for a stock separation in the whole northern area, and this conclusion is supported by the results in Lambert *et al.* (2009).

Ecological role: The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short life span of the species (Nielsen *et al.*, 2012; ICES-WGSAM 2011; Sparholt *et al.* 2002a,b; Lambert *et al.* 2009). Norway pout natural mortality is likely influenced by spawning and maturity having implications its age specific availability to predators in the ecosystem and the fishery (Nielsen *et al.*, 2012). With present fishing mortality levels in recent years the status of the stock is more determined by natural processes and less by the fishery, and in general the fishing mortality on 0-group Norway pout is low (Nielsen *et al.*, 2012; ICES WGNSSK Reports). There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. This stock is among other important as food source for the species saithe, haddock, cod, whiting, and mackerel and predation mortality is significant (ICES-WGSAM 2011, ICES-SGMSNS 2006; ICES-WGSAM 2011). Especially the more recent high abundance of saithe predators and the more constant high stock level of western mackerel as likely predators on smaller Norway pout are likely to significantly affect the Norway pout population dynamics. Interspecific and intraspecific density patterns in Norway pout mortality has been documented (Nielsen *et al*., 2012). However, interspecific density dependent patterns in Norway pout growth and maturity were not found in relation to stock abundance of those predators but rather in relation to North Sea cod and whiting stock abundance (Lambert *et al*., 2009). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES-WGSAM 2011), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used.

Ecosystem impacts of fishery: In order to protect other species (cod, haddock, whiting, saithe and herring as well as mackerel, squids, flatfish, gurnards, Nephrops) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, by-catch regulations, minimum mesh size, and minimum landing size (cf **Stock Annex)**.

5.1.2 Fisheries

The fishery is nearly exclusively performed by Danish and Norwegian vessels using small mesh trawls in the north-western North Sea, especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. See the **Stock Annex** concerning long term trends in average exploitation pattern and average quarterly spatial distribution of the Norway pout catches. The Norway pout fishery is a mixed commercial, small meshed fishery conducted nearly exclusively by Denmark and Norway directed towards Norway pout as one of the target species together with Blue Whiting in the Norwegian fishery.

Landings have been relatively low since 2001, and the 2003-2004 landings were the lowest on record (**Tables** 5.2.1-2). The directed fishery for Norway pout fishery was

closed in 2005, in the first half of 2006, and in 2007 as well as in the first half of 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery around 5 kt, as well as in a small experimental fishery in 2007 (1 kt). In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low, but have been at higher level in 2010, 2012 and 2013. The fishery has in these periods mainly been based on the 2008, 2009, and 2012 year classes being around or above the long term average level. The TAC was not taken in 2008, 2009, 2010, 2012 and 2013, while the small TAC in 2011 was taken. This was likely due to high fishing (fuel) costs in all years as well as bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch). There was only less than 30% quota uptake of the ICES advised TAC for 2012. This low uptake may be explained by the late opening of the fishery at the end of quarter 3 in 2012. In 2013, also the quota uptake was below 30%. Individual quotas for the Danish fishery may also play a role in the uptake. Trends in yield are shown in **Table** 5.3.5 and **Figures** 5.3.1-3.

By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2)), and recent by-catch numbers in the Danish and Norwegian small meshed fisheries are given in section 2 of this report. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from **Table** 5.2.1. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found in the **Stock Annex**.

5.1.3 ICES advice

In September 2013 the advice on North Sea Norway pout was updated with the addition of the 3rd quarter 2013 English and Scottish groundfish surveys.

Based on the estimates of SSB in September 2013, ICES classified the stock to show full reproductive capacity ($SSB>B_{pa}$=MSY $B_{escapement}$).

According to the escapement strategy the fishery was closed 1st of January 2012 because of the well below, nearly historical low, recruitment in 2010 and 2011. A small TAC of 6 kt was set for the second half year 2011 which was taken. Based on the high recruitment in 2012 the fishery was opened again for second half year 2012 and for all of 2013 with a TAC of 71 kt (EU) and 325 kt (EU 168 kt and Norway 157 kt of which 20 kt is in the EU zone), respectively.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.6).

There is bi-annual information available to perform real time monitoring and management of the stock. This can be carried out both with fishery independent and fishery

dependent information as well as a combination of those. Real time advice (forecast) and management options for 2013 will be provided for the stock in autumn 2014 as well.

So far ICES has provided advice according to 3 management strategies for the stock based on a management strategy evaluation made in 2007 (see below). ICES advised in September 2013 - on the basis of precautionary limits and MSY limits - that in order to maintain the spawning stock biomass above B_{pa}= MSY $B_{escapement}$ by 1st January 2015 the directed Norway pout fishery should be maximum 406 kt in 2013 and 216 kt in 2014 under the escapement strategy (real time management), under the long term fixed TAC strategy a TAC on 50 000 t (corresponding to a F around 0.14), and under the long term fixed fishing mortality or fishing effort strategy (TAE) a TAC on 121 000 t corresponding to a fixed F=0.35.

ICES advices that there is a need to ensure that the stock remains high enough to provide food for a variety of predator species. It is advised that by-catches of other species should also be taken into account in management of the fishery. Also it is advised that existing measures to protect other species should be maintained.

5.1.4 Management up to 2013

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the MSY approach (MSY $B_{escapement}$) for short lived species in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing on marine ecosystems.

ICES advised in 2005 real time management of this stock. In previous years the advice was produced in relation to a precautionary TAC, which was set to 198 000 t in the EC zone and 50 000 t in the Norwegian zone. On basis of the real time management advice from ICES, EU and Norway agreed to close the directed Norway pout fishery in 2005, first part of 2006, all of 2007 and in first part of 2011 and 2012. In 2005 and 2007, the TAC was 0 in the EC zone and 5 000 t in the Norwegian zone – the latter to allow for by-catches of Norway pout in the directed Norwegian blue whiting fishery. The final TAC set for 2008 was 115 kt, 116 kt (EU) for 2009, 162 kt for 2010, 6 kt for 2011, 71 kt (EU) for 2012, and 325 kt for 2013, however, the TACs were not taken during this period except for the small TAC in 2011. Fishery was closed in first half year 2011 and 2012. Bycatch regulations have sometimes been restrictive (e.g. in 2009 and 2010 mainly in relation to whiting bycatch).

In managing this fishery by-catches of other species have been taken into account. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained.

Long term management strategies have been evaluated for this stock based on joint EU-Norway requests (see Section 5.10). ICES has evaluated and commented on three management strategies in 2007, although these have not been decided on. Long term management strategies have been evaluated again in September 2012 and June 2013 based on new joint EU-Norway requests (ICES, 2012b) in spring 2012 and spring 2013 to be available for the September 2012 and September 2013 ICES advice, respectively. These MSEs have been presented in a special ICES reports (Vinther and Nielsen, 2012; 2013). No long term management strategies have been decided upon.

An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in the **Stock Annex.**

5.2 Data available

5.2.1 Landings/catches

Data for annual nominal landings of Norway pout as officially reported to ICES are shown in **Table** 5.2.1. The landings equal the catches of Norway pout as discard in this small meshed fishery is negligible. Historical data for annual landings (catches) as provided by ICES (Working Group members) are presented in **Table** 5.2.2, and data for national landings (catches) by quarter of year and by geographical area are given in **Table** 5.2.3. Both the Danish and Norwegian landings (catches) of Norway pout were low in 2007 and 2011. The landings were moderate in 2008, 2009, 2012, and higher in 2010 and 2013, and the TAC was not reached in any of these years. The most recent catches have been included in the assessment.

5.2.2 Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 2007 and 2008). Catch at age by quarter of year is shown in **Table** 5.2.4. Only very few biological samples were taken from the low Norway pout catches in 2005 and 2011, as well as in first half year 2006, 2007, and 2012. Danish data are in the InterCatch database.

As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches, the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery for those years. As no age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches the catch at age numbers from Danish fishery is calculated from Danish total catch weight divided by mean weight at age from the Norwegian fishery in 2010.

5.2.3 Weight at age

Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight at age in the catch is shown in **Table** 5.2.5 and the historical levels, trends and seasonal variation in this is shown in **Figure** 5.2.1. Mean landings weight at age from Danish and Norwegian fishery from 2005-2008 as well as for 2011 are uncertain because of the few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005-2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight at age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight at age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight at age data is available from both Danish and Norwegian fishery in 2009, second half 2010, second half 2011, second half 2012, and all of 2013.

Mean weight at age in the stock is given in **Table** 5.2.6. The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009).

The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. In the **Stock Annex** a summary is given of the Inter-benchmark revisions of the population dynamic parameters in the assessment. No major revision of mean weight at age in the stock has been performed compared to the values used in previous assessments. The estimation of mean weights at age in the catches and the used mean weights in the stock in the assessment is described in the **Stock Annex.** Danish data are in the InterCatch database.

5.2.4 Maturity and natural mortality

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM 2011)). In the **Stock Annex** a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment where maturity and natural mortality used in the assessment is described. Proportion mature and natural mortality by age and quarter used in the assessment is given in **Table** 5.2.6.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a paper by Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, then variable natural mortality between ages have been introduced in the 2012 ICES IBPNorwayPout inter-benchmark assessment (ICES, 2012c) and the present assessment. The revision of the natural mortality parameter is based on results in Nielsen *et al*. (2012) and the ICES WGSAM 2011 multi-species assessment report. The revised values are shown in **Table** 5.2.6.

5.2.5 Summary of Interbenchmark assessment on population dynamic parameters

A summary of the ICES Spring 2012 inter-benchmark assessment with revised weight, maturity and natural mortality parameters at age included in the assessment is given in the Stock Annex as well as in the ICES IBPNorwayPout inter-benchmark assessment report (ICES, 2012c)

5.2.6 Catch, Effort and Research Vessel Data

Description of catch, effort and research vessel data used in the assessment is given in the **Stock Annex.** Data used in the present assessment is given in **Table**s 5.2.7-5.2.11 as described below. No commercial fishery tuning fleet is included for 2005-2011 except for second half year 2006. Recent catch information for 2008-2013 is included in this assessment. Catches in all of 2005, 1st quarter 2009, first half year 2011 and 2012, and first quarter 2013 were nearly 0 and only very limited information exists about this

catch. Consequently, there has been assumed and used low catches of 0.1 million individuals per age (for age groups 1-3) per quarter in the SXSA for 2005 and 0-catches for the other mentioned periods.

5.2.6.1 Effort standardization:

The method for effort standardization of the commercial Norway pout fishery tuning fleet is described in the **Stock Annex**, which has also been used with up-dated data in the May 2014 assessment. However, no standardized effort data and cpue-indices for the commercial fishery tuning fleet have been included for 2005-2011 except for 2nd half year 2006. The results of the standardization are also presented in the **Stock Annex.**

Up-dated effort data from the commercial fishery is given in **Tables** 5.2.8 and 5.2.9, and the CPUE trends in the commercial fishery are shown in **Table** 5.2.10 and **Figure** 5.2.2.

5.2.6.1.1 Danish effort data

Table 5.2.7 shows CPUE data by vessel size category and year for the Danish commercial fishery in ICES area IVa. The basis for these data is described in the **Stock Annex**. However, no Danish effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Data for 2008-2013 has been included.

5.2.6.1.2 Norwegian effort data

Observed average GRT and effort for the Norwegian commercial fleets are given in **Table** 5.2.8, however, no Norwegian effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007. Norwegian effort data for the directed Norway pout fishery in 2008 has not been prepared because the fishery has been on low level, and data for 2010-13 has not been prepared because of introduction of selective grids in the Norwegian fishery from 2010 onwards. Data for 2009 has been included.

5.2.6.1.3 Standardized effort data

The resulting combined and standardized Danish and Norwegian effort for the commercial fishery used in the assessment is presented in **Table** 5.2.9. However, no standardized effort data for the commercial fishery tuning fleet is included for 2005-2011 except for 2nd half year 2006. Standardized effort data for 2008 and 2010-13 for the Danish part of the fleet, as well as for both the Danish and Norwegian fleets in 2009, is presented in the table.

5.2.6.1.4 Commercial fishery standardized CPUE data

Combined CPUE indices by age and quarter for the commercial fishery tuning fleet are shown in **Table** 5.2.10. Trends in CPUE (normalized) by quarterly commercial tuning fleet and survey tuning fleet for each age group and all age groups together are shown in **Figure** 5.2.2. However, no combined CPUE indices by age and quarter for the commercial fishery tuning fleet are used for 2005, first half year 2006 and for 2007-2014.

5.2.6.1.5 Research vessel data

Survey indices series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (International Bottom Trawl Survey 1st and 3rd quarter) and the EGFS (English Ground Fish Survey, 3rd quarter) and SGFS (Scottish

Ground Fish Survey, 3rd quarter), **Table** 5.2.11. The new survey data from the 1st quarter 2014 IBTS and the 3rd quarter 2013 IBTS research surveys have been included in this assessment (as well as the 3rd quarter 2013 EGFS and SGFS research survey information which also were included in the September 2013 assessment). The survey data time series including the new information is presented in **Table** 5.2.11, as well as trends in survey indices in **Figure** 5.2.2. Surveys covering the Norway pout stock are described in the **Stock Annex**. Survey data time series used in tuning of the Norway pout stock assessment are described below.

From 2009 and onwards the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted sub-area averages. The survey data time series including the new information are presented in **Table** 5.2.1.

5.2.6.1.6 Revision of assessment tuning fleets

The revision of the tuning fleets used in the benchmark 2004 assessment - as used also in the 2005-2006 and 2007-2014 assessments - is summarised in **Table** 5.3.1. Details of the revision are described in the **Stock Annex.**

Apart from the up-dated catch data and research survey indices, all other data and data standardization methods used in this assessment are identical to those used and described in the May and September 2013 assessments as well as previous up-date assessments to those (see also **Table** 5.3.1).

5.3 Catch at Age Data Analyses

5.3.1 Review of assessment

The assessment was not reviewed in 2013, but there was made Audit of both the May and September 2013 Assessment:

General comments

The assessment report and advice was well written, fully documented and ordered, especially considering the short amount of time available to do this work. It was easy to follow and interpret, despite the unique aspects of monitoring and managing this stock.

Technical comments

There were no major errors but a few points to note;

- Check the legends for tables and figures as the time series stated in the legend did often not match what was displayed in the table or figure - Table 5.2.1, 5.2.3, Figure 5.2.1.

(Answer: Yes, this has been checked and up-dated in 2014).

- Check the legends for tables and figure which contain landings because sometimes it stated that landings were reported in tonnes when it should be kt or ('000 t) – Table 5.2.1, 5.2.3, 5.2.7).

(Answer: Yes, this has been checked and up-dated in 2014).

- Section 5.1.2, the second paragraph is a little confusing because I was unsure whether you were discussing the landings in terms of the time series in Table 5.2.1 (2002-2012) or Table 5.2.2 (1961-2012 – not including Kattegat).

(Answer: It has been slightly reformulated in 2014 and should be clearer now).

- Section 5.2.1 – it is stated that landings were low in 2008, 2009 and 2011 and moderate in 2010 and 2012, but the landings in 2012 were lower than 2008 and 2009?

(Answer: It has been slightly reformulated in 2014 and should be clearer now).

- Section 5.2.6.1 updated effort data from the commercial fishery is given in Tables 5.2.8 and 5.2.9 (not 5.17-5.19).

(Answer: Yes, this has been checked and up-dated in 2014).

- Section 5.3.2 – paragraph four discusses fishing mortality on a quarterly basis and I found this difficult to follow and thought it may possibly be better displayed in a figure (as well as the table already presented)?

(Answer: It has been slightly modified, but appear clear to the working group. Also, this is described in the Stock Annex).

- The report states that the revised parameters (natural mortality, maturity at age, and mean weight at age) have caused a slight increase in SSB and decrease in recruitment – but I found the difference in SSB difficult to see in any of the figures in the report? Figure 6.4.16a.2 (in the advice sheet) is better but could benefit from a legend stating what the different colours of line represent?

(Answer: This is shown in the Benchmark Report as well as in the Stock Annex, and this has now been written into the text with specific reference to those two reports/documents).

- Section 5.7 – underneath the table is reports "unchanged since 2010" but the sentence below mentions that the reference points have been unchanged since 1997?

(Answer: The MSY approach has not changed since 2010, and the reference points have not changed since 1997. Therefore the WG believe it is correct as presently given in the report).

Conclusions

The assessment has been performed correctly.

(Additional: All comments made to the Advice Sheet in the September 2013 Audit has been addressed in the May 2014 Advice Sheet).

5.3.2 Final Assessment

The SXSA (Seasonal Extended Survivors Analysis) was used to estimate quarterly stock numbers (and fishing mortalities) for Norway pout in the North Sea and Skagerrak in May 2014. A general description of and reference to documentation for the SXSA model is given in the **Stock Annex.** Stock indices and assessment settings used in the assessment are presented in **Tables** 5.3.1-2. The SXSA recruitment estimates are used to estimate the geometric mean for the stock-recruitment which is used in the forecast (see **Table** 5.3.6).

In contrast to the September 2013 assessment, no back-shifting of the third quarter survey indices was undertaken, and the recruitment season to the fishery in the assessment is, accordingly, set to quarter 3 as the standard in the May assessments for the stock. The reason for using the 2nd quarter as recruitment season in the in year September assessments is that these assessments run up to 1st July in the assessment year and the 3rd quarter surveys are back-shifted to 2nd quarter in order to include this in year survey indices and information on 0-group recruitment in the assessment. All other

aspects and settings in the assessment are an up-date of the May 2009 and September 2009 assessments except for the revision of the population dynamic input parameters in the assessment on natural mortality, maturity and mean weight (growth) at age based on the Inter-benchmark assessment in spring 2012 (ICES, 2012c) (see **Table** 5.2.6).

Results of the SXSA analysis are presented in **Table** 5.3.1-2 (assessment model parameters, settings, and options), **Table** 5.3.3 (population numbers at age (recruitment), SSB and TSB), **Table** 5.3.4 (fishing mortalities by year), **Table** 5.3.5 (diagnostics), and Table 5.3.6 (stock summary). The summary of the results of the assessment are shown in **Table** 5.3.6 and **Figures** 5.3.1-5.

Fishing mortality has generally been lower than natural mortality and has decreased in the recent decade below the long term yearly average (0.6). Fishing mortality for the 1st and 2nd quarter has in general decreased in recent years, while fishing mortality for 3rd and especially 4th quarter, that historically constitutes the main part of the annual F, has also decreased moderately during the last decade. Fishing mortality in 2005, first part of 2006, 2007, 2011 and in first part of 2012 was close to zero due to the closure of the Norway pout fishery in these periods. Fishing mortality was moderate in 2008 and 2009, and on a higher level in 2010, second half 2012 and in 2013, and the TACs have not been fished up in any of these recent years. The low TAC of 6kt in 2011 was taken in second half year resulting in a very low F in 2011.

Spawning stock biomass (SSB) has since 2001 decreased continuously until 2005 but has in recent years increased again due to the average 2005, 2007 and 2008 year classes, and the strong 2009 and 2012 year classes, and the lowered fishing mortality. The stock biomass fell to a level well below $\mathbf{B_{lim}}$ in 2005 which is the lowest level ever recorded. By 1st January 2007 and 2008 the stock was at $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{escapement}}$) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1st January 2009, 2010, 2011, 2012, 2013 and 2014 has been above Bpa (i.e. the stock show full reproductive capacity).

The recruitment in 2010 and 2011 was very low and at the same level as the low 2003 and 2004 year classes where these four year classes are the lowest on record since 1983. The recruitment in 2009 and 2012 was very high. Recruitment in 2013 is below long term average, but because of the strong 2012 year class the SSB is expected to be well above $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{escapement}}$) in 2014 even with a high TAC in 2014 considering growth, high natural mortality, and 20% maturation at age 1 (see forecast).

5.3.3 Comparison with 2013 assessment

The final, accepted May 2014 SXSA assessment run was compared to the Inter-benchmark May 2012 and up-date September 2013 Scenario 2 SXSA assessment with new population dynamic parameters. The results of the comparative run between the September 2013 and the May 2014 assessments are shown in **Figure** 5.3.5. The retrospective analysis based on the May 2014 assessment is shown in **Figure** 5.3.4. The resulting outputs of these assessments showed to be identical giving similar perception of stock status and dynamics.

It should be noted that in the 2014 IBTS Q1 survey, less hauls were conducted in the northern part of the North Sea than usual. The assessment results have been checked for year effects and outliers in log inverse catchabilities and weighting factors for computing survivors for this fleet (compared to last year assessments) (**Table** 5.3.5), as well as for year trends in log residual stock numbers by age for this fleet (**Figure** 5.3.1). Also, year effects and outliers were checked in the input data for this survey fleet with respect to trends in normalized CPUE data by age and year (**Figure** 5.2.2). No outliers

and nothing serious were encountered, but an increase in the uncertainty around the survey index for 2014 can be expected because of the lower number of hauls.

5.4 Historical stock trends

The assessment and historical stock performance is consistent with previous years assessments, i.e. the perception of stock dynamics of the SSB, recruitment, and of the average fishing mortality of ages 1 and 2 over time are consistent. However, based on the Inter-Benchmark in spring 2012 with revised estimates of natural mortality, maturity at age and mean weight at age for the stock in the assessment there is a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10 % in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter. This is shown in the ICES IBPNorwayPout Report (ICES 2012c) and the **Stock Annex**.

Recruitment Estimates

The long-term average recruitment (age 0, 3rd quarter) is 45 billions (arithmetic mean) and 36 billions (geometric mean) for the period 1983-2014 (**Table** 5.3.5). Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. The recruitment reached historical minima in 2003-2004 as well as in 2010 and has been around the long term average in 2005, 2007 and 2008, while the 1987, 2002, 2006, 2010 and 2011year classes were weak. The 2008, 2009 and 2012 year classes were very strong. The 2013 recruitment is below average (25 billions).

5.5 Short-term prognoses

Deterministic short-term prognoses were performed for the Norway pout stock. The forecast was calculated as a stock projection up to 1st of January 2015 using full assessment information for 2013 and 1st quarter 2014, i.e. it is based on the SXSA assessment estimate of stock numbers at age at the start of 2014.

The purpose of the forecast is to calculate the catch of Norway pout in 2014 which would result in SSB at or above $\mathbf{B_{pa}}$ = MSY $\mathbf{B_{escapement}}$ (=150 000 t) 1st of January 2015. The forecast is based on an escapement management strategy but also providing output for the long term fixed E or F management strategy and a long term fixed TAC strategy for Norway pout (see ICES WGNSSK Report ICES CM 2007/ACFM:30 section 5.3, and ICES AGNOP Report ICES CM 2007/ACFM:39, and the ICES AGSANNOP Report ICES CM 2007/ACFM:40 as well as section 5.10 below).

Input to the forecast is given in **Table** 5.6.1. Observed fishing mortalities for all quarters of 2013 have been used (assessment year) as well as for first quarter 2014 (forecast year).

The forecast assumes a quarter 2-4 2014 (the forecast year) fishing pattern similar to that in 2013. This most recent fishing pattern is considered the most realistic fishing pattern for the quarter 2-4 2014 fishery as the fishery is open with a relatively high TAC in all of the years 2013 and 2014. The background for selecting the most recent exploitation pattern is that the exploitation pattern between seasons (and ages) has been variable over years and shifted in recent years towards being mainly a quarter 4 fishery.

Recruitment in the forecast year is assumed to the 25th percentile = 24 736 millions of the SXSA recruitment estimates (GM = 35 960 millions) in the 3rd quarter of the year.

The weight at age in the catch per quarter is based on estimated mean weight at age in catches in the assessment year of the forecast (2013) and in first quarter of the forecast

year (2014) and based on recent running 5 year averages (i.e. for the 5 last years with covering observations) for the second to fourth quarter of the forecast year (2014). A 2012 Inter-benchmark assessment revised the values for the natural mortality, maturity-at-age and weight-at-age used in the assessment and the forecast (see **Table** 5.2.6 and ICES 2012a,c). Accordingly, the revised constant weight at age in the stock by year and quarter of year as well as the revised maturity and natural mortality at age used in the SXSA assessment has also been used in the forecast for 2014.

Twenty percent of age 1 is mature and is included in SSB. Therefore, the recruitment in 2013 does influence the SSB in 2014.

The results of the forecasts are presented in **Table** 5.6.2. With catches up to 108 kt in 2014 the spawning-stock biomass will remain above a reference level of MSY $B_{escapement}$ by 1st January 2015 according to the escapement strategy. This is because the SSB is expected to remain high during 2014 due to the very high 2012 recruitment, the growth and 20 % mature as 1-group, and still considering the high natural mortality as well as the short life span of the stock. When combining a fixed F management strategy (F around 0.35 in 2014) with a fixed TAC strategy (a TAC of 50 000 t in 2014) according to the 2007 Long Term Management Strategy evaluation the SSB is expected to be well above B_{pa} and MSY $B_{escapement}$ by 1st January 2015. Under a fixed F-management-strategy with F around 0.35 a catch around 77 000 t can be taken in 2014. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2014 (corresponding to a F around 0.21) according to the long term management strategies evaluated in 2007. In recent years the escapement strategy has been practiced in reality in management. According to the escapement strategy a 108 kt catch in 2014 will result in a spawning stock biomass at MSY $B_{escapement}$. With the objective to maintain the spawning stock biomass at or above a reference level of MSY $B_{escapement}$ by 1st of January 2015 the ICES advice is that the fishery can catch a TAC up to 108 kt in 2014 in the directed Norway pout fishery.

5.6 Medium-term projections

No medium-term projections are performed for this stock. The stock contains only a few age groups and is highly influenced by recruitment.

5.7 Biological reference points

	Type	Value	Technical basis
MSY	MSY Bescapement	150 000 t	= Bpa
Approach	FMSY	Undefined	None advised
	Blim	90 000 t	Blim = Bloss, the lowest observed biomass in the 1980s
Precautionary	Bpa	150 000 t	= Blim e0.3*1.65
Approach	Flim	Undefined	None advised
	Fpa	Undefined	None advised

(unchanged since: 2010)

Biomass based reference points have been unchanged since 1997 given MSY $B_{escapement}$ = B_{pa}. No F-based reference points are advised for this stock.

Norway pout is a short lived species and most likey an one time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen et al., 2012; Sparholt et al. 2002a,b; Lambert *et al.*, 2009). Furthermore, 20 % of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short lived species.

On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$. B_{lim} is defined as B_{loss} and is based on the observations of stock developments in SSB (especially in 1986 and 1989) been set to 90 000 t. MSY $B_{escapement}$ = B_{pa} has been calculated from

$B_{pa} = B_{lim}\, e^{0.3*1.65}$ (SD).

A SD estimate around 0.3-0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2-0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS, 1999). The relationship between the Blim and MSY $B_{escapement}$ = B_{pa} (90 000 and 150 000 t) is 0.6.

An Inter-benchmark in spring 2012 (IBPNorwayPout, ICES, 2012c) used revised estimates of natural mortality, maturity at age and mean weight at age in the assessment. The benchmark group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem.

A segmented regression with current SSB-R data was fit in relation to the benchmarking process (ICES, 2012c). It is obvious that the Norway pout, being a short-lived species, has no well-defined break point (inflection) in the SSB-R relationship and therefore there is not clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high

recruitment observed at B_{loss} as well as more observations above than below the inflection point). The statistics from the segmented regression (ICES, 2012c) shows that the inflection point is rather badly estimated (high value of b), poor convergence, and that the maximum likelihood method cannot estimate the inflection (and the slope before inflection) well. Results therefore suggest that B_{loss} be retained as the B_{lim} reference point = 90 kt and B_{pa} as MSY $B_{escapement}$ reference point = 150kt.

Higher escapement targets could be considered in the future based on the importance of Norway Pout as a forage species in the ecosystem.

The $B_{lim} = B_{loss}$ = 90kt is based on the lowest observed SSBs in the 1980s around 88kt in 1986 and 85kt in 1989 according to the previous baseline assessment. Even though lower biomasses (SSB) were observed for the stock in the period 2004-2006 (84kt in 2004, 54kt in 2005, 76kt in 2006 according to the previous baseline assessment) then the ICES WGNSSK working group at that time advised not to change the reference points because of the status of Norway pout being an important forage fish species in the North Sea. In the scenario 2 benchmark assessment (ICES 2012c) the SSB in 1986 is around 109 kt and in 1989 around 112 kt. A B_{lim} set to 110 kt on this basis instead of the 90 kt would result in a MSY Bescapement = Bpa =180kt instead of 150kt where Bpa = B_{lim} e0.3*1.65 and $B_{lim} = B_{loss}$ = 110 kt.

5.8 Quality of the assessment

The estimates of the SSB, recruitment and the average fishing mortality of the 1- and 2-group are consistent with the estimates of previous years assessment. This appears from the results of the assessment as well as from **Figures** 5.3.4 and 5.3.5 with among other the comparisons with the 2013 assessment. However, based on the Inter-Benchmark in spring 2012 with revised estimates of natural mortality, maturity at age and mean weight at age for the stock in the assessment (ICES, 2012c) there is a consistent (over time) slight increase in SSB (because 20% of the age group 1 is considered mature compared to 10 % in the previous assessments), and a consistent slight decrease in recruitment and total stock biomass compared to previous years mainly because of the revised natural mortality by age and quarter.

The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the seasonal assessment taking into account the seasonality in fishery, use seasonal based fishery independent information, and using most recent information about recruitment. The assessment provides stock status and year class strengths of all year classes in the stock up to the first quarter of the assessment year. The real time assessment method with up-date every half year also gives a good indication of the stock status the 1st January the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

5.9 Status of the stock

Based on the estimates of SSB in September 2013, ICES classified the stock at full reproductive capacity with SSB well above Bpa at the start of 2013 (up to 1st July 2013). Also, the most recent estimates of SSB (Q1 2014) show full reproductive capacity of the stock (SSB> MSY $B_{escapement} = B_{pa}$). With catches up to 108 kt in 2014 the spawning-stock biomass is expected to remain above a reference level of MSY $B_{escapement}$ by 1st January 2015 according to the escapement strategy due to the very strong 2012 recruitment, growth of the stock and still taking into consideration the high natural mortality as well as the short life span of the stock.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years below the long term average F (0.6). Targeted fishery for Norway pout was closed in 2005, first half year 2006, in all of 2007, as well as in first half of 2011 and 2012 and fishing mortality and effort has accordingly reached historical minima in these periods (**Table** 5.3.6). The fishery was open for the second half 2006, 2011 and 2012 as well as in all of 2008, 2009, 2010 and 2013 where fishing mortality was low in 2011, moderate in 2008 and 2009, and on a higher level in 2010, 2012 and 2013.

The recruitment for 2010 and 2011 was low (for 0-group 3rd quarter) resulting in weak year classes here at the same level as in 2003 and 2004 being the lowest on record since 1983. The recruitment in 2008, 2009 and 2012 was high and well above the long term average. (**Tables** 5.3.3 and Table 5.3.6).

5.10 Management considerations

There are no management objectives for this stock.

From the results of the forecast presented here it can be seen that if the objective is to maintain the spawning stock biomass above a reference level of MSY $B_{trigger} = B_{pa}$ by 1st of January 2015 then a catch of 108 kt can be taken in 2014 in the directed Norway pout fishery corresponding to a F=0.54 in 2014 according to the variable TAC escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 77 000 t can be taken in 2014. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2014 (corresponding to a F around 0.21) according to the long term management strategies evaluated in 2007. In recent years the escapement strategy has been practiced in reality in management.

There is consistent bi-annual information available to perform real time monitoring and management of the stock. This can be carried out both with fishery independent and fishery dependent information as well as a combination of those. Real time advice (forecast) and management options for 2014-2015 will be provided for the stock in autumn 2014 (in year September assessment and forecast).

Norway pout is a short lived species and most likely an one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt et al. 2002a,b; Lambert *et al.*, 2009). On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$. (see also the Inter-benchmark assessment from 2012, ICES, 2012c).

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES WGSAM, 2011; ICES-SGMSNS, 2006).

Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in the **c**.

Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. Existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present low level of by-catch of other species in the Norway pout fishery also appears from **Table** 5.2.1. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is ongoing. ICES suggests that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. The implementation of these technical measures shall be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in the **Stock Annex.**

5.10.1 Long term management strategies

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F=0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES does not recommend any particular one of the strategies.

The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The variable TAC escapement strategy as evaluated in 2007 has higher long term yield compared to the fixed fishing mortality strategy (and the fixed TAC strategy), but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better.

There should be no shift in management strategies between years. In recent years the escapement strategy has been practiced.

A detailed description of the long term management strategies and management plan evaluations can be found in the **Stock Annex** and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports as well as in Vinther and Nielsen (2012, 2013).

ICES has again in September-October 2012 and April-May 2013 (Vinther and Nielsen, 2012, 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information.

In September 2012 ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100-250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the

result that an initial TAC between 25-50 kt and a fixed F=0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference between the MSE 1 and 2-3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2-3), while the minimum TAC in MSE 1 can be applied all year.

As a follow up on this, ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1st November – 31st October rather than from 1st January to 31st December, and one annual advice from the September assessment, with the result that a minimum TAC up to 20 kt with maximum TAC of 100 kt (Fmax/cap=0.8) or with maximum TAC of 200 kt (Fmax/cap=0.6) will be long term sustainable with some level of F control according to those Fcap levels.

5.11 Other issues

Recommendations for future assessments:

An Inter-benchmark was carried out in spring 2012 (IBPNorwayPout, ICES, 2012c) evaluating revised estimates of natural mortality, maturity at age and mean weight at age in the assessment. This has lead to a revised assessment, and a summary of the results is given in the present report as well as in the **Stock Annex**, and the details of the inter-benchmarking are given in the IBPNorwayPout Report (ICES, 2012c). The benchmark group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem.

There are no reports of age reading problems of Norway pout otoliths, and no indications of low quality of the age length keys used in the assessment of this stock. However, age reading consistency between Danish and Norwegian age readings from landings should be checked. Also consistency between Danish, Norwegian and UK age readings from surveys should be checked. Possibly there should be made exchange of otoliths for such checks.

Future benchmark should promote that a quarterly based stochastic assessment model is developed which can be applied for the stock assessment, e.g. a quarterly based SAM model.

Data needs:

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. However, some detailed information on distribution of different life stages will be very welcome. For example precise indications on spawning sites and spawning periods (i.e. observations of fish with running roe or just post-spawned fish); information/data on detailed distribution changes of different size groups e.g. on the Fladen Ground (outer bank, inner bank according to age; schools of size groups or mixing; vertical distribution patterns) over the fishing seasons and changes herein will be welcome (especially 1st, 3rd and 4th quarter). Potential distribution patterns regarding when and where it is possible to obtain the cleanest Norway pout fishery, i.e. with

minimum by-catch would be important, as well as information on potential diurnal changes in distribution, density, and availability. Potential changes in the southern borders of its distribution range in the North Sea would also be relevant to obtain according to a potential temperature effect of climate driven sea warming. Detailed sampling of Norway pout individuals from the commercial fishery in quarter 1 will be welcome in order to establish more precisely the exact spawning sites (areas) and precise spawning time based on biological examination of maturity stages of these sampled individuals. The above information will demand self sampling by the fishermen in their quarter 1 and quarter 2 fishery covering all fishing areas and the whole season. In general fishing effort is higher in second half year compared to 1st half year.

The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. This also implies need for information on prey switching dynamics of North Sea fish predators which also are foraging on Norway pout.

Future benchmark should evaluate usefulness of including recent commercial fishery tuning time series in the assessment from Danish and Norwegian commercial fishery. This should take into consideration influence on cpue and targeting in the Norway pout fishery based on the several fishing closures (several real time management closures) in recent years, introduction of selective devices in recent years being different for Norwegian and Danish fishery, different targeting in Danish and Norwegian Norway pout fisheries (Norway pout, blue whiting), different area specific effort allocation of Danish and Norwegian fisheries, as well as yearly changes in fleet specific efficiency given changes in vessel sizes targeting Norway pout over time. Fleet specific catch-effort data time series according to fleet categories (vessel sizes) as well as in relation to use of selective devices and including data on spatio-temporal effort allocation for both Danish and Norwegian fisheries (fleets) will be needed to make the necessary fishing power analyses in order to standardize effort and CPUE indices between fisheries and fleets.

5.12 Sources:

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O. R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fisheries Research, 68: 99–112.

Eigaard, O., and Nielsen, J. R. 2009. Reduction of bycatch in a small meshed trawl fishery through gear developments facilitating ecosystem-based fisheries management. ICES CM 2009/M:22. 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

ICES 2006 SGMSNS 2006.

ICES 2011 WGNSSK Report

ICES 2011. WGSAM Report

ICES. 2012a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 27 April–10 May 2012. ICES CM 2012/ACOM:??.

ICES 2012b (EU Request on new management plan evaluations on Norway pout)

ICES 2012c (IBPNorwayPout Inter-benchmar assessment report)

ICES. 2013. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013. ICES CM 2013/ACOM:13.

Lambert, G. *, Nielsen, J. R. *[1], Larsen, L., and Sparholt, H. 2009. Maturity and growth population dynamics of Norway pout (*Trisopterus esmarkii*) in the North Sea, Skagerrak and Kattegat. ICES Journal of Marine Science, 66(9): 1899–1914; *Authorship equal; [1]Corresponding author. doi:10.1093/icesjms/fsp153.

Nielsen, J. R., and Madsen, N. 2006. Gear technological approaches to reduce unwanted bycatch in commercial Norway Pout Fishery in the North Sea. Working Document No. 23, ICES WGNSSK (2006). ICES CM 2007/ACFM:35. 10 pp.

Nielsen, J.R.*[1], Lambert, G.*, Bastardie, F., Sparholt, H., and M. Vinther. 2012. Do Norway pout (Trisopterus esmarkii) die from spawning stress? Mortality of Norway pout in relation to growth, maturity and density in the North Sea, Skagerrak and Kattegat. ICES J. Mar. Sci. 69(2): 197-207. *Authorship equal; [1]Corresponding author. Doi:10.1093/icesjms/fss001

Poulsen, E.M. 1968. Norway pout: Stock movement in the Skagerrak and in the north-eastern North Sea. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer, 158: 80-85.

Raitt, D.F.S. 1968. The population dynamics of Norway Pout in the North Sea. Marine Research 5 : 1-23.

Sparholt, H., Larsen, L. I., and Nielsen, J. R. 2002a. Verification of multispecies interactions in the North Sea by trawl survey data on Norway pout (*Trisopterus esmarkii*). ICES Journal of Marine Science, 59: 1270–1275.

Sparholt, H., Larsen, L. I., and Nielsen, J. R. 2002b. Non-predation natural mortality of Norway pout (*Trisopterus esmarkii*) in the North Sea. ICES Journal of Marine Science, 59: 1276–1284.

Vinther, M. and Nielsen, J.R. 2012. Evaluations of management strategies for Norway pout in the North Sea and Skagerrak Report (NOP-MSE). ICES NOP-MSE Report 2012. ICES CM 2012/ACOM:69.

Vinther, M. and Nielsen, J.R. 2013. Evaluations of management strategies for Norway pout in the North Sea and Skagerrak. Working document to ICES WGNSSK, May 2013. ICES CM2013/ACOM: xx.

Table 5.2.1 NORWAY POUT IV & IIIa. Nominal landings ('000 tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas IV and IIIa in the period 2003-2013, as officially reported to ICES and EU. By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	4.235	110	-	18	24	156	-	51	2	118 *	6.945 *
Faroe Islands	50	45	-	-	-	-	-	-	-	-	-
Norway	30	41	-	2	-	-	209	711	-	-	147 *
Sweden	-	-	-	-	-	-	-	10	-	-	1 *
Germany	-	54	-	-	-	4	-	-	-	-	-
Total	4.315	250	0	20	24	160	209	772	2	118	7.093

*Preliminary.

Norway pout ICES area IVa

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	12.223	10.762	941***	39.531	59	32.158	19.226	71.032	4.038	24.829 *	31.376 *
Faroe Islands	2.199	1.085	24	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	22	18	-	-	-
Germany	-	-	-	15	-	-	-	-	-	-	-
Norway	11.357	4.953	311	13.618	4.712	6.650	36.961	64.303	3.189	4.528 *	46.187 *
Sweden	-	-	-	-	-	10	-	+	1	3 *	4 *
UK(Scotland)	-	-	-	-	-	-	-	29	-	6 *	-
Total	25.779	16.800	1.092	53.164	4.771	38.818	56.209	135.353	7.228	29.360	77.567

*Preliminary.

Norway pout ICES area IVb

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	191	473	-	394	-	244	595	229	32	611 *	43 *
Faroe Islands	125	29	-	-	-	-	-	-	-	-	-
Germany	-	-	-	19	-	-	75	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	2	-	-	82	620	21	59 *	615 *
Sweden	-	88	-	-	-	-	-	-	-	-	0 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	-	-
Total	316	590	0	415	0	244	752	849	53	670	658

*Preliminary.

Norway pout ICES area IVc

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	+	+	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	0	0	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	16.649	11.345	941***	39.943	83	32.558	19.821	71.312	4.072	25.558	38.364
Faroe Islands	2.374	1.159	24	0	0	0	0	0	0	0	0
Norway	11.387	4.994	311	13.622	4.712	6.650	37.252	65.634	3.210	4.587	46.949
Sweden	0	88	0	0	0	10	0	10	1	3	5
Netherlands	0	0	0	0	0	0	22	18	0	0	0
Germany	0	54	0	34	0	4	75	0	0	0	0
UK	0	0	0	0	0	0	0	0	0	0	0
Total nominal landings	30.410	17.640	1.252	53.599	4.795	39.222	57.170	136.974	7.283	30.148	85.318
By-catch of other species and other	-3.310	-4.140	-	-6.973	-	-3.084	-2.670	-11.019	-759	-3.075	-3.218
ICES estimate of total landings (IV+IIIaN	27.100	13.500	-	46.626	-	36.138	54.500	125.955	6.524	27.073	82.100
Agreed TAC	198.000	198.000	0****	95.000	0****	114.616 x	116.279 x	162.950 x	4.500 x	70.683 x	167.500 x

* provisional / preliminary
** provisional / preliminary
*** 781 ton from trial fishery (directed fishery); 160 ton from by-catches in other fisheries
**** A by-catch qouta of 5000 t has been set.
***** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.
\+ Landings less than 1
n/a not available
x EU TAC

Table 5.2.2 NORWAY POUT IV & IIIa. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, IIIaS) by country, for 1961-2013 (Data provided by ICES WGNSSK Working Group members). (Norwegian landing data include landings of by-catch of other species). Includes by-catch of Norway pout in other (small meshed) fisheries).

Year	Denmark		Faroes	Norway	Sweden	UK (Scotland)	Others	Total
	North Sea	Skagerrak						
1961	20,5	-	-	8,1	-	-	-	28,6
1962	121,8	-	-	27,9	-	-	-	149,7
1963	67,4	-	-	70,4	-	-	-	137,8
1964	10,4	-	-	51	-	-	-	61,4
1965	8,2	-	-	35	-	-	-	43,2
1966	35,2	-	-	17,8	-	-	+	53,0
1967	169,6	-	-	12,9	-	-	+	182,5
1968	410,8	-	-	40,9	-	-	+	451,7
1969	52,5	-	19,6	41,4	-	-	+	113,5
1970	142,1	-	32	63,5	-	0,2	0,2	238,0
1971	178,5	-	47,2	79,3	-	0,1	0,2	305,3
1972	259,6	-	56,8	120,5	6,8	0,9	0,2	444,8
1973	215,2	-	51,2	63	2,9	13	0,6	345,9
1974	464,5	-	85,0	154,2	2,1	26,7	3,3	735,8
1975	251,2	-	63,6	218,9	2,3	22,7	1	559,7
1976	244,9	-	64,6	108,9	+	17,3	1,7	437,4
1977	232,2	-	48,8	98,3	2,9	4,6	1	387,8
1978	163,4	-	18,5	80,8	0,7	5,5	-	268,9
1979	219,9	9	21,9	75,4	-	3	-	329,2
1980	366,2	11,6	34,1	70,2	-	0,6	-	482,7
1981	167,5	2,8	16,4	51,6	-	+	-	238,3
1982	256,3	35,6	12,3	88	-	-	-	392,2
1983	301,1	28,5	30,7	97,3	-	+	-	457,6
1984	251,9	38,1	19,11	83,8	-	0,1	-	393,01
1985	163,7	8,6	9,9	22,8	-	0,1	-	205,1
1986	146,3	4	2,5	21,5	-	-	-	174,3
1987	108,3	2,1	4,8	34,1	-	-	-	149,3
1988	79	7,9	1,3	21,1	-	-	-	109,3
1989	95,7	4,2	0,8	65,3	+	0,1	0,3	166,4
1990	61,5	23,8	0,9	77,1	+	-	-	163,3
1991	85	32	1,3	68,3	+	-	+	186,6
1992	146,9	41,7	2,6	105,5	+	-	0,1	296,8
1993	97,3	6,7	2,4	76,7	-	-	+	183,1
1994	97,9	6,3	3,6	74,2	-	-	+	182
1995	138,1	46,4	8,9	43,1	0,1	+	0,2	236,8
1996	74,3	33,8	7,6	47,8	0,2	0,1	+	163,8
1997	94,2	29,3	7,0	39,1	+	+	0,1	169,7
1998	39,8	13,2	4,7	22,1	-	-	+	57,7
1999	41	6,8	2,5	44,2	+	-	-	94,5
2000	127	9,3	-	48	0,1	-	+	184,4
2001	40,6	7,5	-	16,8	0,7	+	+	65,6
2002	50,2	2,8	3,4	23,6	-	-	-	80,0
2003	9,9	3,4	2,4	11,4	-	-	-	27,1
2004	8,1	0,3	-	5	-	-	0,1	13,5
2005	0.9*	-	-	1	-	-	-	1,9
2006	35,1	0,1	-	11,4	-	-	-	46,6
2007	2.0**	-	-	3,7	-	-	-	5,7
2008	30,4	-	-	5,7	+	-	+	36,1
2009	17,5	-	-	37,0	+	-	+	54,5
2010	64,9	0,2	-	60,9	+	+	+	126,0
2011	3,3	-	-	3,2	+	+	+	6,5
2012	22,3	0,1	-	4,6	+	+	+	27,0
2013	29,0	6,2	-	46,9	+	+	+	82,1

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.
** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 5.2.3 NORWAY POUT IV & IIIa. National landings ('000 tonnes) by quarter of year 1997-2014. (Data provided by Working Group members. Norwegian landing data include landings of by-catch of other species). (By-catch of Norway pout in other (small meshed) fisheries included).

Year	Quarter	Denmark									Norway		Total
	Area	IIIaN	IIIaS	Div. IIIa	IVaE	IVaW	IVb	IVc	Div. IV	Div. IV + IIIaN	IVaE	Div. IV	Div. IV + IIIaN
1997	1	2.707	460	3.167	6.203	2.219	7	-	8.429	11.137	4183	4183	15.320
	2	5.656	200	5.857	141	-	45		185	5.842	8466	8466	14.308
	3	16.432	649	17.081	19.054	21.024	740	-	40.818	57.250	21546	21546	78.796
	4	4.464	1.042	5.505	6.555	38.202	7		44.765	49.228	4884	4884	54.112
	Total	29.259	2.351	31.610	31.953	61.445	799	-	94.197	123.456	39.079	39079	162.535
1998	1	1.117	317	1.434	7.111	2.292	-	-	9.403	10.520	8913	8913	19.433
	2	3.881	103	3.984	131	5	124	-	259	4.140	7885	7885	12.025
	3	6.011	406	6.417	7.161	1.763	2.372	-	11.297	17.308	3559	3559	20.867
	4	2.161	677	2.838	1.051	17.752	77	-	18.880	21.041	1778	1778	22.819
	Total	13.171	1.503	14.673	15.454	21.811	2.573	-	39.838	53.009	22.135	22135	75.144
1999	1	4	12	15	2.769	1.246	1	-	4.016	4.020	3021	3021	7.041
	2	1.568	36	1.605	953	361	418	-	1.731	3.300	10321	10321	13.621
	3	3.094	109	3.203	7.500	3.710	2.584	-	13.794	16.887	24449	24449	41.336
	4	2.156	517	2.673	3.577	16.921	928	1	21.426	23.583	6385	6385	29.968
	Total	6.822	674	7.496	14.799	22.237	3.931	1	40.968	47.790	44.176	44176	91.966
2000	1	0	11	12	3.726	1.038	-	-	4.764	4.765	5440	5440	10.205
	2	929	15	944	684	22	227	-	933	1.862	9779	9779	11.641
	3	7.380	139	7.519	1.708	5.613	515	-	7.836	15.216	28428	28428	43.644
	4	947	209	1.157	1.656	111.732	76	-	113.464	114.411	4334	4334	118.745
	Total	9.257	375	9.631	7.774	118.406	818	-	126.998	136.255	47.981	47981	184.236
2001	1			302	7.341	9.734	103	72	17.250	17.250	3838	3838	21.088
	2			2.174	31	30	269	-	330	330	9268	9268	9.598
	3			2.006	15	154	191	-	360	360	2263	2263	2.623
	4			3.059	2.553	19.826	329	-	22.708	22.708	1426	1426	24.134
	Total			7.541	9.940	29.744	892	72	40.648	40.648	16.795	16795	57.443
2002	1	-	1	1	4.869	1.660	114	-	6.643	6.643	1896	1896	8.539
	2	883	161	1.045	56	9	22	-	87	970	5563	5563	6.533
	3	1.567	213	1.778	2.234	14.739	104	-	17.077	18.644	14147	14147	32.791
	4	393	100	492	1.787	24.273	335	-	26.395	26.788	2033	2033	28.821
	Total	2.843	475	3.316	8.946	40.681	575	-	50.202	53.045	23.639	23639	76.684
2003	1	-	1	1	615	581	22	-	1.218	1.218	1977	1977	3.195
	2	246	160	406	76	-	22	-	98	344	2773	2773	3.117
	3	2.984	1.005	3.989	172	1.613	89	-	1.874	4.858	5989	5989	10.847
	4	188	547	735	0	6270	457	-	6.727	6.915	644	644	7.559
	Total	3.418	1.713	5.131	863	8.464	590	-	9.917	13.335	11.383	11.383	24.718
2004	1	316	-	316	87	650	-	-	737	1.053	989	989	2.042
	2	-	-	-	-	-	7	-	7	7	660	660	667
	3	14	-	14	289	1.195	9	-	1.493	1.507	2484	2484	3.991
	4	13	-	13	93	5.683	107	-	5.883	5.896	865	865	6.761
	Total	343	-	343	469	7.528	123	-	8.120	8.463	4.998	4.998	13.461
2005	1	-	-	-	9	-	-	-	9	9	12	12	21
	2	-	-	-	151	-	-	-	151	151	352	352	503
	3	-	-	-	781	-	-	-	781	781	387	387	1.168
	4	-	-	-	-	-	-	-	-	-	211	211	211
	Total	-	-	-	941	-	-	-	941	941	962	962	1.903
2006	1	-	-	-	75	83	-	-	158	158	2.205	2205	2.363
	2	-	-	-	-	-	15	-	15	15	2.846	2846	2.861
	3	114	-	114	-	649	20	-	669	783	5.749	5749	6.532
	4	3	-	3	-	34.262	-	-	34.262	34.265	605	605	34.870
	Total	117	-	117	75	34.994	35	-	35.104	35.221		11.405	46.626
2007	1	-	-	-	561	789	-	-	1.350	1.350	74	74	1.424
	2	-	-	-	4	-	-	-	4	4	1.097	1097	1.101
	3	1	2	3	-	-	-	-	-	1	2.429	2429	2.430
	4	-	-	-	-	682	-	-	682	682	155	155	837
	Total	1	2	3	565	1.471	-	-	2.036	2.037		3.755	5.792
2008	1	125	-	125	19	86	123	-	228	353	7	7	360
	2	-	-	-	-	-	30	-	30	30	1.803	1803	1.833
	3	-	-	-	-	6.102	-	-	6.102	6.102	3.582	3582	9.684
	4	-	-	-	-	22.686	1.239	-	23.925	23.925	336	336	24.261
	Total	125	-	125	19	28.874	1.392	-	30.285	30.410		5.728	36.138
2009	1	1	-	1	22	515	-	-	537	538	2	2	540
	2	-	-	-	-	-	-	-	-	-	4.026	4026	4.026
	3	2	-	2	-	11.567	-	-	11.567	11.569	31.251	31251	42.820
	4	-	-	-	-	5.399	4	-	5.403	5.403	1.736	1736	7.139
	Total	3	-	3	22	17.481	4	-	17.507	17.510	37.015	37.015	54.525
2010	1	-	-	-	-	194	-	-	194	194	104	104	298
	2	157	-	157	-	478	59	-	537	694	17.906	17906	18.600
	3	37	-	37	-	33.618	213	-	33.831	33.868	41.883	41883	75.751
	4	8	-	8	-	30.276	38	-	30.314	30.322	984	984	31.306
	Total	202	-	202	-	64.566	310	-	64.876	65.078	60.877	60.877	125.955
2011	1	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	-	-	-	-	188	188	188
	3	-	-	-	-	456	5	-	461	461	3.004	3.004	3.465
	4	-	-	-	-	2.853	-	-	2.853	2.853	18	18	2.871
	Total	-	-	-	-	3.309	5	-	3.314	3.314	3.210	3.210	6.524
2012	1	-	-	-	-	15	-	-	15	15	12	12	27
	2	-	-	-	-	-	-	-	-	-	280	280	280
	3	2	-	2	-	62	8	-	70	72	395	395	467
	4	125	-	125	-	22.204	-	-	22.204	22.329	3.900	3.900	26.229
	Total	127	-	127	-	22.281	8	-	22.289	22.416	4.587	4.587	27.003
2013	1	-	-	-	-	59	-	-	59	59	18	18	77
	2	6	-	6	-	409	-	-	409	415	10.045	10.045	10.460
	3	4.791	-	4.791	5	3.260	43	-	3.308	8.099	16.350	16.350	24.449
	4	1.366	-	1.366	-	25.211	-	-	25.211	26.577	20.537	20.537	47.114
	Total	6.163	-	6.163	5	28.939	43	-	28.987	35.150	46.950	46.950	82.100
2014	1	-	-	-	-	1.318	-	-	1.318	1.318	1	1	1.319

Table 5.2.4 NORWAY POUT in IV and IIIaN (Skagerrak). Catch in numbers at age by quarter (millions). SOP is given in tonnes. Data for 1990 were estimated within the SXSA program used in the 1996 assessment.

Age	Year	1983				1984				1985			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	446	2671	0	0	1	2231	0	0	6	678
1		4.207	1826	5825	4296	2.759	2252	5290	3492	2.264	857	1400	2991
2		1.297	1234	1574	379	1.375	1165	1683	734	1.364	145	793	174
3		15	10	17	7	143	269	8	0	192	13	19	0
4+		0	2	0	0	0	0	0	0	1	0	0	0
SOP		58587	69964	216106	131207	56790	56532	152291	110942	57464	15509	62489	92017
Age	Year	1986				1987				1988			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	5572	0	0	8	227	0	0	741	3146
1		396	260	1186	1791	2687	1075	1627	2151	249	95	183	632
2		1069	87	245	39	401	60	171	233	700	74	250	405
3		72	3	6	0	12	0	0	5	20	0	0	0
4+		3	0	0	0	1	0	0	0	0	0	0	0
SOP		37889	7657	45085	89993	33894	15435	38729	60847	22181	3559	21793	61762
Age	Year	1989				1990				1991			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	159	4854	0	0	20	993	0	0	734	3486
1		1736	678	1672	1741	1840	1780	971	1181	1501	636	1519	1048
2		48	133	266	93	584	572	185	116	1336	404	215	187
3		6	6	5	13	20	19	6	4	93	19	22	18
4+		0	0	0	0	10	0	0	0	6	0	0	0
SOP		15379	13234	55066	82880	28287	39713	26156	45242	42776	20786	62518	64380
Age	Year	1992				1993				1994			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	879	954	0	0	96	1175	0	0	647	4238
1		3556	1522	3457	2784	1942	813	1147	1050	1975	372	1029	1148
2		1086	293	389	267	699	473	912	445	591	285	421	134
3		118	20	1	2	15	58	19	2	56	29	71	0
4+		3	0	0	0	0	0	0	0	0	0	0	0
SOP		64224	27973	114122	96177	36206	29291	62290	53470	34575	15373	53799	79838
Age	Year	1995				1996				1997			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	700	1692	0	0	724	2517	0	0	109	343
1		3992	1905	2545	3348	535	560	1043	650	672	99	3090	1922
2		240	256	47	59	772	201	1002	333	325	131	372	207
3		6	32	3	3	14	38	37	0	79	119	105	35
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		36942	28019	69763	97048	21888	13366	74631	46194	15320	8708	78809	54100
Age	Year	1998				1999				2000			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	94	339	0	0	41	1127	0	0	73	302
1		261	210	411	531	202	318	1298	576	653	280	1368	4616
2		690	310	332	215	128	220	338	160	185	207	266	245
3		47	18	2	13	73	93	35	23	3	48	20	6
4+		8	24	0	0	1	0	0	0	0	0	0	0
SOP		19562	12026	20866	22830	7833	12535	41445	30497	10207	11589	44173	119001
Age	Year	2001				2002				2003			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	32	368	0	0	340	290	0	0	7	1
1		220	133	122	267	485	351	621	473	59	64	191	54
2		845	246	27	439	148	24	284	347	76	49	121	161
3		35	100	1	1	17	5	24	26	22	25	16	32
4+		0	0	0	0	0	0	0	0	0	0	0	1
SOP		21400	11778	4630	26565	8553	6686	32922	28947	3190	3106	10842	7549
Age	Year	2004				2005				2006			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	14	57	*	*	*	*			10	368
1		13	4	51	100	*	*	*	*	30	56	130	1086
2		55	16	51	78	*	*	*	*	52	45	65	50
3		9	6	7	2	*	*	*	*	9	24	7	1
4+		0	0	0	0	*	*	*	*	0	0	0	0
SOP		2040	667	4018	6762	8	8	13	13	2205	2848	6551	34949
Age	Year	2007				2008				2009			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	0	0	0	0	1179	0	0	58	12
1		20	41	32	10	5	54	166	438	50	36	621	169
2		43	26	16	6	10	41	115	31	1	47	613	27
3		0	0	2	1	0	0	0	0	0	5	9	1
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		1428	1100	2430	838	361	1840	8532	24111	538	2105	36661	6509
Age	Year	2010				2011				2012			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	0	0	0	0	1	0	0	1	135
1		6	799	1118	716	0	1	44	23	1	5	8	404
2		1	905	738	331	0	5	69	61	0	2	4	185
3		0	17	15	0	0	0	4	0	0	2	1	10
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		198	40322	57487	33071	0	222	3749	2872	29	281	469	26168
Age	Year	2013				2014							
	Quarter	1	2	3	4	1							
0		0	0	8	75	0							
1		3	631	806	1446	10							
2		0	39	130	208	50							
3		0	4	18	25	1							
4+		0	0	0	0	0							
SOP		73	10457	24455	52816	1318							

In 2007-08: Catch numbers from Norwegian fishery calculated from Norwegian total catch weight divided by mean weight at age from Danish Fishery.

Table 5.2.5 NORWAY POUT in IV and IIIaN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1983-2014, from Danish and Norwegian catches combined. Data for 1974 to 1982 are assumed to be the same as in 1983. See footnote concerning data from 2005-2008 and 2010-2013. The mean weights at age weighted with catch number by area, quarter and country (DK, N).

Year	1983				1984				1985			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			4,00	6,00			6,54	6,54			8,37	6,23
1	7,00	15,00	25,00	23,00	6,55	8,97	17,83	20,22	7,86	12,56	23,10	26,97
2	22,00	34,00	43,00	42,00	24,04	22,66	34,28	35,07	22,7	28,81	36,52	40,90
3	40,00	50,00	60,00	58,00	39,54	37,00	34,10	46,23	45,26	43,38	58,99	
4									41,80			

Year	1986				1987				1988			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0				7,20			5,80	7,40			9,42	7,91
1	6,69	14,49	28,81	26,90	8,13	12,59	20,16	23,36	9,23	11,61	26,54	30,60
2	29,74	42,92	43,39	44,00	28,26	31,51	34,53	37,32	27,31	33,26	39,82	43,31
3	44,08	55,39	47,60		52,93			46,60	38,38			
4	82,51				63,09				69,48			

Year	1989				1990				1991			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			7,48	6,69			6,40	6,67			6,06	6,64
1	7,98	13,49	26,58	26,76	6,51	13,75	20,29	28,70	7,85	12,95	30,95	30,65
2	26,74	28,70	35,44	34,70	25,47	25,30	32,92	38,90	20,54	28,75	44,28	43,10
3	39,95	44,39		46,50	37,72	40,35	39,40	52,94	35,43	49,87	67,25	59,37
4					68,00				44,30			

Year	1992				1993				1994			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0		8,00	6,70	8,14			4,40	8,14			5,40	8,81
1	8,78	11,71	26,52	27,49	9,32	14,76	25,03	26,24	8,56	15,22	29,26	31,23
2	25,73	31,25	42,42	44,14	24,94	30,58	35,19	36,44	25,91	29,27	38,91	49,59
3	41,80	49,49	50,00	50,30	46,50	48,73	55,40	70,80	42,09	46,88	53,95	
4	43,90											

Year	1995				1996				1997			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			5,01	7,19			3,88	5,95			3,61	10,18
1	7,70	10,99	25,37	24,6	8,95	12,06	27,81	28,09	7,01	11,69	20,14	22,11
2	24,69	22,95	33,40	39,57	21,47	25,72	40,90	38,81	23,11	26,40	31,13	32,69
3	50,78	37,69	45,56	57,00	37,58	37,94	50,44	56,00	39,11	34,47	44,03	38,62
4												

Year	1998				1999				2000			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			4,82	8,32			2,84	7,56			7,21	13,86
1	8,76	12,55	23,82	24,33	8,98	12,40	22,16	25,60	10,05	15,65	23,76	22,98
2	22,16	25,27	31,73	30,93	25,84	24,15	32,66	37,74	19,21	25,14	38,90	34,48
3	34,84	32,18	44,92	33,24	36,66	35,24	43,98	51,63	32,10	41,30	39,61	50,04
4	42,40	40,00			46,57	46,57						

Year	2001				2002				2003			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			6,34	7,90			7,28	7,20			9,12	9,79
1	8,34	16,79	27,00	30,01	8,59	16,40	27,13	27,47	11,58	13,13	28,33	15,98
2	21,50	23,57	39,54	35,51	25,98	30,39	43,37	36,87	22,85	26,19	38,01	31,87
3	39,84	37,63	54,20	55,70	32,30	40,10	54,11	41,28	34,96	39,89	46,24	45,79
4											70,00	70,00

Year	2004				2005				2006			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			9,80	7,89			9,8	7,89			8,90	8,90
1	11,54	14,63	31,02	31,75	11,97	14,65	31,02	31,75	14,80	14,70	27,42	26,92
2	27,41	26,22	38,44	39,31	27,90	26,24	38,44	39,31	27,20	26,24	39,16	47,80
3	41,52	34,80	49,50	49,80	41,36	34,80	49,50	49,80	40,60	34,80	49,80	48,50
4												

Year	2007				2008				2009			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0			8,9	8,9				9,9			6,6	8,5
1	7,8	7,8	45,00	45,00	11,0	11,0	26,8	24,40	10,2	19,3	28,0	32,7
2	29,86	29,86	57,07	57,07	29,8	29,8	35,6	56,0	24,0	25,8	30,1	32,0
3	41,52	34,80	56,22	56,22	56,0	56,0				39,8	51,5	55,7
4												

Year	2010				2011				2012			
Quarter of year	1	2	3	4	1	2	3	4	1	2	3	4
Age 0								8,90			6,58	6,66
1	25,60	15,51	25,37	27,75		20,33	22,14	30,50	27,24	22,81	28,86	38,52
2	37,20	29,99	38,55	39,88		37,75	37,50	35,61	36,24	40,54	40,30	49,59
3		47,00	45,50	62,20		52,00	52,00	52,00	37,22	46,77	48,33	59,15
4												

Year	2013				2014
Quarter of year	1	2	3	4	1
Age 0			4,30	9,33	
1	18,24	14,48	22,86	28,18	8,70
2	32,61	30,19	39,87	47,67	23,50
3	42,40	40,71	45,50	57,95	50,70
4					

Mean weights at age from Danish and Norwegian landings from 2005-2008 uncertain because of few observations and use of values from 2004 and from adjacent quarters in the same year where observations have been missing. No mean weight at age data delivered by Norway in 2007-2008.
Mean weights at age from quarter 1 and 2 2010 uncertain, as there are no Danish observations and only few fish caught here.
Mean weights at age from quarter 2 and 4 2011 uncertain, as there are no Norwegian observations and only few fish caught here.

Table 5.2.6 NORWAY POUT IV & IIIaN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment. (Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M	
	Q1	Q2	Q3	Q4		Quarterly	
0	-	-	4	6	0	0,29	
1	9	14	28	28	0,2	0,29	
2	26	25	38	40	1	0,39	
3	43	38	51	58	1	0,44	

Table 5.2.7 NORWAY POUT IV & IIIaN (Skagerrak). Danish CPUE data (tonnes / fishing day) and fishing activities by vessel category for 1988-2013. Non-standardized CPUE-data for the Danish part of the commercial tuning fleet. (Logbook information).

Vessel GRT	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
51-100	20,27	14,58	10,03	12,56	31,75	31	24,8	29,53	-	20
101-150	18,83	19,59	17,38	24,14	26,42	23,72	26,76	38,96	20,48	22,68
151-200	22,71	23,17	25,6	28,22	34,2	27,36	31,52	34,73	22,05	27,45
201-250	30,44	26,1	24,87	29,74	36	27,76	40,59	39,34	24,96	30,59
251-300	23,29	26,14	21,3	28,15	31,9	32,05	36,98	38,84	31,43	32,55
301-	38,81	28,58	24,96	36,48	42,6	34,89	44,91	57,9	39,14	43,01

Vessel GRT	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
51-100	-	-	-	-	-	-	-	-	-	-
101-150	-	-	-	-	-	-	-	-	-	-
151-200	16,85	12,43	29,13	-	20,45	-	-	-	-	-
201-250	19,68	26,69	48,55	25,35	17,09	12,94	8,88	n/a*	-	n/a*
251-300	17,48	23,98	45,92	20,02	21,73	10,8	5,50	n/a*	41,11	n/a*
301-	32,32	31	64,33	52,95	46,36	30,86	37,14	n/a*	60,39	n/a*

Vessel GRT	2008	2009	2010	2011	2012	2013
51-100	-	-	-	-	51,67	-
101-150	-	-	-	-	-	-
151-200	-	-	-	-	-	-
201-250	-	-	-	-	-	24,28
251-300	-	-	-	-	-	-
301-	79,13	94,78	106,15	96,63	71,96	68,27

* Non-available data from 2005 and 2007 is due to closure of the Norway pout fishery the whole year

Data for 2006 and 2008 does only cover 2nd half year as the directed fishery was closed 1st half year 2006 and very low 1st half year 2008.

Data for 2008 and onwards only covers Danish directed fishery for Norway pout.

Commercial fishery tuning data only used up to 2006 in the assessment.

Table 5.2.8 NORWAY POUT IV & IIIaN (Skagerrak). Effort in days fishing and average GRT of Norwegian vessels fishing for Norway pout by quarter, 1983-2013.

	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
Year	Effort	Aver. GRT	Effort	Aver. GRT	Effort	Aver. GRT	Effort	Aver. GRT
1983	293	167,6	1168	168,4	2039	159,9	552	171,7
1984	509	178,5	1442	141,6	1576	161,2	315	212,4
1985	363	166,9	417	169,1	230	202,8	250	221,4
1986	429	184,3	598	148,2	195	197,4	222	226,0
1987	412	199,3	555	170,5	208	158,4	334	196,3
1988	296	216,4	152	146,5	73	191,1	590	202,9
1989	132	228,5	586	113,5	1054	192,1	1687	178,7
1990	369	211,0	2022	171,7	1102	193,9	1143	187,6
1991	774	196,1	820	180,0	1013	179,4	836	187,7
1992	847	206,3	352	181,3	1030	202,2	1133	199,8
1993	475	227,5	1045	206,6	1129	217,8	501	219,8
1994	436	226,5	450	223,5	1302	212,0	686	211,4
1995	545	223,6	237	233,8	155	221,7	297	218,1
1996	456	213,6	136	219,9	547	208,3	132	207,2
1997	132	202,4	193	218,9	601	194,8	218	182,3
1998	497	192,6	272	213,6	263	176,8	203	193,8
1999	267	173,0	735	180,1	1165	187,4	229	166,9
2000	294	197,1	348	180,7	929	205,3	196	219,3
2001	252	203,4	297	192,9	130	165,0	65	219,4
2002	90	208,6	246	189,1	1022	211,7	205	182,2
2003	162	219,1	320	215,3	550	252,8	75	208,4
2004	94	214,6	85	196,7	210	220,9	99	197,9
2005*	0	0,0	0	0,0	0	0,0	0	0,0
2006*	0	0,0	0	0,0	169	267,1	132	279,0
2007*	0	0,0	0	0,0	0	0,0	0	0,0
2008	**	**	**	**	**	**	**	**
2009	0	0,0	123	278,0	594	366,8	70	340,7
2010-2013	***	***	***	***	***	***	***	***

* 0-values in all of 2005 and 2007 as well as in first half year 2006 are due to closure of the fishery (no directed fishery for Norway pout)

** No effort data provided from Norway due to small directed Norway pout fishery.

*** Norwegian commercial effort and catch data not delivered for 2010-13 because of introduction of selection devices which changes fishery selection and efficiency to unknown extent.

Table 5.2.9 NORWAY POUT IV and IIIaN (Skagerak). Combined Danish and Norwegian fishing effort (standardised) to be used in the assessment.

	Quarter 1			Quarter 2			Quarter 3			Quarter 4			Year total		
Year	Norway	Denmark	Total	Norway	Denmark	Total	Norway	Denmark	Total	Norway	Denmark	Total	Norway	Denmark	Total
1987	441	1125	1566	547	31	578	197	1192	1388	355	1634	1989	1540	3981	5522
1988	315	881	1196	144	13	156	75	416	491	617	1891	2507	1150	3201	4351
1989	146	776	922	485	195	680	1093	1746	2839	1701	2280	3981	3424	4999	8423
1990	406	990	1395	2002	87	2089	1162	462	1624	1185	1650	2835	4754	3189	7943
1991	824	1316	2140	833	33	866	1027	484	1511	869	1721	2590	3553	3554	7107
1992	866	2089	2955	354	17	371	1051	1527	2578	1154	1240	2393	3424	4873	8298
1993	483	1232	1715	1056	37	1094	1145	1557	2702	508	1668	2176	3193	4494	7687
1994	463	1263	1726	477	74	551	1363	616	1978	717	1224	1942	3020	3177	6197
1995	577	808	1385	254	99	352	164	851	1015	313	1483	1796	1308	3241	4548
1996	478	577	1055	144	184	328	570	758	1328	137	1237	1374	1329	2756	4085
1997	137	393	530	203	17	220	617	1241	1857	220	1118	1338	1177	2768	3945
1998	509	445	954	285	34	319	264	560	824	208	455	663	1265	1494	2760
1999	266	304	571	740	56	796	1184	386	1570	226	731	957	2417	1477	3894
2000	303	302	605	351	75	425	965	220	1185	207	1898	2104	1825	2494	4319
2001	261	440	701	304	15	319	128	48	176	69	540	608	762	1042	1804
2002	94	387	480	251	21	271	1069	674	1744	207	550	757	1621	1632	3252
2003	171	211	382	336	15	351	599	79	678	78	101	179	1184	406	1590
2004	99	151	246	87	35	122	222	65	287	102	95	197	510	346	856
2005*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006*	0	0	0	0	0	0	186	32		147	641	787	333	673	1005
2007*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008**	n/a	6	6	n/a	0	0	n/a	161	161	n/a	244	244	n/a	411	411
2009	0	13	13	137	0	137	699	109	808	81	27	108	917	149	1066
2010**	n/a	0	0	n/a	11	11	n/a	309	309	n/a	174	174	n/a	494	494
2011**	n/a	0	0	n/a	0	0	n/a	14	14	n/a	33	33	n/a	47	47
2012**	n/a	0	0	n/a	0	0	n/a	0	0	n/a	268	268	n/a	268	268
2013**	n/a	1	1	n/a	8	8	n/a	64	64	n/a	366	366	n/a	439	439

* 0-values in all of 2005 and 2007 as well as in first half year 2006 are due to closure of the fishery (no directed fishery for Norway pout). The 0-values not used in assessment.
** Data for 2008 and 2010-12 does only include information from the Danish small meshed fishery as no data was provided from Norway on this. Data not used in assessment.

Table 5.2.10 NORWAY POUT IV & IIIaN (Skagerrak). CPUE indices (´000s per fishing day) by age and quarter from Danish and Norwegian commercial fishery (CF) in the North Sea (Area IV, commercial tuning fleet).

Year	CF, 1st quarter				CF, 3rd quarter				CF, 4th quarter			
	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1982	.	2144,5	169,0	87,9	.	1320,2	86,5	12,4	368,4	1050,5	16,0	0,0
1983	.	1524,2	470,0	5,4	.	969,6	262,0	2,8	604,9	972,9	85,9	1,7
1984	.	1137,9	566,8	59,1	.	990,2	314,9	1,5	462,0	723,1	152,1	0,0
1985	.	877,1	528,2	74,3	.	599,0	339,0	8,3	183,6	809,5	47,2	0,0
1986	.	108,5	292,9	19,8	.	531,1	109,7	2,7	892,9	277,1	5,9	0,0
1987	.	1701,8	254,2	7,7	.	1141,9	118,9	0,0	111,1	1074,9	115,6	2,5
1988	.	205,5	584,0	16,4	.	373,1	510,0	0,0	1175,5	252,0	161,5	0,0
1989	.	1862,8	52,1	7,6	.	386,3	69,7	0,0	1185,8	488,6	22,7	3,2
1990	.	1065,1	451,5	25,7	.	571,3	126,7	7,2	444,6	394,9	39,7	2,3
1991	.	693,9	623,8	43,4	.	668,6	44,0	1,0	1006,5	397,7	71,6	6,6
1992	.	1130,2	361,0	39,7	.	1011,6	144,2	0,4	190,5	1104,5	106,1	1,0
1993	.	1122,3	403,7	7,9	.	384,9	328,9	6,9	427,1	474,8	203,2	0,8
1994	.	1102,1	341,3	32,6	.	520,1	203,4	35,7	1953,6	591,0	69,0	0,0
1995	.	2850,1	171,3	4,0	.	1864,2	38,6	3,0	198,7	1705,6	33,0	1,7
1996	.	365,7	732,0	13,2	.	346,7	715,5	27,5	1066,5	473,4	242,5	0,2
1997	.	990,6	480,2	146,8	.	1256,7	154,4	56,5	75,2	1347,0	152,9	25,9
1998	.	150,0	723,5	49,3	.	319,5	350,1	1,1	233,1	775,7	322,9	20,0
1999	.	351,0	224,6	128,0	.	726,4	213,8	22,0	1086,8	516,2	166,9	24,1
2000	.	1079,3	305,3	4,5	.	895,6	207,0	17,2	122,2	2180,3	114,9	2,8
2001	.	300,7	1198,6	50,1	.	369,2	142,7	6,3	559,2	322,6	720,8	1,5
2002	.	1010,9	308,4	34,8	.	321,3	157,9	13,5	383,2	602,0	454,9	34,9
2003	.	153,6	200,1	57,2	.	174,7	156,1	23,3	3,9	276,4	893,3	178,2
2004	.	26,9	189,7	35,1	.	176,1	177,6	24,0	289,1	505,5	394,6	8,6
2005	.	.	.	.	.	.	.	.	.	.	.	.
2006	.	.	.	.	.	588,6	294,2	32,6	467,1	1379,8	64,0	0,9
2007-2013	.	.	.	.	.	.	.	.	.	.	.	.

Table 5.2.11 NORWAY POUT IV & IIIA (Skagerrak). Research vessel indices (CPUE in catch in number per trawl hour) of abundance for Norway pout.

Year	IBTS/IYFS1 February (1st Q)			EGFS2.3 August				SGFS4 August				IBTS 3rd Quarter1			
	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group	0-group	1-group	2-group	3-group
1971.00	1556.00	22.00	-	-	-	-	-	-	-	-	-	-	-	-	-
1972.00	2578.00	872.00	3.00	-	-	-	-	-	-	-	-	-	-	-	-
1973.00	4207.00	438.00	-	-	-	-	-	-	-	-	-	-	-	-	-
1974.00	25557.00	391.00	24.00	-	-	-	-	-	-	-	-	-	-	-	-
1975.00	4573.00	1880.00	4.00	-	-	-	-	-	-	-	-	-	-	-	-
1976.00	4411.00	371.00	2.00	-	-	-	-	-	-	-	-	-	-	-	-
1977.00	6093.00	274.00	42.00	-	-	-	-	-	-	-	-	-	-	-	-
1978.00	1479.00	575.00	47.00	-	-	-	-	-	-	-	-	-	-	-	-
1979.00	2738.00	316.00	75.00	-	-	-	-	-	-	-	-	-	-	-	-
1980.00	3277.00	550.00	29.00	-	-	-	-	-	1928.00	346.00	12.00	-	-	-	-
1981.00	1092.00	377.00	15.00	-	-	-	-	-	185.00	127.00	9.00	-	-	-	-
1982.00	4537.00	262.00	59.00	6594.00	2609.00	39.00	77.00	8.00	991.00	44.00	22.00	-	-	-	-
1983.00	2258.00	592.00	7.00	6067.00	1558.00	114.00	0.40	13.00	490.00	91.00	1.00	-	-	-	-
1984.00	4994.00	982.00	75.00	457.00	3605.00	359.00	14.00	2.00	615.00	69.00	8.00	-	-	-	-
1985.00	2342.00	1429.00	73.00	362.00	1201.00	307.00	0.00	5.00	636.00	173.00	5.00	-	-	-	-
1986.00	2070.00	383.00	20.00	285.00	717.00	150.00	80.00	38.00	389.00	54.00	9.00	-	-	-	-
1987.00	3171.00	481.00	61.00	8.00	552.00	122.00	0.90	7.00	338.00	23.00	1.00	-	-	-	-
1988.00	124.00	722.00	15.00	165.00	102.00	134.00	20.00	14.00	38.00	209.00	4.00	-	-	-	-
1989.00	2013.00	255.00	172.00	1531.00	1274.00	621.00	20.00	2.00	382.00	21.00	14.00	-	-	-	-
1990.00	1295.00	748.00	39.00	2692.00	917.00	158.00	23.00	58.00	206.00	51.00	2.00	-	-	-	-
1991.00	2450.00	712.00	130.00	1509.00	683.00	399.00	6.00	10.00	732.00	42.00	6.00	7301.00	1039.00	189.00	2.00
1992.00	5071.00	885.00	32.00	2885.00	6193.00	1069.00	157.00	12.00	1715.00	221.00	24.00	2559.00	4318.00	633.00	48.00
1993.00	2682.00	2644.00	258.00	5699.00	3278.00	1715.00	0.00	2.00	580.00	329.00	20.00	4104.00	1831.00	608.00	53.00
1994.00	1839.00	374.00	66.00	7764.00	1305.00	112.00	7.00	136.00	387.00	106.00	6.00	3196.00	704.00	102.00	14.00
1995.00	5940.00	785.00	77.00	7546.00	6174.00	387.00	14.00	37.00	2438.00	234.00	21.00	2860.00	4440.00	597.00	69.00

1996.00	923.00	2631.00	228.00	3456.00	1332.00	319.00	3.00	127.00	412.00	321.00	8.00	4554.00	763.00	362.00	12.00
1997.00	9752.00	1474.00	670.00	1045.00	6262.00	376.00	30.00	1.00	2154.00	130.00	32.00	490.00	3447.00	236.00	47.00
1998.00	1010.00	5336.00	265.00	2573.00	404.00	260.00	0.00	2628.00	938.00	127.00	5.00	2931.00	801.00	748.00	12.00
1999.00	3527.00	597.00	667.00	6358.00	1930.00	88.00	26.00	3603.00	1784.00	179.00	37.00	7844.00	2367.00	201.00	94.00
2000.00	7900.00	1495.00	65.00	2005.00	6261.00	141.00	2.00	2094.00	6656.00	207.00	23.00	1643.00	7868.00	282.00	11.00
2001.00	1305.00	2861.00	235.00	3948.00	1013.00	693.00	5.00	759.00	727.00	710.00	26.00	2088.00	1274.00	862.00	27.00
2002.00	1793.00	809.00	880.00	9737.00	1784.00	61.00	21.00	2559.00	1192.00	151.00	123.00	1974.00	766.00	64.00	48.00
2003.00	1239.00	575.00	94.00	379.00	681.00	85.00	5.00	1767.00	779.00	126.00	1.00	1812.00	1063.00	146.00	7.00
2004.00	895.00	376.00	34.00	564.00	542.00	90.00	7.00	731 3.073	719.00	175.00	19.00	773.00	647.00	153.00	12.00
2005.00	690.00	133.00	37.00	6912.00	803.00	67.00	11.00	1127.00	343.00	132.00	18.00	2618.00	435.00	125.00	17.00
2006.00	3299.00	145.00	27.00	1680.00	2147.00	151.00	18.00	5003.00	1285.00	69.00	9.00	1337.00	1837.00	152.00	15.00
2007.00	1286.00	778.00	23.00	3329.00	1084.00	339.00	1.00	3456.00	1023.00	395.00	8.00	4143.00	1191.00	447.00	11.00
2008.00	2345.00	506.00	186.00	1435.00	1371.00	253.00	35.00	5835.00	1263.00	263.00	57.00	3035.00	1643.00	274.00	58.00
2009.00	5414.00	1618.00	150.00	6401.00	5368.00	428.00	3.00	1449.00	1750.00	202.00	16.00	5898.00	2562.00	254.00	11.00
2010.00	4663.00	1448.00	137.00	235.00	3977.00	626.00	31.00	1895.00	5101.00	930.00	29.00	834.00	4744.00	833.00	17.00
2011.00	535.00	2.23	301.00	1304.00	870.00	1024.00	38.00	10067.00	226.00	935.00	38.00	1797.00	471.00	1126.00	60.00
2012.00	995.00	330.00	537.00	5084.00	835.00	181.00	70.00	1759.00	1070.00	159.00	216.00	6477.00	859.00	146.00	106.00
2013.00	4464.00	517.00	100.00	6231.00	3531.00	79.00	14.00	-	3099.00	111.00	22.00	1287.00	2873.00	125.00	13.00
2014.00	812.00	939.00	52.00	-	-	-	-		-	-	-	-	-	-	-

[1]International Bottom Trawl Survey, arithmetic mean catch in no./h in standard area. [2]English groundfish survey, arithmetic mean catch in no./h, 22 selected rectangles within Roundfish areas 1, 2, and 3. [3]1982-91 EGFS numbers adjusted from Granton trawl to GOV trawl by multiplying by 3.5. Minor GOV sweep changes in 2006 EGFS. [4]Scottish groundfish surveys, arithmetic mean catch no./h. Survey design changed in 1998 and 2000. [5]English groundfish survey: Data for 1996, 2001, 2002, and 2003 have been revised compared to the 2003 assessment. In 2007, numbers for 1997 and 1998 as well as 2002 has been adjusted based on new automatic calculation and processing process has been introduced. SGFS survey area changed slightly in 2009 and onwards, which is evaluated to have no main effect for the Norway pout indices as the indices are weighted by sub-area.

Table 5.3.1 Norway pout IV & IIIaN (Skagerak). Stock indices and tuning fleets used in final 2004 benchmark assessment as well as in the 2005-2014 assessments compared to the 2003 assessment.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-13 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	3rd quarter (SXSA)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	1st quarter (SXSA)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)
FLT01: comm Q1					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT01: comm Q2			NOT USED	NOT USED	NOT USED
	Year range	1982-2003			
	Quarter	2			
	Ages	1-3			
FLT01: comm Q3					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	3	3	3	3
	Ages	0-3	1-3	1-3	1-3
FLT01: comm Q4					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	4	4	4	4
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)
FLT02: ibtsq1					
	Year range	1982-2003	1982-2006	1982-2006	1982-2014
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2013
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT04: sgfs					
	Year range	1982-2003	1998-2006	1998-2006	1998-2013
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED			
	Year range		1991-2005	1991-2005	1991-2013
	Quarter		3	3	Q3
	Ages		2-3	2-3	2-3

Table 5.3.2 Norway pout IV & IIIaN (Skagerrak). Baseline run with SXSA (seasonal extended survivor analysis): Parameters, settings and the options of the SXSA as well as the input data used in the SXSA.

SURVIVORS ANALYSIS OF: Norway pout stock in May 2014

Run: May 2014 (Summary from NP514)

The following parameters were used:

Year range:	1983 - 2014
Seasons per year:	4
The last season in the last year is season:	1
Youngest age:	0
Oldest age:	3
Plus age:	4
Recruitment in season:	3
Spawning in season:	1

The following fleets were included:

Fleet 1: commercial q134 (Q1: Age 1-3; Q2: None; Q3: Age 1-3; Q4: 0-3)

Fleet 2:	ibtsq1	(Age 1-3)
Fleet 3:	egfsq3	(Age 0-1)
Fleet 4:	sgfsq3	(Age 0-1)
Fleet 5:	ibtsq3	(Age 2-3)

The following options were used:

1: Inv. catchability:	2
(1: Linear; 2: Log; 3: Cos. filter)	
2: Indiv. shats:	2
(1: Direct; 2: Using z)	
3: Comb. shats:	2
(1: Linear; 2: Log.)	

4: Fit catches:	0
(0: No fit; 1: No SOP corr; 2: SOP corr.)	
5: Est. unknown catches:	0
(0: No; 1: No SOP corr; 2: SOP corr; 3: Sep. F)	
6: Weighting of rhats:	0
(0: Manual)	
7: Weighting of shats:	2
(0: Manual; 1: Linear; 2: Log.)	
8: Handling of the plus group:	1
(1: Dynamic; 2: Extra age group)	

Data were input from the following files:

Catch in numbers:	canum.qrt
Weight in catch:	weca.qrt
Weight in stock:	west.qrt
Natural mortalities:	natmor.qrt
Maturity ogive:	matprop.qrt
Tuning data (CPUE):	tun2014.xsa
Weighting for rhats:	rweigh.xsa

Table 5.3.3 Norway pout IV & IIIaN (Skagerrak).

Seasonal extended survivor analysis (SXSA).

Stock numbers, SSB and TSB at start of season.

Year	1983				1984				1985			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	85174.	63347.	*	*	46391.	34712.	*	*	31374.	23471.
1	74125.	51826.	37199.	22796.	45089.	31352.	21511.	11520.	24044.	16032.	11255.	7210.
2	12953.	7702.	4199.	1548.	13341.	7902.	4392.	1589.	5600.	2669.	1688.	491.
3	126.	69.	37.	10.	736.	359.	15.	3.	472.	150.	86.	40.
4+	0.	459.	295.	190.	1.	86.	55.	36.	2.	1.	1.	0.
SSN	2716.				3405.				10882.			
SSB	69790.				96167.				202261.			
TSN	87203.	60056.	126905.	87891.	59167.	39698.	72365.	47860.	30117.	18852.	44403.	31212.
TSB	995974.	843609.	1457400.	1012488.	768800.	596516.	899941.	560022.	375375.	266656.	479543.	343017.

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	62990.	47133.	*	*	16651.	12453.	*	*	49502.	36399.
1	16976.	12359.	9023.	5726.	30449.	20459.	14378.	9352.	9122.	6610.	4864.	3481.
2	2808.	1021.	620.	218.	2735.	1522.	981.	524.	5137.	2902.	1904.	1084.
3	189.	64.	39.	20.	116.	65.	42.	27.	163.	89.	57.	37.
4+	26.	14.	9.	6.	17.	10.	6.	4.	16.	10.	7.	4.
SSN	6418.				8958.				7140.			
SSB	109759.				128758.				152249.			
TSN	19998.	13459.	72681.	53103.	33316.	22056.	32059.	22359.	14438.	9612.	56334.	41005.
TSB	231983.	177823.	504655.	435833.	347988.	287352.	467805.	331005.	217926.	156890.	399209.	350907.

Year 1989 1990 1991

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 53328. 39766. * * 47908. 35831. * * 92584. 68642.

1 24515. 16842. 12015. 7545. 25557. 17532. 11579. 7824. 25952. 18120. 13009. 8420.

2 2058. 1354. 807. 327. 4140. 2322. 1102. 594. 4833. 2173. 1139. 594.

3 400. 253. 158. 98. 145. 77. 35. 17. 306. 123. 64. 23.

4+ 26. 17. 11. 7. 57. 29. 19. 12. 16. 5. 3. 2.

SSN 7388. 9453. 10345.

SSB 113080. 158509. 180673.

TSN 27000. 18466. 66319. 47743. 29899. 19960. 60641. 44277. 31107. 20421. 106799. 77681.

TSB 289589. 249560. 555478. 445995. 342519. 273925. 527237. 435339. 367525. 278207. 744951. 647449.

Year 1992 1993 1994

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 39962. 29141. * * 28645. 21351. * * 117457. 87329.

1 48347. 33100. 23451. 14557. 20980. 14019. 9786. 6331. 14960. 9486. 6776. 4180.

2 5394. 2758. 1626. 781. 8485. 5170. 3111. 1356. 3828. 2106. 1191. 460.

3 248. 66. 26. 16. 309. 187. 74. 32. 552. 311. 177. 57.

4+ 2. 0. 0. 0. 9. 5. 4. 2. 21. 13. 9. 6.

SSN 15314. 12998. 7393.

SSB 231914. 262727. 145877.

TSN 53991. 35924. 65065. 44495. 29783. 19381. 41620. 29072. 19361. 11915. 125609. 92032.

TSB 580015. 469432. 812737. 570943. 413785. 307137. 488122. 342477. 253589. 182746. 697466. 650181.

Year 1995 1996 1997

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 36917. 27018. * * 89204. 66121. * * 24361. 18134.

1 61679. 42699. 30302. 20473. 18753. 13570. 9669. 6333. 47299. 34810. 25962. 16754.

2 2135. 1248. 634. 391. 12423. 7775. 5099. 2628. 4176. 2559. 1625. 795.

3 201. 125. 55. 33. 216. 128. 52. 4. 1505. 906. 488. 230.

4+ 40. 26. 17. 11. 26. 17. 11. 7. 7. 4. 3. 2.

SSN 14712. 16415. 15148.

SSB 174692. 354405. 250131.

TSN 64055. 44098. 67925. 47926. 31418. 21490. 104035. 75093. 52987. 38281. 52439. 35914.

TSB 618781. 551298. 933894. 691485. 489429. 364550. 805622. 660412. 590682. 527267. 840788. 572779.

Year 1998 1999 2000

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 34769. 25935. * * 85098. 63640. * * 28258. 21081.

1 13273. 9706. 7081. 4942. 19114. 14127. 10296. 6581. 46645. 34338. 25452. 17861.

2 10874. 6794. 4345. 2668. 3239. 2087. 1232. 556. 4426. 2844. 1755. 970.

3 367. 199. 113. 72. 1630. 991. 564. 335. 245. 156. 61. 23.

4+ 122. 72. 27. 17. 47. 30. 19. 12. 205. 132. 85. 55.

SSN 14017. 8738. 14205.

SSB 317234. 183176. 215901.

TSN 24635. 16770. 46335. 33635. 24029. 17235. 97209. 71125. 51521. 37470. 55611. 39990.

TSB 412798. 300286. 496695. 390067. 320793. 272915. 680896. 588059. 551746. 498344. 823210. 613148.

Table 5.3.3 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Year	2001				2002				2003			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	26035.	19453.	*	*	17643.	12908.	*	*	7958.	5949.
1	15513.	11418.	8429.	6202.	14238.	10234.	7354.	4965.	9407.	6988.	5173.	3705.
2	9371.	5650.	3623.	2430.	4410.	2864.	1919.	1066.	3306.	2176.	1433.	871.
3	455.	265.	91.	57.	1284.	814.	520.	316.	436.	263.	150.	84.
4+	46.	29.	19.	12.	44.	28.	18.	12.	190.	122.	79.	50.
SSN	12975.				8585.				5814.			
SSB	282965.				189702.				127679.			
TSN	25385.	17362.	38196.	28155.	19976.	13940.	27454.	19266.	13340.	9550.	14793.	10659.
TSB	394661.	293147.	465208.	372308.	292214.	236671.	362388.	262531.	195411.	158274.	227478.	168018.

Year	2004				2005				2006			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	10066.	7520.	*	*	39511.	29565.	*	*	19283.	14420.
1	4450.	3319.	2480.	1812.	5577.	4173.	3123.	2336.	22122.	16527.	12318.	9105.
2	2726.	1800.	1206.	774.	1269.	859.	582.	394.	1748.	1141.	735.	444.
3	457.	287.	180.	111.	460.	296.	191.	123.	267.	165.	87.	50.
4+	60.	39.	25.	16.	80.	52.	33.	21.	93.	60.	38.	25.
SSN	4133.				2925.				6532.			
SSB	97796.				64674.				99382.			
TSN	7693.	5444.	13957.	10232.	7387.	5381.	43439.	32439.	24229.	17892.	32461.	24044.
TSB	129839.	101345.	161318.	127804.	104831.	89271.	270824.	258671.	258660.	238434.	419703.	334823.

Year 2007 2008 2009

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 31400. 23495. * * 60470. 45248. * * 80871. 60463.

1 10472. 7819. 5814. 4323. 17581. 13151. 9794. 7185. 32837. 24528. 18323. 13173.

2 5874. 3942. 2648. 1780. 3226. 2176. 1439. 880. 4997. 3382. 2251. 1020.

3 259. 167. 107. 68. 1200. 773. 497. 320. 570. 367. 232. 142.

4+ 48. 31. 20. 13. 51. 33. 21. 14. 215. 139. 89. 57.

SSN 8275. 7993. 12350.

SSB 178732. 163172. 218885.

TSN 16652. 11958. 39989. 29679. 22058. 16132. 72222. 53647. 38620. 28416. 101766. 74856.

TSB 254130. 202432. 383303. 324168. 289752. 252696. 574134. 504883. 455315. 405011. 885542. 741166.

Year 2010 2011 2012

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 10394. 7778. * * 16964. 12693. * * 64979. 48621.

1 45232. 33841. 24631. 17463. 5820. 4355. 3257. 2399. 9497. 7106. 5313. 3968.

2 9711. 6573. 3706. 1902. 12448. 8428. 5702. 3804. 1776. 1202. 812. 547.

3 669. 431. 264. 158. 1016. 654. 421. 268. 2525. 1626. 1046. 672.

4+ 128. 83. 53. 34. 124. 80. 51. 33. 194. 125. 81. 52.

SSN 19554. 14751. 6395.

SSB 358122. 369220. 173367.

TSN 55740. 40927. 39048. 27335. 19407. 13516. 26396. 19198. 13992. 10059. 72231. 53860.

TSB 683792. 596588. 821416. 568490. 411122. 300118. 402643. 303863. 241745. 203632. 487978. 451801.

Year 2013 2014

Season 1 2 3 4 1

AGE

0 * * 25110. 18782. *

1 36265. 27133. 19756. 14086. 13989.

2 2620. 1774. 1169. 685. 9289.

3 218. 140. 87. 42. 292.

4+ 459. 295. 190. 123. 86.

SSN 10550. 12465.

SSB 165199. 273915.

TSN 39562. 29343. 46314. 33717. 23656.

TSB 426307. 393506. 646367. 494660. 374634.

Table 5.3.4 Norway pout IV & IIIaN (Skagerrak).

Seasonal extended survivor analysis (SXSA).

Fishing mortalities by quarter of year.

Year	1983				1984				1985			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.006	0.050	*	*	0.000	0.077	*	*	0.000	0.034
1	0.067	0.041	0.197	0.242	0.073	0.086	0.326	0.417	0.114	0.063	0.154	0.614
2	0.128	0.212	0.570	0.342	0.132	0.194	0.586	0.748	0.339	0.068	0.764	0.533
3	0.156	0.185	0.766	1.540	0.270	1.584	0.911	0.000	0.649	0.115	0.319	0.000
4+	*	0.000	0.000	0.000	*	0.000	0.000	0.000	0.458	0.000	0.000	0.000
F (1- 2)	0.098	0.127	0.383	0.292	0.102	0.140	0.456	0.582	0.227	0.065	0.459	0.574

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.145	*	*	0.001	0.021	*	*	0.017	0.104
1	0.027	0.025	0.163	0.433	0.107	0.062	0.139	0.302	0.032	0.017	0.044	0.232
2	0.581	0.108	0.609	0.239	0.193	0.049	0.232	0.711	0.178	0.031	0.171	0.568
3	0.601	0.058	0.210	0.000	0.137	0.000	0.010	0.259	0.164	0.000	0.000	0.000
4+	0.154	0.000	0.000	0.000	0.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.304	0.066	0.386	0.336	0.150	0.056	0.185	0.506	0.105	0.024	0.108	0.400

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.003	0.150	*	*	0.000	0.032	*	*	0.009	0.060
1	0.085	0.047	0.173	0.303	0.086	0.124	0.101	0.189	0.069	0.041	0.144	0.154
2	0.029	0.125	0.487	0.406	0.185	0.344	0.223	0.264	0.393	0.250	0.255	0.459

3 0.019 0.030 0.037 0.177 0.184 0.351 0.237 0.324 0.451 0.209 0.539 1.677

4+ 0.000 0.000 0.000 0.000 0.239 0.000 0.000 0.000 0.596 0.000 0.000 0.000

F (1- 2) 0.057 0.086 0.330 0.355 0.135 0.234 0.162 0.227 0.231 0.145 0.199 0.306

Year 1992 1993 1994

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 0.026 0.038 * * 0.004 0.065 * * 0.006 0.057

1 0.088 0.054 0.184 0.245 0.112 0.069 0.144 0.210 0.164 0.046 0.190 0.371

2 0.273 0.136 0.333 0.508 0.104 0.116 0.422 0.483 0.204 0.177 0.529 0.418

3 0.794 0.454 0.048 0.165 0.060 0.462 0.370 0.079 0.133 0.122 0.639 0.000

4+ * * * * 0.024 0.000 0.000 0.000 0.000 0.000 0.000 0.000

F (1- 2) 0.181 0.095 0.258 0.377 0.108 0.093 0.283 0.346 0.184 0.111 0.360 0.395

Year 1995 1996 1997

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 0.022 0.075 * * 0.009 0.045 * * 0.005 0.022

1 0.077 0.053 0.101 0.207 0.033 0.049 0.132 0.125 0.016 0.003 0.146 0.141

2 0.145 0.280 0.093 0.200 0.078 0.032 0.266 0.165 0.098 0.063 0.316 0.368

3 0.034 0.365 0.069 0.118 0.083 0.439 1.425 0.093 0.067 0.175 0.302 0.203

4+ 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

F (1- 2) 0.111 0.166 0.097 0.203 0.056 0.040 0.199 0.145 0.057 0.033 0.231 0.254

Year 1998 1999 2000

Season 1 2 3 4 1 2 3 4 1 2 3 4

AGE

0 * * 0.003 0.015 * * 0.001 0.021 * * 0.003 0.017

1 0.023 0.025 0.069 0.131 0.012 0.026 0.156 0.106 0.016 0.009 0.064 0.346

2	0.079	0.056	0.096	0.102	0.049	0.135	0.390	0.412	0.052	0.092	0.199	0.354
3	0.171	0.119	0.017	0.255	0.057	0.122	0.078	0.089	0.014	0.464	0.501	0.367
4+	0.084	0.514	0.000	0.000	0.014	0.007	0.000	0.000	0.000	0.000	0.000	0.000

F (1- 2) 0.051 0.041 0.083 0.117 0.031 0.081 0.273 0.259 0.034 0.051 0.132 0.350

Year	2001				2002				2003			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.001	0.022	*	*	0.022	0.026	*	*	0.001	0.000
1	0.016	0.013	0.017	0.051	0.040	0.040	0.102	0.116	0.007	0.011	0.043	0.017
2	0.115	0.054	0.009	0.242	0.041	0.010	0.194	0.478	0.028	0.027	0.107	0.248
3	0.100	0.589	0.015	0.020	0.016	0.007	0.058	0.108	0.064	0.123	0.138	0.596
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.031

F (1- 2) 0.065 0.034 0.013 0.147 0.041 0.025 0.148 0.297 0.018 0.019 0.075 0.133

Table 5.3.4 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Year	2004				2005				2006			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.002	0.009	*	*	0.000	0.000	*	*	0.001	0.030
1	0.003	0.001	0.024	0.065	0.000	0.000	0.000	0.000	0.002	0.004	0.012	0.147
2	0.025	0.011	0.052	0.129	0.000	0.000	0.000	0.000	0.037	0.049	0.113	0.146
3	0.025	0.024	0.048	0.019	0.000	0.000	0.001	0.001	0.040	0.195	0.106	0.017
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.014	0.006	0.038	0.097	0.000	0.000	0.000	0.000	0.019	0.027	0.062	0.147

Year	2007				2008				2009			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.000	*	*	0.000	0.030	*	*	0.001	0.000
1	0.002	0.006	0.006	0.003	0.000	0.005	0.020	0.073	0.002	0.002	0.040	0.015
2	0.009	0.008	0.007	0.004	0.004	0.023	0.101	0.044	0.000	0.017	0.386	0.032
3	0.000	0.001	0.018	0.011	0.000	0.001	0.000	0.000	0.000	0.018	0.049	0.003
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.005	0.007	0.007	0.003	0.002	0.014	0.060	0.058	0.001	0.009	0.213	0.023

Year	2010				2011				2012			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.000	*	*	0.000	0.000	*	*	0.000	0.003
1	0.000	0.028	0.054	0.048	0.000	0.000	0.016	0.011	0.000	0.001	0.002	0.124
2	0.000	0.180	0.270	0.232	0.000	0.001	0.015	0.020	0.000	0.002	0.006	0.501
3	0.000	0.050	0.072	0.002	0.000	0.000	0.011	0.000	0.000	0.001	0.002	0.018
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

F (1- 2) 0.000 0.104 0.162 0.140 0.000 0.001 0.015 0.015 0.000 0.002 0.004 0.312

Year	2013				2014
Season	1	2	3	4	1
AGE					
0	*	*	0.000	0.005	*
1	0.000	0.027	0.048	0.125	0.001
2	0.000	0.027	0.143	0.440	0.007
3	0.001	0.033	0.286	1.099	0.004
4+	0.000	0.000	0.000	0.000	0.000

F (1- 2) 0.000 0.027 0.096 0.283 0.004

Table 5.3.5 Norway pout IV & IIIaN (Skagerrak).

SXSA (Seasonal extended survivor analysis).

Diagnostics of the SXSA.

Log inverse catchabilities, fleet no: 1 (commercial q134)

Year 1983-2014 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	11.107
1	10.386	*	9.734	9.136
2	9.266	*	8.800	8.500
3	9.266	*	8.800	8.500

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2014 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	2.148	*	*	*
2	1.528	*	*	*
3	1.528	*	*	*

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	2.320	*
1	*	*	1.498	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	2.317	*
1	*	*	1.765	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.551	*
3	*	*	1.551	*

Table 5.3.5 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:

Fleet no: 1 (commercial q134)

Year 1983-2014 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	1.077
1	1.358	*	3.239	2.115
2	2.178	*	1.696	1.237
3	1.232	*	0.823	0.747

Weighting factors for computing survivors:

Fleet no: 2 (ibtsq1)

Year 1983-2014 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.800	*	*	*
2	1.911	*	*	*
3	1.151	*	*	*

Weighting factors for computing survivors:

Fleet no: 3 (egfsq3)

Year 1992-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	1.281	*
1	*	*	2.506	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:

Fleet no: 4 (sgfsq3)

Year 1998-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	1.802	*
1	*	*	2.419	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:

Fleet no: 5 (ibtsq3)

Year 1991-2013 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*

2 * * 1.599 *

3 * * 0.966 *

Table 5.3.6 Norway pout IV & IIIaN (Skagerrak). Stock summary table. (SXSA May 2013).

(Recruits in millions. SSB and TSB in t, and Yield in '000 t).

Year	Recruits (age 0 3rd qrt)	SSB (Q1)	TSB (Q3)	Landings ('000 t)	Fbar(1-2)
1983	85174	69790	1457400	457,6	0,900
1984	46391	96167	899941	393,0	1,280
1985	31374	202261	479543	205,1	1,325
1986	62990	109759	504655	174,3	1,092
1987	16651	128758	467805	149,3	0,897
1988	49502	152249	399209	109,3	0,637
1989	53328	113080	555478	166,4	0,828
1990	47908	158509	527237	163,3	0,758
1991	92584	180673	744951	186,6	0,881
1992	39962	231914	812737	296,8	0,911
1993	28645	262727	488122	183,1	0,830
1994	117457	145877	697466	182,0	1,050
1995	36917	174692	933894	236,8	0,577
1996	89204	354405	805622	163,8	0,440
1997	24361	250131	840788	169,7	0,575
1998	34769	317234	496695	57,7	0,292
1999	85098	183176	680896	94,5	0,644
2000	28258	215901	823210	184,4	0,567
2001	26035	282965	465208	65,6	0,259
2002	17643	189702	362388	80,0	0,511
2003	7958	127679	227478	27,1	0,245
2004	10066	97796	161318	13,5	0,155
2005	39511	64674	270824	1,9	0,000
2006	19283	99382	419703	46,6	0,255
2007	31400	178732	383303	5,7	0,022
2008	60470	163172	574134	36,1	0,134
2009	80871	218885	885542	54,5	0,246
2010	10394	358122	821416	126,0	0,406
2011	16964	369220	402643	6,5	0,031
2012	64979	173367	487978	27,0	0,318
2013	25110	165199	646367	82,1	0,406
2014		273915			
Arit mean	**44.557**	**190.941**	**603.998**		**0,564**
Geomean	**35.960**				

Table 5.6.1 NORWAY POUT IV and IIIaN (Skagerrak). Input data to forecast May 2011.

Basis: HCR with quarter 1 to 4 2012 (assessment year) and quarter 1 2014 (forecast year) observed exploitation pattern and 2014 quarter 2 to quarter 4 fishing pattern similar to the 2013 fishing pattern. Recruitment in the forecast year is assumed to the 25% percentile = 24736 millions (of the long term geometric mean 35960 millions) in the 3rd quarter of the year.
Basis: F (2013) = F (1,2) = 0.406; R (2014) = 25% percentile of long-term recruitment (1983–2013) = 36 billion (3rd quarter); SSB (2014) = 274 (assessment); SSB (2014) (forecast model output) = 281; Catches (2013) = 82 kt.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2013	1	0	0	0,000	0,000	0,000	0,29	0
2013	1	1	36265	0,000	0,009	0,018	0,29	0,2
2013	1	2	2620	0,000	0,026	0,033	0,39	1
2013	1	3	677	0,001	0,043	0,042	0,44	1
2013	2	0	0	0,000	0,000	0,000	0,29	0
2013	2	1	27133	0,027	0,014	0,014	0,29	0
2013	2	2	1774	0,027	0,025	0,030	0,39	0
2013	2	3	435	0,033	0,038	0,041	0,44	0
2013	3	0	25110	0,000	0,004	0,004	0,29	0
2013	3	1	19756	0,048	0,028	0,023	0,29	0
2013	3	2	1169	0,143	0,038	0,040	0,39	0
2013	3	3	277	0,286	0,051	0,046	0,44	0
2013	4	0	18782	0,005	0,006	0,009	0,29	0
2013	4	1	14086	0,125	0,028	0,028	0,29	0
2013	4	2	685	0,440	0,040	0,048	0,39	0
2013	4	3	165	1,099	0,058	0,058	0,44	0

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2014	1	0	0	0,000	0,000	0,000	0,29	0
2014	1	1	13989	0,001	0,009	0,020	0,29	0,2
2014	1	2	9289	0,007	0,026	0,033	0,39	1
2014	1	3	378	0,004	0,043	0,040	0,44	1
2014	2	0	0	0,000	0,000	0,000	0,29	0
2014	2	1	0	0,027	0,014	0,018	0,29	0
2014	2	2	0	0,027	0,025	0,033	0,39	0
2014	2	3	0	0,033	0,038	0,046	0,44	0
2014	3	0	24736	0,000	0,004	0,006	0,29	0
2014	3	1	0	0,048	0,028	0,025	0,29	0
2014	3	2	0	0,143	0,038	0,037	0,39	0
2014	3	3	0	0,286	0,051	0,049	0,44	0
2014	4	0	0	0,005	0,006	0,008	0,29	0
2014	4	1	0	0,125	0,028	0,032	0,29	0
2014	4	2	0	0,440	0,040	0,041	0,39	0
2014	4	3	0	1,099	0,058	0,057	0,44	0

Table 5.6.2 Results of the short term forecast for Norway pout May 2014.

Basis: HCR with 2013 quarter 1-4 assessment year and 2014 quarter 1 forecast year observed fishing mortality (F) and 2014 quarter 2-4 fishing pattern similar to the 2013 fishing pattern. Recruitment in forecast year is assumed to the 25% percentile = 24 736 millions (of the long term geometric mean 35 960) in the 3rd quarter of the year.

Basis: F (2013) = F (1,2) = 0.406; R (2014) = 25% percentile of long-term recruitment (1983–2013) = 25 billion (3rd quarter); SSB (2014) = 274 (assessment); SSB (2014) (forecast model output) = 281; Catches (2013) = 82 kt.

RATIONALE	LANDINGS	BASIS	F	SSB	%SSB
	2014		2014	2015	change1)
MSY approach	108	MSY Bescapement	0.54	150	-45
Precautionary approach	108	Bpa	0.54	150	-45
Zero Catch	0	No fishery	0	225	-18
F (2013=0.41)	87	F (2013)	0.41	164	-40
Other options	50	Fixed TAC Strat.	0.21	190	-31
		(2007 LTMP MSE)			
(2007 LTMP MSE)	77	Fixed F Strat.	0.35	171	-38
		(2007 LTMP MSE)			
	204	Blim	1.44	90	-67
Weights in '000 tonnes.					
1) SSB 2015 relative to SSB 2014.					

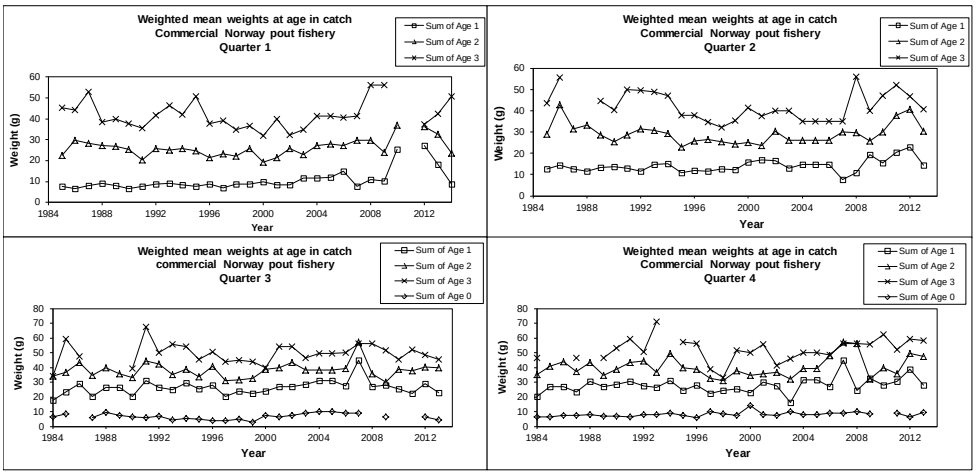


Figure 5.2.1. NORWAY POUT IV and IIIaN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1983-2013.

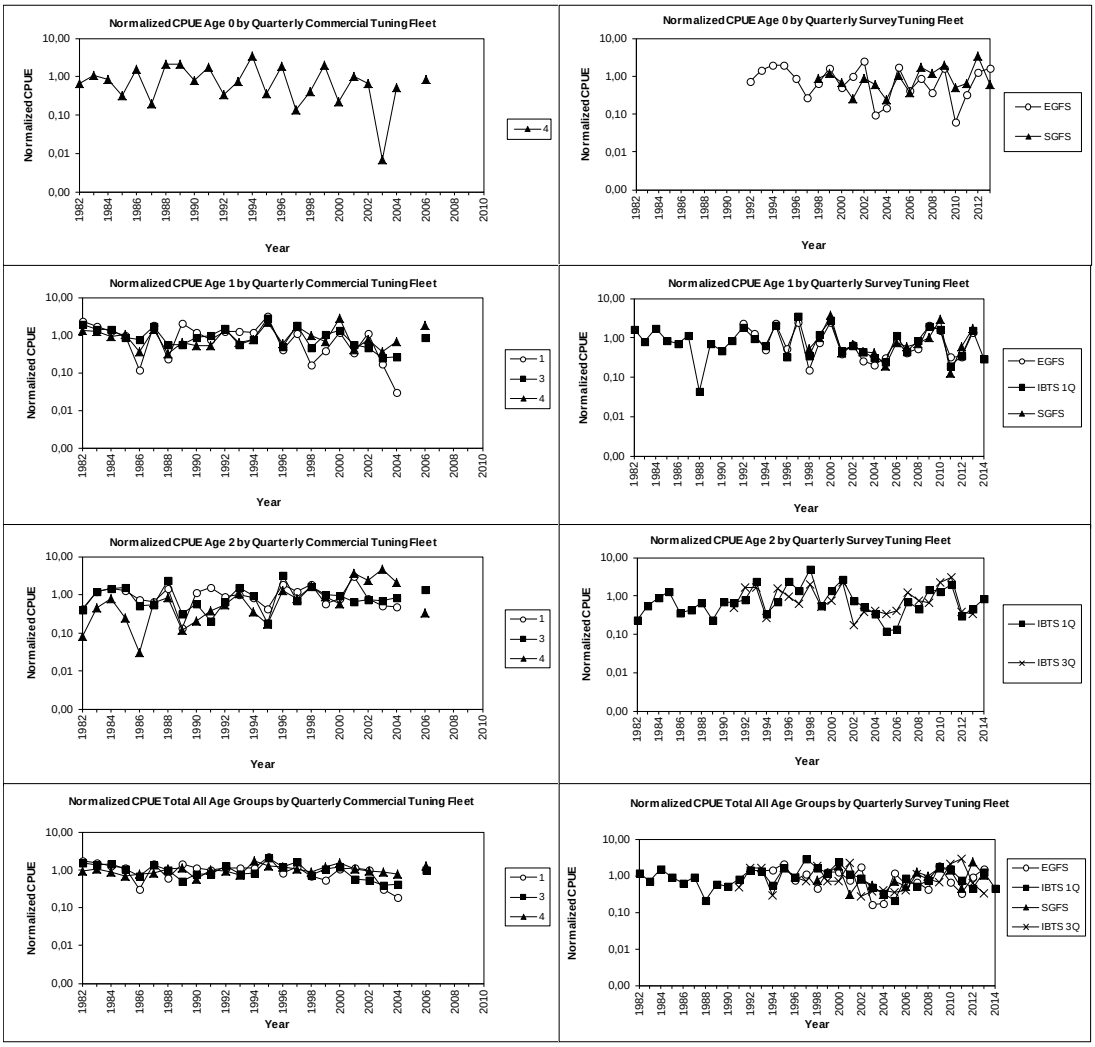


Figure 5.2.2 NORWAY POUT IV and IIIaN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly commercial tuning fleet and survey tuning fleet used in the Norway pout SXSA assessment for each age group and all age groups together.

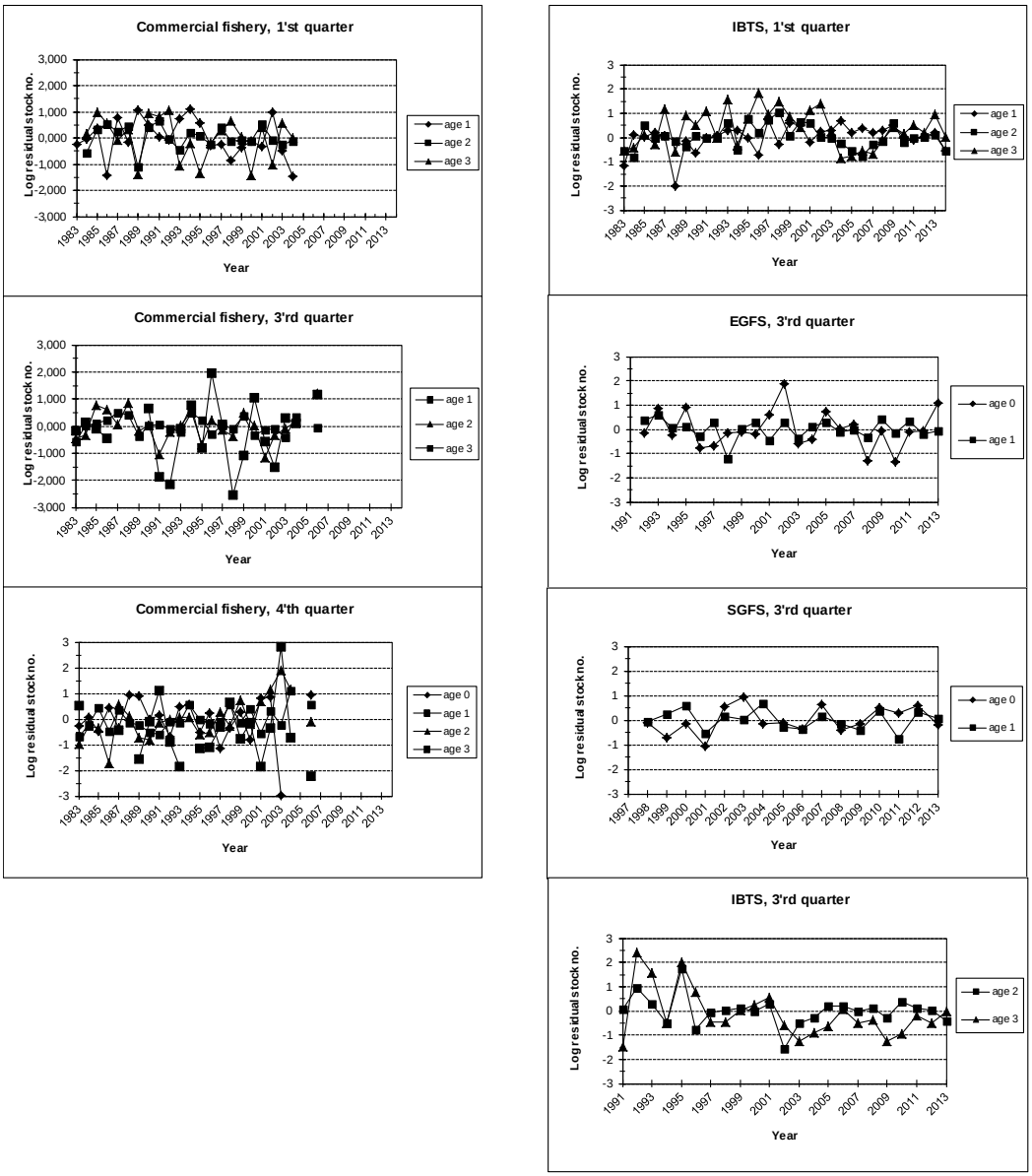


Figure 5.3.1 Norway pout IV & IIIaN (Skagerrak). Log residual stock numbers (log (Nhat/N)) per age group. SXSA divided by fleet and season.

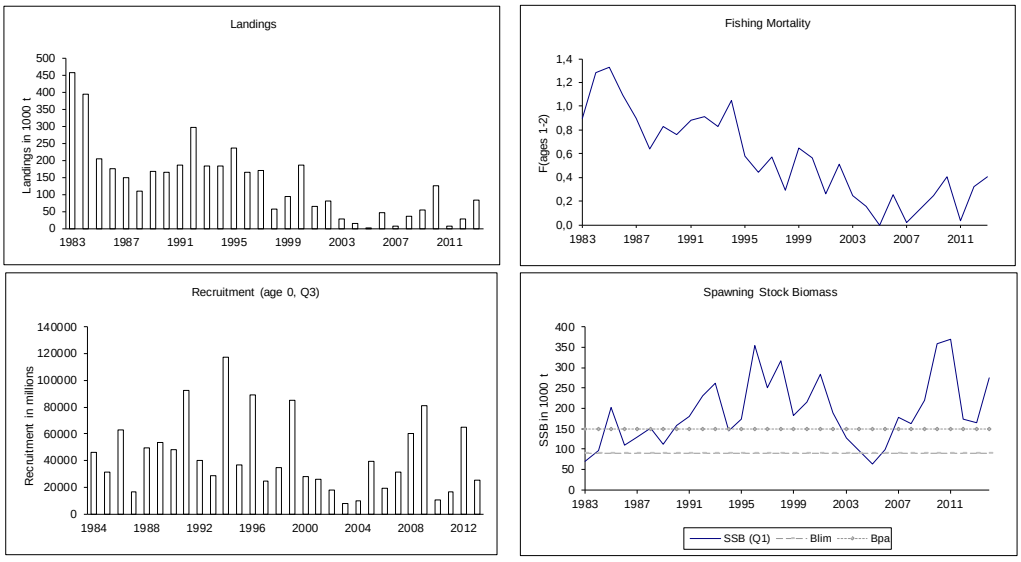


Figure 5.3.2 Norway Pout IV and IIIaN (Skagerrak). Stock Summary Plots. SXSA baseline run May 2014.

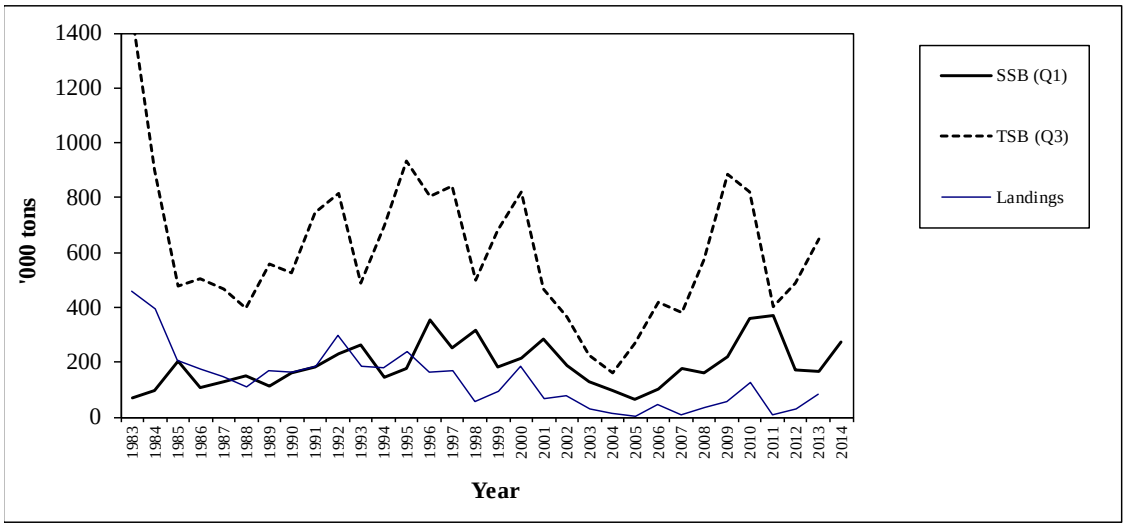


Figure 5.3.3 Norway pout IV & IIIaN (Skagerrak). Trends in yield, SSB and TSB during the period 1983-2014.

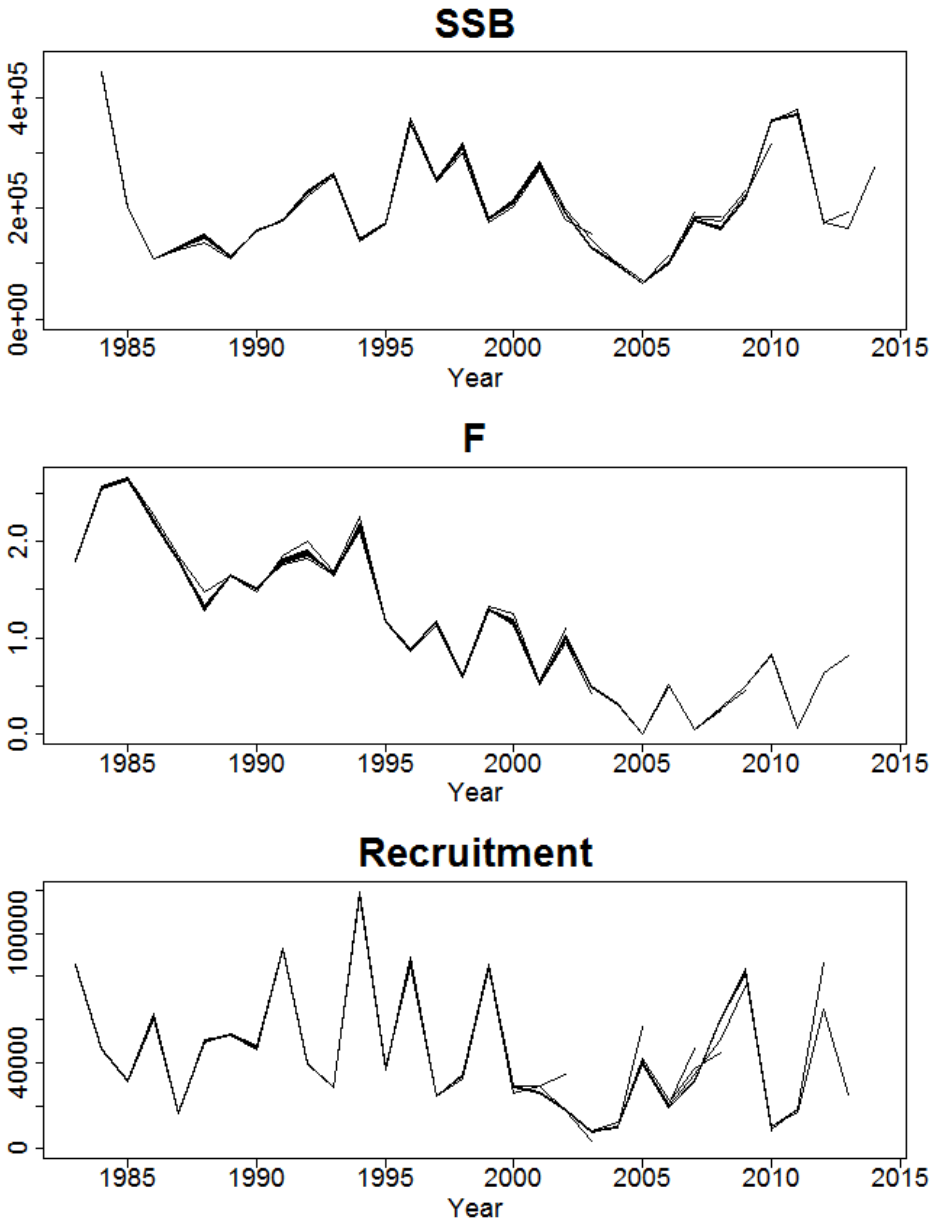


Figure 5.3.4 Norway pout IV & IIIaN (Skagerrak). Retrospective plots of final SXSA assessment May 2014, with terminal assessment year ranging from 2003-2014.

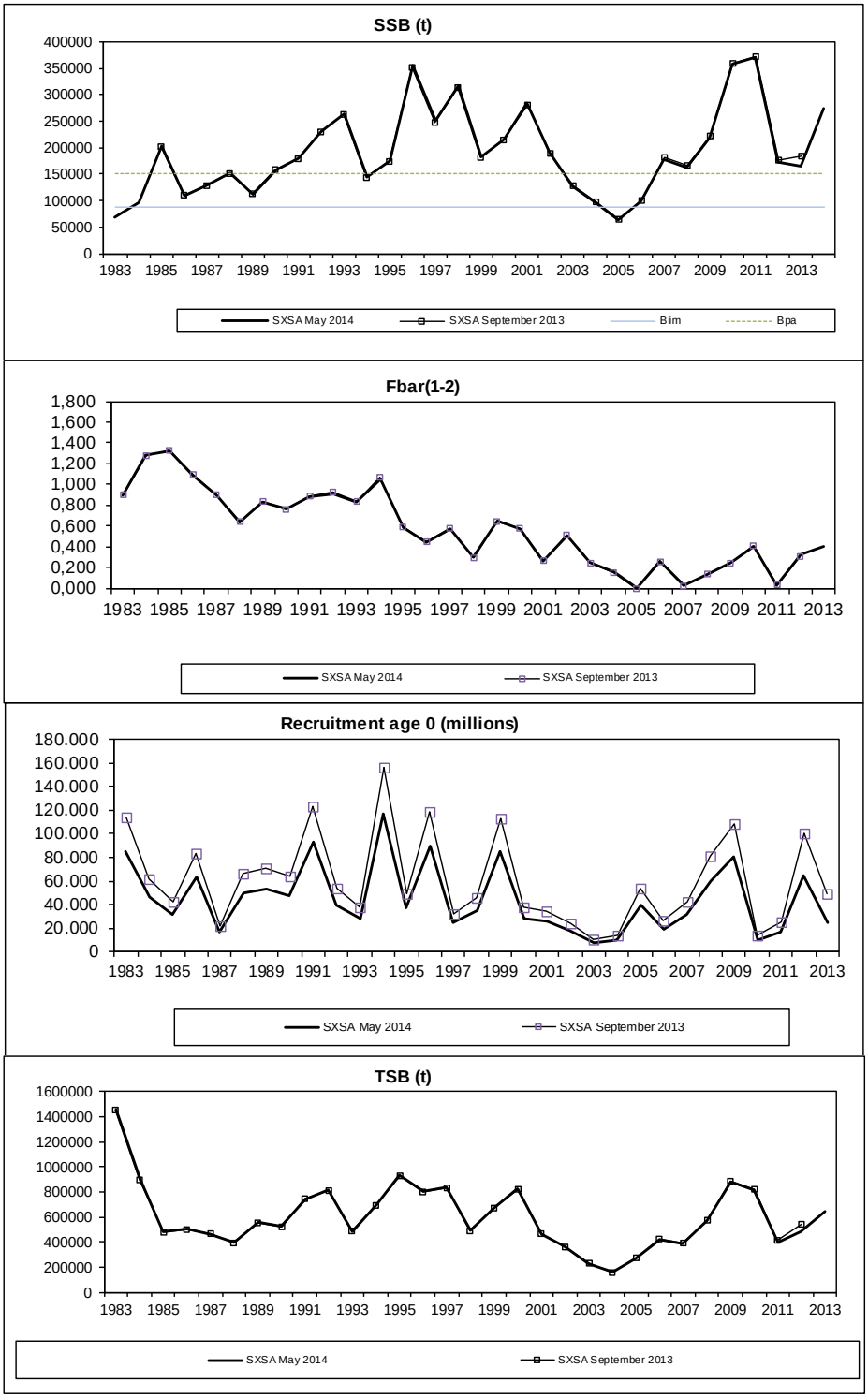


Figure 5.3.5 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2014 SXSA with the September 2013 assessment based on the new benchmark baseline assessment SXSA May 2012 Scenario 2.

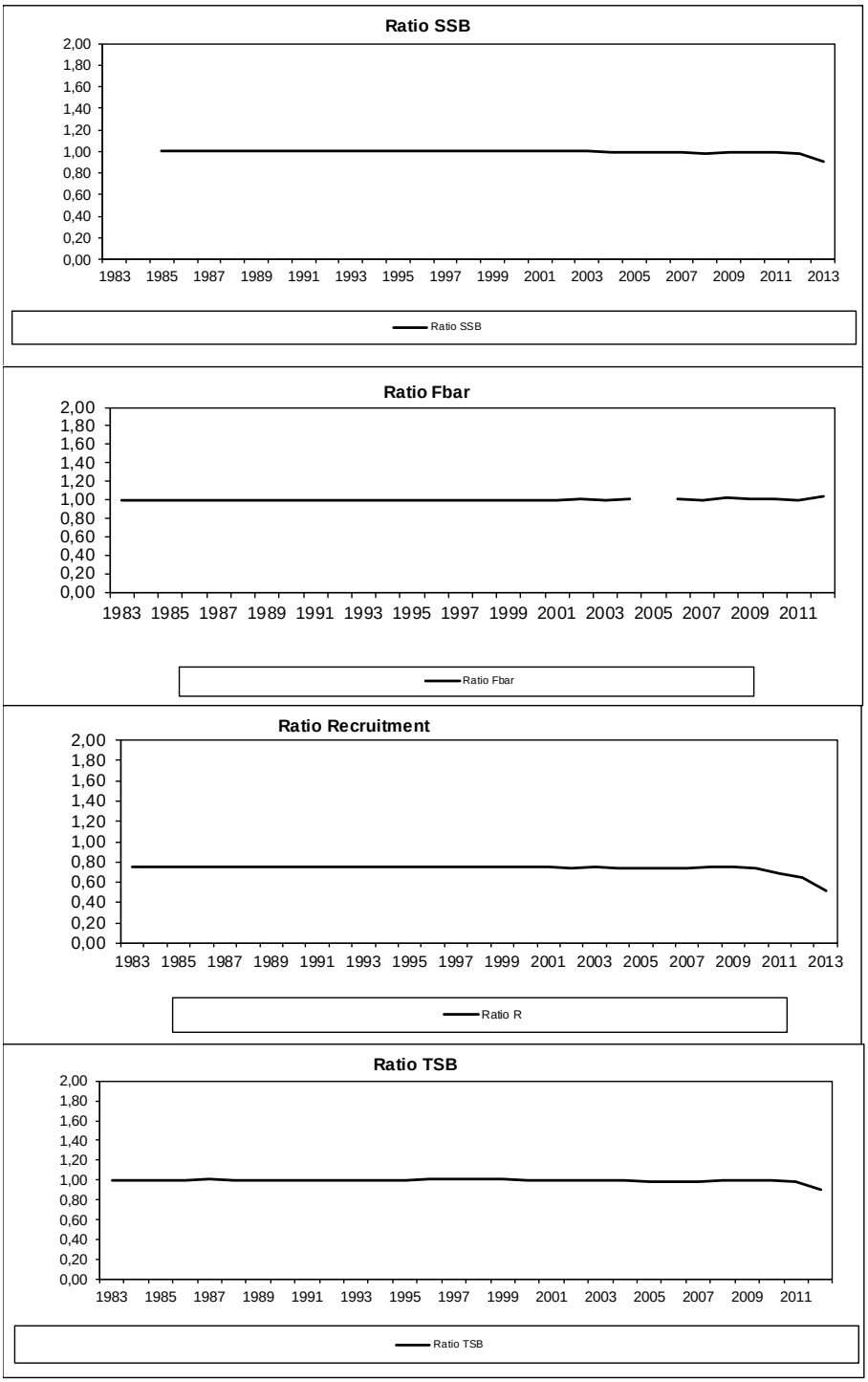


Figure 5.3.6 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2014 SXSA with the September 2013 SXSA based on the new benchmark baseline assessment SXSA May 2012 Scenario 2: Ratios.

6 Plaice in Division VIId

This assessment of plaice in Division VIId was made following methodological information described in the Stock Annex revised during ICES WKFLAT 2010 (ICES, 2010) concerning spawning migration from areas IV and VIIe during the first quarter.

Following last year's conclusions, the assessment was run with a plus group reduced to 7 and parameters described in the text.

6.1 General

6.1.1 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2013.

All available information on ecological aspects can be found in the Stock Annex.

6.1.2 Fisheries

Plaice is mainly caught in two offshore fisheries, i.e. the beam trawl sole fishery and the mixed demersal fishery using otter trawls.

In the first one, the Belgian beam trawlers used to fish mainly in the 1st (targeting spawning concentrations in the central Eastern Channel) and 4th quarter and their area of activity covers almost the whole of VIId south of the 6 miles contour off the English coast. In the last years however, due to high sole abundance in the Celtic Sea, this fleet changed its fishing pattern, spending less time in the Eastern Channel in the first quarter, resulting in a lesser importance of that quarter in the total catches.

The second fleet consists mainly of French large otter trawlers from Boulogne to Dieppe. The target species of these vessels are cod, whiting, plaice, mackerel, gurnards and cuttlefish and the fleet operates throughout VIId.

There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. These are mainly vessels <12 m operating on a daily basis within 12 miles of the coast, from small ports along the French and English coast. They target sole, plaice, cod and cuttlefish.

The otter trawl mixed demersal fishery and the inshore fishery are active when plaice is spread over the whole area and IVc.

Due to the minimum mesh size (80 mm) in the mixed beam trawl fishery, a large number of undersized plaice are discarded. The 80-mm mesh size is not matched to the minimum landing size of plaice (27 cm). Management measures directed at sole fisheries will also impact the plaice fisheries.

The first quarter used to be the most important for the fisheries but the share of the landings for this quarter has been decreasing from the early 1990s. In 2013, catches were roughly equally distributed among the year (see text table below).

Quarter	Landings	%
1	1174	29%
2	930	23%
3	871	21%
4	1123	27%

Following the ICES WKFLAT 2010 (ICES, 2010) conclusions, 65% of the first quarter catches were removed. These 65% were estimated during ICES WKFLAT 2010, based on published tagging results and some previous studies (e.g. Burt *et al.* 2006, Hunter *et al.* 2004, Kell *et al.* 2004) showing that 50% of the fish caught during the first quarter are fish coming from area IV to spawn. The same study also shown that 15% of the fish caught during the first quarter were fishes from area VIIe. Table 6.1.2.1 shows the Quarter1 landings and the corresponding removals. Removing this part of the catches allows for assessing the stock resident biomass**. All the following figures will take into account this Quarter 1 removal.**

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2012 in Figure 6.1.2.1, with recruit at age 2 starting to be caught after summer. This is in line with what is known of the biology of this species, which operates spawning migration (from VIId, VIIe and IV) in the centre of the Eastern channel during winter.

6.1.3 ICES advices for previous years

2010 advice: *In the absence of a short-term forecast, ICES advises on the basis of exploitation boundaries in relation to precautionary considerations that landings in 2011 should not increase above the average of landings from the last three years (2007–2009), corresponding to landings less than 3 400 t.*

2011 advice: *ICES advises on the basis of precautionary considerations that catches of plaice should not be allowed to increase in 2012, and discarding should be reduced.*

2012 advice: *Based on the ICES approach for data limited stocks, ICES advises that catches of plaice in Division VIId should be no more than 4300 t, and discarding should be reduced.*

2013 advice*: Based on the ICES approach for data limited stocks, ICES advises that landings of plaice in Division VIId should be no more than 3925 tonnes, and discarding should be reduced. Discards are known to be high but cannot be quantified; therefore total catches cannot be calculated.*

6.1.4 Management

There are no explicit management objectives for this stock.

The TACs have been set to **for the combined ICES Divisions VIId & VIIe**.

The minimum landing size for plaice is 27 cm, which is not in accordance with the minimum mesh size of 80 mm, permitted for catching plaice by beam and otter trawling. Fixed nets are required to use 90-mm mesh as an absolute minimum.

For 2010, 2011 and 2012, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011 and Council Regulation (EC) N°43/2012 were updates of the Council Regulation (EC) N°43/2009 with new allocations, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009. However fishing effort regulations have not been restrictive so far for the fishery on that stock.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

6.2 Data available

6.2.1 Catch

Landings data as reported to ICES together with the total landings estimated by the Working Group are shown in Table 6.2.1.1. The 2013 landings of 4099 t (3335 t attributed to the resident stock and 764 t removed from the first quarter as estimated to be resulting from catches coming from VIIe and IV to spawn) are in the catch level of the past 8 years (between 3200 and 4200 t). As usual, France contributed the largest share (51%) of the total VIId landings in 2012 followed by Belgium (31%) and UK (15%) which is nearly unchanged since 2007.

Uk, France, Netherland and Belgian have been providing data under the ICES InterCatch format since 2011, and Inter Catch was used to produce the input data.

Routine discard monitoring has recently begun following the introduction of the EU data collection regulations.

Discards data for the period 2003-2013 are available from France, Belgium and UK although the sampling intensity before 2008 do not allow for using the discards information in the assessment yet. The discards rates estimated for the years 2011 to 2013 (for which data were uploaded in InterCatch) are presented in table 6.2.1.2. The weighted average discard rate for those 3 years is 0.37.

6.2.2 Age compositions

Age compositions of the landings are presented in Table 6.2.2.1. Age composition of the landings per quarter for the year 2012 is presented in Table 6.2.2.2.

6.2.3 Weight at age

Weight at age in the catch is presented in Table 6.2.3.1 and weight at age in the stock in Table 6.2.3.2, both are presented in Figure 6.2.3.1. The procedure for calculating mean weights is described in the Stock Annex.

These weights at age do not show specific trends, apart from a general decrease in stock weights in 2013, which is also observed in the North Sea (Plaice IV).

6.2.4 Maturity and natural mortality

Information about maturity per age class is given with the table included in this section. At an age of three years more than 50%and at age four years 96% of the plaice are mature. The natural mortality is assumed at a fixed value of 0.1 through all ages.

Age	1	2	3	4	5	6	7	8	9	10
Proportion of mature	0	0.15	0.53	0.96	1	1	1	1	1	1

6.2.5 Catch, effort and research vessel data

All survey and commercial data available for calibration of the assessment are presented in Table 6.2.5.1 and Figure 6.2.5.1 and fully described in the Stock Annex. The survey series consist of: (1) the UK Beam Trawl Survey; (2) the French Ground Fish Survey; and (3) the International Young fish survey.

The effort and LPUE data of the commercial tuning fleet, i.e. the Belgian Beam Trawlers commercial fleets are shown in Figure 6.2.5.2.

The Belgian beam trawler fleet increased from 1998 to 2007 due to the absence of restriction on fishing efforts. It has been decreasing since then. LPUE decreased to its lowest level in 2003 and has been increasing since then.

6.3 Data analyses

6.3.1 Reviews of last years assessment

The RG reported on assumptions about M values, and retrospectives patterns in R. M values and incorporation of discards were not taken into account yet in the assessment. This issue will be addressed during the benchmark in 2015.

Discard time series are available for monitoring and should be used to explore the SCA model that is used for North Sea Plaice to estimate discards and abundance for this stock.

Inconsistencies between survey trends and commercial fleets were still observed this year. This might be the result of the quarter one removals which accounts for plaice spawning migrations from area IV and VIIe into VIId. Unfortunately, this is a period where no survey is conducted, but the timing of the survey cannot be changed. However, these inconsistencies should be addressed during the benchmark in 2015.

WKFLAT 2010 concluded that:

- The discard time series was considered too short and too variable to be used in the assessment
- The retrospective pattern in the assessment without discards was largely reduced, when 65% of quarter 1 catches were removed as well as removal of younger ages (1,2 and 3) from the survey UK BTS.
- The recommendation from WKFLAT is that **this assessment is useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F**. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.

6.3.2 Exploratory catch-at-age-based analyses

Catch at age analysis was carried out according to the specifications in the Stock Annex. The model used was XSA.

The log catchability residuals from single fleet runs (with settings as in XSA and F shrinkage = 1.0) are shown in Figure 6.3.2.2 for all the fleets. There is a jump in the

residuals of the UK BTS and French GFS (the two surveys covering the entire geographical area of the stock) in 2000, coinciding with the decrease of the SSB that same year. The discrepancy between the surveys and the commercial fleets originates from that period. A similar pattern occurs also in the log catchability residuals of this survey for sole VIId. The log catchability residuals from a XSA run combining all fleets are shown in Figure 6.3.2.3. The patterns in log q residuals, already shown in the previous assessment, remained unchanged.

6.3.3 Exploratory survey-based analyses

From 2012 SURBAR runs were not executed. Based on the previous diagnostics in Z, it was concluded that surveys could not estimate any trend in fishing mortality.

6.3.4 Conclusions drawn from exploratory analyses

There is a decreasing trend in the contribution of the first quarter to the whole landings, where a fishery on the spawners takes place, yielding an age distribution different from the rest of the year. It is unknown whether there is major inter-annual variability in the immigration from the North Sea to these spawning grounds, which could distort any catch-based analysis. Any migration events taking place in the first quarter cannot be represented in the surveys in the second semester.

Discarding is shown to take place and is substantial, but is constrained to younger ages. The year range of the data series is too short to make use of it in the analysis.

Both landings-at-age and tuning fleets information are highly dependent on the accuracy of the spatial declaration of the fishing activity as an important component of the fisheries operates on the borderline to ICES subdivision IVc.

Figure 6.3.4.1 compares the single fleet performances to the final assessment. The two main surveys, and particularly the UK BTS, keep diverging from the commercial fleet.

6.3.5 Final assessment

The settings in the XSA assessment:

Year of assessment:		2013	2014
Assessment model:		XSA	XSA
Assessment software		FLR library	FLR library
Fleets:			
BE Beam Trawlers	Age range	2–5	2–5
	Year range	1981 onwards	1981 onwards
			1997 onwards
UK Beam Trawl Survey	Age range	4–6	4–6
	Year range	1988 onwards	1988 onwards
FR Ground Fish Survey	Age range	2–3	2–3
	Year range	1988 onwards	1988 onwards
Intern'l Young Fish Survey	Age range	1	1
	Year range	1988 onwards	1988 onwards
Catch/Landings			
Age range:		1–7+	1–7+
Landings data:		1980–2012	1980–2013
Discards data		None	None
Model settings			
Fbar:		3–6	3–6
Time series weights:		None	None
Power model for ages:		No	No
Catchability plateau:		Age 5	Age 5
Survivor est. shrunk towards the mean F:		5 years / 3 ages	5 years / 3 ages
S.e. of mean (F-shrinkage):		1.0	1.0
Min. s.e. of population estimates:		0.3	0.3
Prior weighting:		No	no

The final XSA output is given in Table 6.3.5.1 (diagnostics), table 6.3.5.2 (fishing mortalities) and Table 6.3.5.3 (stock numbers). A summary of the XSA results is given in Table 6.5.3.4 and trends in yield, fishing mortality, recruitment and spawning stock and Total Stock biomass are shown in Figure 6.3.5.1. Retrospective patterns for the final run are shown in Figure 6.3.5.2

6.4 Historic Stock Trends

The 1985 year class dominates the history of this stock. The 1985 year class was followed by the 4 most productive years in history in terms of landings. A second peak occurred with the 1996 year class, although estimated to be at 65% of the 1985 year class. The ephemeral peak of SSB in 1999 has been followed by years of stepped decline. Previous reports (WGNSSK, 2008 and 2009) considered the SSB to be stable at its lowest level for the 2003–2007 period. This low SSB situation was confirmed by the fisher's perception and assessed by a survey in France in 2006. The SSB is now increasing in the recent years.

6.5 Biological reference points

It was decided by ACOM that for Category 2 stocks in the ICES DLS $F_{0.1}$ is a more precautionary proxy for F_{MSY}. $F_{0.1}$ was estimated to 0.15 in yield per recruit analyses using the latest assessment results during the WGNSSK 2014.

F_{MSY} was also estimated using the procedure advised during WKMSYREF II2014. Three stock-recruitment relationships were assessed which led to the selection of the hockey-stick model (Figure 6.5.1). Then, F_{MSY} was determined using the eqsim method from the R library MSY (Figure 6.5.2 and Table 6.5.1). A test was carried out whether F_{msy} leads to a less than 5% probability to fall below B_{lim}. In the absence of an officially agreed B_{lim}, the breack point of the hockey stick was used as B_{lim} proxy. The F_{msy} value is considerably lower than the F leading to a more than 5% probability to fall below B_{lim} (F_{lim} in table 6.5.1).

6.6 Short-term forecasts

The short term forecast was carried out following the procedure for Category 2 stocks in the ICES approach for data-limited stocks (DLS; ICES 2013a). It was conducted with FLSTF (FLR package).

Weight-at-age in the stock and in the catch were taken to be the average over the last 3 years. The exploitation pattern was taken to be the mean value of the last three years. Population number at age 3 and older in 2013 is XSA survivors estimates.

6.6.1 Recruitment estimates

Considering the truncation of the surveys ages ranges for the XSA agreed during the Benchmark, the recruitment is poorly estimated.

For 2013 and the previsions (2014 and 2015), the recruitment was calculated as the geometric mean recruitment over the period 2001-2011 (taken into account the relative stability of the recruitment in the recent years at a lower level than at the beginning of the series). The 2011 year class, aged 2 in 2013 was calculated as the geometric mean age 2 abundance over the period 2001-2011.

Year class strength estimates used for short term prognosis are summarized in the text table below.

Year Class	Age in 2013	XSA (Thousands)	GM (01-11) (Thousands)	Accepted estimate (Thousands)
2012	1	514	13205	13205
2011	2	6260	11120	11120

6.6.2 Calculation of the VIId resident stock

Following the DLS Category 2 protocol, F for the intermediate year is set such as landings equal the TAC for that year. TAC for area VIId is a combined TAC for area VIId and VIIe. The proportion of catches taken in area VIId used to compute the TAC in this area is the long term average proportion of catches taken in the area over the total catches.

As landings numbers and XSA survivors in 2013 are computed from the resident population (catches made on fishes from area VIIe and IV in quarter 1 are removed), the TAC in VIId and resulting F in intermediate year was also computed to take into account this first quarter removal. The first quarter removal was also estimated as the long term average, and TAC reduced by this average.

The proportion of the catch taken during the first quarter of the year, and therefore the proportion of the fish caught in VIId which migrate in from areas VIIe and IV, have been significantly lower over the last 11 years as shown in figure 6.6.1; therefore 2 options were considered for the calculation of the long-term averages, (1) over the whole time series, as done previously, or (2) only over the last 11 years.

6.6.3 Management options tested

TACs for 2015 were calculated using both the F_{MSY} proxy recommended for Category 2 stocks in the ICES DLS $F_{0.1}$ as well as the estimated F_{MSY} (see section 6.5) and Fmax. A more conservative option consisting in a 20% decrease in the TAC compared to 2013 was also tested.

Input to the short term predictions are presented in Table 6.6.1 and results in Table 6.6.2.1.

Following the ICES DLS protocol ($F_{MSY}=F_{0.1}$ for Category 2 stocks) would lead to a TAC in 2015 of 2309/2173 t (depending on the resident stock calculation options, 1 and 2 respectively, see section 6.6.2), which is a substantial reduction compared to 2013 landings. This substantial reduction in advice compared to last year is a result of the much lower F_{MSY} proxy (in 2013 $F_{MSY}=F_{max}=0.23$, in 2014 $F_{MSY}=F_{0.1}=0.15$), rather than a declining stock, since in all scenarios examined the stock is projected to increase.

6.7 Medium-term forecasts

No medium-term forecast is available for this stock.

6.8 Quality of the assessment

The sampling for plaice in VIId is considered to be at a reasonable level.

Discarding of plaice is significant and variable depending on the gear used. The omission of young fish discards has influence on the forecast and the predictions, but is not considered to severely affect the estimates of F and SSB. The average discard rate over the years 2011 to 2013 is estimated at 0.37. The quality of the assessment is considered to have improved in 2012. In particular, the adjustment of plus group from age 10 to 7 has reduced consequently the retrospective bias. The patterns in log q residuals, already shown in the previous assessment, remained unchanged.

6.9 Status of the stock

Fishing mortality and SSB are only given here for trends.

The spawning stock biomass has followed a stepped decline from 1990 to the early 2000s. It stayed stable at low levels until 2008 and this confirms the fisher's impression assessed by a survey in France in 2006.

Results of the assessment indicate that F is being reduced, while SSB seems to be increasing in recent years.

6.10 Management considerations

The stock identity of plaice in the Channel is unclear and may raise some issues:

- The TAC is combined for Divisions VIId and VIIe. Plaice in VIIe is considered at risk of being harvested unsustainably (F above Fmsy).
- The plaice stock in VIId is mostly harvested in a mixed fishery with sole in VIId.
- Due to the minimum mesh size (80 mm) in the mixed beam and otter trawl fisheries, a large number of undersized plaice are discarded. The 80 mm mesh size is not matched to the minimum landing size of plaice (27 cm). Measures taken specifically to control sole fisheries will impact the plaice fisheries.

The retrospective pattern in the assessment caused by the difference in the mortality signals between commercial and survey information has improved due to the removal of the first ages of the UK-BTS and the removal of the first quarter catches and the change of the plus group to age 7.

The perception of historical stock trends from UK BTS differs from that of the commercial tuning series. Possible causes include: (1) the truncated age structure of the commercial series due to the discarding behaviour compared to the survey; (2) the F estimated from the survey data are based on the resident stock only, while the F estimated from the commercial data include an additional migratory component that enters VIId to spawn during the first quarter (as the commercial fleets operate throughout the year).

6.11 Sources

Burt, G., D. Goldsmith, and M. Armstrong. 2006. A summary of demersal fish tagging data maintained and published by Cefas. Sci. Ser. Tech Rep., Cefas Lowestoft, 135: 40pp.

Hunter, E. J. D. Metcalfe, G. P. Arnold and J. D. Reynolds. 2004. Impacts of migratory behaviour on population structure in North Sea plaice. *Journal of Animal Ecology* 73, 377–385.

Kell L.T., R. Scott, and E. Hunter. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51, 287– 299.

ICES 2010. Report of the Benchmark Workshop on Flatfish (WKFLAT). ICES CM 2010/ACOM:37

ICES 2012. Report of the Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). ICES CM 2012/ACOM:36

ICES, 2013a. (DRAFT) ICES Implementation of Advice for Data-limited Stocks in 2013. ICES CM 2012/ACOM: 68. 42pp.

ICES. 2013b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:13. 1435 pp.

Table 6.1.2.1 - Plaice in VIId. Nominal landings, and Quarter1 removal

Year	TotalLandings	Landings Quarter1	Total Landings after removing 65% of Q1 catches	Percentage Removed
1980	2650	908	2060	22
1981	4769	1635	3706	22
1982	4865	1668	3781	22
1983	5043	1729	3919	22
1984	5161	1770	4011	22
1985	6022	2064	4680	22
1986	6834	2343	5311	22
1987	8366	2868	6502	22
1988	10420	3572	8098	22
1989	8758	3002	6807	22
1990	9047	3101	7031	22
1991	7813	2678	6072	22
1992	6337	2173	4925	22
1993	5331	1828	4143	22
1994	6121	2099	4757	22
1995	5130	1758	3987	22
1996	5393	1849	4191	22
1997	6307	2207	4872	23
1998	5762	1993	4467	22
1999	6326	2116	4951	22
2000	6015	2647	4293	29
2001	5266	1820	4083	22
2002	5777	2340	4256	26
2003	4536	1340	3665	19
2004	4007	1268	3183	21
2005	3446	1114	2722	21
2006	3305	1019	2643	20
2007	3674	1207	2889	21
2008	3491	1120	2763	21
2009	3503	945	2889	18
2010	3812	977	3177	17
2011	3537	1154	2787	21
2012	3587	1033	2915	19
2013	4099	1174	3335	19

Table 6.2.1.1 - Plaice in VIId. Nominal landings (tonnes) as officially reported to ICES , 1976-2010.

Year	BEL	DNK	FRA	UK(E+W)	Others	Tot. Rep.	Un-Alloc.	Tot. Land. VIId	Q1 Remov.	Tot. as used by WG (6)	Tot. land. rep. in VIIe	Agreed TAC (5)
1976	147	1(1)	1439	376	-	1963	-	1963		1963	640	
1977	149	81(2)	1714	302	-	2246	-	2246		2246	702	
1978	161	156(2)	1810	349	-	2476	-	2476		2476	784	
1979	217	28(2)	2094	278	-	2617	-	2617		2617	977	
1980	435	112(2)	2905	304	-	3756	-1106	2650	590	2060	1215	
1981	815	-	3431	489	-	4735	34	4769	1063	3706	1746	
1982	738	-	3504	541	22	4805	60	4865	1084	3781	1938	
1983	1013	-	3119	548	-	4680	363	5043	1124	3919	1754	
1984	947	-	2844	640	-	4431	730	5161	1151	4011	1813	
1985	1148	-	3943	866	-	5957	65	6022	1342	4680	1751	
1986	1158	-	3288	828	488 (2)	5762	1072	6834	1523	5311	2161	
1987	1807	-	4768	1292	-	7867	499	8366	1864	6502	2388	8300
1988	2165	-	5688 (2)	1250	-	9103	1317	10420	2322	8098	2994	9960
1989	2019	+	3265 (1)	1383	-	6667	2091	8758	1951	6807	2808	11700
1990	2149	-	4170 (1)	1479	-	7798	1249	9047	2016	7031	3058	10700
1991	2265	-	3606 (1)	1566	-	7437	376	7813	1741	6072	2250	10700
1992	1560	1	3099	1553	19	6232	105	6337	1412	4925	1950	9600
1993	877	+(2)	2792	1075	27	4771	560	5331	1188	4143	1691	8500
1994	1418	+	3199	993	23	5633	488	6121	1364	4757	1471	9100
1995	1157	-	2598 (2)	796	18	4569	561	5130	1143	3987	1295	8000
1996	1112	-	2630 (2)	856	+	4598	795	5393	1202	4191	1321	7530
1997	1161	-	3077	1078	+	5316	991	6307	1435	4872	1654	7090
1998	854	-	3603 (2)	700	+	4830	932	5762	1295	4467	1430	5700
1999	1306	-	3388 (1)	743	+	5437	889	6326	1375	4951	1616	7400
2000	1298	-	3183	752	+	5233	781	6014	1721	4293	1678	6500
2001	1346	-	2962	655	+	4963	303	5266	1183	4083	1379	6000
2002	1204		3454	841		5499	278	5777	1521	4256	1608	6700
2003	998	-	2893	756	3	4650	-114	4536	871	3665	1478	6000
2004	954		2766	582	10	4312	-305	4007	824	3183	1402	6060
2005	832		2432	421	21	3706	-260	3446	724	2722	1370	5150
2006	1024		1935	549	17	3525	-220	3305	662	2643	1466	5080
2007	1355		2017	461	12	3845	-171	3674	785	2889	1184	5050
2008	1386		1740	471	12	3609	-118	3491	728	2763	1144	4646
2009	1002		1892	612	16	3522	-19	3503	614	2889	1043	4274
2010	1123		2190	517	62	3892	-80	3812	635	3177	2240	4665
2011	1067		2000	460	56	3549	-12	3537	750	2787	1192	4665
2012	995		1962	529	63	3486	101	3587	672	2915	1339	5092
2013	1299		2134	641	87	4161	-62	4099	764	3335		6400

1	Estimated by the working group from combined Division VIId+e
2	Includes Division VIIe
4	Data provided to the WG but not officially provided to ICES
5	TAC´s for Divisions VII d, e.

6	takes into account the removal of 65% of the Quarter 1 catches

Table 6.2.1.2. Plaice in VIId. Discard rates estimated from the data uploaded in Intercatch for 2011 to 2013.

	Discard rates			Cover1			Landings			Weighted average discard rate
year	TBB	OTB	GTR	TBB	OTB	GTR	TBB	OTB	GTR	ALL
2011	0.28	0.52	0.23	0.61	0.75	0.79	1710	1072	509	0.35
2012	0.37	0.56	0.23	0.66	0.74	0.95	1522	1076	626	0.41
2012	0.35	0.53	0.28	0.86	0.92	1	1600	1239	669	0.40

[1]: Proportion of the landings for which discard data are available

Table 6.2.2.1. Plaice in VIId. Landings in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

age							
year	1	2	3	4	5	6	7
1980	53	2336	1077	363	324	50	133
1981	16	2161	5041	1612	192	106	238
1982	265	1231	5125	2219	505	138	179
1983	92	2676	2374	3970	617	151	214
1984	350	1653	5423	1891	1242	356	312
1985	142	5047	4595	3282	274	409	300
1986	679	4315	5219	2462	965	375	247
1987	25	7508	5570	2334	833	287	512
1988	16	4427	13957	3293	741	362	561
1989	826	3214	5362	6353	1770	392	497
1990	1632	2320	6489	4021	2386	535	572
1991	1542	5177	4039	3040	1614	1123	429
1992	1665	5471	3301	1160	786	697	745
1993	740	6719	2832	846	359	313	581
1994	1242	3210	5169	2090	563	280	781
1995	2592	3834	2176	1968	611	152	591
1996	1119	4282	2675	1039	951	326	585
1997	550	3727	5293	2338	724	506	722
1998	464	3888	6436	2290	360	94	289
1999	741	1616	9064	4505	696	121	223
2000	1383	5966	2677	3856	752	150	142
2001	2682	3568	2888	1353	1253	203	145
2002	902	5019	3987	1368	1144	603	288
2003	646	4318	4389	1236	273	264	329
2004	967	4349	3923	620	244	105	240
2005	324	2908	2963	1430	302	129	208
2006	509	2584	2421	1171	603	146	202
2007	790	2740	2132	1146	549	313	155
2008	360	3399	1835	930	439	186	214
2009	472	2760	3250	1067	427	284	285
2010	595	3855	2378	1214	273	228	278
2011	66	3535	2819	966	433	51	96
2012	18	999	3344	1837	550	207	189
2013	10	728	3338	3039	1069	229	139

Table 6.2.2.2. Plaice in VIId. Landings in numbers (thousands) by quarter for 2013, not taking into account the first quarter removal.

		1	2	3	4	5	6	7+
Quarter	1	0	56	768	1400	436	93	55
	2	1	12	296	633	329	63	31
	3	5	321	921	393	123	25	17
	4	0	191	888	762	252	69	41

Table 6.2.3.1. Plaice in VIId. Weights in the landings

	1	2	3	4	5	6	7
1980	0.309	0.312	0.499	0.627	0.787	1.139	1.376
1981	0.239	0.299	0.373	0.464	0.712	0.87	0.982
1982	0.245	0.271	0.353	0.431	0.64	0.795	1.270
1983	0.266	0.296	0.349	0.42	0.542	0.822	1.158
1984	0.233	0.295	0.336	0.402	0.508	0.689	1.026
1985	0.254	0.278	0.301	0.427	0.502	0.57	0.977
1986	0.226	0.306	0.331	0.406	0.546	0.486	1.131
1987	0.251	0.282	0.36	0.477	0.577	0.783	1.165
1988	0.292	0.268	0.321	0.432	0.56	0.657	1.056
1989	0.201	0.268	0.321	0.37	0.473	0.648	1.117
1990	0.201	0.256	0.326	0.378	0.483	0.61	1.053
1991	0.225	0.277	0.311	0.39	0.454	0.556	1.090
1992	0.182	0.277	0.352	0.429	0.509	0.585	0.896
1993	0.22	0.272	0.336	0.432	0.507	0.591	0.913
1994	0.243	0.27	0.288	0.356	0.466	0.576	0.968
1995	0.218	0.271	0.313	0.39	0.485	0.688	0.967
1996	0.221	0.3	0.29	0.396	0.475	0.643	1.017
1997	0.199	0.252	0.298	0.332	0.442	0.577	1.036
1998	0.159	0.244	0.267	0.381	0.502	0.762	1.046
1999	0.197	0.245	0.235	0.306	0.461	0.751	1.007
2000	0.207	0.245	0.261	0.283	0.375	0.576	0.889
2001	0.215	0.252	0.303	0.37	0.447	0.642	1.063
2002	0.254	0.256	0.309	0.376	0.438	0.562	0.937
2003	0.254	0.268	0.271	0.363	0.556	0.643	0.816
2004	0.217	0.243	0.295	0.421	0.493	0.61	1.003
2005	0.21	0.263	0.293	0.36	0.527	0.536	0.841
2006	0.209	0.263	0.318	0.374	0.463	0.611	0.843
2007	0.246	0.293	0.322	0.382	0.473	0.541	0.914
2008	0.244	0.286	0.334	0.404	0.509	0.596	1.055
2009	0.119	0.248	0.301	0.398	0.498	0.626	1.071
2010	0.329	0.298	0.326	0.411	0.452	0.578	0.910
2011	0.249	0.278	0.329	0.435	0.489	0.756	1.197
2012	0.256	0.294	0.331	0.428	0.518	0.712	1.150
2013	0.137	0.244	0.296	0.363	0.457	0.671	1.066

Table 6.2.3.2. Plaice in VIId. Weights in the stock.

year	1	2	3	4	5	6	7
1980	0.171	0.332	0.482	0.622	0.751	0.870	1.197
1981	0.110	0.216	0.317	0.414	0.506	0.594	0.924
1982	0.105	0.208	0.308	0.406	0.502	0.596	0.869
1983	0.097	0.192	0.286	0.379	0.470	0.560	0.854
1984	0.082	0.164	0.248	0.333	0.420	0.507	0.738
1985	0.084	0.171	0.259	0.348	0.440	0.533	0.778
1986	0.101	0.205	0.311	0.420	0.532	0.646	0.850
1987	0.122	0.242	0.361	0.479	0.596	0.712	0.929
1988	0.084	0.168	0.254	0.340	0.427	0.514	0.715
1989	0.079	0.162	0.250	0.342	0.439	0.541	0.855
1990	0.085	0.230	0.322	0.346	0.465	0.549	1.118
1991	0.143	0.219	0.275	0.335	0.375	0.472	0.958
1992	0.088	0.241	0.336	0.421	0.477	0.521	0.725
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.727
1994	0.165	0.198	0.276	0.331	0.383	0.493	0.866
1995	0.124	0.257	0.286	0.354	0.442	0.707	0.855
1996	0.178	0.229	0.263	0.347	0.354	0.474	0.934
1997	0.059	0.202	0.256	0.266	0.417	0.530	0.902
1998	0.072	0.203	0.273	0.361	0.530	0.670	0.873
1999	0.072	0.172	0.213	0.351	0.429	0.644	0.904
2000	0.068	0.184	0.204	0.246	0.355	0.554	0.928
2001	0.093	0.206	0.274	0.338	0.404	0.624	1.104
2002	0.102	0.206	0.281	0.379	0.467	0.558	0.809
2003	0.103	0.191	0.249	0.330	0.496	0.492	0.627
2004	0.172	0.183	0.268	0.408	0.471	0.521	0.867
2005	0.096	0.201	0.269	0.308	0.470	0.492	0.739
2006	0.106	0.209	0.275	0.336	0.397	0.525	0.804
2007	0.125	0.224	0.265	0.323	0.431	0.463	0.828
2008	0.155	0.253	0.285	0.343	0.410	0.447	0.730
2009	0.000	0.224	0.279	0.372	0.460	0.494	0.935
2010	0.000	0.250	0.270	0.347	0.378	0.539	0.760
2011	0.215	0.258	0.309	0.412	0.391	0.638	1.157
2012	0.194	0.237	0.281	0.375	0.480	0.650	1.057
2013	0.144	0.091	0.179	0.274	0.395	0.544	0.978

Table 6.2.5.1. Plaice in VIId. Tuning fleets

UK	BTS		
1 988	2012		
1	1	0.5	0.75
4	6		
1	7	4.6	1.5
1	19.9	3.3	1.5
1	6.7	7.5	1.8
1	5.3	5.4	3.2
1	4.2	5.6	4.9
1	1.7	1.9	1.6
1	5.6	1.9	0.8
1	3.7	1.5	0.6
1	0.7	1.3	0.9
1	0.6	0.3	0.3
1	3.1	0.3	0.2
1	2.9	1	0.2
1	13.8	3.5	0.9
1	7.1	10.9	1.9
1	3.5	1.8	3.5
1	2.9	1.6	0.8
1	3.4	0.9	0.2
1	10.3	2.9	1.2
1	3.3	2.6	0.8
1	3.9	1.7	2
1	3	2.3	1.1
1	5.7	3.2	2.2
1	8.9	3	1.9
1	9.3	6.7	2.8
1	12.7	3.5	1.6
1	45.5	10.6	3.5

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

FR	GFS		
1988	2012		
1	1	0.75	1
2	3		
1	17.6	9.9	
1	7.4	2.7	
1	1.2	2.7	
1	2.1	0.8	
1	3.6	1.9	
1	8.8	4.2	
1	2.2	0.8	
1	3	1.1	
1	2.6	0.3	
1	8.3	4.3	
1	14	3.1	
1	4.2	7.7	
1	13.7	3.4	
1	3.5	1.2	
1	6.5	3.4	
1	9.4	1.3	
1	9.3	4.5	
1	12.4	6.8	
1	9.9	3.8	
1	8.6	3.6	
1	19.2	2.5	
1	7.4	1.8	
1	16.6	2	
1	24	5	
1	30	22.6	
1	13.9	23.5	

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

BE	CBT				
1981	2012				
1	1	0	1		
2	6				
24,4	217	650	285	35	12
29,8	112	615	331	96	31
26,4	362	377	666	85	29
35,4	70	906	343	241	75
33,4	423	649	536	48	110
30,8	531	659	321	139	81
49,3	1475	946	428	177	52
48,9	586	2460	626	122	61
43,8	56	1000	1420	501	119
38,5	282	1551	935	518	103
32,8	452	975	553	561	389
30,9	675	595	194	143	157
28,2	371	395	132	102	68
32,8	322	726	686	138	74
31,7	30	341	445	204	46
32,6	197	398	261	259	77
39,7	0	166	448	293	165
23,6	125	520	297	63	22
27,6	31	974	657	191	38
37	46	213	255	121	24
40,2	321	1015	522	363	67
41,1	313	785	308	297	77
40	309	689	280	74	99
39,13	241	767	151	80	27
44	227	426	341	123	41
56,9	361	509	365	227	44
65,1	627	526	349	254	209
54,5	565	558	406	158	72
49,9	630	630	146	121	68
42	674	604	290	113	80
41	729	675	187	74	11
34.1	76	646	315	119	50
35.8	53	541	987	291	65

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

IN	YFS		
1987	2006		
1	1	0.5	0.75
1	1		
1	1.44		
1	1.3		
1	0.6		
1	0.7		
1	0.6		
1	1.8		
1	0.8		
1	0.8		
1	1.7		
1	0.7		
1	0.8		
1	0.8		
1	0.8		
1	0.48		
1	0.83		
1	0.92		
1	0.2		
1	0.78		
1	0.17		
1	0.3		

Table 6.3.5.1. Plaice in VIId. XSA diagnostics

FLR XSA Diagnostics 2014-05-06 16:35:55

CPUE data from indices

Catch data for 34 years. 1980 to 2013. Ages 1 to 7.

	fleet	first age	last age	first year	last year	alpha	beta
1	BE CBT	2	5	1981	2013	0	1
2	UK BTS	4	6	1988	2013	0.5	0.75
3	FR GFS	2	3	1988	2013	0.75	1
4	IN YFS	1	1	1987	2006	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 5

Terminal population estimation :

Survivor estimates shrunk towards the mean F

of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1

Minimum standard error for population

estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

	Year								
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

	year									
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.095	0.037	0.059	0.068	0.036	0.032	0.029	0.005	0.003	0.021
2	0.530	0.401	0.405	0.448	0.406	0.368	0.344	0.215	0.088	0.130
3	0.750	0.748	0.605	0.607	0.542	0.754	0.550	0.403	0.289	0.415
4	0.544	0.598	0.666	0.571	0.515	0.622	0.624	0.399	0.442	0.410
5	0.401	0.493	0.481	0.674	0.395	0.418	0.279	0.418	0.370	0.443
6	0.875	0.339	0.417	0.436	0.445	0.425	0.366	0.069	0.321	0.230

7 0.875 0.339 0.417 0.436 0.445 0.425 0.366 0.069 0.321 0.230

XSA population number (NA)

age

year 1 2 3 4 5 6 7

2004 11241 11110 7814 1554 776 190 430

2005 9359 9251 5915 3339 816 470 759

2006 9346 8160 5605 2534 1661 451 620

2007 12664 7972 4925 2768 1178 929 458

2008 10801 10707 4607 2429 1415 544 625

2009 15889 9430 6455 2424 1314 863 861

2010 21838 13928 5908 2749 1178 783 952

2011 13854 19194 8936 3083 1332 806 1519

2012 6937 12473 14005 5404 1871 793 717

2013 514 6260 10336 9491 3142 1170 708

Estimated population abundance at 1st Jan 2014

age

year 1 2 3 4 5 6 7

2014 0 456 4971 6177 5698 1826 841

Fleet: BE CBT

Log catchability residuals.

year

age 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991

2 -0.046 -0.132 0.462 -1.284 0.407 0.513 0.349 0.034 -2.001 0.331 0.954 3 0.397 -0.276 0.157 0.101 -0.009 0.083 -0.376 -0.073 -0.379 0.522 0.918

4 0.530 0.149 0.408 0.308 0.223 -0.122 -0.263 -0.389 0.020 -0.004 0.267 5 -0.074 0.189 -0.211 0.057 -0.758 -0.008 -0.350 -0.707 0.364 -0.021 0.321

year

age 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002

2 1.236 0.429 0.882 -1.723 -0.260 0.500 -0.909 -1.475 -1.438 0.373 0.285

3 0.652 -0.060 0.186 0.155 -0.052 -1.459 -0.245 0.038 -0.864 0.966 0.520

4 0.015 -0.204 0.805 0.274 0.315 0.626 0.327 0.510 -1.058 0.265 0.549

5 -0.157 0.161 0.484 0.482 0.577 1.402 0.623 0.771 -0.390 -0.036 0.546

year

age 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

2 0.165 0.158 0.107 0.439 0.900 0.660 0.966 0.805 0.526 -1.177 -0.539

3 0.569 0.262 -0.167 -0.254 -0.226 0.049 0.014 0.144 -0.201 -0.563 -0.530

4 0.251 -0.179 -0.222 -0.106 -0.416 0.019 -0.868 -0.132 -0.762 -0.600 -0.538

5 0.325 -0.231 0.081 -0.282 0.126 -0.479 -0.575 -0.426 -0.883 -0.586 -0.338

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

2 3 4 5

Mean_Logq -7.0809 -5.3046 -4.7827 -4.8095

S.E_Logq 0.5890 0.5890 0.5890 0.5890

Fleet: UK BTS

Log catchability residuals.

year

age 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998

4 -0.310 0.236 -0.615 -0.157 0.305 -0.554 0.209 -0.369 -1.434 -1.434 -0.326

5 0.448 -0.273 -0.041 -0.301 0.577 0.042 0.290 -0.426 -0.637 -1.023 -0.927 6 0.102 0.093 0.038 -0.001 0.177 -0.054 -0.042 -0.044 -0.112 -0.454 -0.055

year

age 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

4 -0.792 0.337 0.316 0.591 0.095 0.348 0.725 -0.095 -0.076 -0.242 0.468

5 -0.560 0.226 0.686 -0.194 0.768 -0.540 0.637 -0.190 -0.152 -0.206 0.213

6 -0.062 0.060 0.164 0.185 0.037 -0.341 0.210 -0.105 0.101 0.045 0.263

year

age 2010 2011 2012 2013

4 0.790 0.579 0.356 1.049

5 0.171 0.938 -0.081 0.554

6 0.177 0.350 -0.036 0.301

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	4	5	6
Mean_Logq	-6.0713	-5.9072	-5.9072
S.E_Logq	0.4743	0.4743	0.4743

Fleet: FR GFS

Log catchability residuals.

year										
age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	0.170	-0.501	-1.711	-1.015	-0.687	-0.114	-0.754	-0.734	-1.306	-0.496
3	-0.004	-0.941	-0.469	-0.894	0.122	0.345	-1.412	-0.460	-2.126	0.312

year												
age	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
2	.205	-0.412	0.924	-0.628	0.010	0.187	0.441	0.799	0.703	0.623	1.094	0.234
3	-0.548	0.222	0.224	-0.331	0.609	-0.063	0.487	1.176	0.524	0.600	0.246	0.236

year				
age	2010	2011	2012	2013
2	0.631	0.567	1.110	1.067
3	-0.219	0.155	1.115	1.568

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3
Mean_Logq	-6.9759	-7.2043
S.E_Logq	0.7825	0.7825

Fleet: IN YFS

Log catchability residuals.

year
age 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998
1 0.199 0.315 0.066 0.039 -0.254 0.574 0.509 0.249 0.652 -0.441 -0.495 0.472

year
age 1999 2000 2001 2002 2003 2004 2005 2006
1 0.167 -0.275 0.136 0.216 -1.136 0.392 -0.984 -0.401

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

1
Mean_Logq -9.8465
S.E_Logq 0.4968

Terminal year survivor and F summaries:

Age 1 Year class = 2012

source
survivors N scaledWts
456 1 1

Age 2 Year class = 2011

source
survivors N scaledWts
BE CBT 2900 1 0.323
FR GFS 14456 1 0.393
fshk 2102 1 0.285

Age 3 Year class = 2010

source
survivors N scaledWts
BE CBT 3149 2 0.543
FR GFS 23706 2 0.302
fshk 4779 1 0.155

Age 4 Year class = 2009

source
survivors N scaledWts
BE CBT 3625 3 0.590
UK BTS 16267 1 0.168
FR GFS 13541 2 0.140
fshk 4213 1 0.102

Age 5 Year class = 2008

source
survivors N scaledWts
BE CBT 1284 4 0.540
UK BTS 2988 2 0.302
FR GFS 2610 2 0.066
fshk 2219 1 0.092

Age 6 Year class = 2007

source
survivors N scaledWts
BE CBT 530 4 0.274
UK BTS 1090 3 0.641
FR GFS 816 2 0.030
fshk 412 1 0.055

Table 6.3.5.2. Plaice in VIId. Fishing mortality (F) at age

Plaice in VIId : harvest 2014-05-06 16:35:55 units= f

year	1	2	3	4	5	6	7
1980	0.003	0.210	0.315	0.533	0.908	0.588	0.588
1981	0.002	0.148	0.813	0.951	0.529	0.768	0.768
1982	0.016	0.183	0.543	0.942	0.797	0.805	0.805
1983	0.007	0.198	0.560	0.961	0.655	0.514	0.514
1984	0.020	0.148	0.676	1.081	0.817	0.893	0.893
1985	0.007	0.384	0.676	1.038	0.373	0.617	0.617
1986	0.017	0.267	0.765	0.848	0.898	1.158	1.158
1987	0.001	0.228	0.574	0.839	0.691	0.650	0.650
1988	0.001	0.244	0.744	0.707	0.618	0.650	0.650
1989	0.076	0.218	0.463	0.812	0.942	0.694	0.694
1990	0.125	0.282	0.784	0.669	0.733	0.740	0.740
1991	0.103	0.626	0.985	0.957	0.549	0.827	0.827
1992	0.085	0.553	0.951	0.760	0.613	0.429	0.429
1993	0.080	0.503	0.549	0.597	0.493	0.465	0.465
1994	0.103	0.506	0.811	0.907	0.919	0.796	0.796
1995	0.150	0.461	0.680	0.747	0.648	0.596	0.596
1996	0.053	0.350	0.600	0.723	0.900	0.771	0.771
1997	0.022	0.226	0.851	1.581	1.692	1.952	1.952
1998	0.048	0.189	0.660	1.027	1.067	1.015	1.015
1999	0.057	0.211	0.770	1.283	0.921	1.234	1.234
2000	0.113	0.735	0.564	0.789	0.656	0.445	0.445
2001	0.189	0.416	0.868	0.550	0.565	0.323	0.323
2002	0.063	0.562	1.014	1.286	1.157	0.517	0.517
2003	0.054	0.422	1.305	0.922	0.863	0.810	0.810
2004	0.095	0.530	0.750	0.544	0.401	0.875	0.875
2005	0.037	0.401	0.748	0.598	0.493	0.339	0.339
2006	0.059	0.405	0.605	0.666	0.481	0.417	0.417
2007	0.068	0.448	0.607	0.571	0.674	0.436	0.436
2008	0.036	0.406	0.542	0.515	0.395	0.445	0.445
2009	0.032	0.368	0.754	0.622	0.418	0.425	0.425
2010	0.029	0.344	0.550	0.624	0.279	0.366	0.366
2011	0.005	0.215	0.403	0.399	0.418	0.069	0.069

2012 0.003 0.088 0.289 0.442 0.370 0.321 0.321

2013 0.021 0.130 0.415 0.410 0.443 0.230 0.230

Table 6.3.5.3. Plaice in VIId. Stock number at age

Plaice in VIId : stock.n

2014-05-06 16:35:55 units= NA

year 1 2 3 4 5 6 7

1980 18270 12984 4184 924 571 119 313

1981 8557 16481 9526 2761 491 209 463

1982 17563 7727 12857 3824 966 262 337

1983 14028 15640 5821 6758 1349 394 558

1984 18765 12605 11606 3009 2338 634 552

1985 21537 16647 9833 5343 924 935 681

1986 43574 19352 10262 4526 1712 575 374

1987 23753 38782 13407 4321 1754 631 1120

1988 19087 21469 27950 6832 1690 795 1226

1989 11843 17256 15215 12014 3049 824 1038

1990 14640 9930 12556 8667 4827 1076 1143

1991 16587 11695 6778 5188 4018 2098 796

1992 21501 13542 5658 2291 1803 2100 2235

1993 10167 17871 7049 1979 969 884 1636

1994 13373 8496 9778 3685 985 536 1486

1995 19559 10919 4634 3931 1346 356 1377

1996 22614 15232 6233 2123 1685 637 1136

1997 26761 19398 9709 3095 933 620 870

1998 10342 23692 14007 3751 576 155 473

1999 14101 8916 17738 6552 1215 179 327

2000 13631 12055 6530 7428 1643 438 413

2001 16385 11018 5233 3362 3053 772 552

2002 15509 12275 6576 1987 1755 1571 746

2003 12957 13175 6332 2158 497 499 618

2004 11241 11110 7814 1554 776 190 430

2005 9359 9251 5915 3339 816 470 759

2006 9346 8160 5605 2534 1661 451 620

2007 12664 7972 4925 2768 1178 929 458

2008 10801 10707 4607 2429 1415 544 625

2009 15889 9430 6455 2424 1314 863 861

2010 21838 13928 5908 2749 1178 783 952

2011 13854 19194 8936 3083 1332 806 1519

2012 6937 12473 14005 5404 1871 793 717

2013 514 6260 10336 9491 3142 1170 708

Table 6.3.5.4. Plaice in VIId. Summary table

	recruitment	ssb	catch	landings	tsb	fbar3-6	Y/ssb
1980	18270	3175	2060	2060	10934	0.586	0.65
1981	8557	4033	3706	3706	9465	0.765	0.92
1982	17563	4764	3781	3781	9898	0.772	0.79
1983	14028	5123	3919	3919	9921	0.673	0.77
1984	18765	4508	4010	4010	9197	0.867	0.89
1985	21537	4996	4680	4680	10496	0.676	0.94
1986	43574	5712	5311	5311	15061	0.917	0.93
1987	23753	8495	6502	6502	21728	0.689	0.77
1988	19087	8540	8098	8098	16639	0.680	0.95
1989	11843	9052	6807	6807	14316	0.728	0.75
1990	14640	9478	7031	7031	14684	0.732	0.74
1991	16587	6300	6072	6072	11795	0.829	0.96
1992	21501	5997	4925	4925	11595	0.688	0.82
1993	10167	4661	4143	4143	10689	0.526	0.89
1994	13373	4781	4757	4757	9735	0.858	0.99
1995	19559	4482	3987	3987	9972	0.668	0.89
1996	22614	4059	4191	4191	11849	0.749	1.03
1997	26761	4198	4872	4872	10308	1.519	1.16
1998	10342	4870	4467	4467	11554	0.942	0.92
1999	14101	5373	4951	4951	9560	1.052	0.92
2000	13631	4002	4294	4294	7514	0.614	1.07
2001	16385	4516	4083	4083	8688	0.577	0.90
2002	15509	4381	4256	4256	9011	0.993	0.97
2003	12957	2776	3665	3665	7019	0.975	1.32
2004	11241	2861	3183	3183	7532	0.643	1.11
2005	9359	3285	2722	2722	6553	0.545	0.83
2006	9346	3285	2643	2643	6484	0.542	0.80
2007	12664	3136	2889	2889	6886	0.572	0.92
2008	10801	3181	2763	2763	7808	0.474	0.87
2009	15889	3973	2889	2889	6651	0.555	0.73
2010	21838	3873	3204	3204	7621	0.455	0.83
2011	13854	6219	2787	2787	14755	0.322	0.45
2012	6937	6648	2916	2916	12437	0.356	0.44

2013 514 6055 3336 3336 7587 0.374 0.55

Table 6.5.1. Plaice in VIId. Outputs from the eqsim fit (age error simulation)

	Flim	Flim10	Flim50	medianMSY	meanMSY	Fcrash05	Fcrash50
catF	0.45	0.48	0.56	0.19	0.19	0.62	0.65
lanF	NA	NA	NA	0.19	0.19	NA	NA
Catch	4877.90	4782.57	3909.68	5523.28	5523.28	1546.79	102.69
Landings	NA	NA	NA	5523.28	5523.28	NA	NA
catB	6525.37	5880.802	3926.52	21398.04	21398.04	1387.59	83.97
lanB	NA	NA	NA	21398.04	21398.04	NA	NA

Table 6.6.1. Plaice in VIId. Input to catch forecast

Age	Stock	Mat	M	F
1	13205	0	0,1	0,02
2	11120	0,15	0,1	0,13
3	10336	0,53	0,1	0,41
4	9491	0,96	0,1	0,41
5	3142	1	0,1	0,44
6	1170	1	0,1	0,23
7	708	1	0,1	0,23

Table 6.6.2.1 Plaice in VIId. Management options for 2015 and their effects on the stock under the 2 different assumptions about the resident stock: the average proportion of VIIe landing over VIIde total landing and the proportion of catch in VIId coming from VIIe and IV are calculated (1) with the whole time series, (2) with only the last 11 years.

(1) F (2014) = 0.3; Landings (2014) = 4135 t, SSB(2015)=9945 t

Rationale	TAC (2015)	F Total (2015)	SSB (2016)	%SSB change (2016)	%Landings change (2015 vs 2013)
Proxy FMSY = F0.1	2309	0.15	12996	+31	-44
FMSY	2875	0.19	12583	+27	-30
Landings 2013 -20%	3279	0.22	12288	+24	-20
Fmax	3947	0.27	11801	+19	-4

(2) F (2014) = 0.31; Landings (2014) = 4072 t, SSB(2015)=9835 t

Rationale	TAC (2015)	F Total (2015)	SSB (2016)	%SSB change (2016)	%Landings change (2015 vs 2013)
Proxy FMSY = F0.1	2173	0.15	12869	+31	-47
FMSY	2705	0.19	12461	+27	-34
Landings 2013 -20%	3279	0.23	12020	+22	-20
Fmax	3714	0.27	11687	+19	-9

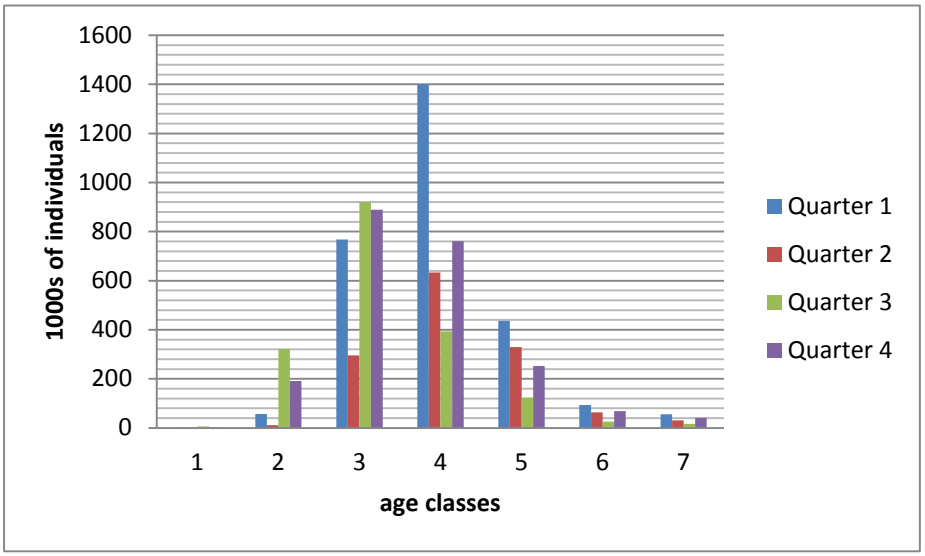


Figure 6.1.2.1. Plaice in VIId. 2012 Age distribution in the landings per quarter of the total landings from VIId (right panel).

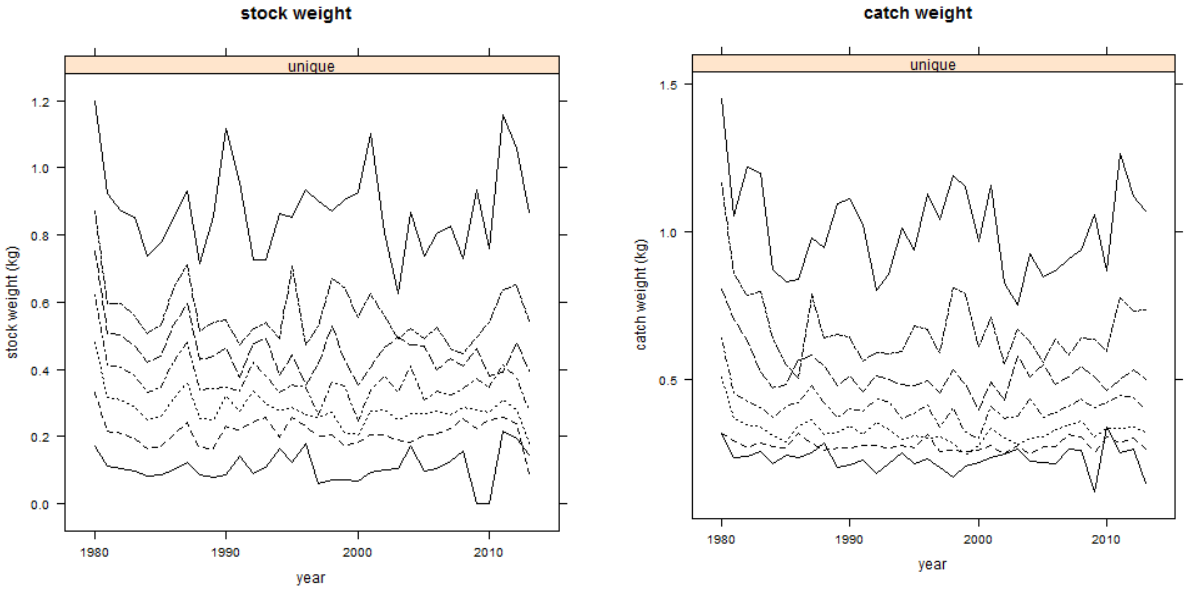


Figure 6.2.3.1. Plaice in VIId. Stock(left panel) and Catch weight (right panel)

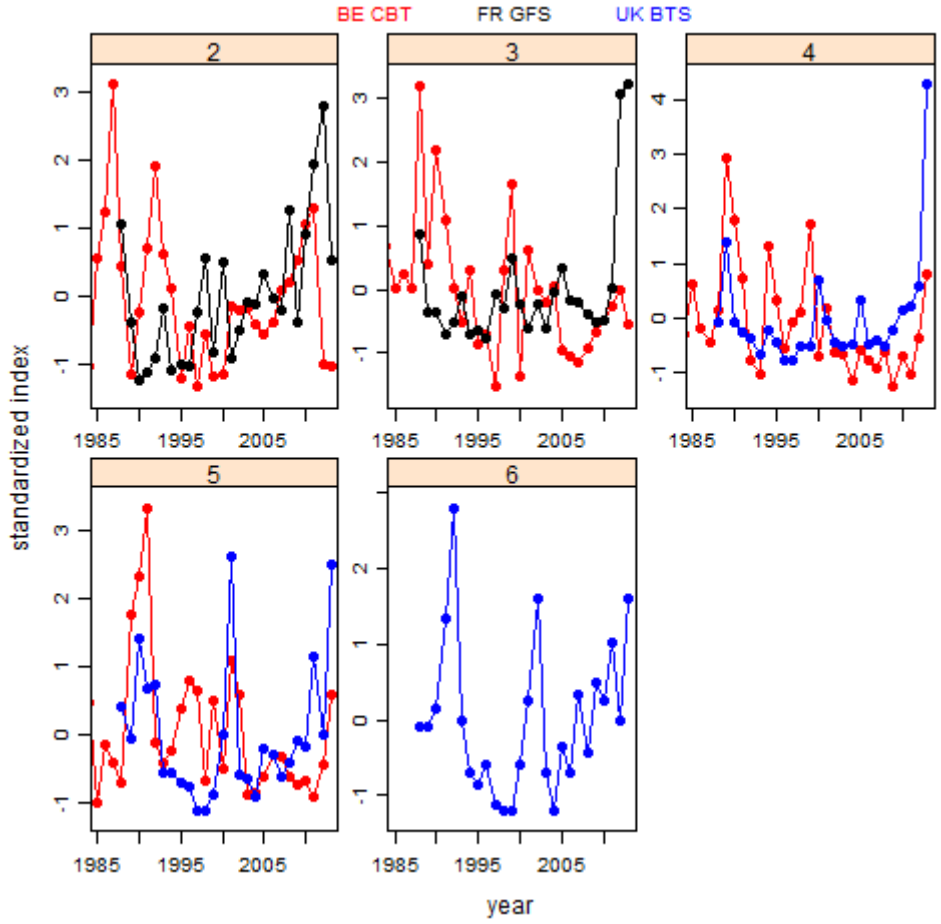


Figure 6.2.5.1. Plaice in VIId. Consistency between surveys: Mean standardised indices by surveys for each age.

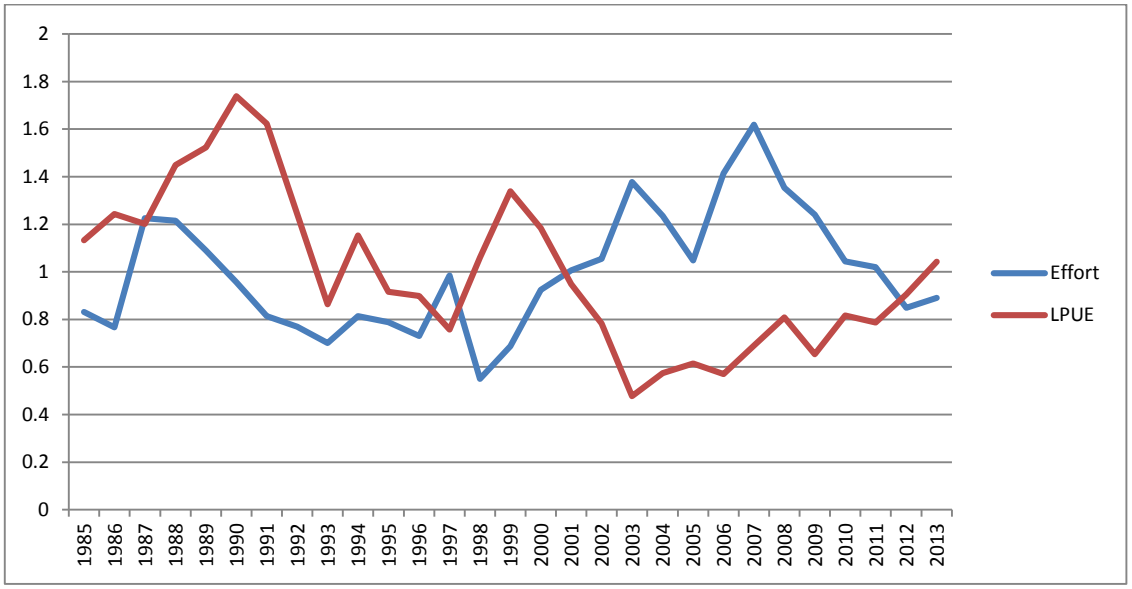


Figure 6.2.5.1 - Plaice in VIId. LPUE and effort of the tuning fleet, i.e; the commercial Belgian Beam Trawl fleet.

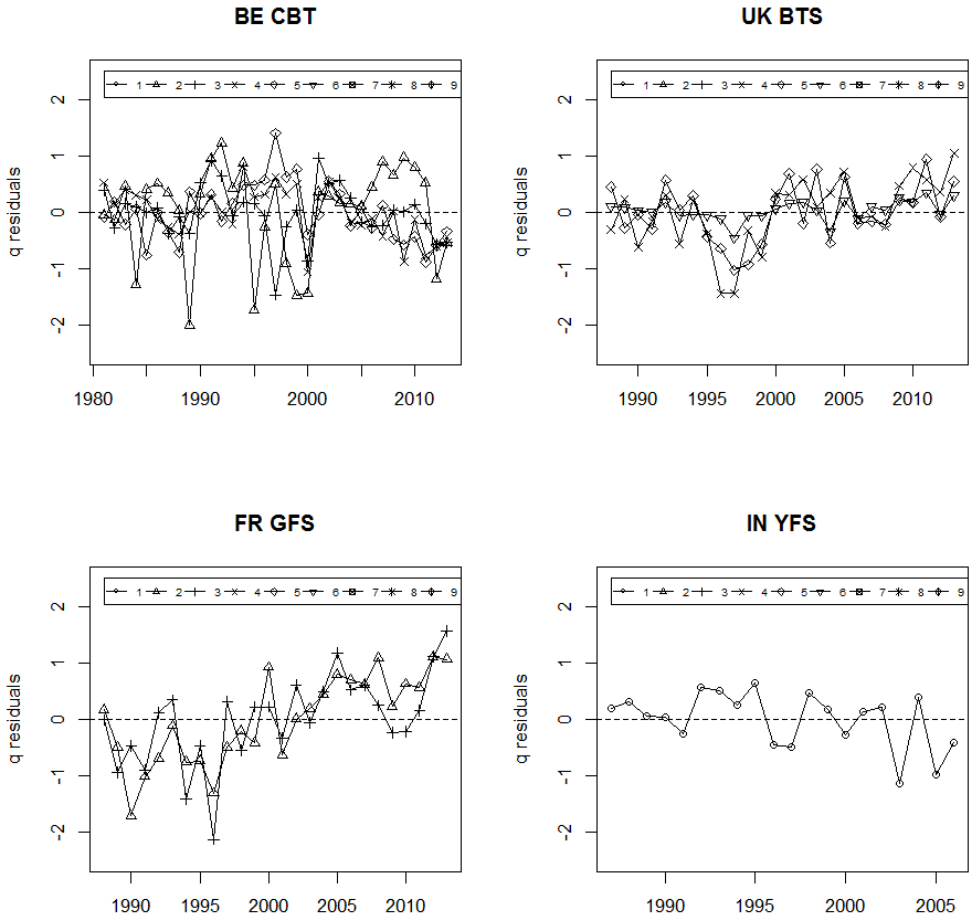


Figure 6.3.2.2. Plaice in VIId. Log q residuals for the single fleet runs (XSA settings and F shrinkage = 1.0)

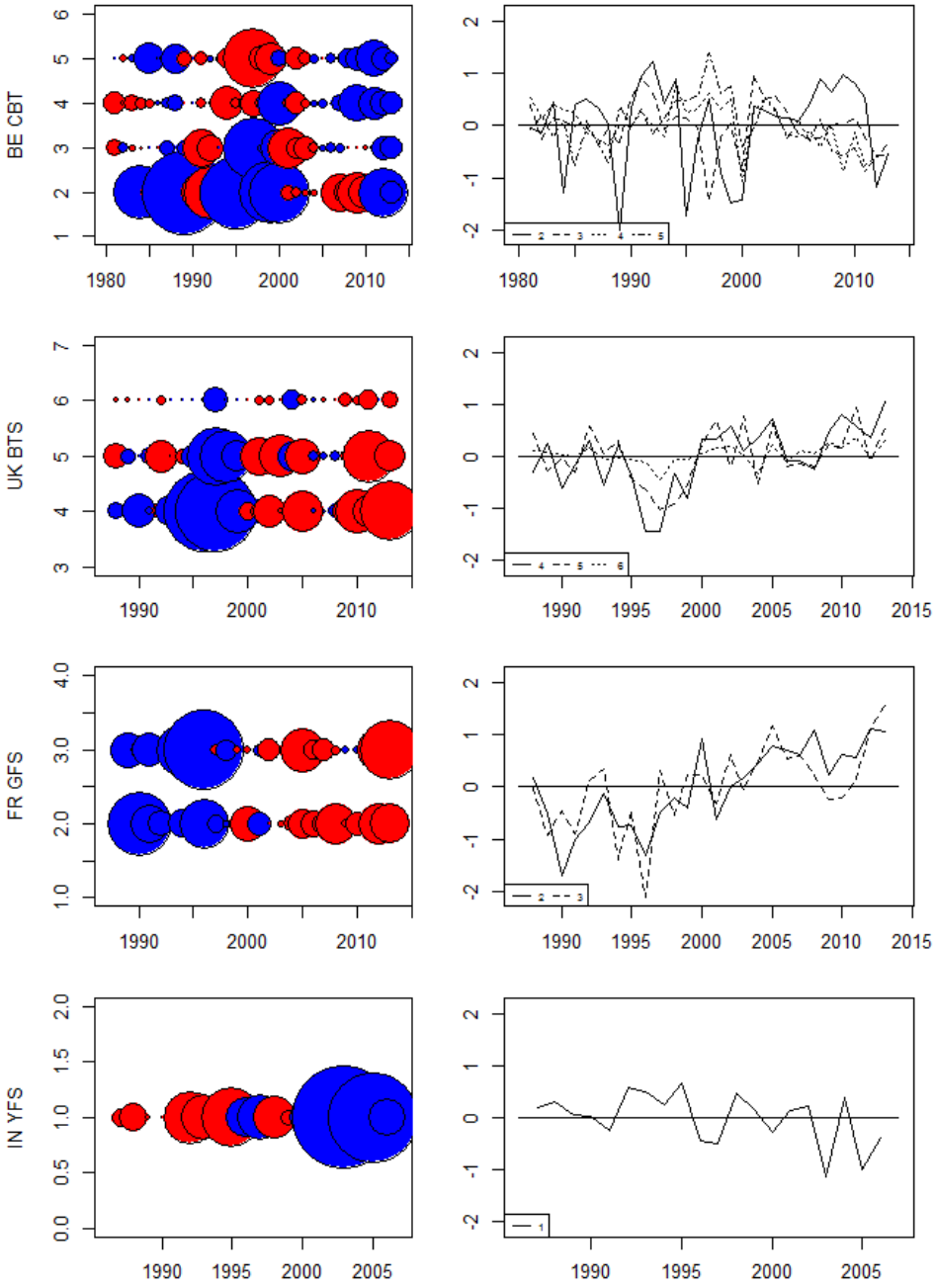


Figure 6.3.2.3. Plaice in VIId. Log q residuals. All fleets combined. Settings as proposed section 6.3.5.

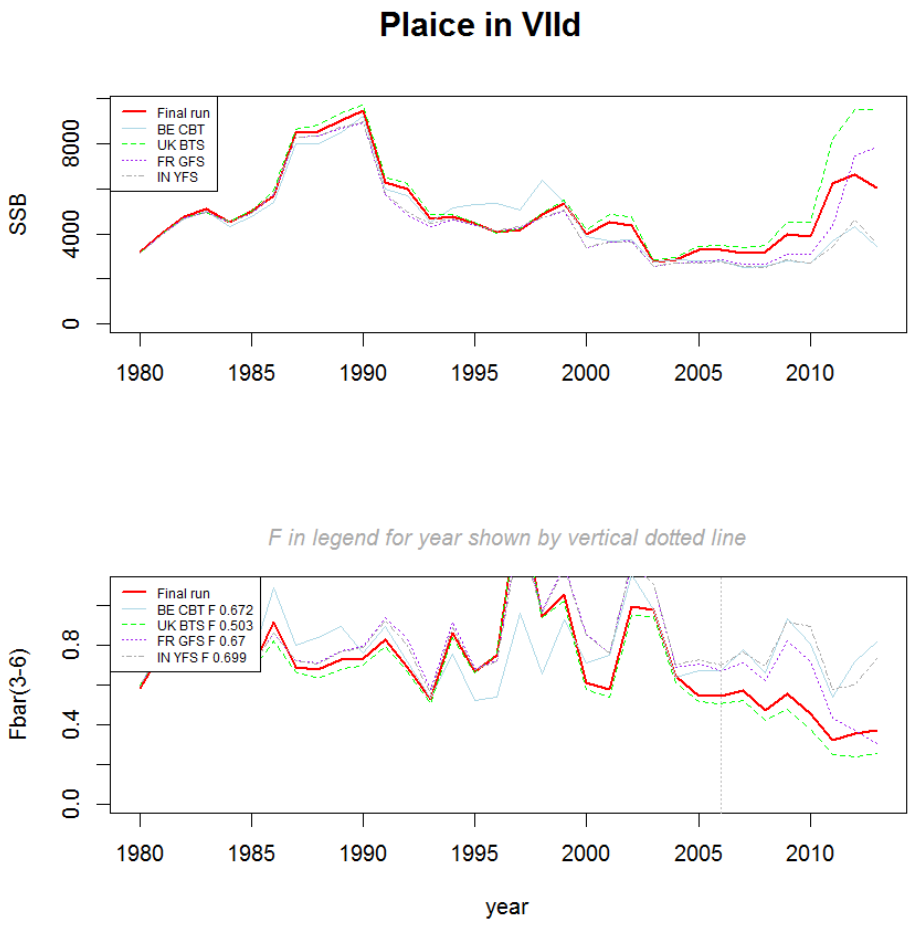


Figure 6.3.4.1. Plaice in VIId. Individual fleet historical performance.

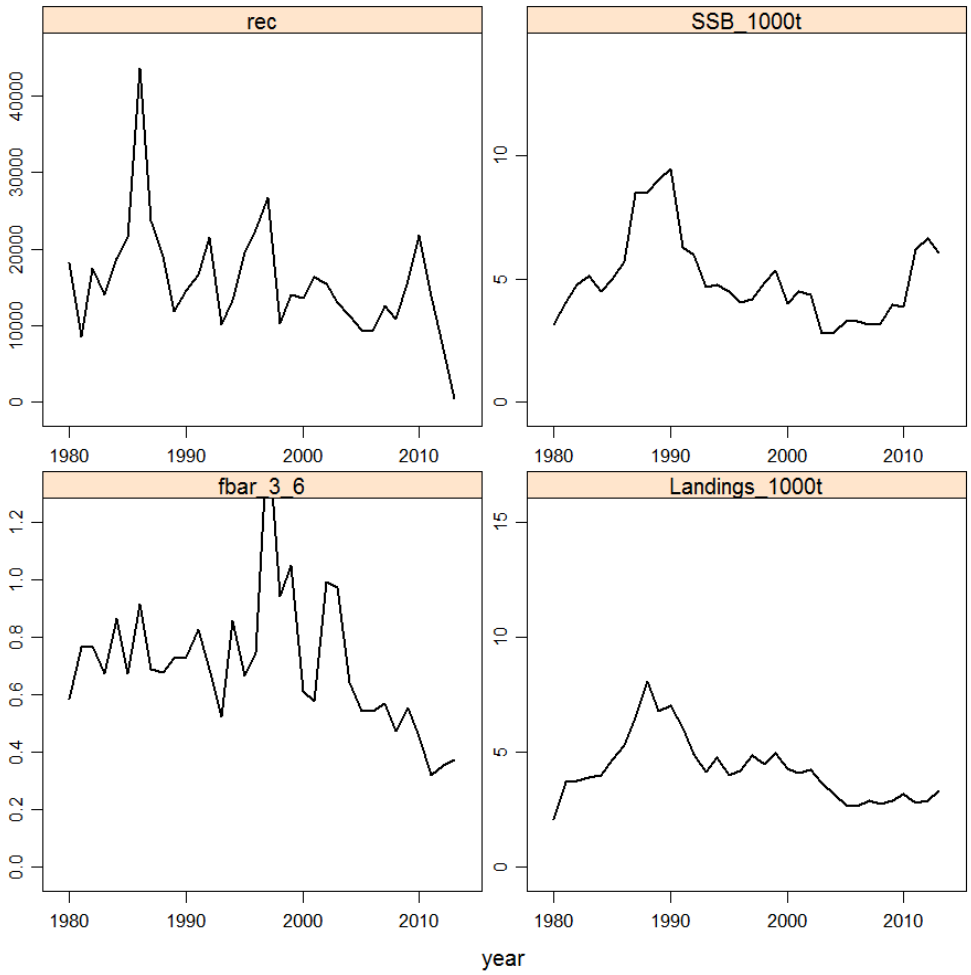


Figure 6.3.5.1. Plaice in VIId. Summary of assessment results

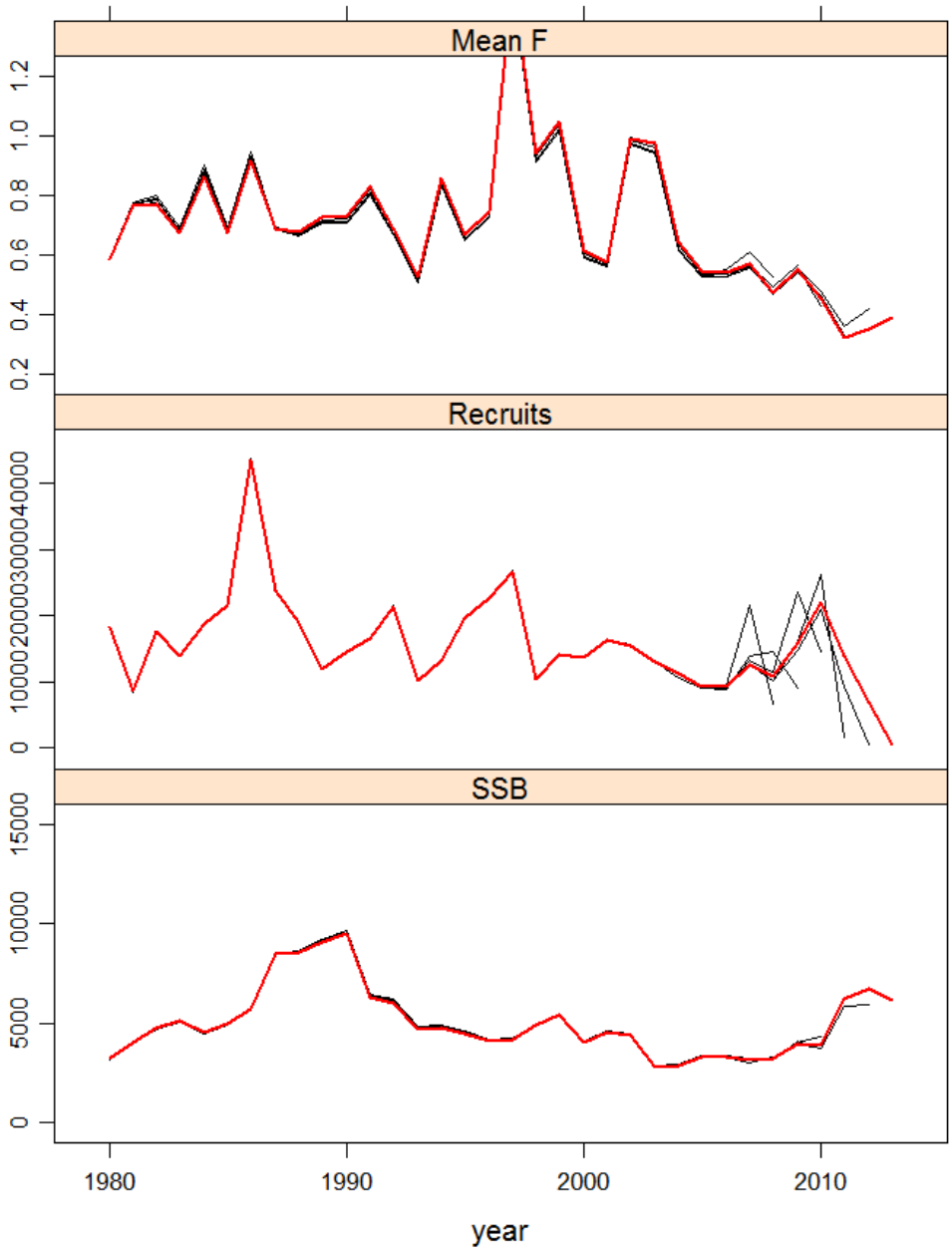


Figure 6.3.5.2. Plaice in VIId. Retrospective patterns for the final run

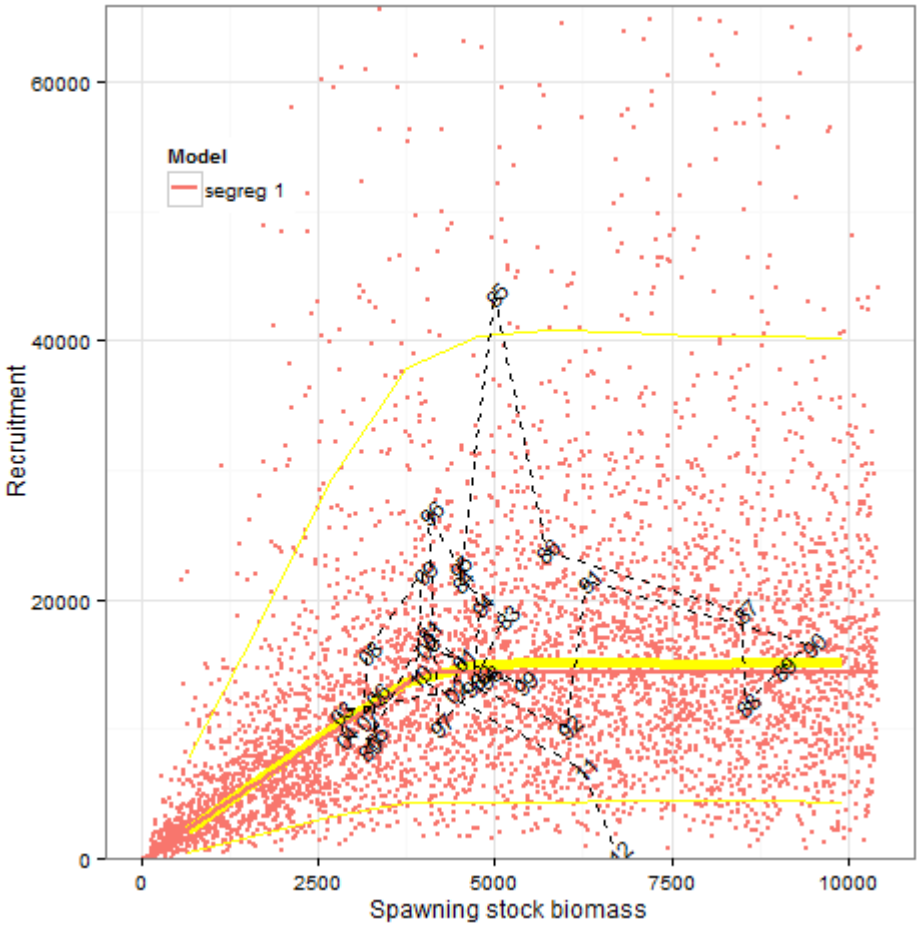


Figure 6.5.1. Plaice in VIId. Stock-recruitment models

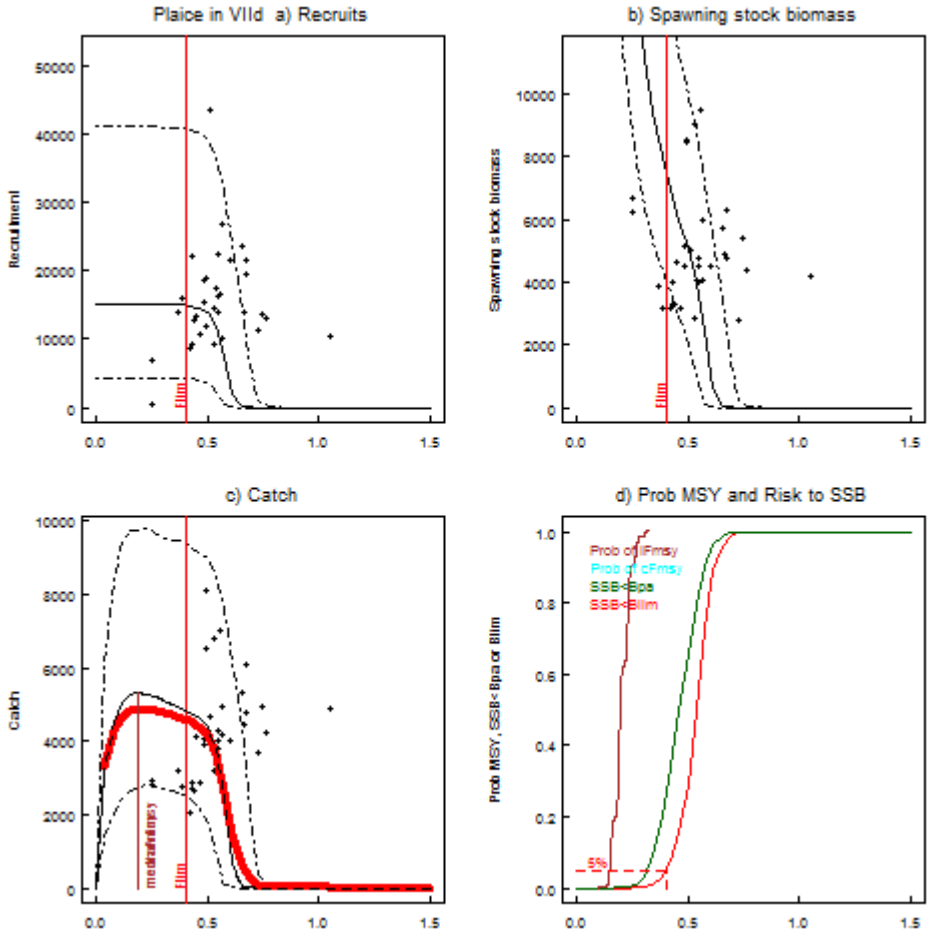


Figure 6.5.2. Plaice in VIId. Outputs from the eqsim fit

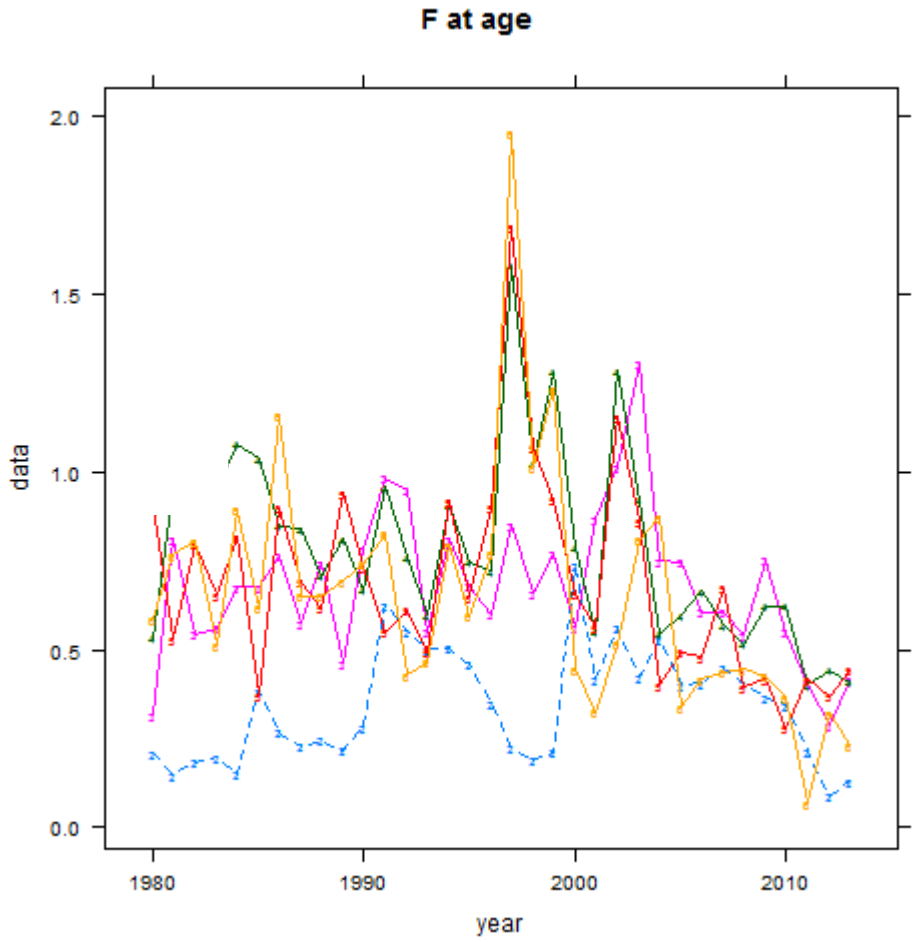
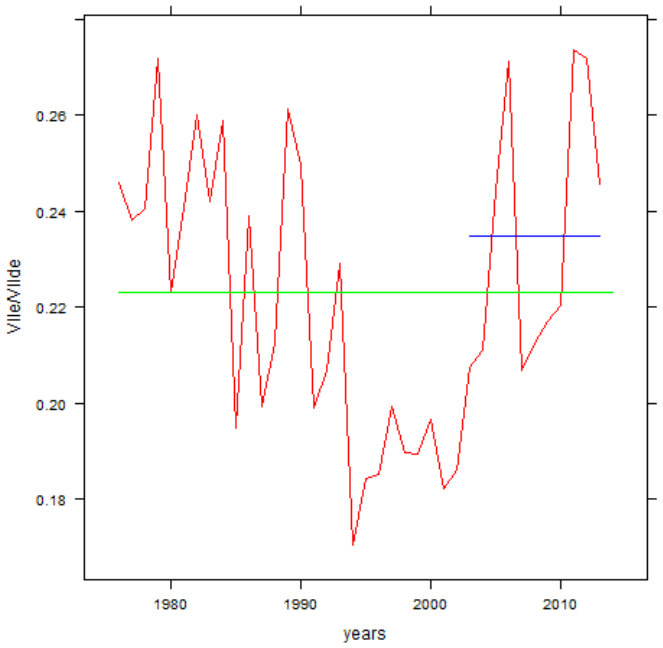
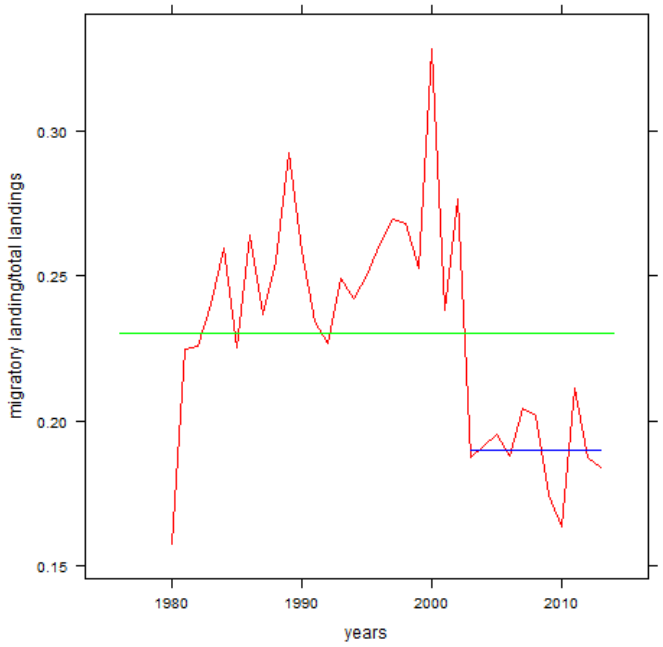


Figure 6.6.1 Plaice in VIId. Exploitation patterns over the last 13 years



(a)



(B)

Figure 6.6.2 Plaice in VIId. Time series of (A) proportion of the catch taken in VIIe over the total catch for VIIde, and (B) proportion of the catch of fish coming from VIIe and IV over the VIId catch, and the averages used.

7 Plaice in Skagerrak (IIIaN)

This year's work is only an update of last year's report, without methodological changes. A benchmark is planned for early 2015.

Significant changes had been provided to the assessment of this stock in 2012. Before then, ICES had presented analyses for the combined area IIIa (Skagerrak + Kattegat), but there hadn't been produced a final assessment since 2005 because of notable discrepancies in the catch at age and tuning information.

Since 2012, Skagerrak plaice has been separated from Kattegat plaice (ICES WKPESTO 2012, ICES WGNSSK 2012). Kattegat plaice is now assessed by ICES WGBFAS together with Belts and Sound areas (stock ple-21-23).

As the methodological approach to this stock is still under development, the stock annex has not been updated this year and relates still to the old combined IIIa setup. The stock annex will be updated during the benchmark.

7.1 Ecosystem aspects

A general description of the ecosystem is given in the Stock Annex.

7.1.1 Fisheries

A general description of the fishery is given in the Stock Annex.

Technical Conservation Measures

Minimum Landing Size is 27 cm.

Changes in fleet dynamics

A detailed description of the fishing activities in area IIIa is available in STECF (2013)[1], separated by area (Skagerrak= area 3b1).

In 2013, 1500 tonnes of plaice were landed by Fully Documented Fisheries in the Skagerrak, corresponding to around 20% of total landings in the area. (STECF data). These come mainly from the Danish seiners operating under that scheme.

Fisheries Science Partnerships

No Fisheries Science Partnerships are applicable for this stock, but national Danish research projects involving both DTU Aqua and Danish Fishermen Association have been ongoing since 2011, driven by the initial need to address the shortcomings of this stock assessment and thereby supporting MSC certification for the Danish plaice fisheries in area IIIa. These collaborations have then extended into some international initiatives led by the NSRAC and involving EU and Norway in order to suggest some harvest control rules that currently form the basis of an interim management plan.

[1] http://stecf.jrc.ec.europa.eu/documents/43805/653873/2013-11_STECF+13-21+-+Evaluation+of+Fishing+Effort+Regimes_JRC86088.pdf

and http://stecf.jrc.ec.europa.eu/data-reports

7.1.2 ICES Advice

Until 2011, ICES produced advice for the combined area IIIa. Given that no assessment was produced, ICES advice was only based on trends in recent catches.

In 2012, ICES produced for the first time a separate advice for the Skagerrak, based on the new guidelines for the Data Limited Stocks (DLS). ICES used as harvest control rule an index-adjusted *status quo* catch. The advice was based on a comparison of the two most recent index values with the three preceding values, combined with recent catch or landings data. The index value used was the Western Skagerrak IBTS biomass index from Cardinale *et al.* (2011) as modified by ICES WKPESTO (2012) and ICES WGNSSK (2012). On these considerations, ICES advised that catches in Skagerrak could increase by 7% compared to the recent average catch of the last 3 years, corresponding to catches of no more than 8400 t. ICES noted also that in the depleted Eastern Skagerrak, no directed fisheries should occur and bycatch and discards should be minimized.

In 2013, the ICES approach for data-limited stocks (category 3.2) was also used, and ICES advised that landings should be no more than 8972 tonnes, and catches no more than 10 196 tonnes. It was reiterated that no directed fisheries should occur in the Eastern Channel and bycatch and discards should be minimized.

Also, ICES provided options for potential interim management plans, on the basis of the assumed links between this stock and North Sea Plaice. These options are based on ICES feedback on an EU-Norway request on this topic (ICES, 2012a). ICES had concluded that such a strategy could potentially form the basis of an *interim* harvest control rule until the biological knowledge on the stocks structure is consolidated.

Provided explicit monitoring of the dynamics in local components within Skagerrak, those options index the Skagerrak TAC to either;

a) Changes in the North Sea TAC or

b) Changes in SSB of the combined assessment.

The SSB estimated from the combined assessment increased by 10% between 2011 and 2012 and was well above MSY Btrigger for the North Sea stock. The West Skagerrak survey index also showed a slightly increasing trend.

a) A change in the TAC in Skagerrak based on the changes in TAC in the North Sea (+15%) would imply catches in 2014 to be no more than 11 880 t (TAC 2013 = 9142 t landings x 1.15 = 10 513 t landings, with 12% discard ratio to catches = 11 880 tonnes catches).

b) A change in the TAC in Skagerrak based on the changes in the combined assessment SSB would imply catches in 2014 to be no more than 11 364 t (TAC 2013 = 9142 t landings x 1.1 = 10 056 t landings, with 12% discard rate = 11 364 tonnes catches)

This interim harvest control rule should be reconsidered after the next benchmark of the assessment.

7.1.3 Management

There are no explicit management objectives for this stock.

In 2013, the TAC for Skagerrak was decoupled from the TAC in Kattegat for the first time. The Skagerrak TAC was increased by 15% compared to 2012, on the basis of the increasing stock and TAC in the neighbouring North Sea.

In 2014, The EU and Norway agreed to set the TAC for plaice in the Skagerrak on the basis of the strategy b) above. This resulted in a TAC for 2014 of 10 056 tonnes (+10% compared to 2013)[2].

The TAC uptake has been low in 2013 (around 75%), compared to previous years where it was close to 100%, (Figure 7.1.1)

Effort restrictions in the EC were introduced in 2003 (annual annexes to the TAC regulations) for the protection of the cod stock in North Sea, Skagerrak and Eastern Channel. In 2009, the management programme switched from a days-at-sea to a kW-day system (2009 Council Regulation (EC) N° 43/2009), in which different amounts of kW-days are allocated within each area by member state to different groups of vessels, depending on gear and mesh size. Effort ceilings are updated annually. Plaice in Skagerrak is primarily caught by Danish seines with >120 mm mesh size with limited by-catch of cod; however, this fishery is included in the regulated TR1 category and has been deemed to annual effort ceilings reductions.

7.2 Data available

7.2.1 Catch

The official landings reported to ICES were not distinguished between Skagerrak (IIIasN) and Kattegat (IIIaS) until 2011. Official statistics for Skagerrak were made available in 2012, but no more in 2013 because the distinction between both subdivisions is not made in the FAO areas definitions used by Eurostat.

The annual landings used by the Working Group, available since 1972, are given by country in Tables 7.1.1. Denmark usually stands for more than 90% of the landings (93% in 2013). Misreporting is not considered an issue.

As in previous years, information was provided by DCF metier as specified in the data call and InterCatch was used to raise catch-at-age information and (see section 1)

Landings at age information is available from Denmark only, and this was used to raise to international landings, all metiers together. Landings strata for which discards ratios are available summed up to 82% of all landings weight. Landings strata for which age composition was available summed up to more than 95% of all landings weight. (Figure 7.2.1).

A discards time series for the full area IIIa from Denmark and Sweden over 2002-2011 is available, but these data have not been re-compiled yet to distinguish between Skagerrak and Kattegat (the work is planned for the 2015 benchmark). Discards data since 2012 have been worked out separately for the two areas. Age information is also available for a number of discards strata (Figure 7.2.2)

Discards in bulk weight for missing strata were raised in InterCatch using all available discards information except those from the Swedish *Nephrops* and *Pandalus* fisheries using sorting devices, which have very low landings and consequently relatively high discards rates. Average age composition was applied to all unsampled strata.

Overall 2013 discards were estimated at 1148 tonnes, corresponding to a discards ratio to landings of 16.8 % (=14% ratio of discards to catches).

[2] http://www.regjeringen.no/pages/38649625/2014Skagerrakavtalen12March.pdf

7.2.2 Weight at age

Weight at age in landings is presented in Table 7.2.2 and Figure 7.2.3.

A major issue for this stock assessment is the extreme variability of the growth patterns obtained from biological samples, with extreme overlap of length distributions of the main ages (ICES, 2012 and Ulrich *et al.*, 2013).

7.2.3 Maturity and natural mortality

Not estimated

7.2.4 Catch, effort and research vessel data

Landings and effort data by gear were computed at the level of the ICES rectangle. 2012 Data for the European fleet was available from the STECF online data [http://stecf.jrc.ec.europa.eu/data-reports], on the basis of the main "cod plan categories". 2013 data from Sweden, Denmark and Germany were added in the same format.

IBTS data are available in the area IIIaN. Since 2007 the WG discussed the limited spatial coverage of the surveys with regards to main fishing grounds. The IBTS sampling in Skagerrak has only few hauls in the Western Skagerrak. In 2014, the Danish part of IBTS added one haul in Skagerrak, located more coastally (43F9) than usual IBTS hauls (Figure 7.2.4), and thus more directly into the expected plaice distribution area (cf VMS plot Figure 7.3.5).

Also, the Beam Trawl Survey (BTS) undertook a number of hauls in Skagerrak for the first time in 2014, more coastly than IBTS (Figure 7.2.5).

It can be noted that the Danish Institute will start with a new medium-size research vessel in 2015 (replacing the current Havfisken vessel). As this will de facto imply a break in the time series, Danish sampling strategy will be reorganised at the same time in order to better monitor the coastal areas around Denmark in the future..

7.3 Data analyses

7.3.1 Catch-at-age matrix

There are almost no landings from age 1 plaice, and generally poor tracking of the cohorts in the landings. (Figure 7.2.3). Weight at age has been increasing over the decade for the main ages.

7.3.2 Spatial information on catches

ICES (2012) and Ulrich *et al.* (2013) considered that the area IIIa should be split in various spatial components with potentially different stock origins (Figure 7.3.1). Since 2010, nearly all catches have been taken in the Western area (~ 99% in 2013), while plaice by-catches in the targeted Nephrops fishery in the Eastern area have dropped to very low levels with the increased adoption of more selective gears (Figure 7.3.2). Skagerrak landings amount to around 10% of North Sea landings.

Catches trends in fishing patterns by the main gear groups across both areas were computed (Figure 7.3.3). 2013 lpue for the main fishery (TR1 in Western Skagerrak, 87% of total landings for the stock in 2012) have remained at the recent high level.

Since 2012, the fishing pattern has moved slightly away from the North Sea boundary rectangle (43F8) towards the more central Skagerrak (Figure 7.3.4).

Plaice in Skagerrak is fished in the relatively shallow waters of the Western Skagerrak (<50m), where it is the main target species. (Figure 7.3.5).

7.3.3 Survey series

The addition of the Danish IBTS haul closer to the coast (rectangle 43F9) than other IBTS hauls had a very large impact on the survey data available. The CPUE in this haul have been really higher than observed in any other haul, which sustained the concern that the current survey design is not so well suited for plaice (Fig 7.2.4).

In term of the update assessment, the WG decided to run the time series without this new haul included in calculations. Further analyses of this will be done during the benchmark in 2015.

Trends in IBTS area different between spring and autumn (Figure 7.3.6). The autumn survey seems to show consistent high signals for some year classes, and in particular at age 3 the picks correspond to the large year classes 2007, 2004 and 2002 observed in the North Sea. The spring survey is less consistent.

However, the correlations between the IBTS abundance indices in Eastern North Sea (area 7) and the Skagerrak (area 8) are not very strong (Figure 7.3.7)

A spatially-disaggregated abundance index from IBTS Quarter 1 (modified from Cardinale *et al.*, 2011) has been suggested by ICES WKPESTO (2012) and ICES WGNSSK (2012). This index measures the density of adult aggregation during spawning and is used as an indicator of abundance of local components outside of migration periods. In 2013, the computation of this index was redrawn and made directly calculated from ICES DATRAS database (Figure 7.3.8 and Table 7.3.1).

This index is relatively noisy and based on a limited number of hauls.

7.4 Exploratory analysis

No analytical assessment is presented for this stock. However, a combined assessment, where Skagerrak landings are included in the North Sea catches, is performed (Figure 7.4.1). Overall, an addition of around 10% of the catches scales the assessment, with a 15-17% increase of the SSB estimates and a 5-10% decrease in F. The reason why the SSB estimate is increased relatively higher than the increase in catches is that catches in Skagerrak are mainly of larger animals compared to the North Sea, as the fishery takes place with targeted and larger meshed gears.

7.4.1 Final assessment

The WG decided not to include a final assessment

7.5 Historic Stock Trends

No historical stock trends are available from the final assessment.

7.5.1 Stock perception from the North Sea fishers survey (FNSSS)

The annual FNSSS was not made available to the WG.

7.6 Recruitment estimates

Not available

7.7 Short-term forecasts

Not performed

7.8 Medium-term forecasts - none

7.9 Biological reference points

No reference points

7.10 Quality of the assessment

The sustained research activity has led to some major changes in the perception of plaice stock structure in the IIIa transition area (Ulrich *et al.*, 2013). Skagerrak and Kattegat are no longer considered to be from the same biological unit, and the assessment has been changed accordingly.

The approach for plaice in Skagerrak is now based on a non-standard tailored approach. As the stock structure is still poorly defined in Skagerrak, the assessment now builds on survey trends (Data Limited Stock category 3.2) by areas defined within the subdivision IIIaN, with a combined North Sea-Skagerrak.

Further work is now ongoing, aiming at clarifying the knowledge base on stock structure and growth patterns using a combination of genetics, otolith analysis and hydrodynamic modelling, which may shed new light on the dynamics of plaice population in Skagerrak. A benchmark is scheduled for 2015.

7.11 Status of the Stock

It is not possible to provide a reliable status of the stock based on analytical assessment. Since 2003 where a final assessment was presented for the last time, a number of indicators tended to sustain the hypothesis that the stock is currently not exploited unsustainably. Landings have been stable over a long time period, and the effort of commercial fleets has decreased. There had never been sign of impaired recruitment.

The landings and lpue have been high in the recent years. The spring survey indicates that there has not been large year classes in the recent years in Skagerrak but that the abundance is globally increasing in the Western area, while the autumn survey reflect to some extent some of the large year-classes estimated in the North Sea. It is therefore suggested that landings in the West are driven to some extent by the increased abundance of the North Sea stock.

7.12 Management Considerations

No analytical assessment is available for the Skagerrak alone. Therefore, detailed management options cannot be presented.

ICES approach to data-limited stocks

For data-limited stocks for which a biomass index is available, ICES uses as harvest control rule an index-adjusted *status quo* catch. This year advice is based on an estimation of the most recent trends in survey index values, combined with recent catch or

landings data. Knowledge about the exploitation status also influences the advised catch.

Area-based IBTS Q1 indices are uncertain and variable around their mean because of the limited number of hauls in the Skagerrak. Therefore trends are estimated using 3 vs 5 years average rather than ICES DLS standard 2 vs. 3 to limit the influence on the advice of the noise in the survey data.

For the Western component (where nearly all catches take place) the biomass index in the last three years (2012–2014) is 13% lower than the average of the five previous years (2007–2011). This implies a decrease of catches of at most 13% in relation to the last two years average catches (=8.286 t), corresponding to catches of no more than 7 209 t in 2015.

Even though exploitation status is unknown, the effort of the main fleets with plaice catches has declined substantially.. For trawling and Danish seines (mesh sizes above 90 mm) a reduction of effort of 45% was recorded in Skagerrak between 2003 and 2013. Therefore no additional precautionary reduction of catches is needed.

If discards ratios do not change from the average of the last two years (2012-2013) at 13%, this implies landings of no more than 6 135 t. Discard mortality is assumed to be 100%.

In the Eastern component, the biomass that was previously considered depleted has shown higher indices over the last two years. The biomass in the last three years (2012–2014) is 69% higher than the average of the five previous years (2007–2011). Catches in the Eastern area are very low (under 1.5% of the Skagerrak landings since 2010), and the fisheries operate with selective devices. But the actual exploitation rate and stock status remains uncertain. Therefore, no directed fisheries should occur and bycatch and discards should be minimized.

In comparison, ICES 2 vs. 3 DLS rule estimates that the average (2012-2013) is 47% lower and 420% higher than the average (2009-2011) in the Western and Eastern Skagerrak respectively.

Alternative options for potential interim management plans

Since 2013, EU and Norway and the North Sea RAC have considered further options for an interim management plan for plaice in Skagerrak, on the basis of the links between this stock and North Sea Plaice. This work is based on ICES feedback on an EU-Norway request on this topic (ICES, 2012a). ICES concluded that such a strategy could potentially form the basis of an *interim* harvest control rule until the biological knowledge on the stocks structure is consolidated.

In 2012 ICES considered that a pragmatic harvest control rule could be used indexing the Skagerrak TAC to either;

a) Changes in the North Sea TAC or

b) Changes in SSB of the combined assessment.

These options could potentially form the basis of an *interim* management plan, with provisions explicitly linked to a monitoring of the dynamics in local components within Skagerrak (ICES, 2012a and Appendix 6.3.17.4).

The SSB estimated from the combined assessment increased by 10% between 2012 and 2013 and is well above MSY Btrigger for the North Sea stock. The West Skagerrak survey index shows a noisy trend, stable or slightly decreasing. Therefore the TAC in the

Skagerrak would remain at the same level as in 2014 (10 056 tonnes landings, 11 544 tonnes catches).

7.13 References

Cardinale, M., Bartolino, V., Llope, M., Maiorano, L., Sköld M., Hagberg., J., 2011. Historical spatial baselines in conservation and management of marine resources. Fish Fish 12, 289–298.

ICES. 2012. Report of the Workshop on the Evaluation of Plaice Stocks (WKPESTO), 28 February - 1 March 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:32. 29 pp

Ulrich, C., Boje, J., Cardinale, M., Gatti, P., LeBras, Q., Andersen, M., Hemmer-Hansen, J., Hintzen, N.T., Jacobsen, J.B., Jonsson, P., Miller, D.C.M., Nielsen, E.E., Rijnsdorp, A.D., Sköld, M., Svedäng, H., Wennhage, H. 2013. Variability and connectivity of plaice populations from the Eastern North Sea to the Western Baltic Sea, and implications for assessment and management, Journal of Sea Research, 10.1016/j.seares.2013.04.007.

Table 6.4.17.2 Plaice in Subdivision 20 (Skagerrak). ICES estimates of landings by country in tonnes.

Year	Denmark	Sweden	Germany	Belgium	Norway	Netherlands	Total	Discard ratio	TAC
							landings		
1972	5 095	70			3		5 168		
1973	3 871	80			6		3 957		
1974	3 429	70			5		3 504		
1975	4 888	77			6		4 971		
1976	9 251	51		717	6		10 025		
1977	12 855	142		846	6		13 849		
1978	13 383	94		371	9		13 857		
1979	11 045	67		763	9		11 884		
1980	9 514	71		914	11		10 510		
1981	8 115	110		263	13		8 501		
1982	7 789	146		127	11		8 073		
1983	6 828	155		133	14		7 130		
1984	7 560	311		27	22		7 920		
1985	9 646	296		136	18		10 096		
1986	10 645	202		505	26		11 378		
1987	11 327	241		907	27		12 502		
1988	9 782	281		716	41		10 820		
1989	5 414	320		230	33		5 997		
1990	8 729	779		471	69		10 048		
1991	5 809	472	15	315	68		6 679		
1992	8 514	381	16	537	106		9 554		11 200
1993	9 125	287	37	326	79		9 854		11 200
1994	8 783	315	37	325	91		9 551		11 200
1995	8 468	337	48	302	224		9 379		11 200
1996	7 304	260	11		428		8 003		11 200
1997	7 306	244	14		249		7 813		11 200
1998	6 132	208	11		98		6 449		11 200
1999	6 473	233	7		336		7 049		11 200
2000	6 680	230	5		67		6 982		11 200
2001	9 045	125			61		9 231		9 400
2002	6 470	140	3		58		6 671		6 400
2003	4 847	143	8		74	1 584	6 656		1 400
2004	5 717	179			106	1 511	7 513		9 500
2005	4 515	144			116	915	5 690		7 600
2006	6 334	175	14		142	1 190	7 855		7 600
2007	5 467	159	21		100	1 659	7 406		8 500
2008	6 901	219	5		79	403	7 607		9 300
2009	5 617	92	13		60	253	6 035		9 300
2010	7 644	153	10		49	1 332	9 187		9 300
2011	7 744	179	13	185	215	6	8 342		7 900
2012	7 328	155	12		122	10	7 627	12%	7 900

2013	6 326	160	10	148	181	6 825	14%	9 142
2014								10 056

Table 7.2.1. Plaice in Skagerrak. Landings number at age.

	1	2	3	4	5	6	7	8	9	10+
1984	1	809	8059	9177	3915	1760	375	73	25	23
1985	1	142	3816	17915	5815	1633	624	154	116	97
1986	1	3	2172	12185	17220	3886	509	214	107	152
1987	1	16	1814	8845	16315	9804	1983	293	167	121
1988	1	33	1922	10081	12460	6358	2512	803	254	148
1989	1	296	2256	6024	5530	2404	1032	468	194	216
1990	1	1311	6462	7785	9284	3084	888	436	319	358
1991	1	851	5312	8195	4480	2810	828	268	129	162
1992	1	54	1406	9159	16174	4146	932	260	89	71
1993	1	224	2369	9351	12579	6392	1381	309	82	43
1994	1	19	5087	7295	9521	7596	2129	292	91	34
1995	1	0	655	5404	11006	6475	4848	843	119	69
1996	1	863	3517	6322	4849	4609	1768	1318	137	25
1997	1	0	541	4647	8783	4875	2985	1332	832	121
1998	1	198	4783	5307	5991	2700	685	348	210	200
1999	1	0	1160	6174	7456	7234	1239	361	71	129
2000	1	0	1114	7270	10566	3276	854	109	10	22
2001	1	1035	5422	8212	10722	4540	288	76	8	33
2002	1	68	1513	6294	6760	4526	1672	412	44	24
2003	6	2606	3271	6378	7429	3942	885	121	12	9
2004	0	1299	14378	2847	2169	1206	173	81	8	11
2005	37	2449	3876	8787	2873	1334	583	144	65	11
2006	0	810	11177	8397	6366	840	316	141	34	16
2007	143	3989	6079	6977	4130	3329	486	101	34	13
2008	16	1183	5786	8111	5339	2260	1413	63	57	36
2009	0	871	7347	6457	2715	995	207	97	0	4
2010	26	1365	7399	9297	2826	741	186	62	51	18
2011	214	3494	4503	6869	5676	1796	245	124	47	0
2012	165	1701	8461	5514	2898	1675	180	134	68	50
2013	0	2839	9867	4821	1206	734	295	26	16	3

Table 7.2.2. Plaice in Skagerrak. Landings weight at age.

CW	1	2	3	4	5	6	7	8	9	10+
1984		0.276	0.299	0.301	0.373	0.423	0.548	0.817	1.029	1.319
1985		0.212	0.294	0.309	0.351	0.434	0.55	0.759	0.872	0.993
1986		0.395	0.26	0.28	0.304	0.379	0.543	0.736	0.94	1.041
1987		0.205	0.245	0.266	0.285	0.358	0.525	0.728	0.911	1.127
1988		0.22	0.251	0.261	0.285	0.343	0.466	0.551	0.746	1.111
1989		0.216	0.24	0.274	0.315	0.372	0.465	0.639	0.703	0.876
1990		0.267	0.28	0.289	0.333	0.389	0.484	0.667	0.756	1.077
1991		0.27	0.26	0.248	0.27	0.361	0.49	0.577	0.653	1.032
1992		0.274	0.318	0.265	0.278	0.334	0.506	0.67	0.85	0.872
1993		0.229	0.25	0.266	0.291	0.338	0.456	0.581	0.669	0.884
1994		0.365	0.246	0.265	0.286	0.33	0.41	0.586	0.653	0.785
1995			0.297	0.296	0.286	0.325	0.366	0.498	0.726	0.767
1996		0.225	0.252	0.282	0.384	0.399	0.437	0.428	0.559	1.013
1997			0.248	0.266	0.291	0.335	0.408	0.458	0.441	0.492
1998		0.226	0.242	0.273	0.328	0.401	0.468	0.513	0.574	0.655
1999			0.277	0.294	0.287	0.292	0.33	0.357	0.661	0.585
2000			0.24	0.273	0.301	0.351	0.38	0.489	0.857	0.911
2001		0.257	0.282	0.292	0.322	0.306	0.423	0.604	0.876	0.658
2002		0.219	0.274	0.27	0.285	0.336	0.399	0.6	0.794	1.153
2003	0.217	0.238	0.254	0.271	0.292	0.297	0.4	0.45	0.647	0.83
2004		0.237	0.278	0.338	0.379	0.405	0.576	0.783	0.816	0.827
2005	0.227	0.25	0.258	0.29	0.327	0.357	0.398	0.523	0.644	0.823
2006	0.166	0.254	0.264	0.287	0.346	0.357	0.405	0.478	0.578	0.646
2007	0.245	0.246	0.29	0.318	0.308	0.343	0.347	0.528	0.511	1.016
2008	0.239	0.274	0.299	0.295	0.328	0.396	0.456	0.567	0.551	0.476
2009		0.24	0.284	0.326	0.375	0.479	0.518	0.646	1.121	0.758
2010	0.206	0.271	0.307	0.331	0.393	0.482	0.524	0.453	0.526	0.786
2011	0.254	0.296	0.318	0.353	0.417	0.456	0.565	0.617	0.487	
2012	0.232	0.271	0.347	0.366	0.406	0.473	0.492	0.498	0.605	0.638
2013		0.283	0.317	0.373	0.44	0.522	0.51	0.555	0.609	0.565

Table 7.3.1 Plaice in Subdivision 20 (Skagerrak). Biomass indices per local component. NumObs = number of observations, avg.cpue= adult biomass indices (g/hour), sd. = standard deviation. Lowess : lowess smoothed cpue value (span=0.5)

West Skagerrak				East Skagerrak			
	Number of observations	average catch/unit effort (g/hour)	Standard deviation		Number of observations	average catch/unit effort (g/hour)	Standard deviation
1974	4	4038	3097	1974	1	2464	NA
1975	4	2428	3782	1975	1	2909	NA
1976	9	3465	6291	1976	2	1418	1597
1977	5	1816	1108	1977	6	3189	1472
1978	6	3579	4951	1978	2	2584	2837
1979	8	2591	2952	1979	4	2055	1300
1980	8	5050	3699	1980	4	1256	559
1981	12	9085	11638	1981	6	1736	1034
1982	6	10455	11913	1982	6	3023	2225
1983	9	2290	1418	1983	10	3521	2232
1984	11	4652	3579	1984	11	6366	3379
1985	8	5605	5569	1985	9	6781	5089
1986	7	3714	2253	1986	13	3622	2573
1987	12	9700	6122	1987	13	6438	4594
1988	7	10129	9012	1988	9	5591	4021
1989	11	7236	7289	1989	10	10243	7094
1990	9	7516	7001	1990	9	9788	7980
1991	11	5905	3950	1991	8	2692	1713
1992	11	7155	4801	1992	9	10123	6841
1993	10	13403	10930	1993	9	5414	5034
1994	10	8661	6426	1994	11	3704	2982
1995	10	13497	15000	1995	12	7376	2458
1996	10	6574	6168	1996	10	8240	13898
1997	10	4402	3359	1997	12	2886	3327
1998	10	4434	2045	1998	10	6078	4323
1999	11	5234	3562	1999	11	3268	2621
2000	11	7287	4838	2000	9	4300	2713
2001	11	5421	2053	2001	9	2814	1679
2002	11	6135	4249	2002	6	1731	1046
2003	8	3386	2296	2003	9	3013	1353
2004	11	6258	4254	2004	11	2625	1867
2005	15	5577	3198	2005	11	7905	5144
2006	11	8591	11885	2006	11	6041	3947
2007	11	20122	19808	2007	11	5206	4559
2008	10	6829	4085	2008	11	1891	1182
2009	11	4332	3676	2009	10	3239	3426
2010	11	12126	7694	2010	9	1709	915
2011	11	10556	17801	2011	7	1451	813
2012	10	15979	13023	2012	9	1266	899
2013	11	6693	8865	2013	10	6028	4845
2014	11	5612	3742	2014	10	6357	5393

Table 7.12.1. candidate harvest control rule for an interim management plan (as evaluated by ICES, 2012)

a) If the survey abundance is at or below the lower abundance threshold*, then advise a decrease or no fishing.

b) If the survey abundance is above the lower abundance threshold* then:

North Sea / Skagerrak combined assessment SSB		**West Skagerrak Survey abundance**	
		RISING ↗	STABLE / FALLING → ↘
Above MSY $B_{trigger}$ ✓	RISING ↗	Skagerrak TAC increases with same rate as NS SSB** *(a)*	Skagerrak TAC remains at same level as previous year *(b)*
	STABLE / FALLING → ↘	Skagerrak TAC remains at same level as previous year *(c)*	Skagerrak TAC decreases with same rate as NS SSB ** *(d)*
Below MSY $B_{trigger}$ ✗	RISING ↗	Skagerrak TAC remains at same level as previous year *(e)*	Skagerrak TAC remains at same level as previous year *(f)*
	STABLE / FALLING → ↘	Skagerrak TAC decreases with same rate as NS SSB ** *(g)*	Skagerrak TAC decreases with the rate of the NS SSB ** *(h)*

*** Lower abundance threshold to be decided.**

**** It could be considered to use the rate of the North Sea TAC increases/decreases rather than the SSB value.**

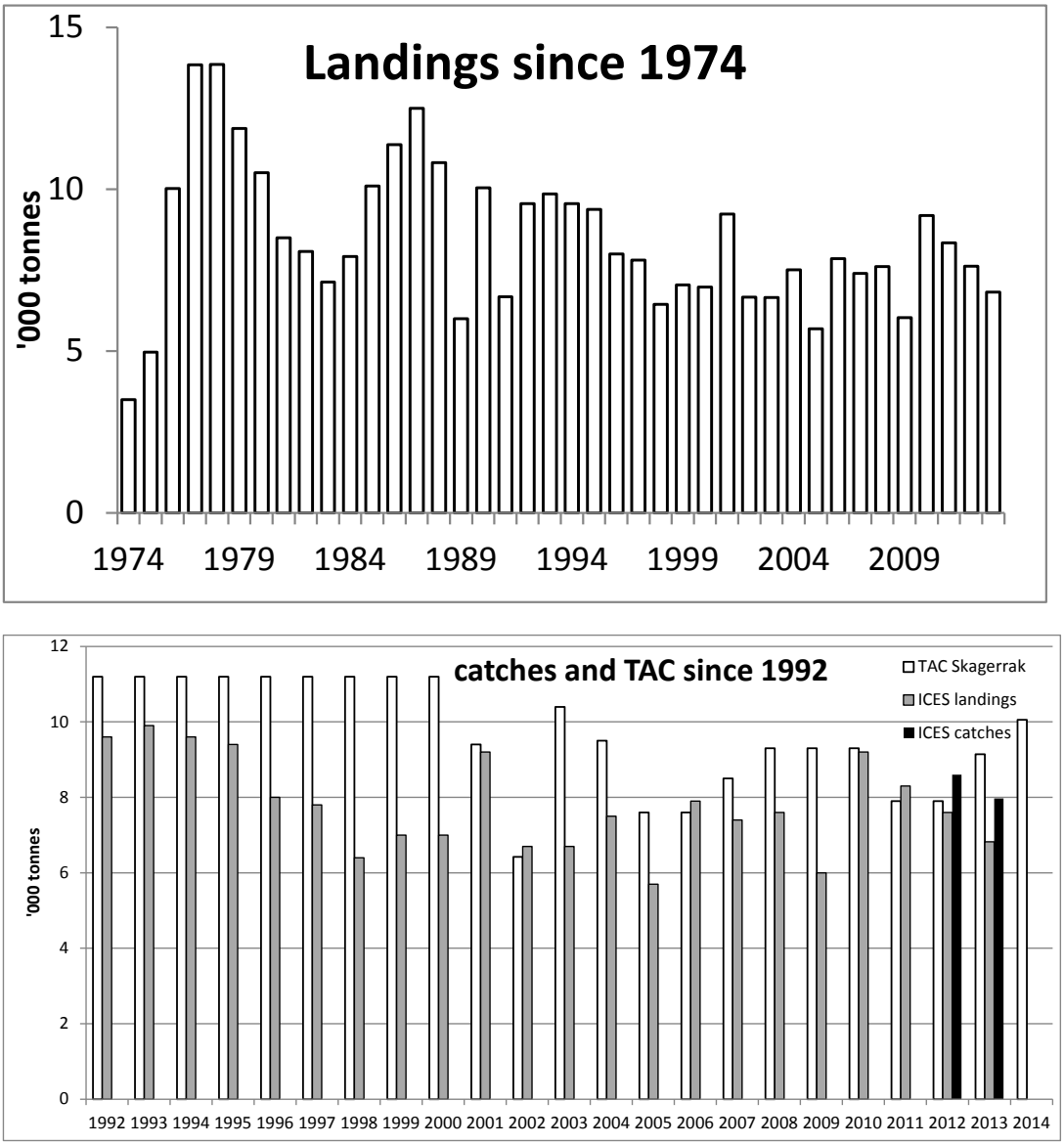


Figure 7.1.1. Plaice Skagerrak. Upper : total landings 1974-2013. Lower : Landings vs. TAC in Skagerrak, 1992-2014.

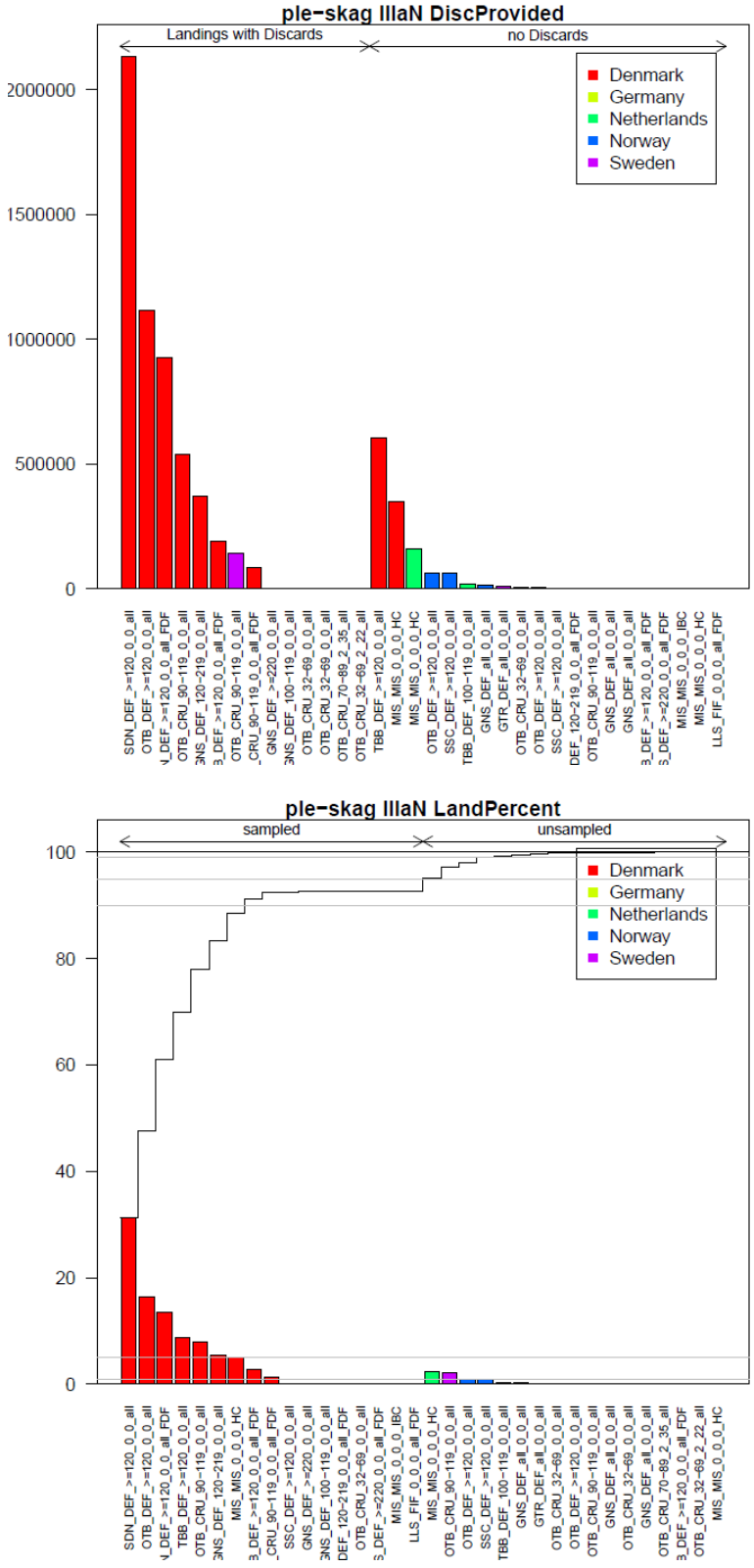


Figure 7.2.1. Landings strata with discards ratios available (top) and with age information available (down) as provided to InterCatch before raising.

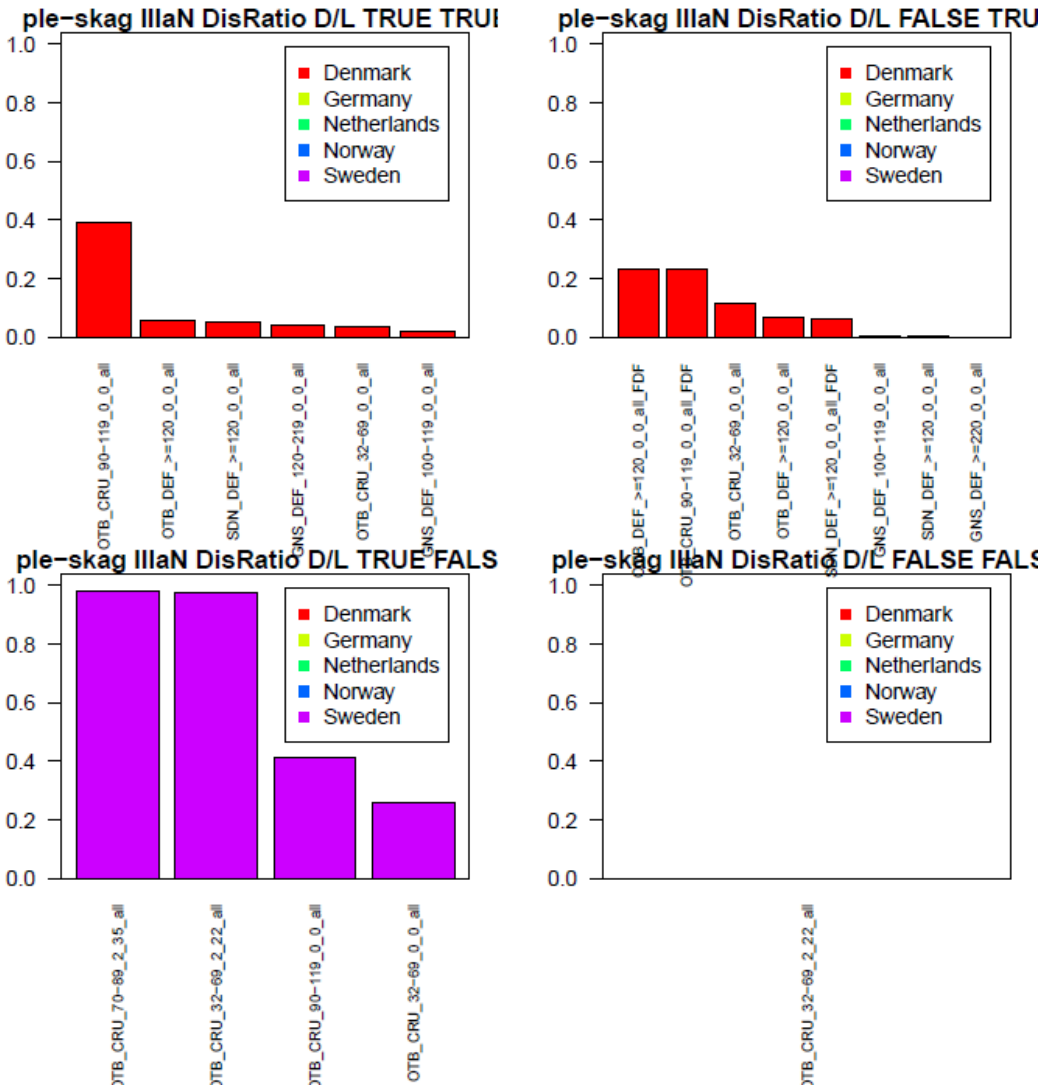


Figure 7.2.2. Discards ratio (discards/landings) by country and fleet as provided to InterCatch before raising, showing also whether age information is available (TRUE) or not (FALSE) for landings and discards respectively.

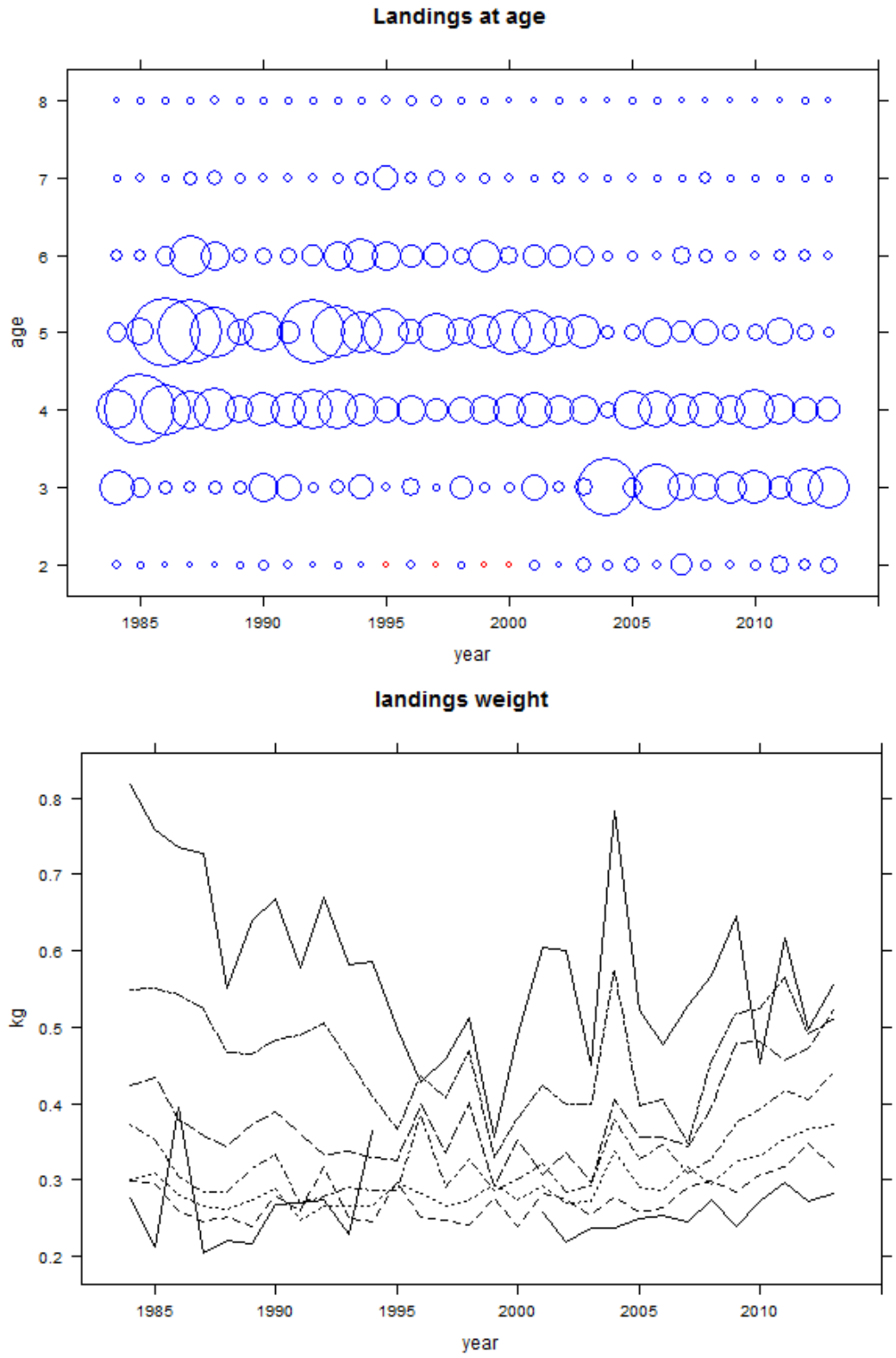


Figure 7.2.3. Landings number and landings weight at age (age 2 to 8) in Skagerrak

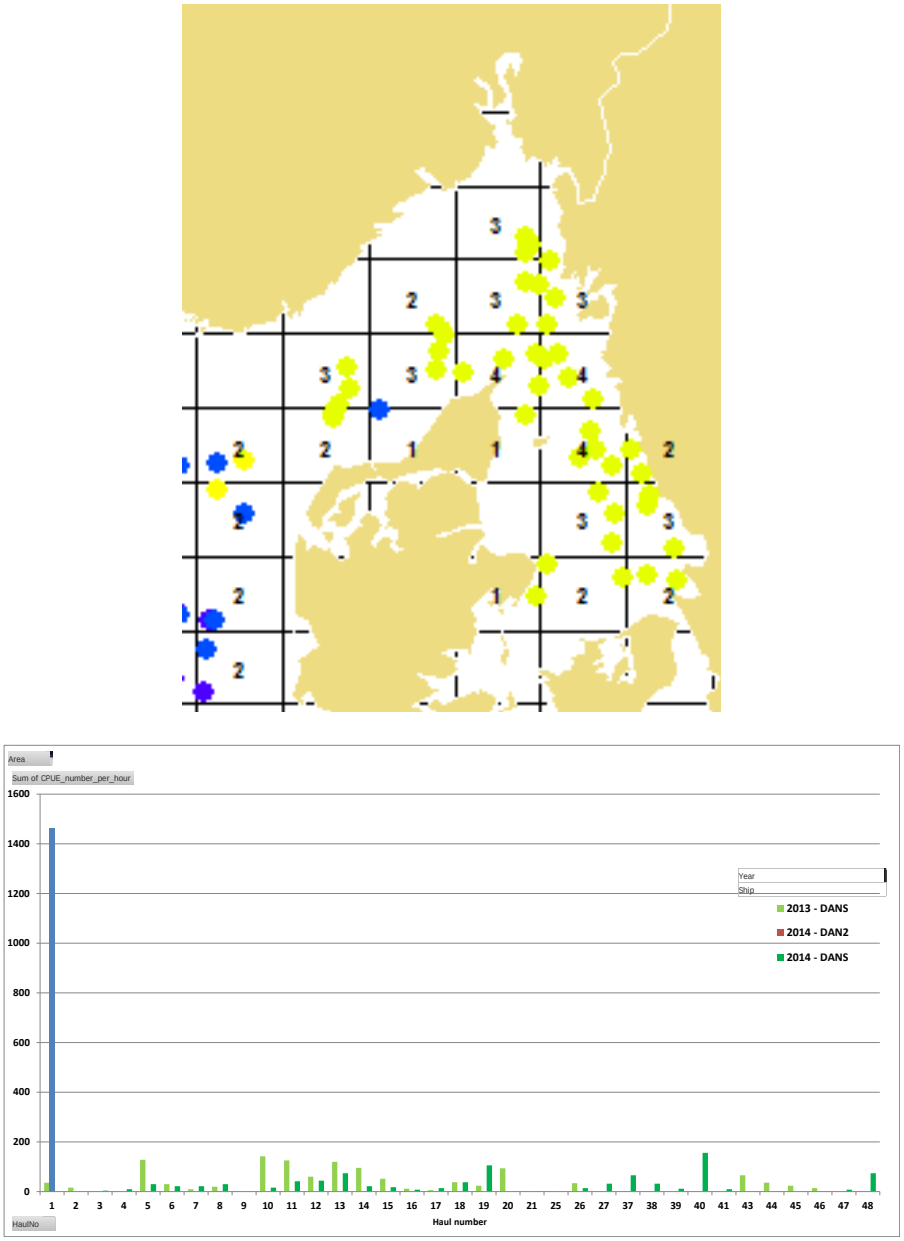


Figure 7.2.4. Top : IBTS Q1 2014 hauls (Skagerrak subset). Blue : Danish hauls. Green : Swedish hauls

Bottom: Sum of IBTS Q1 plaice CPUE (no/hour) by haul in the Skagerrak in 2013 and 2014. Blue : Danish hauls (DAN2). Green : Swedish hauls (DANS).

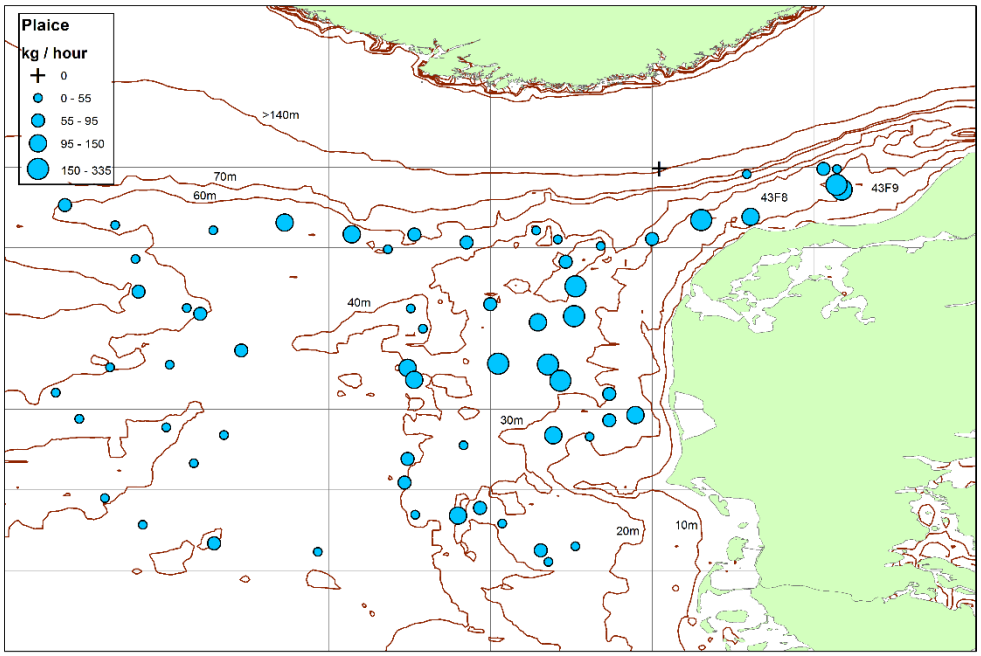


Figure 7.2.5 : Plaice CPUE from Beam Trawl Survey (BTS) Q1 2014. Also showing depth strata every 10m.

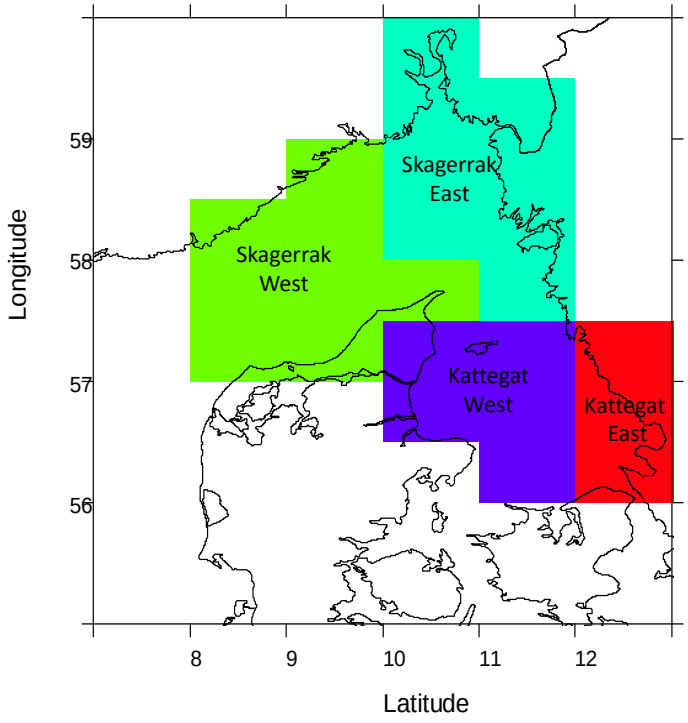


Figure 7.3.1 Areas defined within ICES division IIIa. From ICES WKPESTO 2012.

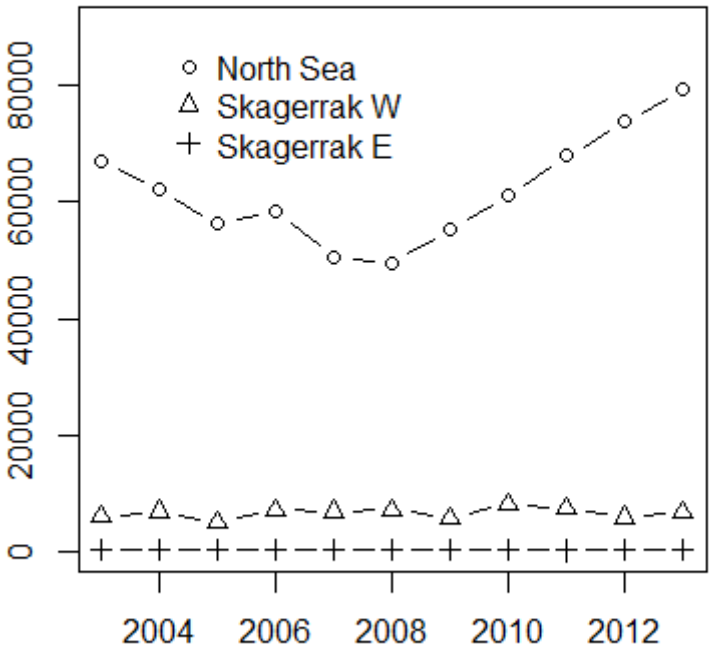


Figure 7.3.2 Landings in Skagerrak areas and compared with the North Sea.

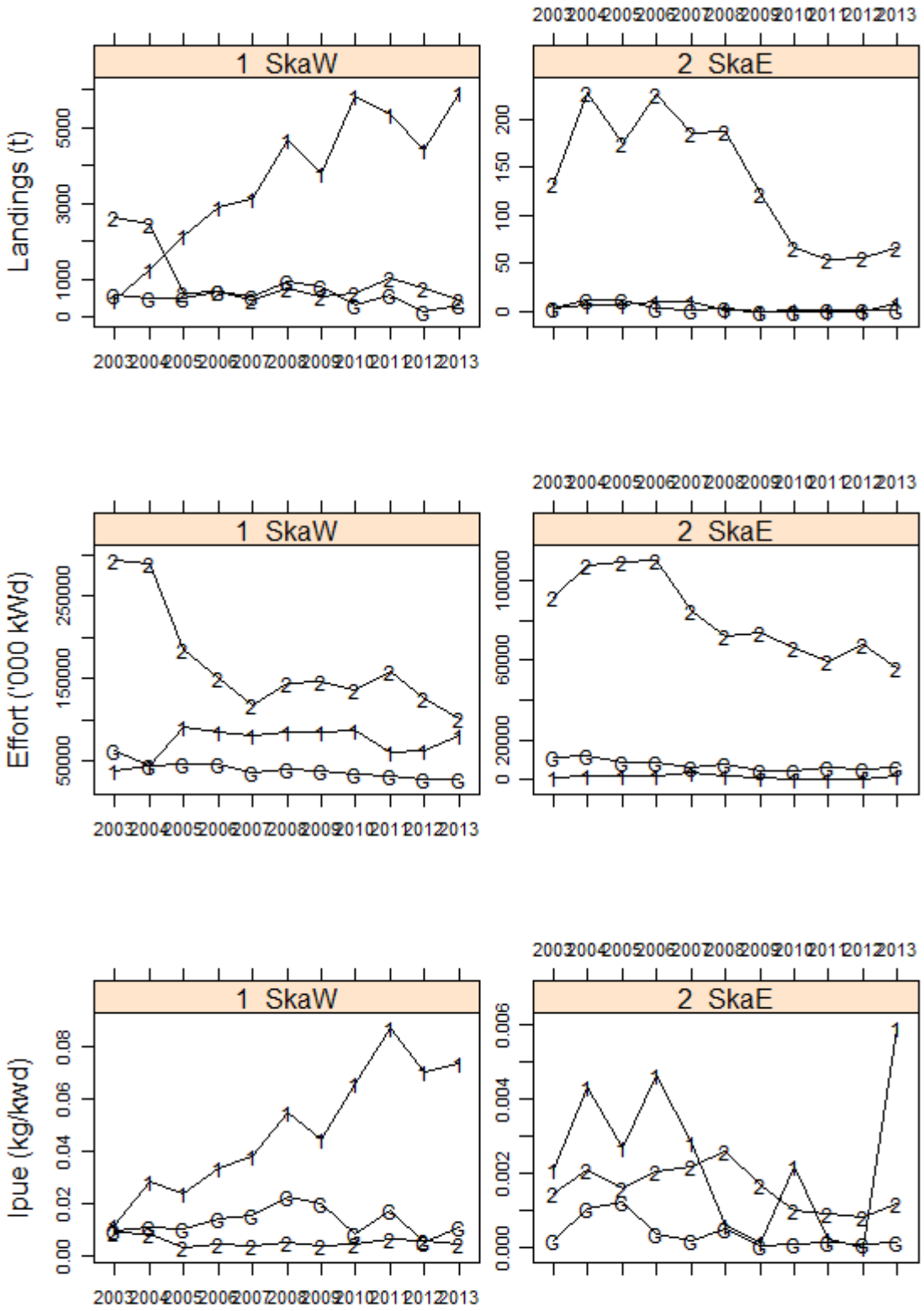


Figure 7.3.3 Trends in EU Landings, effort and lpue by gear and Skagerrak area. G=Gillnets , 1 = TR1, 2= TR2.(STECF data)

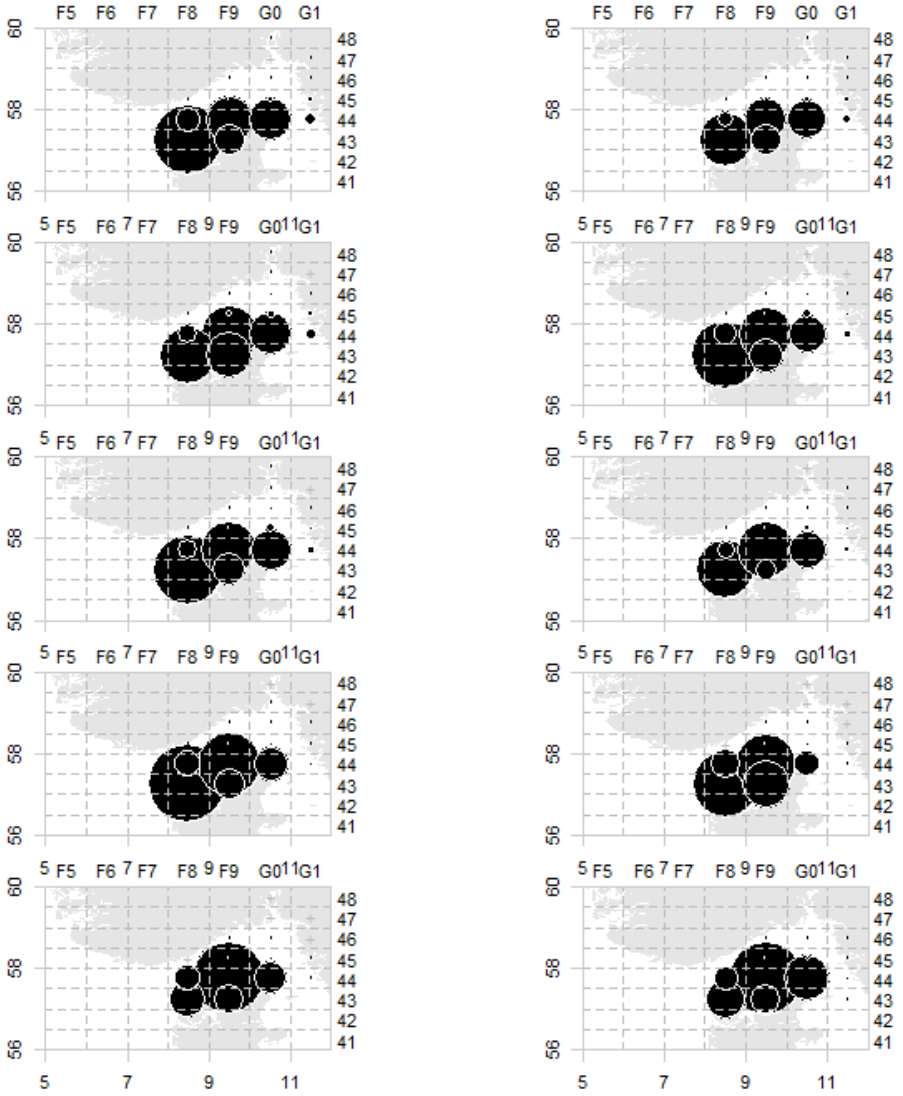


Figure 7.3.4. EU plaice Landings 2004-2013 (from left to right then top to bottom) for the main fisheries (TR1, TR2, GN1) all gears (STECF data). Bubble max size= 3500 tonnes.

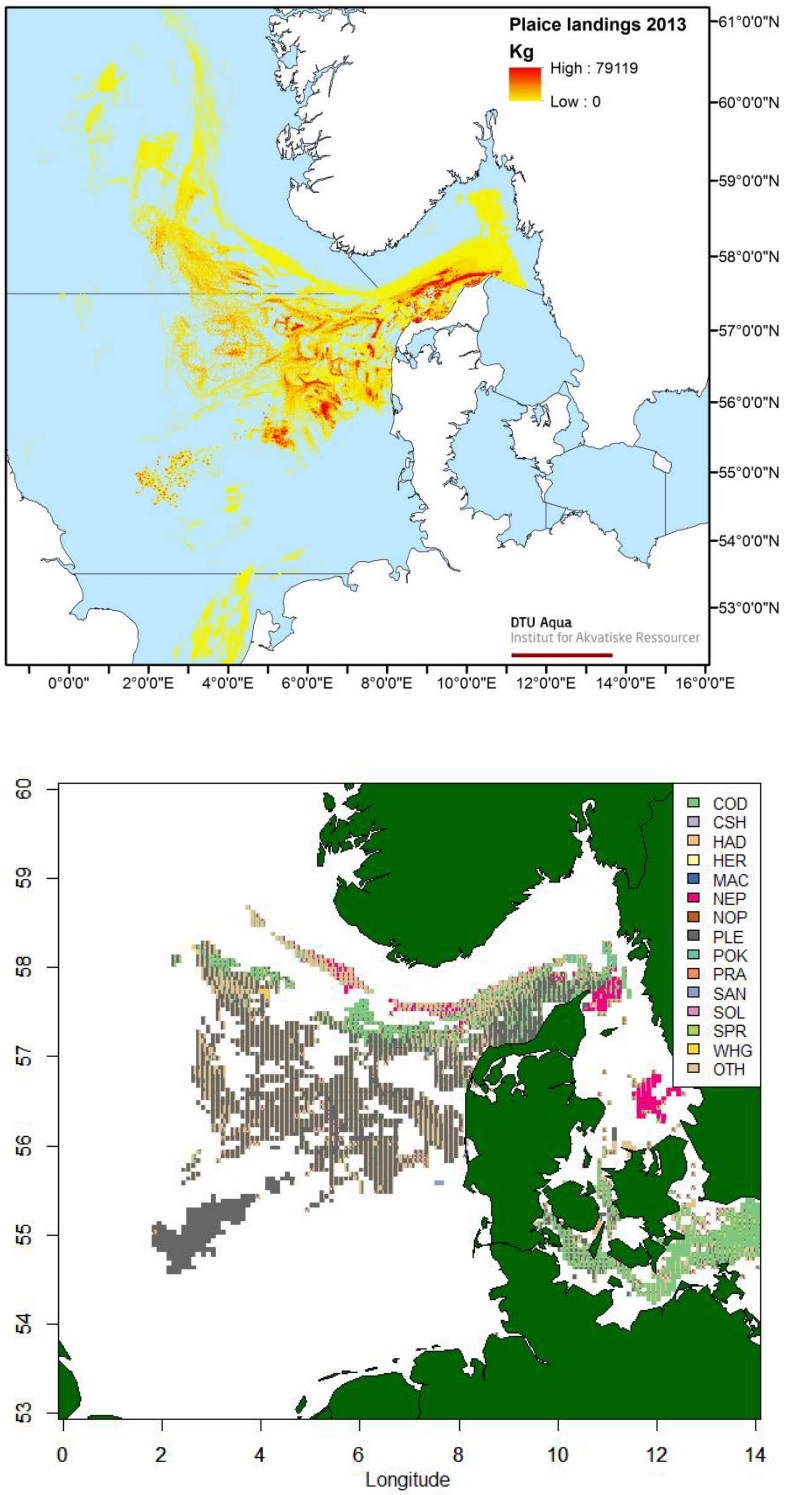
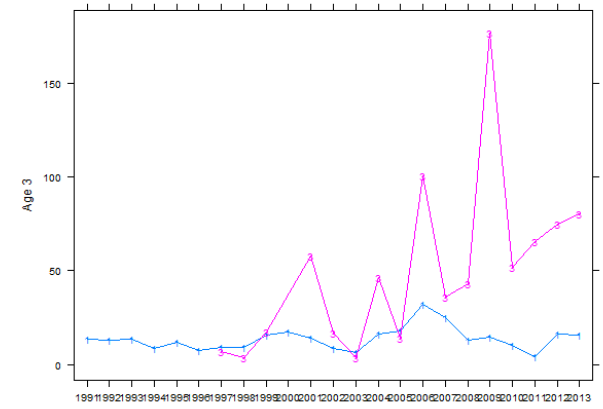
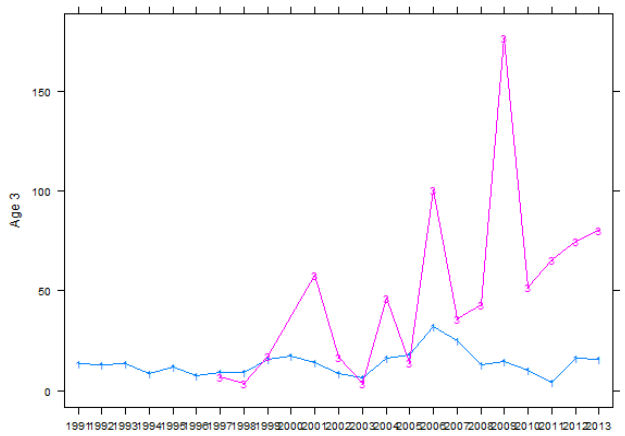


Figure 7.3.5 :Danish 2013 landings by VMS location. Top : Plaice landings in Skagerrak and North Sea. Bottom: Mixed-fisheries figure highlighting the distribution of landings of the main species for trawls and seines above 100 mm mesh size (TR1), vessels 0-24m.


Age 3
0
50
100
150
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


Age 3
0
50
100
150
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

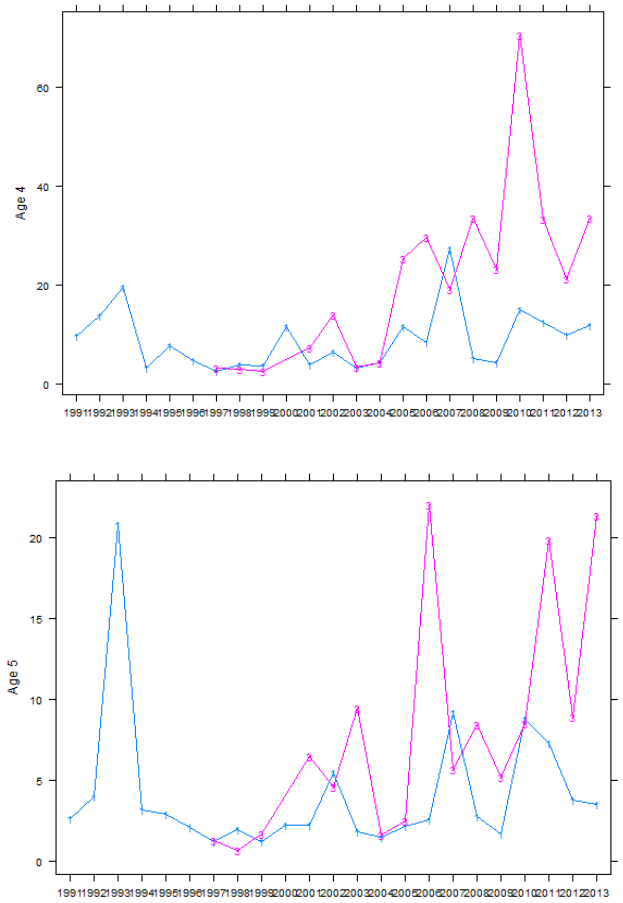


Figure 7.3.6. IBTS index (No/hour) in Skagerrak (area 8) by quarter (1 and 3) and age (ages 2 to 5).

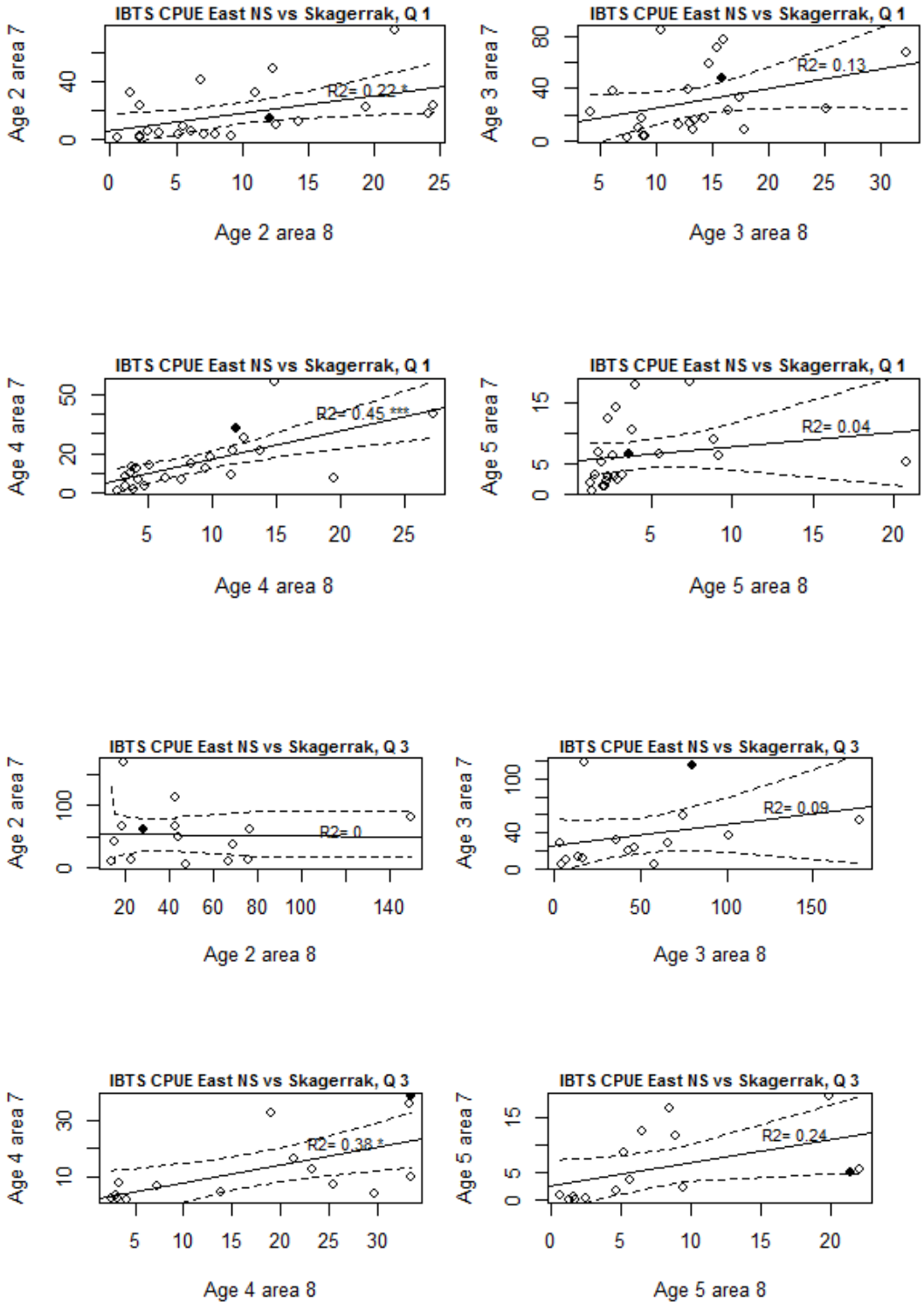


Figure 7.3.7 correlation between IBTS index at age (2-5) in the Skagerrak (area 8, x-axis) and in the Eastern North Sea (area 7, y-axis). Quarter 1 : 1991-2013. Quarter 3 : 1997-2013.

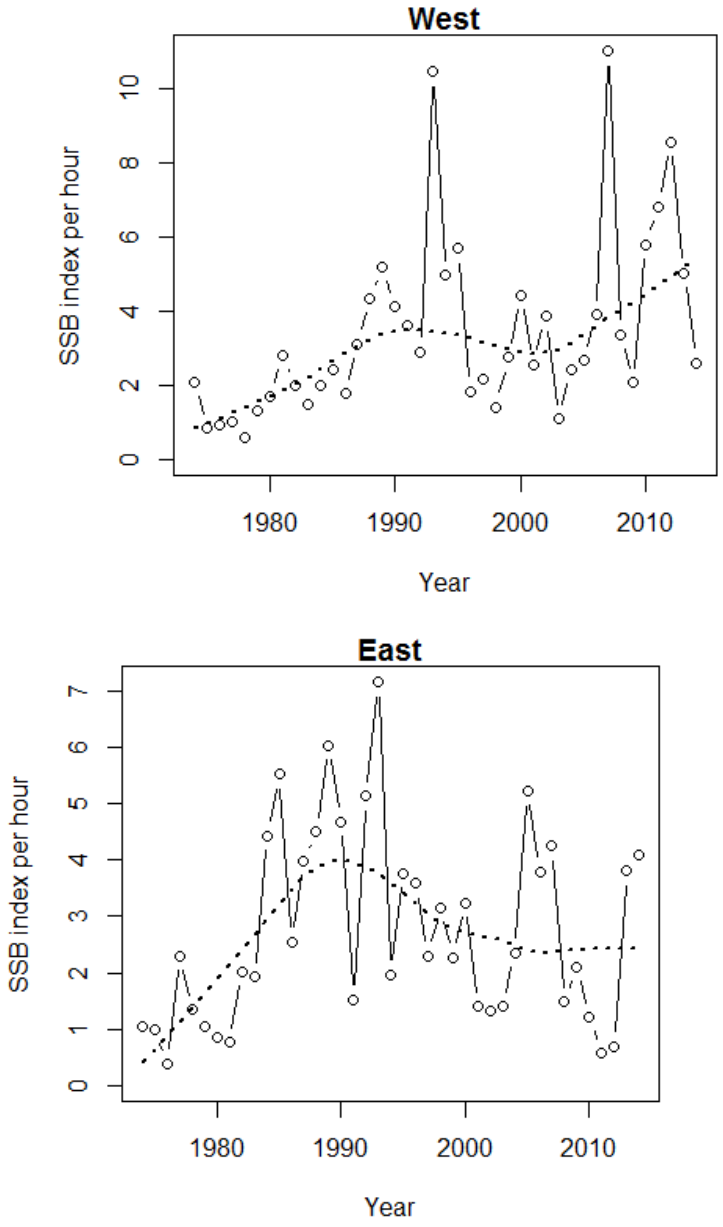


Figure 7. 3.8 Trends in the spawning-stock biomass index (cpue of fish above 25 cm, kg/hour) in the local Skagerrak components Eastern and Western (IBTS). The dotted line is a loess smoother (span 0.5).

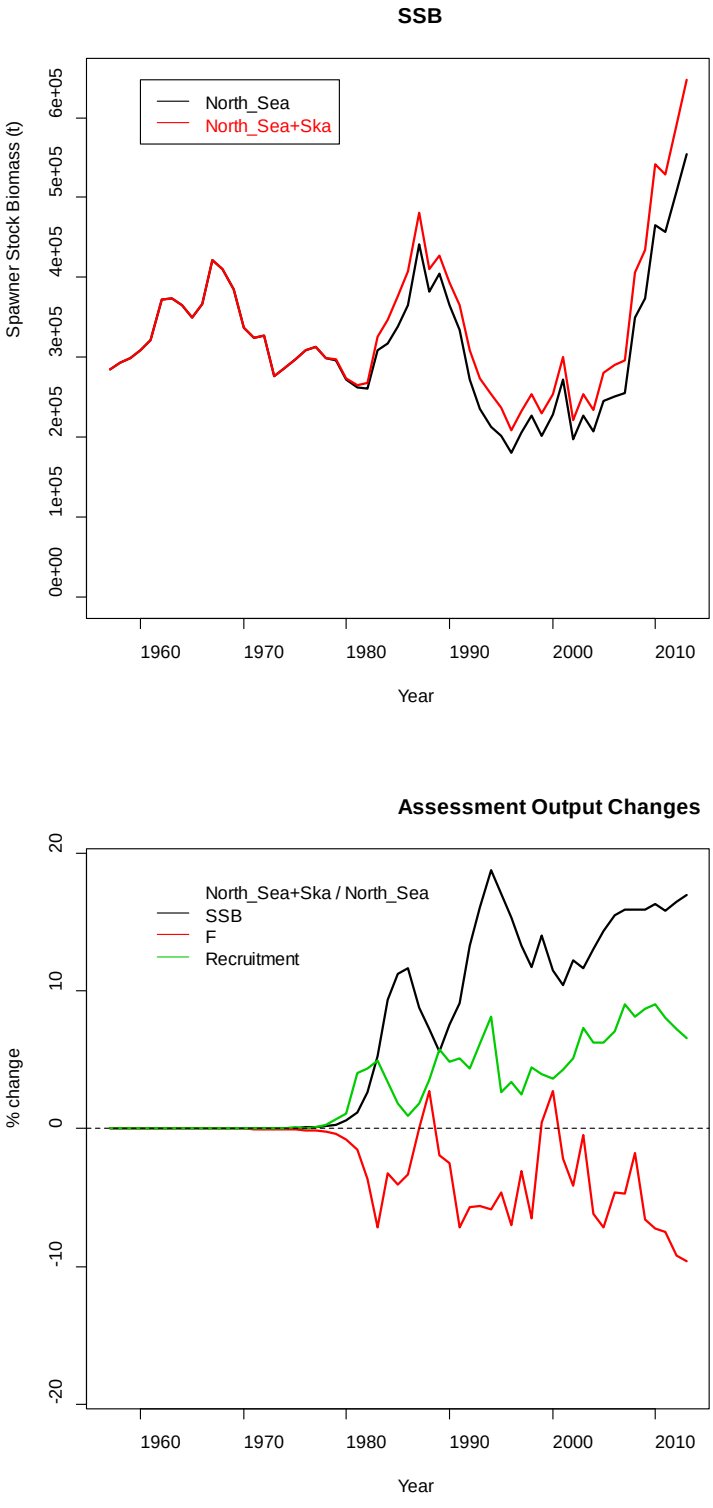


Figure 7.4.1. top: SSB for the North Sea stock, with and without the Skagerrak landings data included in the assessment. Bottom: differences in North Sea plaice assessment with and without the Skagerrak landings included.

8 Plaice in Subarea IV

A Stock Annex is available for North Sea plaice. Therefore only a comprehensive description of the methods and deviations from the stock annex are presented within this Section of the report.

8.1 General

8.1.1 Stock structure

The flatfish benchmark group WKFLAT (ICES 2010a) recommended to explore the potential to perform an integrated assessment of the continuum of plaice stocks from the Baltic to the English Channel. ICES evaluated the stock identity of plaice in the Skagerrak and Kattegat during a dedicated workshop (WKPESTO; ICES 2012b) for which until now combined advice was given. Although work on stock identity was still under development, the collected information on the biology and fishery of plaice in area IIIa and adjacent waters led to the decision to split the assessment area in two and provide advice for 2013 for the Skagerrak and Kategat separately. Subsequently, 2013 TACs for plaice were established for the Kattegat and the Skagerrak areas separately as well.

Plaice in the Skagerrak is considered to have two components: an Eastern and Western. The latter occurs in a mix with plaice migrating in from the North Sea (Ulrich et al 2013). Local indices suggest an increase in the Western component since the 2000s, and conversely a decrease in the Eastern component. Based on work from WKPESTO and following the EU-Norway request in 2012 to develop a management plan for plaice in the Skagerrak, ICES advices for a separate TAC for the Skagerrak, which is based on information on local trends and – acknowledging the mixing in the West – developments in the North Sea plaice stock. In order to investigate the potential impact of linking the management of the Skagerrak place on the North Sea stock, a 'combined' assessment was run including Skagerrak catches in the North Sea plaice stock assessment. This showed a consistent upward scaling of the total spawning stock biomass, while leaving the overall trend unaffected.

In addition, as in previous years, part of the catches in the VIId area in the first quarter are included in the North Sea plaice assessment, since North Sea plaice migrates into the area in that season (ICES 2010a).

8.1.2 Ecosystem considerations

Available information on ecosystem aspects can be found in the Stock Annex. In addition, the ICES Working Group on the Ecosystem Effects of Fishing Activities (WGECO) met in April 2014 and addressed a specific question in relation to North Sea plaice, in response to a request from WGNSSK in 2013:

"According to WGNSSK estimates, the North Sea is currently ongoing a plaice outburst without precedent. However, plaice is not included in multispecies models, so the consequences of this outburst on the North Sea ecosystem are unclear and would potentially require additional focus".

WGECO addressed the trends shown in the stock assessment of plaice, which show how increasing fishing pressure on the stock has progressively moved SSB away from the desired state (in the 1980s and 1990s), and then how management has rectified this situation in recent years, which has brought the North Sea plaice stock in a situation unlike any other over the whole 57 year period for which data is available. The group

investigated a possible relationship of these trends with abundance of benthic biomass, which is a predominant food source for plaice. Q1 IBTS data showed a two-fold increase in demersal benthivore biomass over the last 29 year period of the survey, and that species composition of the demersal benthivore guild has changed as well. The data showed that predation loading by plaice on benthic invertebrates increased by a factor of 8.8 in just eleven years (2000-2011).

The increase in the consumption of benthic invertebrate prey by the whole demersal benthivore guild, and particularly by plaice, raises the question as to whether the abundance of benthic invertebrate prey might be becoming limiting. If the biomass of demersal benthivorous fish is approaching its carrying capacity, then growth rates in the dominant species in the guild, in this case plaice, might start to decline. Computed growth coefficients for the 1956 to 2002 cohorts showed a strong declining linear trend over the whole period (albeit with clear systematic variation in the residuals), and this has been related to increasing water temperature in the North Sea. However, fitting a 4th order polynomial function to the data suggested a marked decline in cohort growth towards the end of the time-series. This is perhaps indicative of plaice becoming food limited, possibly suggesting that B_{MSY} targets for the stock might be marginally too high to be supported by available benthic invertebrate food supplies. However, this evidence is by no means conclusive as polynomial functions are known to show a tendency for marked swings at the extremes of the data range. The situation will become clearer in a few years time when data for more recent cohorts can be added to the analysis.

On another issue, moving towards better informed estimations of natural mortality (M) may be timely, since fishing mortality now is at a relatively low level, and the assessment model will become more sensitive to the assumption of M. Plaice is not usually included in multi-species models, since it is commonly assumed that plaice is not a common prey species. Another source of natural mortality may be disease outbreaks. Such outbreaks may be more severe when population density and thus population size is high. McVicar and McLay (1981) showed that plaice are relatively susceptible to *Ichthyophonus*. Patterson (1996) showed that an outbreak of this fungus was responsible for the mortality of approximately 10% of the North Sea herring population between 1991-1994. In order to obtain more realistic estimates of M for plaice in the near future it may be worthwhile to consider the impact of diseases.

8.1.3 Fisheries

A basic description of the fisheries is available in the Stock Annex. In recent years, the adoption of innovative gears – which are often aimed at reduction of fuel consumption and reduction of bottom disturbance – may be contributing to changes in fishing patterns however. In 2011, approximately 30 derogation licenses for Pulse trawls were taken into operation, which increased to 42 in 2012. An additional 42 derogation licenses have been extended in spring 2014. At the same time, possible amendments to EU regulations which would permanently legalize the use of pulse gears for the whole fleet are ongoing. Potential future impact either on the plaice stock itself or the stock assessment is unknown. ICES recommends that further studies aimed at investigating catch composition of these innovative gears in comparison to traditional beam trawls are undertaken. Furthermore, the Dutch industry representatives informed scientists that in 2012, contrary to previous years, the Dutch beamtrawl fleet shifted towards targeted plaice fisheries in more central parts of the North Sea (e.g. Doggerbank area) because of decreased sole prices and increased plaice prices, in the combination with relatively high catch rates for plaice.

8.1.4 ICES Advice

The information in this section is taken from the ICES advice sheet 2013, section 6.4.18:

ICES advises on the basis of stage one of the EU management plan (Council Regulation No. 676/2007) that landings should be no more than 111 631 tonnes in 2014. If discard rates do not change from the average of the last three years (2010–2012), this implies catches of no more than 159 584 tonnes.

Management plan

The North Sea plaice and sole stocks have both been within safe biological limits in the last two years. According to the management plan (Article 3.2), this signals the end of stage one. Application of the plan is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). Following the EU multiannual plan stage 1 (as rules relating to the setting of F for stage 2 are not yet defined) would imply fishing at the target rate of 0.3, which results in a TAC (landings) increase of more than 15%. Therefore, the maximum TAC increase of 15% is applied, resulting in landings of no more than 111 631 t in 2014. If discard rates do not change from the average of the last three years (2010–2012), this implies catches of no more than 159 584 t. This is expected to lead to an SSB of 737 017 t in 2015. ICES has evaluated this management plan and considers it to be precautionary (Miller and Poos, 2010).

MSY approach

Following the ICES MSY approach implies an increase in fishing mortality to 0.25, resulting in catches of 153 069 t in 2014. If discard rates do not change from the average of the last three years (2010–2012), this implies landings of no more than 106 226 t. This is expected to lead to an SSB of 743 656 t in 2015. Given that the current (2012) estimate of fishing mortality is slightly below FMSY, there is no need to follow a transition scheme towards this reference value.

Precautionary approach

The fishing mortality in 2014 should be no more than Fpa (0.6), corresponding to catches of no more than 317 395 t in 2014. If discard rates do not change from the average of the last three years (2010–2012), this implies landings of no more than 222 529 t. This is expected to keep SSB above Bpa in 2015.

Mixed fisheries

In contrast to single-species advice there is no single recommendation for mixed fisheries, but rather a range of example scenarios, assuming fishing patterns and catchability in 2013 and 2014 are unchanged from those in 2012. Major differences between the outcomes of the various scenarios indicate potential undershoot or overshoot of the advised landings corresponding to the single-species advice. As a result, fleet dynamics may change, but cannot be determined. Cod is the main limiting species for the North Sea demersal fisheries in 2014. In all scenarios except the "Maximum", the Plaice IV management plan catch options could not be fully utilized.

Other key points highlighted in the 2013 advice sheet

The stock is well within precautionary boundaries. Recruitment has been around long-term average since the mid-2000's.

The overall capacity and effort of North Sea beam trawl vessels has been substantially reduced since 1995, including the decommissioning of 25 vessels in 2008. Fishing mortality has been dramatically reduced because of this as well as TAC reductions prescribed by the management plan.

Both the North Sea sole and plaice stocks are presently in stage two of the EU management plan. Implementation of this second stage (as stipulated in article 5 of the EC regulation) is not yet fully defined.

8.1.5 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages of which the first stage should be deemed a recovery plan and its second stage a management plan. ICES has evaluated the plan as in agreement with the precautionary approach (Miller and Poos 2010; Simmonds 2010). A subsequent evaluation in 2012 (Coers *et al*, 2012) addressed amendments to the plan in the context of moving towards stage two of the plan. These amendments do not affect the current advice for plaice.

8.2 Data available

8.2.1 Landings

During the benchmark of the eastern channel (VIId) plaice stock (WKFLAT) it was decided that 50% of Q1 landings taken in the eastern channel are actually plaice from the North Sea stock migrating in and out of the area (ICES 2010). As in 2012, 50% of the Q1 eastern channel (VIId) plaice landings are included in the assessment of the North Sea plaice stock. See the stock annex for plaice in division VIId for further details. Total landings (including VIId) of North Sea plaice in 2013 were estimated by the WG at 78905t; an increase of 7% from the 2012 landings, but 18% less than the 97070 t TAC for 2013. Total landings (in tonnes) by country are presented in Table 8.2.1 and landings in numbers at age in Table 8.2.2.

8.2.2 Discards

The discards time series used in the assessment includes Dutch, Danish, German and UK discards observations for 2000–2013, as is described in the stock annex. From Belgium, discards data have been available as well but were only used in the assessment since 2012, since it became available through InterCatch. See section 8.2.7 for more information on the use of InterCatch for raising discards rates across metiers and countries. The Dutch discards data for 2009 and 2010 were derived from a combination of the observer programme that has been running since 2000, and a new self-sampling programme. The estimates from both programmes were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet. Since 2011, estimates were derived exclusively from the self-sampling data. There is an on-going project within IMARES to validate these estimates by examining matched (same vessel and haul) trips where both observer estimates and self-sampling estimates are derived.

To reconstruct the number of plaice discards at age before 2000, catch numbers at age data was reconstructed in 2005 based on a model-based analysis of growth, selectivity of the 80-mm beam trawl gear, and the availability of undersized plaice on the fishing grounds. Discards numbers at age are presented in Table 8.2.3. Figure 8.2.1 presents a time series of landings, catches and discards from these different sources.

8.2.3 Catch

The total catch at age as used in the assessment including all landings and all discards are presented in table 8.2.4. These include landings of NS plaice in the 1st quarter from division VIId. Landings-at-age, discards-at-age and catch-at-age bubble plots are presented in figures 8.2.2 and 8.2.3.

8.2.4 Weight at age

Stock weights at age are presented in Table 8.2.5. Stock weight at age has varied considerably over time, especially for the older ages. Landing, discards and catch weights at age are presented in Table 8.2.6, 8.2.7 and 8.2.8 respectively. Catch weights at age are derived from the discards and landings weights at age according to the relative contributions of each to the overall catch for each age. Figure 8.2.4 presents the stock, discards, landings and catch weights at age. Notably, there has been a long-term decline in the observed stock weight at age.

8.2.5 Maturity and natural mortality

Natural mortality is assumed to be 0.1 for all age groups and constant over time. A fixed maturity ogive (Table 8.2.9) is used for the estimation of SSB in North Sea plaice.

8.2.6 Catch, effort and survey data

Three survey indices are used as tuning indices, as decided during an Inter Benchmark Protocol, in March 2013 (Miller and Coers 2013). For some additional explanation, see also the WGNSSK report of 2013 (ICES 2013).

Table 8.2.10 and Figure 8.2.5 show the index values for the years that they are used in the assessment:

- Beam Trawl Survey combined for RV Tridens and ISIS (BTS-combined); (1996-2013)
- Beam Trawl Survey RV Isis (BTS-Isis) for the older part of the time series; (1985-1995)
- Sole Net Survey (SNS); (1970-2013)

Of the BTS-combined survey index, ages 1-9 are used for tuning the North Sea plaice assessment. Of the BTS-Isis older survey index, ages 1-8 are used. And of the Sole Net Survey (SNS & SNSQ2) ages 1-3 are used in the assessment, while the 0-group index is used in the RCT3 analysis for recent recruitment estimates. The internal consistency of the survey indices used for tuning appears relatively high for the entire age-range of each individual survey (Figures 8.2.6–8.2.8).

An additional survey index is used for recruitment estimates in the RCT3 analysis (Table 8.2.11):

- Demersal Fish Survey (DFS) age-0

Several commercial LPUE series consisting of an effort series and landings-at-age series are available for usage as tuning fleets. These include time series for the Dutch beam trawl fleet and the UK beam trawl fleet (excluding all flag vessels). Since the benchmark group recommended to exclude LPUE series from the final assessment run upon which management advice is based, they have not been included in the assessment.

8.2.7 InterCatch

Since 2012, national research institutes submitted landings and discard estimates by métier and quarter in InterCatch. Figure 8.2.9. shows the landings and discards by country and by metier. Approximately 60% of the landings are sampled to obtain information on age-composition. (Note that the UK vessels of the TBB_DEF_70-99_mm metier are exclusively Dutch owned flag vessels and de facto are thus sampled in the Dutch market sampling programme). For the fleet responsible for 68 % of the landings discards estimates from monitoring programmes were available. Of the metiers for which discards are monitored in sampling programmes, the largest part of these discards are covered in the TBB_DEF_70-99_mm fleet. In most discards monitoring programmes, age composition information is also collected. Discard rates vary slightly (between 80-100% on top of landings) within the TBB_DEF_70-99_mm fleet among countries (Netherlands, Belgium, Germany). Figure 8.2.10 shows varying discard rates (percentage catch discarded) among metiers.

8.3 Data analyses

The assessment of North Sea plaice by XSA was carried out using the FLR (FLCore v. 2.3 and FLXSA v.2.0) in R version 2.14. All other post-analyses were done using FLR packages.

8.3.1 Review of last year's assessment

Since 2013, ICES does not operate with external review groups anymore. The information and comments below were provided by two internal reviewers (members of the WGNSSK group: Knut Korsbrekke and Youen Vermard). The reviewers generally concluded that the assessment and forecast were a good basis for advice.

The distribution of plaice in the North Sea along with the fishery has seen substantial changes over time. Such changes may challenge the basic assumptions used in assessing the stock. Any increase in the "level of complexity" in the assessment modeling must be supported with high quality data appropriate for the choice of model.	No changes were made to the assessment in 2014.
The overall reduction in fishing mortality will lead to more uncertain assessments since unknown and possibly varying natural mortality will have a relatively larger impact on stock development. The increase in stock size is likely to more than compensate for this "inconvenience", but will trigger a need to move towards a statistical approach in assessment modeling with realistic estimates of variance for essential parameters (year class strength). This will allow for probabilistic predictions/forecasts and will much clearer show the link between input quality and the ability to predict (and give advice). Avoiding bias in the input data will still be a major challenge.	Indeed the assumption of natural mortality (M) may have gained importance in the assessment. Moving towards better informed estimations of M may be timely. In order to obtain more realistic estimates of M for plaice in the near future it may be worthwhile to consider the impact of diseases (see also section 8.1.2. Ecosystem Considerations).
The much needed change in sampling programmes is likely to have changed the relative perception of the stock to some extent. To distinguish such changes from changes due to changes in distribution and exploitation will be difficult. The estimated exploitation pattern sees a drastic change in the period 1997-2002. The exploitation pattern before this period is completely different from the period after (with discards sampling) with a more erratic behavior in the transition period.	Indeed there appears to be a difference in terms of abundance of age-1 fish between the two periods. In the late period, where the data is observation based, strong cohorts are generally detectible in the discards data already at age-1. In contrast, they are not detectible in the earlier period, where the data is model based. It would be sensible to re-consider the reconstruction of historic discards data with a next benchmark of the stock. Although it may not affect the perception of the stock in the recent period much, it might provide a better historic context.
Improved estimation of catch at age with corresponding parameters length and weight at age split on discards and retained catch. Estimates should be presented with estimates of sampling variance. Surveys of the fishing activity are a major challenge both due to the central role of this information, but also from a practical side. This challenge will not be lessened with the introduction of discard bans/limitations.	Indeed, if the introduction of the landing obligation for the fisheries on sole and plaice in 2016 will affect the quality of catch data available to ICES, the quality of the assessment and advice by ICES may particularly be affected in the case of plaice, given that (substantial) discards are included in the assessment. It is unclear how these programmes will continue under a landing obligation.
Continue research into suitable assessment models with a statistical handling of sampling errors. Model formulation and choice of basic assumptions regarding natural mortality, survey catchability and exploitation pattern should be explored.	This could be addressed at a next benchmark (see also section 8.1.2 'Ecosystem considerations'.
We recommend that the ongoing work on stock structure and the effect of (possibly varying) migrations continue. This will also link to the previous paragraph. This year combination of survey indices was one way of handling surveys with time varying catchability.	Work on stock structure will be still ongoing for the Skagerrak area.

Technical comments by the review group

We have not been able to find any "technical errors" in how the model was set up or the input data use. The much needed deviation from the stock annex benchmark (the combining of two tuning series) was well documented and one important error was detected and handled (sum of products related).	Ok.

8.3.2 Adaptations to the assessment in comparison to last year

There were no changes to the assessment in comparison to 2013.

8.3.3 Exploratory catch-at-age-based analyses

The following exploratory analyses have been carried out:

1. Single-fleet (BTS-combined index only) XSA run
2. Stock assessment using the statistical catch-at-age model as described in Aarts & Poos (2009).

BTS-combined index only XSA run

A single fleet run of the XSA assessment was conducted, leaving out the SNS-survey indices (age 1-3). All other settings were as described below under 'Final XSA assessment'. The reason for this exploratory run was the observed residual pattern in the SNS survey with the final assessment run, which signals that this survey is capturing the trends in the stock (ages 1-3) poorly. This may be due to the observed shift in the location of juvenile plaice offshore, away from the SNS survey area towards the BTS-Tridens survey area. The shift posed a substantial problem in assessments in recent years (before 2013), because the SNS survey was weighted relatively high (approximately 40%) in estimating age 1 recruits (Miller and Coers 2013). This caused recruitment to be underestimated annually and each year it was revised upwards. Combining the BTS-indices in 2013 (because also the BTS-Isis survey was suffering from the distribution shift), however, substantially improved the residual pattern of the BTS indices and consequently, the BTS received substantially more weighting in estimating age-1 recruits, 'at the expense of' weight for the SNS-index. The SNS-index now receives only approximately 15% weighting. Consequently, recruitment is ultimately estimated at a higher value by the model.

The results of the exploratory run showed a modest improvement in the residuals (magnitude as well as distribution between positives and negatives) of the combined BTS indices. Since the SNS survey does not receive much weighting in the final assessment (albeit still higher than is perhaps appropriate due this being based on its historical performance), the results in terms of perception of the stock size and the current level of fishing mortality of this exploratory run were only marginally different from the final assessment.

The working group in the end agreed to accept the update assessment (including the SNS survey data) but not by a 100% consensus, since one member of the group objected against using the method of the benchmark protocol (see also chapter 8.3.5). The working group agreed that survey coverage and increase in distribution area of plaice is a major challenge in future stock assessment along with potential survey catchability issues since the survey history does not include periods with such high densities of plaice. Substantial discarding forms a part of the catch estimation and is likely to add

to the uncertainty in the estimated catch at age. The group further agreed that with a future benchmark of this stock, removing the SNS survey from the data to feed into the assessment should be considered.

Statistical catch at age-model

The statistical catch at age (SCA) model that can be used to assess the North Sea plaice stock is described in Aarts and Poos (2009). This model uses the same tuning survey indices as the XSA used in the final run. Rather than using the reconstructed discards, the model estimates the discards based on the total fishing mortality that can be estimated from the tuning series in the presence of landings and discards. Discards can then be estimated from the difference between the landings and the catches that correspond to a fishing mortality predicted by the historic tuning indices. The background natural mortality is assumed to be constant for all ages and years. The starting values for the optimizer are taken from the Aarts and Poos article, except for the recruitment and F estimates after 2008. Given the model formulation, the SCA model greatly suffered from having combined the BTS-indices which was decided upon during the Inter Benchmark Protocol in 2013. As a consequence, the combined BTS-indices cover the period from 1996 until present, while the early part of the time series of the BTS-Isis is retained for the period 1985-1995. This means that the model no longer has an index available as a continuous index throughout the historic period for which discards are being estimated by the model (before 2000) into the recent period for which data are available (from 2000 onwards), which was previously the case. The model then has difficulty in estimating catchability of the survey in the earlier period. Because of this, the SCA model run estimates much higher discard quantities in the historic period than it did in last year's run, and/or than the XSA does. If the AAP model will be considered a candidate replacement model to be explored at a next benchmark assessment, than a this issue needs to be dealt with. Some results for this exploratory run are presented in figures 8.3.1 – 8.3.3.

Final XSA assessment

The settings for the final assessment that is used for the catch option table is given below:

Year	2014
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + DE fleets and BE (since 2012)
Fleets (years; ages)	BTS-Isis-early 1985–1995; 1–8 BTS-combined 1996–2013; 1–9 SNS 1982–2013 (excl. 2003); 1–3
Plus group	10
First tuning year	1982
Last data year	2013
Time series weights	No taper
Catchability dependent on stock size for age <	1
Catchability independent of ages for ages >=	6
Survivor estimates shrunk towards the mean F	5 years / 5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

The full diagnostics are presented in Table 8.3.1. The XSA model converged after 36 iterations. Figure 8.3.4. shows internal consistency plots for the three tuning indices used. The model fits well to the combined BTS tuning indices (small residuals and no clear patterns), but the SNS tuning index shows strong negative values until the late 1990's and exclusively positive values in the most recent period.

Fishing mortality and stock numbers are shown in Tables 8.3.2 and 8.3.3. respectively. Figure 8.3.5 shows retrospective pattern of the final XSA run with respect to SSB, recruitment and F. Retrospective analyses indicate that this year's assessment is cause for a substantial revision in SSB for a number of years. To a lesser extent,similar revisions have taken place in recent years. This more erratic behaviour of the model may be caused by the overall reduction in fishing mortality, which leads to more uncertain assessments since unknown and possibly varying natural mortality will have a relatively larger impact on stock development (see also last year's reviewers' comments in section 8.3.1.). Historic Stock Trends

8.3.4 Final XSA results

Table 8.4.1. shows the stock summary table. Figures 8.4.1 and 8.4.2 present the trends in landings, mean F(2–6), F(human consumption, 2–6), F(discards, 2–3), SSB, TSB and recruitment since 1957. Reported landings gradually increased up to the late 1980s and then rapidly declined until 1995, in line with the decrease in TAC. The landings show a general decline from 1987 onwards, increasing slowly but steadily in recent years. Discards were particularly high in 1997 and 1998 (reconstructed), and in 2001 and 2003 (observed), resulting from strong year classes. Fishing mortality increased until the late 1990s and reached its highest observed level in 1997. Since the early 2000's, fishing mortality (human consumption as well as discards) has been rapidly decreasing. Since 2007 it has been slightly below the fishing mortality target established in the management plan. It is currently (2013) estimated at 0.21. Over the last five years SSB has been rapidly increasing and is currently (2014) estimated at a record high (within the assessment's time series) of 670 kt,. Recruitment varies inter-annually around the long term geometric mean of approximately 1 million recruits. It appears to have been lower on average during the 1960's and 1970's, then above average in the 1980's and fluctuating around the average since the 1990's.

The stock dynamics are affected by the occurrence of strong year classes, but increased stock size in recent years is most likely the direct consequence of reduced fishing mortality, given that no exceptionally strong year classes have been observed in recent years.

The predominant age in the landings is currently age-4 (in 2013 as well as in the past decade). See figure 8.11.3. Notably, during the time series, this was only also observed in the 1960's. In contrast, the predominant age in the landings in the 1970's, 1980's and 1990's, was age-3. The age distribution in the landings in in recent years furthermore shows more similarity with the 1960's in that age-5 and age-6 fish are relatively abundant in the landings in comparison to the rest of the time series and age-2 fish are notably underrepresented in the landings. These shifts in age distribution may be explained by the still relatively low exploitation level in the 1960's, which subsequently substantially increased over the next three decades and since the early 2000's has shown a dramatic decline. Changes in spatial distribution of fishing effort and shifts in spatial distribution of the fish may also have affected these changes. The 'lack' of age-2 fish in the landings in the 1960's as well as in recent years may be for a number of reasons. When considering the age distribution in the catches age-2 fish were also lack-

ing in the catches in the 1960's, while this is not the case in 2013. One possible explanation may be the occurrence of high grading (discarding of smaller fish in order to allow for landing more larger fish for which a higher price may be received or to avoid exhaustion of quota. The latter seems unlikely since the TAC has not been fully utilised in recent years. Another explanation may be that plaice have become mature at younger ages than in the past since this shift in maturation also leads to mature fish being of a smaller size at age, because growth rate diminishes after maturation. Grift *et al.* 2003 observed that this may occur due to fisheries-induced genetic change: those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This could cause age-2 fish to be discarded more abundantly in recent years because a larger fraction of them being under the minimum size in comparison to the past. Reversal of such a genetic shift may be difficult.

8.3.5 Additional considerations regarding the final assessment

In the last years a strong residual pattern has been observed for the SNS survey. The working group agrees that survey coverage and increase in distribution area of plaice is a major challenge in future stock assessment along with potential survey catchability issues since the survey history does not include periods with such high densities of plaice. However, the working group did not reach a 100% consensus whether the update assessment can be used for one more year as basis for forecast and advice (and the issue can be solved during an Interbenchmark) or whether an adhoc solution is needed aside from the ICES benchmark protocol. The disagreement by one member of the working group can be summarized as follows:

The residual pattern observed for one tuning fleet (SNS) is not acceptable for any model used as basis for forecasts and advice.

The main counter arguments in the group were:

This is an update assessment and more detailed analyses are needed before the exclusion of the SNS survey from the assessment can be finally decided .

The SNS has very little weight in the assessment.

The SNS is making the estimate more conservative.

Removing the SNS tuning series will have no effect at all on the advice (due to the 15% increase limitation in the HCR) and on the perception of the status of the stock in relation to reference points.

Removing the SNS tuning series now will release a heavy workload including the re-estimation of reference points.

Based on the arguments it was decided to accept the update assessment for this year but to propose an Interbenchmark before the next working group. An exploratory run with SNS series removed was carried out during WGNSSK (see chapter 8.3.3) and gave a slight increase in the biomass estimates and decrease in corresponding estimates of fishing mortality. The distinct retrospective pattern was further enhanced by the removal of the tuning fleet. However, more detailed analyses are needed to finally decide

whether the SNS or the combined BTS survey index is more representative for the abundance of juvenile plaice in the main nursery areas.

8.3.6 The Fishers' North Sea Stock Survey

The Fishers' North Sea Stock Survey (FNSSS) did not take place in 2013. In previous years, this survey was carried out using a questionnaire circulated to North Sea fishermen in five countries: Belgium, Denmark, England, the Netherlands, and Scotland. The questionnaire had changed slightly since 2010 and fishermen were asked to record their perceptions of changes in their economic circumstances, as well as in the state of selected fish stocks. In recent years, the overall perceptions of the fishing industry as presented in the questionnaires reflected the trends in abundances of plaice rather well.

8.4 Recruitment estimates

In the short term forecasts, assumptions are made on a number of things (see also section 8.5). One of the more difficult things to predict is the strength of incoming year classes (abundance of ages 0-2) in the assessment year. A number of options are considered as follows:

Age-0: More specifically, the abundance estimate of age-1 fish in the year after the assessment year, i.e. in the TAC-year) needs to be assumed and no data is available from surveys or otherwise. Therefore, the geometric mean of the time series is used.

Age-1: The RCT3 analysis is run which combines DFS and SNS survey data and the assessment results to predict the abundance of age-1. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise, the geometric mean is used.

Age-2: The RCT3 analysis is run which combines DFS, BTS and SNS survey data and the assessment results to predict the abundance of age-2. Depending on the indicated predictive strength of the RCT3 model (typically the magnitude of the standard error) the RCT3 estimate is used in the short-term forecasts. Otherwise the XSA survivors estimate is used.

Input to the RCT3 analysis is presented in Table 8.5.1. The results for age-1 and age-2 abundance estimates are presented in Table 8.5.2, and in Table 8.5.3 respectively. For year class 2013 (age 1 in 2014) the values predicted by the DFS-0 and the SNS-0 survey estimates in RCT3 are lower and higher from the VPA mean respectively and have high prediction standard errors. Therefore the geometric mean, was used for the short-term forecasts as in previous years. For year class 2012 (age 2 in 2014), the estimates from BTS 1-group (comparable to the VPA mean) has a relatively low standard error (compared to the other surveys). The other survey indices provide estimates as much as an order of magnitude different from than the VPA mean. A retrospective analysis for age-2 survivors shows that the XSA is relatively strong in predicting age-2 survivors (see retrospective plot in figure 8.11.3). Hence, the WG decided to use the XSA estimate rather than the RCT3 estimate for the 2012 year class. The recruitment estimates from the different sources are summarized in the text table below. Underlined values were used in the forecast.

Year class	At age in 2014	XSA Survivors	RCT3	GM 1957–2011	Accepted estimate
2012	2	1071141	1024633	686995	XSA survivors
2013	1		1160658	936981	GM 1957–2011

2014	0	936981	GM 1957–2011

8.5 Short-term forecasts

Short-term prognoses were carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2013 (the last data year) into 2014 (the intermediate year in which the assessment is done); into 2014 (the TAC year) and finally into 2015 (the 'result' of the TAC year). For these years, a number of assumptions need to be made. Weight-at-age in the stock and weight-at-age in the catch are taken to be the average over the last 3 years. The exploitation pattern (selectivity of the fishery) was taken to be the mean value of the last three years. The relative proportions of landings versus discards in the catch were taken to be the mean of the last three years.

In the intermediate year F is assumed to be equal to the estimate for F in 2013 ("F-status quo" or F_{sq}). The option of assuming F to correspond to the TAC being fully landed was considered, but abandoned as an option to pursue considering the fact that the TAC has not been fully utilised in previous years. No results for this option are presented here further for that reason. Population numbers in the intermediate year for ages 2 and older are taken from the XSA survivor estimates. Numbers at age 1 for all years of the STF are taken from the long-term geometric mean (1957-2011). Input to the short term forecast is presented in table 8.6.1 and a summary of the intermediate year assumptions are given in the table below.

Assumption	F2013	SSB2015	Landings2014
F2014 = F2013 (Fsq)	0.21	731845 t	93090 t

Resulting management options for 2015 are given in Table 8.6.2.

8.6 Biological reference points

8.6.1 Precautionary approach reference points

The current precautionary approach reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock-recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks. Therefore, ICES considered that $\mathbf{B_{lim}}$ can be set at $\mathbf{B_{loss}}$=160 000 t and that $\mathbf{B_{pa}}$ can then be set at 230 000 t using the default multiplier of 1.4. $\mathbf{F_{lim}}$ was set at $\mathbf{F_{loss}}$ (0.74). $\mathbf{F_{pa}}$ was proposed to be set at 0.6 which is the 5th percentile of $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 t.

8.6.2 F_{MSY} reference points

In 2010 ICES implemented the MSY framework for providing advice on the exploitation of stocks. The aim is to manage all stocks at an exploitation rate (F) that is consistent with maximum (high) long term yield while providing a low risk to the stock. In 2010 IMARES provided a thorough simulation Management Strategy Evaluation (MSE) of the EU management plan for sole and plaice in the North Sea (Council Regulation (EC) No 676/2007). This evaluation (Miller and Poos 2010) was approved by ICES as providing high long term yields while posing low risks of the stocks falling out of safe biological limits. This was followed by an STECF evaluation of the same plan (Simmonds *et al.* 2010) where again the plan was found to be precautionary while providing

high long term yields. The report also included an additional equilibrium analysis approach to determining F_{MSY}, taking into account uncertainty in stock recruitment relationships. In light of these analyses revised MSY framework reference points, and ranges, for both sole and plaice in the North Sea were proposed. The WGNSSK concluded that F=0.25 is an appropriate value for F_{MSY} for North Sea plaice as it results in a high long term yield, with low risk to stock. In addition, it seems that any F value on the range 0.2-0.3 produces similarly high yields without increasing the risk to the stock. Therefore it is recommended that while MSY framework advice should be provided on the basis of F_{MSY}=0.25, the stock should be considered to be sustainably fished (e.g. in stock status tables) for any F on the range 0.2-0.3. No changes to Fmsy reference points have been made this year.

8.7 Quality of the assessment

Although discards form a substantial part of total plaice catches, for which estimates are less certain than for landings, the assessment at present includes 13 years of discards data obtained from sampling programs in several countries and is considered to be robust and consistent between years. Discards data are now for instance available from Denmark (beamtrawls, ottertrawls, Scottish seines and Danish seines, gillnets and longliners); the United Kingdom (for beamtrawls up to 2007); Germany (beamtrawls, ottertrawls, gillnets); Belgium (beamtrawls, ottertrawls, Scottish seines) and the Netherlands (beamtrawls and ottertrawls).The improvement of retrospective patterns observed in the recent years might have beneficiated from increased coverage of discards estimates from the main fishing nations, through self-sampling and observers programs.

A self-sampling programme by the Dutch beam-trawl fleet has been in place since 2004. This sampling programme indicates spatial and temporal trends in discarding (higher discards are observed in coastal regions and late summer), but it was considered inappropriate for overall estimates of discarding because of differences in the implementations of sampling methods. In 2009, a new self-sampling programme was launched to address this. For the 2009 and 2010 assessments, discarded numbers-at-age for the Netherlands have been estimated using data from both the self-sampling and the observer programmes. It is noted that estimates of discard numbers in 2010 differed between the two programmes. Mid 2011 the programme was redesigned again, to allow for better comparison between self-sampling and observer estimates through paired measurements. From 2011 onwards, Dutch discard estimates are derived exclusively from the self-sampling programme, while observer estimates are used for validation of the self-sampling data only. Preliminary analyses suggest that the self-sampling estimates are as reliable as those from the observer programme. Further analyses will be conducted in 2013 as more data from 'matched trips' (self-sampling and observer estimates from the same vessel trip) become available.

If the introduction of the landing obligation for the fisheries on sole and plaice in 2016 will affect the quality of catch data available to ICES, the quality of the assessment and advice by ICES may particularly be affected in the case of plaice, given that (substantial) discards are included in the assessment. It is unclear how these programmes will continue under a landing obligation.

The flatfish benchmark group (ICES, 2010) recommended to explore the potential to perform an integrated assessment of the continuum of plaice stocks from the Baltic to the English Channel. ICES evaluated the stock identity of plaice in the Skagerrak and Kattegat (ICES 2012a,b) for which until now combined advice was given. Although

work on stock identity is still under development, the collected information on the biology and fishery of plaice in area IIIa and adjacent waters lead to decisions upon changes in assessment units as well as in management areas. In 2013 and 2014, TACs for plaice were established for the Kattegat and the Skagerrak areas separately.

Plaice in the Skagerrak is considered to have two components: an Eastern and Western. The latter occurs in a mix with plaice migrating in from the North Sea. Local indices suggest an increase in the Western component since the 2000s, and conversely a decrease in the Eastern component. Based on work from WKPESTO and following the EU-Norway request in 2012 to develop a management plan for plaice in the Skagerrak, ICES advices for a separate TAC for the Skagerrak, which is based on information on local trends and – acknowledging the mixing in the West – developments in the North Sea plaice stock. In order to investigate the potential impact of linking the management of the Skagerrak place to the North Sea stock, a 'combined' assessment was run including Skagerrak catches in the North Sea plaice stock assessment. This showed a consistent upward scaling of the total spawning stock biomass, while leaving the overall trend unaffected. However, additional data on the migratory behaviour of plaice between the North Sea and adjacent waters would improve determining stock units for management of plaice in the Skagerrak and in the English Channel and their effects to the North Sea stock.

ICES has developed a generic approach to evaluate whether new survey information that becomes available in September forms a basis to update the advice. If this is the case, ICES will publish new advice in November 2014.

8.8 Status of the Stock

The stock is well within precautionary boundaries, and has reached a record high level of over 2.5 times the level in 2002. SSB in 2014 is estimated around 670 thousand tonnes which is well above Bpa (230 000 t). Fishing mortality in 2013 is estimated to be at a value of 0.21 (both below Fpa of 0.60 and the long term management target F of 0.30). Fishing mortality of the human consumption part of the catch is estimated to be 0.11.

8.9 Management Considerations

Plaice is mainly taken by beam trawlers in a mixed fishery with sole in the southern and central part of the North Sea. There are a number of EC regulations that affect the fisheries on plaice and sole in the North Sea, e.g. as a basis for setting the TAC, limiting effort, minimum landing size and minimum mesh size.

8.9.1 Multiannual plan

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) which describes two stages: to be deemed a recovery plan during its first stage and a management plan during its second stage. ICES has evaluated this management plan in 2010 and considers it to be precautionary (Miller and Poos, 2010). Objectives are defined for these two stages; to rebuild the stocks to within safe biological limits and to exploit the stocks at MSY respectively. Simulation studies and equilibrium analyses taking into account a number of stock–recruitment relationships, suggest FMSY to be within a range between 0.2 and 0.3 and ICES has consequently identified the point estimate as 0.25, that generated (ICES, 2011).

Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years. TAC setting procedures are provided to accommodate

stage 1 as well as a transitional period during which and Impact Assessment an evaluation should take place to reconsider long term objectives. The plaice stock has been within safe biological limits as defined by the plan since 2005. The sole stock has been within safe biological limits in terms of fishing mortality since 2008, while SSB has been slightly fluctuating around the biomass limit (Bpa=35 kt) in recent years and has been well above Bpa in the last two years. According to the management plan (Article 3.2), this signals the end of stage one. Consequently, utilisation of the plan as a basis for advice is on the basis of transitional arrangements until an evaluation of the plan has been conducted (as stipulated in article 5 of the EC regulation). In 2012, ICES evaluated a proposal by the Netherlands for an amended management plan, which could serve as the 'stage 2' plan (Coers *et al.* 2012). ICES concluded that the plan – subject to those amendments –is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY). However, implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined. The amendments do not affect the current TAC advice for plaice as the changes were in relation to (1) the target F for sole and (2) ceasing reductions in effort limitations.

Since both the sole and plaice stocks have been within safe biological limits for a number of consecutive years and the management plan is now in stage 2, the EU regulation stipulates that the stocks should be managed on the basis of MSY. In line with this, ICES advice for sole in 2014 is provided on the basis of the ICES Fmsy estimate (0.22), which is slightly higher that the target F in the plan (0.20). With plaice, the situation is the reverse, where the ICES Fmsy estimate is 0.25, which is below the target F (0.3) defined in the plan. Considering that the plan specifies that fishing mortality in stage 2 should not be below the target of 0.3 (which coincides with the upper bound of a range of Fmsy values suggested by ICES), the current advice for plaice is still on the basis of moving towards that target, rather than on the basis of Fmsy point estimate of 0.25 (albeit that the TAC change is restricted to a maximum 15% change). This apparent conflict in the basis for TAC setting in the management plan should be addressed. Allowing for flexibility within a range of values consistent with MSY could resolve this conflict. Effort regulations

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In 2009, the effort management programme switched from a days-at-sea to a kW-day system (EC regulation 43/2009), in which different amounts of kW-days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. A minor part of the fleets exploiting sole, i.e. otter trawls (OTB) with a mesh size equal to or larger than 100 mm included in TR1, have since 2009 been affected by the regulation. The beam trawl fleet (BT2) was affected by this regulation only once in 2009 but not afterwards.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995 (see Table. 10.2.7), likely due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. 25 vessels were decommissioned in 2008. In addition, the current sole and plaice long-term management plan specifically reduces effort as a management measure. However, the evaluation of amendments to the plan in 2012 showed that the plan is consistent with the precautionary approach and the principle of maximum sustainable yield (MSY) also without reductions of effort (Coers et al 2012). Subsequently, the European Council decided upon a roll-over of the effort level of 2012 into 2013.

Fishing effort of the beamtrawl fleet has shifted towards the southern North Sea to target sole over the past decade. Juvenile plaice tend to be relatively abundant there, leading to relatively high discarding rates of small plaice. This shift was amongst others driven by a number of economic factors, such as the prices for sole and plaice respectively and fuel costs, which meant that the sole fishery was the most profitable fishery. With the recent substantial increases in biomass of the plaice stock, and thus to be expected increased catch rates, targeting plaice further North has and may become more economically favourable again. With the relatively low fishing mortality levels in recent years, it is also to be expected that a larger proportion of the population will be made up of older fish, of which the fishery could potentially benefit, since larger plaice receive higher prices on the market than small plaice. At present, the beam trawl fleet is limited in its ability to move northwards (where larger plaice are more abundant) by effort restrictions for the BT1 fleet, which are imposed on the basis of the North Sea cod management plan. This trade-off between objectives in the cod and flatfish plans deserves some attention. Ongoing work in the Netherlands on the levels of cod catch rates (which are considered to be low) in the beam trawl fisheries should help quantification of this trade-off. The introduction of the landing obligation will likely provide an additional strong driver for at least part of the beam trawl fleet to focus on a more northerly plaice fishery, to avoid the complications of the high unwanted bycatches of undersized plaice in the South.

8.9.2 Technical measures

Technical measures applicable to the mixed flatfish beam-trawl fishery in the southern North Sea where sole has become relatively more abundant, affect both sole and plaice. The minimum mesh size of 80 mm selects sole at the minimum landing size. However, this mesh size generates high discards of plaice with a larger minimum landing size than sole. For the overall fleet the discards ratio has been slightly decreasing since 2003 and at present is approximately 45% by weight. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. Furthermore, the size selectivity of the fleet may lead to a shift in the age and size at maturation. For example, in recent years plaice and sole have become mature at younger ages and at smaller sizes than in the past (Grift *et al.*, 2003). The introduction of the Omega (mesh size) meter in 2010 has led to a slight increase in the effective mesh size in the fishery.

Technical management measures have caused a shift towards two categories of vessels: 2000 HP (the maximum engine power allowed) and 300 HP. The 300 HP vessels are allowed to fish within the 12-nautical mile coastal zone and in the Plaice Box. The Plaice Box is a partially closed area along the continental coast that was implemented in phases, starting in 1989. The area has been closed to most categories of vessels >300 HP all year round since 1995. The most recent EU-funded evaluation by Beare *et al.* (2010) reported the Plaice Box as having very little impact on the plaice stock.

Large scale adoption of innovative gears, when EU regulations for instance would permanently legalize the use of pulse gears could cause changes in fishing patterns in the near future. See section 8.1.3.

8.10 References

Aarts, G. and Poos, J. J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science, 66.

Beare, D.J., Rijnsdorp, A.D., Kooten, T. van, Fock, H., Witbaard, R., Meesters, H.W.G., and Quirijns, F.J. (2010) Study for the revision of the plaice box - Draft Final Report. IMARES Report C002/10

Beek, F.A. van, Leeuwen, P.I. van, and Rijnsdorp, A.D. (1990) On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research 26: 151-160.

Coers, A, Miller, D.C.M. and Poos, J.J. 2012. Evaluation of Proposed Amendments to the North Sea Flatfish Multiannual Plan, ICES CM 2012/ACOM:70.

Grift, R. E., Rijnsdorp, A. D., Barot, S., Heino, M., and Dieckmann, U. 2003. Fisheries-induced trends in reaction norms for maturation in North Sea plaice. Marine Ecology Progress Series, 257: 247–257.

ICES. 2010. Report of the Benchmark Workshop on Flatfish (WKFLAT), 25 February–4 March 2010, Copenhagen, Denmark. ICES CM 2010/ACOM:37.

ICES. 2011. Report of the Workshop on Implementing the ICES Fmsy Framework (WKFRAME-2), Copenhagen, Denmark. ICES Document CM 2011/ACOM: 33. 109 pp.

ICES. 2012a. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH2): August Meeting. ICES CM 2012/ACOM:74.

ICES. 2012b. Report of the Workshop on the Evaluation of Plaice Stocks (WKPESTO), 28 February–1 March 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:32.

ICES. 2013. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 24–30 April 2013. ICES CM 2013/ACOM:13.

McVicar and McLay. 1981. Tissue response of plaice, haddock, and rainbow trout to the systemic fungus *Ichthyophonus*.

Miller, D. C. M. and Poos, J. J. 2010. Combined Ex post and ex ante evaluation of the long term management plan for sole and plaice in the North Sea, including responses to ICES review. ICES Document CM 2010/ACOM: 62. 109 pp.

Miller, D. C. M. and Coers, A. 2013. An examination of the use of the combined BTS index in the North Sea plaice assessment.

Patterson,K.R., 1996. Modelling the impact of disease-induced mortality in an exploited population: the outbreak of the fungal parasite (*Ichthyophonus*) (hoferi) in the North Sea herring (*Clupea harengus*). Canadian Journal of Fisheries and Aquatic Sciences. 53(12): 2870-2887, 10.1139/f96-234

Simmonds, E.J., Miller, D.C.M., Bartelings, H., Vanhee, W. 2010. Report of the Sub Group on Management Objectives and Strategies (SGMOS 10-06). Part b) Impact assessment of North Sea plaice and sole multi-annual plan. EUR 24629 EN, ISBN 978-92-79-18743-8. pp. 124.

Ulrich, C., Boje, J., Cardinale, M., Gatti, P., LeBras, Q., Andersen, M., *et al.* 2013. Variability and connectivity of plaice populations from the Eastern North Sea to the Western Baltic Sea, and implications for assessment and management. Journal of Sea Research, 10.1016/j.seares.2013.04.007.

Plaice IV WGNSSK 2012 Tables

Table 8.2.1. North Sea Plaice. Nominal landings

YEAR	Belgium	Denmark	France	Ger-many	Nether-lands	Norway	Swe-den	UK	Others	Total	Un-allocated	ICES estimate	TAC
1980	7005	27057	711	4319	39782	15	7	23032		101928	38023	139951	
1981	6346	22026	586	3449	40049	18	3	21519		93996	45701	139697	105000
1982	6755	24532	1046	3626	41208	17	6	20740		97930	56616	154546	140000
1983	9716	18749	1185	2397	51328	15	22	17400		100812	43218	144030	164000
1984	11393	22154	604	2485	61478	16	13	16853		114996	41153	156149	182000
1985	9965	28236	1010	2197	90950	23	18	15912		148311	11527	159838	200000
1986	7232	26332	751	1809	74447	21	16	17294		127902	37445	165347	180000
1987	8554	21597	1580	1794	76612	12	7	20638		130794	22876	153670	150000
1988	11527	20259	1773	2566	77724	21	2	24497	43	138412	16063	154475	175000
1989	10939	23481	2037	5341	84173	321	12	26104		152408	17410	169818	185000
1990	13940	26474	1339	8747	78204	1756	169	25632		156261	-21	156240	180000
1991	14328	24356	508	7926	67945	560	103	27839		143565	4438	148003	175000
1992	12006	20891	537	6818	51064	836	53	31277		123482	1708	125190	175000
1993	10814	16452	603	6895	48552	827	7	31128		115278	1835	117113	175000
1994	7951	17056	407	5697	50289	524	6	27749		109679	713	110392	165000
1995	7093	13358	442	6329	44263	527	3	24395		96410	1946	98356	115000
1996	5765	11776	379	4780	35419	917	5	20992		80033	1640	81673	81000
1997	5223	13940	254	4159	34143	1620	10	22134		81483	1565	83048	91000
1998	5592	10087	489	2773	30541	965	2	19915	1	70365	1169	71534	87000
1999	6160	13468	624	3144	37513	643	4	17061		78617	2045	80662	102000
2000	7260	13408	547	4310	35030	883	3	20710		82151	-1001	81150	97000
2001	6369	13797	429	4739	33290	1926	3	19147		79700	2147	81847	78000
2002	4859	12552	548	3927	29081	1996	2	16740		69705	512	70217	77000
2003	4570	13742	343	3800	27353	1967	2	13892		65669	820	66489	73250
2004	4314	12123	231	3649	23662	1744	1	15284		61008	428	61436	61000
2005	3396	11385	112	3379	22271	1660	0	12705		54908	792	55700	59000
2006	3487	11907	132	3599	22764	1614	0	12429		55933	2010	57943	57441
2007	3866	8128	144	2643	21465	1224	4	11557	-	49031	713	49744	50261
2008	3396	8229	125	3138	20312	1051	20	11411		47682	1193	48875	49000
2009	3474	N/A*	N/A*	2931	29142	1116	1	13143	-	N/A*	-	54973	55500
2010	3699	435	383	3601	26689	1089	5	14765	-	50666	10008	60674	63825
2011	4466	11634	344	3812	29272	1223	3	15169	-	65923	1463	67386	73400
2012	4862	12245	281	3742	32201	1022	5	16888	-	71246	2584	73830	84410
2013	6462	13650	249	4903	33537	843	3	19334	-	78982	-77	78905	97070

*** Official estimates not available.**

Table 8.2.2 . Plaice in IV . landings.n (including 1st quarter of VIId NS plaice catches)

2014-05-03 09:38:47 units= thousands

year	age 1	2	3	4	5	6	7	8	9	10
1957	0	4792	66427	49659	35281	9867	12248	10026	5522	12059
1958	0	7581	23612	65979	36274	20836	8696	8507	6497	13981
1959	0	16915	31088	26042	41991	23434	14174	6547	6739	16531
1960	0	5999	62288	51362	21463	27511	14280	9073	5121	15254
1961	0	2299	33911	68962	33208	12957	14908	9900	6089	14888
1962	0	2075	34676	64545	48385	19938	8757	8733	5081	12373
1963	0	4424	21885	78410	55413	32412	13096	6965	7183	16912
1964	0	14818	40789	65220	57838	37369	15938	6644	4010	17013
1965	0	9914	42442	53490	43922	30322	18465	8603	4237	17687
1966	0	4220	66194	52426	37335	27869	16801	10981	6585	15200
1967	0	6101	30905	115155	42203	22490	16496	8163	6861	11397
1968	0	9750	41884	39251	127221	17638	10642	10396	4039	13754
1969	3	15891	47816	38184	37655	107950	11016	6440	8669	17028
1970	74	16851	49863	54714	39644	34175	76865	6149	4078	14460
1971	20	30570	49879	34582	26921	23661	17472	30713	6626	17469
1972	2296	37562	63960	54404	23695	17479	14787	11212	19111	16094
1973	1332	33344	62099	76774	44400	14518	9336	10348	6393	25195
1974	2305	23974	57600	43681	42592	20392	8301	6554	5774	22792
1975	1042	29879	65468	33213	27005	22510	12614	6293	4362	20924
1976	2892	34497	79620	98844	14129	10155	9351	6553	3022	12871
1977	3225	57061	43359	66120	83840	9157	5922	5030	4068	9206
1978	1102	58413	60115	52399	48311	34241	5728	3232	2333	7201
1979	1316	57932	118660	48878	47804	39864	24187	4154	2802	9272
1980	993	66080	135962	78779	25464	18261	13972	8592	1892	5479
1981	257	102859	125737	59194	36427	12666	9740	8240	4972	6051
1982	3351	48148	211463	70740	29002	16865	7654	5515	4510	8719
1983	1205	119070	114804	99815	29380	12867	8179	4193	2991	8249
1984	106	62337	270953	53332	37307	13561	6417	5476	2682	6475
1985	119	72540	142550	182596	31955	15377	6774	3600	2678	5690
1986	1654	66740	163102	93571	83824	23898	9254	4453	2705	6873
1987	0	84915	116115	110848	64350	34444	11441	4331	2157	5434

1988 0 15346 250328 74358 46905 24824 16622 5327 3139 6172

1989 1241 46321 105626 230014 52735 19084 10473 7484 2106 5535

1990 1525 32249 97922 110720 158197 26534 8065 4201 3441 3801

1991 1408 42200 81606 113033 70919 75152 14442 5073 3055 5416

1992 3352 43759 84553 71699 71780 33105 29234 6904 3176 6839

1993 3386 53440 96972 71021 50422 28486 13266 11099 3592 5790

1994 1357 44281 100299 78896 37746 19957 15003 6298 5296 5361

1995 7706 36751 81509 78654 36527 17908 9790 4399 2353 3791

1996 1088 42314 64163 46078 32036 14375 10501 4508 2629 4902

1997 883 42822 87522 44066 22587 13571 6422 3644 2185 4215

1998 193 30250 69358 56186 16552 6356 4941 2483 1746 3111

1999 539 8640 155475 40620 23942 6745 2756 2228 1502 3055

2000 2550 15497 39479 161586 15183 9161 2092 1007 924 2057

2001 4465 35983 53099 48363 89620 6851 4393 1122 634 2301

2002 1209 16937 58023 47815 36149 37347 4607 1769 733 1573

2003 680 42131 47775 48354 26678 15750 16808 1597 650 858

2004 538 10686 102523 35034 20440 11220 4775 4542 417 547

2005 2877 16472 26220 81226 16808 9387 5250 2584 2192 613

2006 360 19608 68994 25963 43356 6696 5060 2106 1276 1354

2007 1270 19095 37360 46934 15025 17113 2479 1848 541 1265

2008 377 11254 43095 38145 29404 5734 6791 907 670 892

2009 1554 11558 53242 35485 21959 17291 3144 4142 582 806

2010 2017 18209 39971 58410 21814 11752 9394 1769 2424 1247

2011 233 10330 40985 54859 46166 12956 6266 6742 1183 2695

2012 2 4489 52448 56491 41787 30067 7246 3217 3351 1817

2013 551 7844 54060 72139 41124 28753 15014 3865 2422 3760

Table 8.2.3 . Plaice in IV . discards.n

2014-05-03 09:39:05 units= thousands

year	age 1	2	3	4	5	6	7	8	9	10
1957	32356	45596	9220	909	961	25	0	0	0	0
1958	66199	73552	23655	2572	2137	65	0	0	0	0
1959	116086	127771	46402	11407	4737	106	0	0	0	0
1960	73939	167893	44948	997	1067	519	0	0	0	0
1961	75578	144609	89014	538	1612	130	0	0	0	0
1962	51265	181321	87599	21716	799	186	0	0	0	0
1963	90913	136183	129778	9964	2112	188	0	0	0	0
1964	66035	153274	64156	33825	3011	323	0	0	0	0
1965	43708	426021	59262	3404	923	267	0	0	0	0
1966	38496	163125	349358	14399	1402	125	0	0	0	0
1967	20199	133545	87532	152496	623	260	0	0	0	0
1968	73971	72192	46339	26530	22436	58	0	0	0	0
1969	85192	67378	16747	19334	773	2024	0	0	0	0
1970	123569	152480	27747	1287	5061	161	0	0	0	0
1971	69337	96968	42354	2675	426	81	0	0	0	0
1972	70002	55470	33899	5714	567	73	0	0	0	0
1973	132352	49815	4008	673	1289	67	0	0	0	0
1974	211139	308411	3652	285	611	109	0	0	0	0
1975	244969	280130	190536	4807	253	123	0	0	0	0
1976	183879	140921	71054	18013	174	41	0	0	0	0
1977	256628	103696	79317	33552	9317	129	0	0	0	0
1978	226872	154113	27257	10775	1244	570	0	0	0	0
1979	293166	215084	57578	18382	589	310	0	0	0	0
1980	226371	122561	932	687	193	86	0	0	0	0
1981	134142	193241	1850	373	431	55	0	0	0	0
1982	411307	204572	4624	1109	216	98	0	0	0	0
1983	261400	436331	30716	2235	804	72	0	0	0	0
1984	310675	313490	52651	24529	1492	69	0	0	0	0
1985	405385	229208	35566	2221	200	78	0	0	0	0
1986	1117345	490965	48510	26470	1451	146	0	0	0	0
1987	361519	1374202	180969	1427	1348	248	0	0	0	0

1988 348597 608109 459385 61167 882 177 0 0 0 0

1989 213291 485845 193176 85758 7224 115 0 0 0 0

1990 145314 279298 168674 28102 5011 177 0 0 0 0

1991 183126 301575 141567 40739 5528 939 0 0 0 0

1992 138755 219619 94581 34348 4307 880 0 0 0 0

1993 96371 154083 48088 11966 1635 216 0 0 0 0

1994 62122 95703 35703 1038 822 144 0 0 0 0

1995 118863 82676 15753 860 663 120 0 0 0 0

1996 111250 331065 27606 3930 451 116 0 0 0 0

1997 128653 510918 193828 588 271 108 0 0 0 0

1998 104538 646250 191631 53354 297 33 0 0 0 0

1999 127321 208401 231769 54869 278 58 0 0 0 0

2000 103468 171213 51092 64971 1230 241 263 167 0 0

2001 30346 352452 186900 74744 54276 152 45 1 0 0

2002 309822 177574 76246 12113 1571 661 107 1 0 0

2003 67718 517641 52582 19130 3843 386 5751 1 0 0

2004 232936 179561 115746 6614 1047 232 37 1 0 0

2005 93585 324744 43297 19440 4098 5968 147 1 0 0

2006 220501 223814 107163 9129 2324 249 732 194 0 0

2007 77239 203775 66539 8999 736 6972 170 1644 0 0

2008 135339 251389 34997 4568 1644 328 8845 885 0 0

2009 148639 191957 66063 9165 1973 1106 136 3220 0 0

2010 165914 177912 58279 22582 2672 1726 2073 281 0 0

2011 117296 150354 60525 36447 12789 2920 143 2273 0 0

2012 91138 309982 121128 32335 9394 1535 226 7 0 0

2013 127716 151213 122365 23630 4641 1027 219 15 0 0

Table 8.2.4 . Plaice in IV . catch.n (including 1st quarter of VIId NS plaice catches)

2014-05-03 09:39:23 units= thousands

year	age 1	2	3	4	5	6	7	8	9	10
1957	32356	50388	75647	50568	36242	9892	12248	10026	5522	12059
1958	66199	81133	47267	68551	38411	20901	8696	8507	6497	13981
1959	116086	144686	77490	37449	46728	23540	14174	6547	6739	16531
1960	73939	173892	107236	52359	22530	28030	14280	9073	5121	15254
1961	75578	146908	122925	69500	34820	13087	14908	9900	6089	14888
1962	51265	183396	122275	86261	49184	20124	8757	8733	5081	12373
1963	90913	140607	151663	88374	57525	32600	13096	6965	7183	16912
1964	66035	168092	104945	99045	60849	37692	15938	6644	4010	17013
1965	43708	435935	101704	56894	44845	30589	18465	8603	4237	17687
1966	38496	167345	415552	66825	38737	27994	16801	10981	6585	15200
1967	20199	139646	118437	267651	42826	22750	16496	8163	6861	11397
1968	73971	81942	88223	65781	149657	17696	10642	10396	4039	13754
1969	85195	83269	64563	57518	38428	109974	11016	6440	8669	17028
1970	123643	169331	77610	56001	44705	34336	76865	6149	4078	14460
1971	69357	127538	92233	37257	27347	23742	17472	30713	6626	17469
1972	72298	93032	97859	60118	24262	17552	14787	11212	19111	16094
1973	133684	83159	66107	77447	45689	14585	9336	10348	6393	25195
1974	213444	332385	61252	43966	43203	20501	8301	6554	5774	22792
1975	246011	310009	256004	38020	27258	22633	12614	6293	4362	20924
1976	186771	175418	150674	116857	14303	10196	9351	6553	3022	12871
1977	259853	160757	122676	99672	93157	9286	5922	5030	4068	9206
1978	227974	212526	87372	63174	49555	34811	5728	3232	2333	7201
1979	294482	273016	176238	67260	48393	40174	24187	4154	2802	9272
1980	227364	188641	136894	79466	25657	18347	13972	8592	1892	5479
1981	134399	296100	127587	59567	36858	12721	9740	8240	4972	6051
1982	414658	252720	216087	71849	29218	16963	7654	5515	4510	8719
1983	262605	555401	145520	102050	30184	12939	8179	4193	2991	8249
1984	310781	375827	323604	77861	38799	13630	6417	5476	2682	6475
1985	405504	301748	178116	184817	32155	15455	6774	3600	2678	5690
1986	1118999	557705	211612	120041	85275	24044	9254	4453	2705	6873
1987	361519	1459117	297084	112275	65698	34692	11441	4331	2157	5434

1988 348597 623455 709713 135525 47787 25001 16622 5327 3139 6172

1989 214532 532166 298802 315772 59959 19199 10473 7484 2106 5535

1990 146839 311547 266596 138822 163208 26711 8065 4201 3441 3801

1991 184534 343775 223173 153772 76447 76091 14442 5073 3055 5416

1992 142107 263378 179134 106047 76087 33985 29234 6904 3176 6839

1993 99757 207523 145060 82987 52057 28702 13266 11099 3592 5790

1994 63479 139984 136002 79934 38568 20101 15003 6298 5296 5361

1995 126569 119427 97262 79514 37190 18028 9790 4399 2353 3791

1996 112338 373379 91769 50008 32487 14491 10501 4508 2629 4902

1997 129536 553740 281350 44654 22858 13679 6422 3644 2185 4215

1998 104731 676500 260989 109540 16849 6389 4941 2483 1746 3111

1999 127860 217041 387244 95489 24220 6803 2756 2228 1502 3055

2000 106018 186710 90571 226557 16413 9402 2355 1174 924 2057

2001 34811 388435 239999 123107 143896 7003 4438 1123 634 2301

2002 311031 194511 134269 59928 37720 38008 4714 1770 733 1573

2003 68398 559772 100357 67484 30521 16136 22559 1598 650 858

2004 233474 190247 218269 41648 21487 11452 4812 4543 417 547

2005 96462 341216 69517 100666 20906 15355 5397 2585 2192 613

2006 220861 243422 176157 35092 45680 6945 5792 2300 1276 1354

2007 78509 222870 103899 55933 15761 24085 2649 3492 541 1265

2008 135716 262643 78092 42713 31048 6062 15636 1792 670 892

2009 150193 203515 119305 44650 23932 18397 3280 7362 582 806

2010 167931 196121 98250 80992 24486 13478 11467 2050 2424 1247

2011 117529 160684 101510 91306 58955 15876 6409 9015 1183 2695

2012 91140 314471 173576 88826 51181 31602 7472 3224 3351 1817

2013 128267 159057 176425 95769 45765 29780 15233 3880 2422 3760

Table 8.2.5 . Plaice in IV . stock.wt

2014-05-03 09:39:41 units= kg

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.038	0.102	0.157	0.242	0.325	0.485	0.719	0.682	0.844	1.143
1958	0.041	0.093	0.180	0.272	0.303	0.442	0.577	0.778	0.793	1.112
1959	0.045	0.106	0.173	0.264	0.329	0.470	0.650	0.686	0.908	1.042
1960	0.038	0.111	0.181	0.272	0.364	0.469	0.633	0.726	0.845	1.090
1961	0.037	0.098	0.185	0.306	0.337	0.483	0.579	0.691	0.779	1.067
1962	0.036	0.096	0.173	0.301	0.424	0.573	0.684	0.806	0.873	1.303
1963	0.041	0.103	0.176	0.273	0.378	0.540	0.663	0.788	0.882	1.252
1964	0.024	0.113	0.184	0.296	0.373	0.477	0.645	0.673	0.845	1.232
1965	0.031	0.068	0.198	0.294	0.333	0.430	0.516	0.601	0.722	0.909
1966	0.031	0.099	0.127	0.305	0.403	0.455	0.503	0.565	0.581	0.984
1967	0.029	0.104	0.179	0.205	0.442	0.528	0.585	0.650	0.703	0.985
1968	0.055	0.094	0.175	0.287	0.344	0.532	0.592	0.362	0.667	0.887
1969	0.047	0.158	0.188	0.266	0.344	0.390	0.565	0.621	0.679	0.857
1970	0.043	0.113	0.236	0.274	0.369	0.410	0.468	0.636	0.732	0.896
1971	0.051	0.109	0.251	0.344	0.413	0.489	0.512	0.583	0.696	0.877
1972	0.056	0.158	0.218	0.407	0.473	0.534	0.579	0.606	0.655	0.929
1973	0.037	0.134	0.237	0.308	0.468	0.521	0.566	0.583	0.617	0.804
1974	0.049	0.105	0.217	0.416	0.437	0.524	0.570	0.629	0.652	0.852
1975	0.063	0.141	0.187	0.388	0.483	0.544	0.610	0.668	0.704	0.943
1976	0.082	0.169	0.226	0.308	0.484	0.550	0.593	0.658	0.694	0.931
1977	0.064	0.184	0.265	0.311	0.405	0.551	0.627	0.690	0.667	0.938
1978	0.064	0.151	0.319	0.373	0.411	0.467	0.547	0.630	0.704	0.943
1979	0.062	0.179	0.258	0.365	0.414	0.459	0.543	0.667	0.764	1.004
1980	0.049	0.163	0.289	0.428	0.444	0.524	0.582	0.651	0.778	1.058
1981	0.041	0.140	0.239	0.421	0.473	0.536	0.570	0.624	0.707	1.031
1982	0.048	0.128	0.250	0.351	0.490	0.589	0.631	0.679	0.726	0.981
1983	0.045	0.128	0.242	0.381	0.494	0.559	0.624	0.712	0.754	0.917
1984	0.048	0.129	0.216	0.413	0.464	0.571	0.649	0.692	0.787	1.028
1985	0.048	0.146	0.232	0.320	0.452	0.536	0.635	0.656	0.764	1.011
1986	0.043	0.126	0.245	0.311	0.440	0.533	0.692	0.779	0.888	1.092
1987	0.036	0.105	0.200	0.383	0.401	0.503	0.573	0.711	0.747	0.984

1988 0.036 0.097 0.172 0.264 0.426 0.467 0.547 0.644 0.706 0.973

1989 0.039 0.101 0.192 0.247 0.362 0.484 0.553 0.616 0.759 0.883

1990 0.043 0.108 0.176 0.261 0.343 0.422 0.555 0.647 0.701 0.969

1991 0.048 0.131 0.184 0.260 0.342 0.401 0.463 0.633 0.652 0.826

1992 0.043 0.121 0.199 0.270 0.318 0.403 0.500 0.573 0.683 0.833

1993 0.050 0.119 0.208 0.315 0.330 0.391 0.490 0.587 0.633 0.811

1994 0.053 0.141 0.214 0.290 0.360 0.404 0.462 0.533 0.653 0.797

1995 0.050 0.142 0.254 0.336 0.399 0.448 0.509 0.584 0.678 0.804

1996 0.044 0.117 0.229 0.368 0.390 0.462 0.488 0.554 0.660 0.815

1997 0.035 0.115 0.233 0.359 0.439 0.492 0.521 0.543 0.627 0.850

1998 0.038 0.081 0.207 0.333 0.474 0.577 0.581 0.648 0.656 0.809

1999 0.044 0.091 0.150 0.319 0.437 0.524 0.586 0.644 0.664 0.779

2000 0.051 0.106 0.165 0.219 0.408 0.467 0.649 0.695 0.656 0.786

2001 0.061 0.122 0.202 0.233 0.331 0.452 0.560 0.641 0.798 0.830

2002 0.048 0.118 0.213 0.301 0.319 0.403 0.446 0.612 0.685 0.872

2003 0.057 0.111 0.227 0.269 0.344 0.391 0.464 0.600 0.714 0.790

2004 0.047 0.116 0.201 0.306 0.384 0.430 0.489 0.495 0.780 0.876

2005 0.053 0.106 0.216 0.237 0.378 0.422 0.434 0.527 0.621 1.006

2006 0.052 0.130 0.190 0.316 0.354 0.424 0.439 0.506 0.583 0.730

2007 0.047 0.093 0.235 0.238 0.337 0.394 0.458 0.412 0.526 0.548

2008 0.048 0.114 0.196 0.274 0.355 0.429 0.484 0.627 0.598 0.730

2009 0.052 0.114 0.194 0.344 0.373 0.412 0.472 0.540 0.565 0.632

2010 0.053 0.116 0.179 0.340 0.361 0.401 0.448 0.572 0.568 0.644

2011 0.039 0.100 0.187 0.209 0.355 0.483 0.438 0.422 0.530 0.552

2012 0.052 0.093 0.142 0.188 0.331 0.393 0.484 0.479 0.480 0.650

2013 0.043 0.107 0.153 0.208 0.320 0.354 0.434 0.493 0.662 0.587

Table 8.2.6 . Plaice in IV . landings.wt

2014-05-03 09:39:59 units= kg

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.000	0.165	0.201	0.258	0.353	0.456	0.533	0.589	0.396	0.998
1958	0.000	0.198	0.221	0.259	0.337	0.453	0.513	0.615	0.665	0.992
1959	0.000	0.218	0.246	0.293	0.362	0.473	0.592	0.623	0.750	1.000
1960	0.000	0.200	0.236	0.289	0.386	0.485	0.601	0.683	0.724	1.094
1961	0.000	0.191	0.233	0.302	0.412	0.509	0.604	0.671	0.812	1.071
1962	0.000	0.211	0.248	0.300	0.400	0.541	0.570	0.692	0.777	1.127
1963	0.000	0.253	0.286	0.319	0.399	0.533	0.624	0.667	0.715	1.028
1964	0.000	0.250	0.273	0.312	0.388	0.487	0.628	0.700	0.737	1.005
1965	0.000	0.242	0.282	0.321	0.385	0.471	0.539	0.663	0.726	0.887
1966	0.000	0.232	0.270	0.348	0.436	0.484	0.559	0.624	0.690	0.933
1967	0.000	0.232	0.279	0.322	0.425	0.547	0.597	0.662	0.738	0.978
1968	0.000	0.267	0.298	0.331	0.366	0.517	0.590	0.596	0.686	0.911
1969	0.217	0.294	0.310	0.333	0.359	0.412	0.573	0.655	0.658	0.893
1970	0.315	0.286	0.318	0.356	0.419	0.443	0.499	0.672	0.744	0.892
1971	0.256	0.318	0.356	0.403	0.448	0.514	0.542	0.607	0.699	0.891
1972	0.246	0.296	0.352	0.428	0.493	0.541	0.608	0.646	0.674	0.939
1973	0.272	0.316	0.344	0.405	0.486	0.539	0.605	0.627	0.677	0.842
1974	0.285	0.311	0.354	0.405	0.476	0.554	0.609	0.693	0.707	0.926
1975	0.249	0.300	0.330	0.420	0.495	0.587	0.636	0.703	0.783	1.019
1976	0.265	0.295	0.338	0.375	0.513	0.594	0.641	0.705	0.741	0.980
1977	0.254	0.323	0.353	0.380	0.418	0.556	0.647	0.721	0.715	0.978
1978	0.244	0.315	0.369	0.397	0.438	0.491	0.609	0.687	0.776	0.950
1979	0.235	0.311	0.349	0.388	0.429	0.474	0.550	0.675	0.796	0.960
1980	0.238	0.286	0.344	0.401	0.473	0.545	0.588	0.662	0.772	1.013
1981	0.237	0.274	0.329	0.416	0.505	0.558	0.604	0.642	0.725	1.006
1982	0.279	0.262	0.311	0.424	0.514	0.608	0.664	0.712	0.738	0.983
1983	0.200	0.250	0.300	0.383	0.515	0.604	0.677	0.771	0.815	0.984
1984	0.233	0.263	0.283	0.375	0.491	0.613	0.684	0.725	0.837	1.034
1985	0.247	0.264	0.290	0.337	0.462	0.577	0.678	0.729	0.804	1.021
1986	0.221	0.269	0.304	0.347	0.425	0.488	0.675	0.751	0.853	1.013
1987	0.221	0.249	0.300	0.351	0.402	0.504	0.583	0.728	0.829	0.990

1988 0.221 0.254 0.278 0.352 0.453 0.512 0.608 0.699 0.813 1.014

1989 0.236 0.280 0.309 0.332 0.392 0.533 0.603 0.670 0.792 0.942

1990 0.271 0.285 0.298 0.317 0.366 0.447 0.597 0.692 0.761 1.002

1991 0.227 0.286 0.294 0.306 0.365 0.455 0.528 0.671 0.747 0.920

1992 0.251 0.263 0.290 0.318 0.341 0.425 0.531 0.605 0.715 0.890

1993 0.249 0.273 0.289 0.326 0.356 0.423 0.518 0.631 0.721 0.855

1994 0.229 0.263 0.286 0.339 0.397 0.449 0.502 0.611 0.732 0.905

1995 0.272 0.277 0.301 0.338 0.402 0.454 0.528 0.611 0.734 0.908

1996 0.240 0.280 0.307 0.355 0.420 0.486 0.499 0.589 0.720 0.858

1997 0.208 0.271 0.313 0.364 0.457 0.524 0.603 0.616 0.683 0.922

1998 0.152 0.260 0.310 0.394 0.497 0.607 0.633 0.695 0.700 0.912

1999 0.245 0.253 0.280 0.355 0.455 0.547 0.630 0.682 0.752 0.812

2000 0.228 0.267 0.284 0.314 0.432 0.500 0.684 0.710 0.751 0.887

2001 0.238 0.267 0.292 0.309 0.365 0.482 0.592 0.708 0.795 0.800

2002 0.237 0.264 0.289 0.316 0.348 0.445 0.511 0.692 0.761 0.899

2003 0.232 0.253 0.287 0.326 0.371 0.414 0.487 0.654 0.766 0.856

2004 0.214 0.247 0.283 0.328 0.398 0.437 0.510 0.557 0.797 0.869

2005 0.273 0.267 0.283 0.334 0.393 0.436 0.473 0.556 0.616 0.907

2006 0.253 0.268 0.285 0.333 0.393 0.403 0.468 0.482 0.525 0.744

2007 0.265 0.270 0.307 0.350 0.383 0.458 0.546 0.487 0.598 0.625

2008 0.249 0.267 0.308 0.345 0.406 0.456 0.542 0.731 0.645 0.642

2009 0.176 0.262 0.313 0.360 0.418 0.481 0.531 0.607 0.667 0.791

2010 0.210 0.267 0.308 0.351 0.420 0.472 0.511 0.622 0.682 0.643

2011 0.217 0.225 0.277 0.339 0.412 0.507 0.600 0.516 0.554 0.800

2012 0.201 0.251 0.299 0.350 0.376 0.431 0.515 0.556 0.550 0.668

2013 0.031 0.226 0.274 0.310 0.362 0.412 0.491 0.597 0.605 0.679

Table 8.2.7 . Plaice in IV . discards.wt

2014-05-03 09:40:18 units= kg

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.044	0.104	0.146	0.181	0.206	0.244	0.244	0.231	0	0
1958	0.047	0.096	0.158	0.188	0.200	0.244	0.000	0.000	0	0
1959	0.051	0.107	0.155	0.186	0.197	0.231	0.000	0.000	0	0
1960	0.045	0.112	0.159	0.188	0.204	0.212	0.244	0.000	0	0
1961	0.044	0.100	0.160	0.194	0.204	0.220	0.220	0.000	0	0
1962	0.042	0.098	0.155	0.193	0.213	0.221	0.221	0.231	0	0
1963	0.048	0.105	0.156	0.188	0.205	0.231	0.221	0.231	0	0
1964	0.032	0.114	0.160	0.192	0.204	0.221	0.244	0.231	0	0
1965	0.038	0.072	0.166	0.192	0.212	0.221	0.231	0.000	0	0
1966	0.038	0.101	0.125	0.194	0.205	0.231	0.231	0.244	0	0
1967	0.036	0.105	0.158	0.169	0.220	0.220	0.244	0.244	0	0
1968	0.060	0.096	0.156	0.191	0.192	0.244	0.220	0.000	0	0
1969	0.052	0.146	0.162	0.186	0.211	0.212	0.000	0.231	0	0
1970	0.049	0.114	0.179	0.189	0.196	0.000	0.220	0.231	0	0
1971	0.057	0.110	0.183	0.200	0.212	0.000	0.000	0.231	0	0
1972	0.061	0.147	0.173	0.211	0.211	0.244	0.000	0.000	0	0
1973	0.043	0.131	0.179	0.195	0.211	0.244	0.000	0.000	0	0
1974	0.054	0.106	0.173	0.212	0.220	0.231	0.244	0.000	0	0
1975	0.068	0.136	0.162	0.206	0.221	0.244	0.244	0.000	0	0
1976	0.085	0.153	0.176	0.195	0.220	0.000	0.244	0.000	0	0
1977	0.069	0.160	0.186	0.196	0.198	0.220	0.000	0.000	0	0
1978	0.069	0.143	0.197	0.205	0.211	0.213	0.231	0.000	0	0
1979	0.066	0.158	0.185	0.204	0.220	0.231	0.221	0.244	0	0
1980	0.055	0.149	0.191	0.212	0.231	0.000	0.000	0.000	0	0
1981	0.048	0.135	0.179	0.212	0.220	0.000	0.000	0.000	0	0
1982	0.054	0.126	0.182	0.203	0.231	0.244	0.244	0.000	0	0
1983	0.051	0.126	0.180	0.205	0.211	0.244	0.000	0.000	0	0
1984	0.053	0.127	0.172	0.211	0.205	0.000	0.244	0.000	0	0
1985	0.054	0.139	0.177	0.197	0.231	0.244	0.000	0.000	0	0
1986	0.049	0.124	0.181	0.196	0.220	0.244	0.244	0.000	0	0
1987	0.043	0.105	0.166	0.205	0.220	0.231	0.000	0.000	0	0

1988 0.043 0.098 0.153 0.185 0.220 0.244 0.000 0.000 0 0

1989 0.046 0.102 0.163 0.181 0.196 0.000 0.000 0.000 0 0

1990 0.051 0.111 0.157 0.186 0.212 0.231 0.000 0.000 0 0

1991 0.055 0.130 0.161 0.185 0.203 0.221 0.231 0.231 0 0

1992 0.050 0.122 0.167 0.188 0.204 0.212 0.231 0.244 0 0

1993 0.056 0.121 0.171 0.197 0.211 0.231 0.244 0.000 0 0

1994 0.060 0.140 0.175 0.194 0.213 0.244 0.244 0.221 0 0

1995 0.058 0.141 0.186 0.201 0.220 0.232 0.232 0.244 0 0

1996 0.052 0.122 0.179 0.205 0.221 0.232 0.000 0.000 0 0

1997 0.044 0.117 0.178 0.203 0.221 0.244 0.000 0.000 0 0

1998 0.047 0.086 0.170 0.199 0.220 0.000 0.244 0.000 0 0

1999 0.053 0.097 0.143 0.197 0.220 0.000 0.000 0.000 0 0

2000 0.059 0.110 0.151 0.174 0.244 0.000 0.203 0.000 0 0

2001 0.068 0.122 0.167 0.178 0.197 0.244 0.000 0.244 0 0

2002 0.056 0.119 0.172 0.193 0.198 0.220 0.000 0.000 0 0

2003 0.064 0.113 0.176 0.187 0.203 0.211 0.221 0.000 0 0

2004 0.054 0.117 0.167 0.194 0.198 0.220 0.204 0.000 0 0

2005 0.061 0.108 0.172 0.179 0.221 0.206 0.221 0.231 0 0

2006 0.060 0.128 0.163 0.196 0.199 0.204 0.212 0.220 0 0

2007 0.055 0.097 0.179 0.179 0.196 0.199 0.231 0.200 0 0

2008 0.056 0.116 0.165 0.188 0.189 0.231 0.220 0.191 0 0

2009 0.060 0.116 0.164 0.200 0.203 0.212 0.211 0.220 0 0

2010 0.060 0.117 0.158 0.199 0.188 0.197 0.211 0.231 0 0

2011 0.047 0.103 0.162 0.171 0.191 0.196 0.199 0.211 0 0

2012 0.052 0.093 0.142 0.188 0.198 0.206 0.215 0.215 0 0

2013 0.051 0.080 0.127 0.150 0.170 0.194 0.228 0.346 0 0

Table 8.2.8 . Plaice in IV . catch.wt

2014-05-03 09:40:35 units= kg

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.044	0.110	0.194	0.257	0.349	0.455	0.533	0.589	0.396	0.998
1958	0.047	0.106	0.189	0.256	0.329	0.452	0.513	0.615	0.665	0.992
1959	0.051	0.120	0.192	0.260	0.345	0.472	0.592	0.623	0.750	1.000
1960	0.045	0.115	0.204	0.287	0.377	0.480	0.601	0.683	0.724	1.094
1961	0.044	0.101	0.180	0.301	0.402	0.506	0.604	0.671	0.812	1.071
1962	0.042	0.099	0.181	0.273	0.397	0.538	0.570	0.692	0.777	1.127
1963	0.048	0.110	0.175	0.304	0.392	0.531	0.624	0.667	0.715	1.028
1964	0.032	0.126	0.204	0.271	0.379	0.485	0.628	0.700	0.737	1.005
1965	0.038	0.076	0.214	0.313	0.381	0.469	0.539	0.663	0.726	0.887
1966	0.038	0.104	0.148	0.315	0.428	0.483	0.559	0.624	0.690	0.933
1967	0.036	0.111	0.190	0.235	0.422	0.543	0.597	0.662	0.738	0.978
1968	0.060	0.116	0.223	0.275	0.340	0.516	0.590	0.596	0.686	0.911
1969	0.052	0.174	0.272	0.284	0.356	0.408	0.573	0.655	0.658	0.893
1970	0.049	0.131	0.268	0.352	0.394	0.441	0.499	0.672	0.744	0.892
1971	0.057	0.160	0.277	0.388	0.444	0.512	0.542	0.607	0.699	0.891
1972	0.067	0.207	0.290	0.407	0.486	0.540	0.608	0.646	0.674	0.939
1973	0.045	0.205	0.334	0.403	0.478	0.538	0.605	0.627	0.677	0.842
1974	0.056	0.121	0.343	0.404	0.472	0.552	0.609	0.693	0.707	0.926
1975	0.069	0.152	0.205	0.393	0.492	0.585	0.636	0.703	0.783	1.019
1976	0.088	0.181	0.262	0.347	0.509	0.592	0.641	0.705	0.741	0.980
1977	0.071	0.218	0.245	0.318	0.396	0.551	0.647	0.721	0.715	0.978
1978	0.070	0.190	0.315	0.364	0.432	0.486	0.609	0.687	0.776	0.950
1979	0.067	0.190	0.295	0.338	0.426	0.472	0.550	0.675	0.796	0.960
1980	0.056	0.197	0.343	0.399	0.471	0.542	0.588	0.662	0.772	1.013
1981	0.048	0.183	0.327	0.415	0.502	0.556	0.604	0.642	0.725	1.006
1982	0.056	0.152	0.308	0.421	0.512	0.606	0.664	0.712	0.738	0.983
1983	0.052	0.153	0.275	0.379	0.507	0.602	0.677	0.771	0.815	0.984
1984	0.053	0.150	0.265	0.323	0.480	0.610	0.684	0.725	0.837	1.034
1985	0.054	0.169	0.267	0.335	0.461	0.575	0.678	0.729	0.804	1.021
1986	0.049	0.141	0.276	0.314	0.422	0.487	0.675	0.751	0.853	1.013
1987	0.043	0.113	0.218	0.349	0.398	0.502	0.583	0.728	0.829	0.990

1988 0.043 0.102 0.197 0.277 0.449 0.510 0.608 0.699 0.813 1.014
1989 0.047 0.117 0.215 0.291 0.368 0.530 0.603 0.670 0.792 0.942
1990 0.053 0.129 0.209 0.290 0.361 0.446 0.597 0.692 0.761 1.002
1991 0.056 0.149 0.210 0.274 0.353 0.452 0.528 0.671 0.747 0.920
1992 0.055 0.145 0.225 0.276 0.333 0.419 0.531 0.605 0.715 0.890
1993 0.063 0.160 0.250 0.307 0.351 0.422 0.518 0.631 0.721 0.855
1994 0.064 0.179 0.257 0.337 0.393 0.448 0.502 0.611 0.732 0.905
1995 0.071 0.183 0.282 0.337 0.399 0.453 0.528 0.611 0.734 0.908
1996 0.054 0.140 0.268 0.343 0.417 0.484 0.499 0.589 0.720 0.858
1997 0.045 0.129 0.220 0.362 0.454 0.522 0.603 0.616 0.683 0.922
1998 0.047 0.094 0.207 0.299 0.492 0.604 0.633 0.695 0.700 0.912
1999 0.054 0.103 0.198 0.264 0.452 0.542 0.630 0.682 0.752 0.812
2000 0.063 0.123 0.209 0.274 0.418 0.487 0.630 0.609 0.751 0.887
2001 0.090 0.135 0.195 0.229 0.302 0.477 0.586 0.708 0.795 0.800
2002 0.057 0.132 0.223 0.291 0.342 0.441 0.499 0.692 0.761 0.899
2003 0.066 0.124 0.229 0.287 0.350 0.409 0.419 0.654 0.766 0.856
2004 0.054 0.124 0.221 0.307 0.388 0.433 0.508 0.557 0.797 0.869
2005 0.067 0.116 0.214 0.304 0.359 0.347 0.466 0.556 0.616 0.907
2006 0.060 0.139 0.211 0.297 0.383 0.396 0.436 0.460 0.525 0.744
2007 0.058 0.112 0.225 0.322 0.374 0.383 0.526 0.352 0.598 0.625
2008 0.057 0.122 0.244 0.328 0.395 0.444 0.360 0.464 0.645 0.642
2009 0.061 0.124 0.230 0.327 0.400 0.465 0.518 0.438 0.667 0.791
2010 0.062 0.131 0.219 0.309 0.395 0.437 0.457 0.568 0.682 0.643
2011 0.047 0.111 0.208 0.272 0.364 0.450 0.591 0.439 0.554 0.800
2012 0.052 0.095 0.189 0.291 0.343 0.420 0.506 0.555 0.550 0.668
2013 0.051 0.087 0.172 0.271 0.343 0.404 0.487 0.596 0.605 0.679

Table 8.2.9 . North Sea plaice. Natural mortality at age and maturity ate age

age	1	2	3	4	5	6	7	8	9	10
natural mortality	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
maturity	0	0.5	0.5	1	1	1	1	1	1	1

Table 8.2.10 . North Sea plaice. Survey tuning indices

BTS-Isis (older part of time series) units= NA

	1	2	3	4	5	6	7	8	9
1985	1	137	173.9	36.1	11.00	1.27	0.973	0.336	0.155	0.091
1986	1	667	131.7	50.2	9.21	3.78	0.400	0.418	0.147	0.070
1987	1	226	764.2	33.8	4.88	1.84	0.607	0.252	0.134	0.078
1988	1	680	147.0	182.3	9.99	2.81	0.814	0.458	0.036	0.112
1989	1	468	319.3	38.7	47.30	5.85	0.833	0.311	0.661	0.132
1990	1	185	146.1	79.3	26.35	5.47	0.758	0.189	0.383	0.239
1991	1	291	159.4	34.0	13.57	4.31	5.659	0.239	0.204	0.092
1992	1	361	174.5	29.3	5.96	3.75	2.871	1.186	0.346	0.050
1993	1	189	283.4	62.8	8.27	1.13	1.130	0.584	0.464	0.155
1994	1	193	77.1	34.5	10.59	2.67	0.600	0.800	0.895	0.373
1995	1	266	40.6	13.2	7.53	1.11	0.806	0.330	1.051	0.202

BTS-Combined units= NA

	1	2	3	4	5	6	7	8	9
1996	1	143.9	99.6	13.3	4.27	3.04	1.65	0.676	0.442	0.214
1997	1	386.8	28.7	14.9	4.01	2.04	1.54	0.428	0.797	0.327
1998	1	131.2	177.6	25.5	7.27	2.50	1.35	0.955	0.808	0.323
1999	1	117.0	53.6	96.3	6.49	3.00	1.93	0.659	0.756	0.314
2000	1	108.4	38.9	22.9	23.68	3.02	1.73	1.113	0.797	0.219
2001	1	80.3	39.8	15.7	8.75	9.30	1.08	0.624	0.420	0.511
2002	1	217.3	26.7	14.0	7.62	4.79	4.64	0.754	0.765	0.385
2003	1	53.6	94.4	15.9	10.30	5.36	3.08	4.007	0.732	0.760
2004	1	101.4	30.3	51.2	11.21	4.96	2.88	1.538	3.402	0.391
2005	1	70.8	45.6	13.8	20.39	3.04	6.94	1.568	0.571	3.570
2006	1	54.9	42.9	29.2	11.75	12.05	2.11	3.938	0.844	0.767
2007	1	139.4	44.4	24.6	26.58	5.68	11.69	2.091	3.947	0.364
2008	1	98.9	89.7	33.8	20.73	20.61	6.33	13.054	2.727	6.718
2009	1	170.8	76.5	54.1	21.48	12.83	12.19	3.139	10.254	1.585
2010	1	144.8	69.5	47.9	40.35	17.91	6.84	15.841	3.179	8.306
2011	1	226.5	126.0	58.1	32.75	33.17	15.09	5.808	11.940	1.124

2012 1 118.4 149.6 79.8 35.86 22.17 16.39 7.216 3.544 8.696

2013 1 192.8 90.5 90.3 46.71 27.60 15.37 11.273 4.523 3.224

SNS units= NA

1970 1 9311 9732 3273 770 170

1971 1 13538 28164 1415 101 50

1972 1 13207 10780 4478 89 84

1973 1 65643 5133 1578 461 15

1974 1 15366 16509 1129 160 82

1975 1 11628 8168 9556 65 15

1976 1 8537 2403 868 236 0

1977 1 18537 3424 1737 590 213

1978 1 14012 12678 345 135 45

1979 1 21495 9829 1575 161 17

1980 1 59174 12882 491 180 24

1981 1 24756 18785 834 38 32

1982 1 69993 8642 1261 88 8

1983 1 33974 13909 249 71 6

1984 1 44965 10413 2467 42 0

1985 1 28101 13848 1598 328 17

1986 1 93552 7580 1152 145 30

1987 1 33402 32991 1227 200 30

1988 1 36609 14421 13153 1350 88

1989 1 34276 17810 4373 7126 289

1990 1 25037 7496 3160 816 422

1991 1 57221 11247 1518 1077 128

1992 1 46798 13842 2268 613 176

1993 1 22098 9686 1006 98 60

1994 1 19188 4977 856 76 23

1995 1 24767 2796 381 97 38

1996 1 23015 10268 1185 45 47

1997 1 95901 4473 497 32 0

1998 1 33666 30242 5014 50 10

1999 1 32951 10272 13783 1058 17

2000 1 22855 2493 891 983 17

2001 1 11511 2898 370 176 691

2002 1 30809 1103 265 65 69

2003 1 NA NA NA NA NA

2004 1 18202 1350 1081 51 27

2005 1 10118 1819 142 366 8

SNS - continued

2006 1 12164 1571 385 52 54

2007 1 14175 2134 140 52 0

2008 1 14706 2700 464 179 34

2009 1 14860 2019 492 38 20

2010 1 11947 1812 529 55 10

2011 1 18349 1143 308 75 60

2012 1 5893 2929 682 82 30

2013 1 15395 3021 1638 428 89

Table 8.2.11. North Sea plaice DFS index catches (numbers per hour)

Note: used only for RCT3.

year	effort	age-0
1973	1	NA
1974	1	NA
1975	1	NA
1976	1	NA
1977	1	NA
1978	1	NA
1979	1	NA
1980	1	NA
1981	1	NA
1982	1	NA
1983	1	NA
1984	1	NA
1985	1	NA
1986	1	NA
1987	1	NA

1988	1	NA
1989	1	NA
1990	1	439.59
1991	1	332.36
1992	1	180.31
1993	1	216.99
1994	1	283.44
1995	1	146.08
1996	1	619.61
1997	1	229.24
1998	1	NA
1999	1	NA
2000	1	124.93
2001	1	313.18
2002	1	122.91
2003	1	238.63
2004	1	126.74
2005	1	85.88
2006	1	167.99
2007	1	98.25
2008	1	129.71
2009	1	141.87
2010	1	179.61
2011	1	92.96
2012	1	181.12
2013	1	164.44

Table 8.2.12. Allocation scheme for raising discard rates across countries and metiers

		Sampled metiers														
		DE_IV_OTB_DEF_>=120_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_1_D	DE_IV_TBB_DEF_70-99_0_0_all_2_D	DE_IV_TBB_DEF_70-99_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_4_D	DK_IV_OTB_DEF_>=120_0_0_all_2012_D	DK_IV_SDN_DEF_>=120_0_0_all_FDF_2012_D	NL_IV_OTB_CRU_70-99_0_0_all_1_D	NL_IV_OTB_CRU_70-99_0_0_all_2_D	NL_IV_OTB_CRU_70-99_0_0_all_3_D	NL_IV_OTB_CRU_70-99_0_0_all_4_D	NL_IV_TBB_DEF_70-99_0_0_all_1_D	NL_IV_TBB_DEF_70-99_0_0_all_2_D	NL_IV_TBB_DEF_70-99_0_0_all_3_D	NL_IV_TBB_DEF_70-99_0_0_all_4_D
Unsampled metiers	BE_IV_GNS_DEF_all_0_0_all_1_D												X	X	X	X
	BE_IV_GNS_DEF_all_0_0_all_2_D												X	X	X	X
	BE_IV_GNS_DEF_all_0_0_all_3_D												X	X	X	X
	BE_IV_GNS_DEF_all_0_0_all_4_D												X	X	X	X
	BE_IV_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	BE_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	BE_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	BE_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	BE_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	BE_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	BE_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	BE_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	BE_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	BE_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	BE_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	BE_IV_TBB_CRU_16-31_0_0_all_1_D												X	X	X	X
	BE_IV_TBB_CRU_16-31_0_0_all_2_D												X	X	X	X
	BE_IV_TBB_CRU_16-31_0_0_all_3_D												X	X	X	X
	BE_IV_TBB_CRU_16-31_0_0_all_4_D												X	X	X	X
	BE_IV_TBB_DEF_>=120_0_0_all_2_D	X					X									
	BE_IV_TBB_DEF_>=120_0_0_all_3_D	X					X									
	BE_IV_TBB_DEF_>=120_0_0_all_4_D	X					X									
	DE_IV_GNS_DEF_all_0_0_all_1_D												X	X	X	X
	DE_IV_GNS_DEF_all_0_0_all_2_D												X	X	X	X
	DE_IV_GNS_DEF_all_0_0_all_3_D												X	X	X	X
	DE_IV_GNS_DEF_all_0_0_all_4_D												X	X	X	X
	DE_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	DE_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	DE_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	DE_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	DE_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	DE_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	DE_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	DE_IV_OTB_DEF_>=120_0_0_all_FDF_1_D												X	X	X	X
	DE_IV_OTB_DEF_>=120_0_0_all_FDF_2_D												X	X	X	X
	DE_IV_OTB_DEF_>=120_0_0_all_FDF_3_D												X	X	X	X
	DE_IV_OTB_DEF_>=120_0_0_all_FDF_4_D												X	X	X	X
	DE_IV_TBB_CRU_16-31_0_0_all_2_D												X	X	X	X
	DE_IV_TBB_CRU_16-31_0_0_all_3_D												X	X	X	X
	DE_IV_TBB_CRU_16-31_0_0_all_4_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_1_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_2_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_2012_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_3_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_4_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_GNS_DEF_>=220_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_1_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_2_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_3_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_4_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_FDF_1_D												X	X	X	X
	DK_IV_GNS_DEF_100-119_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_1_D												X	X	X	X

Table 8.2.12. continued. Allocation scheme for raising discard rates across countries and metiers

		Sampled metiers														
		DE_IV_OTB_DEF_>=120_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_1_D	DE_IV_TBB_DEF_70-99_0_0_all_2_D	DE_IV_TBB_DEF_70-99_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_4_D	DK_IV_OTB_DEF_>=120_0_0_all_2012_D	DK_IV_SDN_DEF_>=120_0_0_all_FDF_2012_D	NL_IV_OTB_CRU_70-99_0_0_all_1_D	NL_IV_OTB_CRU_70-99_0_0_all_2_D	NL_IV_OTB_CRU_70-99_0_0_all_3_D	NL_IV_OTB_CRU_70-99_0_0_all_4_D	NL_IV_TBB_DEF_70-99_0_0_all_1_D	NL_IV_TBB_DEF_70-99_0_0_all_2_D	NL_IV_TBB_DEF_70-99_0_0_all_3_D	NL_IV_TBB_DEF_70-99_0_0_all_4_D
Unsampled metiers	DK_IV_GNS_DEF_120-219_0_0_all_2_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_3_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_4_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_FDF_1_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_FDF_2012_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_GNS_DEF_120-219_0_0_all_FDF_4_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_1_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_2_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_3_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_FDF_1_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_LLS_FIF_0_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	DK_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	DK_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	DK_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	DK_IV_MIS_MIS_0_0_0_IBC_2_D												X	X	X	X
	DK_IV_OTB_CRU_32-69_0_0_all_1_D												X	X	X	X
	DK_IV_OTB_CRU_32-69_0_0_all_2012_D												X	X	X	X
	DK_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	DK_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	DK_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	DK_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	DK_IV_OTB_CRU_70-99_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	DK_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	DK_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	DK_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	DK_IV_OTB_DEF_>=120_0_0_all_FDF_1_D												X	X	X	X
	DK_IV_OTB_DEF_>=120_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_OTB_DEF_>=120_0_0_all_FDF_2012_D												X	X	X	X
	DK_IV_OTB_DEF_>=120_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_OTB_DEF_>=120_0_0_all_FDF_4_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_1_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_2_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_3_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_4_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_FDF_1_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_FDF_2_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_SDN_DEF_>=120_0_0_all_FDF_4_D												X	X	X	X
	DK_IV_SSC_DEF_>=120_0_0_all_2_D												X	X	X	X
	DK_IV_SSC_DEF_>=120_0_0_all_3_D												X	X	X	X
	DK_IV_SSC_DEF_>=120_0_0_all_4_D												X	X	X	X
	DK_IV_SSC_DEF_>=120_0_0_all_FDF_3_D												X	X	X	X
	DK_IV_SSC_DEF_>=120_0_0_all_FDF_4_D												X	X	X	X
	DK_IV_TBB_DEF_>=120_0_0_all_1_D	X					X									
	DK_IV_TBB_DEF_>=120_0_0_all_2_D	X					X									
	DK_IV_TBB_DEF_>=120_0_0_all_3_D	X					X									
	DK_IV_TBB_DEF_>=120_0_0_all_4_D	X					X									
	FR_IV_DRB_MOL_0_0_0_all_1_D												X	X	X	X
	FR_IV_GNS_DEF_120-219_0_0_all_2_D												X	X	X	X

Table 8.2.12. continued. Allocation scheme for raising discard rates across countries and metiers

		Sampled metiers														
		DE_IV_OTB_DEF_>=120_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_1_D	DE_IV_TBB_DEF_70-99_0_0_all_2_D	DE_IV_TBB_DEF_70-99_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_4_D	DK_IV_OTB_DEF_>=120_0_0_all_2012_D	DK_IV_SDN_DEF_>=120_0_0_all_FDF_2012_D	NL_IV_OTB_CRU_70-99_0_0_all_1_D	NL_IV_OTB_CRU_70-99_0_0_all_2_D	NL_IV_OTB_CRU_70-99_0_0_all_3_D	NL_IV_OTB_CRU_70-99_0_0_all_4_D	NL_IV_TBB_DEF_70-99_0_0_all_1_D	NL_IV_TBB_DEF_70-99_0_0_all_2_D	NL_IV_TBB_DEF_70-99_0_0_all_3_D	NL_IV_TBB_DEF_70-99_0_0_all_4_D
Unsampled metiers	FR_IV_GNS_DEF_120-219_0_0_all_3_D												X	X	X	X
	FR_IV_GTR_DEF_all_0_0_all_1_D												X	X	X	X
	FR_IV_GTR_DEF_all_0_0_all_2_D												X	X	X	X
	FR_IV_GTR_DEF_all_0_0_all_3_D												X	X	X	X
	FR_IV_GTR_DEF_all_0_0_all_4_D												X	X	X	X
	FR_IV_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	FR_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	FR_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	FR_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	FR_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	FR_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	FR_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	FR_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	FR_IV_OTB_DEF_100-119_0_0_all_3_D												X	X	X	X
	FR_IV_OTB_DEF_70-99_0_0_all_1_D		X						X				X			
	FR_IV_OTB_DEF_70-99_0_0_all_2_D												X	X	X	X
	FR_IV_OTB_DEF_70-99_0_0_all_3_D												X	X	X	X
	FR_IV_OTB_DEF_70-99_0_0_all_4_D												X	X	X	X
	FR_IV_OTB_SPF_32-69_0_0_all_1_D												X	X	X	X
	FR_IV_OTB_SPF_32-69_0_0_all_2_D												X	X	X	X
	FR_IV_OTB_SPF_32-69_0_0_all_3_D												X	X	X	X
	FR_IV_OTB_SPF_32-69_0_0_all_4_D												X	X	X	X
	FR_IV_PTB_all_0_0_all_2_D												X	X	X	X
	FR_IV_PTB_all_0_0_all_3_D												X	X	X	X
	FR_IV_PTB_all_0_0_all_4_D												X	X	X	X
	FR_IV_TBB_DEF_70-99_0_0_all_1_D												X	X	X	X
	FR_IV_TBB_DEF_70-99_0_0_all_2_D			X						X				X		
	FR_IV_TBB_DEF_70-99_0_0_all_3_D				X						X				X	
	FR_IV_TBB_DEF_70-99_0_0_all_4_D					X						X				X
	NL_IV_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	NL_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	NL_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	NL_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	NL_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	NL_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	NL_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	NL_IV_SSC_DEF_>=120_0_0_all_2_D												X	X	X	X
	NL_IV_SSC_DEF_>=120_0_0_all_3_D							X								
	NL_IV_SSC_DEF_>=120_0_0_all_4_D							X								
	NL_IV_TBB_DEF_>=120_0_0_all_1_D	X					X									
	NL_IV_TBB_DEF_>=120_0_0_all_2_D	X					X									
	NL_IV_TBB_DEF_>=120_0_0_all_3_D	X					X									
	NL_IV_TBB_DEF_>=120_0_0_all_4_D	X					X									
	NL_IV_TBB_DEF_100-119_0_0_all_1_D												X	X	X	X
	NL_IV_TBB_DEF_100-119_0_0_all_2_D			X						X				X		
	NL_IV_TBB_DEF_100-119_0_0_all_3_D				X						X				X	
	NL_IV_TBB_DEF_100-119_0_0_all_4_D					X						X				X
	NO_IV_OTB-DEF_2012_D												X	X	X	X
	NO_IVa_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	NO_IVa_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	NO_IVa_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	NO_IVa_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	NO_IVb_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	NO_IVb_MIS_MIS_0_0_0_HC_2_D												X	X	X	X

Table 8.2.12. continued. Allocation scheme for raising discard rates across countries and metiers

		Sampled metiers														
		DE_IV_OTB_DEF_>=120_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_1_D	DE_IV_TBB_DEF_70-99_0_0_all_2_D	DE_IV_TBB_DEF_70-99_0_0_all_3_D	DE_IV_TBB_DEF_70-99_0_0_all_4_D	DK_IV_OTB_DEF_>=120_0_0_all_2012_D	DK_IV_SDN_DEF_>=120_0_0_all_FDF_2012_D	NL_IV_OTB_CRU_70-99_0_0_all_1_D	NL_IV_OTB_CRU_70-99_0_0_all_2_D	NL_IV_OTB_CRU_70-99_0_0_all_3_D	NL_IV_OTB_CRU_70-99_0_0_all_4_D	NL_IV_TBB_DEF_70-99_0_0_all_1_D	NL_IV_TBB_DEF_70-99_0_0_all_2_D	NL_IV_TBB_DEF_70-99_0_0_all_3_D	NL_IV_TBB_DEF_70-99_0_0_all_4_D
Unsampled metiers	NO_IVb_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	NO_IVb_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	SE_IV_LLS_FIF_0_0_0_all_1_D												X	X	X	X
	SE_IV_LLS_FIF_0_0_0_all_3_D												X	X	X	X
	SE_IV_LLS_FIF_0_0_0_all_4_D												X	X	X	X
	SE_IV_OTB_CRU_32-69_0_0_all_1_D												X	X	X	X
	SE_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	SE_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	SE_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	SE_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	SE_IV_SDN_DEF_>=120_0_0_all_3_D												X	X	X	X
	UKE_IV_GNS_DEF_all_0_0_all_1_D												X	X	X	X
	UKE_IV_GNS_DEF_all_0_0_all_2_D												X	X	X	X
	UKE_IV_GNS_DEF_all_0_0_all_3_D												X	X	X	X
	UKE_IV_GNS_DEF_all_0_0_all_4_D												X	X	X	X
	UKE_IV_GTR_DEF_all_0_0_all_1_D												X	X	X	X
	UKE_IV_GTR_DEF_all_0_0_all_2_D												X	X	X	X
	UKE_IV_GTR_DEF_all_0_0_all_3_D												X	X	X	X
	UKE_IV_GTR_DEF_all_0_0_all_4_D												X	X	X	X
	UKE_IV_LLS_FIF_0_0_0_all_4_D												X	X	X	X
	UKE_IV_MIS_MIS_0_0_0_HC_1_D												X	X	X	X
	UKE_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	UKE_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	UKE_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	UKE_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	UKE_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	UKE_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	UKE_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	UKE_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	UKE_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	UKE_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	UKE_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	UKE_IV_TBB_DEF_>=120_0_0_all_1_D	X					X									
	UKE_IV_TBB_DEF_>=120_0_0_all_2_D	X					X									
	UKE_IV_TBB_DEF_>=120_0_0_all_3_D	X					X									
	UKE_IV_TBB_DEF_>=120_0_0_all_4_D	X					X									
	UKE_IV_TBB_DEF_70-99_0_0_all_1_D												X	X	X	X
	UKE_IV_TBB_DEF_70-99_0_0_all_2_D			X						X				X		
	UKE_IV_TBB_DEF_70-99_0_0_all_3_D				X						X				X	
	UKE_IV_TBB_DEF_70-99_0_0_all_4_D					X						X				X
	UKS_IV_FPO_CRU_0_0_0_all_3_D												X	X	X	X
	UKS_IV_FPO_CRU_0_0_0_all_4_D												X	X	X	X
	UKS_IV_MIS_MIS_0_0_0_HC_2_D												X	X	X	X
	UKS_IV_MIS_MIS_0_0_0_HC_3_D												X	X	X	X
	UKS_IV_MIS_MIS_0_0_0_HC_4_D												X	X	X	X
	UKS_IV_OTB_CRU_70-99_0_0_all_1_D		X						X				X			
	UKS_IV_OTB_CRU_70-99_0_0_all_2_D			X						X				X		
	UKS_IV_OTB_CRU_70-99_0_0_all_3_D				X						X				X	
	UKS_IV_OTB_CRU_70-99_0_0_all_4_D					X						X				X
	UKS_IV_OTB_DEF_>=120_0_0_all_1_D	X					X									
	UKS_IV_OTB_DEF_>=120_0_0_all_2_D	X					X									
	UKS_IV_OTB_DEF_>=120_0_0_all_3_D	X					X									
	UKS_IV_OTB_DEF_>=120_0_0_all_4_D	X					X									
	UKS_IV_TBB_DEF_70-99_0_0_all_4_D					X						X				X

Table 8.2.15. North Sea Plaice. Numbers-at-age (x1000) and weights-at-age (kilograms) in the landings by quarter.

	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
Age	numbers	weight	numbers	weight	numbers	weight	numbers	weight
1	0.0	--	0.0	--	381.1	0.241	484.9	0.265
2	304.4	0.216	1453.0	0.238	8203.3	0.286	4284.9	0.285
3	2458.9	0.289	9241.4	0.276	13900.8	0.315	12427.0	0.330
4	13444.7	0.299	18712.3	0.316	14788.6	0.365	13875.5	0.421
5	7754.7	0.361	7047.0	0.395	3830.1	0.457	4123.9	0.526
6	5155.4	0.401	3036.5	0.463	1682.0	0.553	2231.8	0.595
7	4912.2	0.448	2028.4	0.513	976.5	0.557	1830.8	0.650
8	873.9	0.572	423.7	0.578	153.2	0.962	319.3	0.699
9	1019.9	0.568	796.6	0.524	246.6	0.981	418.3	1.055
10	225.0	0.655	69.0	0.803	7.4	0.952	215.4	0.433
11	198.7	0.517	121.6	0.435	0.0	--	26.1	0.965
12	51.1	0.893	15.4	1.250	20.4	0.886	20.5	1.213
13	30.5	1.107	3.9	1.716	0.0	--	10.2	1.711
14	171.5	0.594	3.9	0.583	85.5	0.511	13.1	1.972
15+	3.6	1.052	3.9	2.016	0.0	--	0.0	--

Table 8.3.1. North Sea plaice. XSA diagnostics from final run

FLR XSA Diagnostics 2014-05-03 09:41:33

CPUE data from indices

Catch data for 57 years. 1957 to 2013. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-Isis-early	1	8	1985	1995	0.66	0.75
2	BTS-Combined	1	9	1996	2013	0.66	0.75
3	SNS	1	3	1982	2013	0.66	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages >= 6

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

year

age 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

all 1 1 1 1 1 1 1 1 1 1

Fishing mortalities

year

age 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

1 0.216 0.146 0.304 0.078 0.152 0.155 0.146 0.077 0.112 0.108

2 0.661 0.492 0.578 0.505 0.359 0.317 0.276 0.182 0.272 0.259

3 0.467 0.476 0.451 0.460 0.293 0.244 0.221 0.201 0.272 0.215

4 0.504 0.361 0.416 0.223 0.309 0.243 0.233 0.294 0.242 0.211

5 0.239 0.452 0.246 0.295 0.166 0.254 0.182 0.237 0.238 0.169

6 0.538 0.240 0.235 0.177 0.158 0.126 0.198 0.154 0.172 0.189

7 0.351 0.463 0.120 0.119 0.150 0.108 0.097 0.122 0.091 0.105

8 0.142 0.287 0.325 0.089 0.099 0.088 0.082 0.093 0.075 0.056

9 0.102 0.085 0.200 0.105 0.020 0.038 0.034 0.056 0.041 0.067

10 0.102 0.085 0.200 0.105 0.020 0.038 0.034 0.056 0.041 0.067

XSA population number (Thousand)

age

year 1 2 3 4 5 6 7 8 9 10

2004 1265282 413296 615219 110582 106190 28945 17104 36148 4505 5899

2005 745754 922788 192998 349050 60442 75646 15297 10898 28386 7931

2006 885430 583029 510399 108505 220077 34804 53841 8708 7403 7839

2007 1094759 591081 295996 294262 64799 155681 24886 43208 5691 13287

2008 1014129 915899 322832 168997 213053 43640 117956 19998 35775 47619

2009 1102499 788525 578907 217827 112284 163244 33721 91857 16390 22678

2010 1300045 854714 519897 410330 154625 78835 130210 27392 76113 39139

2011 1658442 1016589 586822 376964 294240 116619 58512 106911 22836 51979

2012 906860 1388824 767000 434419 254238 210160 90419 46848 88162 47759

2013 1318731 733866 957526 528899 308585 181359 160100 74707 39323 60969

Estimated population abundance at 1st Jan 2014

age

year 1 2 3 4 5 6 7 8 9 10

2014 0 1071252 512750 698614 387491 235702 135786 130388 63912 33279

Fleet: BTS-Isis-early

Log catchability residuals.

year

age 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995

1 -1.152 -0.496 -0.733 0.476 0.489 -0.339 0.294 0.651 0.388 0.551 -0.128

2 0.017 -0.590 0.269 -0.567 0.291 -0.185 0.078 0.336 0.906 -0.012 -0.544

3 -0.249 0.204 -0.446 0.337 -0.446 0.320 -0.197 -0.136 0.744 0.209 -0.339

4 -0.355 -0.202 -0.603 -0.168 0.442 0.568 0.027 -0.449 0.063 0.453 0.224

5 -0.513 0.078 -0.286 0.356 0.740 -0.261 0.152 0.284 -0.605 0.341 -0.287

6 0.246 -0.696 -0.744 -0.047 0.135 -0.354 0.816 0.660 0.141 -0.232 0.076

7 0.019 0.064 -0.282 -0.250 -0.250 -0.676 -0.740 -0.008 -0.381 0.728 -0.065

8 -0.149 -0.077 -0.429 -1.188 0.889 0.605 0.152 0.466 -0.368 0.477 1.801

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

1 2 3 4 5 6 7 8

Mean_Logq -8.1012 -8.0925 -8.8322 -9.5457 -10.2253 -10.4520 -10.4520 -10.452

S.E_Logq 0.6059 0.4581 0.3856 0.3921 0.4198 0.4925 0.3981 0.787

Fleet: BTS-Combined

Log catchability residuals.

year

age 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007

1 -0.105 0.354 0.360 0.174 -0.104 0.165 0.097 -0.163 -0.349 -0.228 -0.544 0.017
2 0.381 -0.820 0.255 0.159 -0.306 -0.252 -0.185 0.075 0.087 -0.426 0.032 0.001
3 0.098 -0.543 0.160 0.317 -0.154 -0.243 -0.555 0.069 0.138 -0.008 -0.249 0.131
4 -0.335 -0.227 -0.094 0.052 -0.389 -0.243 -0.089 -0.244 0.395 -0.257 0.398 0.081
5 -0.183 -0.185 0.108 -0.080 0.154 -0.454 0.041 0.366 -0.537 -0.315 -0.374 0.132
6 -0.188 -0.085 -0.006 0.450 -0.058 -0.356 -0.545 0.303 0.379 0.087 -0.333 -0.158
7 -0.609 -0.823 0.138 -0.276 0.365 -0.556 -0.124 -0.131 0.145 0.355 -0.224 -0.087
8 -0.310 0.263 0.396 0.487 0.238 -0.278 0.031 0.303 0.043 -0.441 0.202 -0.024
9 -0.221 0.191 -0.032 -0.003 -0.303 0.042 -0.080 0.276 -0.066 0.293 0.180 -0.369

year
age 2008 2009 2010 2011 2012 2013
1 -0.198 0.267 -0.069 0.086 0.066 0.176
2 0.163 0.124 -0.081 0.273 0.197 0.322
3 0.246 0.095 0.067 0.124 0.222 0.085
4 0.448 0.183 0.173 0.092 0.005 0.050
5 0.139 0.368 0.331 0.342 0.086 0.063
6 0.487 -0.199 0.002 0.370 -0.123 -0.028
7 0.211 0.008 0.268 0.083 -0.158 -0.273
8 0.384 0.176 0.210 0.180 -0.222 -0.458
9 0.648 -0.003 0.115 -0.666 0.019 -0.148

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

	1	2	3	4	5	6	7	8	9
Mean_Logq	-8.8600	-9.0707	-9.1317	-9.1657	-9.1949	-9.1436	-9.1436	-9.1436	-9.1436
S.E_Logq	0.2424	0.3030	0.2510	0.2561	0.2858	0.2952	0.3332	0.2931	0.2889

Fleet: SNS

Log catchability residuals.

year
age 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995

1 0.522 0.234 0.596 -0.287 -0.014 -0.197 0.001 0.323 0.107 1.113 1.055 0.689 0.689 -0.053

2 0.765 0.461 0.627 0.956 0.024 0.596 0.580 0.874 0.315 0.896 1.271 1.000 0.717 0.249

3 0.412 -1.055 0.470 0.435 0.230 0.036 1.508 1.174 0.896 0.496 1.107 0.410 0.314 -0.085

year

age 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

1 -0.249 0.648 0.688 0.596 0.028 -0.089 -0.168 NA -0.378 -0.486 -0.362 -0.580 -0.415

2 0.600 -0.186 0.976 0.998 -0.562 -0.380 -0.881 NA -0.533 -1.158 -0.785 -0.544 -0.849

3 1.182 -0.442 2.035 1.873 0.101 -0.490 -1.024 NA -0.220 -1.084 -1.077 -1.537 -0.543

year

age 2009 2010 2011 2012 2013

1 -0.486 -0.876 -0.738 -1.246 -0.663

2 -1.020 -1.237 -1.938 -1.245 -0.586

3 -1.103 -0.939 -1.616 -1.039 -0.424

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

1 2 3

Mean_Logq -3.6408 -4.6541 -5.7245

S.E_Logq 0.5812 0.8701 0.9917

Terminal year survivor and F summaries:

Age = 1 . Catchability constand w.r.t. time and dependant on age

Year class = 2012

Fleet = BTS-Combined

1

Survivors 1277159.000

Raw weights 9.975

Fleet = fshk

1

Survivors 890378.00

Raw weights 0.25

Fleet = SNS
     1
Survivors 551965.000
Raw weights 2.575

 Fleet   Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BTS-Combined" "1277159" "0.3" "Inf" "Inf" "1" "0.779" "0.091"
[2,] "fshk"   "890378" "1.895" "Inf" "Inf" "1" "0.02" "0.128"
[3,] "SNS"   "551965" "0.59" "Inf" "Inf" "1" "0.201" "0.2"

Weighted prediction:

 Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "1071252" "" "" "" "0.108"

Age = 2 . Catchability constand w.r.t. time and dependant on age
 Year class = 2011

Fleet = BTS-Combined
     2   1
Survivors 707640.000 547634.000
Raw weights 7.968 7.673

Fleet = fshk
     2
Survivors 465068.00
Raw weights 0.25

Fleet = SNS

2 1

Survivors 285387.000 147453.000

Raw weights 0.988 1.981

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F

[1,] "BTS-Combined" "624024" "0.216" "0.128" "0.593" "2" "0.829" "0.217"

[2,] "fshk" "465068" "1.757" "Inf" "Inf" "1" "0.013" "0.282"

[3,] "SNS" "183696" "0.492" "0.311" "0.632" "2" "0.157" "0.601"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "512750" "" "" "" "0.259"

Age = 3 . Catchability constand w.r.t. time and dependant on age

Year class = 2010

Fleet = BTS-Combined

3 2 1

Survivors 760914.000 850662.00 761515.000

Raw weights 8.959 6.34 6.318

Fleet = fshk

3

Survivors 599424.00

Raw weights 0.25

Fleet = SNS

3 2 1

Survivors 457090.000 201080.000 333901.000

Raw weights 0.794 0.786 1.631

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BTS-Combined" "786388" "0.177" "0.036" "0.203" "3" "0.862" "0.193"
[2,] "fshk" "599424" "1.796" "Inf" "Inf" "1" "0.01" "0.247"
[3,] "SNS" "318737" "0.446" "0.206" "0.462" "3" "0.128" "0.423"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "698614" "" "" "" "0.215"

Age = 4 . Catchability constand w.r.t. time and dependant on age
Year class = 2009

Fleet = BTS-Combined
4 3 2 1
Survivors 407521.000 484005.000 509338.000 361542.00
Raw weights 8.996 6.856 5.309 4.94

Fleet = fshk
4
Survivors 300738.00
Raw weights 0.25

Fleet = SNS
3 2 1
Survivors 137122.000 55799.000 161436.000
Raw weights 0.608 0.658 1.275

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BTS-Combined" "436146" "0.155" "0.073" "0.471" "4" "0.903" "0.19"
[2,] "fshk" "300738" "1.8" "Inf" "Inf" "1" "0.009" "0.265"
[3,] "SNS" "117904" "0.445" "0.316" "0.71" "3" "0.088" "0.572"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "387491" "" "" "" "0.211"

Age = 5 . Catchability constand w.r.t. time and dependant on age
Year class = 2008

Fleet = BTS-Combined
5 4 3 2 1
Survivors 250979.000 236811.000 266803.000 217386.000 307835.000
Raw weights 9.379 7.363 6.024 4.245 3.916

Fleet = fshk
5
Survivors 180834.00
Raw weights 0.25

Fleet = SNS
3 2 1
Survivors 46831.000 68396.000 144903.000
Raw weights 0.534 0.526 1.011

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BTS-Combined" "252038" "0.142" "0.049" "0.345" "5" "0.93" "0.159"
[2,] "fshk" "180834" "1.837" "Inf" "Inf" "1" "0.008" "0.216"

[3,] "SNS" "89483" "0.448" "0.346" "0.772" "3" "0.062" "0.396"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "235702" "" "" "" "0.169"

Age = 6 . Catchability constand w.r.t. time and dependant on age
Year class = 2007

Fleet = BTS-Combined
6 5 4 3 2 1
Survivors 131996.000 147905.000 148917.000 145172.000 153699.00 111386.000
Raw weights 8.995 7.248 5.402 4.329 2.93 2.711

Fleet = fshk
6
Survivors 161097.00
Raw weights 0.25

Fleet = SNS
3 2 1
Survivors 53072.000 48965.000 89622.0
Raw weights 0.384 0.363 0.7

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F
[1,] "BTS-Combined" "140057" "0.134" "0.039" "0.291" "6" "0.949" "0.184"
[2,] "fshk" "161097" "1.819" "Inf" "Inf" "1" "0.008" "0.162"
[3,] "SNS" "67009" "0.45" "0.2" "0.444" "3" "0.043" "0.353"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "135786" "" "" "" "0.189"

Age = 7 . Catchability constand w.r.t. time and dependant on age

Year class = 2006

Fleet = BTS-Combined

7 6 5 4 3 2 1

Survivors 99251.000 115241.000 183494.000 154995.000 143436.000 153492.000 132605.000

Raw weights 7.088 8.237 6.646 5.267 4.126 2.677 2.665

Fleet = fshk

7

Survivors 120214.00

Raw weights 0.25

Fleet = SNS

3 2 1

Survivors 43252.000 55768.000 72976.000

Raw weights 0.366 0.332 0.688

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F

[1,] "BTS-Combined" "134373" "0.128" "0.087" "0.68" "7" "0.957" "0.102"

[2,] "fshk" "120214" "1.897" "Inf" "Inf" "1" "0.007" "0.114"

[3,] "SNS" "59597" "0.449" "0.156" "0.347" "3" "0.036" "0.218"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "130388" "" "" "" "0.105"

Age = 8 . Catchability constand w.r.t. time and dependant on age

Year class = 2005

Fleet = BTS-Combined

8 7 6 5 4 3 2 1

Survivors 40405.000 54581.000 92552.000 88948.000 76743.000 81707.000 63980.000 37082.000

Raw weights 9.904 6.799 8.042 6.851 5.375 4.008 2.247 1.785

Fleet = fshk

8

Survivors 40380.00

Raw weights 0.25

Fleet = SNS

3 2 1

Survivors 37122.000 37108.000 44499.000

Raw weights 0.355 0.279 0.461

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F

[1,] "BTS-Combined" "64807" "0.122" "0.127" "1.041" "8" "0.971" "0.055"

[2,] "fshk" "40380" "1.945" "Inf" "Inf" "1" "0.005" "0.087"

[3,] "SNS" "40061" "0.468" "0.063" "0.135" "3" "0.024" "0.088"

Weighted prediction:

Suvivors Int.s.e. Ext.s.e. Var.Ratio F

[1,] "63912" "" "" "" "0.056"

Age = 9 . Catchability constand w.r.t. time and dependant on age

Year class = 2004

Fleet = BTS-Combined

9 8 7 6 5 4 3 2

Survivors 28709.000 26642.000 36141.000 33348.000 48057.000 52087.000 37938.000 34352.000

Raw weights 10.392 9.089 6.046 6.846 5.429 3.986 2.515 1.311

1

Survivors 26488.000

Raw weights 1.219

Fleet = fshk

9

Survivors 14599.00

Raw weights 0.25

Fleet = SNS

3 2 1

Survivors 7155.000 15183.000 20472.000

Raw weights 0.223 0.163 0.315

Fleet Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N Scaled Wgts Estimated F

[1,] "BTS-Combined" "33874" "0.12" "0.079" "0.658" "9" "0.98" "0.066"

[2,] "fshk" "14599" "1.934" "Inf" "Inf" "1" "0.005" "0.147"

[3,] "SNS" "13666" "0.464" "0.324" "0.698" "3" "0.015" "0.156"

Weighted prediction:

```
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "33279" ""  ""  ""  "0.067"
```

Table 8.3.2 . Plaice in IV . harvest

2014-05-03 18:00:32 units= f

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.077	0.228	0.271	0.325	0.370	0.224	0.293	0.336	0.311	0.311
1958	0.105	0.250	0.308	0.373	0.389	0.336	0.280	0.303	0.337	0.337
1959	0.152	0.310	0.356	0.379	0.416	0.389	0.355	0.314	0.372	0.372
1960	0.108	0.317	0.353	0.385	0.366	0.419	0.383	0.359	0.384	0.384
1961	0.096	0.288	0.345	0.362	0.423	0.334	0.365	0.443	0.386	0.386
1962	0.095	0.316	0.366	0.385	0.417	0.409	0.347	0.336	0.380	0.380
1963	0.148	0.361	0.415	0.435	0.425	0.476	0.452	0.454	0.450	0.450
1964	0.031	0.395	0.443	0.464	0.536	0.484	0.400	0.387	0.455	0.455
1965	0.068	0.264	0.391	0.407	0.350	0.501	0.411	0.347	0.404	0.404
1966	0.071	0.352	0.382	0.426	0.475	0.341	0.503	0.406	0.432	0.432
1967	0.054	0.347	0.400	0.403	0.472	0.501	0.307	0.432	0.425	0.425
1968	0.195	0.283	0.342	0.359	0.366	0.323	0.410	0.289	0.350	0.350
1969	0.146	0.312	0.336	0.348	0.327	0.445	0.304	0.414	0.369	0.369
1970	0.218	0.424	0.473	0.482	0.442	0.481	0.567	0.247	0.445	0.445
1971	0.191	0.325	0.383	0.387	0.407	0.394	0.427	0.411	0.406	0.406
1972	0.227	0.373	0.394	0.409	0.416	0.440	0.404	0.474	0.430	0.430
1973	0.113	0.392	0.438	0.548	0.553	0.419	0.393	0.487	0.482	0.482
1974	0.220	0.397	0.495	0.518	0.598	0.456	0.397	0.467	0.489	0.489
1975	0.356	0.503	0.535	0.578	0.625	0.643	0.499	0.525	0.576	0.576
1976	0.334	0.411	0.433	0.442	0.393	0.445	0.531	0.464	0.456	0.456
1977	0.323	0.474	0.499	0.504	0.672	0.424	0.445	0.539	0.519	0.519
1978	0.303	0.423	0.453	0.459	0.447	0.504	0.447	0.413	0.455	0.455
1979	0.423	0.632	0.660	0.669	0.679	0.703	0.699	0.601	0.673	0.673
1980	0.237	0.466	0.670	0.627	0.514	0.522	0.497	0.506	0.535	0.535
1981	0.179	0.486	0.587	0.614	0.592	0.459	0.515	0.545	0.547	0.547
1982	0.243	0.521	0.702	0.688	0.615	0.529	0.490	0.547	0.576	0.576
1983	0.239	0.524	0.572	0.758	0.615	0.538	0.465	0.483	0.574	0.574
1984	0.302	0.555	0.587	0.609	0.647	0.551	0.495	0.576	0.578	0.578
1985	0.263	0.475	0.493	0.701	0.482	0.512	0.517	0.506	0.546	0.546
1986	0.285	0.611	0.638	0.643	0.730	0.717	0.584	0.678	0.790	0.790
1987	0.218	0.645	0.685	0.741	0.789	0.660	0.801	0.529	0.733	0.733

1988 0.233 0.624 0.668 0.685 0.727 0.704 0.682 0.999 0.816 0.816

1989 0.212 0.585 0.614 0.629 0.655 0.643 0.640 0.668 1.385 1.385

1990 0.162 0.477 0.579 0.571 0.694 0.608 0.543 0.507 0.659 0.659

1991 0.240 0.607 0.662 0.694 0.633 0.726 0.694 0.696 0.756 0.756

1992 0.214 0.557 0.656 0.679 0.793 0.569 0.603 0.753 1.191 1.191

1993 0.220 0.487 0.605 0.645 0.750 0.702 0.402 0.426 1.039 1.039

1994 0.164 0.482 0.605 0.706 0.625 0.647 0.887 0.301 0.329 0.329

1995 0.121 0.461 0.646 0.771 0.749 0.596 0.673 0.622 0.156 0.156

1996 0.096 0.546 0.688 0.725 0.744 0.654 0.743 0.670 0.843 0.843

1997 0.065 0.794 0.929 0.760 0.771 0.722 0.601 0.550 0.716 0.716

1998 0.154 0.495 0.997 1.075 0.644 0.445 0.549 0.434 0.491 0.491

1999 0.174 0.480 0.520 1.178 0.638 0.516 0.310 0.454 0.452 0.452

2000 0.120 0.367 0.334 0.582 0.556 0.483 0.299 0.188 0.305 0.305

2001 0.070 0.722 0.995 0.907 0.807 0.432 0.392 0.203 0.132 0.132

2002 0.210 0.595 0.518 0.636 0.693 0.450 0.515 0.238 0.177 0.177

2003 0.146 0.624 0.622 0.473 0.695 0.640 0.466 0.291 0.115 0.115

2004 0.216 0.661 0.467 0.504 0.239 0.538 0.351 0.142 0.102 0.102

2005 0.146 0.492 0.476 0.361 0.452 0.240 0.463 0.287 0.085 0.085

2006 0.304 0.578 0.451 0.416 0.246 0.235 0.120 0.325 0.200 0.200

2007 0.078 0.505 0.460 0.223 0.295 0.177 0.119 0.089 0.105 0.105

2008 0.152 0.359 0.293 0.309 0.166 0.158 0.150 0.099 0.020 0.020

2009 0.155 0.317 0.244 0.243 0.254 0.126 0.108 0.088 0.038 0.038

2010 0.146 0.276 0.221 0.233 0.182 0.198 0.097 0.082 0.034 0.034

2011 0.077 0.182 0.201 0.294 0.237 0.154 0.122 0.093 0.056 0.056

2012 0.112 0.272 0.272 0.242 0.238 0.172 0.091 0.075 0.041 0.041

2013 0.108 0.259 0.215 0.211 0.169 0.189 0.105 0.056 0.067 0.067

Table 8.3.3 . Plaice in IV . stock.n

table 8.3.3 . Plaice in IV . stock.n

2014-05-03 18:26:04 units= thousands

age

year 1 2 3 4 5 6 7 8 9 10

1957 460521 260191 335430 191665 123255 51720 50634 36913 21748 47346

1958 700348 385919 187501 231551 125324 77051 37389 34165 23863 51186

1959 864884 570730 272018 124696 144309 76860 49837 25559 22822 55786

1960 760714 672155 378788 172421 77206 86127 47154 31611 16898 50156

1961 866067 617990 442780 240736 106208 48428 51268 29083 19973 48656

1962 593500 711758 419437 283714 151716 62980 31370 32208 16899 41002

1963 694667 488256 469574 263211 174662 90493 37844 20055 20836 48855

1964 2254801 542082 308043 280621 154099 103321 50871 21786 11522 48679

1965 701912 1977414 330602 178902 159702 81553 57635 30870 13392 55694

1966 594039 593540 1374564 202397 107758 101846 44695 34586 19749 45406

1967 407183 500890 377874 848472 119570 60655 65526 24460 20849 34494

1968 438877 349221 320389 229254 513131 67454 33243 43599 14368 48762

1969 658773 326749 238042 205980 144865 321942 44202 19956 29561 57866

1970 664183 515043 216447 153975 131666 94525 186695 29517 11931 42133

1971 420267 483365 304957 122025 86052 76612 52868 95813 20858 54784

1972 374193 314299 316049 188202 74972 51850 46738 31216 57480 48213

1973 1319825 269812 195895 192887 113107 44759 30220 28224 17581 68984

1974 1135130 1067063 165033 114370 100861 58882 26625 18463 15695 61681

1975 863655 824073 649344 91063 61664 50167 33777 16196 10472 49969

1976 690881 547454 450763 344032 46232 29867 23863 18564 8669 36768

1977 988522 447473 328494 264542 200134 28227 17326 12697 10564 23796

1978 916917 647272 251974 180541 144557 92475 16708 10044 6704 20610

1979 897617 612805 383515 144885 103268 83662 50562 9670 6014 19781

1980 1133010 532078 294788 179376 67117 47408 37486 22743 4798 13828

1981 864123 808915 302003 136518 86716 36324 25444 20629 12406 15024

1982 2017226 654046 450278 151898 66865 43403 20767 13758 10827 20822

1983 1300560 1430826 351411 201880 69099 32709 23137 11510 7202 19758

1984 1253422 926998 766351 179546 85595 33812 17288 13155 6426 15432

1985 1843651 838519 481285 385601 88396 40543 17628 9539 6694 14155

1986 4742574 1282478 471692 266055 173103 49397 21984 9508 5206 13139

1987 1940642 3226834 629929 225512 126550 75514 21825 11090 4367 10928
1988 1763214 1412078 1531805 287388 97252 52014 35327 8865 5914 11547
1989 1179320 1263826 684653 710934 131124 42541 23282 16154 2954 7673
1990 1031648 863024 637346 335271 342909 61611 20230 11105 7498 8232
1991 910359 793796 484544 323101 171314 155028 30340 10634 6052 10658
1992 775023 648193 391248 226145 146081 82293 67896 13715 4797 10226
1993 530061 566093 335976 183618 103750 59803 42134 33626 5843 9335
1994 442351 384728 314820 166019 87205 44358 26810 25505 19869 20047
1995 1164069 339872 214959 155492 74185 42219 21016 9988 17087 27478
1996 1292393 932897 193926 101985 65059 31749 21052 9703 4853 8983
1997 2148445 1062546 488951 88179 44710 27966 14943 9060 4491 8611
1998 771547 1820775 434698 174793 37311 18713 12293 7412 4732 8395
1999 840137 598502 1003998 145070 53961 17733 10855 6423 4344 8803
2000 989336 638563 335091 540097 40433 25787 9574 7201 3692 8191
2001 540716 794341 400191 217049 273193 20972 14390 6423 5399 19575
2002 1728770 456147 349259 133814 79291 110317 12315 8798 4744 10160
2003 528668 1268394 227715 188302 64074 35866 63665 6659 6277 8270
2004 1265282 413296 615219 110582 106190 28945 17104 36148 4505 5899
2005 745754 922788 192998 349050 60442 75646 15297 10898 28386 7931
2006 885430 583029 510399 108505 220077 34804 53841 8708 7403 7839
2007 1094759 591081 295996 294262 64799 155681 24886 43208 5691 13287
2008 1014129 915899 322832 168997 213053 43640 117956 19998 35775 47619
2009 1102499 788525 578907 217827 112284 163244 33721 91857 16390 22678
2010 1300045 854714 519897 410330 154625 78835 130210 27392 76113 39139
2011 1658442 1016589 586822 376964 294240 116619 58512 106911 22836 51979
2012 906860 1388824 767000 434419 254238 210160 90419 46848 88162 47759
2013 1318731 733866 957526 528899 308585 181359 160100 74707 39323 60969
2014 NA 1071226 512730 698584 387469 235686 135773 130374 63907 84870

Table 8.4.1. North Sea plaice. Stock summary table.

recruits	ssb	catch	landings	discards	fbar2-6	fbar hc2-6	fbar dis2-3	Y/ssb
1957	460521	285168	78443	70563	7880	0.28	0.23	0.12	0.25
1958	700348	293812	88191	73354	14837	0.33	0.25	0.19	0.25
1959	864884	299088	109164	79300	29864	0.37	0.24	0.24	0.27
1960	760714	308720	117334	87541	29793	0.37	0.27	0.23	0.28
1961	866067	321356	118474	85984	32490	0.35	0.24	0.27	0.27
1962	593500	371851	125375	87472	37903	0.38	0.24	0.29	0.24
1963	694667	373663	148376	107118	41258	0.42	0.27	0.35	0.29
1964	2254801	366000	147571	110540	37031	0.46	0.30	0.32	0.30
1965	701912	349389	140223	97143	43080	0.38	0.28	0.24	0.28
1966	594039	366355	166552	101834	64718	0.40	0.24	0.33	0.28
1967	407183	421537	163365	108819	54546	0.42	0.25	0.31	0.26
1968	438877	410960	139521	111534	27987	0.33	0.21	0.21	0.27
1969	658773	385427	142820	121651	21169	0.35	0.26	0.17	0.32
1970	664183	336816	159982	130342	29640	0.46	0.34	0.28	0.39
1971	420267	325080	136939	113944	22995	0.38	0.29	0.21	0.35
1972	374193	327459	142475	122843	19632	0.41	0.32	0.18	0.38
1973	1319825	276793	143783	130429	13354	0.47	0.41	0.13	0.47
1974	1135130	286007	157485	112540	44945	0.49	0.41	0.20	0.39
1975	863655	297128	195235	108536	86699	0.58	0.39	0.43	0.37
1976	690881	308562	166917	113670	53247	0.42	0.30	0.27	0.37
1977	988522	312575	176689	119188	57501	0.51	0.34	0.31	0.38
1978	916917	298625	159639	113984	45655	0.46	0.35	0.22	0.38
1979	897617	296724	213282	145347	67935	0.67	0.49	0.36	0.49
1980	1133010	272363	171485	140405	31080	0.56	0.50	0.15	0.52
1981	864123	262315	173596	140565	33031	0.55	0.48	0.16	0.54
1982	2017226	260511	204508	155381	49127	0.61	0.52	0.22	0.60
1983	1300560	309609	219386	144903	74483	0.60	0.49	0.27	0.47
1984	1253422	316982	227848	157032	70816	0.59	0.43	0.28	0.50
1985	1843651	338997	221419	160870	60549	0.53	0.44	0.23	0.47
1986	4742574	365403	296472	166519	129953	0.67	0.50	0.34	0.46
1987	1940642	441906	345628	155104	190524	0.70	0.49	0.51	0.35
1988	1763214	382252	312684	156261	156423	0.68	0.41	0.52	0.41
1989	1179320	405052	279112	171319	107793	0.63	0.39	0.47	0.42

1990 1031648 365460 229016 157791 71225 0.59 0.40 0.40 0.43

1991 910359 334858 230278 149343 80935 0.66 0.43 0.48 0.45

1992 775023 272423 183326 126277 57049 0.65 0.43 0.41 0.46

1993 530061 235734 153043 118027 35016 0.64 0.50 0.28 0.50

1994 442351 213206 135227 111442 23785 0.61 0.51 0.24 0.52

1995 1164069 202396 121063 99235 21828 0.64 0.55 0.21 0.49

1996 1292393 180524 134647 82598 52049 0.67 0.52 0.35 0.46

1997 2148445 205945 184297 84152 100145 0.80 0.52 0.69 0.41

1998 771547 227261 176282 72531 103751 0.73 0.38 0.60 0.32

1999 840137 201924 152696 81720 70976 0.67 0.37 0.39 0.40

2000 989336 228388 126783 82472 44311 0.46 0.32 0.26 0.36

2001 540716 272077 183182 82873 100309 0.77 0.31 0.72 0.30

2002 1728770 197124 125777 71387 54390 0.58 0.38 0.42 0.36

2003 528668 227511 144964 67172 77792 0.61 0.38 0.45 0.30

2004 1265282 207801 116536 62070 54466 0.48 0.29 0.44 0.30

2005 745754 245238 110133 56257 53876 0.40 0.20 0.38 0.23

2006 885430 251419 120299 58453 61846 0.39 0.20 0.40 0.23

2007 1094759 254947 89783 50348 39435 0.33 0.16 0.38 0.20

2008 1014129 350277 95309 49434 45875 0.26 0.15 0.24 0.14

2009 1102499 374276 100671 55446 45225 0.24 0.13 0.22 0.15

2010 1300045 465482 106980 61163 45817 0.22 0.12 0.19 0.13

2011 1658442 456786 108523 67963 40560 0.21 0.12 0.14 0.15

2012 906860 507032 132903 73830 59073 0.24 0.12 0.23 0.15

2013 1318731 553631 118135 79396 38739 0.21 0.11 0.20 0.14

Table 8.5.1. North Sea plaice. Input table for RCT3 analysis.

Plaice	NorthSea							
Year	Age1	Age2	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1973	1135130	824073	7183	15366.4	8168.4	NA	NA	NA
1974	863655	547454	2568.1	11628.2	2402.6	NA	NA	NA
1975	690881	447473	1314.4	8536.5	3423.8	NA	NA	NA
1976	988522	647272	11166	18536.7	12678	NA	NA	NA
1977	916917	612805	4372.5	14012	9828.8	NA	NA	NA
1978	897617	532078	3267.5	21495.4	12882.3	NA	NA	NA
1979	1133010	808915	29058.1	59174.2	18785.3	NA	NA	NA
1980	864123	654046	4210.4	24756.2	8642	NA	NA	NA
1981	2017226	1430826	35506.4	69993.3	13908.6	NA	NA	NA
1982	1300560	926998	24401.9	33974.2	10412.8	NA	NA	NA
1983	1253422	838519	32941.9	44964.5	13847.8	NA	NA	NA
1984	1843651	1282478	7918.3	28100.5	7580.4	NA	NA	NA
1985	4742574	3226834	47256.4	93551.9	32991.1	NA	NA	NA
1986	1940642	1412078	8819.9	33402.4	14421.1	NA	NA	NA
1987	1763214	1263826	21334.9	36608.6	17810.2	NA	NA	NA
1988	1179320	863024	15669.7	34276.3	7496	NA	NA	NA
1989	1031648	793796	24585.3	25036.6	11247.2	NA	NA	NA
1990	910359	648193	9368.5	57221.3	13841.8	NA	NA	439.6
1991	775023	566093	17256.7	46798.2	9685.6	NA	NA	332.4
1992	530061	384728	6472.5	22098.3	4976.6	NA	NA	180.3
1993	442351	339872	9234.3	19188.4	2796.4	NA	NA	217
1994	1164069	932897	26781.3	24767	10268.2	NA	99.6	283.4
1995	1292393	1062546	12541.3	23015.4	4472.7	143.9	28.7	146.1
1996	2148445	1820775	84041.8	95900.9	30242.2	386.8	177.6	619.6
1997	771547	598502	17344.1	33665.7	10272.1	131.2	53.6	229.2
1998	840137	638563	25521.6	32951.3	2493.4	117	38.9	NA
1999	989336	794341	39262.3	22855	2898.5	108.4	39.8	NA
2000	540716	456147	24213.5	11510.5	1102.7	80.3	26.7	124.9
2001	1728770	1268394	99628	30809.2	NA	217.3	94.4	313.2
2002	528668	413296	31202	NA	1349.7	53.6	30.3	122.9
2003	1265282	922788	NA	18201.6	1818.9	101.4	45.6	238.6
2004	745754	583029	13537.2	10118.4	1571	70.8	42.9	126.7
2005	885430	591081	27390.6	12164.2	2133.9	54.9	44.4	85.9
2006	1094759	915899	51124.2	14174.5	2700.4	139.4	89.7	168
2007	1014129	788525	40580.9	14705.8	2018.7	98.9	76.5	98.3
2008	1102499	854714	50179.3	14860	1811.5	170.8	69.5	129.7
2009	1300045	1016589	53258.8	11946.9	1142.514815	144.8	126	141.9
2010	NA	NA	49347.2	18348.6	2928.6	226.5	149.6	179.6
2011	NA	NA	52643	5893.4	3021.3	118.4	90.5	93
2012	NA	NA	45027.1	15394.9	NA	192.8	NA	181.1
2013	NA	NA	44327.5	NA	NA	NA	NA	164.4

Table 8.5.2. North Sea plaice. RCT3 results for age 1 in 2014.

Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 41 years : 1973 - 2013
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
SNS0	1.1598	2.576	1.0783	0.1585	36	10.699	14.99	1.1389	0.1213
SNS1	1.2267	1.493	0.6233	0.3451	36	NA	NA	NA	NA
SNS2	0.8263	6.709	0.6650	0.3252	36	NA	NA	NA	NA
BTS1	0.8948	9.559	0.2635	0.6967	15	NA	NA	NA	NA
BTS2	0.8951	10.199	0.3482	0.5522	16	NA	NA	NA	NA
DFS0	2.0617	2.902	1.0443	0.1515	18	5.102	13.42	1.1408	0.1209
VPA Mean	NA	NA	NA	NA	37	NA	13.89	0.4557	0.7578

	WAP	logWAP	int.se
yearclass:2013	1160728	13.96	0.3967

Table 8.5.3. North Sea plaice. RCT3 results for age 2 in 2014.

Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 41 years : 1973 - 2013
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2012

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
SNS0	0.9235	4.571	0.8106	0.2500	36	10.715	14.47	0.8566	0.05339
SNS1	1.2371	1.077	0.6295	0.3432	36	9.642	13.00	0.6621	0.08935
SNS2	0.9214	5.576	0.7758	0.2614	36	NA	NA	NA	NA
BTS1	0.8605	9.474	0.2162	0.7793	15	5.262	14.00	0.2471	0.64154
BTS2	0.9036	9.917	0.3475	0.5624	16	NA	NA	NA	NA
DFS0	2.1739	2.051	1.1048	0.1459	18	5.199	13.35	1.2044	0.02700
VPA Mean	NA	NA	NA	NA	37	NA	13.58	0.4556	0.18873

	WAP	logWAP	int.se
yearclass:2012	1024696	13.84	0.1979

Table 8.6.1. North Sea plaice. Input to the short term forecast (F values presented are for Fsq)

age	year M	f	f.disc	f.land	stock.n	c.wt	land.wt	dis.wt	st.wt	mat
1	2014 0.1	0.094	0.09	0	936994	0.05	0.15	0.05	0.04	0
2	2014 0.1	0.225	0.22	0.01	1071226	0.1	0.23	0.09	0.1	0.5
3	2014 0.1	0.217	0.14	0.07	512730	0.19	0.28	0.14	0.16	0.5
4	2014 0.1	0.236	0.08	0.16	698584	0.28	0.33	0.17	0.2	1
5	2014 0.1	0.203	0.03	0.17	387469	0.35	0.38	0.19	0.34	1
6	2014 0.1	0.163	0.01	0.15	235686	0.42	0.45	0.2	0.41	1
7	2014 0.1	0.101	0	0.1	135773	0.53	0.54	0.21	0.45	1
8	2014 0.1	0.071	0.01	0.06	130374	0.53	0.56	0.26	0.46	1
9	2014 0.1	0.052	0	0.05	63907	0.57	0.57	0	0.56	1
10	2014 0.1	0.052	0	0.05	84870	0.72	0.72	0	0.6	1
1	2015 0.1	0.094	0.09	0	936994	0.05	0.15	0.05	0.04	0
2	2015 0.1	0.225	0.22	0.01	NA	0.1	0.23	0.09	0.1	0.5
3	2015 0.1	0.217	0.14	0.07	NA	0.19	0.28	0.14	0.16	0.5
4	2015 0.1	0.236	0.08	0.16	NA	0.28	0.33	0.17	0.2	1
5	2015 0.1	0.203	0.03	0.17	NA	0.35	0.38	0.19	0.34	1
6	2015 0.1	0.163	0.01	0.15	NA	0.42	0.45	0.2	0.41	1
7	2015 0.1	0.101	0	0.1	NA	0.53	0.54	0.21	0.45	1
8	2015 0.1	0.071	0.01	0.06	NA	0.53	0.56	0.26	0.46	1
9	2015 0.1	0.052	0	0.05	NA	0.57	0.57	0	0.56	1

10	2015 0.1	0.052	0	0.05	NA	0.72	0.72	0	0.6	1
1	2016 0.1	0.094	0.09	0	936994	0.05	0.15	0.05	0.04	0
2	2016 0.1	0.225	0.22	0.01	NA	0.1	0.23	0.09	0.1	0.5
3	2016 0.1	0.217	0.14	0.07	NA	0.19	0.28	0.14	0.16	0.5
4	2016 0.1	0.236	0.08	0.16	NA	0.28	0.33	0.17	0.2	1
5	2016 0.1	0.203	0.03	0.17	NA	0.35	0.38	0.19	0.34	1
6	2016 0.1	0.163	0.01	0.15	NA	0.42	0.45	0.2	0.41	1
7	2016 0.1	0.101	0	0.1	NA	0.53	0.54	0.21	0.45	1
8	2016 0.1	0.071	0.01	0.06	NA	0.53	0.56	0.26	0.46	1
9	2016 0.1	0.052	0	0.05	NA	0.57	0.57	0	0.56	1
10	2016 0.1	0.052	0	0.05	NA	0.72	0.72	0	0.6	1

Table 8.6.2. North Sea plaice. Results from the short term forecast assuming $F_{2014} = F_{2013}$ (rescaled)

basis	landings	f2-6	f_hc2-6	f_dis2-3	discards	catch	ssb2015	ssb2016	ssb_change	tac_change
Fmp	127632	0.3	0.16	0.26	51517	178696	704979	702606	0	14
Ftar	127632	0.3	0.16	0.26	51517	178696	704979	702606	0	14
Fmsy	108503	0.25	0.13	0.21	43932	152049	704979	729299	3	-3
Fpa	227433	0.6	0.32	0.52	90154	316789	704979	564991	-20	104
Flim	266432	0.74	0.39	0.64	104759	370261	704979	512093	-27	139
SSB>Bpa	484814	2.026	1.08	1.74	178836	662033	704979	230000	-67	334
TACsq	111631	0.258	0.14	0.22	45176	156410	704979	724928	3	0
15%_TAC_inc	128376	0.302	0.16	0.26	51810	179731	704979	701570	0	15
15%_TAC_dec	94886	0.216	0.12	0.19	38501	133050	704979	748355	6	-15
Fsq*0	0	0	NA	NA	0	0	704979	882296	25	-100
Fsq*0.25	29971	0.064	0.03	0.06	12278	42142	704979	839786	19	-73
Fsq*0.5	58375	0.128	0.07	0.11	23818	81984	704979	799667	13	-48
Fsq*0.9	100628	0.23	0.12	0.2	40794	141064	704979	740315	5	-10
Fsq*1	110451	0.255	0.14	0.22	44707	154765	704979	726576	3	-1
Fsq*1.1	120074	0.28	0.15	0.24	48526	168174	704979	713141	1	8
Fsq*1.25	134698	0.319	0.17	0.27	54305	188525	704979	692769	-2	21
Fsq*1.5	157357	0.382	0.2	0.33	63196	219996	704979	661315	-6	41
Fsq*1.75	179219	0.446	0.24	0.38	71696	250283	704979	631104	-10	61
Fsq*2	199980	0.51	0.27	0.44	79695	278971	704979	602545	-15	79

Table 8.6.3. North Sea plaice. Detailed STF table by age, assuming $F_{2013} = F_{2012}$, rescaled.

	age	year	f	f.disc	f.land	stock.n	catch.wt	ndings.wt	iscards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	1	2013	0.131	0.13	0	930070	0.05	0.21	0.05	0.05	0	0.1	109003	5855	509	107	108494	5750	0	44643
2	2	2013	0.266	0.25	0.02	590490	0.11	0.25	0.1	0.1	0.5	0.1	131625	14787	7521	1863	124104	12948	30410	60820
3	3	2013	0.249	0.16	0.09	942072	0.21	0.29	0.15	0.17	0.5	0.1	198036	40722	73455	21645	124581	19185	79762	159524
4	4	2013	0.267	0.09	0.17	530181	0.29	0.35	0.19	0.25	1	0.1	118445	34412	77305	26799	41141	7652	130248	130248
5	5	2013	0.214	0.04	0.18	310564	0.37	0.4	0.19	0.35	1	0.1	57057	20960	47365	19072	9692	1864	108387	108387
6	6	2013	0.166	0.02	0.15	193295	0.44	0.47	0.2	0.43	1	0.1	28136	12255	24754	11635	3382	675	82279	82279
7	7	2013	0.1	0.01	0.09	186004	0.52	0.54	0.21	0.46	1	0.1	16801	8701	15494	8398	1307	272	84942	84942
8	8	2013	0.083	0.01	0.07	94368	0.52	0.56	0.22	0.49	1	0.1	7118	3708	6189	3495	929	203	46335	46335
9	9	2013	0.044	0	0.04	44711	0.6	0.6	0	0.53	1	0.1	1817	1082	1817	1082	0	0	23518	23518
10	10	2013	0.044	0	0.04	125683	0.7	0.7	0	0.62	1	0.1	5108	3595	5108	3595	0	0	77326	77326
11	1	2014	0.131	0.13	0	930070	0.05	0.21	0.05	0.05	0	0.1	109003	5855	509	107	108494	5750	0	44643
12	2	2014	0.266	0.25	0.02	738032	0.11	0.25	0.1	0.1	0.5	0.1	164513	18482	9400	2328	155113	16183	38009	76017
13	3	2014	0.249	0.16	0.09	409421	0.21	0.29	0.15	0.17	0.5	0.1	86066	17698	31923	9407	54143	8338	34664	69329
14	4	2014	0.267	0.09	0.17	664513	0.29	0.35	0.19	0.25	1	0.1	148455	43131	96891	33589	51564	9591	163249	163249
15	5	2014	0.214	0.04	0.18	367356	0.37	0.4	0.19	0.35	1	0.1	67491	24793	56026	22560	11464	2205	128207	128207
16	6	2014	0.166	0.02	0.15	226855	0.44	0.47	0.2	0.43	1	0.1	33021	14382	29052	13655	3969	792	96564	96564
17	7	2014	0.1	0.01	0.09	148185	0.52	0.54	0.21	0.46	1	0.1	13385	6932	12344	6690	1041	217	67671	67671
18	8	2014	0.083	0.01	0.07	152341	0.52	0.56	0.22	0.49	1	0.1	11491	5986	9992	5642	1499	328	74800	74800
19	9	2014	0.044	0	0.04	78625	0.6	0.6	0	0.53	1	0.1	3195	1902	3195	1902	0	0	41357	41357
20	10	2014	0.044	0	0.04	147598	0.7	0.7	0	0.62	1	0.1	5998	4221	5998	4221	0	0	90809	90809
21	1	2015	0.131	0.13	0	930070	0.05	0.21	0.05	0.05	0	0.1	109003	5855	509	107	108494	5750	0	44643
22	2	2015	0.266	0.25	0.02	738032	0.11	0.25	0.1	0.1	0.5	0.1	164513	18482	9400	2328	155113	16183	38009	76017
23	3	2015	0.249	0.16	0.09	511720	0.21	0.29	0.15	0.17	0.5	0.1	107570	22120	39899	11757	67671	10421	43326	86651
24	4	2015	0.267	0.09	0.17	288795	0.29	0.35	0.19	0.25	1	0.1	64518	18744	42109	14598	22410	4168	70947	70947
25	5	2015	0.214	0.04	0.18	460432	0.37	0.4	0.19	0.35	1	0.1	84591	31075	70222	28276	14369	2764	160691	160691
26	6	2015	0.166	0.02	0.15	268339	0.44	0.47	0.2	0.43	1	0.1	39059	17012	34365	16152	4694	937	114223	114223
27	7	2015	0.1	0.01	0.09	173913	0.52	0.54	0.21	0.46	1	0.1	15709	8136	14487	7852	1222	255	79420	79420
28	8	2015	0.083	0.01	0.07	121367	0.52	0.56	0.22	0.49	1	0.1	9155	4769	7960	4495	1194	262	59591	59591
29	9	2015	0.044	0	0.04	126926	0.6	0.6	0	0.53	1	0.1	5158	3071	5158	3071	0	0	66763	66763
30	10	2015	0.044	0	0.04	195956	0.7	0.7	0	0.62	1	0.1	7963	5604	7963	5604	0	0	120562	120562

Plaice IV WGNSSK 2012 Figures

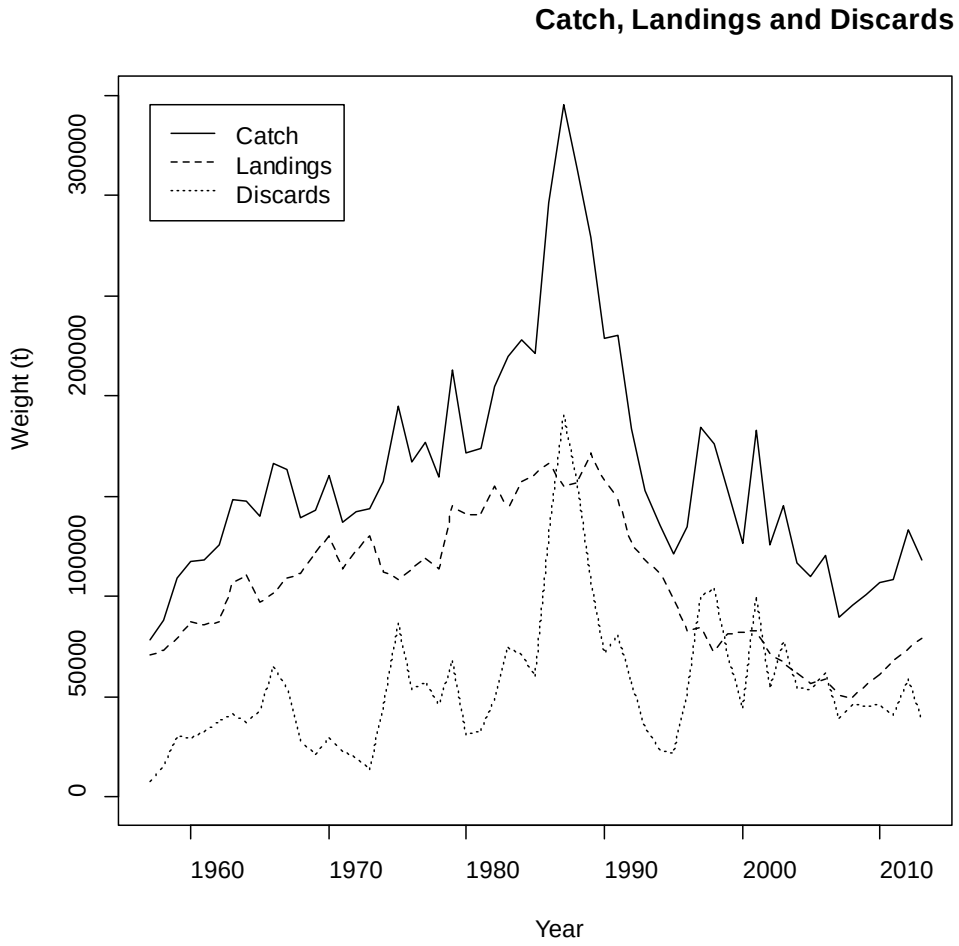


Figure 8.2.1 North Sea plaice. Time series of catch (solid line), landings (dashed line) and discards (dotted line) estimates.

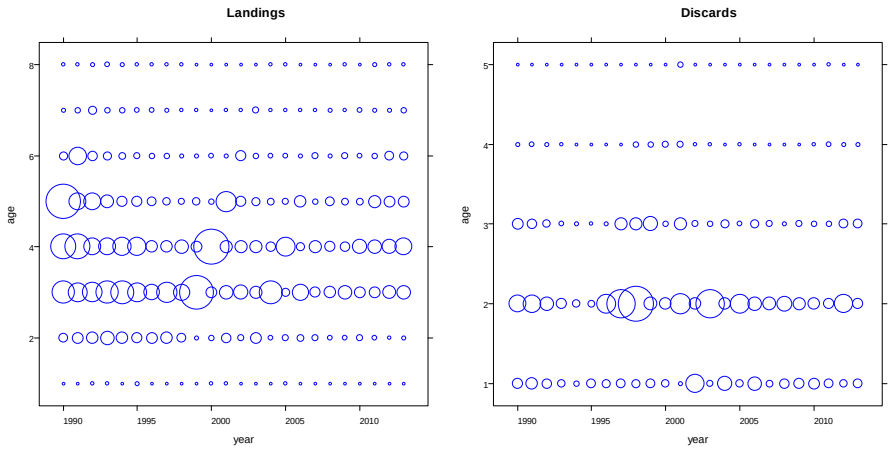


Figure 8.2.2 North Sea plaice. Landing numbers-at-age (left) and discards numbers-at-age (right).

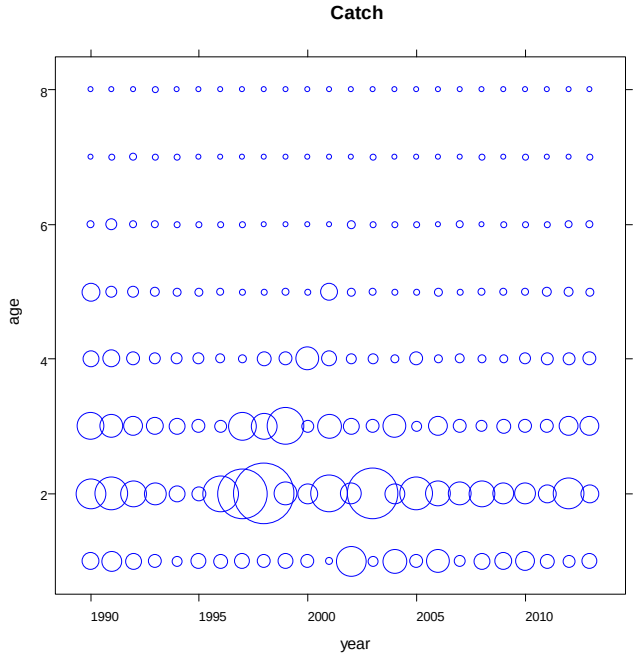


Figure 8.2.3 North Sea plaice. Catch numbers-at-age.

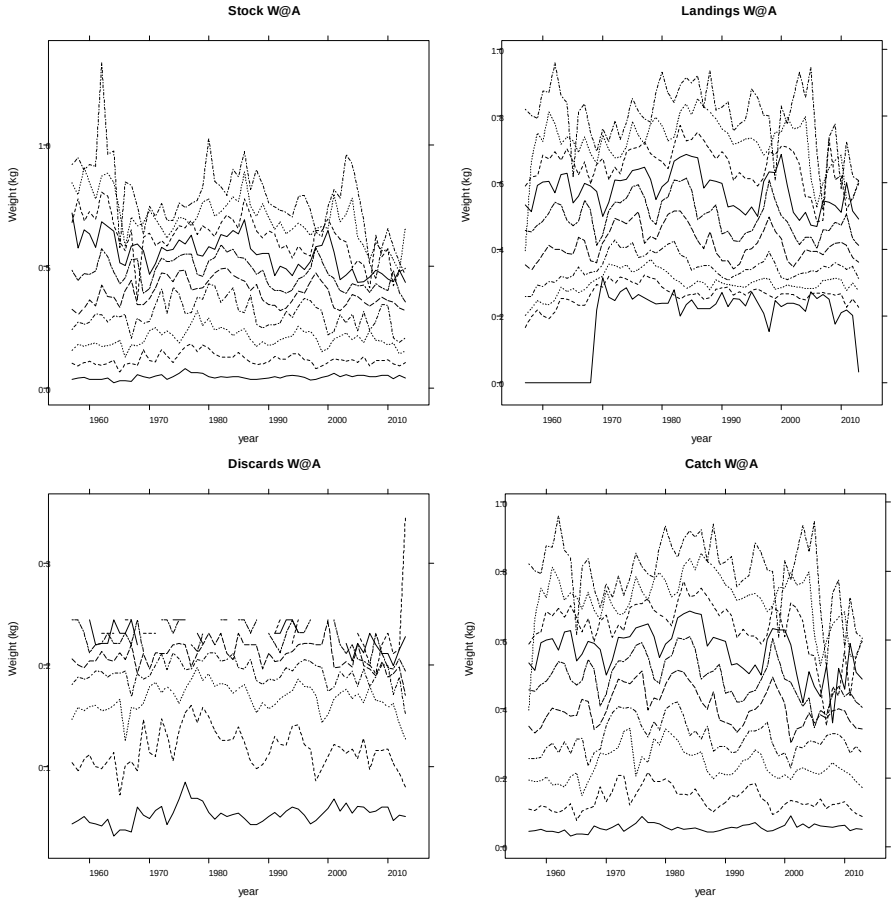


Figure 8.2.4 North Sea plaice. Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

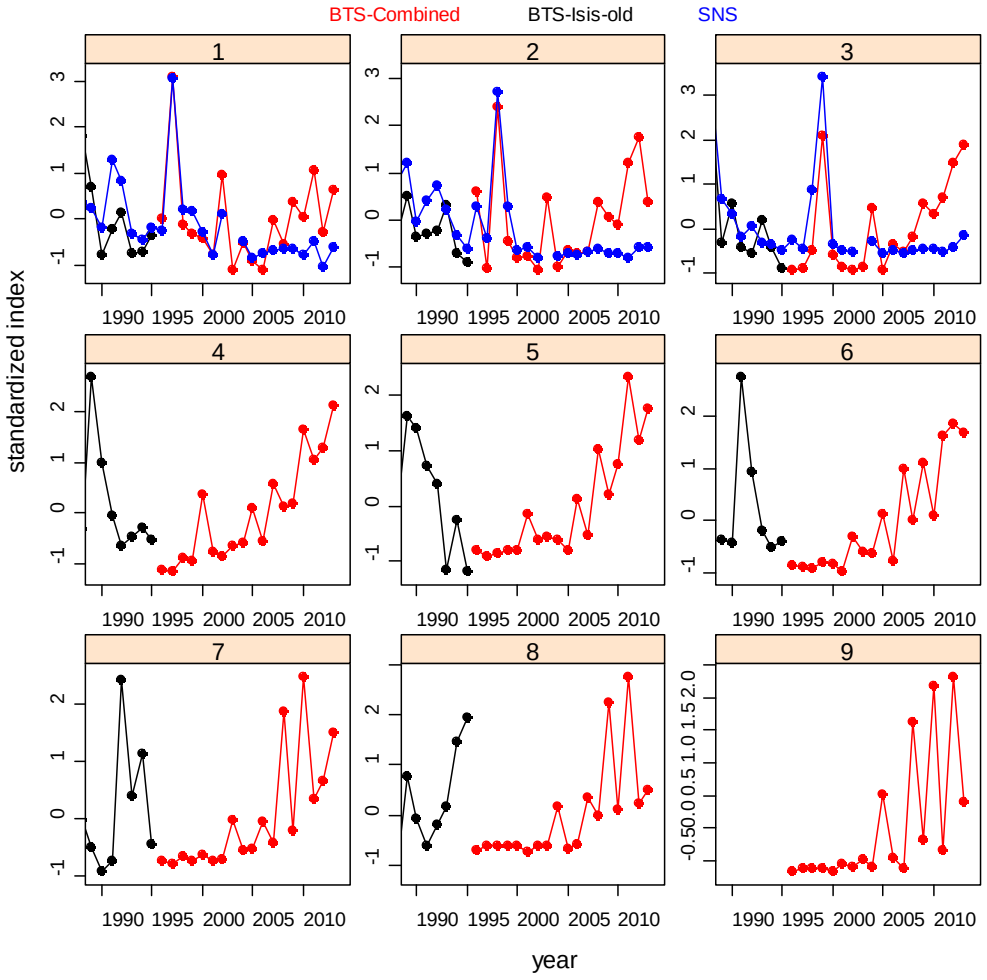


Figure 8.2.5 North Sea plaice. Standardized survey tuning indices used for tuning XSA: BTS-combined (red), BTS-Isis-old (black) and SNS (blue). Note: only ages used in the assessment are presented. The BTS-combined index combines BTS-Tridens and BTS-Isis indices.

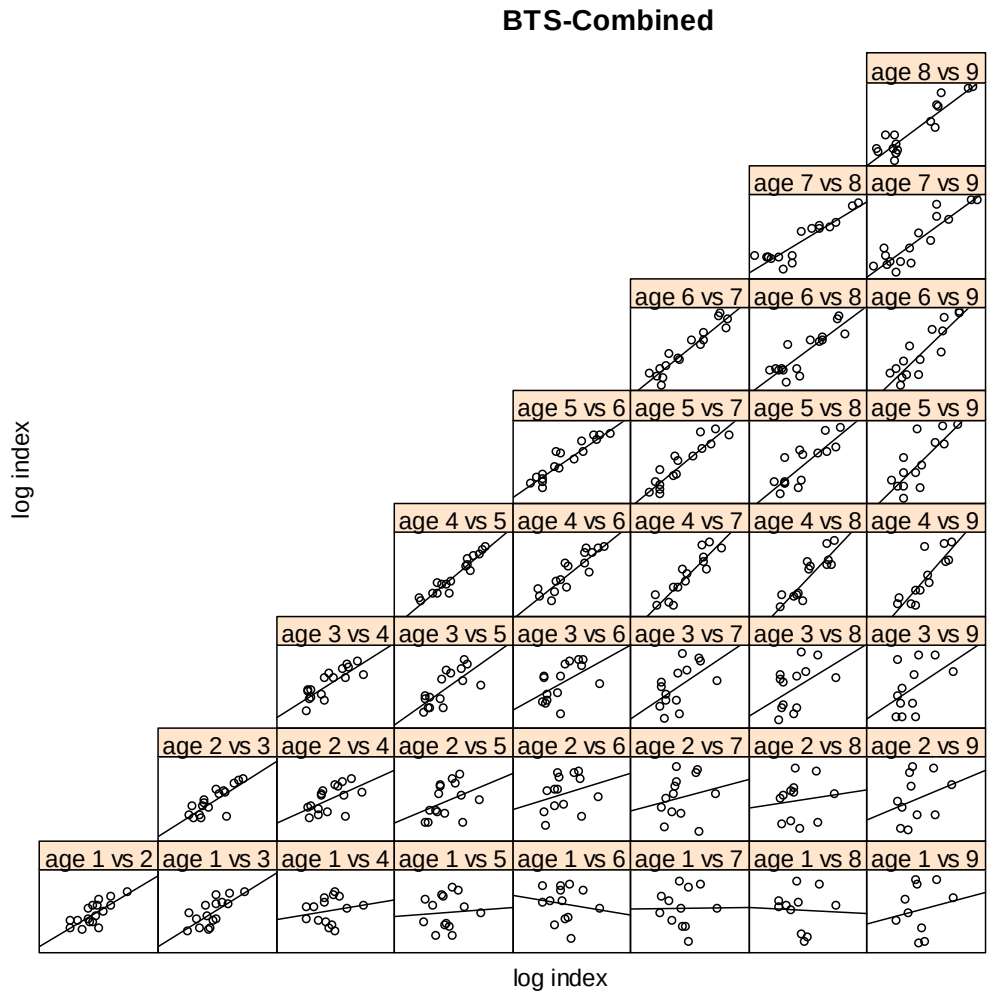


Figure 8.2.6 North Sea plaice. Internal consistency plot for the BTS-combined survey index.

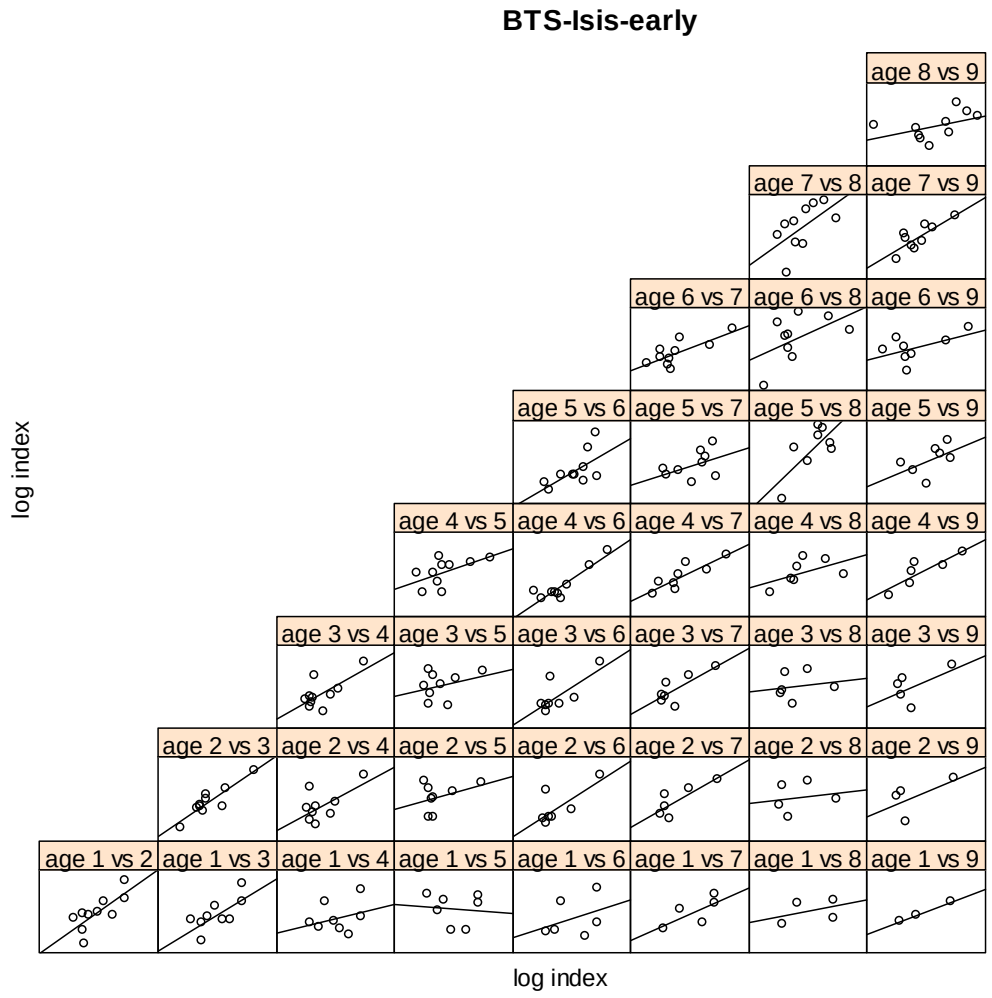


Figure 8.2.7. North Sea plaice. Internal consistency plot for the BTS-Isis-early survey index.

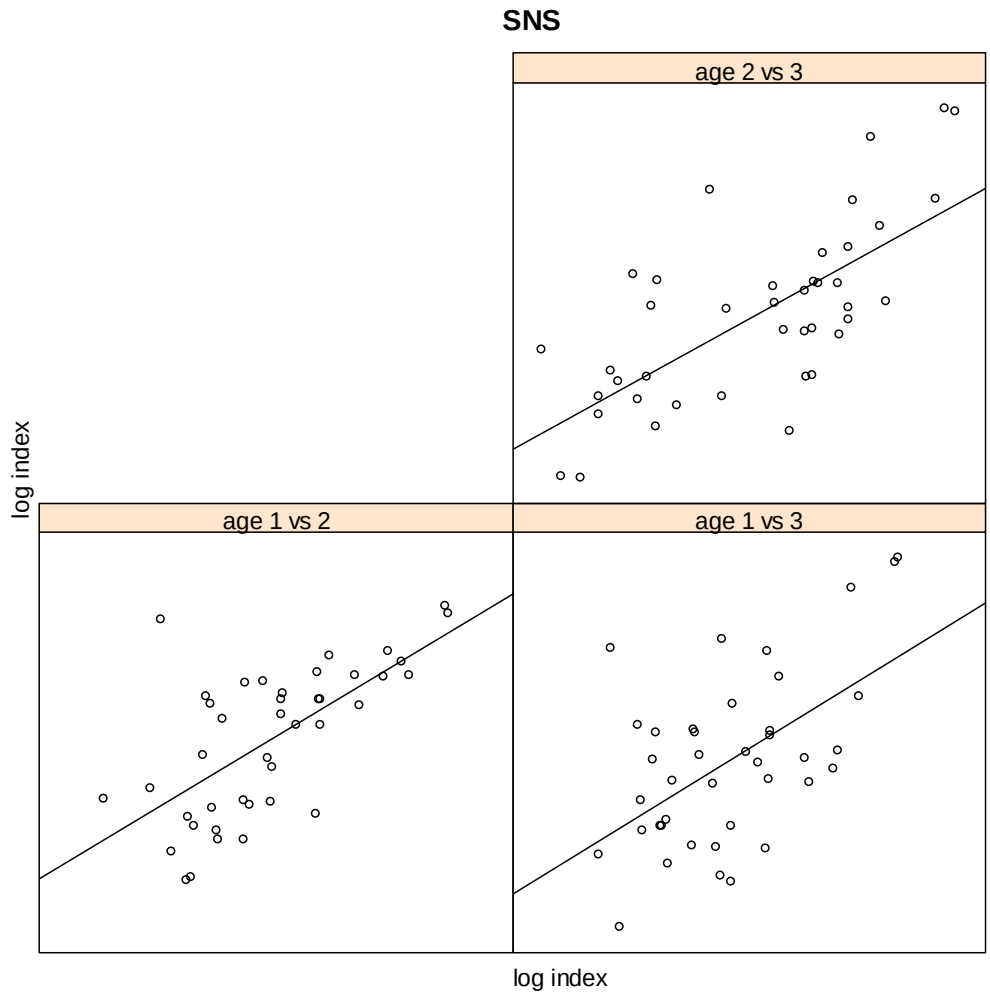


Figure 8.2.8. North Sea plaice. Internal consistency plot for the SNS survey index.

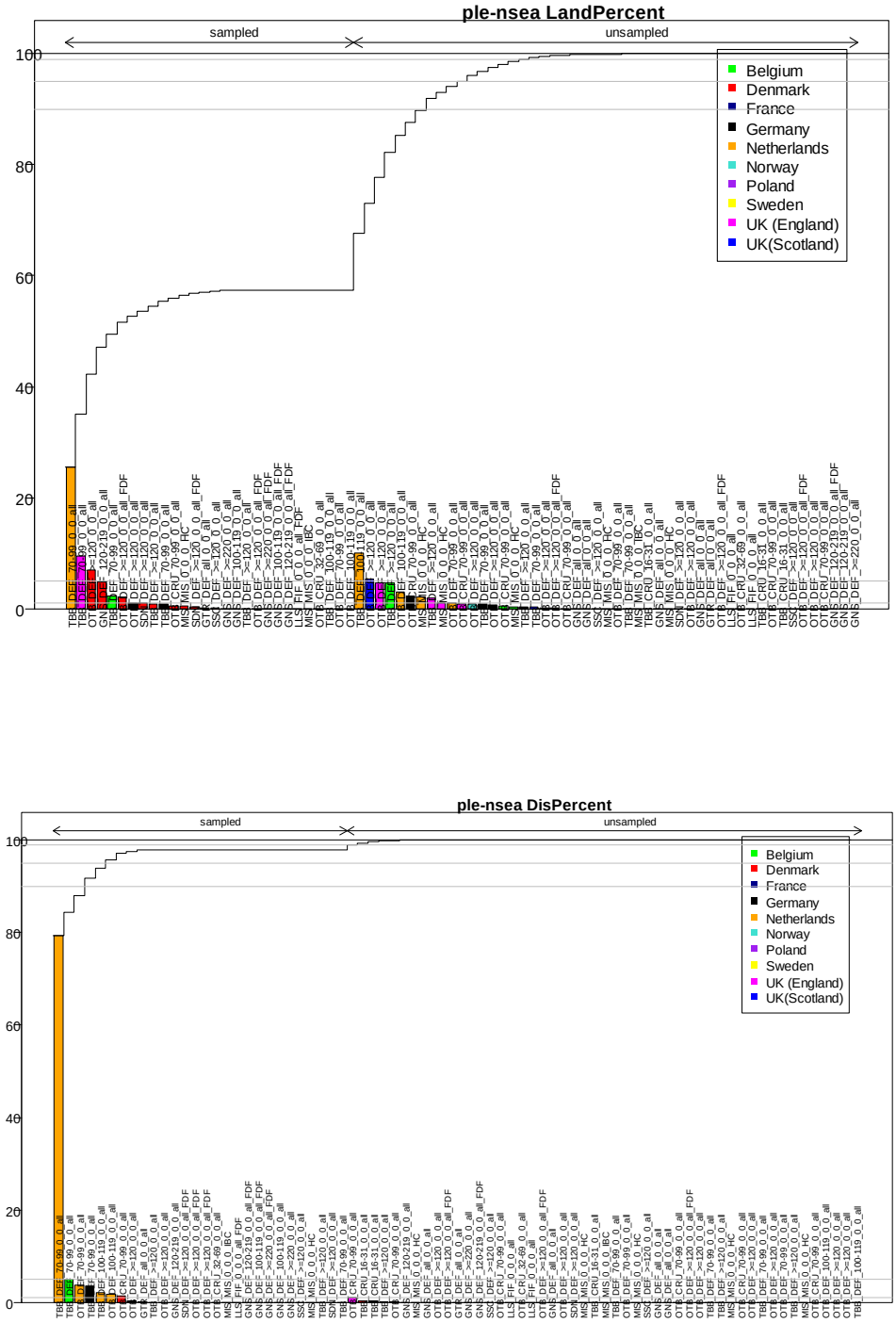


Figure 8.2.9. Data upload in InterCatch: landings % by country by metier (top); discards in weight (kg) by country by metier (bottom). Sampled and unsampled refers to availability of age-composition information.

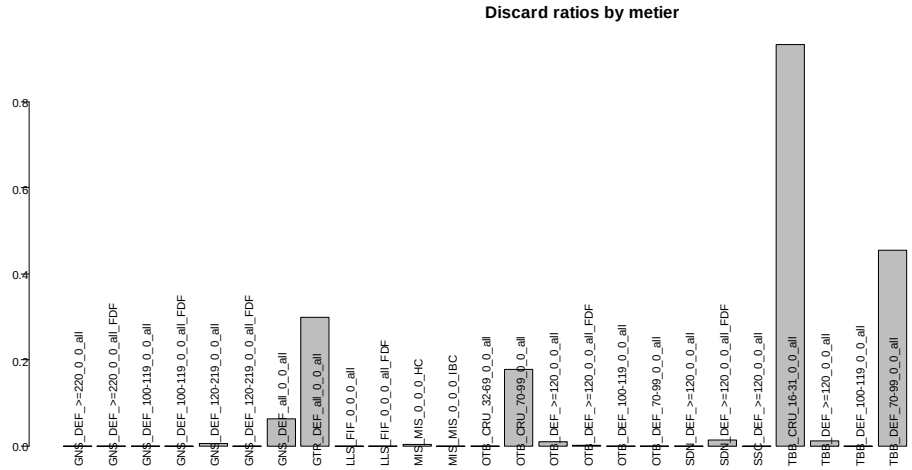
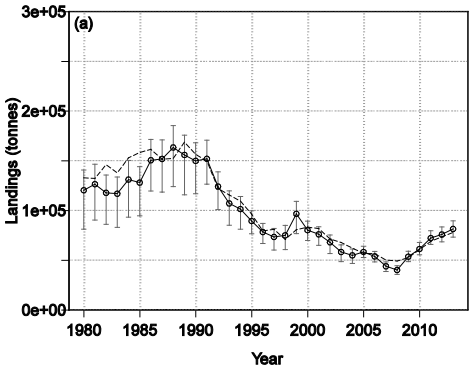
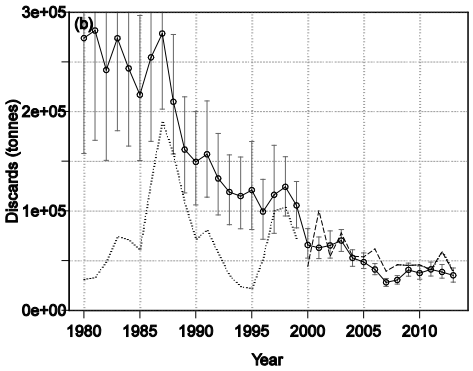
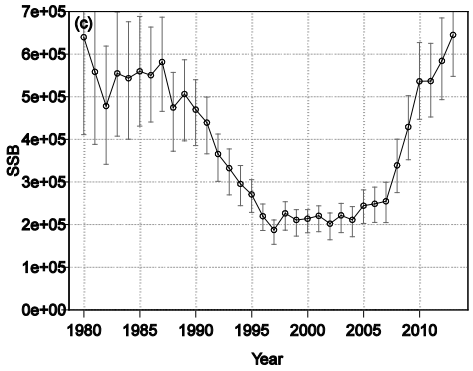
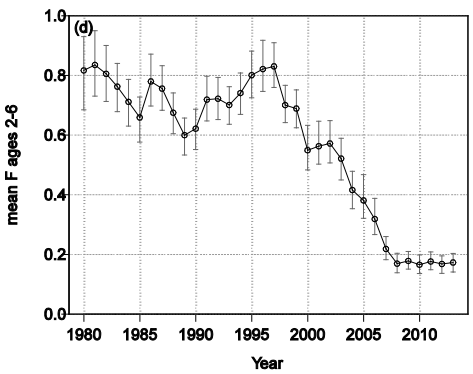


Figure 8.2.10. Data upload in InterCatch: discards ratios in weight (kg) by metier. (as percentage of catch being discarded).


(a)
Landings (tonnes)
3e+05
2e+05
1e+05
0e+00
1980
1985
1990
1995
2000
2005
2010
Year


(b)
Discards (tonnes)
3e+05
2e+05
1e+05
0e+00
1980
1985
1990
1995
2000
2005
2010
Year


(c)
SSB
7e+05
6e+05
5e+05
4e+05
3e+05
2e+05
1e+05
0e+00
1980
1985
1990
1995
2000
2005
2010
Year


(d)
mean F ages 2-6
1.0
0.8
0.6
0.4
0.2
0.0
1980
1985
1990
1995
2000
2005
2010
Year

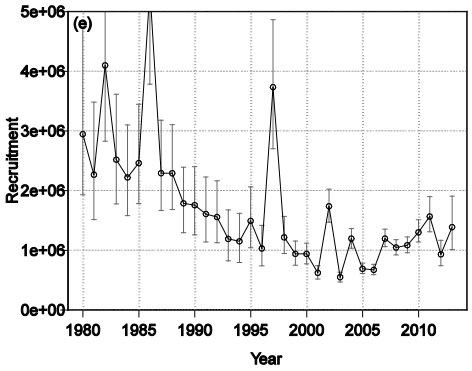


Figure 8.3.1. Statistical Catch at Age model results (see Aarts & Poos 2009) assessment results: (a) Estimated Landings, (b) Discard estimates, (c) SSB, (d) Mean F (ages 2-6), (e) recruitment. Horizontal bars indicate 95% confidence levels.

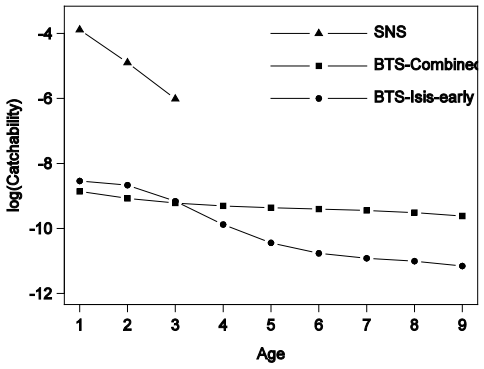


Figure 8.3.2. Statistical Catch at Age model results (see Aarts & Poos 2009) assessment results: Catchability as estimated by the model

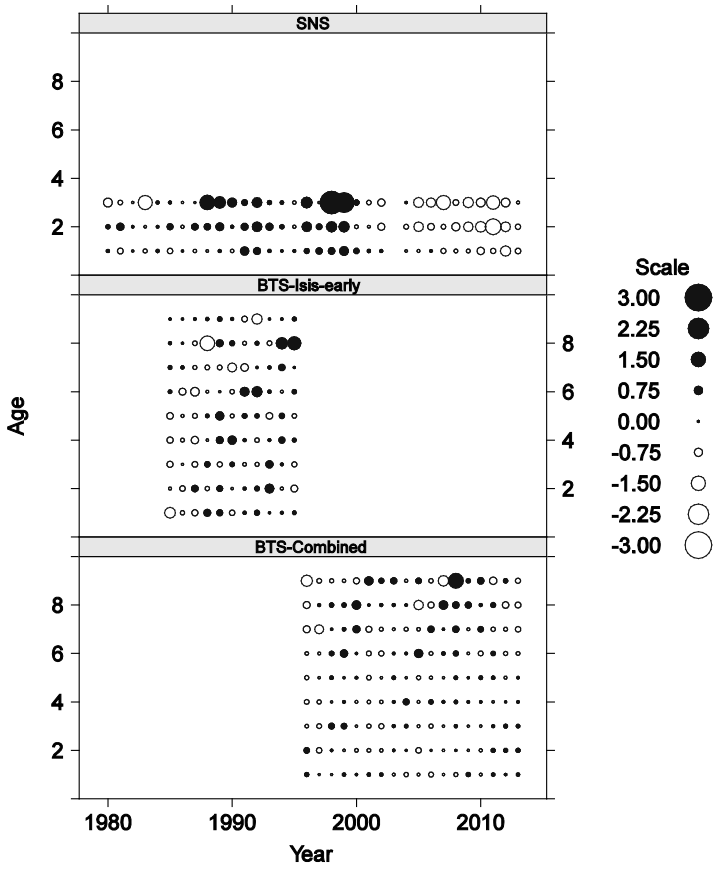


Figure 8.3.3. North Sea plaice. Log catchability residuals for the landings and discard estimates from the SCA model (Aarts and Poos 2009).

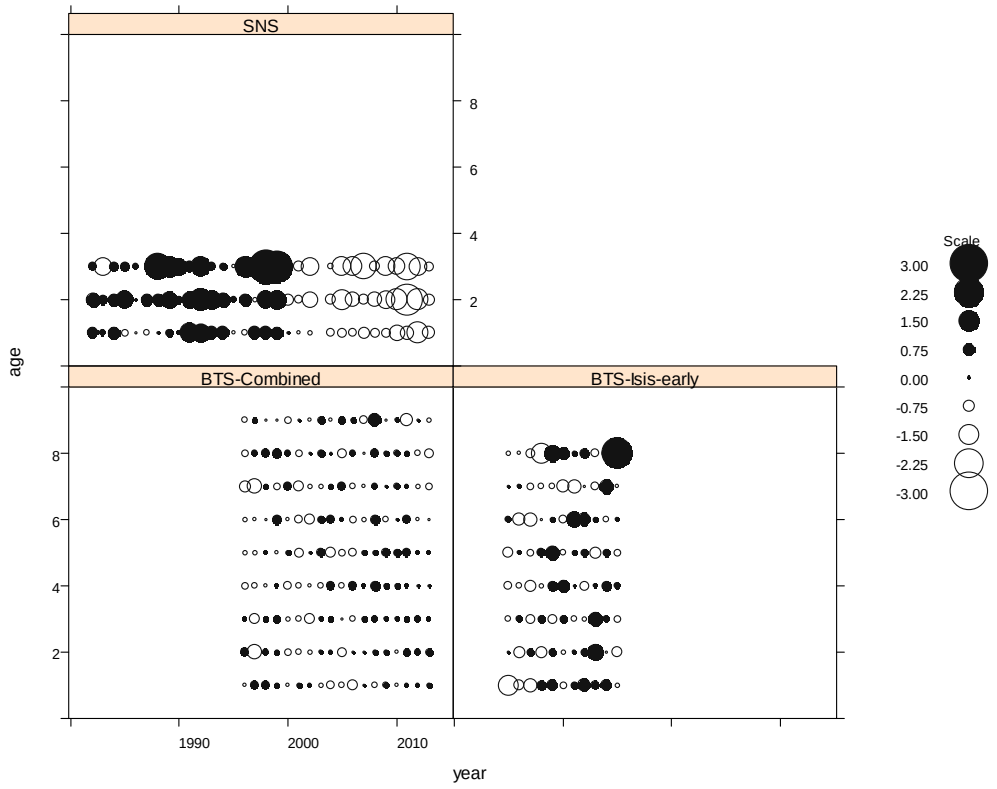


Figure 8.3.4. North Sea plaice. Log catchability residuals for the final XSA run from the three tuning series.

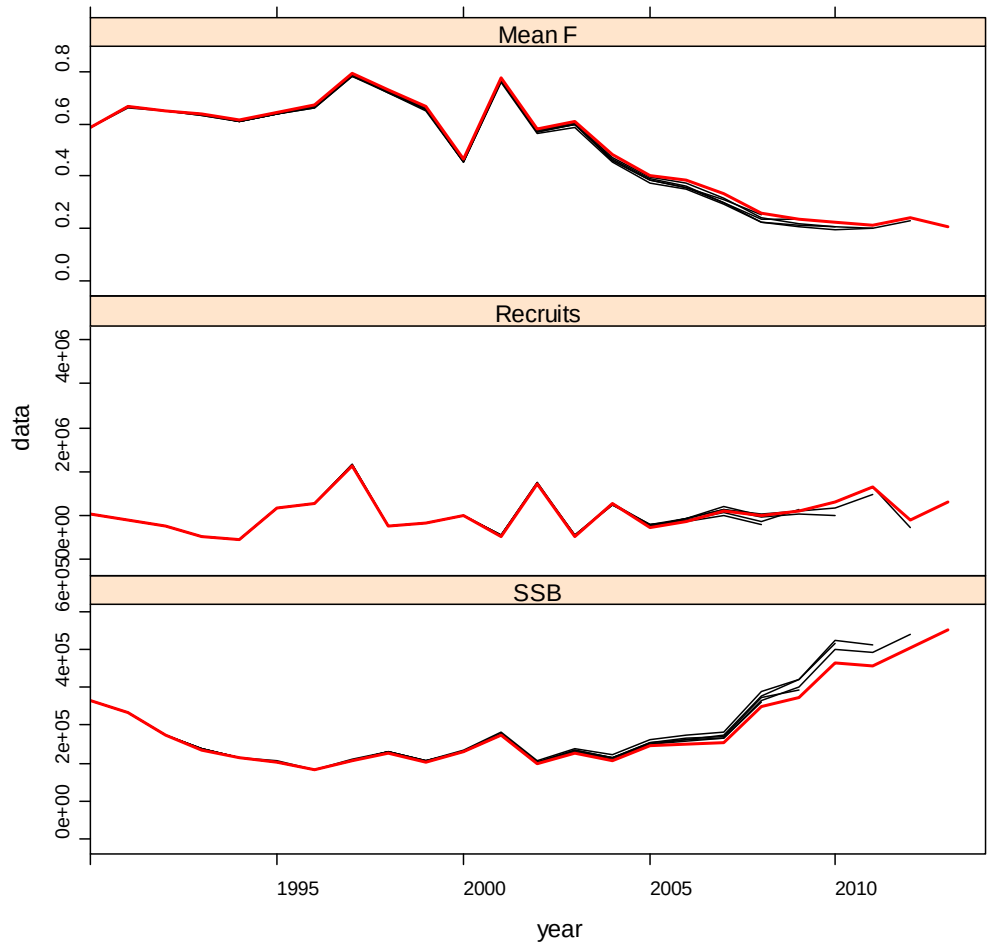


Figure 8.3.5. North Sea plaice. Retrospective pattern of the final XSA run with respect to SSB, recruitment and F.

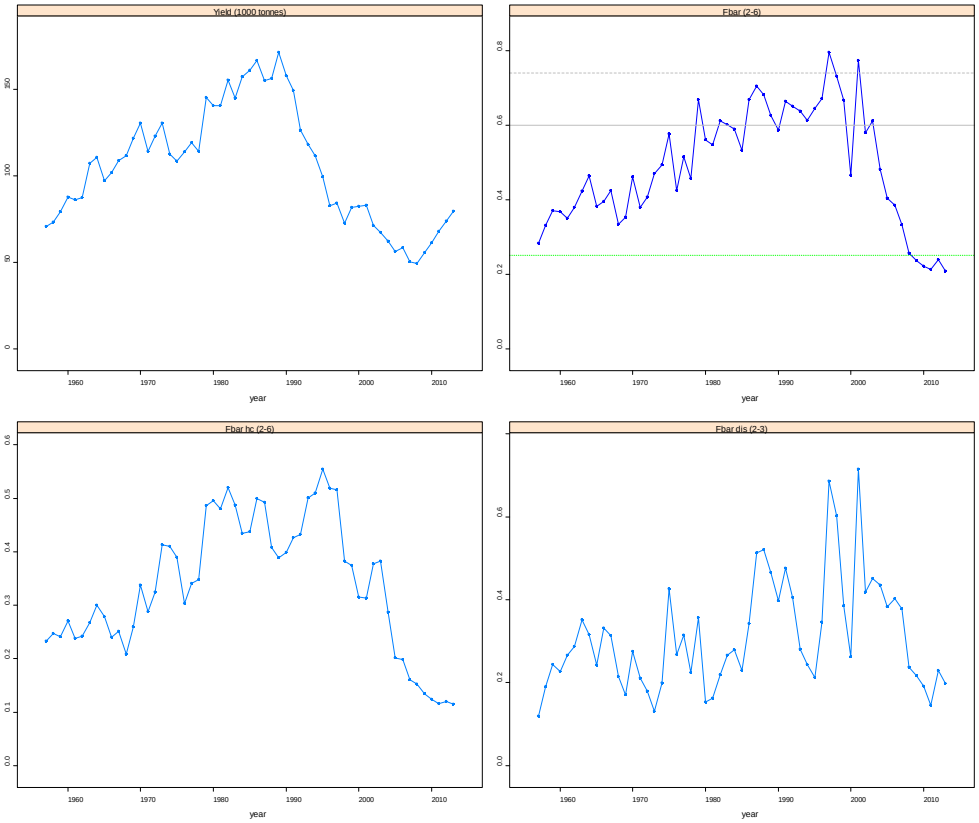


Figure 8.4.1. North Sea plaice. Stock summary figure, time series on Yield (top left), fishing mortality for ages 2-6 (drawn grey line indicates F_{pa}, dashed grey line indicates F_{lim}, green dashed line indicates MP target F; top right), human consumption fishing mortality(bottom left) and fishing mortality of discards ages 2-3 (bottom right).

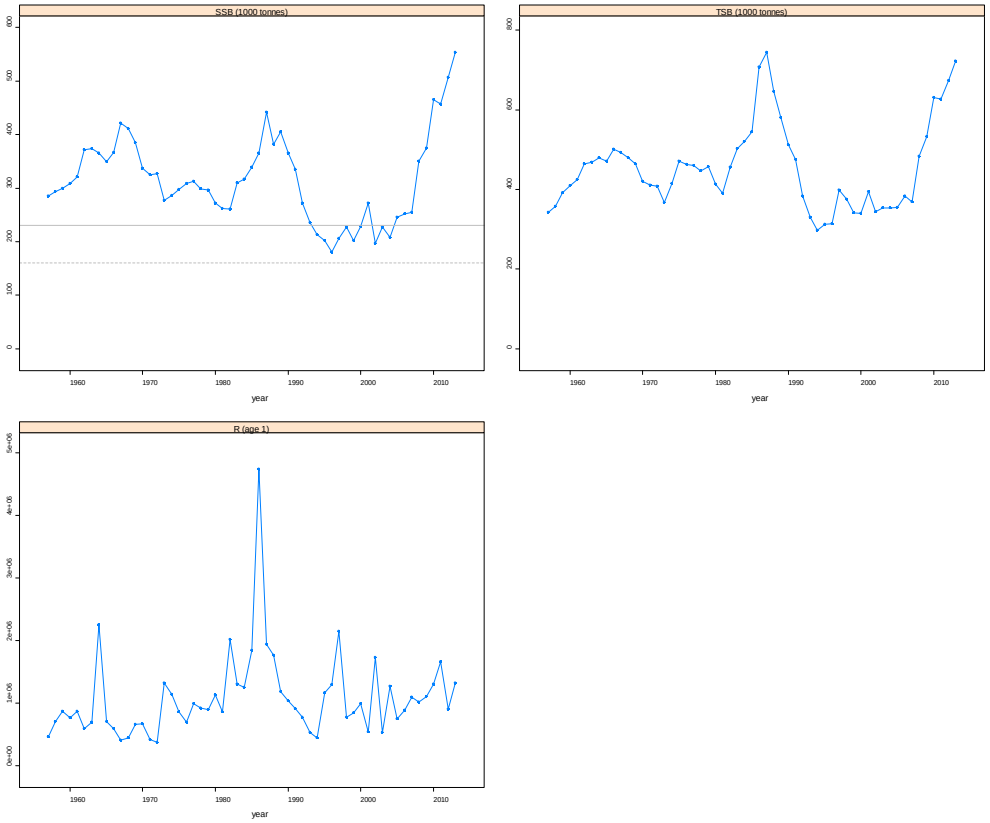


Figure 8.4.2. North Sea plaice. Stock summary figure. Time series of SSB (grey solid line indicates B_{pa}, dashed line indicates B_{lim}; top left), total stock biomass (top right) and recruitment at age 1 (bottom left).

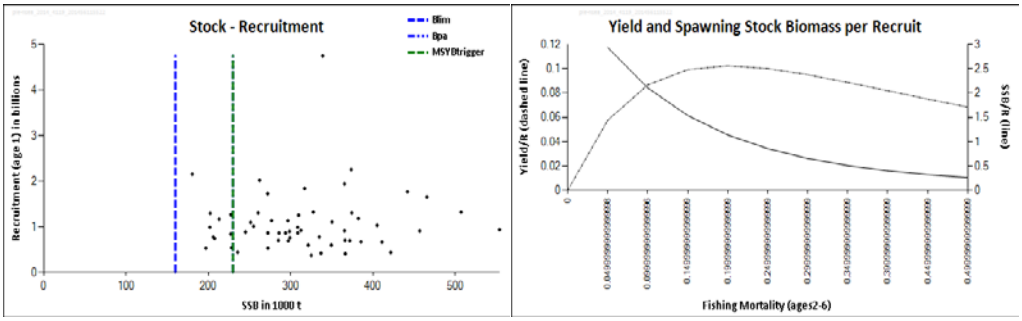


Figure 6.3.18.3 Plaice in Subarea IV (North Sea). Stock–recruitment plot and yield-per-recruit analysis.

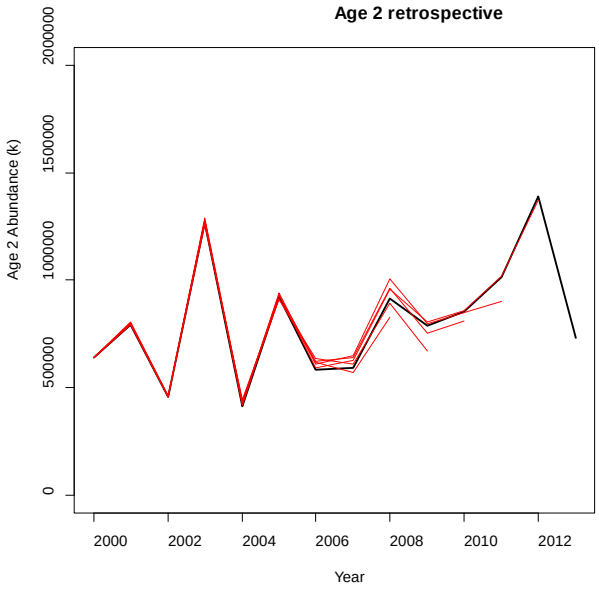


Figure 8.11.3. Retrospective analysis plot for abundance of age-2 fish.

9 Sole in Subarea VIId

The assessment of sole in sub-area VIId is presented here as an update assessment.

All the relevant biological and methodological information can be found in the Stock Annex dealing with this stock. Here, only the basic input and output from the assessment model will be presented.

9.1 General

9.1.1 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2014.

All available information on ecological aspects can be found in the Stock Annex.

9.1.2 Fisheries

A detailed description of the fishery can be found in the Stock Annex.

Except for 2010, the TAC was not restrictive for France, Belgium or the UK since 1997.

9.1.3 ICES advice

In 2012 the stock status was presented as follows:

F (Fishing Mortality)				
	2009	2010	**2011**	
MSY (F_{MSY})	✗	✗	✗	Above target
Precautionary approach (F_{pa},F_{lim})	o	o	o	Increased risk

SSB (Spawning-Stock Biomass)				
	2010	2011	**2012**	
MSY ($B_{trigger}$)	✓	✓	✓	Above trigger
Precautionary approach (B_{pa},B_{lim})	✓	✓	✓	Full reproductive capacity

The ICES advice for 2013 was as follows:

ICES advises on the basis of the transition to the MSY approach that landings in 2013 should be no more than 5900 tonnes

MSY approach

Following the ICES MSY framework implies fishing mortality to be reduced to 0.29 resulting in landings of less than 4800 t in 2013. This is expected to lead to a record high SSB of 17 200 t in 2014.

*Following the transition scheme towards the ICES MSY framework implies that (F_{2010}*0.4) + (0.6*F_{MSY}) is 0.37, resulting in landings of less than 5900 t in 2013. This is expected to lead to an SSB of 16 000 t in 2014.*

PA approach

The fishing mortality in 2013 should be no more than F_{pa}, corresponding to landings of less than 6300 t in 2013. This is expected to keep SSB well above B_{pa} in 2014.

In 2013 the stock status was presented as follows:

F (Fishing Mortality)				
	2010	2011	**2012**	
MSY (F_{MSY})	✗	✗	✗	Above target
Precautionary approach (F_{pa},F_{lim})	o	o	o	Increased risk

SSB (Spawning-Stock Biomass)				
	2011	2012	**2013**	
MSY ($B_{trigger}$)	✓	✓	✓	Above trigger
Precautionary approach (B_{pa},B_{lim})	✓	✓	✓	Full reproductive capacity

The ICES advice for 2014 was as follows:

ICES advises on the basis of the transition to the MSY approach that catches in 2014 should be no more than 3251 t. All catches are assumed to be landed.

MSY approach

Following the ICES MSY approach implies fishing mortality to be reduced to 0.29 resulting in catches of less than 2894 t in 2014. This is expected to lead to an SSB of 11 319 t in 2015.

*Following the transition scheme towards the ICES MSY approach implies that (F2010*0.2) + (0.8*FMSY) is 0.32, resulting in catches of less than 3251 t in 2014. This is expected to lead to an SSB of 11 054 t in 2015. Discards are not taken into account, but are considered to be small and all catches are assumed to be landed.*

PA approach

The fishing mortality in 2014 should be no more than Fpa, corresponding to catches of less than 3803 t in 2014. This is expected to keep SSB well above Bpa in 2015. All catches are assumed to be landed.

9.1.4 Management

No explicit management objectives are set for this stock.

Management of sole in VIId is by TAC and technical measures. The agreed TACs in 2013 and 2014 are 5900t and 4838t respectively. Technical measures in force for this stock are minimum mesh sizes and minimum landing size. The minimum landing size for sole is 24cm. Demersal gear mesh sizes permitted to catch sole are 80mm for beam trawling and 80mm for otter trawlers. Fishing with fixed nets requires the use of 100mm mesh since 2002, although an exemption to permit 90mm has been in force since that time.

In 2009, the cod plan covered by Council Regulation (EC) N°43/2009 allocated different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. The areas were Kattegat, part of IIIa not covered by Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned were: Bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≤ 100 mm) – TR2 (≤ 70 and < 100 mm) – TR3 (≤ 16 and < 32 mm); Beam trawl of mesh size: BT1 (≤ 120 mm) – BT2 (≤ 80 and < 120 mm); Gill nets excluding trammel nets: GN1; Trammel nets: GT1 and Longlines: LL1.

For 2010-14, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011, Council Regulation (EC) N°43/2012, Council Regulation (EC) N°39 and 40/2013 and Council Regulation (EC) N°43/2014 were updates of the Council Regulation (EC) N°43/2009 with new allocations, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009. (see section 1.2.1 for complete list).

9.2 Data available

9.2.1 Catch

There were no revisions to the 2012 landings data provided last year by Belgian and The Netherlands. UK(E&W) revised the total landings with 1 ton. Although France did not revise the total landings, trammel net landings were incorrectly provided as gill net landings without age composition. These landings were allocated a gill net age distribution from UK(E&W). This year, these French trammel net landings were provided as trammel net landings with their appropriate age distribution by France. The revisions had a minimal impact on this year's assessment results (ICES files).

Landing data reported to ICES are shown in Table 9.2.1 together with the total landings estimated by the Working Group. The 2013 landings used by the Working Group were 4390t which is 26% below the agreed TAC of 5900t and 8% below the predicted landings at a status quo fishing mortality in 2013 (4752t).The contribution of France, Belgium and the UK to the landings in 2013 is 53%, 30% and 17% respectively.

As in last year's assessment, misreporting by UK beam trawlers from Division VIIe into VIId have been taken into account and corrected accordingly (see also section 9.11). It should be noted that historically there is also thought to be a considerable under-reporting by small vessels, which take up a substantial part of the landings in the eastern Channel. In the UK buyers and sellers registration is considered to have reduced this significantly since 2005. Substantial progress has been made in recent years by including all returns from the small vessels.

Discard estimates since 2005 are available for the UK static gear by quarter. French static gear, otter trawl and beam trawl is available from 2005 on an annual basis. Belgian beam trawl discard estimates were available from 2010 on a quarterly basis. Numbers are raised to the sampled trips. It should be noted that the number of sampled trips is low. Figures were presented in previous WGNSSK reports and are available in ICES files.

The available information suggests that discards are not a substantial part of the catch for this high valued species. Although French otter trawl discards information suggest that occasionally discarding of predominantly 1-year old fish occur (especially in the first and second quarter). These otter trawls only comprise 12% of the sole landings in VIId. Belgian beam trawl discard information suggest that predominantly 1-year old fish are discarded which amount to a maximum of 11% in weight. Observer information from UK beam trawl trips also suggests low discard rates. The Working Group decided not to include discards in the assessment at this stage due to the scarcity of the data but will monitor the situation in the future.

As a first attempt at estimating an overall discard rate for the stock, individual discard rates for 2010, 2011 and 2012 from the different main métiers and countries were weighted proportionally to their landed weights to arrive at an overall discard rate by year (Table 9.2.2). The percent of the métiers with discard information covering the total international landings is 78%, 79% and 79% for 2011, 2012 and 2013 respectively.

Assuming that discard rates do not change from the average of the last 3 years (2011-2013) and a fixed proportion of discards survive, a discard rate of around 0.10 could be assumed for this stock at the moment. It should be noted that the discard rates were provided by the experts from the different countries at the Working Group and not taken from Intercatch as not all countries had uploaded discard estimates and there were some doubts about some uploaded discard values.

Belgium, France and UK have provided data on a metier basis this year under the ICES InterCatch format. Allocation has been made according the agreed scheme by the Expert group. 3 groups of metiers with age distributions were set up as follows: All-TBB metiers, All-OTB-CRU_70-99 metiers, and a group of all available metiers with age distributions (Overall). The TBB metiers without age distributions were allocated with the group All-TBB, the OTB-CRU_70-99 metiers without age distributions with All-OTB-CRU_70-99. The rest of the metiers without age distributions were allocated to the group Overall. The metiers with age distribution account for 88% of the total international landings. The metiers allocated with All-TBB and All-OTB-CRU_70-99 account for 5% of the total landings and the metiers allocated with the Overall group amount for the remaining 7% of the total landings (Figure 9.2.1a,b).

9.2.2 Age compositions

Quarterly data for 2013 were available for landing numbers and weight at age, for the French, Belgian, and UK fleets. These comprise 100% of the international landings. The annual age compositions of the landings are presented in Table 9.2.3. The quarterly age composition for 2012 (numbers and weights at age) are presented in Table 9.2.4

9.2.3 Weight at age

Weight at age in the catch is presented in Table 9.2.5 and Figure 9.2.2; and weight at age in the stock in Table 9.2.6 and Figure 9.2.3. The procedure for calculating mean weights is described in the Stock Annex.

9.2.4 Maturity and natural mortality

As in previous assessments, a knife-edged maturity-ogive was used at age 3.

Natural mortality is assumed to be a fixed value (0.1) for all ages across all years.

9.2.5 Catch, effort and research vessel data

Available estimates of effort and LPUE are presented in Tables 9.2.7a,b and Figures 9.2.4a-c. Slight revisions have been made to the UK effort and LPUE series for 2012. There were no revisions to the Belgium and French data series.

Effort for the Belgian beam trawl fleet increased to the highest level in 2007 with a decrease in the last six years to the level of the early 2000s. The peak in 2007 is mainly due to the unrestrictive "days at sea" EU regulation in ICES subdivision VIId from 2005 until 2007, as well as the good fishing opportunities for sole in that area. The mobile Belgian fleet fishes predominantly in the most favourable area which is presently subdivision VIIfg and VIId. The UK (E&W) beam trawl fleet effort increased from the late 80's, reaching its peak in 1997. Since then, effort has decreased and fluctuated around 60% of its peak level. Effort in 2013 is the second lowest value of the time series.

Information has been provided on effort and LPUE from the recent period for the French fleets in the Eastern Channel. This short data series will be extended historically and therefore will provide information on the trends in the main French fisheries. French effort (LPUE is not available yet) for 2009-2013 was extracted from a different database and therefore are not compatible with the earlier part of the series. It is the intention to update the earlier part of the series using the same extraction procedure as for 2009, 2010, 2011, 2012 and 2013, before the next WGNSSK. It appears that for the 3 main French fleets (Gill/trammel nets, Otter trawls and Beam trawls), effort decreased.

Belgian and UK beam trawl LPUE have been fluctuating around the mean with no strong trend. After a period of higher catch rates between 2004 and 2008, the UK beam trawl has decreased to the levels of the early 2000s. The Belgian beam trawl LPUE has declined over the last 3 years to the lower levels of the time series.

Survey and commercial data used for calibration of the assessment are presented in Table 9.2.8.

The data for 2013 for the UK beam trawl series was slightly revised. The UK survey component of the Young fish survey (YFS) was last conducted in 2006. In the absence of any update of the UK component, it was decided at the Benchmark working group (WKFLAT – February 2009) that the UK component should still be used in the assessment independently from the French component of the YFS index. It was also noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. (see also section 9.3.2).

9.3 Data analyses

9.3.1 Reviews of last year's assessment

No major deficiencies for the sole assessment in the Eastern English Channel were reported.

9.3.2 Exploratory catch at age analysis

Catch at age analysis was carried out according to the specifications in the Stock Annex. The model used was XSA. The results of exploratory XSA runs, which are not included in this report, are available in ICES files.

A preliminary inspection of the quality of international catch-at-age data was carried out using separable VPA with a reference age of 4, terminal F=0.5 and terminal S=0.8. The log-catch ratios for the fully recruited ages (3-10) did not show any patterns or large residuals (available in ICES files).

The tuning data were examined for trends in catchability by carrying out XSA tuning runs (lightly shrunk (se=2.0), mean q model for all ages, full time series and un-tapered), using data for each of the four fleets individually (in ICES files). Apart from the first few years in the Belgian series (1982-1985, which were excluded from the analyses, as in previous assessments), there were no strong trends for any of the fleets. The Belgian beam trawl fleet had a somewhat noisier log catchability residual pattern, especially for age 2 and age 11. Year effects were noted for the UK beam trawl fleet (UK(E&W)-CBT) in 2000 and 2005. The UK beam trawl survey (UK (E&W)-BTS) showed year effects for 3 consecutive years (1999, 2000 and 2001) as well as for 2009. It was also noted that the log catchability residual of the separate Young Fish Survey components (UK(E&W)-YFS and FR-YFS) were noisier than the combined Young Fish Survey index, used in previous assessments.

The time series of the standardized indices for ages 1 to 6 from the five tuning fleets (BE-CBT, UK(E&W)-CBT, UK(E&W)-BTS, UK(E&W)-YFS and the FR-YFS) are plotted in Figure 9.3.1. All tuning fleets appear to track the year classes reasonably well for ages 2 to 6. For age 1, the two Young Fish Survey components from UK and France are not always consistent in estimating the year class strength. It should be noted that the estimate of the 2008 year class from the French Young Fish Survey is twice the magnitude of the UK beam trawl survey. Both surveys estimate the 2011 and 2012 year class at age 1 to be very low. Investigations of the standardised indices from both the separate components of the Young Fish Survey and the combined index for age 1 (ICES files, 2010WG), show that the combined index and the UK component estimate year class strength to be more similar than the French component. Internal consistency plots for the 2 commercial fleets and the UK beam trawl survey are presented in Figure 9.3.2-4. The internal consistency of the Belgian beam trawl fleet appears to be relatively high for the older ages. The UK commercial fleet and the UK beam trawl survey show high consistencies for the entire age-range.

The catchability residuals for the proposed final XSA are shown in Figure 9.3.5a-b and the XSA tuning diagnostics are given in Table 9.3.1.

In general, estimates between fleets are rather consistent for most of the older ages (Figure 9.3.6), apart from the estimates from the FR-YFS.

In this year's assessment the estimates for the recruiting year class 2012 were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have weightings of about 50% and 40% respectively in the final survivor estimates. Shrinkage takes about 10% of the weighting. Both surveys, (UK(E&W)-BTS) and (FR-YFS) are estimating this year class to be the weakest in the time series. Although it should be noted that the internal standard errors of both surveys are around 1.0, indicating a high variability and therefore an uncertain estimate providing for this year class strength, the Expert group decided to use this estimate in the forecast.

At age 2, the 2011 year-class is predominantly estimated by the commercial UK beam trawl fleet and UK beam trawl survey, with weightings of 41% and 40% respectively. Both these tuning fleets estimate the survivors of that year class to be weak with somewhat different values (3211 and 9686). The Belgian commercial beam trawl fleet estimate this year class to be even weaker (2927) with a weighting of 10%. The French component of the Young Fish Survey estimates this year class to be about average (25633) but only accounts for 7% of the final survivor estimate.

F shrinkage gets low weights for all ages older than 2 (< 2%). The weighting of the 3 surveys decreases for the older ages as the commercial fleets are given more weight (Figure 9.3.6).

9.3.3 Exploratory survey-based analyses

In 2005, exploratory SURBA-runs (v3.0) were carried out on the UK(E&W) Beam-trawl Survey (UK-BTS) (1988-2004) and the International Young Fish Survey (1988-2004) to investigate whether the surveys-only analysis suggests different trends in Recruitment, SSB and fishing mortality. From the diagnostics on Mean Z, it was concluded that the surveys could not estimate any trend in fishing mortality. Given also that the SSB and recruitment trends from both XSA and SURBA runs showed similar patterns, the Expert Group decided to accept the XSA as the final assessment.

In this update assessment Surba runs were not executed.

This year, plots of standardised indices by year and year class are available in ICES files. They show a rather noisy pattern for the Belgian commercial beam trawl fleet but year class strength are relatively similarly estimated for all ages. The UK(E&W) commercial beam trawl fleet, as well as the UK(E&W) Beam-trawl Survey Log catch curves show a more consistent pattern and the year class strengths are similarly estimated by all ages.

Conclusion drawn from exploratory analyses

The XSA was taken as the final assessment, giving mostly consistent survivor estimates between fleets for ages 4 and above. Although the final XSA estimate for age 2 and 3 is coming from a wider range of estimates through the different tuning fleets, the Working Group decided that they could be accepted for any forecast.

The estimate of the recruiting age 1 (year class 2012) is a record low value for the time series. (Table 9.3.1 and Table 9.3.4). As both surveys (UK(E&W)-BTS and FR-YFS) estimate the 2012 year class rather similar as "very weak", the Expert Group decided that the final XSA survivor estimate of 3201 fish at age 1 could be accepted for any forecasts.

9.3.4 Final assessment

The final settings used in this year's assessment are specified as in the stock annex and are detailed below:

	2014 assessment		
Fleets	Years	Ages	α-β
BE-CBT commercial	86-13	2-10	0-1
UK(E&W)-CBT commercial	86-13	2-10	0-1
UK(E&W)-BTS survey	88-13	1-6	0.5-0.75
YFS – survey (combined index UK-FR)			
UK-YFS - survey	87-06	1-1	0.5-0.75
FR-YFS - survey	87-13	1-1	0.5-0.75
-First data year	1982		
-Last data year	2013		
-First age	1		
-Last age	11+		
Time series weights	None		
-Model	No Power model		
-Q plateau set at age	7		
-Survivors estimates shrunk towards mean F	5 years / 5 ages		
-s.e. of the means	2.0		
-Min s.e. for pop. Estimates	0.3		
-Prior weighting	None		

The final XSA output is given in Table 9.3.2 (fishing mortalities) and Table 9.3.3 (stock numbers). A summary of the XSA results is given in Table 9.3.4 and trends in yield, fishing mortality, recruitment and spawning stock biomass are shown in Figure 9.3.7. The high fishing mortality at age 4 in 2010 (0.57), at age 5 (0.50) in 2011, at age 6 (0.64) in 2012 and at age 7 (0.89) in 2013 was investigated for possible errors in raw data or raising procedures in WGNSSK-2013. No anomalies were found in the catch at age matrix. Total numbers at age for age 6, expressed as % to the overall numbers at age by the different métiers ranged from 3% to 4% with the exception of the French GTR_DEF_all_0_0_all métier which amounted to 10% for age 6 (ICES files). The high fishing mortalities for ages 4 to 7 result from the UK(E&W) commercial Beam-trawl fleet (UK(E&W)-CBT) which tunes the XSA. In that tuning fleet the % of 6 year old fish in 2012 only accounts for 1% and apparently this year class (2006) was also not abundant in that tuning fleet at ages 4, 5 and 7 (Table 9.2.7). Age reading problems are very unlikely to be the cause for these differences in age structure of the UK(E&W) tuning fleet compared to the other metiers catching sole in VIId. It was however noted by the Expert Group that the age composition of the UK(E&W) metier TBB_DEF_70-99_0_0_all, accounted for 3% fish in numbers for age 6 in 2012 (compared to the 1% in the tuning file), which may indicate a different raising procedure for the UK(E&W) metier and the tuning file. This will hopefully be investigated before the next WGNSSK.

Retrospective patterns for the final run are shown in Figure 9.3.8. There is good consistency between estimates in successive years for fishing mortality and SSB. However, the retrospective output shows a massive downward revision of the 2010 year class (age 1 in 2011) by 88% (ie. 157 912 to 18 452 fish). It should be noted that the high XSA estimate (157 912) in the 2010 assessment was replaced with an RCT3 estimate of 47 475 in the forecast.

Fishing mortality for 2012 has been revised downward by 11% and SSB upward by 2%.

9.4 Historical Stock Trends

Trends in landings, SSB, F(3-8) and recruitment are presented Table 9.3.4 and Figure 9.3.7.

For most of the time series, fishing mortality has been fluctuating between Fpa (0.4) and Flim (0.57). In the early 90's it dropped below Fpa. Since 1999 it decreased steadily from 0.55 to around 0.4 in 2001 after which it remained stable until 2005. In the last 8 years fishing mortality has increased again above the Fpa value.

Recruitment has fluctuated around 24 million recruits with occasional strong year classes. Five of the highest values in the time series have been recorded in the last 12 years. The last two year classes are predicted to be very weak.

The spawning stock biomass has been stable for most of the time series. Since 2001 SSB has increased to well above Bpa (8000 t) due to average and above average year classes. The incoming very weak year classes of 2011 and 2012 are likely to reverse the increasing trend in SSB.

9.5 Recruitment estimates

The 2011 year class in 2012 was estimated to be around 8 million fish at age 1, which is the second lowest value in the time series and 19% lower than estimated last year. This revision is mainly due to the availability in this year's assessment of survivor estimates from two commercial fleets. The XSA survivor estimates for this year class were used for further prediction.

The 2012 year class in 2013 was estimated by XSA to be 3.5 million one year olds, which is by far the lowest value of the time series. Both surveys (UK-BTS (age1) and FR-YFS (age1)) estimate the 2012 year class somewhat different (2 826 and 4 949 respectively), however both estimates are record low values. The Expert Group decided that the XSA survivor estimate for this year class was used for further prediction.

The long term GM recruitment (24 million, 1982-2011) was assumed for the 2013 and subsequent year classes.

Although the RCT3 results for the 2013 year class are not used for prediction (highly variable with a standard error close to 0.9), it should be noted that the French Young fish survey (FR-YFS) at age 0 indicates an average 2013 year class. The RCT3 input is presented in Table 9.5.1 and the results in Tables 9.5.2a and b.

The working group estimates of year class strength used for prediction can be summarised as follows:

Year class	At age in 2014	XSA	GM 82-11	RCT3	Accepted Estimate
2011	3	5729	15831	-	XSA
2012	2	3201	21403	14773	XSA
2013	1	-	23913	22728	GM 1982-11
2014 & 2015	recruits	-	23913	-	GM 1982-11

9.6 Short term forecasts

The short term prognosis was carried out according to the specifications in the stock annex. As fishing mortality has fluctuated in the last three years, the selection pattern

for prediction has been taken as a 3 year unscaled average. Weights at age in the catch and in the stock are averages for the years 2011-2013.

Input to the short term predictions and the sensitivity analysis are presented in Table 9.6.1. The *status quo* assumption for 2014 (intermediate year) resulted in a much lower landings (3 415t) than the agreed TAC of 4838t. Although TAC's have not been taken in the last 17 years, apart from in the year 2010, the Expert Group decided that total international landings of around 3 500t may not be a realistic assumption for 2014. Taking into account that the average landings for the last 3 years (2010-2013) is estimated at 4 190t, the Expert Group have run an alternative forecast assuming this mean landings value for 2014. However, it should be noted that this assumption is speculative and not based on any preliminary landings information for 2014. It also would assume a fishing mortality in 2014 of 0.56, the third highest in the time series.

The Results of the *status quo* assumption for 2014 are presented in Table 9.6.2a (management options) and Table 9.6.3a (detailed output).

The Results of the alternative forecast, assuming 4 190t landings for 2014 are presented in Table 9.6.2b (management options) and Table 9.6.3b (detailed output).

Assuming *status quo* F, implies a catch in 2014 of 3 415t (the agreed TAC is 4 838t) and a catch of 2 889 t in 2015. The corresponding SSB's in 2014 and 2015 are 10 088t and 7 394t respectively.

Assuming a status quo F for 2014 and 2015, the proportional contributions of recent year classes to the landings in 2015 and SSB in 2016 are given in Table 9.6.4. The assumed GM recruitment accounts for 14 % of the landings in 2015 and 39 % of the 2016 SSB.

Results of a sensitivity analysis are presented in Figure 9.6.1 (probability profiles). The approximate 90% confidence intervals of the expected status quo yield in 2015 are 2 250t and 3 750t. There is about 5% probability that at current fishing mortality SSB will fall below the B_{pa} of 8000t in 2016.

9.7 Medium-term forecasts and Yield per recruit analyses

This year, no Medium-term forecasts were carried out for this stock.

Yield-per-recruit results, long-term yield and SSB, conditional on the present exploitation pattern and assuming a *status quo* F in 2014, are given in Table 9.7.1 and Figure 9.7.1. F_{max} is calculated by this year's assessment to be 0.34 (0.43 = F_{sq}).

9.8 Biological reference points

		Basis
Flim	0.55	Fishing mortality at or above which the stock has shown continued decline.
Fpa	0.40	F is considered to provide approximately 95% probability of avoiding Flim
Blim	-	Not defined
Bpa	8000	Lowest observed biomass at which there is no indication of impaired recruitment.
Fmax	0.28- 0.30	Using MFDP program Using PLOTMSY program
Fmsy	0.29	PLOTMSY program

F2010	0.49
Fsq	0.46

Exploratory analysis investigating possible revisions of MSY estimates were conducted with the recent version of PlotMSY (ICES 2014, WKMSYREF2). Results are presented in Table 9.8.1 and Figures 9.8.1-6.

The simulations indicate that the use of a Ricker or Beverton-Holt stock recruitment relationship are not appropriate (high CV's and poor fit) and therefore 100% weighting was given to the Smooth hokeystick relationship. The 50% percentile as well as the deterministic result suggest that Fmsy could be revised from 0.29 to 0.34.

Further exploratory analysis on Fmsy was conducted using EQsim. The results were not satisfactory as there were no estimates from the segmented regression stock recruitment relationship and FCrash was not calculated. The expert group decided not to present the results of that analysis.

9.9 Quality of the assessment

- This year's assessment revised fishing mortality in 2012 downward by 11% and SSB upward by only 2%. The XSA recruitment estimate in 2012 (year class 2011) was revised downward by 19% mainly due to the availability in this year's assessment of survivor estimates of two commercial fleets. In last year's assessment, the XSA estimates were replaced with RCT3 estimates in the forecast. Therefore, recruitment was revised downward by 60% compared to the forecast input. Estimates of the incoming recruitment (year class 2012) are based on 2 surveys, the UK-BTS and FR-YFS at age1, both estimating it to be the lowest of the time series.
- The trends and estimates of fishing mortality, SSB and recruitment were consistent with last year's assessment apart from the downward revision of the 2011 year class (see above).
- Since 2001 SSB has increased to well above Bpa (8000 t) due to average and above average year classes. The incoming very weak year classes of 2011 and 2012 are predicted to reverse the increasing trend in SSB.
- Information available on discards suggests that discards are not substantial (around 10% in weight) and therefore discards are not incorporated in the assessment. Discard information from French otter trawls and Belgian beam trawl suggest however that some discarding of 1 year old sole is taking place in the first 2 quarters of the year. Although the observed discarding at age 1 will not affect the assessment substantially, they will have an impact on forecasts, but the low level of discards are not considered a significant factor in catch forecasts.
- The UK component of the YFS index is not available since 2007, resulting in the unavailability of the combined YFS-index. This combined index estimated the incoming year class strength very consistently and provided reliable estimates for the forecasts. Although results of using the YFS indices separately (FR-YFS for 1987-present and UK-YFS for 1987-2006), did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. The Working Group suggests that the assessment could benefit if the French Young Fish survey could be extended

to include some of the sampling points from the former UK Young Fish survey along the English coast. The extended French survey might then mimic the earlier available combined Young Fish survey which was an excellent estimator of the incoming recruitment.

- There is no apparent stock/recruitment relationship for this stock and no evidence of reduced recruitment at low levels of SSB (Figure 9.9.1). However ICES has used a smooth hockey stick as the best possible stock/recruitment relationship in calculating Fmsy (0.29 estimated in 2009). At this Working Group new analysis has been conducted, suggesting that a revision of Fmsy to 0.34 could be considered.
- The historical performance of this assessment is rather noisy (Figure 9.9.2) but has been more constant in recent years. It should be noted that settings have been changed and XSA estimates of recruitment have been adjusted during several assessments in the past e.g. where adjustment were made of the XSA recruitment by utilising RCT3 estimates in the 2010 assessment.
- There has been misreporting from adjacent areas. The Working group has addressed this by modifying landings data accordingly. Since 2002 the UK(E&W) beam trawl landings from two rectangles 28E8 and 29E8 (in VIId) were re-allocated to VIIe on a quarterly basis, (based on information provided to the Working Group by the fishing industry) and the age compositions raised accordingly. This was carried out back to 1986. For VIId sole, UK(E&W) beam trawl and otter trawl data are processed together (as trawl), so the landings from these two rectangles were removed from the trawl data on a quarterly basis, and the age compositions adjusted to take that into account.
- Sampling for sole landings in division VIId are considered to be at a reasonable level.

9.10 Status of the Stock

Fishing mortality has been stable between 2000 and 2005 around Fpa. In the last 8 years fishing mortality has increased to values between Fpa (0.4) and Flim (0.57).

The spawning stock biomass has been stable for most of the time series and SSB is presently well above Bpa. The strong 2004 and 2005 year class increased SSB to around record high level of the time series in 2008. The incoming very weak year classes of 2011 and 2012 are likely to reverse the increasing trend in SSB.

9.11 Management Considerations

- There is misreporting from adjacent areas. The Working group has addressed this by modifying landings data accordingly. Since 2002 the UK(E&W) beam trawl landings from two rectangles 28E8 and 29E8 (in VIId) were re-allocated to VIIe on a quarterly basis, (based on information provided to the Working Group by the fishing industry) and the age compositions raised accordingly.
- There is a less than 5% probability that SSB will decrease to B_{pa} in the short term due to the strong 2008 and 2009 year classes.
- EU Council Regulation (EC) N°43/2014 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. This regime has only slightly reduced effort directed at sole in this area.

- Due to the minimum mesh size (80 mm) in the mixed beam trawl fishery, a large number of (undersized) plaice are discarded. The 80-mm mesh size is matched to the minimum landing size of sole but not matched to the minimum landing size of plaice. Measures to reduce discarding of plaice in the sole fishery would greatly benefit the plaice stock and future yields. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole. An increase in the minimum landing size of sole could provide an incentive to fish with larger mesh sizes and therefore mean a reduction in the discarding of plaice.

Sole VIId – Tables

Table 9.2.1 Sole VIId. Nominal landings (tonnes) as officially reported to ICES and used by the Working Group

Year	Belgium	France	UK(E+W)	others	reported	Unallocated*	Total used by WG	TAC
1974	159	383	309	3	854	30	884	
1975	132	464	244	1	841	41	882	
1976	203	599	404	.	1206	99	1305	
1977	225	737	315	.	1277	58	1335	
1978	241	782	366	.	1389	200	1589	
1979	311	1129	402	.	1842	373	2215	
1980	302	1075	159	.	1536	387	1923	
1981	464	1513	160	.	2137	340	2477	
1982	525	1828	317	4	2674	516	3190	
1983	502	1120	419	.	2041	1417	3458	
1984	592	1309	505	.	2406	1169	3575	
1985	568	2545	520	.	3633	204	3837	
1986	858	1528	551	.	2937	995	3932	
1987	1100	2086	655	.	3841	950	4791	3850
1988	667	2057	578	.	3302	551	3853	3850
1989	646	1610	689	.	2945	860	3805	3850
1990	996	1255	785	.	3036	611	3647	3850
1991	904	2054	826	.	3784	567	4351	3850
1992	891	2187	706	10	3794	278	4072	3500
1993	917	2322	610	13	3862	437	4299	3200
1994	940	2382	701	14	4037	346	4383	3800
1995	817	2248	669	9	3743	677	4420	3800
1996	899	2322	877	.	4098	699	4797	3500
1997	1306	1702	933	.	3941	823	4764	5230
1998	541	1703	803	.	3047	316	3363	5230
1999	880	2251	769	.	3900	235	4135	4700
2000	1021	2190	621	.	3832	-356	3476	4100
2001	1313	2482	822	.	4617	-592	4025	4600
2002	1643	2780	976	.	5399	-666	4733	5200
2003	1657	3475	1114	1	6247	-1209	5038	5400
2004	1485	3070	1112	.	5667	-841	4826	5900
2005	1221	2832	567	.	4620	-236	4384	5700
2006	1547	2627	678	.	4852	-18	4834	5720
2007	1530	2981	801	1	5313	-147	5166	6220
2008	1368	2880	724	.	4972	-455	4517	6593
2009	1475	2886	754	6	5121	145	5266	5274
2010	1294	2407	674		4374	35	4409	4219
2011	1181	2283	686		4150	-17	4133	4852
2012	920	2475	623	0.25	4018	30	4048	5580
2013**	954	2865	605		4424	-34	4390	5900

* Unallocated mainly due to misreporting

** Preliminary

Table 9.2.2 - Sole VIId - Discard rates

Year	BE-TBB-Rate	BE-TBB-Landings	FR-GTR-Rate	FR-GTR-Landings	FR-OTB-Rate	FR-OTB-Landings	UK-TBB-Rate	UK-TBB-Landings	UK-OTB-Rate	UK-OTB-Landings	UK-GNS-Rate	UK-GNS-Landings
2011	0.05	1178	0.024	1500	0.326	500	0.014	94	0.056	135	0.039	284
2012	0.11	893	0.018	1583	0.426	470	0.014	113	0.002	131		
2013	0.11	911	0.021	1920	0.667	542	0.002	103			0.051	195

SUM-Landings-with discard rates	Total Landings (info)	%-Coverage of total landings
3407	4133	**82**
3190	4048	**79**
3476	4390	**79**

	Rate	Percent	Rate	Percent	Rate	Percent	Rate	Percent	Rate	Percent	Rate	Percent
2011	0.05	0.35	0.024	0.44	0.326	0.15	0.014	0.03	0.056	0.04	0.039	0.08
2012	0.11	0.28	0.018	0.50	0.426	0.15	0.014	0.04	0.002	0.04	0	0.00
2013	0.11	0.26	0.021	0.55	0.667	0.16	0.002	0.03	0	0.00	0.051	0.06

	Rate	Rate	Rate	Rate	Rate	Rate
2011	0.017	0.011	0.048	0.000	0.002	0.003
2012	0.031	0.009	0.063	0.000	0.000	0.000
2013	0.029	0.012	0.104	0.000	0.000	0.003

Year	Rate-Year
2011	0.08
2012	0.10
2013	0.15
Average	**0.11**

Table 9.2.3 - Sole VIId - Landing numbers at age (kg)

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:04

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1982	1983
AGE		
1	155	0
2	2625	852
3	5256	3452
4	1727	3930
5	570	897
6	653	735
7	549	627
8	240	333
9	122	108
10	83	89
+gp	202	193
0 TOTALNUM	12182	11216
TONSLAND	3190	3458
SOPCOF %	97	99

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
AGE										
1	24	49	49	9	95	163	1245	383	105	85
2	1977	3693	1251	3117	2162	3484	2851	7166	4046	5028
3	3157	5211	5296	3730	7174	3220	5580	4105	8789	6442
4	2610	1646	3195	3271	1602	4399	1151	4160	1888	5444
5	1900	1027	904	2053	1159	1434	1496	604	1993	1008
6	742	1860	768	1042	856	840	301	996	288	563
7	457	144	1056	1090	388	571	390	257	368	162
8	317	158	155	784	255	201	260	247	135	188
9	136	156	190	111	256	166	129	258	171	116
10	99	69	212	163	83	224	126	92	95	62
+gp	238	128	372	459	275	282	489	382	231	129
0 TOTALNUM	11657	14141	13448	15829	14305	14984	14018	18650	18109	19227
TONSLAND	3575	3837	3932	4791	3853	3805	3647	4351	4072	4299
SOPCOF %	99	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
1	31	838	9	24	33	168	138	168	707	379
2	694	2977	1825	1489	1376	3268	3586	6042	7011	10957
3	6203	4375	7764	6068	5609	8506	4852	6194	7513	5086
4	5902	4765	3035	5008	2704	3307	4395	1595	3767	3178
5	3404	2968	3206	2082	1636	1311	1076	2491	1414	1805
6	584	1980	1823	1670	609	869	505	728	655	671
7	567	375	1283	916	558	350	319	290	298	588
8	109	278	271	775	441	672	148	128	129	198
9	147	88	319	239	354	351	328	56	97	70
10	93	106	112	169	239	192	150	81	57	88
+gp	258	241	344	267	301	359	248	265	197	245
0 TOTALNUM	17992	18991	19991	18707	13860	19353	15745	18038	21845	23265
TONSLAND	4383	4420	4797	4764	3363	4135	3476	4025	4733	5038
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
AGE										
1	1030	206	608	175	149	231	139	0	5	5
2	4254	3468	7370	6511	2702	3006	5276	4636	1106	1062
3	8623	4034	3753	7316	8516	4418	4453	6230	6752	5289
4	2545	5458	2821	2990	4145	7092	3289	2884	4388	6023
5	2272	1543	3433	1500	1267	2378	3083	1510	1382	2361
6	1108	1143	1103	2038	849	798	1327	1432	1001	791
7	371	633	796	751	751	615	328	554	643	600
8	448	218	403	467	356	642	267	179	485	499
9	94	283	191	257	164	277	336	148	124	244
10	88	127	208	162	134	251	99	105	59	79
+gp	233	271	307	230	247	451	290	222	389	168
0 TOTALNUM	21066	17384	20993	22397	19280	20159	18887	17900	16334	17121
TONSLAND	4826	4383	4833	5166	4517	5266	4409	4133	4048	4390
SOPCOF %	100	100	100	100	100	100	100	100	100	103

Table 9.2.4 - Sole VIId - Quaterly landings composition for 2013

	Q1		Q2		Q3		Q4	
Age	Numbers	Weights	Numbers	Weights	Numbers	Weights	Numbers	Weights
1	0.1	0.096	0.1	0.085	1.6	0.058	0.0	0.082
2	25.2	0.150	61.6	0.133	755.3	0.153	111.3	0.143
3	459.3	0.143	881.6	0.168	2381.6	0.200	790.0	0.221
4	1245.8	0.268	2039.6	0.253	1053.4	0.246	448.9	0.254
5	245.9	0.324	798.3	0.324	298.4	0.283	143.6	0.319
6	63.8	0.328	228.8	0.357	158.4	0.287	68.3	0.285
7	81.3	0.447	219.8	0.432	110.2	0.341	40.6	0.350
8	104.8	0.451	184.9	0.518	70.0	0.389	12.7	0.359
9	11.9	0.401	67.6	0.461	32.4	0.381	17.4	0.536
10	20.0	0.290	19.7	0.472	12.4	0.454	0.9	0.464
11	1.6	0.566	5.2	0.546	5.6	0.472	3.3	0.414
12	2.6	0.497	8.2	0.386	3.7	0.417	0.7	0.426
13	0.9	0.704	10.1	0.439	0.7	0.584	0.2	0.620
14	1.3	0.576	11.0	0.607	1.5	0.496	3.3	0.307
15+	2.2	0.580	9.5	0.765	6.7	0.469	8.3	0.541

Nominal landings (t)	660.6	1237.6	1148.4	432.5

Table 9.2.5 - Sole VIId - Catch weights at age (kg)

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:05

Table 2 Catch weights at age (kg)

	YEAR	1982	1983
	AGE		
	1	0.102	0
	2	0.171	0.173
	3	0.225	0.23
	4	0.312	0.302
	5	0.386	0.404
	6	0.428	0.436
	7	0.439	0.435
	8	0.509	0.524
	9	0.502	0.537
	10	0.463	0.583
	+gp	0.6729	0.6283
0	SOPCOFAC	0.9713	0.991

Table 2 Catch weights at age (kg)

	YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
	AGE										
	1	0.100	0.090	0.135	0.095	0.102	0.106	0.12	0.114	0.103	0.085
	2	0.178	0.182	0.180	0.175	0.152	0.154	0.178	0.161	0.153	0.147
	3	0.234	0.230	0.212	0.236	0.226	0.192	0.238	0.208	0.203	0.197
	4	0.314	0.281	0.306	0.295	0.278	0.271	0.289	0.266	0.267	0.247
	5	0.380	0.368	0.363	0.353	0.360	0.293	0.349	0.354	0.29	0.335
	6	0.436	0.394	0.387	0.407	0.409	0.358	0.339	0.394	0.403	0.384
	7	0.417	0.516	0.437	0.411	0.459	0.388	0.47	0.421	0.391	0.537
	8	0.538	0.543	0.520	0.482	0.514	0.472	0.465	0.43	0.462	0.553
	9	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459	0.515
	10	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463	0.766
	+gp	0.7135	0.8005	0.6015	0.6176	0.6647	0.7014	0.5621	0.5656	0.5661	0.6666
0	SOPCOFAC	0.9884	0.998	1.0006	1.0004	1.0001	0.9994	0.9995	1.0001	1.0001	1.0002

Table 2 Catch weights at age (kg)

	YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
	AGE										
	1	0.099	0.129	0.142	0.139	0.132	0.130	0.145	0.108	0.120	0.114
	2	0.150	0.176	0.165	0.153	0.159	0.151	0.142	0.152	0.162	0.170
	3	0.186	0.179	0.178	0.188	0.172	0.189	0.176	0.211	0.204	0.208
	4	0.235	0.230	0.229	0.233	0.235	0.215	0.223	0.283	0.253	0.257
	5	0.288	0.255	0.269	0.292	0.286	0.260	0.332	0.288	0.316	0.277
	6	0.355	0.333	0.324	0.343	0.343	0.280	0.377	0.334	0.375	0.357
	7	0.381	0.357	0.361	0.390	0.383	0.290	0.424	0.367	0.376	0.381
	8	0.505	0.385	0.405	0.404	0.417	0.341	0.427	0.374	0.393	0.438
	9	0.484	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469	0.482
	10	0.496	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420	0.494
	+gp	0.6156	0.6536	0.5854	0.6509	0.6162	0.5354	0.68	0.5445	0.5308	0.5274
0	SOPCOFAC	1.0001	0.9997	0.9999	1	1.0013	0.9992	1.0009	1.0005	0.9995	1.0002

Table 2 Catch weights at age (kg)

	YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	AGE										
	1	0.120	0.135	0.139	0.163	0.148	0.143	0.124	0.123	0.173	0.076
	2	0.179	0.172	0.162	0.190	0.164	0.177	0.161	0.161	0.179	0.150
	3	0.205	0.208	0.192	0.202	0.201	0.203	0.195	0.204	0.204	0.189
	4	0.255	0.253	0.249	0.227	0.244	0.260	0.239	0.252	0.245	0.245
	5	0.296	0.303	0.284	0.276	0.262	0.279	0.287	0.295	0.288	0.297
	6	0.304	0.337	0.328	0.294	0.321	0.358	0.340	0.326	0.301	0.315
	7	0.348	0.368	0.353	0.315	0.435	0.321	0.342	0.342	0.377	0.389
	8	0.403	0.433	0.402	0.378	0.411	0.464	0.355	0.399	0.355	0.446
	9	0.492	0.570	0.457	0.441	0.377	0.406	0.512	0.352	0.467	0.406
	10	0.509	0.445	0.450	0.439	0.498	0.476	0.438	0.441	0.365	0.441
	+gp	0.525	0.5369	0.557	0.5206	0.5127	0.6185	0.4504	0.5216	0.5169	0.5381
0	SOPCOFAC	0.9983	0.9989	1	1.0026	0.9991	1.0009	0.9998	1.0004	1.0006	1.0292

Table 9.2.6 - Sole VIId - Stock weights at age (kg)

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:05

Table 3 Stock weights at age (kg)

YEAR	1982	1983
AGE		
1	0.059	0.07
2	0.114	0.135
3	0.167	0.197
4	0.217	0.255
5	0.263	0.309
6	0.306	0.359
7	0.347	0.406
8	0.384	0.448
9	0.418	0.487
10	0.45	0.522
+gp	0.53	0.6008

Table 3 Stock weights at age (kg)

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
AGE										
1	0.067	0.065	0.070	0.072	0.050	0.050	0.05	0.05	0.05	0.05
2	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138	0.144	0.13
3	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225	0.199	0.189
4	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279	0.277	0.246
5	0.304	0.315	0.309	0.318	0.365	0.323	0.4	0.38	0.305	0.366
6	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384	0.454	0.377
7	0.403	0.436	0.403	0.417	0.477	0.480	0.476	0.41	0.405	0.545
8	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449	0.459	0.56
9	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474	0.43	0.559
10	0.5290	0.6110	0.5120	0.5360	0.6360	0.5360	0.507	0.451	0.528	0.813
+gp	0.6265	0.7798	0.5761	0.6156	0.7498	0.7135	0.5765	0.6203	0.5269	0.5664

Table 3 Stock weights at age (kg)

YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.116	0.126	0.155	0.139	0.140	0.128	0.122	0.127	0.136	0.151
3	0.161	0.129	0.176	0.165	0.158	0.180	0.148	0.157	0.179	0.207
4	0.215	0.220	0.258	0.220	0.233	0.205	0.208	0.216	0.209	0.249
5	0.273	0.234	0.286	0.264	0.299	0.253	0.402	0.226	0.258	0.314
6	0.316	0.333	0.308	0.317	0.374	0.277	0.440	0.223	0.254	0.376
7	0.368	0.357	0.366	0.376	0.363	0.298	0.395	0.231	0.301	0.399
8	0.530	0.330	0.391	0.404	0.357	0.324	0.554	0.253	0.234	0.418
9	0.461	0.614	0.438	0.563	0.450	0.336	0.443	0.256	0.326	0.446
10	0.470	0.382	0.466	0.494	0.372	0.323	0.420	0.301	0.404	0.444
+gp	0.6122	0.6292	0.6304	0.6536	0.5768	0.5118	0.6822	0.4204	0.4170	0.5032

Table 3 Stock weights at age (kg)

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
AGE										
1	0.050	0.144	0.141	0.139	0.131	0.141	0.143	0.050	0.172	0.085
2	0.137	0.157	0.161	0.163	0.158	0.169	0.149	0.142	0.165	0.133
3	0.185	0.203	0.185	0.195	0.191	0.186	0.185	0.189	0.182	0.168
4	0.236	0.241	0.246	0.239	0.250	0.243	0.210	0.244	0.243	0.253
5	0.265	0.267	0.272	0.286	0.294	0.278	0.267	0.277	0.259	0.324
6	0.267	0.309	0.326	0.297	0.368	0.352	0.316	0.318	0.284	0.357
7	0.273	0.349	0.339	0.340	0.401	0.341	0.341	0.336	0.365	0.432
8	0.331	0.401	0.394	0.400	0.476	0.430	0.326	0.375	0.344	0.518
9	0.504	0.608	0.416	0.433	0.463	0.449	0.440	0.386	0.338	0.461
10	0.409	0.425	0.461	0.446	0.402	0.456	0.416	0.501	0.521	0.472
+gp	0.4501	0.5602	0.5553	0.5182	0.5663	0.6598	0.4192	0.5147	0.4788	0.5709

Table 9.2.7a **Sole in VIId. Indices of effort**

Year	France Beam trawl[1]	France GTR_Demersal_fish[4]	France OTB_Demersal_fish[4]	France TBB_Demersal_fish[4]	England & Wales Beam trawl[2]	Belgium Beam trawl[3]
1971						
1972						
1973						
1974						
1975						5.02
1976						6.56
1977						6.87
1978						8.22
1979						7.30
1980						12.81
1981						19.00
1982						23.94
1983						23.64
1984						28.00
1985						25.29
1986					2.79	23.54
1987					5.64	27.11
1988					5.09	38.52
1989					5.65	35.67
1990					7.27	30.33
1991	10.69				7.67	24.29
1992	10.52				8.78	21.99
1993	10.22				6.40	20.02
1994	10.61				5.43	25.17
1995	12.38				6.89	24.17
1996	14.09				10.31	25.00
1997	10.92				10.25	30.89
1998	11.71				7.31	18.12
1999	10.63				5.86	21.39
2000	13.78				5.65	30.54
2001	11.38				7.64	32.39
2002		14.91	23.88	4.06	7.90	33.68
2003		15.35	23.18	4.16	6.69	47.50
2004		15.07	21.16	4.00	4.87	41.60
2005		16.60	17.57	3.16	6.00	35.80
2006		16.87	20.74	3.68	5.94	48.80
2007		17.18	20.72	3.39	5.00	57.90
2008		13.16	16.43	3.44	6.21	48.50
2009		104.81*	100.18*	30.38*	6.21	45.27
2010		116.50*	94.98*	29.03*	4.35	35.93
2011		61.75*	73.60*	17.59*	3.00	34.80
2012		n/a	n/a	n/a	3.31	30.27
2013		n/a	n/a	n/a	2.88	33.15

[1]in Kg/1000 h*KW-04

[1] Beam trawl >= 10m in millions hp hrs >10% sole

[3]Fishing hours (x 10^3) corrected for fishing power using P = 0.000204 BHP^1.23

[4] Days at sea (x 10^3)

* extracted using a different system then before 2009

Table 9.2.7b **Sole in VIId. LPUE indices**

Year	France[1] Beam trawl	France GTR_Demersal_fish[4]	France OTB_Demersal_fish[4]	France TBB_Demersal_fish[4]	England & Wales[2] Beam trawl	Belgium[3] Beam trawl
1971						
1972						
1973						
1974						
1975						24.09
1976						27.28
1977						29.99
1978						26.27
1979						37.42
1980						23.26
1981						24.52
1982						23.65
1983						22.37
1984						21.61
1985						22.90
1986					39.48	33.48
1987					32.82	36.56
1988					27.67	15.89
1989					26.59	16.82
1990					26.88	25.94
1991	18.52				22.09	22.56
1992	18.12				25.29	29.11
1993	21.60				23.75	34.77
1994	17.78				31.83	27.89
1995	18.46				28.39	24.70
1996	19.79				25.79	29.80
1997	14.41				25.40	32.57
1998	17.33				25.71	23.51
1999	30.40				27.29	26.41
2000	19.10				27.46	24.49
2001	46.10				26.58	24.58
2002		101.29	30.39	152.67	31.63	27.33
2003		111.29	31.43	142.72	32.81	33.13
2004		102.13	26.96	132.65	38.80	30.86
2005		101.53	27.47	124.39	40.51	31.97
2006		90.48	30.39	90.06	39.01	27.47
2007		99.68	32.31	110.72	35.58	23.43
2008		107.17	34.39	116.23	37.51	24.58
2009		n/a	n/a	n/a	29.42	29.27
2010		n/a	n/a	n/a	31.71	31.23
2011		n/a	n/a	n/a	30.16	29.78
2012		n/a	n/a	n/a	29.70	26.35
2013		n/a	n/a	n/a	30.22	23.42

[1] in h*KW-04

[2] in Kg/1000 HP*HRS >10% sole

[3] in Kg/hr corrected for fishing power using P = 0.000204 BHP^1.23

[4] in Kilos/days at sea

Table 9.2.8 - Sole VIId - tuning files

Bolded numbers = used in XSA

SOLE 7d,TUNING - Tun7d.txt - 2014WG

105

BE-CBT

1980 2013

1 1 0 1

2 15

12.8	**69.3**	**46.1**	**298.7**	**189.6**	**57.4**	**24.7**	**10.3**	**5.1**	**8.6**	3.1	5.5	2.4	2.6	37.9
19.0	**640.7**	**161.4**	**82.1**	**312.8**	**229.6**	**44.7**	**32.9**	**33.1**	**6.9**	9.0	18.4	9.3	0.8	51.9
23.9	**148.7**	**980.9**	**128.0**	**93.4**	**155.9**	**112.6**	**38.8**	**60.1**	**15.2**	14.0	7.4	12.5	5.9	54.3
23.6	**190.4**	**373.0**	**818.9**	**65.5**	**54.0**	**81.7**	**73.2**	**23.5**	**20.2**	27.0	5.0	1.0	7.1	33.0
28.0	**603.8**	**347.2**	**311.2**	**436.0**	**53.7**	**38.5**	**104.9**	**59.9**	**25.4**	23.2	25.3	9.0	8.2	42.4
25.3	**382.9**	**612.1**	**213.0**	**209.1**	**260.2**	**58.2**	**34.1**	**48.0**	**31.0**	16.9	19.6	9.2	7.7	21.3
23.4	**215.0**	**1522.3**	**675.0**	**233.7**	**170.6**	**194.0**	**30.1**	**53.1**	**64.2**	32.6	12.7	2.6	43.0	29.3
27.1	**843.6**	**451.0**	**739.3**	**724.4**	**344.5**	**232.4**	**152.7**	**25.3**	**86.5**	56.0	56.1	54.5	9.3	109.0
38.5	**131.6**	**990.4**	**243.3**	**362.9**	**216.7**	**111.8**	**41.8**	**73.8**	**47.0**	9.8	22.3	35.8	8.6	25.3
35.7	**47.5**	**512.6**	**543.6**	**748.0**	**276.6**	**225.0**	**53.1**	**36.4**	**12.7**	4.7	0.0	0.0	4.7	27.0
30.3	**1011.4**	**1375.2**	**218.1**	**366.2**	**85.3**	**198.2**	**65.5**	**39.0**	**22.4**	22.2	25.4	2.8	24.0	18.2
24.3	**320.2**	**1358.6**	**710.1**	**125.6**	**283.9**	**60.6**	**56.2**	**21.0**	**19.8**	22.2	18.0	5.6	0.3	21.4
22.0	**499.3**	**1613.7**	**523.3**	**477.7**	**36.9**	**67.9**	**28.2**	**31.7**	**11.2**	11.4	6.0	5.7	3.2	16.7
20.0	**1654.5**	**1520.4**	**889.5**	**215.5**	**78.5**	**38.9**	**40.8**	**37.8**	**11.3**	8.7	13.3	1.5	3.0	22.4
22.2	**196.9**	**1183.2**	**1598.5**	**912.9**	**201.0**	**160.0**	**39.5**	**33.8**	**46.2**	16.0	10.2	14.9	8.8	18.6
24.2	**206.2**	**542.7**	**671.3**	**590.9**	**409.4**	**100.6**	**40.3**	**25.4**	**14.2**	9.3	5.0	11.9	3.4	8.0
25.0	**284.1**	**975.5**	**628.7**	**560.1**	**354.3**	**316.8**	**68.3**	**77.6**	**34.2**	26.2	15.8	10.8	1.1	4.2
30.9	**196.0**	**1282.3**	**966.1**	**500.2**	**422.3**	**301.1**	**144.7**	**56.6**	**29.3**	25.8	12.1	12.6	3.4	1.4
18.1	**254.1**	**450.3**	**375.4**	**175.1**	**54.8**	**116.1**	**95.9**	**59.1**	**12.4**	16.0	7.7	2.9	4.4	19.2
21.4	**367.7**	**1043.6**	**640.2**	**308.3**	**94.6**	**48.7**	**90.6**	**68.3**	**28.2**	44.7	22.9	4.7	8.5	11.3
30.5	**569.1**	**1170.7**	**1225.1**	**239.1**	**139.4**	**68.4**	**66.6**	**74.4**	**46.0**	26.9	7.6	6.6	0.3	1.9
32.4	**1055.5**	**1385.4**	**375.0**	**617.9**	**351.1**	**105.4**	**31.6**	**15.2**	**18.7**	35.5	11.6	6.9	12.3	4.6
33.7	**1267.7**	**1612.6**	**804.3**	**286.3**	**122.4**	**95.7**	**45.2**	**24.8**	**28.6**	15.8	13.8	8.0	6.0	2.6
47.5	**2157.2**	**1848.1**	**1368.5**	**737.0**	**395.3**	**191.8**	**97.9**	**15.0**	**47.9**	33.5	30.8	37.9	0.0	1.2
41.6	**959.7**	**1846.2**	**778.1**	**1050.9**	**331.1**	**82.3**	**93.5**	**30.7**	**51.2**	22	34.8	0.7	8.3	0.7
35.8	**1150.8**	**1156.5**	**1259.7**	**309.1**	**201.7**	**156.5**	**74.2**	**37.9**	**16.4**	44.8	1.3	6.2	0.8	3.3
48.8	**1341.0**	**1050.9**	**1009.4**	**885.8**	**434.9**	**370.7**	**147.7**	**79.2**	**75.7**	35.9	25.4	27.4	19.5	4.1
57.9	**1736.5**	**1888.6**	**808.5**	**415.2**	**550.6**	**207.8**	**258.0**	**117.2**	**47.6**	36.6	21.5	9.2	5.5	31.4
48.5	**249.7**	**1383.2**	**1435**	**427.6**	**217.5**	**324.1**	**137.3**	**75.7**	**65.6**	48.5	7.5	7.0	0.0	24.7
45.3	**1095.4**	**1185.9**	**1333.6**	**930.5**	**280.7**	**192**	**169.8**	**68.1**	**64.8**	42.6	19.4	24.6	4.9	37.9
35.9	**1470.6**	**1380.4**	**442.1**	**726.2**	**492.4**	**142.6**	**66.0**	**137.3**	**39.5**	76.7	25.5	17.1	0.0	36.4
34.8	**1303.1**	**2102.8**	**861.5**	**289.3**	**292.6**	**138.9**	**47.4**	**48.4**	**37.3**	7.7	37.6	3.9	0.0	10.3
30.3	**135.6**	**1510**	**1114.2**	**415.2**	**173.7**	**164.5**	**167.4**	**50**	**6.4**	33.6	13.8	34.6	18.9	28.9
33.1	**93**	**661.9**	**1052.8**	**745.9**	**231.2**	**126.4**	**107.8**	**97.9**	**22**	15.8	19.1	5.0	11.7	17

UK(E&W)-CBT

1986 2013

1 1 0 1

2 15

2.8	**30.0**	**144.8**	**100.5**	**28.0**	**28.8**	**39.4**	**1.2**	**2.4**	**5.2**	2.5	2.8	1.5	1.7	5.3
5.6	**251.8**	**106.0**	**143.5**	**99.2**	**18.6**	**14.6**	**37.6**	**1.4**	**0.4**	3.3	1.1	1.5	3.3	2.4
5.1	**112.3**	**281.3**	**56.4**	**62.9**	**39.6**	**9.0**	**11.5**	**16.2**	**2.0**	0.2	4.6	4.9	0.0	0.2
5.7	**162.3**	**78.1**	**144.2**	**18.2**	**31.7**	**23.1**	**5.1**	**4.2**	**16.3**	1.0	0.6	2.2	2.7	12.9
7.3	**112.6**	**327.4**	**47.7**	**66.1**	**14.1**	**15.1**	**15.1**	**4.1**	**7.4**	22.2	1.9	0.4	3.4	7.6
7.7	**349.0**	**139.2**	**195.2**	**8.4**	**30.7**	**5.1**	**7.4**	**10.9**	**2.7**	1.9	8.4	0.3	0.0	5.0
8.8	**240.1**	**516.6**	**81.3**	**167.5**	**11.1**	**20.3**	**6.4**	**14.6**	**4.9**	2.2	1.5	3.3	0.1	2.5
6.4	**174.9**	**222.5**	**218.9**	**34.6**	**52.7**	**5.2**	**10.7**	**4.5**	**3.0**	3.3	1.1	1.3	2.1	2.8
5.4	**33.6**	**260.9**	**144.1**	**113.3**	**27.5**	**45.5**	**4.4**	**10.5**	**3.2**	4.1	3.7	2.4	1.6	9.3
6.9	**181.1**	**106.9**	**220.4**	**107.6**	**94.6**	**18.3**	**37.5**	**5.4**	**9.4**	2.0	4.3	4.4	0.9	7.7
10.3	**295.8**	**251.3**	**79.5**	**169.0**	**84.6**	**67.4**	**17.5**	**33.2**	**4.1**	8.8	4.2	5.4	3.6	11.9
10.3	**268.5**	**331.1**	**158.5**	**42.4**	**125.2**	**50.8**	**48.7**	**11.6**	**23.0**	2.7	7.1	1.1	3.8	7.6
7.3	**252.6**	**169.4**	**97.5**	**65.2**	**22.1**	**51.7**	**28.8**	**22.4**	**5.8**	12.5	2.0	5.3	1.5	9.0
5.9	**170.0**	**300.0**	**105.6**	**43.6**	**31.8**	**12.3**	**26.3**	**12.9**	**7.3**	3.4	3.8	0.7	2.5	4.1
5.7	**152.1**	**178.8**	**171.4**	**54.7**	**25.8**	**18.2**	**6.9**	**21.6**	**9.7**	5.7	2.3	4.2	0.6	7.9
7.6	**284.3**	**268.0**	**101.0**	**111.9**	**44.0**	**19.0**	**19.6**	**5.8**	**14.7**	12.1	5.0	1.4	3.0	4.7
7.9	**314.6**	**449.0**	**222.2**	**71.7**	**54.9**	**22.9**	**18.6**	**6.0**	**3.1**	5.2	2.3	2.4	0.4	2.9
6.7	**386.0**	**220.8**	**149.5**	**64.8**	**27.2**	**32.0**	**15.0**	**5.6**	**5.8**	0.9	4.2	2.8	1.9	5.1
4.9	**111.9**	**440.4**	**103.2**	**62.2**	**32.6**	**9.6**	**18.2**	**4.3**	**3.2**	2.9	0.5	3.3	1.2	4.2
6.0	**170.7**	**178.3**	**376.4**	**69.4**	**72.3**	**35.4**	**17.4**	**15.6**	**11.2**	4.3	7.9	2.7	3.2	10.9
5.9	**395.2**	**350.5**	**113.5**	**189.0**	**31.7**	**28.1**	**13.6**	**9.0**	**5.4**	2.8	0.8	1.5	0.3	2.9
5.0	**167.8**	**303.7**	**114.9**	**34.6**	**102.8**	**24.0**	**23.6**	**9.4**	**1.3**	4.1	2.8	0.9	1.8	6.0
6.2	**152.5**	**612.9**	**184.7**	**40.7**	**24.7**	**34.2**	**12.6**	**4.4**	**6.4**	4.6	1.3	2.3	0.1	3.6
6.2	**290.0**	**113.5**	**273.0**	**98.9**	**15.3**	**12.5**	**26.6**	**7.7**	**13.8**	2.7	0.3	1.9	1.9	0.9
4.4	**153.1**	**151.9**	**50.9**	**101.0**	**33.9**	**11.9**	**7.8**	**14.0**	**4.9**	3.4	3.7	0.6	0.6	2.8
3.0	**227.0**	**121.4**	**59.6**	**16.5**	**37.2**	**10.8**	**2.5**	**2.5**	**2.6**	0.9	2.1	0.6	0.1	0.8
3.3	**44.7**	**323.9**	**59.6**	**34.4**	**5.9**	**16.0**	**8.5**	**1.4**	**1.4**	3.7	0.7	0.3	0.9	1.6
2.9	**15.6**	**109.6**	**200.7**	**36.5**	**21.4**	**6.7**	**9.0**	**2.7**	**0.8**	0.4	2.2	0.5	0.3	1.1

Table 9.2.8 - Sole VIId - tuning files - continued

Bolded numbers = used in XSA

UK(E&W)-BTS-Q3

1988	**2013**					
1	**1**	**0.5**	**0.75**			
1	**6**					
1	**8.20**	**14.20**	**9.90**	**0.80**	**1.30**	**0.60**
1	**2.60**	**15.40**	**3.40**	**1.70**	**0.60**	**0.20**
1	**12.10**	**3.70**	**3.40**	**0.70**	**0.80**	**0.20**
1	**8.90**	**22.80**	**2.20**	**2.30**	**0.30**	**0.50**
1	**1.40**	**12.00**	**10.00**	**0.70**	**1.10**	**0.30**
1	**0.50**	**17.50**	**8.40**	**7.00**	**0.80**	**1.00**
1	**4.80**	**3.20**	**8.30**	**3.30**	**3.30**	**0.20**
1	**3.50**	**10.60**	**1.50**	**2.30**	**1.20**	**1.50**
1	**3.50**	**7.30**	**3.80**	**0.70**	**1.30**	**0.90**
1	**19.00**	**7.30**	**3.20**	**1.30**	**0.20**	**0.50**
1	**2.00**	**21.20**	**2.50**	**1.00**	**0.90**	**0.10**
1	**28.10**	**9.40**	**13.20**	**2.50**	**1.70**	**1.30**
1	**10.49**	**22.03**	**4.15**	**4.24**	**1.03**	**0.58**
1	**9.09**	**21.01**	**8.36**	**1.20**	**1.91**	**0.54**
1	**31.76**	**11.42**	**5.42**	**3.45**	**0.27**	**0.71**
1	**6.47**	**28.48**	**4.13**	**2.46**	**1.58**	**0.30**
1	**7.35**	**8.49**	**7.71**	**1.57**	**1.45**	**0.99**
1	**25**	**5.04**	**2.86**	**3.47**	**1.63**	**1.02**
1	**6.3**	**29.2**	**2.8**	**2**	**1.9**	**0.3**
1	**2.1**	**21.9**	**12.9**	**1.2**	**0.8**	**1.2**
1	**2.9**	**6.5**	**7.2**	**4.8**	**0.2**	**0.5**
1	**30.5**	**13.3**	**5.4**	**4.3**	**3.8**	**0.4**
1	**15.9**	**30.1**	**5.3**	**1.7**	**2.8**	**2.4**
1	**11.9**	**23.5**	**11.6**	**1.2**	**0.6**	**2.6**
1	**1.7**	**9.1**	**6.5**	**3.4**	**0.9**	**0.4**
1	**0.78**	**9.2**	**15.54**	**8.91**	**2.95**	**1.35**

UK(E&W)-YFS

1981	**2006**	
1	**1**	**0.5** **0.75**
0	**1**	
1	0.11	0.45
1	4.63	0.36
1	25.45	1.52
1	4.33	4.04
1	7.65	2.94
1	6.45	1.45
1	16.85	**1.38**
1	2.59	**1.87**
1	6.67	**0.62**
1	6.7	**1.90**
1	1.81	**3.69**
1	2.26	**1.50**
1	14.19	**1.33**
1	13.07	**2.68**
1	7.53	**2.91**
1	1.85	**0.57**
1	4.23	**1.12**
1	7.97	**1.12**
1	2.63	**1.47**
1	1.16	**2.47**
1	4.75	**0.38**
1	4.45	**4.15**
1	4.55	**1.44**
1	6.98	**2.72**
1	9.97	**4.07**
1	3.09	**2.21**

FR-YFS

1987	**2013**	
1	**1.00**	**0.50** **0.75**
0	1	
1	0.75	**0.07**
1	0.04	**0.17**
1	17.43	**0.14**
1	0.57	**0.54**
1	1.04	**0.38**
1	0.48	**0.22**
1	0.27	**0.03**
1	4.04	**0.70**
1	3.50	**0.28**
1	0.28	**0.15**
1	0.07	**0.03**
1	10.52	**0.10**
1	2.84	**0.35**
1	2.41	**0.31**
1	4.32	**1.21**
1	0.94	**0.11**
1	0.21	**0.32**
1	7.29	**0.15**
1	0.05	**0.82**
1	1.04	**0.83**
1	0.03	**0.08**
1	6.58	**0.06**
1	2.47	**2.78**
1	0.20	**0.10**
1	2.78	**0.32**
1	0.44	**0.35**
1	0.72	**0.052**

Table 9.3.1 - Sole VIId - XSA diagnostics

26/04/2014 15:04

Extended Survivors Analysis

Sole in Division VIId - 2014 WG.

CPUE data from file sol7dtun.txt

Catch data for 32 years. 1982 to 2013. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BE-CBT	1986	2013	2	10	0	1
UK(E&W)-CBT	1986	2013	2	10	0	1
UK(E&W)-BTS-Q3	1988	2013	1	6	0.5	0.75
UK(E&W)-YFS	1987	2013	1	1	0.5	0.75
FR-YFS	1987	2013	1	1	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 7

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2.000

Minimum standard error for population
estimates derived from each fleet = .300

Prior weighting not applied

Tuning had not converged after 70 iterations

Regression weights

1	1	1	1	1	1	1	1	1

Fishing mortalities

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.058	0.006	0.016	0.009	0.008	0.008	0.003	0	0.001	0.001
2	0.275	0.25	0.293	0.208	0.175	0.184	0.212	0.135	0.072	0.162
3	0.412	0.404	0.415	0.467	0.408	0.425	0.402	0.369	0.264	0.504
4	0.371	0.441	0.485	0.604	0.466	0.623	0.571	0.437	0.427	0.353
5	0.439	0.359	0.487	0.457	0.491	0.473	0.537	0.496	0.342	0.381
6	0.406	0.366	0.417	0.53	0.449	0.583	0.467	0.454	0.636	0.299
7	0.373	0.38	0.416	0.493	0.335	0.606	0.445	0.321	0.335	0.888
8	0.418	0.347	0.394	0.407	0.406	0.472	0.51	0.413	0.456	0.418
9	0.183	0.451	0.515	0.416	0.217	0.563	0.429	0.523	0.497	0.387
10	0.313	0.357	0.621	0.996	0.352	0.528	0.355	0.205	0.361	0.603

1

XSA population numbers (Thousands)

YEAR	AGE 1	2	3	4	5	6	7	8	9	10
2004	1.93E+04	1.86E+04	2.68E+04	8.62E+03	6.72E+03	3.49E+03	1.25E+03	1.38E+03	5.90E+02	3.44E+02
2005	3.40E+04	1.65E+04	1.28E+04	1.61E+04	5.38E+03	3.92E+03	2.10E+03	7.81E+02	8.20E+02	4.45E+02
2006	4.08E+04	3.05E+04	1.16E+04	7.72E+03	9.36E+03	3.40E+03	2.46E+03	1.30E+03	4.99E+02	4.73E+02
2007	1.97E+04	3.64E+04	2.06E+04	6.94E+03	4.30E+03	5.21E+03	2.03E+03	1.47E+03	7.95E+02	2.70E+02
2008	2.09E+04	1.77E+04	2.67E+04	1.17E+04	3.43E+03	2.47E+03	2.77E+03	1.12E+03	8.84E+02	4.74E+02
2009	3.23E+04	1.88E+04	1.34E+04	1.61E+04	6.63E+03	1.90E+03	1.42E+03	1.79E+03	6.76E+02	6.43E+02
2010	4.29E+04	2.90E+04	1.42E+04	7.94E+03	7.80E+03	3.74E+03	9.60E+02	7.03E+02	1.01E+03	3.49E+02
2011	1.85E+04	3.87E+04	2.12E+04	8.57E+03	4.06E+03	4.13E+03	2.12E+03	5.56E+02	3.82E+02	5.97E+02
2012	8.24E+03	1.67E+04	3.06E+04	1.33E+04	5.01E+03	2.24E+03	2.37E+03	1.39E+03	3.33E+02	2.05E+02
2013	3.54E+03	7.45E+03	1.41E+04	2.13E+04	7.83E+03	3.22E+03	1.07E+03	1.53E+03	7.99E+02	1.83E+02

Estimated population abundance at 1st Jan 2014

0.00E+00	3.20E+03	5.73E+03	7.69E+03	1.35E+04	4.84E+03	2.16E+03	3.99E+02	9.14E+02	4.91E+02

Taper weighted geometric mean of the VPA populations:

2.18E+04	2.05E+04	1.61E+04	9.11E+03	4.82E+03	2.75E+03	1.60E+03	9.77E+02	5.97E+02	3.63E+02

Standard error of the weighted Log(VPA populations) :

0.5261	0.4096	0.3545	0.429	0.4227	0.438	0.4689	0.4783	0.4657	0.5096

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Log catchability residuals.

Fleet : BE-CBT

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	No data for this fleet at this age							
2	0.05	0.59	-0.72	-2.55	1.13	-0.75	-0.02	1.32
3	0.75	-0.19	-0.42	0.02	0.11	0.85	0.12	0.27
4	0.21	0.39	-0.7	-0.37	-0.12	0.1	0.42	-0.02
5	-0.08	0.6	-0.2	1.03	-0.07	-0.02	0.27	-0.02
6	-0.13	0.9	-0.22	0.29	-0.18	0.65	-0.49	-0.84
7	-0.2	0.59	0.03	0.34	0.58	0.06	-0.22	0.01
8	0	-0.09	-0.77	-0.08	-0.23	0.01	-0.16	-0.23
9	0.77	0.24	-0.72	-0.35	0.33	-0.62	0.03	0.69
10	0.09	2.28	1.28	-2.06	-0.11	0.54	-0.58	-0.47

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	No data for this fleet at this age									
2	-0.28	-0.74	-0.1	-0.72	-0.33	0.4	0.08	0.49	0.86	0.48
3	0	-0.27	-0.03	0.4	-0.2	0.05	0.44	0.06	0.1	0.15
4	0.59	-0.31	0.29	0.37	0.3	0.54	0.36	-0.32	-0.09	0
5	0.29	-0.05	-0.1	0.48	-0.14	0.48	-0.3	0.14	-0.25	-0.1
6	0.4	0.08	0.12	0.15	-0.27	-0.09	0.08	0.7	-0.83	0.46
7	0.04	-0.04	0.25	0.22	-0.21	-0.01	-0.24	0.15	-0.24	-0.39
8	0.31	-1.08	-0.05	-0.18	0.08	-0.19	0.52	-0.66	-0.33	-0.18
9	-0.16	0.2	-0.1	0.05	0	0.01	-0.22	-0.61	-0.6	-1.47
10	1.4	-0.72	1.16	-0.9	-0.08	-0.46	-0.31	-1.3	0.36	0.11

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	No data for this fleet at this age									
2	0.57	1.01	0.26	0.13	-0.92	0.57	0.67	0.26	-1.06	-0.67
3	-0.33	0.09	-0.21	-0.35	-0.77	-0.16	0.17	0.2	-0.41	-0.44
4	-0.21	-0.17	0.06	-0.18	-0.01	-0.26	-0.45	0.11	0.06	-0.59
5	0.25	-0.64	-0.39	-0.56	-0.11	0.07	-0.08	-0.33	-0.12	-0.05
6	-0.1	-0.58	0.04	-0.27	-0.31	0.33	0.4	-0.2	0.12	-0.2
7	-0.55	-0.28	0.14	-0.39	-0.15	0.19	0.44	-0.4	-0.2	0.49
8	-0.5	-0.05	-0.16	0.12	-0.07	-0.23	0.01	-0.1	0.4	-0.24
9	-0.88	-0.72	0.23	-0.06	-0.52	-0.13	0.34	0.35	0.65	0.3
10	0.24	-0.99	0.29	0.37	0.03	-0.14	0.13	-0.5	-0.99	0.38

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7	8	9	10
Mean Log q	-7.0828	-5.833	-5.7	-5.5729	-5.7367	-5.6694	-5.6694	-5.6694	-5.6694
S.E(Log q)	0.823	0.3554	0.3368	0.3545	0.4262	0.3095	0.3601	0.5318	0.8897

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.72	1.009	7.88	0.34	28	0.6	-7.08
3	1.44	-1.638	4.14	0.35	28	0.5	-5.83
4	1.04	-0.232	5.57	0.59	28	0.36	-5.7
5	1.1	-0.552	5.27	0.53	28	0.4	-5.57
6	1.09	-0.425	5.54	0.46	28	0.47	-5.74
7	1.11	-0.764	5.48	0.65	28	0.35	-5.67
8	1.17	-1.12	5.64	0.64	28	0.38	-5.82
9	1.37	-1.291	5.55	0.32	28	0.7	-5.77
10	-10.11	-4.566	8.14	0.01	28	6.82	-5.7
1							

Fleet : UK(E&W)-CBT

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	No data for this fleet at this age							
2	-0.36	0.39	0.59	-0.04	-0.2	-0.07	-0.4	-0.35
3	0.49	-0.1	0.32	-0.05	0.07	-0.31	-0.13	-0.54
4	0.53	0.42	-0.04	0.24	-0.11	0.06	-0.42	-0.18
5	0.29	0.55	0.44	-0.48	0.01	-1.21	0.51	-0.35
6	0.41	-0.26	0.3	0.16	-0.36	-0.23	-0.58	0.1
7	0.64	-0.31	-0.16	0.21	-0.27	-0.96	-0.2	-0.56
8	-0.79	0.38	0.26	-0.28	0.03	-0.56	-0.43	-0.13
9	0.1	-0.78	0.09	-0.36	-0.19	0.18	0.48	0
10	0	-1.23	0.45	0.34	0.51	0	-0.18	-0.35

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	No data for this fleet at this age									
2	-1.21	-0.18	0.26	0.14	0.01	0.36	-0.12	0.06	0.35	0.16
3	-0.14	-0.67	-0.53	0.12	-0.3	0.07	0.22	-0.17	0.24	-0.05
4	-0.31	-0.07	-0.79	-0.23	-0.04	0.13	0.18	-0.09	0.17	-0.15
5	-0.03	-0.13	-0.05	-0.52	0.14	0.19	0.28	0.24	0.19	-0.21
6	0.01	0.07	-0.23	0.23	-0.08	0.31	0.28	0.26	0.02	-0.07
7	0.5	-0.18	-0.11	-0.15	0.19	0.21	0.42	0.19	0.08	0.08
8	-0.18	0.41	-0.22	0.14	0.08	0.17	0.24	0.61	0.54	0.2
9	0.38	0.21	0.24	-0.13	0.23	-0.06	0.53	0.18	-0.26	-0.19
10	0.44	0.43	0.22	0.26	0.37	-0.22	0.12	0.2	-0.11	0.26

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	No data for this fleet at this age									
2	0.01	0.33	0.58	-0.32	0.08	0.66	-0.04	0.4	-0.51	-0.58
3	0.35	-0.02	0.77	0.25	0.44	-0.55	0.04	-0.23	0.23	0.18
4	0.02	0.51	0.08	0.42	0.1	0.24	-0.4	-0.01	-0.55	0.3
5	-0.07	0.02	0.53	-0.23	-0.04	0.18	0.42	-0.38	-0.03	-0.26
6	-0.08	0.37	-0.28	0.69	-0.24	-0.39	0.03	0.39	-0.86	0.05
7	-0.25	0.32	-0.03	0.21	-0.04	-0.26	0.37	-0.2	-0.01	0.3
8	0.31	0.59	-0.14	0.47	-0.1	0.2	0.29	-0.29	-0.05	0.03
9	-0.39	0.48	0.47	0.17	-1	-0.02	0.48	0.14	-0.41	-0.55
10	-0.09	0.72	0.06	-0.45	0.05	0.6	0.45	-0.43	0.03	-0.14

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	2	3	4	5	6	7	8	9	10
Mean Log q	-6.5207	-5.8027	-5.8003	-5.9377	-5.9301	-5.9719	-5.9719	-5.9719	-5.9719
S.E(Log q)	0.4113	0.3433	0.3166	0.3834	0.3365	0.339	0.3555	0.3911	0.4107

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
2	0.87	0.799	6.97	0.59	28	0.36	-6.52
3	0.92	0.437	6.1	0.56	28	0.32	-5.8
4	0.9	0.803	6.15	0.69	28	0.29	-5.8
5	0.72	2.364	6.66	0.73	28	0.25	-5.94
6	0.73	2.629	6.46	0.79	28	0.22	-5.93
7	0.82	1.578	6.23	0.75	28	0.27	-5.97
8	0.81	1.814	6.1	0.78	28	0.27	-5.91
9	0.84	1.23	6.04	0.69	28	0.32	-5.97
10	0.88	0.956	5.89	0.71	28	0.35	-5.89
1							

Fleet : UK(E&W)-BTS

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	99.99	99.99	0.22	-0.5	0.09	0.01	-1.81	-2.15
2	99.99	99.99	0.96	0.13	-0.83	0.04	-0.43	0.01
3	99.99	99.99	0.58	0.55	-0.55	-0.45	0.05	-0.02
4	99.99	99.99	-0.33	-0.08	0	0.02	-0.67	0.57
5	99.99	99.99	0.43	0.15	-0.16	-0.25	-0.09	-0.01
6	99.99	99.99	-0.01	-0.9	-0.39	-0.03	0.23	0.22
7	No data for this fleet at this age							
8	No data for this fleet at this age							
9	No data for this fleet at this age							
10	No data for this fleet at this age							

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.35	-0.32	-0.32	0.99	-0.83	1.44	0.27	0.3	1	0.2
2	-1.09	-0.29	-0.32	-0.35	0.3	0.04	0.48	0.3	-0.07	0.27
3	0.05	-1.05	-0.41	-0.19	-0.55	0.7	0.18	0.36	-0.14	-0.16
4	-0.04	-0.36	-0.82	-0.3	-0.26	0.54	0.58	-0.16	0.43	-0.02
5	0.39	-0.44	-0.31	-1.23	0.13	0.99	0.28	0.49	-1.06	0.23
6	-0.97	0.11	-0.17	-0.7	-1.21	1.17	0.47	0.16	-0.03	-0.41
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.43	1.06	-0.5	-0.87	-0.61	1.31	0.37	0.92	-0.22	-0.12
2	-0.18	-0.59	0.57	0.06	-0.46	0.2	0.61	0.02	-0.13	0.75
3	-0.15	-0.4	-0.32	0.66	-0.22	0.19	0.11	0.47	-0.54	1.25
4	-0.25	-0.04	0.17	-0.16	0.62	0.29	0.04	-0.47	0.13	0.57
5	0.01	0.3	-0.02	-0.13	-1.27	1.01	0.58	-0.33	-0.23	0.55
6	0.26	0.15	-0.9	0.13	-0.04	0.08	1.12	1.09	-0.05	0.63
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1	2	3	4	5	6
Mean Log q	-8.2077	-7.2805	-7.6862	-8.0674	-8.1163	-8.1168
S.E(Log q)	0.8696	0.4771	0.5039	0.392	0.5753	0.6183

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	0.72	1.215	8.72	0.44	26	0.62	-8.21
2	0.96	0.182	7.39	0.46	26	0.47	-7.28
3	1.02	-0.081	7.64	0.32	26	0.53	-7.69
4	0.72	2.414	8.38	0.75	26	0.26	-8.07
5	0.76	1.18	8.21	0.5	26	0.43	-8.12
6	0.82	0.773	8.08	0.43	26	0.51	-8.12
1							

Fleet : UK(E&W)-YFS

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	99.99	0.64	0.1	-0.58	-0.41	0.48	-0.39	0.18
2	No data for this fleet at this age							
3	No data for this fleet at this age							
4	No data for this fleet at this age							
5	No data for this fleet at this age							
6	No data for this fleet at this age							
7	No data for this fleet at this age							
8	No data for this fleet at this age							
9	No data for this fleet at this age							
10	No data for this fleet at this age							

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.42	0.85	-0.79	-0.49	-0.06	-0.16	0.18	-1.53	0.31	0.05
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.79	0.6	-0.19	99.99	99.99	99.99	99.99	99.99	99.99	99.99
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time

Age	1
Mean Log q	-9.5602
S.E(Log q)	0.5897

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.26	-0.563	9.41	0.2	20	0.76	-9.56

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Fleet : FR-YFS

Age	1986	1987	1988	1989	1990	1991	1992	1993
1	99.99	-0.4	-0.36	-0.12	0.27	0.15	-0.37	-1.67
2	No data for this fleet at this age							
3	No data for this fleet at this age							
4	No data for this fleet at this age							
5	No data for this fleet at this age							
6	No data for this fleet at this age							
7	No data for this fleet at this age							
8	No data for this fleet at this age							
9	No data for this fleet at this age							
10	No data for this fleet at this age							

Age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	1.02	0.45	-0.18	-2.17	-0.53	0.34	0.04	1.57	-1.38	0.49
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	-0.16	0.94	0.77	-0.85	-1.19	2.21	-1.4	0.6	1.5	0.44
2	No data for this fleet at this age									
3	No data for this fleet at this age									
4	No data for this fleet at this age									
5	No data for this fleet at this age									
6	No data for this fleet at this age									
7	No data for this fleet at this age									
8	No data for this fleet at this age									
9	No data for this fleet at this age									
10	No data for this fleet at this age									

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	1
Mean Log q	-11.5016
S.E(Log q)	1.0304

Regression statistics :

Ages with q independent of year class strength and constant w.r.t. time.

Age	Slope	t-value	Intercept	RSquare	No Pts	Reg s.e	Mean Q
1	1.23	-0.513	11.85	0.16	27	1.29	-11.5

Terminal year survivor and F summaries :

Age 1 Catchability constant w.r.t. time and dependent on age

Year class = 2012

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	1	0	0	0	0	0	0
UK(E&W)-CBT□	1	0	0	0	0	0	0
UK(E&W)-BTS-Q3□	2826	0.886	0	0	1	0.524	0.002
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	4949	1.049	0	0	1	0.373	0.001
F shrinkage mean	1242	2				0.103	0.004

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3201	0.64	0.3	3	0.472	0.001

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 2 Catchability constant w.r.t. time and dependent on age

Year class = 2011

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	2927	0.838	0	0	1	0.103	0.296
UK(E&W)-CBT□	3211	0.419	0	0	1	0.413	0.274
UK(E&W)-BTS-Q3[	9686	0.426	0.406	0.95	2	0.398	0.099
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	25633	1.049	0	0	1	0.066	0.039
F shrinkage mean	5988	2				0.021	0.156

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5729	0.27	0.32	6	1.183	0.162

Age 3 Catchability constant w.r.t. time and dependent on age

Year class = 2010

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	4536	0.332	0.22	0.66	2	0.275	0.746
UK(E&W)-CBT□	6993	0.268	0.338	1.26	2	0.414	0.542
UK(E&W)-BTS-Q3[	14004	0.328	0.463	1.41	3	0.273	0.307
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	14030	1.049	0	0	1	0.026	0.306
F shrinkage mean	11075	2				0.013	0.375

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
7686	0.17	0.21	9	1.235	0.504

Age 4 Catchability constant w.r.t. time and dependent on age

Year class = 2009

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	8477	0.241	0.145	0.6	3	0.314	0.516
UK(E&W)-CBT□	18193	0.209	0.041	0.19	3	0.404	0.274
UK(E&W)-BTS-Q3[	16256	0.257	0.259	1.01	4	0.263	0.302
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	3325	1.049	0	0	1	0.012	1.002
F shrinkage mean	8682	2				0.007	0.507

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
13538	0.13	0.14	12	1.026	0.353

Age 5 Catchability constant w.r.t. time and dependent on age

Year class = 2008

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	5138	0.21	0.082	0.39	4	0.364	0.363
UK(E&W)-CBT□	3490	0.194	0.099	0.51	4	0.394	0.497
UK(E&W)-BTS-Q3[	7337	0.248	0.139	0.56	5	0.227	0.267
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	44096	1.049	0	0	1	0.007	0.05
F shrinkage mean	3748	2				0.008	0.47

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4843	0.12	0.1	15	0.85	0.381

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 6 Catchability constant w.r.t. time and dependent on age

Year class = 2007

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	2076	0.198	0.084	0.43	5	0.351	0.309
UK(E&W)-CBT□	2295	0.18	0.083	0.46	5	0.435	0.284
UK(E&W)-BTS-Q3[	2137	0.245	0.195	0.8	6	0.202	0.302
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	655	1.049	0	0	1	0.005	0.765
F shrinkage mean	1104	2				0.007	0.52

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2160	0.12	0.07	18	0.56	0.299

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2006

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	483	0.199	0.167	0.84	6	0.434	0.78
UK(E&W)-CBT□	332	0.189	0.218	1.16	6	0.443	1.001
UK(E&W)-BTS-Q3[	352	0.261	0.104	0.4	6	0.107	0.964
UK(E&W)-YFS□	1	0	0	0	0	0	0
FR-YFS□	172	1.049	0	0	1	0.002	1.465
F shrinkage mean	1127	2				0.015	0.41

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
399	0.13	0.11	20	0.852	0.888

Age 8 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	731	0.18	0.047	0.26	7	0.448	0.5
UK(E&W)-CBT□	1043	0.174	0.078	0.45	7	0.462	0.375
UK(E&W)-BTS-Q3[	1531	0.267	0.21	0.78	6	0.076	0.27
UK(E&W)-YFS□	754	0.604	0	0	1	0.004	0.488
FR-YFS□	1974	1.049	0	0	1	0.001	0.215
F shrinkage mean	829	2				0.008	0.453

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
914	0.12	0.06	23	0.55	0.418

Age 9 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	539	0.177	0.129	0.73	8	0.421	0.358
UK(E&W)-CBT□	408	0.17	0.104	0.61	8	0.504	0.45
UK(E&W)-BTS-Q3[	1158	0.257	0.102	0.4	6	0.061	0.183
UK(E&W)-YFS□	892	0.604	0	0	1	0.004	0.231
FR-YFS□	1253	1.049	0	0	1	0.001	0.17
F shrinkage mean	412	2				0.009	0.447

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
491	0.12	0.08	25	0.701	0.387

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT□	117	0.194	0.109	0.56	9	0.365	0.497
UK(E&W)-CBT□	79	0.182	0.099	0.55	9	0.578	0.67
UK(E&W)-BTS-Q3[	63	0.264	0.232	0.88	6	0.039	0.786
UK(E&W)-YFS□	201	0.604	0	0	1	0.002	0.318
FR-YFS□	77	1.049	0	0	1	0.001	0.681
F shrinkage mean	123	2				0.015	0.476

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
91	0.13	0.07	27	0.548	0.603

Table 9.3.2 - Sole VIId - Fishing mortality (F) at age

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:05

Table 8 Fishing mortality (F) at age

YEAR	1982	1983
AGE		
1	0.0129	0
2	0.1863	0.0821
3	0.3117	0.3534
4	0.4845	0.3599
5	0.231	0.4429
6	0.2288	0.4626
7	0.4676	0.3186
8	0.4104	0.5103
9	0.3465	0.2909
10	0.3378	0.4063
+gp	0.3378	0.4063
0 FBAR 3- 8	0.3557	0.408

Table 8 Fishing mortality (F) at age

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
AGE										
1	0.0012	0.004	0.002	0.0009	0.0039	0.0103	0.0301	0.0116	0.0033	0.0053
2	0.1142	0.2234	0.12	0.1523	0.2603	0.172	0.2222	0.216	0.1469	0.1919
3	0.4314	0.4346	0.5053	0.545	0.5419	0.6722	0.4038	0.5041	0.3957	0.3262
4	0.4373	0.3722	0.4601	0.5956	0.4215	0.6684	0.4759	0.5275	0.4052	0.4039
5	0.2633	0.2725	0.3198	0.5361	0.3839	0.7309	0.4424	0.4362	0.4586	0.3493
6	0.7122	0.3943	0.2996	0.654	0.3957	0.4698	0.2875	0.5266	0.3399	0.2005
7	0.5179	0.2520	0.3614	0.7937	0.478	0.443	0.3677	0.3773	0.3328	0.2898
8	0.2353	0.3001	0.4169	0.4419	0.3758	0.4321	0.3292	0.3726	0.3094	0.2522
9	0.3574	0.1558	0.6258	0.5266	0.2238	0.3977	0.4834	0.5578	0.4238	0.422
10	0.4185	0.2756	0.292	1.7405	0.8504	0.2778	0.5271	0.6732	0.3623	0.2376
+gp	0.4185	0.2756	0.292	1.7405	0.8504	0.2778	0.5271	0.6732	0.3623	0.2376
0 FBAR 3- 8	0.4329	0.3376	0.3938	0.5944	0.4328	0.5694	0.3844	0.4574	0.3736	0.3037

Table 8 Fishing mortality (F) at age

YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
1	0.0012	0.0465	0.0005	0.0009	0.0019	0.0068	0.0046	0.0067	0.0162	0.0192
2	0.0495	0.1398	0.1216	0.0961	0.0594	0.2376	0.1743	0.2549	0.3704	0.3281
3	0.3404	0.4366	0.5664	0.6446	0.5447	0.5421	0.5799	0.4517	0.5091	0.4453
4	0.4953	0.4220	0.5442	0.7835	0.5902	0.6383	0.5291	0.3362	0.4841	0.3715
5	0.4214	0.4404	0.4949	0.7947	0.5609	0.5639	0.3875	0.5743	0.4968	0.4001
6	0.3115	0.4108	0.4710	0.4599	0.4982	0.5827	0.3893	0.4368	0.2555	0.4117
7	0.2838	0.3003	0.4523	0.4065	0.2428	0.5279	0.3870	0.3596	0.2847	0.3408
8	0.2877	0.1958	0.3281	0.4810	0.3104	0.4554	0.3930	0.2351	0.2392	0.2769
9	0.2849	0.3530	0.3206	0.4757	0.3737	0.3860	0.3728	0.2248	0.2510	0.1768
10	0.6259	0.3047	0.9050	0.2501	1.1182	0.3169	0.2516	0.1316	0.3334	0.3370
+gp	0.6259	0.3047	0.9050	0.2501	1.1182	0.3169	0.2516	0.1316	0.3334	0.3370
0 FBAR 3- 8	0.3567	0.3676	0.4762	0.5950	0.4579	0.5517	0.4443	0.3989	0.3782	0.3744

Table 8 Fishing mortality (F) at age

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	FBAR 11-13
AGE											
1	0.0578	0.0064	0.0158	0.0094	0.0075	0.0076	0.0034	0.0000	0.0006	0.0015	0.0007
2	0.2752	0.2501	0.2928	0.2085	0.1752	0.1840	0.2123	0.1345	0.0722	0.1624	0.1230
3	0.4121	0.4035	0.4152	0.4671	0.4080	0.4246	0.4017	0.3692	0.2636	0.5035	0.3788
4	0.3714	0.4412	0.4848	0.6037	0.4665	0.6231	0.5713	0.4367	0.4271	0.3529	0.4056
5	0.4392	0.3587	0.4869	0.4566	0.4913	0.4730	0.5368	0.4959	0.3425	0.3810	0.4065
6	0.4061	0.3662	0.4168	0.5302	0.4495	0.5828	0.4668	0.4538	0.6356	0.2989	0.4627
7	0.3729	0.3802	0.4161	0.4928	0.3352	0.6057	0.4452	0.3209	0.3354	0.8876	0.5146
8	0.4184	0.3474	0.3937	0.4073	0.4059	0.4719	0.5099	0.4129	0.4557	0.4183	0.4290
9	0.1832	0.4506	0.5145	0.4156	0.2171	0.5630	0.4289	0.5233	0.4965	0.3871	0.4690
10	0.3130	0.3569	0.6206	0.9962	0.3523	0.5277	0.3547	0.2045	0.3609	0.6028	0.3894
+gp	0.3130	0.3569	0.6206	0.9962	0.3523	0.5277	0.3547	0.2045	0.3609	0.6028	
0 FBAR 3- 8	0.4034	0.3829	0.4356	0.4930	0.4261	0.5302	0.4886	0.4149	0.4100	0.4737	

Table 9.3.3 - Sole VIId - Stock numbers at age

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:05

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1982	1983
AGE		
1	12722	21281
2	16232	11364
3	20631	12190
4	4728	13668
5	2905	2635
6	3356	2086
7	1545	2416
8	749	876
9	438	450
10	304	280
+gp	738	605
0 TOTAL	64350	67853

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
AGE										
1	21460	12905	25690	10969	25713	16796	44170	34818	33559	16776
2	19256	19395	11630	23199	9917	23176	15043	38783	31140	30265
3	9472	15543	14036	9333	18026	6916	17656	10899	28275	24328
4	7747	5568	9107	7663	4897	9486	3195	10668	5957	17224
5	8629	4527	3472	5201	3822	2907	4399	1796	5696	3595
6	1531	6001	3119	2282	2753	2356	1266	2558	1051	3258
7	1188	680	3660	2092	1074	1677	1333	860	1367	677
8	1590	641	478	2308	856	602	974	835	533	887
9	476	1137	429	285	1342	532	354	634	520	354
10	304	301	880	208	152	971	323	197	329	308
+gp	729	557	1540	577	501	1219	1249	815	796	640
0 TOTAL	72382	67253	74042	64116	69053	66639	89963	102863	109224	98311

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
AGE										
1	26544	19400	18888	27725	17989	26227	31346	26494	46259	20941
2	15098	23988	16757	17082	25063	16246	23571	28231	23813	41184
3	22603	13001	18873	13426	14040	21369	11591	17917	19798	14877
4	15885	14551	7602	9692	6377	7368	11245	5873	10320	10767
5	10407	8759	8634	3992	4006	3198	3521	5994	3797	5755
6	2294	6178	5102	4763	1632	2069	1646	2163	3054	2090
7	2412	1520	3707	2883	2721	897	1045	1009	1264	2140
8	458	1644	1018	2134	1737	1931	479	642	637	861
9	623	311	1223	664	1194	1152	1108	292	459	454
10	210	424	198	803	373	743	709	691	211	323
+gp	580	962	603	1265	466	1385	1169	2256	728	897
0 TOTAL	97114	90739	82605	84428	75597	82586	87430	91562	110341	100291

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	GMST 82-11	AMST 82-11
AGE													
1	19293	33951	40842	19720	20934	32286	42945	18452	8236	3543	0*	23913	25570
2	18588	16477	30524	36377	17677	18800	28994	38726	16696	7448	3201	21403	22887
3	26842	12772	11610	20609	26722	13425	14152	21216	30631	14055	5729	15831	16738
4	8624	16086	7720	6935	11689	16078	7945	8569	13271	21293	7686	8741	9441
5	6719	5382	9363	4302	3431	6633	7802	4060	5010	7834	13538	4741	5178
6	3490	3919	3402	5206	2465	1899	3740	4127	2237	3219	4843	2751	3029
7	1253	2104	2459	2029	2772	1423	960	2122	2372	1072	2160	1598	1776
8	1377	781	1302	1467	1122	1794	703	556	1393	1535	399	951	1066
9	590	820	499	795	884	676	1013	382	333	799	914	602	670
10	344	445	473	270	474	643	349	597	205	183	491	379	428
+gp	909	946	694	380	872	1151	1018	1259	1345	388	283		
0 TOTAL	88030	93683	108888	98091	89042	94810	109619	100066	81730	61369	39244		

* Replaced with GM (23913) in prediction

Table 9.3.4 - Sole VIId - Summary

Run title : Sole in Division VIId - 2014 WG.

At 26/04/2014 15:05

Table 16 Summary (without SOP correction)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1982	12722	10399	7798	3190	0.4091	0.3557
1983	21281	12576	9552	3458	0.3620	0.4080
1984	21460	12917	8956	3575	0.3992	0.4329
1985	12905	13283	9942	3837	0.3859	0.3376
1986	25690	13911	10531	3932	0.3734	0.3938
1987	10969	12960	8946	4791	0.5356	0.5944
1988	25713	12800	10076	3853	0.3824	0.4328
1989	16796	11808	8349	3805	0.4557	0.5694
1990	44170	13814	9529	3647	0.3827	0.3844
1991	34818	15809	8716	4351	0.4992	0.4574
1992	33559	17269	11106	4072	0.3666	0.3736
1993	16776	17829	13055	4299	0.3293	0.3037
1994	26544	15570	12492	4383	0.3509	0.3567
1995	19400	15021	11029	4420	0.4008	0.3676
1996	18888	15628	12087	4797	0.3969	0.4762
1997	27725	14215	10455	4764	0.4557	0.5950
1998	17989	12473	8064	3363	0.4170	0.4579
1999	26227	12359	8968	4135	0.4611	0.5517
2000	31346	12901	8459	3476	0.4109	0.4443
2001	26494	12455	7545	4025	0.5335	0.3989
2002	46259	14076	8524	4733	0.5552	0.3782
2003	20941	17631	10365	5038	0.4861	0.3744
2004	19293	14870	11359	4826	0.4249	0.4034
2005	33951	18858	11382	4383	0.3851	0.3829
2006	40842	20533	9860	4833	0.4902	0.4356
2007	19720	19062	10391	5166	0.4972	0.4930
2008	20934	18216	12681	4517	0.3562	0.4261
2009	32286	19259	11530	5266	0.4567	0.5302
2010	42945	19586	9125	4409	0.4832	0.4886
2011	18452	16975	10554	4133	0.3916	0.4149
2012	8236	17112	12941	4048	0.3128	0.4100
2013	3543	14662	13370	4390	0.3283	0.4737
2014	23913[2]	13004[3]	10088[3]			0.4329[4]
Arith. Mean	24340	15214	10242	4247	0.4211	0.4345
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

[1] Geometric mean 1982-2011

[2] From forecast

[3] $F_{(11-13)}$ NOT rescaled to F_{2013}

Table 9.5.1 - Sole VIId – RCT3 input

Yearclass	XSA (Age 1)	XSA (Age 2)	FR-YF0	FR-YF1	BTS1	BTS2
1981	12722	11364	3.33	0.07	-11	-11
1982	21281	19256	1.04	0.02	-11	-11
1983	21460	19395	0.79	-11	-11	-11
1984	12905	11630	-11	-11	-11	-11
1985	25690	23199	-11	-11	-11	-11
1986	10969	9917	-11	0.07	-11	14.20
1987	25713	23176	0.75	0.17	8.20	15.40
1988	16796	15043	0.04	0.14	2.60	3.70
1989	44170	38783	17.43	0.54	12.10	22.80
1990	34818	31140	0.57	0.38	8.90	12.00
1991	33559	30265	1.04	0.22	1.40	17.50
1992	16776	15098	0.48	0.03	0.50	3.20
1993	26544	23988	0.27	0.70	4.80	10.60
1994	19400	16757	4.04	0.28	3.50	7.30
1995	18888	17082	3.50	0.15	3.50	7.30
1996	27725	25063	0.28	0.03	19.00	21.20
1997	17989	16246	0.07	0.10	2.00	9.44
1998	26227	23571	10.52	0.35	28.14	22.03
1999	31346	28231	2.84	0.31	10.49	21.01
2000	26494	23813	2.41	1.21	9.09	11.42
2001	46259	41184	4.32	0.11	31.76	28.48
2002	20941	18588	0.94	0.32	6.47	8.49
2003	19293	16477	0.21	0.15	7.35	5.04
2004	33951	30524	7.29	0.82	25.00	29.20
2005	40842	36377	0.05	0.83	6.30	21.86
2006	19720	17677	1.04	0.08	2.14	6.50
2007	20934	18800	0.03	0.06	2.90	13.3
2008	32286	28994	6.58	2.78	30.5	30.1
2009	42945	38726	2.47	0.10	15.9	23.50
2010	-11	-11	0.20	0.32	11.92	9.14
2011	-11	-11	2.78	0.35	1.75	9.20
2012	-11	-11	0.44	0.052	0.78	-11
2013	-11	-11	0.72	-11	-11	-11

Table 9.5.2a - Sole VIId – RCT3 output (1 year olds)

Analysis by RCT3 ver3.1 of data from file :

S7DREC1.TXT

7D Sole (1year olds)

Data for 4 surveys over 33 years : 1981 - 2013

Regression type = C
Tapered time weighting not applied
Survey weighting not applied

Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Yearclass = 2011

	I----------Regression----------I				I----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
FR-YF0	1.18	9.00	.91	.129	26	1.33	10.57	.966	.049
FR-YF1	3.09	9.27	.86	.169	26	.30	10.20	.907	.055
BTS1	.57	9.00	.38	.430	23	1.01	9.57	.423	.255
BTS2	.85	7.90	.35	.532	24	2.32	9.88	.377	.322

VPA Mean = 10.09 .378 .319

Yearclass = 2012

I----------Regression----------I I----------Prediction---------I

Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
Series cept Error Pts Value Value Error Weights

FR-YF0 1.18 9.00 .91 .129 26 .36 9.43 .972 .073
FR-YF1 3.09 9.27 .86 .169 26 .05 9.43 .917 .082
BTS1 .57 9.00 .38 .430 23 .58 9.32 .436 .363
BTS2

VPA Mean = 10.09 .378 .482

Yearclass = 2013

I----------Regression----------I I----------Prediction---------I

Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
Series cept Error Pts Value Value Error Weights

FR-YF0 1.18 9.00 .91 .129 26 .54 9.64 .967 .133
FR-YF1
BTS1
BTS2

VPA Mean = 10.09 .378 .867

Year Weighted Log Int Ext Var VPA Log
Class Average WAP Std Std Ratio VPA
Prediction Error Error

2011 20348 9.92 .21 .13 .36
2012 16490 9.71 .26 .21 .66
2013 22728 10.03 .35 .15 .19

Table 9.5.2b - Sole VIId – RCT3 output (2 year olds)

Analysis by RCT3 ver3.1 of data from file :

S7DREC2.TXT

7D Sole (2year olds)

Data for 4 surveys over 33 years : 1981 - 2013

Regression type = C
Tapered time weighting not applied
Survey weighting not applied

Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Yearclass = 2011

	I----------Regression----------I				I----------Prediction---------I			
Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
FR-YF0	1.20	8.87	.93	.124	26	1.33	10.46	.989	.046
FR-YF1	3.10	9.16	.86	.169	26	.30	10.09	.910	.055
BTS1	.57	8.87	.39	.425	23	1.01	9.45	.430	.245
BTS2	.84	7.82	.34	.546	24	2.32	9.77	.367	.337
VPA Mean = 9.98 .378 .317									

Yearclass = 2012

I----------Regression----------I I----------Prediction---------I

Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
Series cept Error Pts Value Value Error Weights

FR-YF0 1.20 8.87 .93 .124 26 .36 9.30 .996 .071
FR-YF1 3.10 9.16 .86 .169 26 .05 9.32 .920 .083
BTS1 .57 8.87 .39 .425 23 .58 9.20 .443 .357
BTS2

VPA Mean = 9.98 .378 .490

Yearclass = 2013

I----------Regression----------I I----------Prediction---------I

Survey/ Slope Inter- Std Rsquare No. Index Predicted Std WAP
Series cept Error Pts Value Value Error Weights

FR-YF0 1.20 8.87 .93 .124 26 .54 9.52 .990 .127
FR-YF1
BTS1
BTS2

VPA Mean = 9.98 .378 .873

Year Weighted Log Int Ext Var VPA Log
Class Average WAP Std Std Ratio VPA
Prediction Error Error

2011 18213 9.81 .21 .13 .36
2012 14773 9.60 .26 .22 .67
2013 20375 9.92 .35 .15 .19

Table 9.6.1 - Sole in VIId
Input for catch forecast, linear sensitivity analysis and Fmsy analysis

Label	Value	CV	Label	Value	CV
Number at age			Weight in the stock		
N1	23913	0.37	WS1	0.122	0.52
N2	3201	0.64	WS2	0.152	0.11
N3	5729	0.32	WS3	0.186	0.06
N4	7686	0.21	WS4	0.232	0.02
N5	13538	0.14	WS5	0.268	0.13
N6	4843	0.12	WS6	0.305	0.12
N7	2160	0.12	WS7	0.343	0.14
N8	399	0.13	WS8	0.346	0.27
N9	914	0.12	WS9	0.389	0.16
N10	491	0.12	WS10	0.465	0.05
N11	283	0.13	WS11	0.462	0.10
H.cons selectivity			Weight in the HC catch		
sH1	0.0007	1.08	WH1	0.124	0.39
sH2	0.1230	0.38	WH2	0.163	0.09
sH3	0.3788	0.32	WH3	0.199	0.04
sH4	0.4056	0.11	WH4	0.247	0.02
sH5	0.4065	0.20	WH5	0.293	0.02
sH6	0.4627	0.36	WH6	0.314	0.04
sH7	0.5146	0.63	WH7	0.369	0.07
sH8	0.4290	0.05	WH8	0.400	0.11
sH9	0.4690	0.15	WH9	0.408	0.14
sH10	0.3894	0.52	WH10	0.416	0.11
sH11	0.3894	0.52	WH11	0.526	0.02
Natural mortality			Proportion mature		
M1	0.1	0.1	MT1	0	0
M2	0.1	0.1	MT2	0	0.1
M3	0.1	0.1	MT3	1	0.1
M4	0.1	0.1	MT4	1	0
M5	0.1	0.1	MT5	1	0
M6	0.1	0.1	MT6	1	0
M7	0.1	0.1	MT7	1	0
M8	0.1	0.1	MT8	1	0
M9	0.1	0.1	MT9	1	0
M10	0.1	0.1	MT10	1	0
M11	0.1	0.1	MT11	1	0
Relative effort in HC fihery			Year effect for natural mortality		
HF14	1	0.09	K14	1	0.1
HF15	1	0.09	K15	1	0.1
HF16	1	0.09	K16	1	0.1
Recruitment in 2015 and 2016					
R15	23913	0.37			
R16	23913	0.37			

Table 9.6.2a Sole in VIId - Management option table

MFDP version 1a **F - status quo**
Run: SOL7D_fin_SQ
Sole in VIId
Time and date: 15:38 01/05/2014
Fbar age range: 3-8

2014 Biomass	SSB	FMult	FBar	Landings
13004	10088	1.0000	0.4329	3415

2015 Biomass	SSB	FMult	FBar	Landings	2016 Biomass	SSB
13012	7394	0.0000	0.0000	0	16778	11157
.	7394	0.1000	0.0433	343	16405	10785
.	7394	0.2000	0.0866	672	16048	10427
.	7394	0.3000	0.1299	989	15704	10084
.	7394	0.4000	0.1731	1293	15374	9755
.	7394	0.5000	0.2164	1586	15058	9438
.	7394	0.6000	0.2597	1867	14753	9134
.	7394	0.7000	0.3030	2138	14461	8842
.	7394	0.8000	0.3463	2398	14180	8561
.	7394	0.9000	0.3896	2648	13910	8291
.	7394	1.0000	0.4329	2889	13650	8032
.	7394	1.1000	0.4761	3121	13401	7783
.	7394	1.2000	0.5194	3344	13161	7543
.	7394	1.3000	0.5627	3559	12930	7312
.	7394	1.4000	0.6060	3766	12708	7091
.	7394	1.5000	0.6493	3965	12495	6877
.	7394	1.6000	0.6926	4157	12289	6672
.	7394	1.7000	0.7359	4341	12092	6475
.	7394	1.8000	0.7792	4519	11902	6285
.	7394	1.9000	0.8224	4691	11719	6102
.	7394	2.0000	0.8657	4856	11542	5926

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.93						
.	7394	0.93	0.4026	2722	13831	8212
Fmult corresponding to Fmsy = 0.67						
.	7394	0.67	0.29	2058	14547	8928

Bpa/Btrigger = 8 000 t

Table 9.6.2b Sole in VIId - Management option table

MFDP version 1a
Run: SOL7D_fin_Mean
Sole in VIId
Time and date: 14:36 03/05/2014
Fbar age range: 3-8

Mean landings 2011-2013: 4190 t

2014 Biomass	SSB	FMult	FBar	Landings
13004	10088	1.2983	0.5620	4190

2015 Biomass	SSB	FMult	FBar	Landings	2016 Biomass	SSB
12178	6560	0.0000	0.0000	0	15925	10305
.	6560	0.1000	0.0433	309	15590	9970
.	6560	0.2000	0.0866	605	15268	9648
.	6560	0.3000	0.1299	891	14958	9338
.	6560	0.4000	0.1731	1165	14661	9041
.	6560	0.5000	0.2164	1429	14375	8756
.	6560	0.6000	0.2597	1683	14100	8481
.	6560	0.7000	0.3030	1928	13836	8217
.	6560	0.8000	0.3463	2163	13582	7964
.	6560	0.9000	0.3896	2389	13338	7720
.	6560	1.0000	0.4329	2607	13104	7485
.	6560	1.1000	0.4761	2817	12878	7260
.	6560	1.2000	0.5194	3019	12660	7042
.	6560	1.3000	0.5627	3213	12451	6834
.	6560	1.4000	0.6060	3401	12250	6633
.	6560	1.5000	0.6493	3582	12057	6439
.	6560	1.6000	0.6926	3756	11870	6253
.	6560	1.7000	0.7359	3923	11691	6074
.	6560	1.8000	0.7792	4085	11518	5901
.	6560	1.9000	0.8224	4241	11351	5735
.	6560	2.0000	0.8657	4391	11191	5575

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.93						
.	6560	0.93	0.4026	2455	13267	7648
Fmult corresponding to Fmsy = 0.67						
.	6560	0.67	0.29	1855	13915	8295

Bpa/Btrigger = 8 000 t

Table 9.6.3a Sole in VIId. Detailed results

MFDP version 1a
Run: SOL7D_fin_SQ
Time and date: 15:38 01/05/2014
Fbar age range: 3-8

F - status quo

Year: 2014 F multiplier: 1 Fbar: 0.4329

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0007	16	2	23913	2447	0	0	0	0
2	0.1230	353	58	3201	469	0	0	0	0
3	0.3788	1724	343	5729	1029	5729	1029	5729	1029
4	0.4056	2447	605	7686	1896	7686	1896	7686	1896
5	0.4065	4318	1266	13538	3881	13538	3881	13538	3881
6	0.4628	1714	538	4843	1548	4843	1548	4843	1548
7	0.5146	830	307	2160	816	2160	816	2160	816
8	0.4290	133	53	399	165	399	165	399	165
9	0.4690	327	133	914	361	914	361	914	361
10	0.3894	151	63	491	245	491	245	491	245
11	0.3894	87	46	283	148	283	148	283	148
Total		12100	3415	63157	13004	36043	10088	36043	10088

Year: 2015 F multiplier: 1 Fbar: 0.4329

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0007	16	2	23913	2447	0	0	0	0
2	0.1230	2384	389	21622	3171	0	0	0	0
3	0.3788	771	153	2561	460	2561	460	2561	460
4	0.4056	1130	279	3549	876	3549	876	3549	876
5	0.4065	1478	434	4636	1329	4636	1329	4636	1329
6	0.4628	2887	907	8158	2608	8158	2608	8158	2608
7	0.5146	1061	392	2759	1042	2759	1042	2759	1042
8	0.4290	389	156	1168	482	1168	482	1168	482
9	0.4690	84	34	235	93	235	93	235	93
10	0.3894	159	66	517	258	517	258	517	258
11	0.3894	146	77	474	247	474	247	474	247
Total		10506	2889	69594	13012	24059	7394	24059	7394

Year: 2016 F multiplier: 1 Fbar: 0.4329

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0007	16	2	23913	2447	0	0	0	0
2	0.1230	2384	389	21622	3171	0	0	0	0
3	0.3788	5207	1036	17300	3108	17300	3108	17300	3108
4	0.4056	505	125	1587	391	1587	391	1587	391
5	0.4065	683	200	2141	614	2141	614	2141	614
6	0.4628	989	310	2794	893	2794	893	2794	893
7	0.5146	1787	660	4647	1755	4647	1755	4647	1755
8	0.4290	497	199	1492	615	1492	615	1492	615
9	0.4690	246	101	688	272	688	272	688	272
10	0.3894	41	17	133	66	133	66	133	66
11	0.3894	187	98	608	317	608	317	608	317
Total		12542	3138	76925	13650	31390	8032	31390	8032

Input units are thousands and kg - output in tonnes

Table 9.6.3b Sole in VIId. Detailed results

MFDP version 1a
Run: SOL7D_fin_Mean
Time and date: 14:36 03/05/2014
Fbar age range: 3-8

Mean landings 2011-2013: 4190 t

Year: 2014 F multiplier: 1.2983 Fbar: 0.562

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0009	21	3	23913	2447	0	0	0	0
2	0.1597	450	74	3201	469	0	0	0	0
3	0.4917	2126	423	5729	1029	5729	1029	5729	1029
4	0.5265	3007	744	7686	1896	7686	1896	7686	1896
5	0.5277	5306	1556	13538	3881	13538	3881	13538	3881
6	0.6008	2092	657	4843	1548	4843	1548	4843	1548
7	0.6681	1007	372	2160	816	2160	816	2160	816
8	0.5569	163	65	399	165	399	165	399	165
9	0.6089	399	163	914	361	914	361	914	361
10	0.5056	186	77	491	245	491	245	491	245
11	0.5056	107	56	283	148	283	148	283	148
Total		14865	4190	63157	13004	36043	10088	36043	10088

Year: 2015 F multiplier: 1 Fbar: 0.4329

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0007	16	2	23913	2447	0	0	0	0
2	0.1230	2384	389	21618	3171	0	0	0	0
3	0.3788	743	148	2469	444	2469	444	2469	444
4	0.4056	1009	250	3170	782	3170	782	3170	782
5	0.4065	1310	384	4108	1178	4108	1178	4108	1178
6	0.4628	2558	803	7227	2310	7227	2310	7227	2310
7	0.5146	924	341	2403	908	2403	908	2403	908
8	0.4290	334	134	1002	413	1002	413	1002	413
9	0.4690	74	30	207	82	207	82	207	82
10	0.3894	139	58	450	224	450	224	450	224
11	0.3894	130	68	422	220	422	220	422	220
Total		9620	2607	66988	12178	21458	6560	21458	6560

Year: 2016 F multiplier: 1 Fbar: 0.4329

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0007	16	2	23913	2447	0	0	0	0
2	0.1230	2384	389	21622	3171	0	0	0	0
3	0.3788	5206	1036	17296	3108	17296	3108	17296	3108
4	0.4056	487	120	1530	377	1530	377	1530	377
5	0.4065	610	179	1912	548	1912	548	1912	548
6	0.4628	876	275	2475	791	2475	791	2475	791
7	0.5146	1583	585	4117	1555	4117	1555	4117	1555
8	0.4290	433	173	1300	536	1300	536	1300	536
9	0.4690	211	86	590	233	590	233	590	233
10	0.3894	36	15	117	58	117	58	117	58
11	0.3894	165	87	535	279	535	279	535	279
Total		12007	2947	75407	13104	29872	7485	29872	7485

Input units are thousands and kg - output in tonnes

Table 9.6.4 **Sole VIId**
Stock numbers of recruits and their source for recent year classes used in predictions, and the relative (%) contributions to landings and SSB (by weight) of these year classes

Year-class	2010	2011	2012	2013	2014
Stock No. (thousands) of 1 year-olds	18452	8236	3543	23913	23913
Source	XSA	XSA	XSA	GM82-11	GM82-11
Status Quo F:					
% in 2014 landings	17.7	10.0	1.7	0.1	-
% in 2015 landings	15.0	9.7	5.3	13.5	0.1
% in 2014 SSB	18.8	10.2	0.0	0.0	-
% in 2015 SSB	18.0	11.8	6.2	0.0	0.0
% in 2016 SSB	11.1	7.6	4.9	38.7	0.0

GM : geometric mean recruitment

Sole VIId : Year-class % contribution to

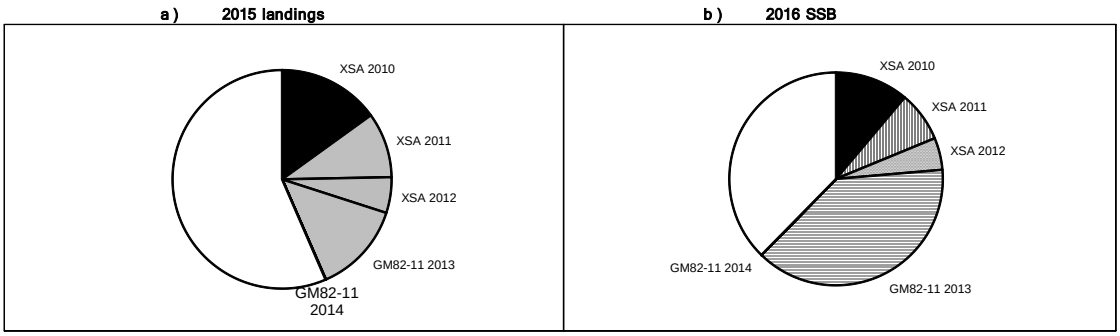


Table 9.7.1 - Sole in VIId Yield per recruit summary table

MFYPR version 2a
Run: S7d_Yield_fin
Time and date: 17:53 01/05/2014
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0.0000	0.0000	0.0000	0.0000	10.5083	3.7587	8.6035	3.5236	8.6035	3.5236
0.1000	0.0433	0.2475	0.0909	8.0367	2.5521	6.1320	2.3171	6.1320	2.3171
0.2000	0.0866	0.3838	0.1312	6.6763	1.9132	4.7716	1.6781	4.7716	1.6781
0.3000	0.1299	0.4696	0.1509	5.8214	1.5280	3.9168	1.2930	3.9168	1.2930
0.4000	0.1731	0.5283	0.1609	5.2367	1.2757	3.3322	1.0407	3.3322	1.0407
0.5000	0.2164	0.5710	0.1660	4.8125	1.1004	2.9079	0.8654	2.9079	0.8654
0.6000	0.2597	0.6034	0.1685	4.4906	0.9729	2.5862	0.7379	2.5862	0.7379
0.7000	0.3030	0.6289	0.1696	4.2380	0.8768	2.3336	0.6418	2.3336	0.6418
0.8000	0.3463	0.6496	0.1698	4.0342	0.8022	2.1299	0.5673	2.1299	0.5673
0.9000	0.3896	0.6666	0.1695	3.8662	0.7429	1.9619	0.5079	1.9619	0.5079
1.0000	0.4329	0.6810	0.1690	3.7249	0.6947	1.8207	0.4597	1.8207	0.4597
1.1000	0.4761	0.6933	0.1683	3.6044	0.6548	1.7003	0.4198	1.7003	0.4198
1.2000	0.5194	0.7039	0.1676	3.5003	0.6213	1.5962	0.3863	1.5962	0.3863
1.3000	0.5627	0.7132	0.1668	3.4092	0.5927	1.5052	0.3578	1.5052	0.3578
1.4000	0.6060	0.7215	0.1660	3.3288	0.5682	1.4248	0.3332	1.4248	0.3332
1.5000	0.6493	0.7288	0.1652	3.2572	0.5468	1.3533	0.3119	1.3533	0.3119
1.6000	0.6926	0.7354	0.1645	3.1931	0.5280	1.2892	0.2931	1.2892	0.2931
1.7000	0.7359	0.7414	0.1637	3.1352	0.5114	1.2314	0.2765	1.2314	0.2765
1.8000	0.7792	0.7469	0.1630	3.0826	0.4965	1.1789	0.2617	1.1789	0.2617
1.9000	0.8224	0.7519	0.1624	3.0346	0.4832	1.1310	0.2484	1.1310	0.2484
2.0000	0.8657	0.7565	0.1617	2.9907	0.4712	1.0871	0.2364	1.0871	0.2364

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4329
FMax	0.7858	0.3401
F0.1	0.299	0.1294
F35%SPR	0.3204	0.1387

Table 9.8.1 Sole in VIId - PLotMSY results

Stock name
solviid
Sen filename
solviid.sen
pf, pm
0 0
Number of iterations
1000
Simulate variation in Biological parameters
TRUE
SR relationship constrained
TRUE

Ricker
1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpl	ADMB Beta	Unscaled A	Unscaled Beta	AICc
Determinis	5	3	6042	4352	1.46	1.49	15	0.00019	52
Mean	1.95	1.08	6789	5010	1.53	1.57	21	0.00020	54
5%ile	0.69	0.34	3842	3563	1.12	0.71	5	0.00009	52
25%ile	1.12	0.60	4937	4108	1.35	1.27	12	0.00016	52
50%ile	1.60	0.90	6013	4669	1.51	1.58	17	0.00020	53
75%ile	2.62	1.41	7336	5543	1.67	1.88	26	0.00024	55
95%ile	4.22	2.50	12294	7584	2.00	2.32	46	0.00030	58
CV	0.56	0.60	1	0	0.18	0.31	1	0.31	0
N	480	763	763	763	1000	1000	1000	1000	1000

Beverton-Holt
1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpl	ADMB Beta	Unscaled A	Unscaled Beta	AICc
Determinis	5	0.334154	16330	3983	0.79	0.79	23573	67	54
Mean	1.54	0.23	39846	6135	0.63	0.92	49667	12660	57
5%ile	0.45	0.13	10800	3197	0.25	0.76	20321	178	54
25%ile	0.76	0.17	15052	3690	0.51	0.84	23676	900	55
50%ile	1.19	0.22	19687	4136	0.67	0.91	27630	2517	56
75%ile	2.03	0.28	28172	4802	0.78	0.99	36230	6394	58
95%ile	3.89	0.36	67288	8468	0.91	1.11	74620	26055	61
CV	0.69	0.33	7	5	0.32	0.12	6	10	0
N	585	1000	1000	1000	1000	1000	1000	1000	1000

Smooth hockeystick
997/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpl	ADMB Beta	Unscaled A	Unscaled Beta	AICc
Determinis	1.00	0.34	15246	3762	0.62	0.74	1.47	7545	54
Mean	0.60	0.35	12560	3906	0.57	0.84	1.35	8608	56
5%ile	0.32	0.26	8265	3226	0.46	0.75	1.08	7636	54
25%ile	0.42	0.31	10218	3601	0.52	0.77	1.24	7898	55
50%ile	0.53	0.34	12203	3862	0.57	0.81	1.34	8331	56
75%ile	0.69	0.39	14345	4144	0.61	0.88	1.46	9041	57
95%ile	1.14	0.48	18268	4715	0.69	1.02	1.65	10417	61
CV	0.46	0.19	0	0	0.12	0.11	0.12	0	0
N	997	997	997	997	997	997	997	997	997

Per recruit

	F20	F25	F30	F35	F40	F01	Fmax	Bmsypr	MSYpr	Fpa	Flim
Determinis	0.354077	0.259893	0.20	0.16	0.13	0.13	0.34	0.69	0.17	0.4	0.55
Mean	0.30	0.23	0.18	0.15	0.12	0.14	0.36	0.55	0.17		
5%ile	0.21	0.17	0.14	0.11	0.09	0.09	0.26	0.37	0.16		
25%ile	0.26	0.20	0.16	0.13	0.11	0.11	0.31	0.46	0.17		
50%ile	0.29	0.22	0.18	0.15	0.12	0.13	0.35	0.54	0.17		
75%ile	0.33	0.25	0.20	0.16	0.13	0.16	0.40	0.62	0.17		
95%ile	0.41	0.30	0.24	0.20	0.16	0.22	0.50	0.74	0.18		
CV	0.20	0.18	0.17	0.17	0.18	0.30	0.20	0.21	0.03		
N	1000	1000	1000	1000	1000	1000	994	994	994		

Combining all SRRs
Manually specified weights

0 0 1

Percentag	Fmsy	Fcrash	MSY	Bmsy	Fmsy_w	Fcrash_w	MSY_w	Bmsy_w
5%	0.15	0.34	3269	4600	0.26	0.32	3226	8265
25%	0.25	0.51	3728	8234	0.31	0.42	3601	10218
50%	0.34	0.79	4098	12631	0.34	0.53	3862	12203
75%	0.49	1.44	4714	17507	0.39	0.69	4144	14345
95%	1.65	3.52	7073	38553	0.48	1.14	4715	18268

Sole VIId – Figures

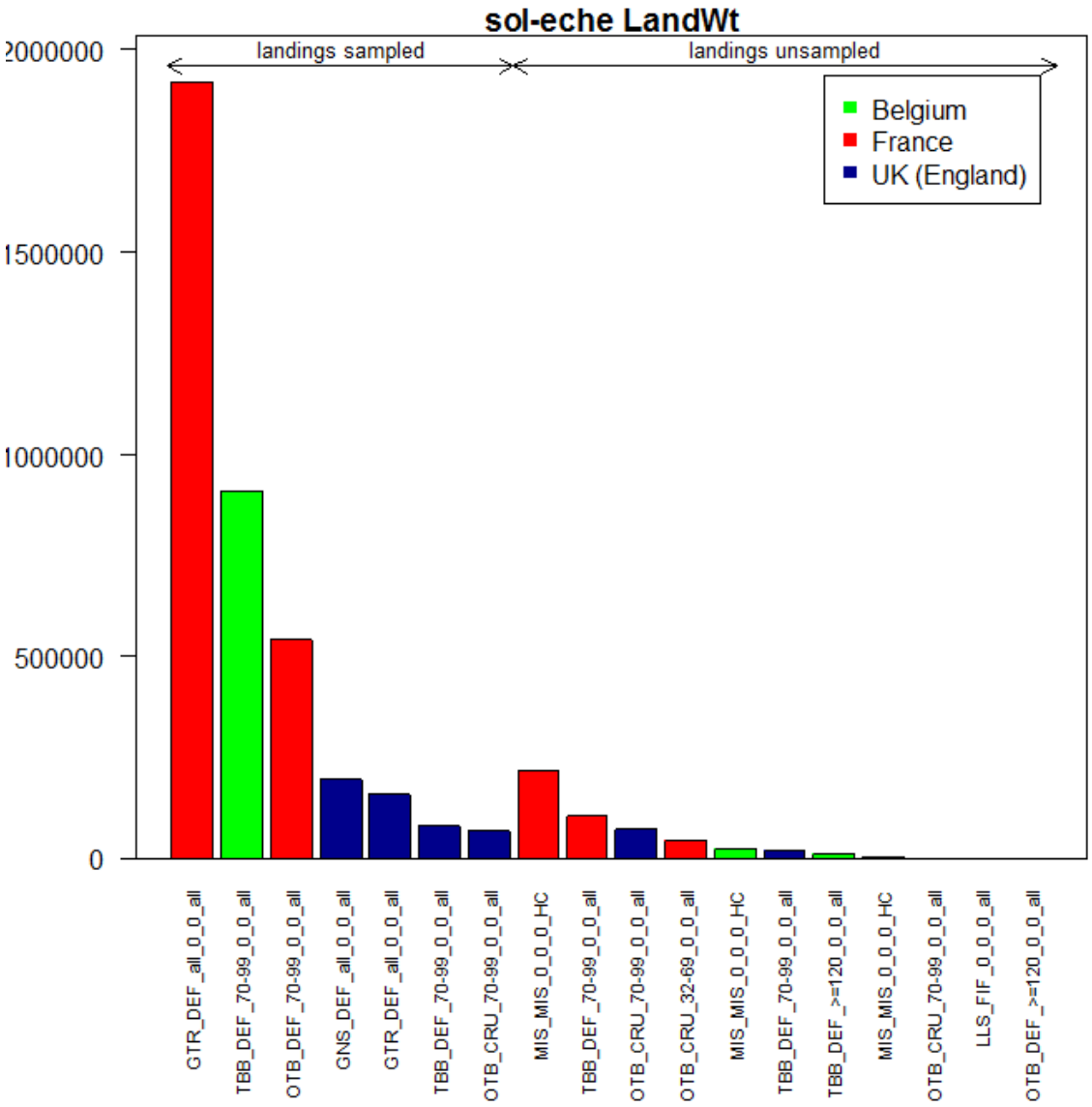


Figure 9.2.1a - Sole in VIId – Landings by country and métier (sampled and unsampled)

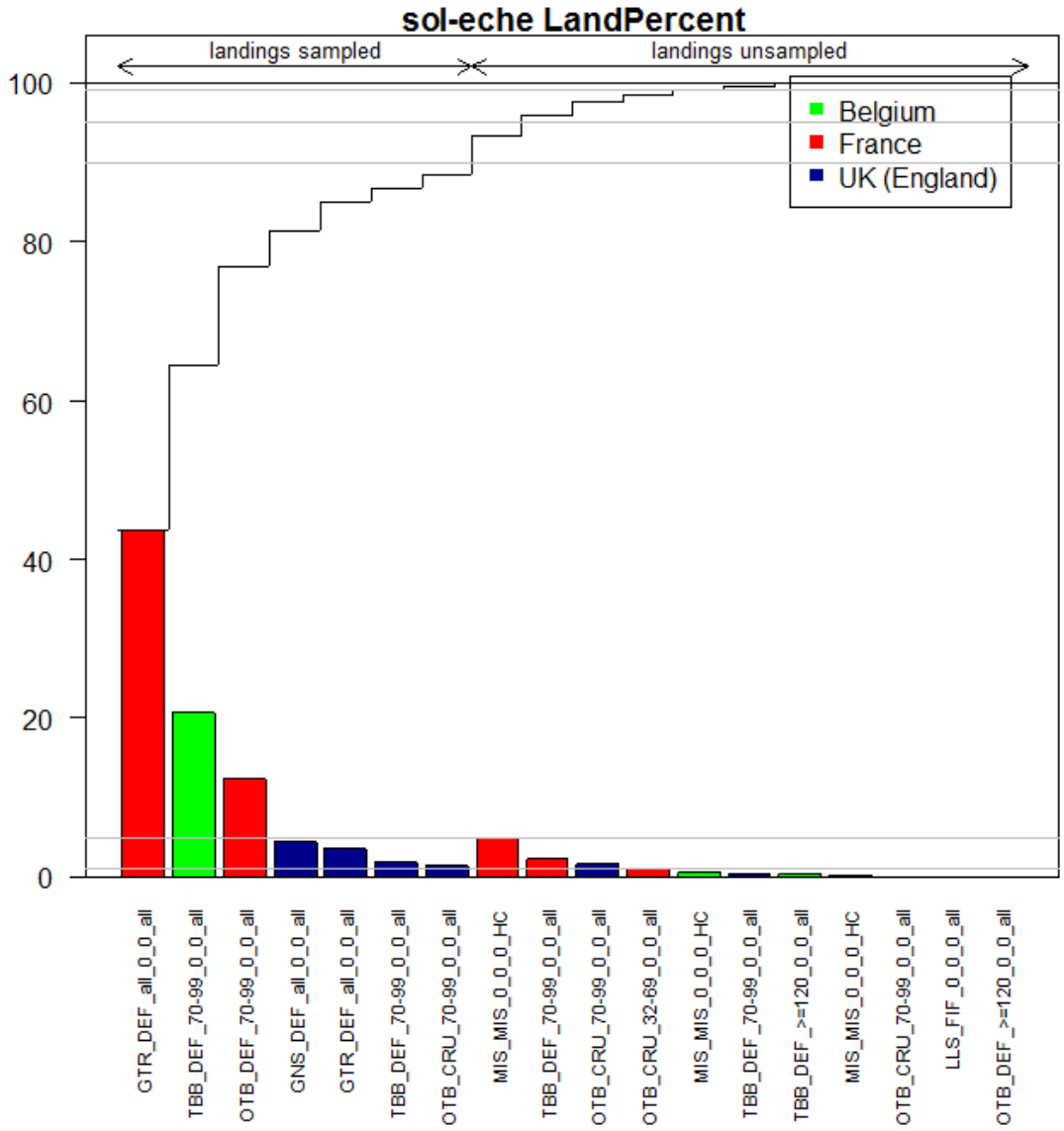


Figure 9.2.1b - Sole in VIId – Percentage of landings by country and métier (sampled and unsampled)

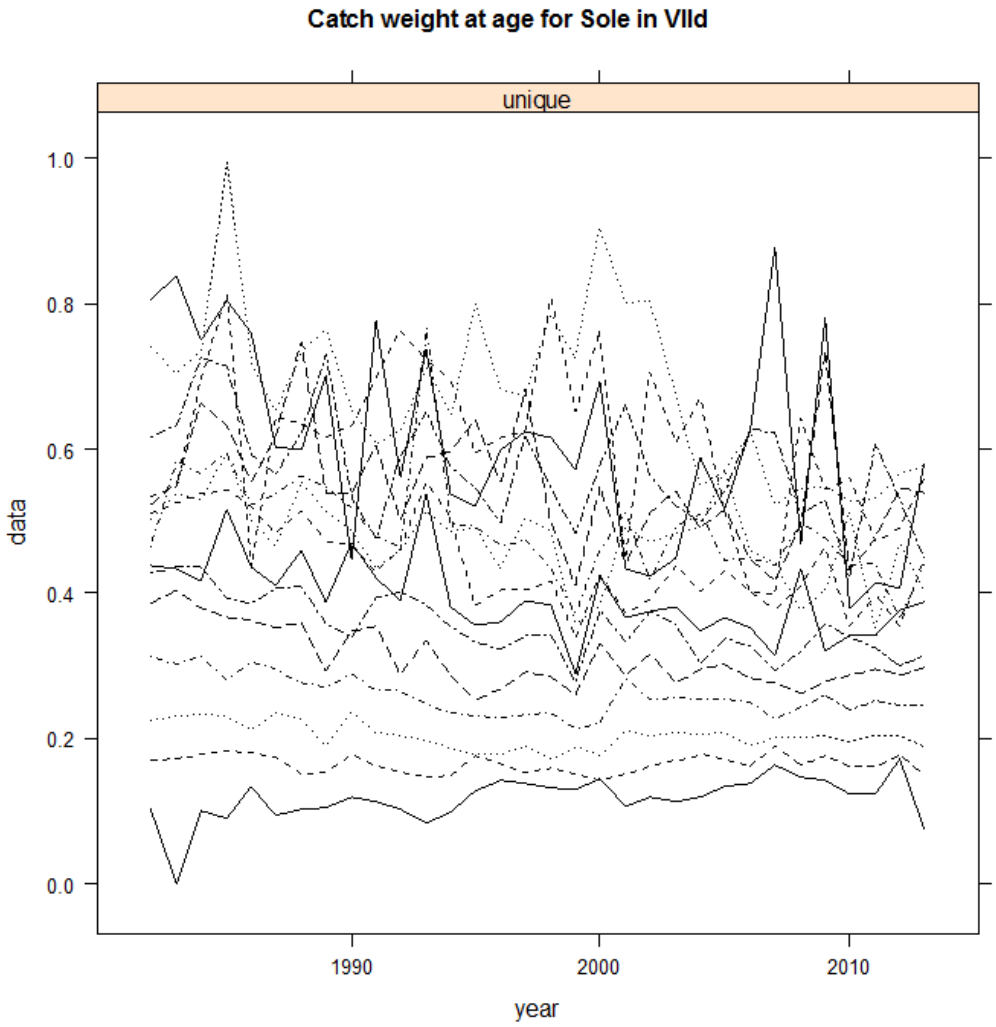


Figure 9.2.2 - Sole in VIId - Catch weight at age

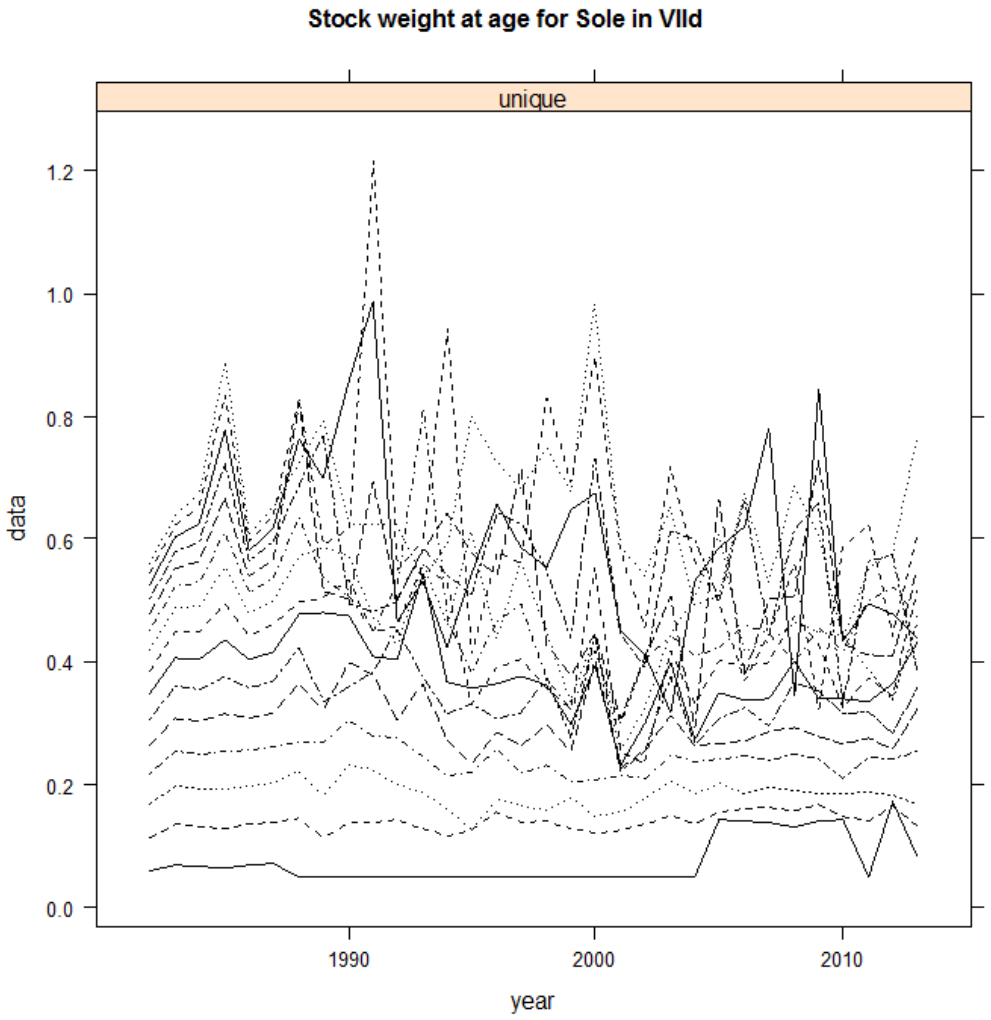


Figure 9.2.3 - Sole in VIId - Stock weight at age

Figure 9.2.4a **Sole VIId - Effort series**

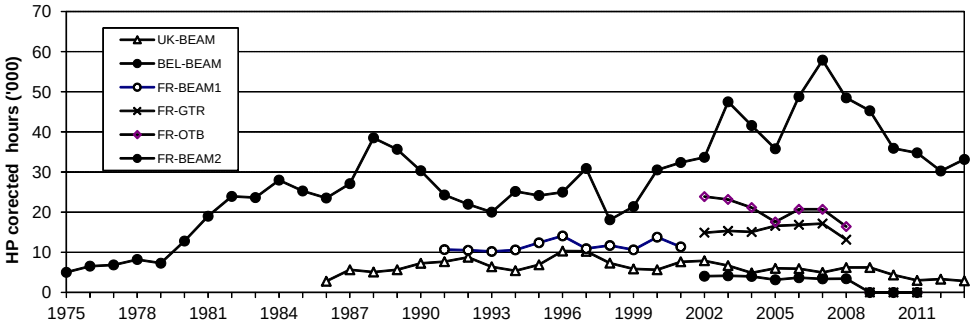


Figure 9.2.4b **Sole VIId - Relative Effort series**

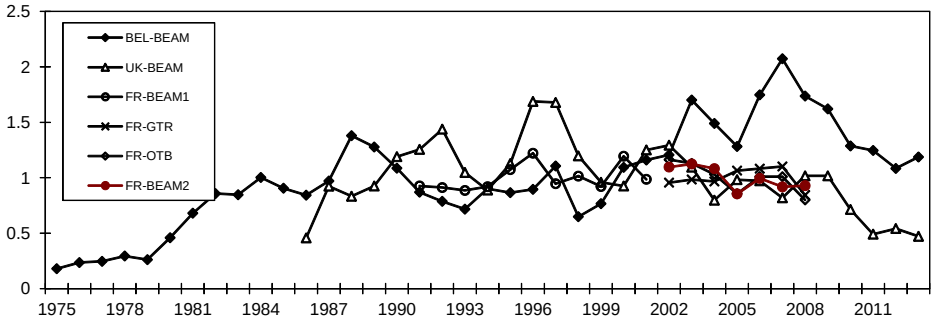
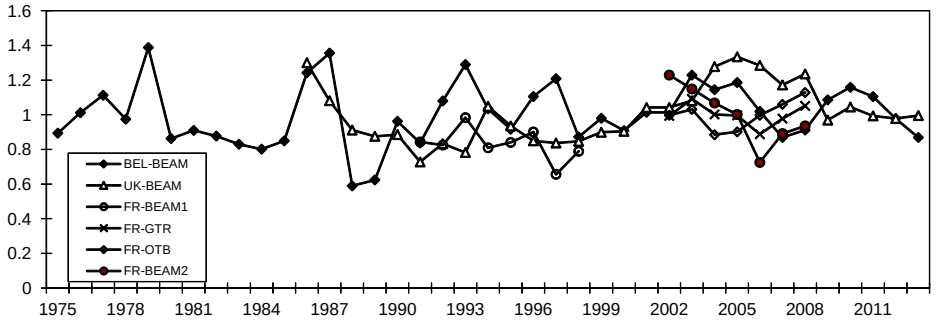


Figure 9.2.4c **Sole VIId - Relative LPUE series**



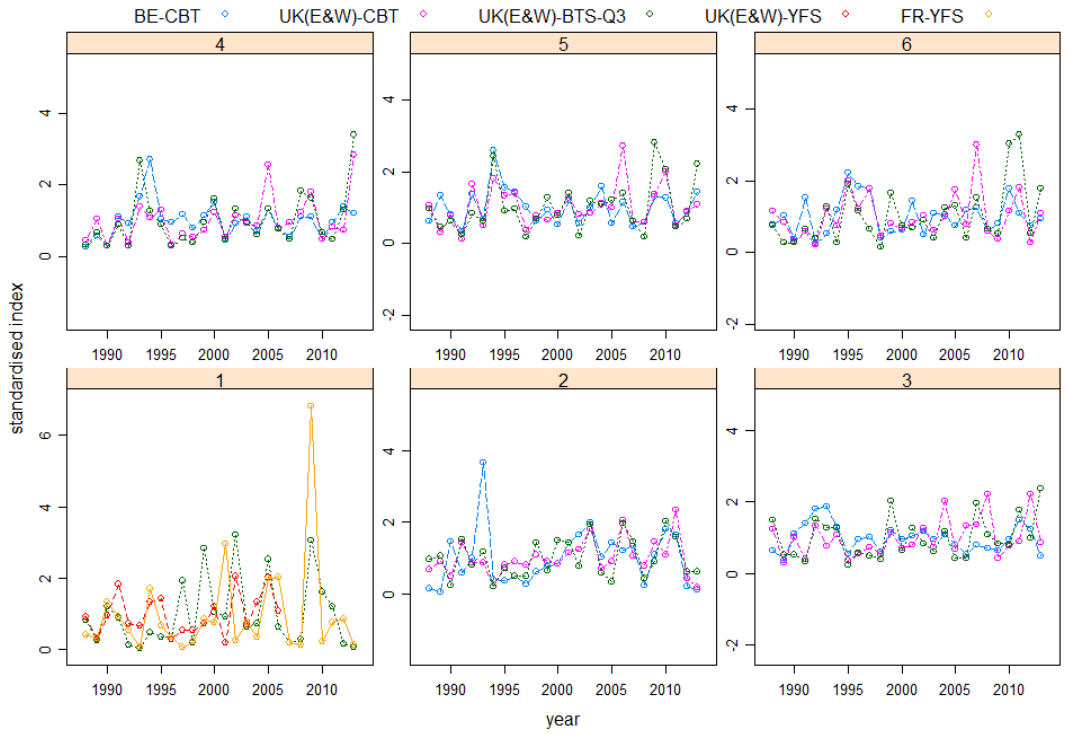


Figure 9.3.1 Sole in VIId. Standardized tuning indices used for tuning XSA:

BE-CBT (blue), UK(E&W)-CBT (pink), UK-BTS (green) UK(E&W)YFS (red) and FR-YFS (orange).

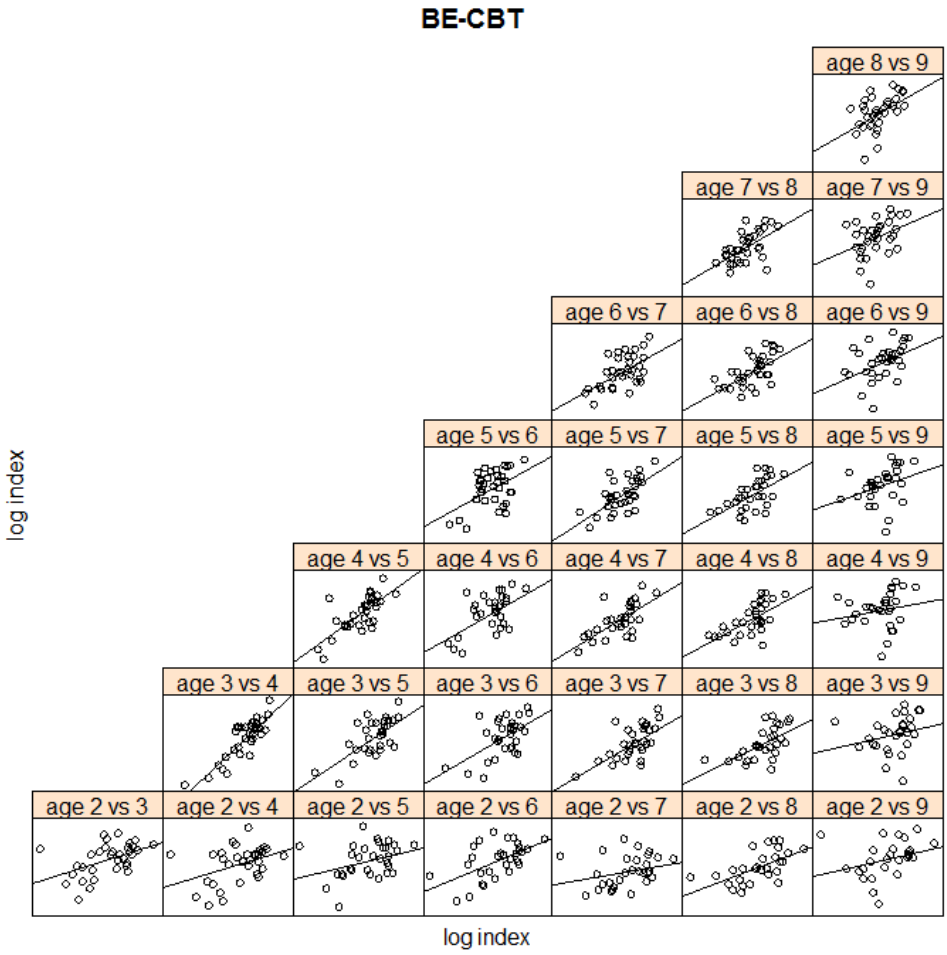


Figure 9.3.2 Sole in VIId. Internal concistency plot for the Belgian commercial fleet (BE-CBT).

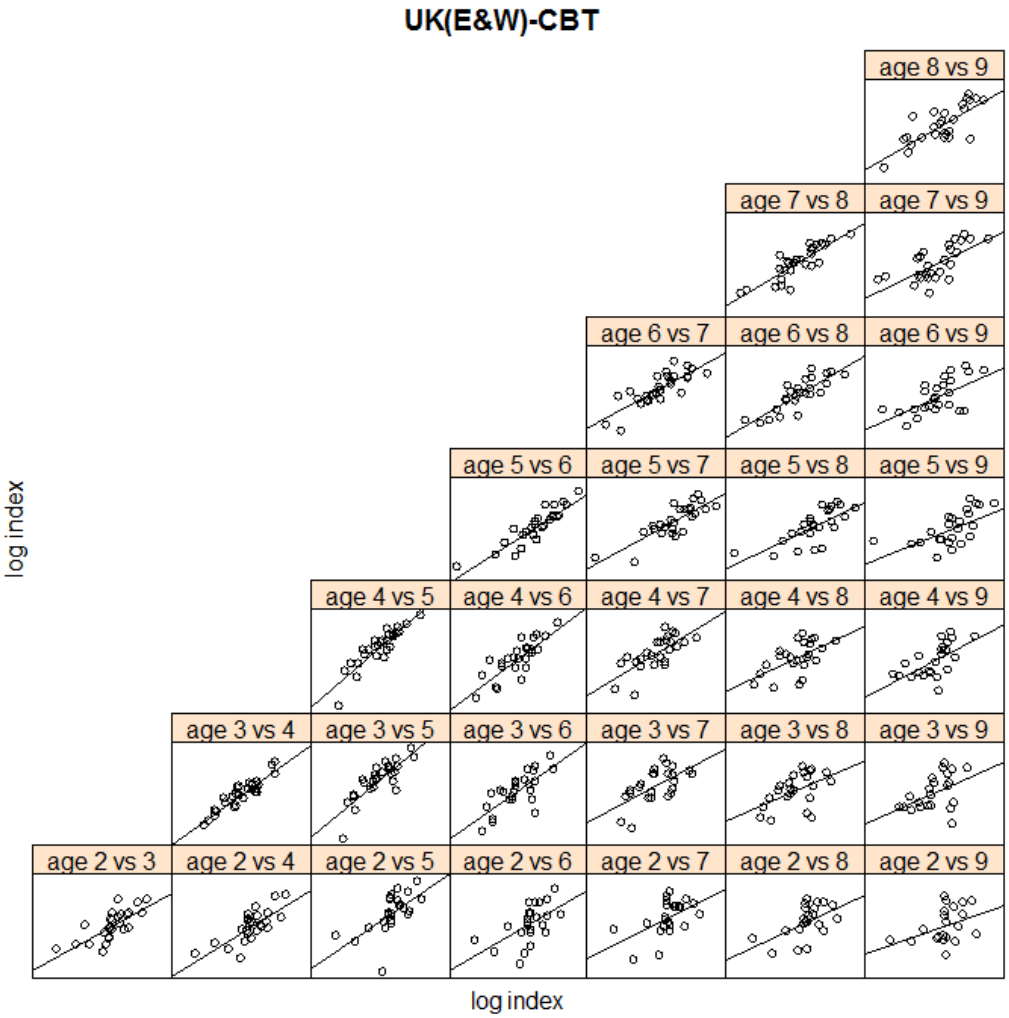


Figure 9.3.3 Sole in VIId. Internal concistency plot for the UK commercial fleet (UK(E&W)-CBT).

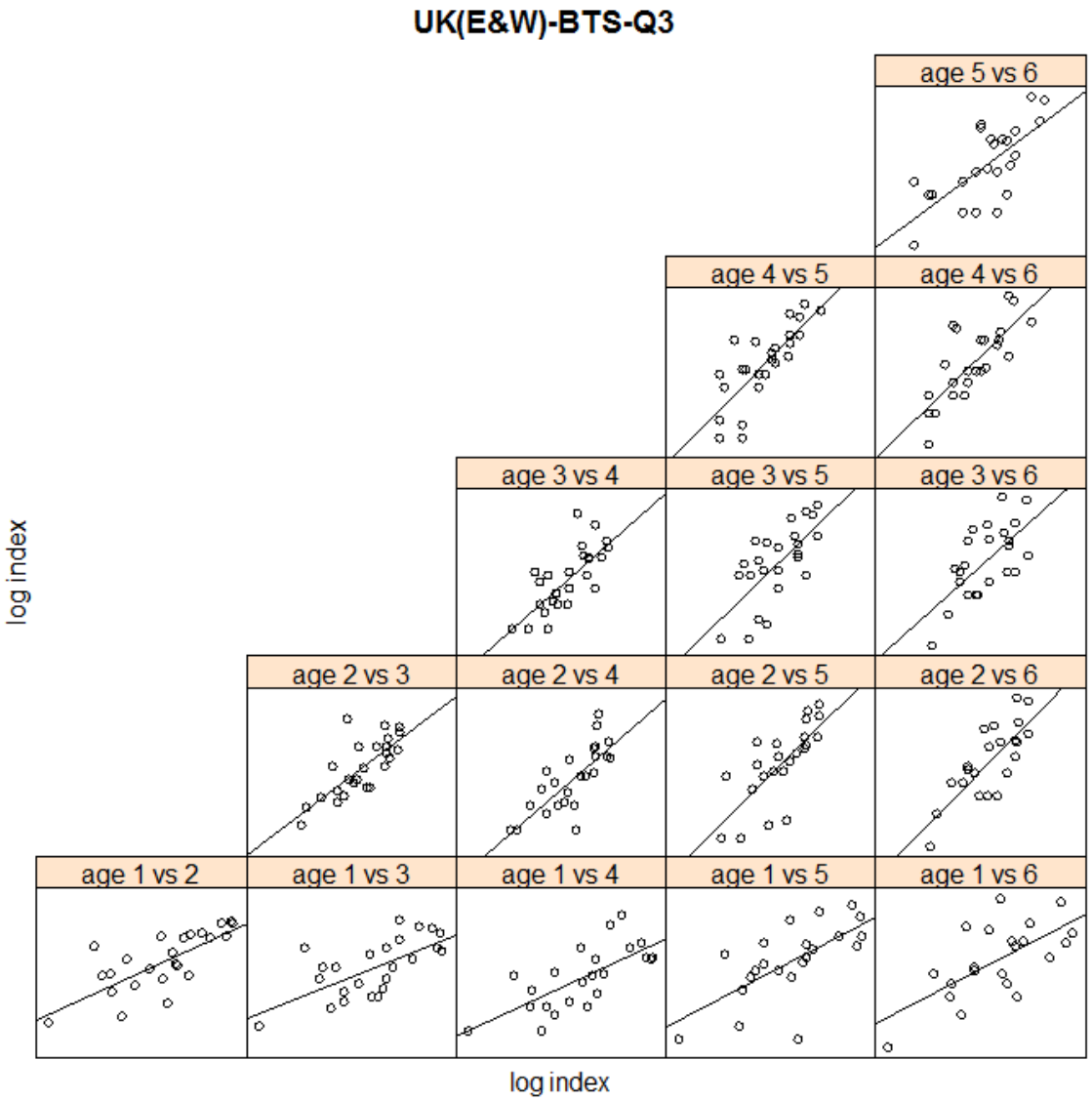


Figure 9.3.4 Sole in VIId. Internal concistency plot for the UK beam trawl survey (UK(E&W)-BTS).

Figure 9.3.5a - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

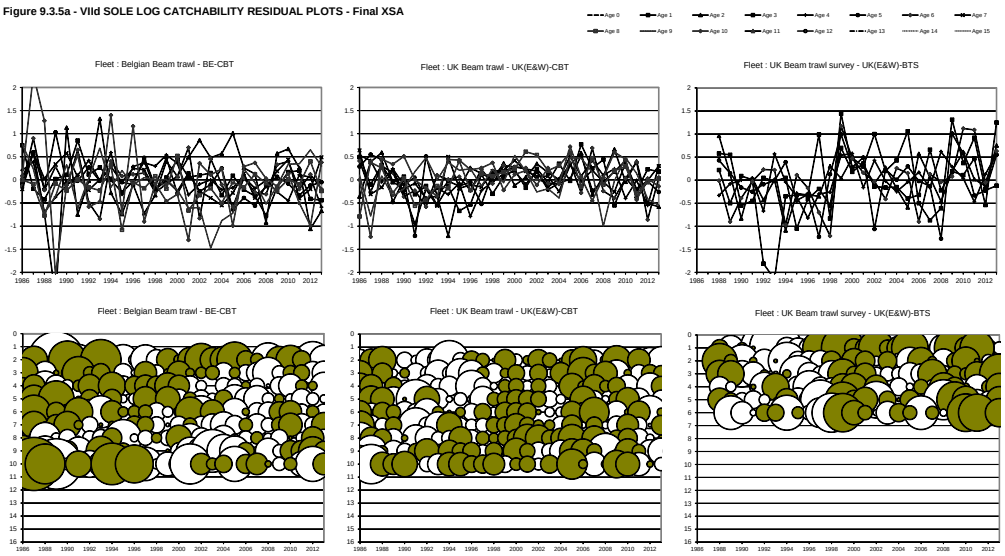


Figure 9.3.5b - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

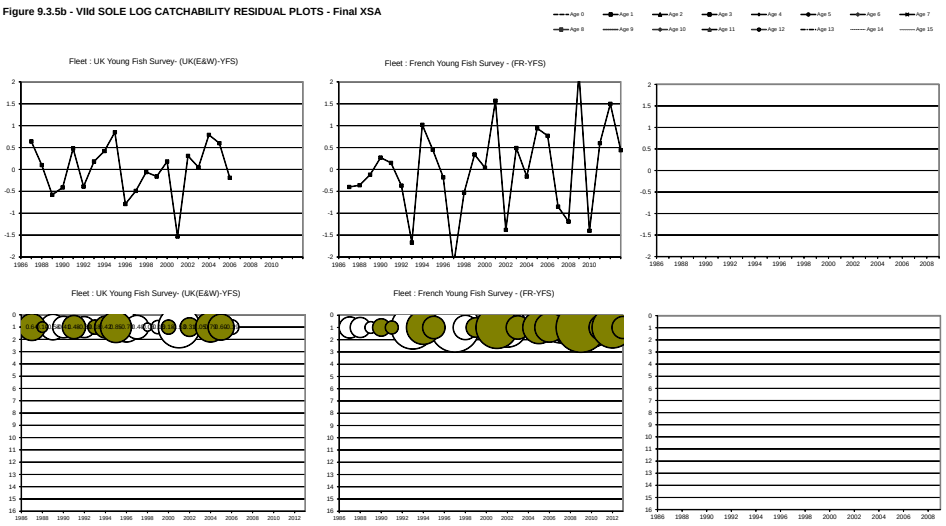


Figure 9.3.6 Sole in VIId. Estimates of survivors from different fleets and shrinkage, as well as their different weighting in the final XSA-run

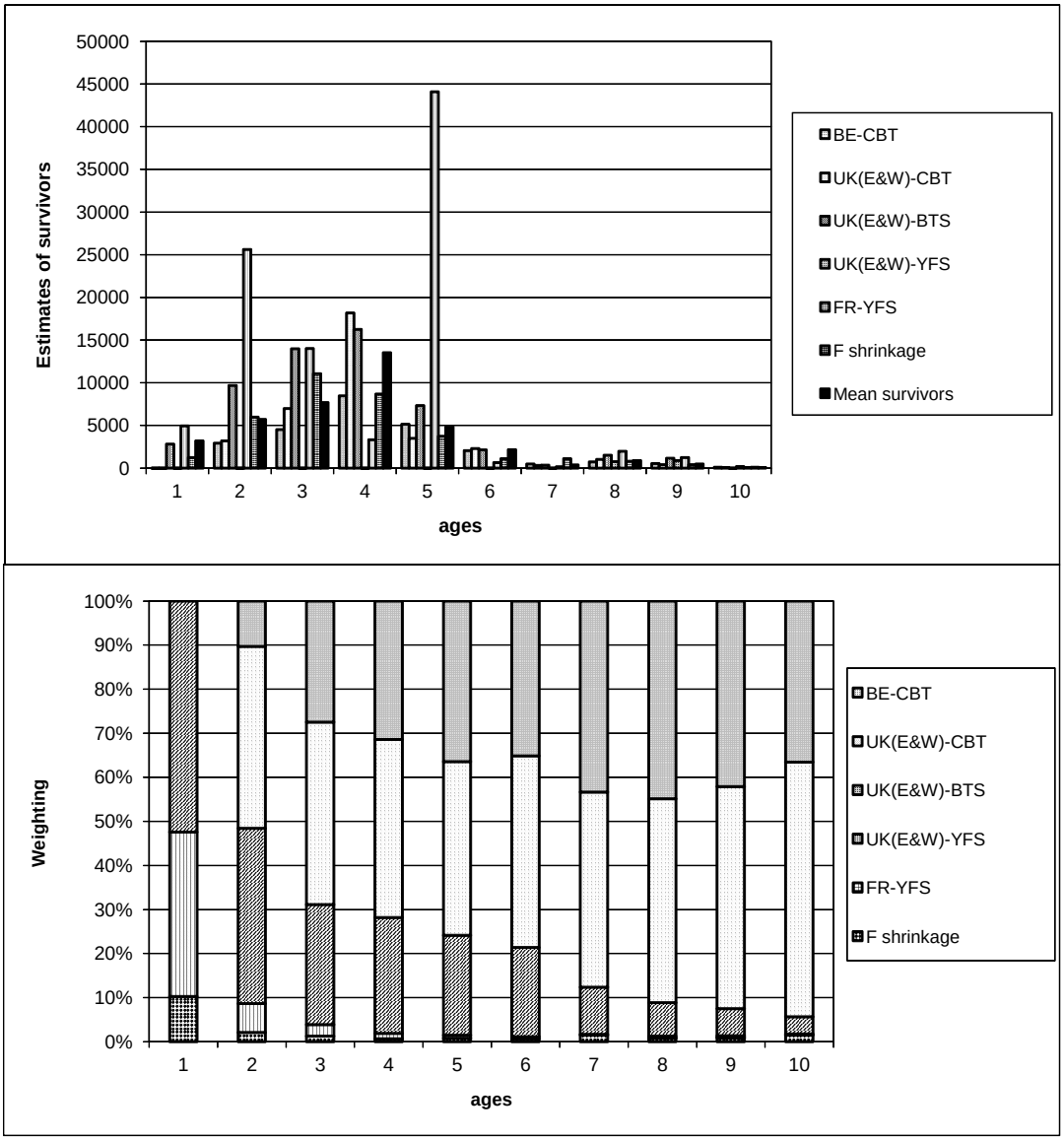


Figure 9.3.7 Sole in VIId. Summary plots

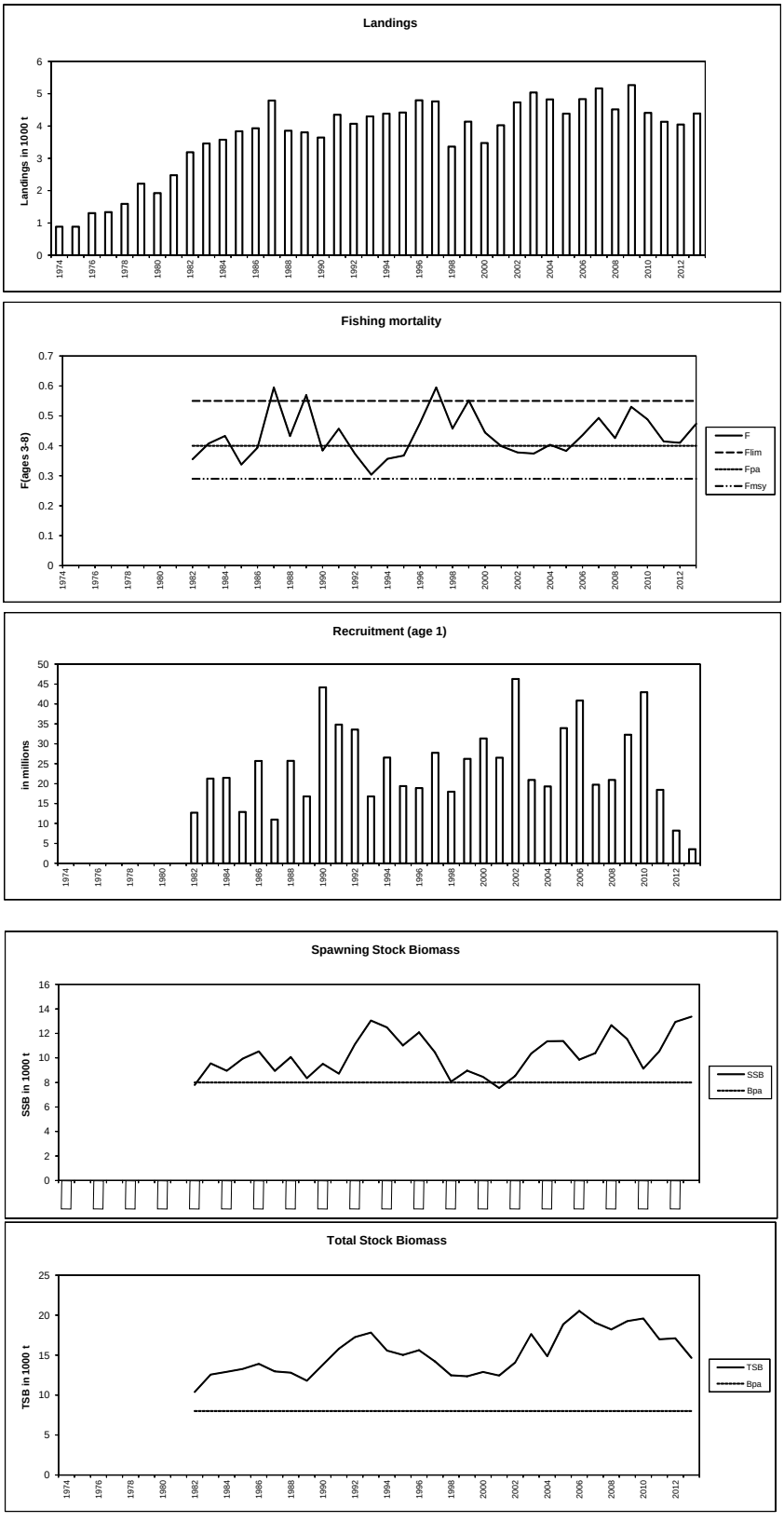


Figure 9.3.8 - Sole VIId retrospective XSA analysys (shinkage SE=2.0)

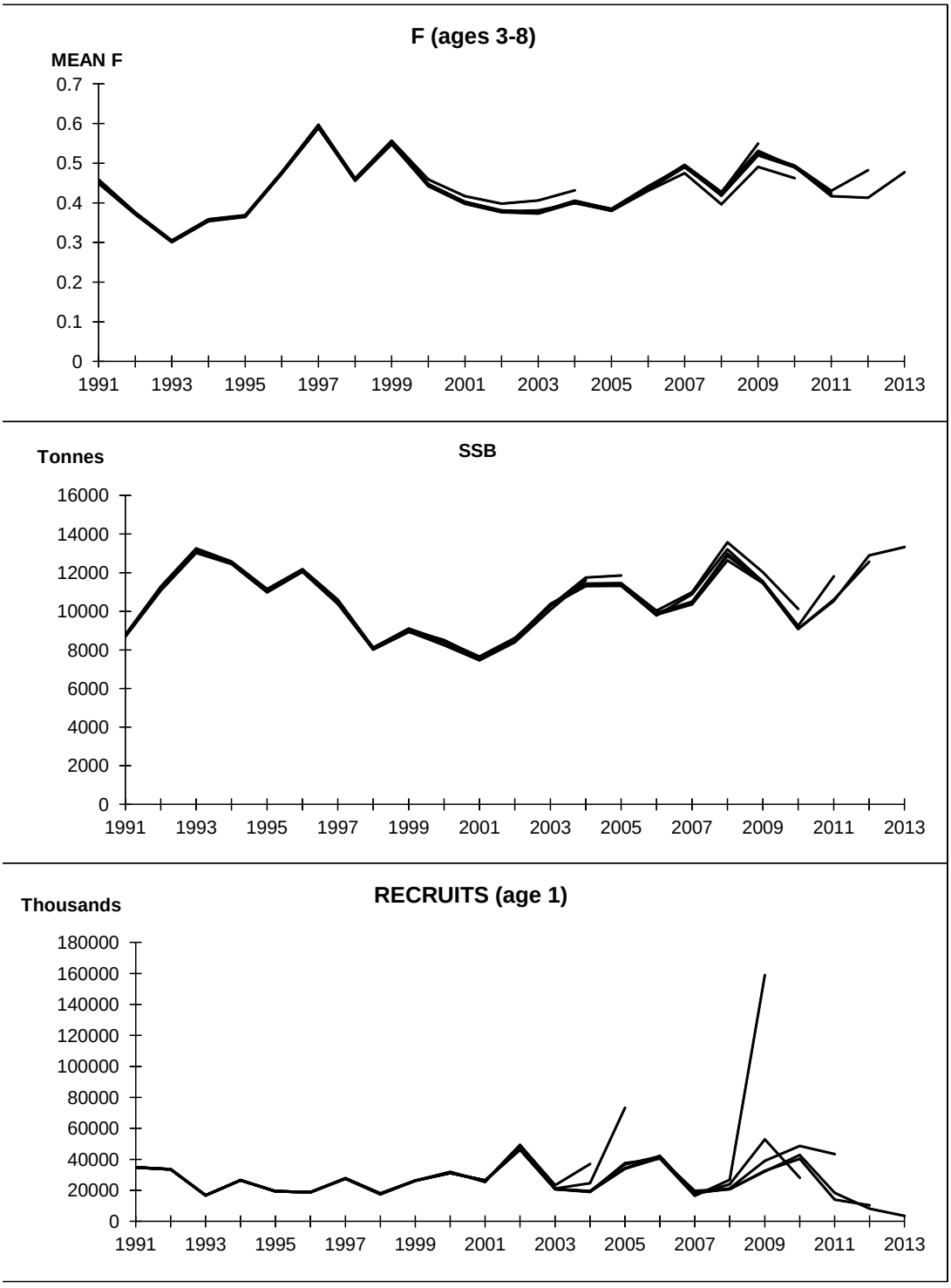
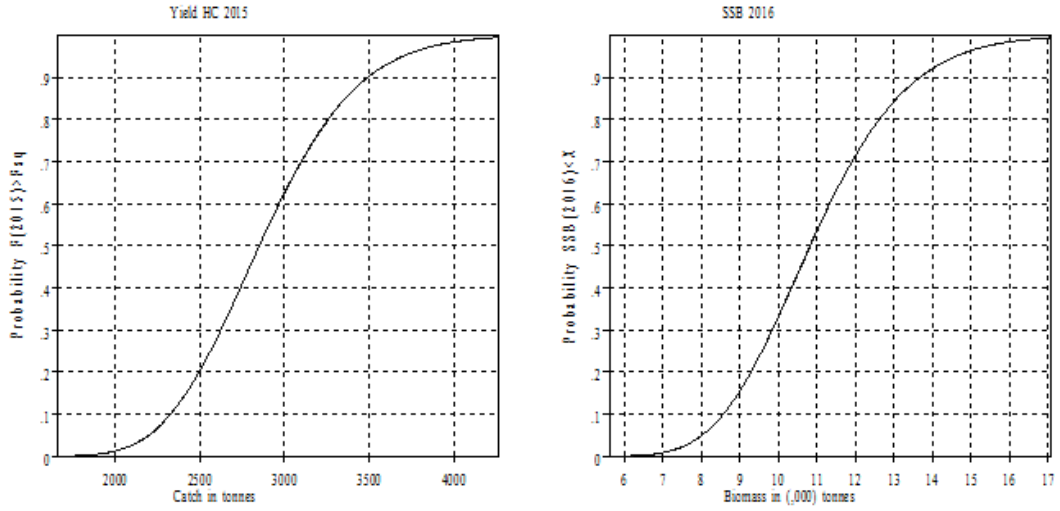
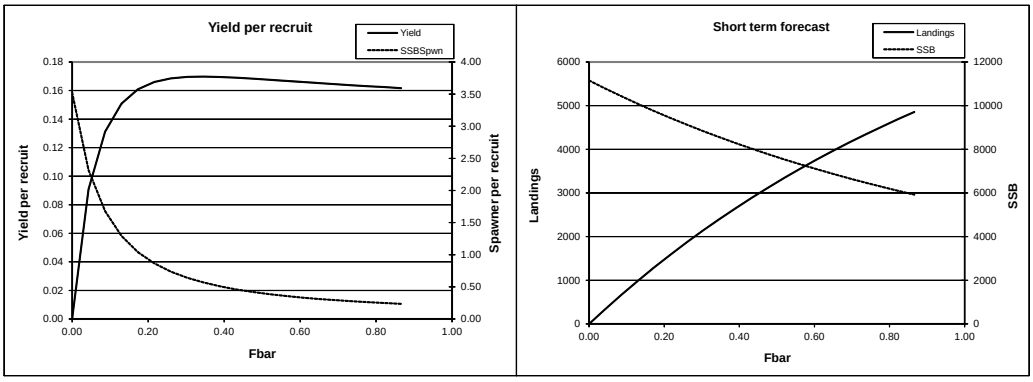


Figure 9.6.1 - Sole VIId - Probability profiles for short term forecast.



Data from file:C:\ILVO\2014\WGNSSK-2014\Sole VIId\Prediction\Sensitivity\Pie & p

Figure 9.7.1 - Sole in VIId Yield per recruit and short term forecast plots



MFYPR version 2a
Run: S7d_Yield_fin
Time and date: 17:53 01/05/2014

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4329
FMax	0.7858	0.3401
F0.1	0.2990	0.1294
F35%SPR	0.3204	0.1387

MFDP version 1a
Run: SOL7D_fin_SQ
Sole in VIId
Time and date: 15:38 01/05/2014
Fbar age range: 3-8

Input units are thousands and kg - output in tonnes

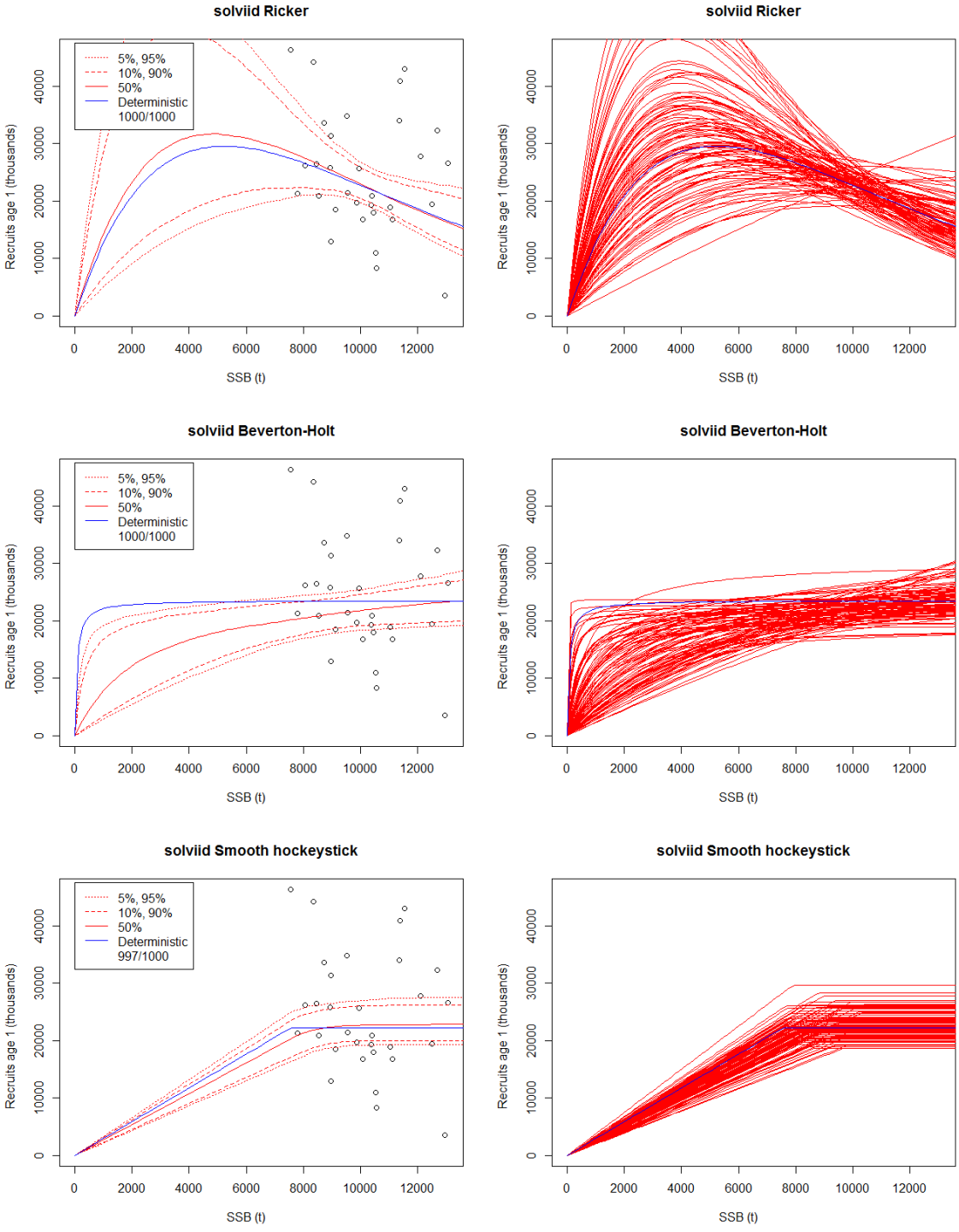


Figure 9.8.1 - Sole in VIId – PLotMSY - 1

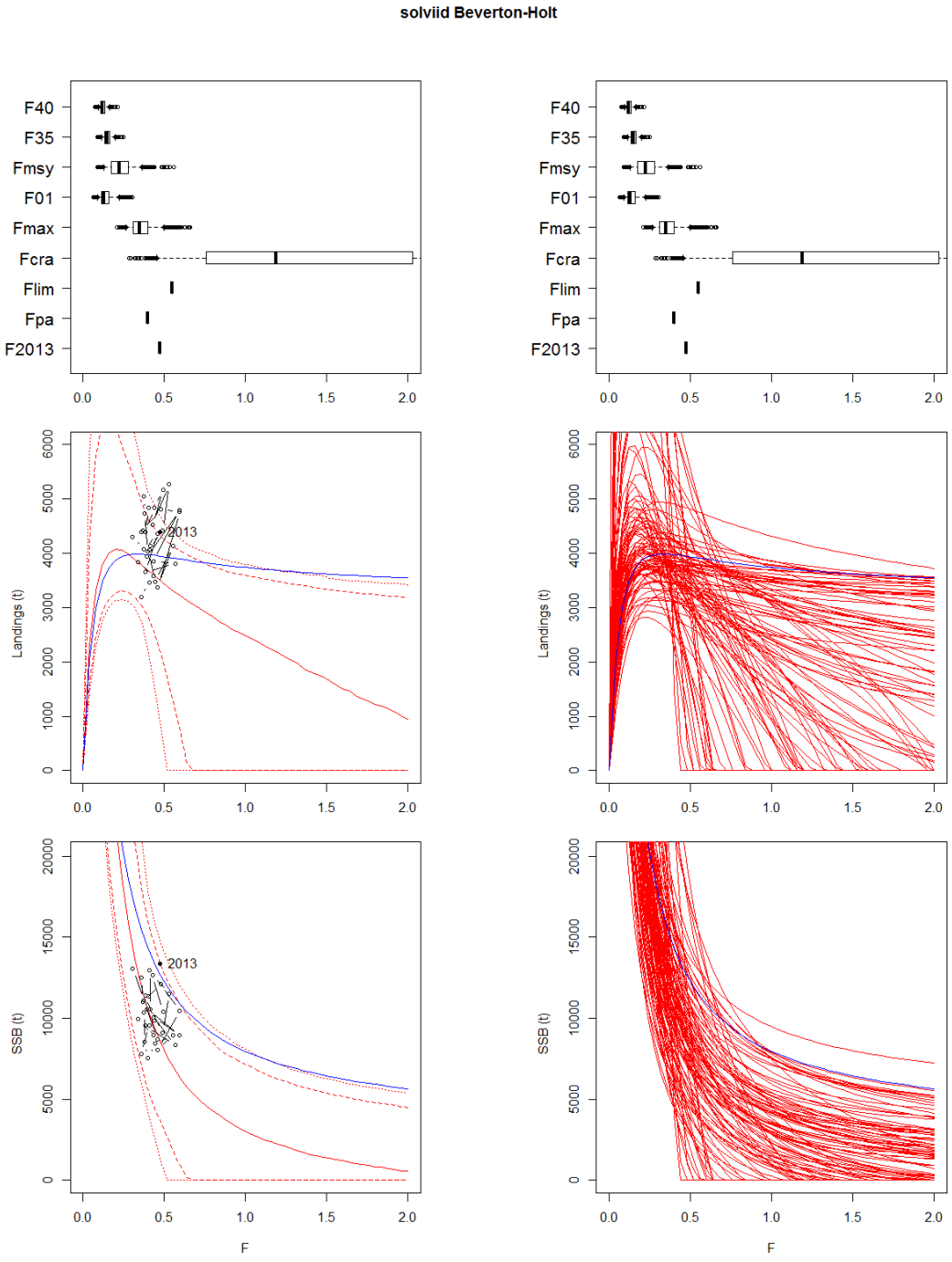


Figure 9.8.2 - Sole in VIId – PLotMSY - 2

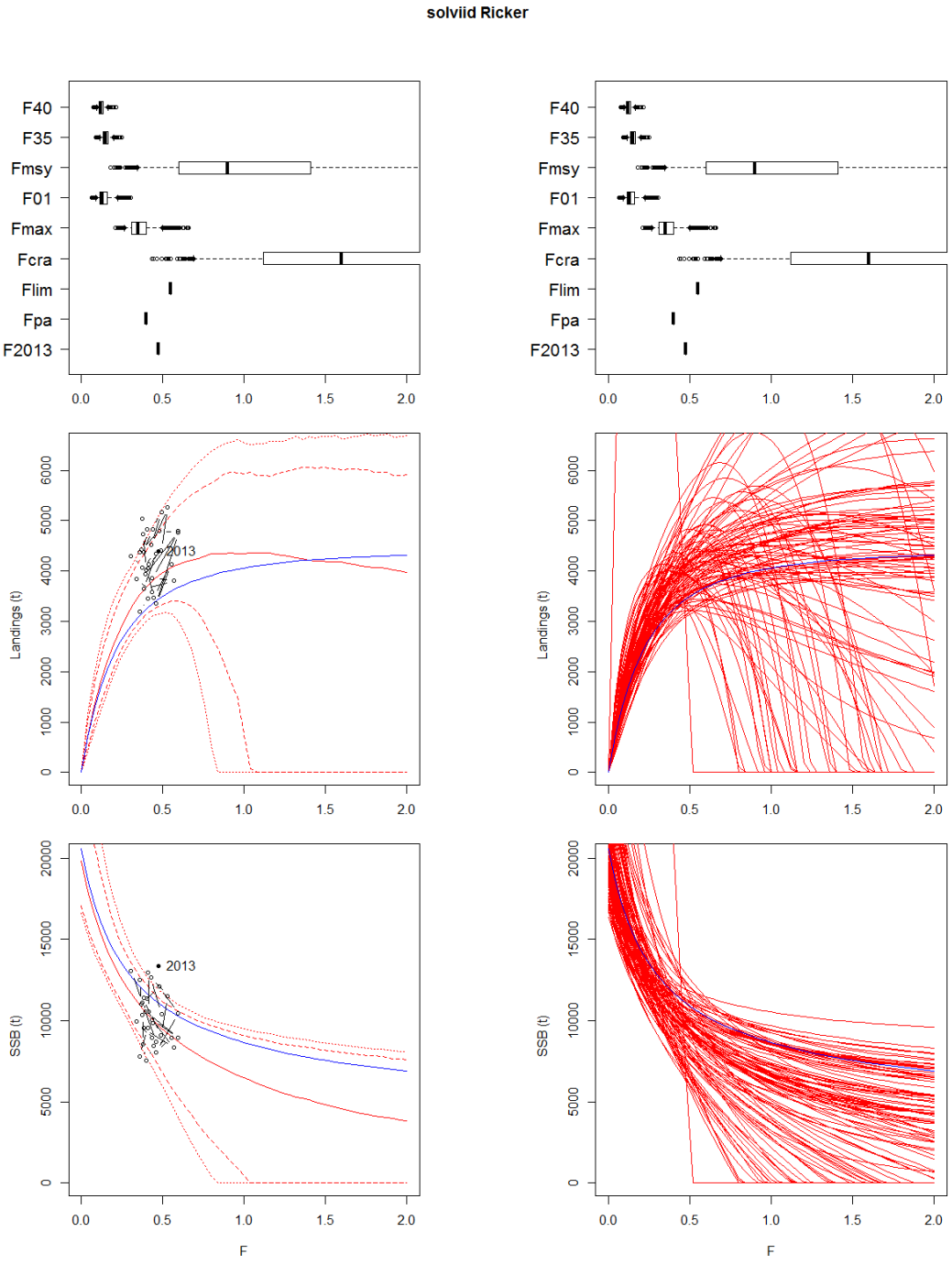


Figure 9.8.3 - Sole in VIId – PLotMSY - 3

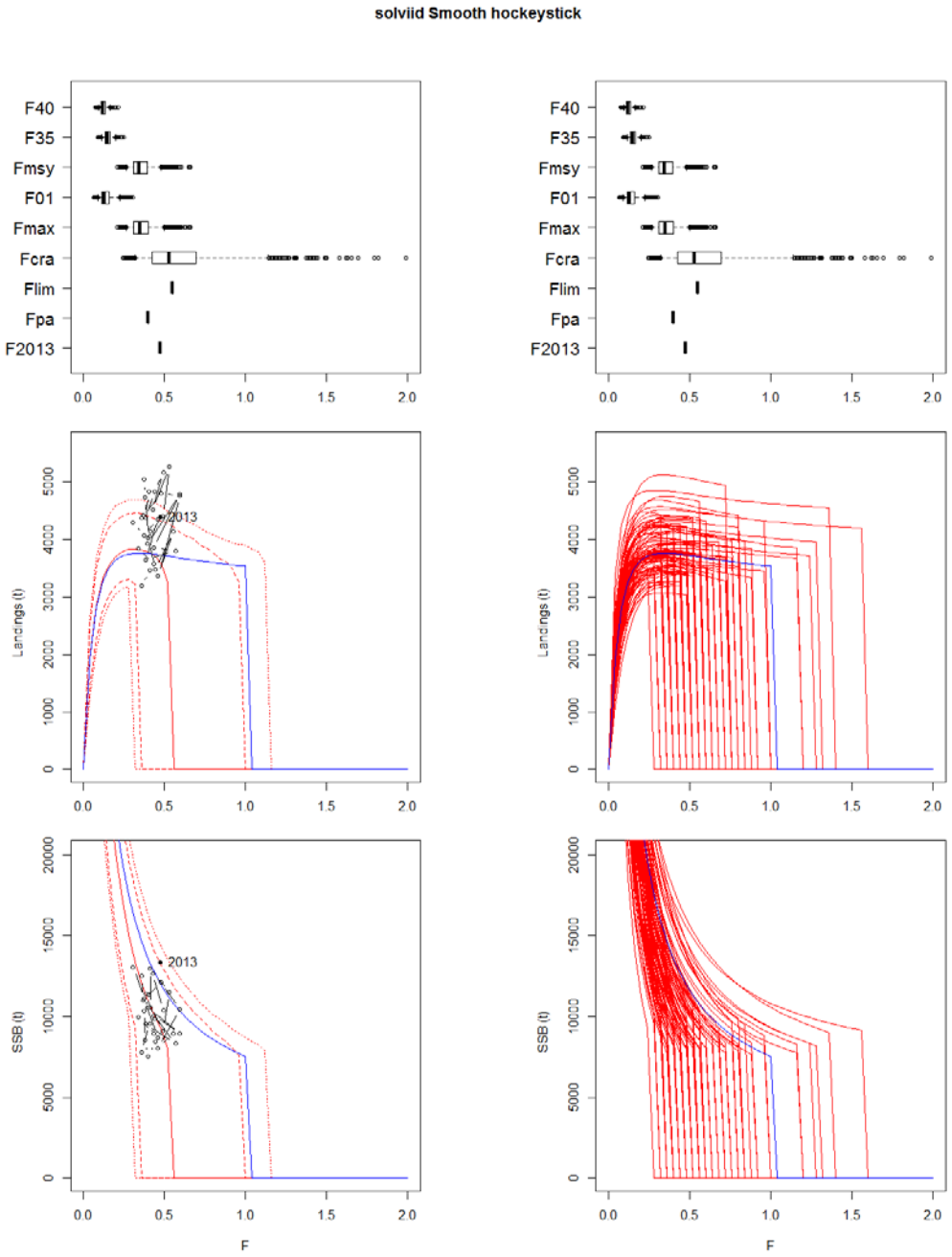
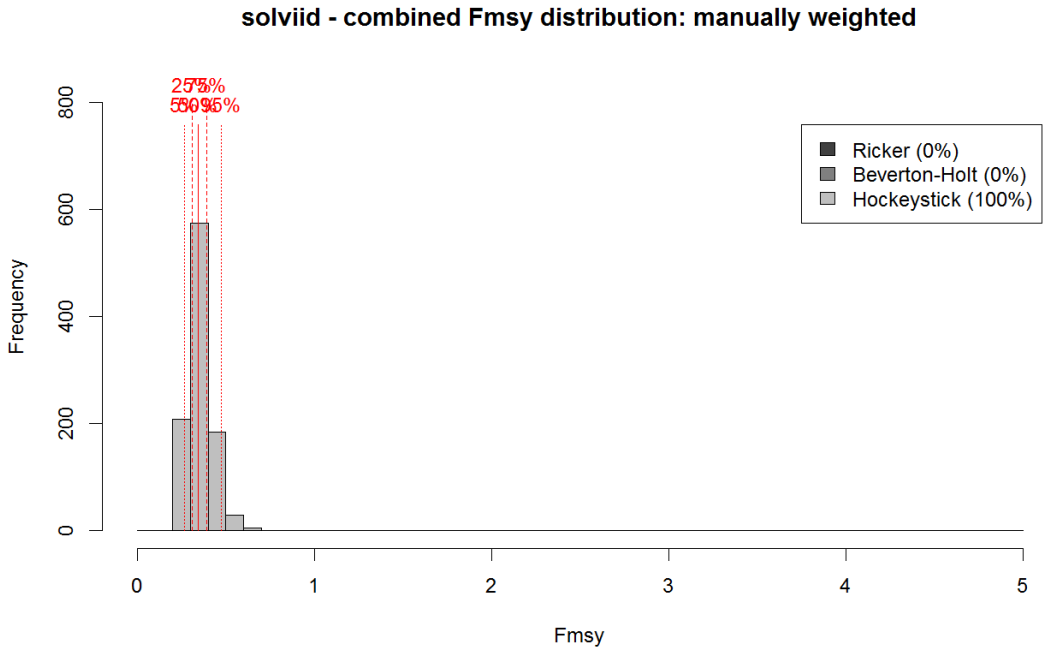


Figure 9.8.4 - Sole in VIId – PLotMSY - 4



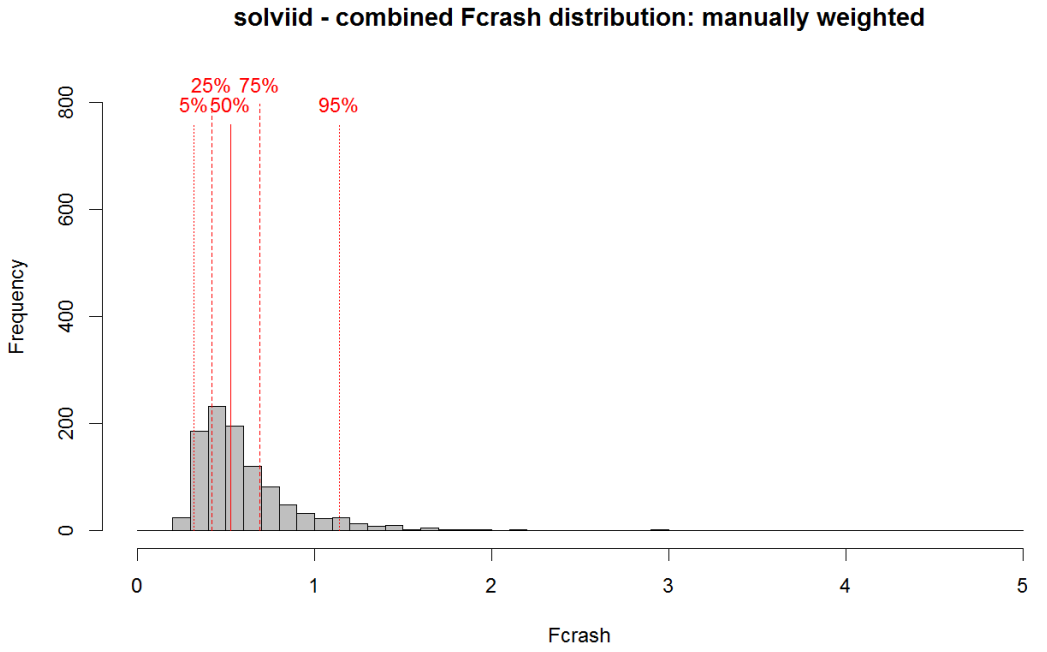


Figure 9.8.5 - Sole in VIId – PLotMSY - 5

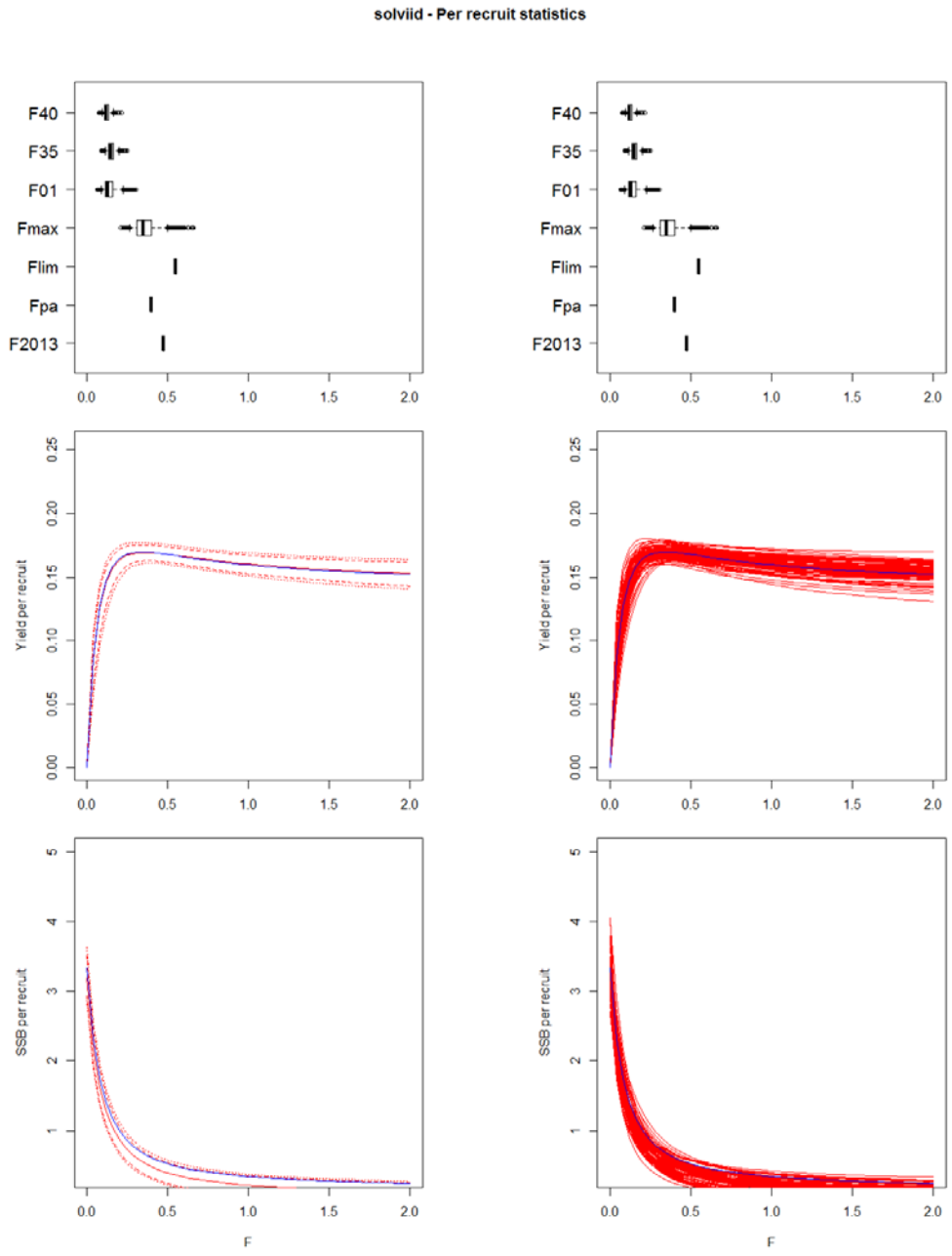
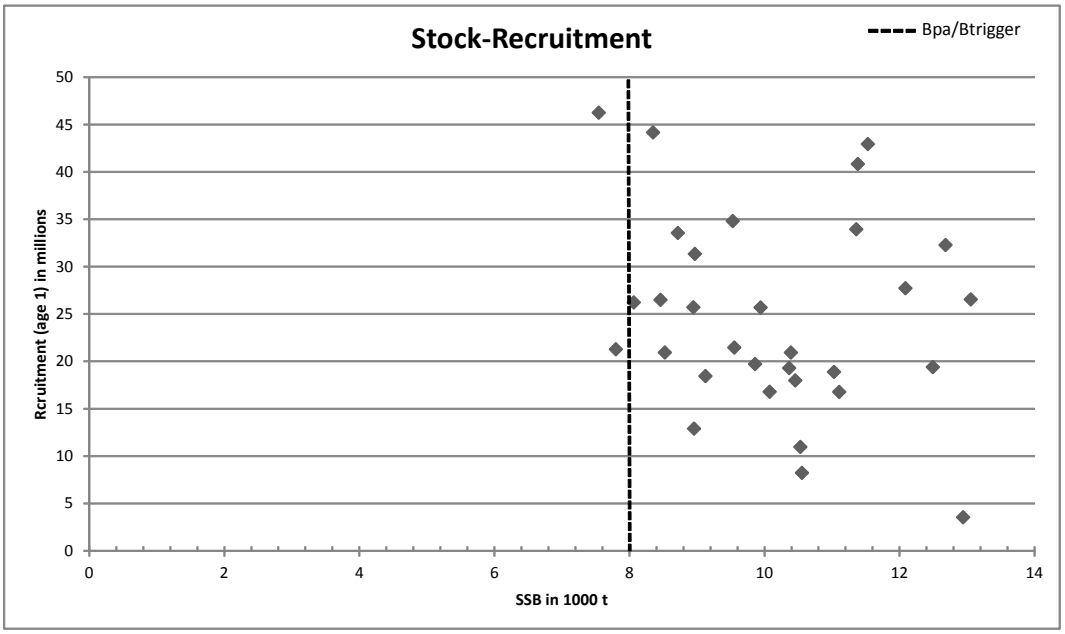


Figure 9.8.6 - Sole in VIId – PLotMSY - 6

Figure 9.9.1 - Sole VIId - Stock/recruiment plot



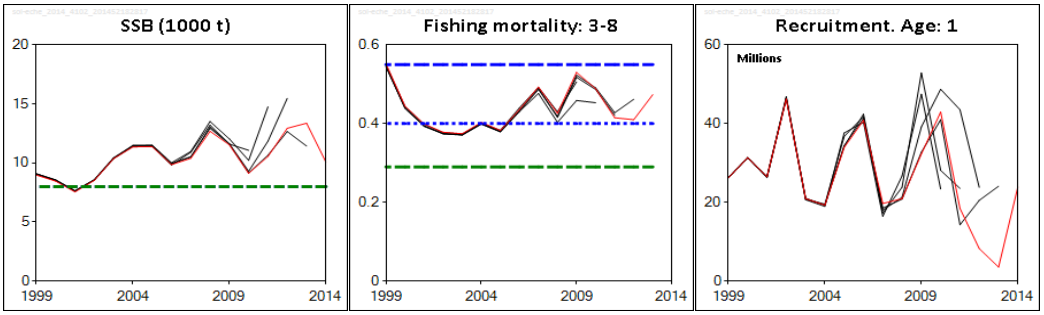


Figure 9.9.2 - Sole VIId – Historical performance

10 Sole in Subarea IV

The assessment of sole in Subarea IV is presented as an update assessment. The most recent benchmark assessment was carried out in early 2010 (ICES WKFLAT 2010). More details can be found in the Stock Annex.

10.1 General

10.1.1 Ecosystem aspects

See Stock Annex.

10.1.2 Fisheries

Soles are caught in the North Sea with a variety of gears. However, the majority of the catch (around 80%) is taken by beam trawlers in the metier TBB_DEF_70-99 mixed with other flatfish and roundfish species. Due to measures resulting from a multiannual management plan for flatfish, actions taken to reduce bycatch and disturbing the sea bottom, and economic incentives (reduce fuel costs), the beam trawl fleet shows developments into new fishing methods. In the most recent years, beam trawl methods using pulse stimulation instead of tickler chains have developed fast. Also alternatives for the beam itself, such as a fly wings have been introduced. The catch composition with these "new gears" is different from the traditional beam trawl. However, in the logbooks, fishing operations using the new gear cannot be distinguished from traditional beam trawling. Also, a gradual switch of beam trawlers towards other fishing methods can be observed in recent years, such as twin trawling, fly shouting, seine and shrimping. Overall, effort in the major sole fishery has reduced considerable in the past 15 years (Figure 10.1.1). More information is available on the North Sea sole fishery in the Stock Annex.

10.1.3 ICES Advice for 2014

The information in this section is taken from section 6.4.27 in the Advice summary sheet 2013.

Advice for 2014

ICES notes that SSB has fluctuated around the precautionary reference points for the last decade and is estimated to be well above B_{pa} in 2013. Fishing mortality has shown a declining trend since 1995 and is estimated to be close to F_{msy} in 2012.

ICES advises on the basis of the EU management plan (Council Regulation No. 676/2007) that landings in 2014 should be no more than 11 900 tonnes. Discards are known to take place but cannot be quantified, therefore total catches cannot be calculated.

Management plan

There is a two-stage management plan for North Sea sole and plaice (Council Regulation (EC) No. 676/2007, see Annex 6.4.27). An evaluation of the plan (ICES, 2010) concluded that the management plan is precautionary. The stocks are presently in stage two of the plan. However, implementation of this second stage (as stipulated in article 5 of the EC regulation) is not yet defined.

Following the EU multiannual plan stage one in 2014 would imply a 10% reduction of F to 0.21, which results in a TAC (landings) reduction of more than 15%. Therefore, the maximum TAC reduction of 15% is applied, resulting in landings of no more than 11 900 t in 2014. This is expected to lead to an SSB of 46 070 t in 2015. The TAC in 2014 was set at 11 900 t in accordance of the stage one procedures of stage 1 in the management plan.

Mixed fishery advice:

The information in this section is taken from the North Sea Advice overview section 6.3 in the ICES Advisory report 2008. The information has not been updated in 2009 - 2014.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a by-catch. The exploitation of sole and plaice are closely connected as they are caught together in fisheries mainly targeting sole, which are more valuable. This means that the minimum mesh size is decided on the basis of the more valuable species (sole), resulting in substantial discards of undersized plaice. The mixed fisheries for flatfish are dominated by a mixed beam trawl fishery using 80 mm mesh in the southern North Sea where up to 80% in number of all plaice caught are being discarded. Additionally, a shift in the age and size at maturation of plaice has been observed (Grift *et al.*, 2004): plaice become mature at younger ages and at smaller sizes in recent years than in the past. There is a risk that this is caused by a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This shift in maturation also leads to mature fish being of a smaller size-at-age. Measures to reduce discarding in the mixed beam trawl fishery would greatly benefit the plaice stock and future yields. In order to improve the selection pattern, mesh size increases or configuration changes (i.e. square mesh) would help reduce the discards. However, this would result in a short-term loss of marketable sole. Readjustment of minimum landing sizes corresponding to an improved selection pattern could be considered.

Improvements to gear selectivity, which would contribute to a reduction in catches of small fish, must take into account the effect on the other species within the mixed fishery. For instance, mesh enlargement in the flatfish fishery would reduce the catch of undersized plaice, but would also result in loss of marketable sole.

10.2 Management

A multiannual plan for plaice and sole in the North Sea was adopted by the EU Council in 2007 (EC regulation 676/2007) describing two stages; of which the first stage should be deemed a recovery plan and its second stage a management plan. The plan was implemented in 2007. ICES has evaluated the plan and found it to be in agreement with the precautionary approach (ICES, 2010).

Several amendments to the plan have been proposed, such as a change in the target fishing mortality for sole from 0.20 to 0.25 and ceasing reductions of the maximum allowable effort. ICES evaluated the proposed amendments and concluded that they do not affect the plan's consistency with the PA and the principle of MSY. In line with

the ICES advice, reductions in maximum allowable effort have been ceased since 2013 and were maintained at the 2012 level. The proposed change on a target fishing mortality for sole was not implemented.

10.2.1 Catch

Annual landings data by country and TACs are presented in Table 10.3.1. In recent years, the TACs have not been taken. The TAC of 14 000 t in 2013 was not taken compared to the landings reported to ICES of 13 291 t.

Discards are not used in the present assessments. The discards percentages estimated in the main fishery for sole, the Dutch beam trawl fishery, vary between 4–20% by weight (Table 10.3.2). The variability in discards is mainly related to variability in recruitment. No significant trends in discard percentages were observed. New information on discarding in the Belgian beam trawl fleet (Table 10.3.3) shows comparable rates and variability as in the Dutch fleet. Part of the observed variability may also be due to the sampling rate.

Recently new information on discards was compiled for the purpose of managing the future introduction of the landing obligation. Preliminary estimates of available discard information by country are presented in Table 10.3.4. This information was extracted from a draft of the Discard Atlas for the North Sea fisheries.

Inclusion of a stable time series of discards in exploratory assessments carried out in the past, had a minor effect on the relative trends in stock indicators (Kraak *et a*l 2002; Van Keeken *et al* 2003). In addition, gaps in times series of the discard sampling programs result in incomplete time series of discard estimates. The inclusion of discards in the assessment of this stock will be considered further in future benchmarks, one of which is planned in 2015.

10.2.2 Age compositions

The age composition of the landings is presented in Table 10.3.5. Until 2013, the age compositions were combined separately by sex on a quarterly basis and then raised to the annual international total. In 2013 and 2014, the age compositions were derived from InterCatch. For metiers where no age was available, age compositions from related metiers were allocated. The age composition of the landings in 2013 were dominated by two year classes (2009 and 2010) which comprised about 76% in numbers or 37% in weight to the total catch.

Log catch ratios and catch curves for sole ages 2 to 9 are summarised in Figures 10.3.1 A and B (1957 to 2013).

InterCatch

Since 2012, InterCatch was used for raising the landings. The comparison with the 'so far used' tools could not be made because the data were not available in the old format. In addition, the raising by InterCatch is done at the metier level while previously, national age compositions were provided. Therefore the raising from InterCatch is not expected to result in exactly the same values as the raising as it was done before. Moreover, for sole, ~80% of the landings come from the Netherlands, for which the age distribution is known. Age distributions were provided by Denmark, Germany, France, UK, and Netherlands, accounting for 88% of the 2013 landings (Figure 10.3.2) Therefore, the use of InterCatch is expected not to result in major differences from the 'so far used' tools. Figure 10.3.3 shows the metiers for which age compositions have been provided. It is noted that in 2013 and 2014, where metier allocation has been applied, the SOP correction in both years was 1.05 which is relatively high compared to previous years.

Discards estimates for 2013 were available for most countries, but not fully (or timely) uploaded in InterCatch.

The approach of borrowing age compositions from sampled metiers for unsampled metiers gives more weight to the small sampled metiers in the total age composition, compared to the procedure applied to the historical time series before the use of InterCatch. Although the new procedure seems to be more realistic, biological sampling of small metiers is, in general, less intense and of lower quality. The higher weight given to the sampled small metiers through the raising procedure in the international age composition may have contributed to an increase in the SOP discrepancy. It is recommended to investigate the effect of the applied raising procedures to the SOP in the upcoming benchmark.

Table of Use and Acceptance of InterCatch

Stock code for each stock of the expert group	InterCatch used as the: 'Only tool' 'In parallel with another tool' 'Partly used' 'Not used'	If InterCatch has not been used what is the reason? Is there a reason why InterCatch cannot be used? Please specify it shortly. For a more detailed description please write it in the 'The use of InterCatch' section.	Discrepancy between output from InterCatch and the so far used tool: Non or insignificant Small and acceptable significant and not acceptable Comparison not made	Acceptance test. InterCatch has been fully tested with at full data set, and the discrepancy between the output from InterCatch and the so far used system is acceptable. Therefore InterCatch can be used in the future.
Sol-nsea (sole in area IV)	Only tool		Comparison not made	The 'so far used' tool was not used this year, so no direct comparison was made.

Estimates of numbers-at-age and weights-at-age in the landings by quarter from InterCatch are given in Table 10.3.6.

10.2.3 Weight at age

Weights at age in the landings for both sexes combined (Table 10.3.7) are measured weights from the various national market sampling programs. Weights at age in the stock (Table 10.3.8) are the average weights from the 2nd Quarter landings. Large trends can be observed in the time series. Weights were higher between the mid 1970s and mid 1980s (Figure 10.3.4c & d) for the younger age groups compared to time periods before and after. Estimates of weights for the older ages fluctuate more because of smaller samples sizes due to decreasing numbers of older fish in the stock and hence landings. Weight at age in recent years are amongst the lowest in the time series.

10.2.4 Maturity and natural mortality

As in previous North Sea sole assessments, a knife-edged maturity-ogive was used, assuming full maturation at age 3.

Natural mortality in the period 1957–2013 has been assumed constant over all ages at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962–1963) (ICES-FWG 1979). The estimate of 0.9 was based on an analysis of cpue in the fisheries before and after the severe winter (CM 1979/G:10). The winters of 2009-2010, 2010-2011 and 2012-2013 have also been particularly cold and WKFLAT suggested that their potential influence on the sole stock should be carefully considered in the future although no time and data was available during WGNSSK 2011-2014 meetings. In April 2013, dead sole with skin injuries were reported by fisherman, pointing to mortality most likely caused by prolonged exposure to cold temperatures. This mortality could not be quantified.

10.2.5 Catch, effort and research vessel data

One commercial and two survey series were used to tune the assessment. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days and was revised in 2009 due to a database change. Since 1998, effort in this fleet has steadily declined with almost 70% (Table 10.3.9 and Figure 10.1.1). Because of changes in the fishery and introduction of different gears in this fleet, only data from 1997 onwards are used in the assessment. The commercial tuning fleet will be subject to revision in the upcoming benchmark in 2015.

The BTS (Beam Trawl Survey) has been carried out by the Netherlands since 1985 in the southern and south-eastern North Sea in August and September using an 8m beam trawl. From 1996 onwards, the western part of the North Sea has been also covered, but with a different vessel. The western survey is mainly directed to plaice and is not used in the sole assessment. The SNS (Sole Net Survey) is a coastal survey along the Dutch, German and Danish coast with a 6m beam trawl, carried out in the 3rd quarter. In 2003, the SNS survey was carried out during the 2nd quarter (Table 10.3.9). In 2012, the SNS was carried out with the large RV "Tridens", replacing the small RV "Isis" because of technical problems with the latter. Also, the survey in 2012 was carried out 2 weeks later than usual. Catches of sole in the 2012 survey were extremely low and contradicted with the BTS, indicating problems with operating the gear properly on board of the vessel. In the assessment, the data from the SNS survey for the years 2003 and 2012 were not used, contrary to last year's assessment.

A comparison of the available indices is given in Figure 10.3.5. The internal consistency of the year class cohorts in the surveys is presented in Figures 10.3.6, 10.3.7 and 10.3.8.

10.3 Data analyses

10.3.1 Exploratory catch-at-age based analysis

This is an update assessment with, in principle, only a update of historical data and addition of the commercial and survey data in the most recent year. Exploratory runs were therefore limited and mostly produced before the meeting of the WG with the Lowestoft VPA suite, as well the FLR package. The settings, defined in the previous benchmark by WKFLAT (2010), were applied in all runs. Small differences in results appeared between the Lowestoft suite and the FLR package. These could be contributed to different procedures in the models for SOP correction. FLR applies an a priori correction to the catch data before analyses of the data. The SOP correction in the Lowestoft suite is done after the analyses. Applying SOP correction to the data before running the Lowestoft suite gave exactly the same output as FLR. Therefore it was decided to continue with FLR.

The results of the assessment in historical as well as in recent years were almost identical to last year's assessment, indicating that the assessment is very consistent. Also, the retrospective pattern is very low. Therefore, no further exploratory analyses was carried out and the update, following the benchmark procedures exactly, was adopted as the basis for the advise.

10.3.2 Exploratory single fleet analyses

No exploratory analyses was carried out with single fleets. Such analyses was not considered to be part of an update assessment.

10.3.3 Final assessment

Catch at age analysis was carried out with XSA using the settings given below.

Year	2011	2012	2013	2014
Catch at age	Landings	Landings	Landings	Landings
Fleets	BTS-Isis 1985–2010 SNS 1970–2010 Nl-BT 1990–2010	BTS-Isis 1985–2011 SNS 1970–2011 Nl-BT 1997–2011	BTS-Isis 1985–2012 SNS 1970–2012 Nl-BT 1997–2012	BTS-Isis 1985–2013 SNS 1970–2013 Nl-BT 1997–2013
Plus group	10	10	10	10
First tuning year	1970	1970	1970	1970
Last data year	2010	2011	2012	2013
Time series weights	No taper	No taper	No taper	No taper
Catchability dependent on stock size for age <	2	2	2	2
Catchability independent of ages for ages >=	7	7	7	7
Survivor estimates shrunk towards the mean F	5 years / 5 ages	5 years / 5 ages	5 years / 5 ages	5 years / 5 ages

s.e. of the mean for shrinkage	2.0	2.0	2.0	2.0
Minimum standard error for population estimates	0.3	0.3	0.3	0.3
Prior weighting	Not applied	Not applied	Not applied	Not applied

The full diagnostics are presented in Table 10.4.1. The XSA model converged after 29 iterations. Figure 10.4.1. shows the log catchability residuals for the tuning fleets in the final run. Fishing mortality and stock numbers per age group are shown in Tables 10.4.2 and 10.4.3 respectively. The SSB in 2013 was estimated at about 48 900 t, which is the highest SSB since 1995. Mean F(2–6) has decreased steadily in recent years and was estimated at 0.23. This is the lowest fishing mortally since 1962. Recruitment of year classes 2009 and 2010 were at or above the long term average and mostly contributing to the increase in SSB. Recruitment of the 2011 and 2012 year classes were estimated to be low (less than 50% average recruitment).

10.3.4 Retrospective analyses and comparison with last years assessment

Retrospective analysis is presented in Figure 10.4.2. There are almost no retrospective patterns suggesting that estimations of mean F, recruitment and SSB were relatively unbiased. Since no changes have been made to data in previous years and in the configuration of the assessment, the comparison with pervious assessments is identical with the retrospective analyses.

	WGNSSK 2013	WGNSSK 2014	% difference
SSB(2013)	50 546	48 873	-3 %
F(2012)	0.238	0.248	+4%

10.4 Historical Stock Trends

Table 10.5.1 and Figure 10.5.1 present the trends in landings, mean F(2–6), recruitment and SSB over the period 1957-2013.

Landings over this period have fluctuated considerable. Peeks of high landings are associated with the occasional occurrence of very strong year classes. The decline in the landings in the past 10 years is related to a reduction of fishing mortality in combination with the absence of very strong year classes.

Fishing mortality increased sharp in the sixties, mainly because of the introduction of the beam trawl fishery. Since 2000, fishing mortality has decreased sharp mainly because of measures associated with the introduction of a Management Plan. In recent years, fishing mortality was estimated to be around Fmsy.

Recruitment is very variable. All very strong year classes have been produced after a cold winters, suggesting that environmental factors play an role in recruitment success. The pattern of recruitment variation in the past 25 years differs from the preceding period. In the past 25 years, year classes of above average strength appear to occur more frequently than in the preceding period.

Historically, periods with high SSB were associated with the occurrence by very strong year classes that dominated in the SSB for a few years. The increase in SSB in recent years is mainly related to a reduction of fishing mortality.

10.5 Recruitment estimates

Recruitment estimation was carried out using RCT3. Input to the RCT3 model is presented in Table 10.6.1. Results are presented in Table 10.6.2 for age 1 and Table 10.6.3 for age 2. Average recruitment of 1-year old fish in the period 1957–2011 was around 94 million (geometric mean) or 124 million (arithmetic mean).

The estimates of the 2012 year class by XSA and RCT3 are both 54 million 2-year olds. The RCT estimate is based on the same data as the XSA. Last year, the WG stated that it was undesirable to use the same data twice and therefore accepted the XSA estimate. Therefore, the XSA estimate was used in the forecast. The year class is estimated to be weak, at about 65% of GM recruitment

For the 2013 year class, the value predicted by the RCT3 was 147 million 1-year olds. This is considerably higher than the geometric mean (Table 10.6.2). The estimate was based on the DFS 0-group survey carried out by Netherlands and Germany. The index of this survey was amongst the highest in the past 25 years, in the German as well as the Dutch survey area. The year class estimate from the combined index (which is not used in the XSA, had a low standard error (0.59). Therefore, like last year, the RCT3 estimate was accepted for the short-term forecasts.

The results are summarized in the table below and the estimates used for the short-term forecast are underlined.

Year Class	Age in 2014	XSA thousands	RCT3 thousands	GM(1957-2011) thousands
2012	2	54 268	54 228	82 889
2013	1		147 276	94 491
2014	Recruit			94 491

Additional recruitment information will be available from the 3rd quarter surveys carried out in 2014. ICES will only issue an updated advice if these surveys provide a very different perspective on the short-term developments.

10.6 Short-term forecasts

The short-term forecasts were carried out with FLR (FLCore 2.3, R 2.13.2). The exploitation pattern (F) was taken to be the mean value of the last three years. Weight-at-age in the stock and weight-at-age in the catch were taken to be the mean of the last three years. Population numbers at ages 2 and older are XSA survivor estimates. Numbers at age 1 are taken from the RCT3 analysis and recruitment of the 2014 and later year-classes are taken from the long-term geometric mean (1957–2010: 94 million). Input to the short term forecast is presented in Table 10.7.1.

The short term forecast is presented in Table 10.7.2 and Figure 10.7.1. For 2014, it was assumed that F2014 = F2013 = 0.232. The expected landings in 2014 of 11 700 t are close to the agreed TAC of 11 900 t. The expected landings in 2014 are assuming that the TAC will not be fully taken. This corresponds with the observations in recent years (Table 10.3.1)

The present F estimated by the assessment is 0.232. The target F in stage 1 of the management plan is 0.200. The management plan dictates that, if present F is higher than the target F, fishing mortality should be reduced by 10%. However, if this leads to a reduction of more than 15% of the present TAC, the maximum reduction applied will be 15%.

The option, following stage 1 of the management plan results in a TAC in 2015 of 10 500 t. This implies a reduction of 12% compared to the TAC in 2014. The expected remaining SSB in 2016 is 54 300 t.

Fishing at Fmsy in 2015 results in a TAC of 11 000 t. This implies a reduction of 8% compared to the TAC in 2014. The expected remaining SSB in 2016 is 53 800 t.

The detailed table for the forecast is given in Table 10.7.3 assuming *status quo* F in all years. A number of alternative forecasts are available at the SharePoint.

Figure 10.7.2 shows the projected contribution of different year classes to the estimates of the landings in 2015 and of the SSB in 2016, when fishing at Fsq. The figure shows that almost all estimated landings in 2015 and remaining SSB is based on information from the XSA and the recruit-surveys. Only for year classes 2014 and 2015 the assumption of GM recruitment have been made, but these do not affect the projections.

10.7 Medium-term forecasts

No medium term projections were done this year.

10.8 Biological reference points

	Type	Value	Technical basis
MSY Approach	MSY Btrigger	35 000 t	Default to value of Bpa
	FMSY	0.22	Median of stochastic MSY analysis assuming Ricker Stock-Recruit relationship (range 0.2-0.25 is considered to result in maximum yield with low risk to the stock).
Precautionary Approach	Blim	25 000 t	Bloss
	Bpa	35 000 t	Bpa1.4*Blim
	Flim	Not defined	
	Fpa	0.4	Fpa = 0.4 implies Beq > Bpa and P(SSBMT <Bpa) < 10%

Yield per Recruit reference points

Yield per Recruit reference points have been re-estimated with the routine ICES standard graphing software. The results are presented in Table 10.8.1.

Precautionary reference points

The current reference points are $\mathbf{B_{lim}}$= $\mathbf{B_{loss}}$= 25 000 t and $\mathbf{B_{pa}}$ is set at 35 000 t using the default multiplier of 1.4. $\mathbf{F_{pa}}$ was proposed to be set at 0.4 which is the 5th percentile of $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.4 is consistent with an SSB of around 35 000 t. In the MSY approach F_{MSY} was estimated to be 0.22 using a Ricker stock recruitment relationship.

***F*$_{MSY}$ reference points**

In 2010, IMARES provided a thorough simulation Management Strategy Evaluation (MSE) of the EU management plan for sole and plaice in the North Sea (Council Regulation (EC) No 676/2007). This evaluation (Miller and Poos 2010) was approved by ICES as providing high long term yields while posing low risks of the stocks falling out of safe biological limits. This was followed by an STECF evaluation of the same plan (Simmonds et al. 2010) where again the plan was found to be precautionary while providing high long term yields. The report also included an additional equilibrium analysis approach to determining FMSY, taking into account uncertainty in stock recruitment relationships.

On the basis of these analyses the working group has concluded that F=0.22 is an appropriate value for F_{MSY} for North Sea sole as it results in a high long term yield, with low risk to the stock. In addition, it seems that any F value on the range 0.2-0.25 produces high yields while maintaining low risk to the stock. Therefore it is recommended that while MSY framework advice should be provided on the basis of F_{MSY}=0.22, the stock should be considered to be sustainably fished (e.g. in stock status tables) for any F on the range 0.2-0.25. This range also includes the management plan target value.

New exploration of F_{MSY} reference points

WGNNSK was requested to re-estimate the MSY reference points using the software packages plotMSY and EQsim. Due to the heavy workload of WGNSSK, limited time was available to interpret the results and rerun analyses. Therefore only the results of standard runs are presented with some comments.

Estimates of Fmsy are very sensitive to the assumptions made in the stock recruitment model used in the calculations. Three different assumptions on stock recruit relationships were explored: Ricker, Beverton & Holt and a smoothed hockey stick model (Figure 10.8.2). The Beverton & Holt recruit curve is flat and assumes average recruitment at low biomasses for which no observations are available. The assumptions made by this S/R model would therefore not likely to be precautionary. The Ricker curve is more dome shaped and assumes that recruitment will drop at high biomasses (density dependent effect). However there is few data in the S/R plot which support this.

The results of the plotMSY are presented in Table 10.8.2, but it is difficult to draw conclusive results from them. Both, the deterministic and stochastic estimates of Fmsy given by the three S/R models are different. For the Ricker and hockey stick S/Rs, the deterministic and stochastic estimates are similar, but this is not the case for the Beverton & Holt run.

Minimum conditions for Fmsy are that fishing at MSY should have a low probability of fishing at F_{crash}. Further there should be a low probability that fishing at F_{msy} brings the stock below B_{lim} (<5%). The estimates of F_{msy} for Ricker (0.32) and Beverton & Holt (0.23) have a low probability at being below F_{crash}. However, F_{crash} is estimated unrealistically high for these S/R models. For the hockey stick model, the F_{msy} (0.46) is estimated close to Fcrash (0.58) and would therefore not be satisfactory.

Table 10.8.3 compares the results of plotMSY with a similar exercise carried out by WGNSSK in 2010. The deterministic Fmsy are estimated to be similar as in 2010. The stochastic estimates, however, are estimated considerably higher in 2014. Without further exploration it is not possible to conclude whether this is a true change or a change in the method itself. The magnitude of the changes seem large given that there has been no significant change in weights and selectivity in the last four years.

Table 10.8.3 also provides an average estimate of F_{msy} (0.33) applying automatically calculated weights to the results of the three S/R model results. However, the approach

of averaging the results from different options is questionable when individual runs contain results which are unrealistic.

The Eqsim software also allows exploration of Fmsy for the same S/R assumptions. The runs with the individual S/R have not been carried out by WGNSSK because of lack of time. However, the estimates of the average results of the runs for the three models were available (Table 10.8.4). The same comments apply to the combined results as made for the plotMSY combined model. F_{msy} is estimated at 0.38, which is associated with a 5% probability of SSB<B_{lim}.

In summary, the estimated median stochastic estimates of F_{msy} by the different models explored this year, range between 0.23 and 0.46 and the estimated deterministic values between 0.32 and 0.50. An evaluation with respect to the F_{crash} objective is problematic because F_{crash} is often estimated to be unrealistically high. This puts also doubts on the F_{MSY} estimates.

Figure 10.8.4 shows that the probability that SSB<B_{lim} is less that 5% for fishing mortalities below F= 0.38 (Figure 10.8.3 and 10.8.4). Therefore F=0.38 should be considered to be maximum candidate estimate of F_{msy}. A candidate for a minimum estimate F_{msy} could be derived from $F_{0.1}$. The present estimate of $F_{0.1}$ is 0.12. The current estimate of F_{MSY} used by ICES is low in relation to estimates from these exploratory analyses.

10.9 Quality of the assessment

The assessment may be biased because it uses a commercial cpue for tuning, which is affected by changes in the fishing gears applied over time. However, this year's assessment of North Sea sole was carried out as an update assessment based on the benchmark analyses performed in early 2010. Retrospective patterns from previous years are very low and suggest that F, SSB and recruitment have been consistent estimated (Figure 10.10.1). Compared to last year, SSB in 2013 was overestimated by 3% and F in 2012 was underestimated by 4%.

10.10 Status of the Stock

Fishing mortality was estimated at 0.23 in 2013 which is well below F_{pa} (0.4) and close to F_{msy} (0.22). The SSB in 2014 was estimated at about 47 000t which is well above both B_{lim} and B_{pa}. The present SSB is dominated by the average year classes 2009 and 2010. Year classes 2011 and 2012 appear to be weak. 0-group surveys indicate that year class 2013 may be above average.

10.11 Management Considerations

The long term management plan for plaice and sole in the North Sea specifies two distinct phases. The objective of stage one of the flatfish management plan was to bring both sole and plaice stocks within safe biological limits. This objective has been achieved for both stocks. The plaice stock is estimated above Bpa since 2005 and the sole stock is above Bpa since 2012. Also fishing mortalities are well below Fpa for both stocks for a number of years.

The management plan foresees a re-evaluation of the biological objectives and introduction of economic and social objectives after stage 1 is completed. The management plan states that when the stocks of plaice and sole have been found for two years in succession to have returned to within safe biological limits, the Council shall decide on the basis of a proposal from the Commission on the amendment of Articles 4(2) and 4(3) and the amendment of Articles 7, 8 and 9 that will, in the light of the latest scientific

advice from the STECF, permit the exploitation of the stocks at a fishing mortality rate compatible with maximum sustainable yield.

The management plan is in stage 2 now and action should be taken to specify the implementation in this stage. The multiannual plan states that, in its second stage, it shall ensure the exploitation of the stocks of plaice and sole on the basis of maximum sustainable yield.

An overall objective of the CFP is to aim exploitation of all fish stocks at Fmsy. The fishing mortality for both plaice and sole in 2013 have been estimated very close to Fmsy. Therefore the object of fishing at Fmsy in 2015 can be achieved both for plaice and sole. The ICES advice for sole in 2015 is based on exploitation at Fmsy.

The majority of the sole catches are taken by beam trawlers in a mixed fishery with other flatfish and roundfish species. In general bycatches and discards of other species in beam trawls are rather high. Also beam trawls are considered to have a undesirable impact on the bottom fauna. Due to measures resulting from the flatfish management plan, actions taken to reduce bycatch, disturbance to the sea bottom, and economic incentives (reduce fuel costs), overall effort in the beam fishery has been reduced in the past 15 years by 65%. The significant reduction of effort in the fleet must have contributed to reduce the impact of this fishery on the marine ecosystem.

Table 10.3.1 Sole in Sub-Area IV: Nominal landings and landings as estimated by the Working Group (tonnes).

Year	BE	DK	FR	GE	NL.	UK	Other	Total	Unallocated	ICES	TAC
						(E/W/NI)		reported	landings	Total	
1982	1900	524	686	266	17686	403	2	21467	112	21579	21000
1983	1740	730	332	619	16101	435		19957	4970	24927	20000
1984	1771	818	400	1034	14330	586	1	18940	7899	26839	20000
1985	2390	692	875	303	14897	774	3	19934	4314	24248	22000
1986	1833	443	296	155	9558	647	2	12934	5266	18200	20000
1987	1644	342	318	210	10635	676	4	13829	3539	17368	14000
1988	1199	616	487	452	9841	740	28	13363	8227	21590	14000
1989	1596	1020	312	864	9620	1033	50	14495	7311	21806	14000
1990	2389	1427	352	2296	18202	1614	263	26543	8577	35120	25000
1991	2977	1307	465	2107	18758	1723	271	27608	5905	33513	27000
1992	2058	1359	548	1880	18601	1281	277	26004	3337	29341	25000
1993	2783	1661	490	1379	22015	1149	298	29775	1716	31491	32000
1994	2935	1804	499	1744	22874	1137	298	31291	1711	33002	32000
1995	2624	1673	640	1564	20927	1040	312	28780	1687	30467	28000
1996	2555	1018	535	670	15344	848	229	21199	1452	22651	23000
1997	1519	689	99	510	10241	479	204	13741	1160	14901	18000
1998	1844	520	510	782	15198	549	339	19742	1126	20868	19100
1999	1919	828		1458	16283	645	501	21634	1841	23475	22000
2000	1806	1069	362	1280	15273	600	539	20929	1603	22532	22000
2001	1874	772	411	958	13345	597	394	18351	1593	19944	19000
2002	1437	644	266	759	12120	451	292	15969	976	16945	16000
2003	1605	703	728	749	12469	521	363	17138	782	17920	15850

2004	1477	808	655	949	12860	535	544	17828	-681	17147	17000
2005	1374	831	676	756	10917	667	357	15578	777	16355	18600
2006	980	585	648	475	8299	910		11897	703	12600	17670
2007	955	413	401	458	10365	1203	5	13800	835	14635	15000
2008	1379	507	714	513	9456	851	15	13435	710	14145	12800
2009	1353	NA	NA	555	12038	951	1	NA	NA	13952	14000
2010	1268	406	621	537	8770	526	1.38	12129	474	12603	14100
2011	857	346	539	327	8133	786	2	10990	495	11485	14100
2012	593	418	633	416	9089	599	3	11751	-141	11610	16200
2013	697	497	680	561	9987	867	0	13289	-151	13138	14000

Table 10.3.2 Sole in Sub-Area IV: Overview of landings and discards numbers and weights (kg) per hour and their percentages in the Dutch discards (metier TBB_DEF_70-99 (taken from Uhlmann et al[1]., 2013; data for 2013 are provisional and provided separately to the WG).

		SOL					
Year/		Numbers			Weight		
Period	N trips	L	D	%D	L	D	%D
1976-1979	21	116	8	6%	32	1	4%
1980-1983	24	85	24	22%	19	3	15%
1989-1990	6	286	83	22%	48	12	20%
1999	3	112	16	13%	32	2	5%
2000	12	90	25	22%	22	2	10%
2001	4	82	17	17%	17	1	6%
2002	6	126	38	23%	18	3	13%
2003	9	95	32	25%	20	3	14%
2004	8	175	69	28%	31	7	17%
2005	8	99	29	23%	20	2	11%
2006	9	64	26	29%	16	2	13%
2007	10	94	27	23%	22	2	10%
2008	10	95	16	16%	23	1	6%
2009	48	113	34	23%	25	3	11%
2010	74	132	42	24%	22	4	14%
2011	67	Nm	50	n/a	23	5	18%
2012	61	Nm	72	n/a	29	6	17%
2013	57	Nm	52	n/a	35	5	13%

Table 10.3.3 Sole in Sub-Area IV: Discard percentages (weights) estimated by observer programmes in the Belgian TBB_DEF_70-99 metier (provided to WGNSSK)

Period	N trips	%D
2004	4	5%
2005	6	10%
2006	10	11%
2007	12	15%
2008	19	14%
2009	16	15%
2010	12	13%
2011	7	24%
2012	7	23%
2013	10	26%

[1] Uhlmann, S.S., A. Coers, A.T.M. van Helmond, R.R. Nijman, R.A. Bol en K. van der Reijden. 2013. Discard sampling of Dutch bottom-trawl and seine fisheries in 2012. CVO report: 13.015

Table 10.3.4 Sole in Sub-Area IV: Overview of landings and discard estimates ('000 tonnes) by country in the years 2010-2012 (informal and preliminary data from draft Discard Atlas for the North Sea fisheries[2].

COUNTRY	2010 Landings	2010 Discards	2010 % DR	2011 Landings	2011 Discards	2011 % DR	2012 Landings	2012 Discards	2012 % DR	Avg 2010–2012 Landings	Avg 2010–2012 Discards	Avg 2010–2012 Catch	Avg 2010–2012 % DR
NLD	9,133	1,308	13%	7,960	997	11%	9,923	2,084	19%	8,639	1,463	10,102	14%
BEL	1,254	127	9%	868	191	18%	602	285	32%	908	201	1,109	18%
ENG	618	16	3%	428	5	15%	313	4	1%	453	8	461	2%
DEU	525	26	5%	329	28	8%	427	32	7%	427	28	455	6%
FRA	245	11	4%	462	2	0%	533	18	3%	413	10	424	2%

same information corrected for identified mistakes by WGNSSK in the calculation of the percentages

COUNTRY	2010 Landings	2010 Discards	2010 % DR	2011 Landings	2011 Discards	2011 % DR	2012 Landings	2012 Discards	2012 % DR	Avg 2010–2012 Landings	Avg 2010–2012 Discards	Avg 2010–2012 Catch	Avg 2010–2012 % DR
NLD	9,133	1,308	14%	7,960	997	13%	9,923	2,084	21%	8,639	1,463	10,102	14%
BEL	1,254	127	10%	868	191	22%	602	285	47%	908	201	1,109	18%
ENG	618	16	3%	428	5	1%	313	4	1%	453	8	461	2%
DEU	525	26	5%	329	28	9%	427	32	7%	427	28	455	6%
FRA	245	11	4%	462	2	0%	533	18	3%	413	10	424	2%

[2] A Discard Atlas for the North Sea fisheries: Version: 25/11/2013

Table 10.3.5 Sole in Sub-Area IV: Landings numbers at age (x1000) (corrected for SOP).

year/age	1	2	3	4	5	6	7	8	9	10
1957	0	1472	10556	13150	3913	3041	6780	1803	529	6541
1958	0	1863	8482	14240	9547	3501	3023	4461	2264	6590
1959	0	3694	12139	10499	9060	5823	1217	2044	2598	5668
1960	0	11965	14043	16691	9248	8313	4815	1583	1049	7850
1961	0	972	50470	19403	12574	4760	3998	4338	847	7354
1962	0	1584	6173	58836	15254	10478	4797	4087	2074	7449
1963	0	670	8271	8485	45823	8420	6603	2403	3365	8315
1964	53	150	2041	5518	3680	16749	3020	1749	790	2913
1965	0	45180	1045	1534	4798	2381	11990	1494	1463	3077
1966	0	12145	132170	979	1168	3649	736	6255	694	2423
1967	0	3769	26260	87039	1998	548	1962	777	5160	2978
1968	1034	17093	13852	24894	48417	461	244	1639	323	6502
1969	404	24404	21884	5433	12638	25646	338	249	1214	5378
1970	1299	6141	25996	8236	1784	3231	11961	246	140	5235
1971	425	33765	14596	12909	4538	1459	2355	7300	194	4649
1972	354	7511	36356	6997	4911	1548	517	1218	4654	2770
1973	716	12459	13025	16493	4101	2368	1013	779	1241	5900
1974	100	15171	21248	5412	6965	1896	1563	649	396	4749
1975	267	23193	28833	11839	2110	3870	798	916	513	3481
1976	1064	3619	28571	14316	4923	987	1950	562	434	2721
1977	1780	22747	12299	15593	7580	1812	325	1133	261	2155
1978	27	24921	29163	6102	6610	4231	1730	608	643	1595
1979	9	8280	41681	16259	3033	3262	1769	826	244	1546
1980	650	1233	12762	18138	7444	1479	2241	1437	374	1227
1981	434	29983	3344	7046	8439	3757	973	909	786	932
1982	2697	26799	46375	1868	3584	4855	1701	623	613	1296
1983	391	34545	41551	21273	626	1383	1958	982	388	1181
1984	192	30839	44081	22631	8821	744	857	1047	526	897
1985	163	16449	42773	20079	9307	3520	207	375	631	965
1986	372	9304	18381	17591	7698	5480	2256	109	281	1671
1987	93	28896	21927	8851	6477	3102	1559	898	81	690
1988	10	13206	47135	15217	4377	3878	1549	890	523	317
1989	115	45652	17973	22295	4551	1627	1414	637	451	461
1990	854	11816	103380	9667	9099	3315	1032	1186	548	836
1991	118	12938	24985	76580	6609	3612	1706	707	718	1071
1992	965	6730	43713	15961	37745	2440	2995	730	393	1162
1993	53	49870	16575	31047	13709	23758	1472	1170	456	832
1994	709	7710	86349	13387	18513	5642	11174	458	905	897
1995	4766	12674	16700	68073	6262	7254	1981	5971	293	663
1996	170	18609	16005	16770	26946	3814	4725	932	3267	977
1997	1574	5987	23418	7253	5058	12667	1189	2303	330	1671
1998	242	56162	15011	14806	3466	1924	4727	787	1022	839
1999	284	15601	71730	8103	6049	1200	657	1964	328	804

2000	2329	14929	32425	42394	3257	2453	796	431	922	707
2001	857	25045	20925	19260	16211	1383	808	266	163	702
2002	1046	10958	32570	12185	8145	6393	667	592	88	361
2003	1047	32295	17479	16072	5814	3902	2427	400	128	451
2004	516	14960	48003	9531	7462	2167	902	962	389	389
2005	1131	7254	22633	28875	4168	3861	1491	602	768	392
2006	7008	9966	10397	9606	10943	1617	1577	724	373	553
2007	315	39643	10820	6407	5706	5479	819	725	498	541
2008	1959	6325	37427	5996	2928	2393	2613	448	491	459
2009	1630	10417	10771	26548	3278	1652	1591	1532	312	864
2010	371	11659	13354	8530	13623	1817	907	809	1196	690
2011	44	11992	19788	8379	5070	6436	983	431	283	765
2012	0	5961	25290	10213	3878	1934	3506	562	232	743
2013	0	2532	26180	20217	5430	1930	1533	2158	238	492

Table 10.3.6 North Sea Sole. Numbers-at-age (x1000) and weights-at-age (kilograms) in the landings by quarter in 2013 (numbers from InterCatch, not corrected for SOP).

	Q1		Q2		Q3		Q4		no specification	
Age	numbers	weight	n	weight	n	weight	n	weight	n	weight
2	60.7	0.143	34.1	0.114	848.5	0.135	1696.2	0.150	25.1	0.180
3	5230.9	0.170	3868.9	0.158	9270.3	0.170	8179.7	0.182	1003.4	0.174
4	4327.2	0.231	5693.8	0.271	6251.2	0.220	4064.7	0.235	940.6	0.200
5	1222.9	0.274	1555.9	0.309	1322.0	0.261	1187.3	0.252	426.6	0.230
6	330.1	0.330	632.8	0.392	465.7	0.295	452.6	0.315	150.3	0.273
7	316.2	0.374	804.2	0.400	142.2	0.372	184.2	0.367	166.7	0.245
8	257.5	0.350	1343.4	0.375	379.6	0.328	182.8	0.327	108.0	0.301
9	10.7	0.444	137.1	0.427	35.0	0.327	37.8	0.300	29.1	0.277
10	10.4	0.601	53.9	0.622	17.7	0.588	4.4	0.682	14.5	0.300
11	5.2	0.498	88.0	0.480	31.7	0.396	6.6	0.438	31.5	0.283
12	13.6	0.506	59.7	0.523	14.6	0.637	30.9	0.479	3.5	0.596
13	0.9	0.367	20.8	0.447	2.2	0.502	1.3	0.447	1.0	0.763
14	2.7	0.614	17.3	0.614	7.4	0.508	4.3	0.463	2.9	0.468
15	0.8	0.713	31.0	0.850	2.5	0.792	1.1	0.931	1.0	0.599
16	0.8	0.340	16.0	0.434	2.5	0.480	0.7	0.394		
17	0.0	0.535	0.0	0.526	0.0	0.575	0.0	0.543		
18	0.3	0.504	5.0	0.494	0.8	0.543	0.2	0.508		
19	0.3	0.462	5.0	0.464	0.8	0.461	0.2	0.461		
20	0.0	0.396	0.1	0.469	0.1	0.504	0.7	0.348		
21	0.0	0.338	0.0	0.411	0.0	0.394	0.0	0.384		
24	0.0	0.535	0.0	0.525	0.0	0.575	0.0	0.543		
25	0.0	0.493	0.0	0.493	0.0	0.493	0.0	0.493		

Table 10.3.7 Sole in Sub-Area IV: Landing weights at age (kg).

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0	0.154	0.177	0.204	0.248	0.279	0.290	0.335	0.436	0.394	0.432	0.471	0.631	0.437	0.533
1958	0	0.145	0.178	0.220	0.254	0.273	0.314	0.323	0.388	0.401	0.409	0.502	0.287	0.578	0.577
1959	0	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.391	0.438	0.417	0.437	0.412	0.589
1960	0	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.363	0.436	0.428	0.442	0.427	0.578
1961	0	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.372	0.369	0.397	0.478	0.450	0.551
1962	0	0.155	0.165	0.208	0.241	0.295	0.320	0.321	0.334	0.349	0.347	0.394	0.435	0.373	0.476
1963	0	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.440	0.397	0.433	0.444	0.490	0.578
1964	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.444	0.439	0.475	0.403	0.447	0.644
1965	0	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.425	0.459	0.480	0.458	0.397	0.528
1966	0	0.177	0.190	0.180	0.301	0.332	0.429	0.399	0.449	0.472	0.541	0.526	0.521	0.491	0.499
1967	0	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.498	0.456	0.389	0.519	0.442	0.591
1968	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.475	0.674	0.524	0.656	0.495	0.650
1969	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.499	0.496	0.538	0.474	0.613	0.613
1970	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.511	0.512	0.541	0.456	0.542	0.542
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.420	0.490	0.534	0.425	0.489	0.466	0.578	0.563	0.583
1972	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.481	0.472	0.577	0.597	0.677	0.647
1973	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.569	0.644	0.399	0.547	0.642	0.670
1974	0.164	0.192	0.233	0.338	0.418	0.448	0.520	0.559	0.609	0.602	0.661	0.678	0.532	0.582	0.679
1975	0.129	0.182	0.225	0.320	0.406	0.456	0.529	0.595	0.629	0.560	0.648	0.683	0.620	0.645	0.678
1976	0.143	0.190	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.658	0.538	0.736	0.668	0.598	0.684
1977	0.147	0.188	0.236	0.307	0.369	0.424	0.430	0.520	0.562	0.622	0.731	0.607	0.605	0.643	0.581
1978	0.152	0.196	0.231	0.314	0.370	0.426	0.466	0.417	0.572	0.471	0.604	0.711	0.588	0.830	0.716
1979	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.657	0.728	0.774	0.806	0.839	0.815
1980	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.550	0.598	0.544	0.658	0.684	0.674	0.661	0.717
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.553	0.403	0.665	0.565	0.721	0.745
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.556	0.628	0.591	0.771	0.898	0.768
1983	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.609	0.622	0.600	0.334	0.631	0.756
1984	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.512	0.655	0.631	0.722	0.845	0.707
1985	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.634	0.509	0.656	0.767	0.801	0.680
1986	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.536	0.575	0.634	0.632	0.789	0.715
1987	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.608	0.646	0.615	0.697	0.728	0.696
1988	0.127	0.175	0.217	0.270	0.354	0.428	0.484	0.521	0.559	0.594	0.808	0.717	0.756	0.771	0.698
1989	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.470	0.512	0.683	0.630	0.737	0.649	0.754
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.602	0.661	0.522	0.583	0.510	0.637
1991	0.127	0.186	0.210	0.263	0.315	0.436	0.443	0.467	0.507	0.567	0.548	0.530	0.949	0.738	0.568
1992	0.146	0.178	0.213	0.258	0.298	0.380	0.409	0.460	0.487	0.531	0.590	0.468	0.630	0.779	0.626
1993	0.097	0.167	0.196	0.239	0.264	0.300	0.338	0.441	0.496	0.636	0.564	0.583	0.651	0.610	0.641
1994	0.143	0.180	0.202	0.228	0.257	0.300	0.317	0.432	0.409	0.415	0.544	0.478	0.702	0.614	0.554
1995	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.511	0.792	0.564	0.764	0.940	0.602
1996	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.370	0.390	0.516	0.546	0.555	0.601	0.700	0.763
1997	0.151	0.180	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.406	0.579	0.605	0.668	0.450	0.762
1998	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.397	0.504	0.433	0.649	0.541	0.735
1999	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.365	0.533	0.561	0.708	0.577	0.696

2000	0.145	0.170	0.200	0.248	0.290	0.299	0.323	0.368	0.402	0.294	0.447	0.409	0.642	1.031	0.740
2001	0.143	0.185	0.202	0.270	0.275	0.333	0.391	0.414	0.433	0.438	0.523	0.646	0.600	0.595	0.830
2002	0.140	0.183	0.211	0.243	0.281	0.312	0.366	0.319	0.571	0.413	0.556	0.456	0.606	0.356	0.797
2003	0.136	0.182	0.214	0.256	0.273	0.317	0.340	0.344	0.503	0.388	0.316	0.498	0.404	0.577	0.625
2004	0.127	0.180	0.209	0.252	0.263	0.284	0.378	0.367	0.327	0.348	0.397	0.387	0.560	0.493	0.474
2005	0.172	0.185	0.207	0.243	0.241	0.282	0.265	0.377	0.318	0.321	0.525	0.578	0.433	0.346	0.512
2006	0.156	0.190	0.220	0.263	0.291	0.322	0.293	0.358	0.397	0.464	0.251	0.450	0.637	0.814	0.359
2007	0.154	0.180	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.351	0.410	0.230	0.457	0.254	0.282
2008	0.150	0.181	0.223	0.240	0.265	0.324	0.314	0.297	0.307	0.307	0.470	0.483	0.695	0.557	0.490
2009	0.138	0.185	0.202	0.256	0.275	0.278	0.325	0.334	0.303	0.358	0.453	0.446	0.509	0.342	0.453
2010	0.163	0.181	0.220	0.236	0.273	0.308	0.283	0.311	0.361	0.423	0.319	0.307	0.474	0.691	0.395
2011	0.152	0.162	0.194	0.233	0.242	0.274	0.272	0.293	0.335	0.344	0.379	0.279	0.401	0.480	0.455
2012	0.170	0.173	0.193	0.246	0.273	0.282	0.297	0.315	0.353	0.322	0.367	0.364	0.362	0.393	0.731
2013	0.170	0.167	0.185	0.225	0.258	0.271	0.312	0.283	0.323	0.530	0.366	0.502	0.452	0.583	0.552

Table 10.3.8 Sole in Sub-Area IV: Stock weights at age (kg) .

Year/age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1957	0.025	0.070	0.147	0.187	0.208	0.253	0.262	0.355	0.390	0.359	0.602	0.370	0.587	0.689	0.254
1958	0.025	0.070	0.164	0.205	0.226	0.228	0.297	0.318	0.393	0.380	0.417	0.610	0.433	0.566	0.518
1959	0.025	0.070	0.159	0.198	0.239	0.271	0.292	0.276	0.303	0.410	0.408	0.406	0.413	0.598	0.599
1960	0.025	0.070	0.163	0.207	0.234	0.240	0.268	0.242	0.360	0.357	0.508	0.390	0.464	0.466	0.573
1961	0.025	0.070	0.148	0.206	0.235	0.232	0.259	0.274	0.281	0.302	0.379	0.335	0.482	0.433	0.548
1962	0.025	0.070	0.148	0.192	0.240	0.301	0.293	0.282	0.273	0.410	0.358	0.315	0.463	0.462	0.539
1963	0.025	0.070	0.148	0.193	0.243	0.275	0.311	0.363	0.329	0.433	0.365	0.352	0.491	0.414	0.54
1964	0.025	0.070	0.159	0.214	0.240	0.291	0.305	0.306	0.365	0.443	0.396	0.458	0.470	0.394	0.631
1965	0.025	0.140	0.198	0.223	0.251	0.297	0.337	0.358	0.526	0.424	0.464	0.456	0.418	0.339	0.504
1966	0.025	0.070	0.160	0.149	0.389	0.310	0.406	0.377	0.385	0.427	0.598	0.555	0.468	0.380	0.538
1967	0.025	0.177	0.164	0.235	0.242	0.399	0.362	0.283	0.381	0.464	0.378	0.372	0.544	0.450	0.546
1968	0.025	0.122	0.171	0.248	0.312	0.280	0.629	0.416	0.410	0.450	0.753	0.445	0.660	0.456	0.698
1969	0.025	0.137	0.174	0.252	0.324	0.364	0.579	0.415	0.469	0.524	0.504	0.564	0.534	0.515	0.551
1970	0.025	0.137	0.201	0.275	0.341	0.367	0.423	0.458	0.390	0.486	0.490	0.535	0.622	0.574	0.622
1971	0.034	0.148	0.213	0.313	0.361	0.410	0.432	0.474	0.483	0.451	0.481	0.425	0.574	0.502	0.568
1972	0.038	0.155	0.218	0.313	0.419	0.443	0.443	0.443	0.508	0.440	0.471	0.503	0.631	0.621	0.659
1973	0.039	0.149	0.226	0.322	0.371	0.433	0.452	0.472	0.446	0.489	0.621	0.466	0.548	0.624	0.642
1974	0.035	0.146	0.218	0.329	0.408	0.429	0.499	0.565	0.542	0.594	0.632	0.594	0.650	0.540	0.623
1975	0.035	0.148	0.206	0.311	0.403	0.446	0.508	0.582	0.580	0.617	0.615	0.647	0.650	0.705	0.669
1976	0.035	0.142	0.201	0.301	0.379	0.458	0.508	0.517	0.644	0.697	0.614	0.786	0.648	0.628	0.679
1977	0.035	0.147	0.202	0.291	0.365	0.409	0.478	0.487	0.531	0.617	0.661	0.656	0.628	0.632	0.665
1978	0.035	0.139	0.211	0.290	0.365	0.429	0.427	0.385	0.542	0.428	0.570	0.675	0.589	0.860	0.697
1979	0.045	0.148	0.211	0.300	0.352	0.429	0.521	0.562	0.567	0.656	0.712	0.716	0.787	0.815	0.791
1980	0.039	0.157	0.200	0.304	0.345	0.394	0.489	0.537	0.579	0.549	0.664	0.676	0.638	0.657	0.638
1981	0.050	0.137	0.200	0.305	0.364	0.402	0.454	0.522	0.561	0.520	0.409	0.713	0.533	0.822	0.720
1982	0.050	0.130	0.193	0.270	0.359	0.411	0.429	0.476	0.583	0.593	0.570	0.531	0.791	0.611	0.691
1983	0.050	0.140	0.200	0.285	0.329	0.435	0.464	0.483	0.510	0.583	0.601	0.721	0.741	0.680	0.719
1984	0.050	0.133	0.203	0.268	0.348	0.386	0.488	0.591	0.567	0.559	0.632	0.731	0.873	0.952	0.700
1985	0.050	0.127	0.185	0.267	0.324	0.381	0.380	0.626	0.554	0.589	0.517	0.734	0.740	0.642	0.673
1986	0.050	0.133	0.191	0.278	0.345	0.423	0.495	0.487	0.587	0.547	0.681	0.646	0.743	0.941	0.888
1987	0.050	0.154	0.191	0.262	0.357	0.381	0.406	0.454	0.332	0.512	0.639	0.582	0.634	0.691	0.671
1988	0.050	0.133	0.193	0.260	0.335	0.409	0.417	0.474	0.486	0.454	0.829	0.658	0.533	0.850	0.696
1989	0.050	0.133	0.195	0.290	0.350	0.340	0.411	0.475	0.419	0.463	0.705	0.788	0.723	0.620	0.736
1990	0.050	0.148	0.203	0.294	0.357	0.447	0.399	0.494	0.481	0.511	0.716	0.557	0.797	0.489	0.765
1991	0.050	0.139	0.184	0.254	0.301	0.413	0.447	0.522	0.548	0.557	0.532	0.566	0.469	1.109	0.665
1992	0.050	0.156	0.194	0.257	0.307	0.398	0.406	0.472	0.500	0.551	0.498	0.443	0.602	0.672	0.612
1993	0.050	0.128	0.184	0.229	0.265	0.293	0.344	0.482	0.437	0.576	0.564	0.504	0.681	0.579	0.670
1994	0.050	0.143	0.174	0.209	0.257	0.326	0.349	0.402	0.494	0.341	0.436	0.519	0.473	0.695	0.498
1995	0.050	0.151	0.179	0.240	0.253	0.321	0.365	0.357	0.545	0.460	0.411	0.715	0.694	0.584	0.661
1996	0.050	0.147	0.178	0.208	0.274	0.268	0.321	0.375	0.402	0.401	0.470	0.548	0.628	0.641	0.810
1997	0.050	0.150	0.190	0.225	0.252	0.303	0.319	0.325	0.360	0.385	0.581	0.635	0.715	0.717	0.654
1998	0.050	0.140	0.173	0.234	0.267	0.281	0.328	0.273	0.336	0.334	0.488	0.306	0.549	0.483	0.641
1999	0.050	0.131	0.187	0.216	0.259	0.296	0.340	0.322	0.369	0.418	0.424	0.499	0.566	0.684	0.627

2000	0.050	0.139	0.185	0.226	0.264	0.275	0.287	0.337	0.391	0.269	0.332	0.300	0.688	1.071	0.634
2001	0.050	0.144	0.185	0.223	0.263	0.319	0.327	0.421	0.410	0.502	0.396	0.600	0.604	0.568	1.016
2002	0.050	0.145	0.197	0.245	0.267	0.267	0.299	0.308	0.435	0.316	0.470	0.358	0.460	0.287	0.661
2003	0.050	0.146	0.194	0.240	0.256	0.288	0.330	0.312	0.509	0.597	0.297	0.370	0.383	0.570	0.696
2004	0.050	0.137	0.195	0.240	0.245	0.305	0.316	0.448	0.356	0.625	0.531	0.376	0.659	0.636	0.711
2005	0.050	0.150	0.189	0.234	0.237	0.258	0.276	0.396	0.369	0.295	0.464	0.631	0.691	0.468	0.565
2006	0.050	0.148	0.197	0.250	0.270	0.319	0.286	0.341	0.409	0.436	0.484	0.465	0.705	1.021	0.390
2007	0.050	0.152	0.179	0.216	0.242	0.245	0.275	0.252	0.257	0.309	0.457	0.333	0.448	0.462	0.395
2008	0.050	0.154	0.198	0.212	0.239	0.302	0.282	0.231	0.274	0.333	0.468	0.712	0.296	0.499	0.580
2009	0.050	0.142	0.185	0.232	0.255	0.279	0.283	0.333	0.302	0.415	0.335	0.371	0.399	0.247	0.391
2010	0.050	0.149	0.200	0.230	0.272	0.307	0.336	0.336	0.361	0.507	0.364	0.281	0.568	0.708	0.392
2011	0.050	0.141	0.179	0.223	0.261	0.276	0.320	0.360	0.444	0.394	0.422	0.264	0.486	0.823	0.381
2012	0.050	0.184	0.171	0.230	0.259	0.291	0.287	0.307	0.481	0.288	0.346	0.416	0.527	0.496	0.604
2013	0.030	0.108	0.161	0.210	0.262	0.263	0.319	0.244	0.337	0.587	0.384	0.516	0.442	0.634	0.543

Table 10.3.9 Sole in subarea IV: Tuning data. BTS and SNS surveys and commercial series from NL beam trawl.

BTS-ISIS

Year/age	1	2	3	4	5	6	7	8	9
1985	7.031	7.121	3.695	1.654	0.688	0.276	0.000	0.000	0.000
1986	7.168	5.183	1.596	0.987	0.623	0.171	0.158	0.000	0.018
1987	6.973	12.548	1.834	0.563	0.583	0.222	0.228	0.058	0.000
1988	83.111	12.512	2.684	1.032	0.123	0.149	0.132	0.103	0.014
1989	9.015	68.084	4.191	4.096	0.677	0.128	0.242	0.000	0.051
1990	37.839	24.487	21.789	0.778	1.081	0.770	0.120	0.115	0.025
1991	4.035	28.841	6.872	6.453	0.136	0.135	0.063	0.045	0.013
1992	81.625	22.284	10.449	2.529	3.018	0.090	0.162	0.078	0.020
1993	6.350	42.345	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	7.660	7.121	19.743	0.124	1.636	0.088	0.983	0.009	0.000
1995	28.125	8.458	6.268	5.129	0.363	0.805	0.316	0.734	0.039
1996	3.975	7.634	1.955	1.785	2.586	0.326	0.393	0.052	0.264
1997	169.343	4.919	2.985	0.739	0.710	0.380	0.096	0.035	0.042
1998	17.108	27.422	1.862	1.242	0.073	0.015	0.391	0.000	0.000
1999	11.960	18.363	15.783	0.584	1.920	0.310	0.218	0.604	0.003
2000	14.594	6.144	4.045	1.483	0.263	0.141	0.06	0.007	0.150
2001	7.998	9.963	2.156	1.564	0.684	0.074	0.037	0.028	0.000
2002	20.989	4.182	3.428	0.886	0.363	0.361	0.032	0.069	0.000
2003	10.507	9.947	2.459	1.670	0.360	0.187	0.319	0.000	0.020
2004	4.192	4.354	3.553	0.644	0.626	0.118	0.070	0.073	0.000
2005	5.534	3.395	2.377	1.303	0.167	0.171	0.077	0.047	0.000
2006	17.089	2.332	0.278	0.709	0.479	0.151	0.088	0.000	0.007
2007	7.498	19.504	1.464	0.565	0.315	0.537	0.031	0.009	0.000
2008	15.247	9.062	12.298	1.313	0.222	0.279	0.202	0.028	0.047
2009	15.95	4.999	2.858	4.791	0.252	0.124	0.272	0.079	0.000
2010	54.811	10.707	2.027	0.774	1.252	0.143	0.122	0.005	0.027
2011	26.166	17.387	4.006	1.094	0.778	0.828	0.013	0.00	0 0.141
2012	5.149	18.212	8.863	1.692	0.764	0.257	0.229	0.046	0.000
2013	6.844	3.558	12.566	5.385	0.871	0.197	0.105	0.078	0.019

SNS

year/age	1	2	3	4	year/age	1	2	3	4
1970	5410	734	238	35	1992	11114	144	360	195
1971	903	1831	113	3	1993	1291	3420	154	213
1972	1455	272	149	0	1994	652	498	934	10
1973	5587	935	84	37	1995	1362	224	143	411
1974	2348	361	65	0	1996	218	349	30	36
1975	525	865	177	18	1997	10279	154	190	27
1976	1399	74	229	27	1998	4095	3126	142	99
1977	3743	776	104	43	1999	1649	972	456	10

1978	1548	1355	294	28	2000	1639	126	166	118
1979	94	408	301	78	2001	970	655	107	36
1980	4313	89	109	61	2002	7548	379	195	0
1981	3737	1413	50	20	2003	NA	NA	NA	NA
1982	5857	1146	228	7	2004	1370	624	393	69
1983	2621	1123	121	40	2005	568	163	124	0
1984	2493	1100	318	74	2006	2726	117	25	30
1985	3619	716	167	49	2007	849	911	33	40
1986	3705	458	69	31	2008	1259	259	325	0
1987	1948	944	65	21	2009	1932	344	62	103
1988	11227	594	282	82	2010	2637	237	67	42
1989	2831	5005	208	53	2011	1248	884	211	112
1990	2856	1120	914	100	2012	227	160	54	18
1991	1254	2529	514	624	2013	967	427	491	179

Table 10.3.9 cont.

Beamtrawl LPUE NL		**age**							
year	effort	2	3	4	5	6	7	8	9
1990	71.1	9071	84630	7242	6587	1669	635	819	376
1991	68.5	7337	17182	59754	4638	2138	683	312	392
1992	71.1	5047	33881	11131	29836	1458	2081	446	219
1993	76.9	39285	10948	24132	9625	18624	887	812	236
1994	81.4	5390	69879	7412	13010	3105	8933	190	524
1995	81.2	9778	11329	53489	2839	5129	897	4682	147
1996	72.1	15843	9094	11171	21212	1570	3173	472	2774
1997	80.5	4506	18427	4504	3329	9771	497	1800	95
1998	89.2	50571	9023	11123	1826	1146	3395	211	337
1999	82.3	11821	55177	4153	4459	730	336	1527	133
2000	68.4	12309	29560	21747	2046	1580	455	322	641
2001	64.8	18724	13660	14969	13081	721	506	136	93
2002	59.1	9006	24797	7936	6034	5082	424	384	54
2003	55.7	25945	11539	12441	3395	2824	1962	225	62
2004	51.5	11190	37220	5633	5058	1190	640	542	135
2005	52.4	5060	16367	21030	3796	2001	921	289	619
2006	46.9	6792	7804	6709	8226	954	945	522	269
2007	45.1	33273	7649	4485	3658	3696	335	326	127
2008	32.5	4716	28760	3257	1864	1268	1435	198	177
2009	34	8656	7715	19140	2012	1100	937	795	62
2010	34.3	8857	10125	5210	10285	1041	677	456	743
2011	33.3	9664	15791	6072	3267	4495	481	294	132
2012	30.8	5714	23086	8037	3107	1100	3058	207	132
2013	29.0	2132	21755	15877	3992	1469	788	1238	135

shaded	invalid/not used

Table 10.4.1. Sole in sub area IV: XSA diagnostics

FLR XSA Diagnostics 2014-04-28 11:55:56

CPUE data from xsa.indices

Catch data for 57 years. 1957 to 2013. Ages 1 to 10.

fleet	first age	last age	first year	last year	alpha	beta
1 BTS-ISIS	1	9	1985	2013	0.66	0.75
2 SNS	1	4	1970	2013	0.66	0.75
3 NL Beam Trawl	2	9	1997	2013	0	1

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for ages > 1

Catchability independent of age for ages > 7

Terminal population estimation :

Survivor estimates shrunk towards the mean F

of the final 5 years or the 5 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population

estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

	year									
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

	year									
age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.012	0.025	0.038	0.006	0.032	0.019	0.002	0.000	0.000	0.000
2	0.243	0.216	0.281	0.275	0.146	0.209	0.162	0.090	0.054	0.080
3	0.553	0.618	0.481	0.494	0.401	0.352	0.399	0.399	0.249	0.314
4	0.712	0.675	0.513	0.547	0.496	0.488	0.461	0.416	0.328	0.287
5	0.617	0.696	0.517	0.579	0.458	0.491	0.441	0.486	0.307	0.259
6	0.471	0.668	0.564	0.469	0.452	0.449	0.492	0.342	0.306	0.220
7	0.412	0.611	0.561	0.552	0.379	0.545	0.422	0.478	0.282	0.377

8 0.343 0.472 0.601 0.482 0.589 0.355 0.522 0.323 0.489 0.250

9 1.263 0.448 0.534 0.984 0.622 0.962 0.459 0.308 0.257 0.350

10 1.263 0.448 0.534 0.984 0.622 0.962 0.459 0.308 0.257 0.350

XSA population number (Thousand)

age

year 1 2 3 4 5 6 7 8 9 10

2004 43913 72773 118816 19678 17047 6069 2806 3484 570 564

2005 48417 39244 51617 61847 8740 8326 3430 1681 2237 1137

2006 199018 42734 28609 25176 28495 3943 3861 1685 948 1399

2007 54267 173413 29187 15996 13643 15374 2030 1994 836 901

2008 66228 48803 119201 16117 8380 6917 8699 1058 1114 1036

2009 92485 58062 38142 72256 8880 4797 3982 5386 531 1458

2010 161746 82133 42628 24267 40127 4917 2769 2090 3416 1962

2011 131731 146001 63227 25869 13844 23350 2721 1643 1121 3022

2012 38304 119154 120700 38387 15437 7704 15005 1527 1077 3443

2013 59975 34658 102144 85157 25019 10279 5131 10242 847 1744

Estimated population abundance at 1st Jan 2014

age

year 1 2 3 4 5 6 7 8 9 10

2014 0 54268 28952 67521 57823 17474 7465 3185 7216 540

Fleet: BTS-ISIS

Log catchability residuals.

age year	1	2	3	4	5	6	7	8	9
1985	-0.225	0.045	-0.072	0.224	-0.044	0.15	0	0	0
1986	-0.709	-0.543	-0.283	-0.28	0.199	-0.404	0.294	0	-0.079
1987	-0.136	-0.254	-0.545	-0.311	0.017	0.092	0.436	0.07	0
1988	-0.129	0.531	-0.619	-0.067	-0.973	-0.43	0.146	0.172	-0.427

1989	-0.287	0.303	0.514	0.884	0.263	-0.124	0.557	0	-0.056
1990	0.145	0.736	0.121	-0.242	0.412	1.225	0.293	0.513	-0.302
1991	-0.416	0.377	0.441	-0.208	-1.06	-0.867	-0.72	-0.015	-0.644
1992	0.057	1.057	0.331	0.296	-0.239	-0.505	-0.058	0.037	-0.025
1993	-0.151	0.132	-0.785	0.616	1.551	1.32	-1.109	-0.028	0.169
1994	0.103	-0.053	0.398	-2.189	0.292	-0.901	-0.018	-1.328	0
1995	0.455	0.443	0.813	0.139	-0.248	0.496	1.231	0.225	0.905
1996	-0.159	-0.163	0.197	0.784	0.433	0.752	0.493	0.5	-0.302
1997	0.664	-0.073	0.024	0.327	0.977	-0.394	0.242	-0.948	1.592
1998	0.034	0.037	0.075	0.28	-0.988	-1.773	0.367	0	0
1999	0.078	0.429	0.638	0.007	1.759	1.431	1.552	1.521	-0.7
2000	-0.109	-0.294	0.019	-0.574	0.113	0.267	0.627	-1.042	0.788
2001	0.049	-0.174	-0.244	0.169	-0.335	-0.268	-0.405	0.795	0
2002	-0.22	-0.42	-0.083	-0.116	-0.312	0.042	-0.596	1.21	0
2003	0.004	-0.638	0.185	0.234	-0.125	0.158	0.494	0	0.763
2004	-0.047	-0.635	-0.574	-0.072	0.121	-0.394	-0.265	-0.489	0
2005	0.04	-0.285	-0.097	-0.538	-0.476	-0.2	-0.231	-0.109	0
2006	-0.382	-0.7	-1.749	-0.362	-0.73	0.35	-0.251	0	-1.398
2007	0.117	0.018	-0.099	-0.112	-0.369	0.191	-0.658	-1.926	0
2008	0.373	0.429	0.557	0.688	-0.317	0.323	-0.36	-0.081	0.408
2009	0.144	-0.295	0.203	0.477	-0.225	-0.124	0.835	-0.836	0
2010	0.408	0.086	-0.218	-0.274	-0.165	0.024	0.31	-2.532	-1.382
2011	0.149	-0.055	0.068	-0.023	0.455	0.117	-1.872	0	1.279
2012	0.165	0.169	0.11	-0.044	0.201	0.031	-0.849	-0.022	0
2013	-0.011	-0.21	0.672	0.288	-0.184	-0.585	-0.488	-1.566	-0.415

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

2 3 4 5 6 7 8 9

Mean_Logq -8.8470 -9.3832 -9.6836 -9.8283 -10.0522 -9.9725 -9.9725 -9.9725

S.E_Logq 0.4226 0.5214 0.5644 0.6487 0.6713 0.7063 0.8679 0.6464

Regression statistics

Ages with q dependent on year class strength

slope intercept

Age 1 0.7465638 9.497882

Fleet: SNS

Log catchability residuals.

year/age	1	2	3	4
1970	0.302	0.792	0.526	0.094
1971	0.17	0.844	0.209	-2.561
1972	-0.009	0.049	-0.261	NA
1973	0.522	0.666	0.284	-0.409
1974	-0.019	-0.624	-0.682	NA
1975	-0.126	0.257	-0.048	-0.705
1976	-0.332	-1.322	0.257	-0.783
1977	0.072	0.124	0.291	-0.19
1978	0.381	0.446	0.476	0.137
1979	-0.169	0.311	0.321	0.379
1980	0.09	0.122	0.297	-0.043
1981	0.027	0.419	0.805	-0.186
1982	0.276	0.217	0.013	0.019
1983	-0.132	0.248	-0.692	-0.388
1984	0.365	0.278	0.436	0.098
1985	0.468	0.559	-0.149	-0.056

1986	-0.022	-0.159	-0.404	-0.501
1987	0.206	-0.031	-0.864	-0.36
1988	-0.182	0.294	0.148	0.64
1989	0.122	0.503	0.532	-0.224
1990	-0.246	0.462	-0.03	0.946
1991	-0.022	0.753	0.869	0.695
1992	0.011	-1.174	-0.016	0.973
1993	0.007	0.426	0.073	0.602
1994	-0.234	0.097	0.368	-1.468
1995	-0.189	-0.378	0.053	0.855
1996	-0.759	-0.438	-0.96	0.12
1997	0.169	-0.726	0.29	0.257
1998	0.298	0.676	0.522	0.991
1999	0.022	0.3	0.114	-0.82
2000	-0.284	-1.37	-0.154	0.135
2001	-0.085	-0.086	-0.227	-0.363
2002	0.276	-0.01	0.071	NA
2003	NA	NA	NA	NA
2004	0.383	0.233	0.245	0.934
2005	-0.193	-0.511	-0.029	NA
2006	-0.358	-0.882	-1.137	-0.285
2007	-0.056	-0.235	-0.871	0.48
2008	0.03	-0.315	-0.056	NA
2009	0.018	-0.161	-0.607	-0.123
2010	-0.234	-0.914	-0.608	0.052
2011	-0.509	-0.223	0.145	0.937
2012	NA	NA	NA	NA

2013	-0.059	0.48	0.45	0.124

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	2	3	4
Mean_Logq	-4.7498	-5.4959	-6.0155
S.E_Logq	0.5715	0.4789	0.7195

Regression statistics

Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7585103	5.655845

Fleet: NL Beam Trawl

Log catchability residuals.

year/age	2	3	4	5	6	7	8	9
1997	-0.699	-0.265	-0.349	-0.167	0.116	-0.652	0.370	-0.318
1998	-0.022	-0.569	-0.138	-0.548	-0.271	-0.127	-0.724	-0.193
1999	-0.578	-0.251	-0.541	-0.103	-0.419	-0.561	-0.103	0.234
2000	0.005	0.059	-0.238	-0.310	0.108	0.199	0.359	-0.114
2001	0.105	-0.283	0.150	0.164	-0.444	-0.100	0.008	0.060
2002	0.100	0.084	-0.081	0.144	0.292	-0.201	0.586	-0.018
2003	0.132	-0.018	0.145	-0.154	0.489	0.172	-0.186	-0.256
2004	0.196	0.119	0.059	0.024	-0.289	-0.089	-0.504	0.308
2005	-0.010	0.143	0.198	0.423	-0.015	0.146	-0.362	0.103
2006	0.341	0.042	-0.007	0.046	0.057	0.142	0.395	0.277
2007	0.565	0.047	0.098	0.039	0.047	-0.217	-0.258	-0.115
2008	0.146	0.250	0.076	0.125	0.096	0.032	0.253	0.104
2009	0.564	0.006	0.297	0.114	0.273	0.417	-0.135	-0.104

2010	0.209	0.179	0.066	0.206	0.204	0.391	0.323	0.291
2011	-0.284	0.259	0.165	0.173	0.070	0.122	0.063	-0.363
2012	-0.546	0.000	0.088	0.010	-0.167	0.252	-0.060	-0.268
2013	-0.224	0.199	0.013	-0.185	-0.147	0.074	-0.225	0.099

Mean log catchability and standard error of ages with catchability
independent of year class strength and constant w.r.t. time
2 3 4 5 6 7 8 9
Mean_Logq -5.8433 -4.9127 -4.8726 -4.8437 -5.0103 -5.0853 -5.0853 -5.0853
S.E_Logq 0.3664 0.2220 0.2129 0.2270 0.2579 0.2941 0.3561 0.2216
Terminal year survivor and F summaries:

Age 1 Year class =2012
scaledWts survivors yrcls
BTS-ISIS 0.411 53446 2012
SNS 0.483 50185 2012
nshk 0.106 82152 2012

Age 2 Year class =2011
scaledWts survivors yrcls
BTS-ISIS 0.345 23461 2011
SNS 0.190 46792 2011
NL Beam Trawl 0.448 23144 2011
fshk 0.017 17003 2011

Age 3 Year class =2010
scaledWts survivors yrcls
BTS-ISIS 0.185 132198 2010
SNS 0.221 105893 2010
NL Beam Trawl 0.577 82363 2010
fshk 0.018 57270 2010

Age 4 Year class =2009
scaledWts survivors yrcls

BTS-ISIS 0.186 77111 2009
SNS 0.115 65425 2009
NL Beam Trawl 0.679 58578 2009
fshk 0.020 34851 2009

Age 5 Year class =2008
scaledWts survivors yrcls
BTS-ISIS 0.167 14534 2008
NL Beam Trawl 0.809 14525 2008
fshk 0.024 9395 2008

Age 6 Year class =2007
scaledWts survivors yrcls
BTS-ISIS 0.158 4160 2007
NL Beam Trawl 0.819 6445 2007
fshk 0.023 3626 2007

Age 7 Year class =2006
scaledWts survivors yrcls
BTS-ISIS 0.142 1955 2006
NL Beam Trawl 0.830 3427 2006
fshk 0.028 2773 2006

Age 8 Year class =2005
scaledWts survivors yrcls
BTS-ISIS 0.104 1507 2005
NL Beam Trawl 0.859 5761 2005
fshk 0.037 3539 2005

Age 9 Year class =2004
scaledWts survivors yrcls
BTS-ISIS 0.107 356 2004
NL Beam Trawl 0.865 596 2004
fshk 0.028 703 2004

Table 10.4.2. Sole in sub area IV: fishing mortality at age.

Year/age	1	2	3	4	5	6	7	8	9	10+
1957	0.000	0.022	0.132	0.264	0.269	0.236	0.303	0.174	0.250	0.250
1958	0.000	0.017	0.150	0.237	0.277	0.364	0.347	0.297	0.305	0.305
1959	0.000	0.034	0.132	0.250	0.208	0.243	0.184	0.371	0.252	0.252
1960	0.000	0.029	0.158	0.241	0.324	0.268	0.289	0.344	0.294	0.294
1961	0.000	0.019	0.148	0.302	0.257	0.245	0.178	0.405	0.278	0.278
1962	0.000	0.019	0.143	0.231	0.366	0.315	0.370	0.249	0.307	0.307
1963	0.000	0.053	0.180	0.427	0.405	0.514	0.486	0.461	0.484	0.484
1964	0.000	0.019	0.319	0.244	0.479	0.358	0.507	0.319	0.382	0.382
1965	0.000	0.103	0.161	0.374	0.309	0.579	0.416	0.448	0.426	0.426
1966	0.000	0.122	0.429	0.200	0.482	0.362	0.312	0.353	0.343	0.343
1967	0.000	0.115	0.371	0.495	0.691	0.387	0.300	0.556	0.488	0.488
1968	0.011	0.304	0.688	0.636	0.501	0.293	0.265	0.390	0.418	0.418
1969	0.008	0.338	0.699	0.560	0.690	0.478	0.323	0.418	0.496	0.496
1970	0.010	0.152	0.641	0.546	0.318	0.330	0.380	0.366	0.389	0.389
1971	0.011	0.338	0.563	0.679	0.584	0.413	0.378	0.374	0.487	0.487
1972	0.005	0.234	0.650	0.511	0.525	0.355	0.223	0.304	0.385	0.385
1973	0.007	0.210	0.703	0.614	0.566	0.459	0.369	0.540	0.511	0.511
1974	0.001	0.184	0.582	0.631	0.504	0.493	0.553	0.379	0.514	0.514
1975	0.007	0.277	0.550	0.666	0.477	0.515	0.351	0.650	0.515	0.515
1976	0.010	0.108	0.569	0.515	0.570	0.379	0.470	0.397	0.652	0.652
1977	0.013	0.266	0.560	0.621	0.502	0.375	0.184	0.487	0.288	0.288
1978	0.001	0.232	0.564	0.530	0.517	0.514	0.654	0.539	0.501	0.501
1979	0.001	0.224	0.658	0.630	0.484	0.460	0.372	0.668	0.381	0.381
1980	0.004	0.129	0.558	0.594	0.587	0.409	0.587	0.519	0.645	0.645
1981	0.003	0.259	0.533	0.608	0.540	0.589	0.458	0.443	0.530	0.530
1982	0.019	0.234	0.703	0.571	0.635	0.608	0.514	0.529	0.537	0.537
1983	0.003	0.312	0.602	0.727	0.335	0.476	0.467	0.559	0.654	0.654
1984	0.003	0.295	0.727	0.687	0.674	0.741	0.540	0.434	0.586	0.586
1985	0.002	0.318	0.745	0.772	0.596	0.552	0.412	0.425	0.449	0.449
1986	0.002	0.143	0.620	0.698	0.680	0.756	0.737	0.352	0.578	0.578
1987	0.001	0.239	0.509	0.611	0.529	0.568	0.439	0.652	0.425	0.425
1988	0.000	0.240	0.667	0.712	0.616	0.620	0.548	0.427	0.897	0.897
1989	0.001	0.125	0.525	0.685	0.421	0.431	0.424	0.403	0.354	0.354
1990	0.005	0.138	0.404	0.528	0.587	0.546	0.474	0.673	0.639	0.639
1991	0.002	0.090	0.424	0.522	0.746	0.431	0.534	0.614	1.029	1.029
1992	0.003	0.119	0.436	0.466	0.468	0.601	0.681	0.406	0.737	0.737
1993	0.001	0.182	0.424	0.560	0.830	0.536	0.798	0.547	0.424	0.424
1994	0.013	0.140	0.482	0.637	0.682	0.888	0.460	0.545	0.972	0.972
1995	0.054	0.307	0.448	0.775	0.617	0.551	0.809	0.424	0.718	0.718
1996	0.004	0.275	0.698	0.986	0.717	0.854	0.753	1.044	0.384	0.384
1997	0.006	0.154	0.580	0.704	0.821	0.787	0.625	0.930	1.272	1.272
1998	0.002	0.282	0.621	0.797	0.777	0.767	0.681	1.007	1.397	1.397
1999	0.004	0.177	0.615	0.720	0.799	0.596	0.571	0.594	1.608	1.608

2000	0.020	0.242	0.588	0.810	0.632	0.794	0.911	0.817	0.546	0.546
2001	0.014	0.280	0.553	0.746	0.750	0.534	0.583	0.796	0.751	0.751
2002	0.006	0.231	0.624	0.644	0.730	0.668	0.472	1.022	0.588	0.588
2003	0.014	0.230	0.612	0.640	0.648	0.843	0.508	0.511	0.553	0.553
2004	0.012	0.243	0.553	0.712	0.617	0.471	0.412	0.343	1.263	1.263
2005	0.025	0.216	0.618	0.675	0.696	0.668	0.611	0.472	0.448	0.448
2006	0.038	0.281	0.481	0.513	0.517	0.564	0.561	0.601	0.534	0.534
2007	0.006	0.275	0.494	0.547	0.579	0.469	0.552	0.482	0.984	0.984
2008	0.032	0.146	0.401	0.496	0.458	0.452	0.379	0.589	0.622	0.622
2009	0.019	0.209	0.352	0.488	0.491	0.449	0.545	0.355	0.962	0.962
2010	0.002	0.162	0.399	0.461	0.441	0.492	0.422	0.522	0.459	0.459
2011	0.000	0.090	0.399	0.416	0.486	0.342	0.478	0.323	0.308	0.308
2012	0.000	0.054	0.249	0.328	0.307	0.306	0.282	0.489	0.257	0.257
2013	0.000	0.080	0.314	0.287	0.259	0.220	0.377	0.250	0.350	0.350

Table 10.4.3 Sole in sub area IV: stock numbers at age.

year	1	2	3	4	5	6	7	8	9	10
1957	128368	72365	89497	59635	17459	15182	27300	11899	2518	31060
1958	127923	116152	64078	70939	41451	12075	10845	18252	9052	26270
1959	484218	115749	103326	49912	50642	28425	7596	6937	12272	26706
1960	60766	438138	101220	81946	35175	37205	20181	5715	4332	32333
1961	98193	54984	385063	78230	58271	23031	25757	13680	3666	31745
1962	22503	88849	48827	300411	52329	40765	16311	19503	8252	29555
1963	20438	20362	78887	38308	215857	32839	26919	10196	13759	31742
1964	538603	8309	7851	26799	10165	58543	7983	6734	2613	9601
1965	122919	487297	7376	5163	19000	5697	37040	4350	4430	9280
1966	40147	111222	397949	5680	3212	12628	2890	22110	2515	8756
1967	75741	36326	89085	234355	4208	1796	7955	1915	14056	8076
1968	99998	68534	29284	55628	129258	1907	1103	5332	994	19923
1969	51107	89498	45753	13321	26654	70902	1287	766	3266	14404
1970	138264	45860	57768	20582	6886	12096	39760	843	457	17006
1971	42308	123871	35654	27542	10789	4533	7872	24598	529	12618
1972	76695	37877	79965	18377	12642	5446	2714	4882	15314	9088
1973	105839	69059	27128	37774	9972	6767	3455	1964	3259	15420
1974	111553	95086	50636	12156	18490	5122	3871	2163	1036	12370
1975	41330	100842	71607	25606	5852	10105	2831	2016	1339	9046
1976	114365	37143	69184	37365	11908	3288	5462	1803	952	5937
1977	141787	102469	30166	35422	20192	6092	2036	3087	1097	9030
1978	47986	126601	71081	15596	17219	11060	3788	1533	1716	4237
1979	11833	43394	90848	36576	8308	9293	5983	1782	809	5107
1980	153479	10698	31388	42554	17629	4632	5306	3731	827	2697
1981	149567	138255	8507	16261	21250	8870	2784	2669	2009	2371
1982	152545	134921	96577	4517	8011	11201	4452	1594	1550	3259
1983	140838	135463	96588	43272	2310	3840	5516	2410	849	2571
1984	70397	127064	89712	47873	18919	1495	2159	3129	1247	2115
1985	81515	63515	85638	39244	21790	8728	645	1138	1835	2795
1986	158274	73603	41824	36801	16410	10863	4549	386	673	3982
1987	71959	142858	57748	20359	16566	7525	4617	1970	246	2087
1988	452839	65023	101777	31395	10002	8828	3859	2694	928	558
1989	106698	409736	46273	47256	13933	4887	4299	2018	1591	1614
1990	174825	96435	327318	24773	21550	8278	2874	2545	1220	1853
1991	69557	157376	76019	197833	13220	10844	4337	1619	1175	1739
1992	348980	62826	130093	45019	106163	5675	6377	2301	792	2330
1993	68414	314852	50445	76132	25552	60156	2814	2921	1388	2525
1994	56380	61853	237452	29878	39355	10080	31833	1146	1530	1504
1995	94955	50340	48633	132718	14301	18000	3754	18174	601	1356
1996	48806	81385	33494	28120	55338	6984	9387	1512	10765	3204
1997	267337	44000	55938	15082	9492	24440	2691	3999	482	2416
1998	111994	240400	34118	28340	6748	3777	10065	1304	1428	1157
1999	80926	101106	164098	16592	11559	2809	1588	4611	431	1043

2000	121603	72954	76645	80251	7305	4705	1400	812	2304	1760
2001	62638	107815	51811	38508	32288	3512	1924	510	324	1386
2002	183742	55862	73732	26976	16523	13795	1862	972	208	851
2003	81527	165261	40123	35735	12819	7203	6402	1051	317	1110
2004	43913	72773	118816	19678	17047	6069	2806	3484	570	564
2005	48417	39244	51617	61847	8740	8326	3430	1681	2237	1137
2006	199018	42734	28609	25176	28495	3943	3861	1685	948	1399
2007	54267	173413	29187	15996	13643	15374	2030	1994	836	901
2008	66228	48803	119201	16117	8380	6917	8699	1058	1114	1036
2009	92485	58062	38142	72256	8880	4797	3982	5386	531	1458
2010	161746	82133	42628	24267	40127	4917	2769	2090	3416	1962
2011	131731	146001	63227	25869	13844	23350	2721	1643	1121	3022
2012	38304	119154	120700	38387	15437	7704	15005	1527	1077	3443
2013	59975	34658	102144	85157	25019	10279	5131	10242	847	1744

Table 10.5.1. Sole in sub area IV: XSA summary.

year	recruits age 1	ssb	catch	landings	fbar2-6	Y/ssb
1957	128368	55481	12067	12067	0.18	0.22
1958	127923	60828	14287	14287	0.21	0.23
1959	484218	65340	13832	13832	0.17	0.21
1960	60766	72919	18620	18620	0.2	0.26
1961	98193	116174	23566	23566	0.19	0.2
1962	22503	115311	26877	26877	0.21	0.23
1963	20438	111924	26164	26164	0.32	0.23
1964	538603	36458	11342	11342	0.28	0.31
1965	122919	29716	17043	17043	0.31	0.57
1966	40147	84577	33340	33340	0.32	0.39
1967	75741	83903	33439	33439	0.41	0.4
1968	99998	72660	33179	33179	0.48	0.46
1969	51107	55862	27559	27559	0.55	0.49
1970	138264	50870	19685	19685	0.4	0.39
1971	42308	44004	23652	23652	0.52	0.54
1972	76695	47507	21086	21086	0.45	0.44
1973	105839	37125	19309	19309	0.51	0.52
1974	111553	36139	17989	17989	0.48	0.5
1975	41330	38849	20773	20773	0.5	0.53
1976	114365	39439	17326	17326	0.43	0.44
1977	141787	35140	18003	18003	0.46	0.51
1978	47986	36419	20280	20280	0.47	0.56
1979	11833	45426	22598	22598	0.49	0.5
1980	153479	33938	15807	15807	0.46	0.47
1981	149567	23221	15403	15403	0.51	0.66
1982	152545	33004	21579	21579	0.55	0.65
1983	140838	39873	24927	24927	0.49	0.63
1984	70397	43215	26839	26839	0.62	0.62
1985	81515	40476	24248	24248	0.6	0.6
1986	158274	34043	18201	18201	0.58	0.53
1987	71959	29289	17368	17368	0.49	0.59
1988	452839	38470	21590	21590	0.57	0.56
1989	106698	33617	21805	21805	0.44	0.65
1990	174825	89323	35120	35120	0.44	0.39
1991	69557	77119	33513	33513	0.44	0.43
1992	348980	76988	29341	29341	0.42	0.38
1993	68414	55569	31491	31491	0.51	0.57
1994	56380	73978	33002	33002	0.57	0.45
1995	94955	58879	30467	30467	0.54	0.52
1996	48806	38504	22651	22651	0.71	0.59
1997	267337	27175	14901	14901	0.61	0.55
1998	111994	20060	20868	20868	0.65	1.04

1999	80926	40763	23475	23475	0.58	0.58
2000	121603	37777	22641	22641	0.61	0.6
2001	62638	29496	19944	19944	0.57	0.68
2002	183742	30547	16945	16945	0.58	0.55
2003	81527	24839	17920	17920	0.59	0.72
2004	43913	36909	18757	18757	0.52	0.51
2005	48417	31373	16355	16355	0.57	0.52
2006	199018	23585	12594	12594	0.47	0.53
2007	54267	17351	14635	14635	0.47	0.84
2008	66228	34528	14071	14071	0.39	0.41
2009	92485	31072	13952	13952	0.4	0.45
2010	161746	30201	12603	12603	0.39	0.42
2011	131731	30285	11485	11485	0.35	0.38
2012	38304	42308	11610	11610	0.25	0.27
2013	59975	48873	13138	13138	0.23	0.27
2014	147276	46765				

Table 10.6.1. Sole in sub area IV: RCT3 input table (-11:not available).

year	age1	age2	DFS0	SNS1	SNS2	BTS1
1973	111553	100842	-11	2348	864	
1974	41330	37143	-11	525	74	
1975	114364	102469	-11	1399	776	
1976	141786	126600	-11	3743	1355	
1977	47985	43393	-11	1548	408	
1978	11833	10698	-11	94	89	
1979	153477	138253	-11	4313	1413	
1980	149566	134920	-11	3737	1146	
1981	152546	135464	-11	5856	1123	
1982	140839	127064	-11	2621	1100	
1983	70397	63515	-11	2493	716	
1984	81515	73603	-11	3619	458	7.03
1985	158274	142858	-11	3705	944	7.17
1986	71959	65023	-11	1948	594	6.97
1987	452843	409739	-11	1122	5005	83.11
1988	106700	96436	-11	2831	1120	9.01
1989	174827	157378	-11	2856	2529	37.84
1990	69558	62826	-11	1254	144	4.03
1991	348984	314856	167.5628	11114	3420	81.63
1992	68415	61854	9.266028	1291	498	6.35
1993	56380	50341	15.32398	652	224	7.66
1994	94955	81385	22.06324	1362	349	28.13
1995	48806	44000	7.064778	218	154	3.98
1996	267338	240400	40.27174	10279	3126	169.34
1997	111996	101108	26.93957	4095	972	17.11
1998	80927	72956	-11	1649	126	11.96
1999	121605	107817	-11	1639	655	14.59
2000	62639	55863	9.504133	970	379	8.00
2001	183743	165262	51.42419	7547		20.99
2002	81527	72773	58.58299		624	10.51
2003	43913	39244	10.60934	1370	163	4.19
2004	48417	42734	31.25178	568	117	5.53
2005	199019	173413	40.98701	2726	911	17.09
2006	54267	48803	12.5667	849	259	7.50
2007	66228	58062	13.72748	1259	344	15.25
2008	92485	82134	11.76762	1932	237	15.95
2009	161747	146002	27.33151	2637	884	54.80
2010	-11	-11	42.86197	1248	-11	26.20
2011	-11	-11	12.12998	-11	427	5.10
2012	-11	-11	11.22614	967	-11	6.80
2013	-11	-11	48.30721	-11	-11	-11

Table 10.6.2. Sole in sub area IV: RCT3 analysis – age 1.

yearclass:2013									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	0.9817	8.409	0.5242	0.6145	17	3.878	12.22	0.5886	0.5702
VPAMean	NA	NA	NA	NA	37	NA	11.48	0.678	0.4298

WAP	logWAP	int.se
147276	11.9	0.4445

Table 10.6.3. Sole in sub area IV: Output RCT3 – age 2.

yearclass:2012									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	0.9862	8.28	0.5283	0.612	17	2.418	10.66	0.5903	0.2103
SNS1	0.8949	4.643	0.5438	0.6218	36	6.874	10.79	0.5708	0.225
SNS2	0.7344	6.711	0.3672	0.7787	36	NA	NA	NA	NA
BTS1	0.7388	9.481	0.3969	0.7223	26	1.917	10.9	0.4252	0.4053
VPA mean	NA	NA	NA	NA	37	NA	11.37	0.6782	0.1593

WAP	logWAP	int.se
54228	10.9	0.2707

Table 10.7.1. Sole in sub area IV: STF Input table (F values presented are for Fsq).

	2014							
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
RCT	1	147276	0.1	0.00	0	0	0.043	0.000	0.164
XSA	2	54268	0.1	0.00	0	0	0.144	0.063	0.167
XSA	3	28952	0.1	1.00	0	0	0.170	0.270	0.191
XSA	4	67521	0.1	1.00	0	0	0.221	0.289	0.235
	5	57823	0.1	1.00	0	0	0.261	0.295	0.258
	6	17474	0.1	1.00	0	0	0.277	0.243	0.276
	7	7465	0.1	1.00	0	0	0.309	0.319	0.294
	8	3185	0.1	1.00	0	0	0.304	0.298	0.297
	9	7216	0.1	1.00	0	0	0.421	0.257	0.337
	10	1652	0.1	1.00	0	0	0.422	0.257	0.400
	2015							
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
GM	1	94491	0.1	0.00	0	0	0.043	0.000	0.164
	2		0.1	0.00	0	0	0.144	0.063	0.167
	3		0.1	1.00	0	0	0.170	0.270	0.191
	4		0.1	1.00	0	0	0.221	0.289	0.235
	5		0.1	1.00	0	0	0.261	0.295	0.258
	6		0.1	1.00	0	0	0.277	0.243	0.276
	7		0.1	1.00	0	0	0.309	0.319	0.294
	8		0.1	1.00	0	0	0.304	0.298	0.297
	9		0.1	1.00	0	0	0.421	0.257	0.337
	10		0.1	1.00	0	0	0.422	0.257	0.400
	2016							
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
GM	1	94491	0.1	0.00	0	0	0.043	0.000	0.164
	2		0.1	0.00	0	0	0.144	0.063	0.167
	3		0.1	1.00	0	0	0.170	0.270	0.191
	4		0.1	1.00	0	0	0.221	0.289	0.235
	5		0.1	1.00	0	0	0.261	0.295	0.258
	6		0.1	1.00	0	0	0.277	0.243	0.276
	7		0.1	1.00	0	0	0.309	0.319	0.294
	8		0.1	1.00	0	0	0.304	0.298	0.297
	9		0.1	1.00	0	0	0.421	0.257	0.337
	10		0.1	1.00	0	0	0.422	0.257	0.400

Table 10.7.2. Sole in sub area IV: STF option table, assuming F(2013) = F(sq).

landings	basis	f2-6	f_dis2-3	discards	catch	ssb2015		tac 2014
11.7	Fsq	0.232	0	0	11.7	43.8		11.9

landings	basis	f2-6	f_dis2-3	discards	catch	ssb2016	ssb_change	tac_change
10.1	MP_Ftar	0.2	0	0	10.1	54.7	25	-15
10.5	MP_Fmp stage 1	0.209	0	0	10.5	54.3	24	-12
11.0	Fmsy	0.22	0	0	11.0	53.8	23	-8
11.0	Fhcr	0.22	0	0	11.0	53.8	23	-8
15.3	Fmsy_Trans	0.323	0	0	15.3	49.3	13	28
18.2	Fpa	0.4	0	0	18.2	46.3	6	53
0.0	Flim	NA	NA	0	0.0	NA	NA	-100
29.0	SSB>Bpa	0.754	0	0	29.0	35.1	-20	144
0.0	F=0	0	NA	0	0.0	65.3	49	-100
13.7	15%_TAC_inc	0.284	0	0	13.7	50.9	16	15
11.9	TACsq	0.242	0	0	11.9	52.8	20	0
10.1	15%_TAC_dec	0.201	0	0	10.1	54.7	25	-15
3.8	Fsq*0.3	0.07	0	0	3.8	61.3	40	-68
7.2	Fsq*0.6	0.139	0	0	7.2	57.7	32	-39
9.4	Fsq*0.8	0.186	0	0	9.4	55.4	26	-21
11.5	Fsq*1	0.232	0	0	11.5	53.3	22	-3
12.5	Fsq*1.1	0.255	0	0	12.5	52.2	19	5
15.3	Fsq*1.4	0.325	0	0	15.3	49.2	12	29
19.7	Fsq*1.9	0.441	0	0	19.7	44.7	2	65

Table 10.7.3. Sole in sub area IV: STF detailed, assuming Fsq in 2014, 2015 and 2016.

2014						
Age	No	B	SSB	Fishing Mortality	catchnr	catchw
1	147276	6382	0	0.000	16	3
2	54268	7833	0	0.063	3148	527
3	28952	4931	4931	0.270	6526	1244
4	67521	14922	14922	0.289	16174	3796
5	57823	15073	15073	0.295	14086	3630
6	17474	4834	4834	0.243	3601	993
7	7465	2304	2304	0.319	1944	571
8	3185	967	967	0.298	783	232
9	7216	3036	3036	0.257	1558	525
10	1652	697	697	0.257	357	143
total	392832	60980	46765	0.232	48192	11662

2015						
Age	No	B	SSB	Fishing Mortality	catchnr	catchw
1	94491	4095	0	0.000	10	2
2	133246	19232	0	0.063	7728	1293
3	46112	7854	7854	0.270	10394	1982
4	20005	4421	4421	0.289	4792	1125
5	45753	11926	11926	0.295	11146	2872
6	38960	10779	10779	0.243	8028	2213
7	12394	3826	3826	0.319	3227	948
8	4911	1491	1491	0.298	1207	358
9	2140	900	900	0.257	462	156
10	6208	2620	2620	0.257	1340	536
total	404221	67145	43819	0.232	48335	11484

2016						
Age	No	B	SSB	Fishing ortality	catchnr	catchw
1	94491	4095	0	0.000	10	2
2	85489	12339	0	0.063	4959	830
3	113221	19285	19285	0.270	25521	4866
4	31863	7042	7042	0.289	7633	1791
5	13556	3534	3534	0.295	3302	851
6	30827	8529	8529	0.243	6352	1751
7	27634	8530	8530	0.319	7195	2113
8	8155	2476	2476	0.298	2004	595
9	3299	1388	1388	0.257	712	240
10	5843	2467	2467	0.257	1261	504
total	414379	69684	53250	0.232	58950	13543

Table 10.8.1. Sole in Sub-Area IV. Yield and spawning biomass per Recruit and F-reference points.

	Fish Mort	Yield/R	SSB/R
	Ages 2-6		
Average last 3 years	0.28	0.15	0.52
Fmax	0.47	0.15	0.32
F0.1	0.12	0.13	1.03
Fmed	0.33	0.15	0.43

Table 10.8.2 Sole in sub area IV: Comparison of stochastic and deterministic Fmsy estimates by WGNSSK 2010 and WGNSSK 2014 using PlotMSY software for three different stock-recruit functions. Fmax estimates are also included.

sol-nsea									
Sen filename				sol-nsea.sen					
pf, pm				0,0					
Number of iterations				1000					
Simulate variation in Biological parameters				TRUE					
SR relationship constrained				TRUE					
Ricker									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.89	0.32	46423	16019	0.72	1.14	5.66	0.00	129.53
Mean	0.95	0.33	48670	16686	0.73	1.13	5.87	0.00	131.68
5%ile	0.56	0.22	35764	13707	0.61	0.73	3.89	0.00	129.63
25%ile	0.74	0.27	41405	15281	0.68	0.97	4.89	0.00	130.18
50%ile	0.89	0.32	46707	16633	0.73	1.13	5.71	0.00	131.01
75%ile	1.10	0.38	53305	17815	0.78	1.31	6.65	0.00	132.60
95%ile	1.53	0.49	68356	20303	0.86	1.53	8.42	0.00	135.90
CV	0.33	0.25	0.22	0.12	0.11	0.21	0.24	0.21	0.02
N	999	1000	1000	1000	1000	1000	1000	1000	1000
Beverton-Holt									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	5.00	0.49	28338	14819	1.51	1.51	92995.80	12.12	130.68
Mean	2.16	0.24	65235	15299	1.28	1.49	115172.93	11093.37	132.85
5%ile	0.69	0.13	31261	12215	0.84	1.24	84653.12	607.38	130.79
25%ile	1.20	0.17	45177	13717	1.13	1.38	95910.60	3281.74	131.33
50%ile	1.90	0.23	58273	14805	1.31	1.49	107459.50	7078.63	132.26
75%ile	3.00	0.29	78303	16360	1.46	1.60	124512.50	14835.70	133.70
95%ile	4.30	0.42	117251	19713	1.66	1.75	166548.25	31870.55	137.18
CV	0.53	0.38	0.45	0.17	0.20	0.11	0.26	1.11	0.02
N	799	999	999	999	1000	1000	1000	1000	1000
Smooth hockeystick									
1000/1000 Iterations resulted in feasible parameter estimates									
	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0.61	0.50	28041	14737	0.79	0.48	1.99	23179.40	130.43
Mean	0.60	0.48	31935	15347	0.77	0.54	1.94	26035.84	131.97
5%ile	0.38	0.31	21319	12653	0.52	0.37	1.32	17924.23	130.45
25%ile	0.48	0.40	26519	14148	0.63	0.43	1.60	20768.78	130.65
50%ile	0.58	0.46	30775	15222	0.75	0.51	1.89	24587.75	131.20
75%ile	0.70	0.54	35618	16278	0.90	0.62	2.28	29514.43	132.46
95%ile	0.90	0.68	46236	18303	1.06	0.81	2.69	38666.76	135.75
CV	0.27	0.24	0.26	0.12	0.22	0.28	0.22	0.28	0.02
N	1000	1000	1000	1000	1000	1000	1000	1000	1000
Per recruit									
	F20	F25	F30	F35	F40	F01	Fmax	Bmsypr	MSYpr
Deterministic	0.24	0.18	0.14	0.12	0.09	0.11	0.50	0.303345	0.159422
Mean	0.24	0.19	0.15	0.12	0.10	0.11	0.54	0.33265	0.159659
5%ile	0.20	0.16	0.12	0.10	0.08	0.07	0.32	0.235054	0.152568
25%ile	0.22	0.17	0.13	0.11	0.09	0.09	0.42	0.288868	0.156605
50%ile	0.24	0.18	0.14	0.12	0.09	0.11	0.49	0.327271	0.159609
75%ile	0.26	0.20	0.16	0.13	0.10	0.13	0.60	0.367125	0.162382
95%ile	0.29	0.22	0.18	0.15	0.12	0.19	0.90	0.454022	0.167581
CV	0.11	0.11	0.13	0.14	0.15	0.33	0.40	0.206625	0.027854
N	1000	1000	1000	1000	1000	1000	912	912	912
Combining all SRRs									
Automatically specified weights									
	0.400127	0.223918	0.375955						
Percentage	Fmsy	Fcrash	MSY	Bmsy	Fmsy_w	Fcrash_w	MSY_w	Bmsy_w	
5%	0.15	0.43	12638	24191	0.16	0.43	13039	23528	
25%	0.25	0.62	14250	33673	0.26	0.60	14409	32922	
50%	0.33	0.84	15529	43836	0.35	0.79	15670	42960	
75%	0.44	1.30	16981	55684	0.45	1.10	17077	53845	
95%	0.59	3.45	19618	92687	0.60	2.54	19436	88614	

Table 10.8.3. Sole in sub area IV: Comparison of stochastic and deterministic Fmsy estimates by WGNSSK 2010 and WGNSSK 2014 given three different stock-recruit functions using PlotMSY software. Fmax estimates are also included.

	ICES 2010				ICES 2014			
S/R assumption	Stochastic percentiles			Deterministic	Stochastic percentiles			Deterministic
	5%	50%	95%		5%	50%	95%	
hockey stick	0.1	0.29	0.5	0.49	0.31	0.46	0.68	0.50
Beverton & Holt	0.02	0.16	0.3	0.58	0.13	0.23	0.42	0.49
Ricker	0.13	0.22	0.3	0.31	0.22	0.32	0.49	0.32
Fmax	*	*	*	0.58	*	*	*	0.49

Table 10.8.4. Sole in sub area IV: Estimation by MSY reference points Eqsim software by WGNSSK 2014.

	Flim05	Flim10	Flim50	medianMSY	meanMSY	FCrash05	FCrash50
catF	0.38	0.42	0.57	0.38	0.31	0.62	1.08
catch	18347	18098	15369	18336	18431	14242	821
catB	44198	40262	25004	43794	54260	21605	731
	a	b	cv	model	n	prop	
1	5.66	2.05E-05	0.73	ricker	605	0.605	
2	3.44	2.72E+04	0.73	segreg	215	0.215	
3	133130398.20	1.45E+03	0.73	bevholt	180	0.18	

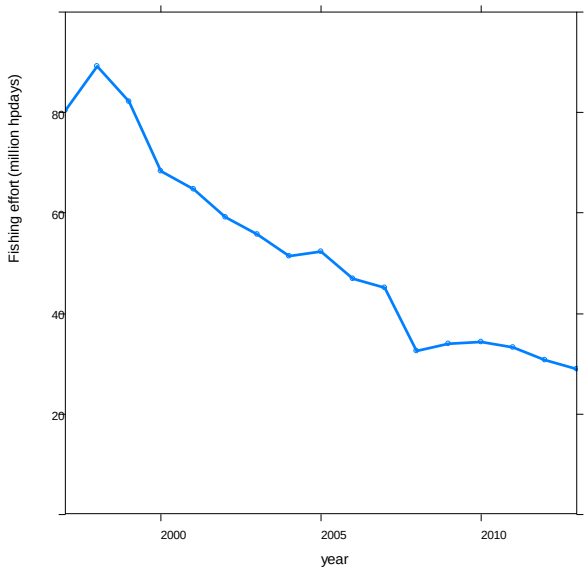


Figure 10.1.1. Sole in Sub-Area IV: Trends in the Dutch beam trawl fleet fishing effort based on days at sea records in Dutch logbook database from vessels landings into the Netherlands.

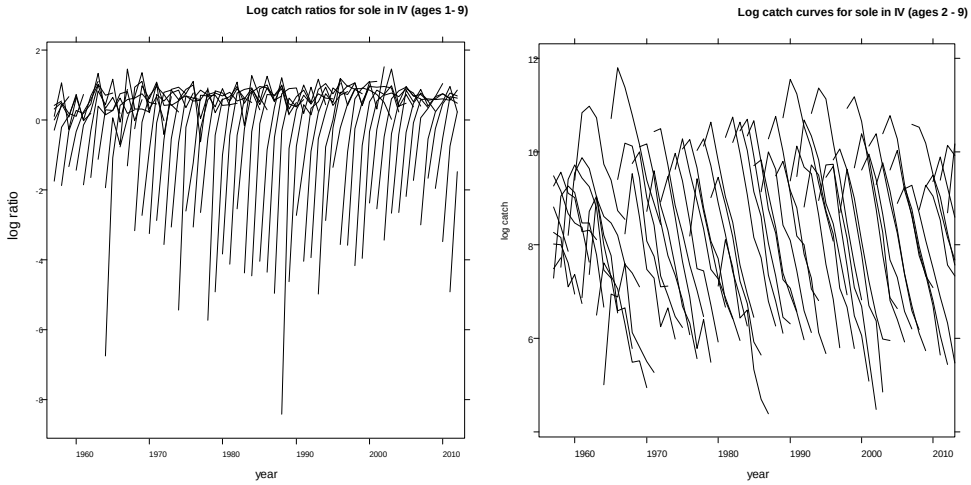


Figure 10.3.1. Sole in Sub-Area IV: Log catch ratios (left) and catch curves (right) from 1957 to 2013.

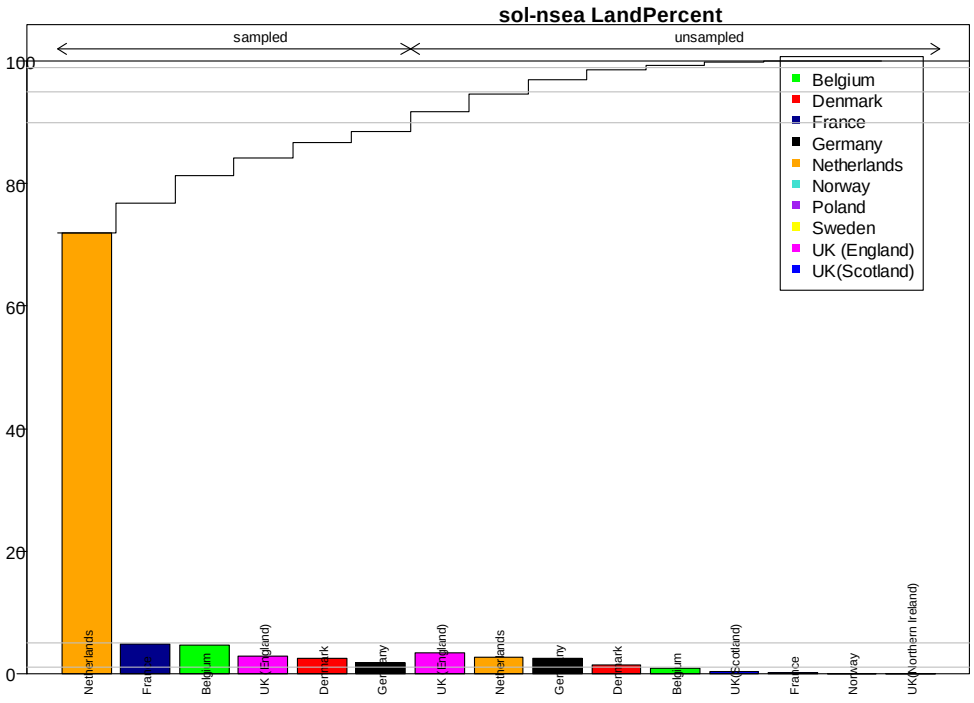


Figure 10.3.2. Sole in Sub-Area IV: Percentage sampled and unsampled landings provided by country.

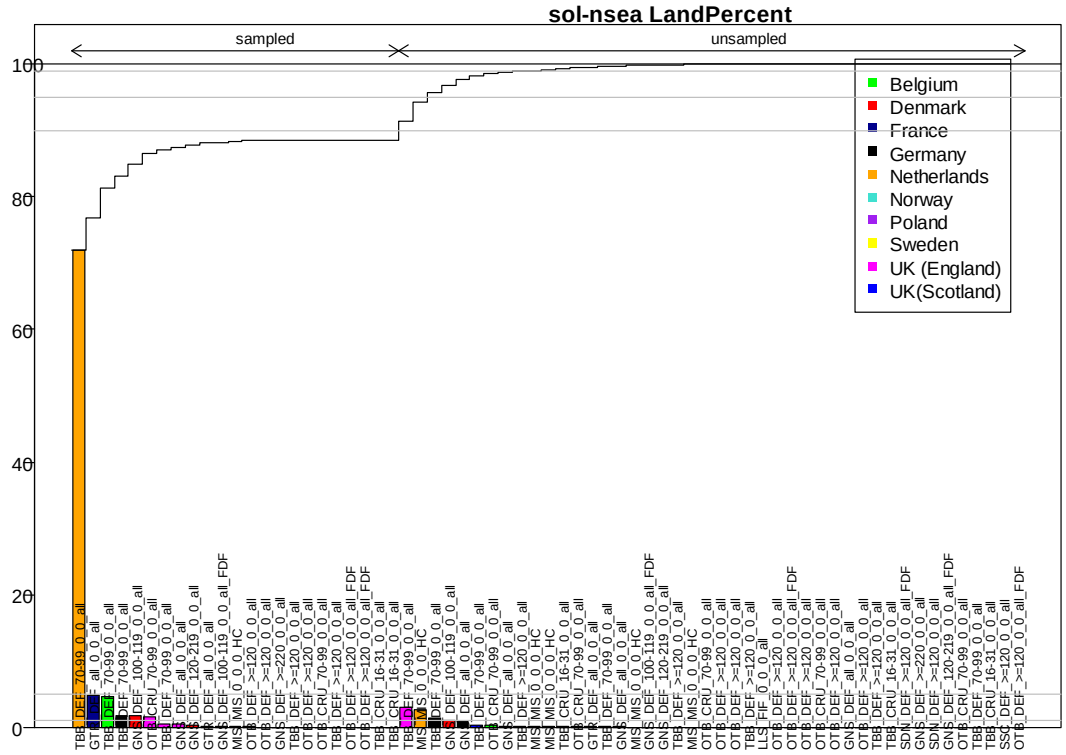


Figure 10.3.3. Sole in Sub-Area IV: Percentage metiers sampled and unsampled for age distributions

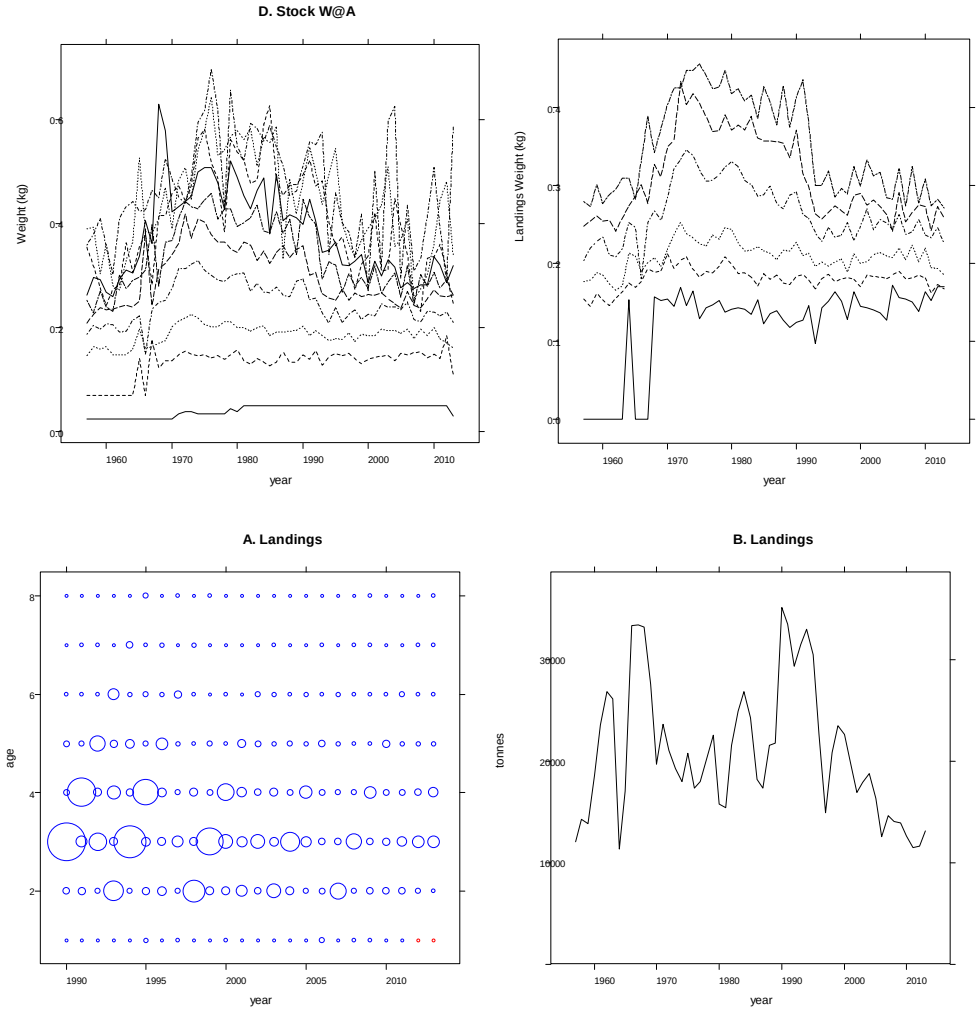


Figure 10.3.4. Sole in Sub-Area IV. A: bubble plot of landings (n) by age and year; B: time series of landings (total tonnages) 1957-2013; Top left: time-series of stock-weights by age 1957-2013; Top right: time-series of landing-weights by age 1957-2013.

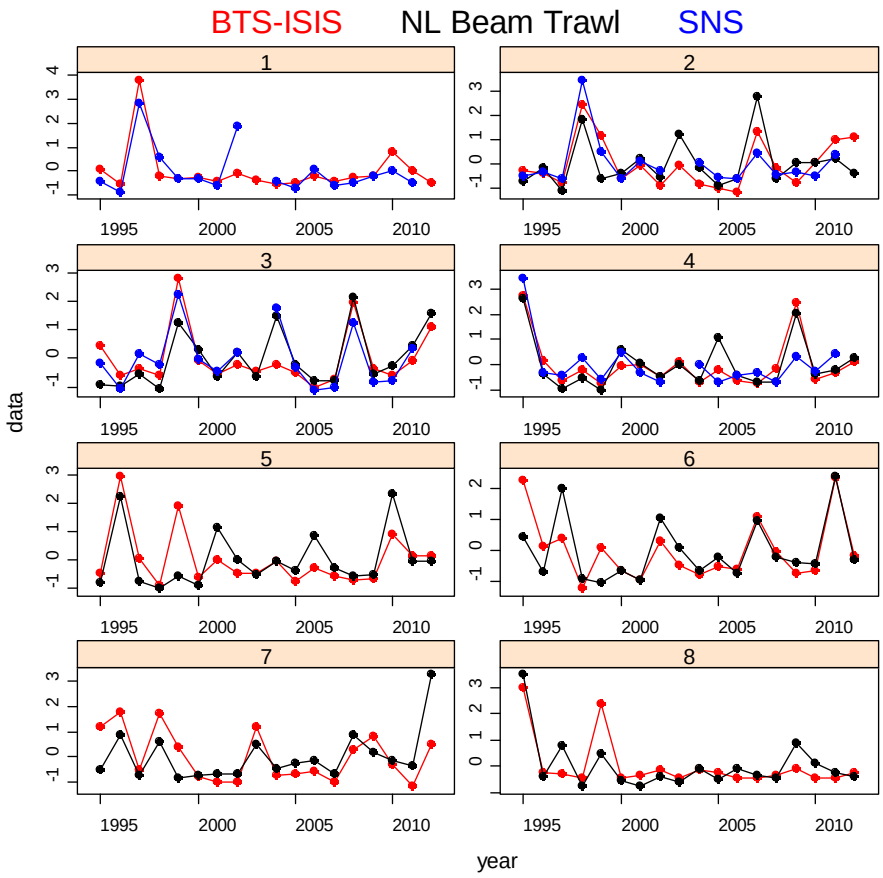


Figure 10.3.5 Sole in Sub-Area IV. Time series of the standardized indices age 1 to 8 from the three tuning fleets used in the final XSA assessment (BTS-ISIS, SNS and NL beam trawl).

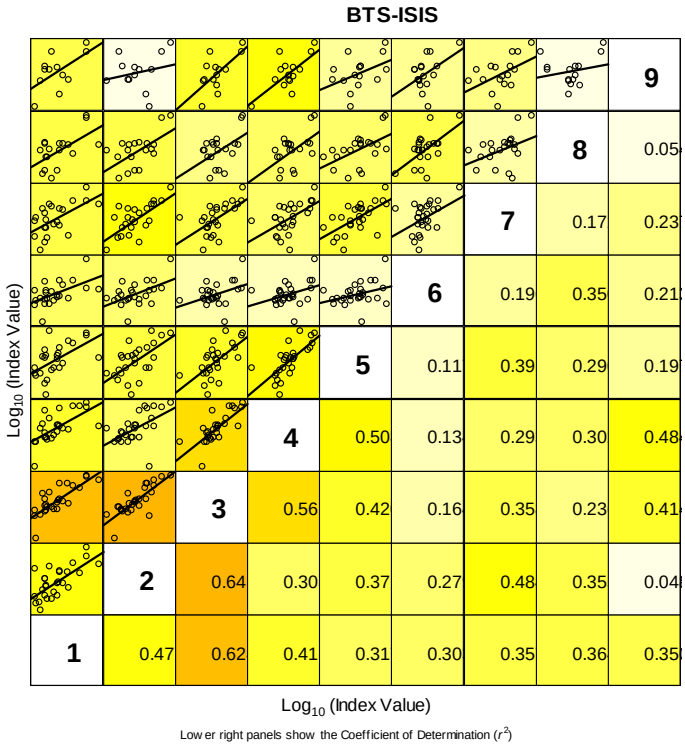


Figure 10.3.6 Sole in Sub-Area IV. Internal consistency in BTS-ISIS survey tuning index.

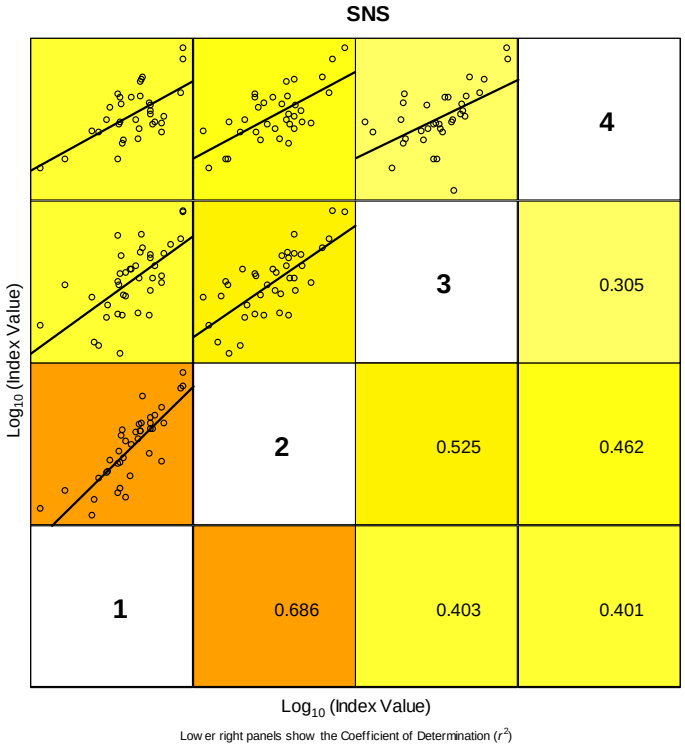


Figure 10.3.7 Sole in Sub-Area IV. Internal consistency in SNS survey tuning index.

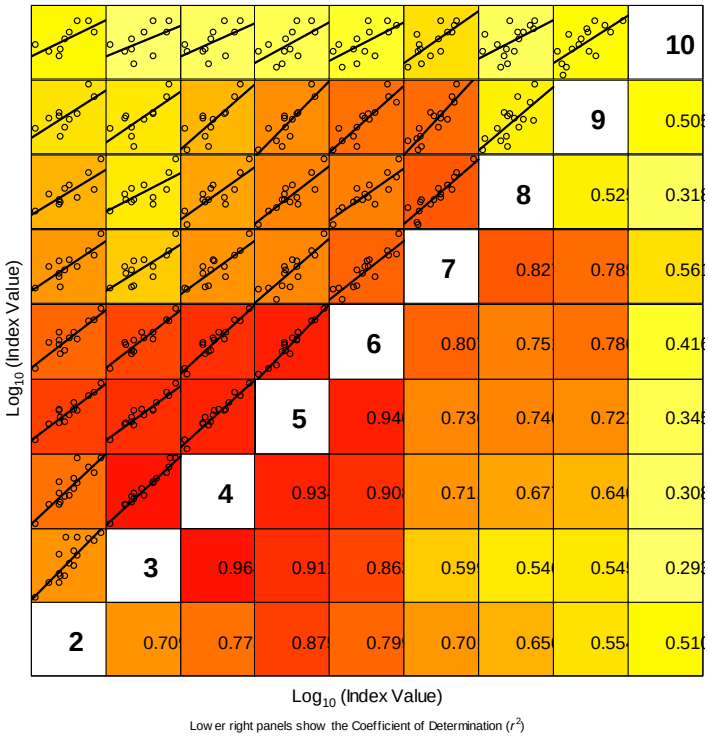


Figure 10.3.8 Sole in Sub-Area IV. Internal consistency in NL Beam trawl commercial tuning index.

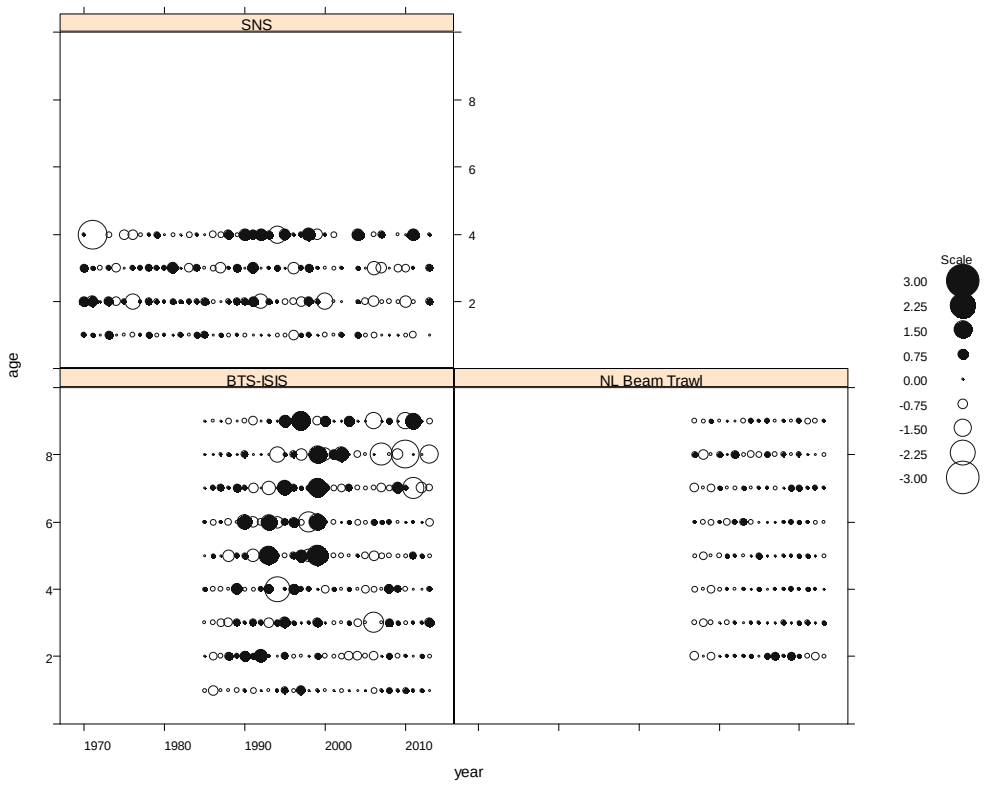


Figure 10.4.1. Sole in Sub-Area IV. Log catchability residuals for the tuning fleets, BTS, SNS and NL beam trawl, in the final run. Closed and dark- circles indicate positive residuals, open circles indicate negative residuals

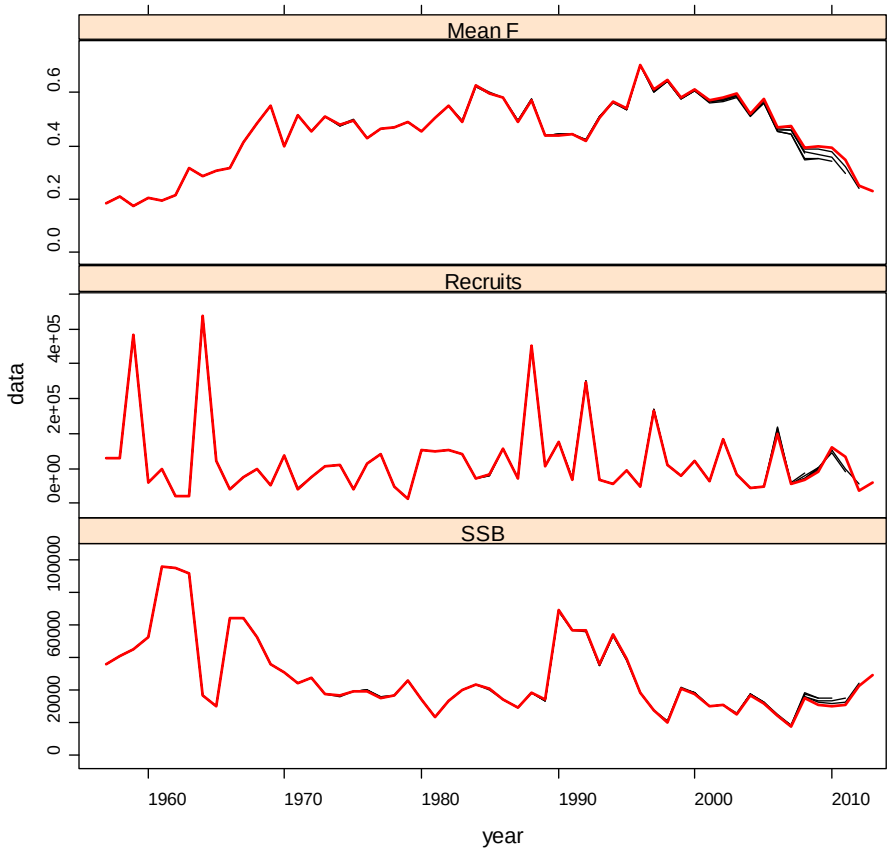


Figure 10.4.2 Sole in Sub-Area IV. Retrospective analysis of F, SSB and recruitment for 1995–2013 for the final XSA run.

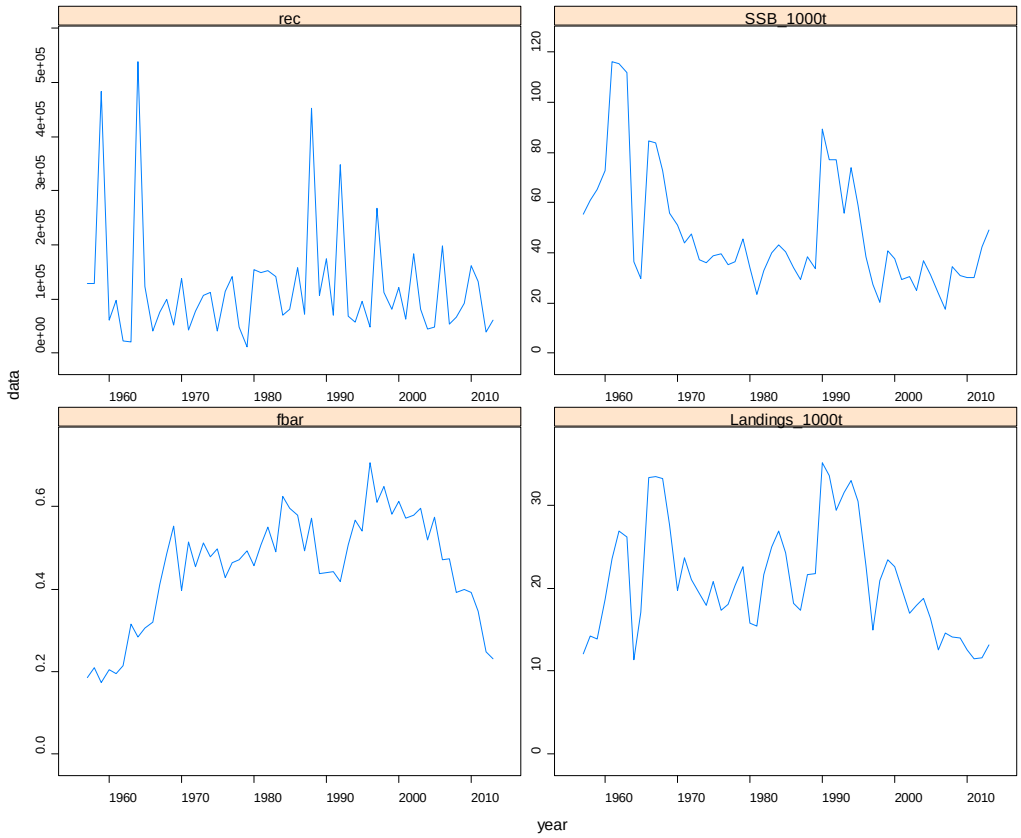


Figure 10.5.1 Sole in Sub-Area IV 1957-2013. XSA summary plots. Time series of recruitment (top left), SSB (top right), mean fishing mortality one ages 2-6 (bottom left) and landings (bottom right).

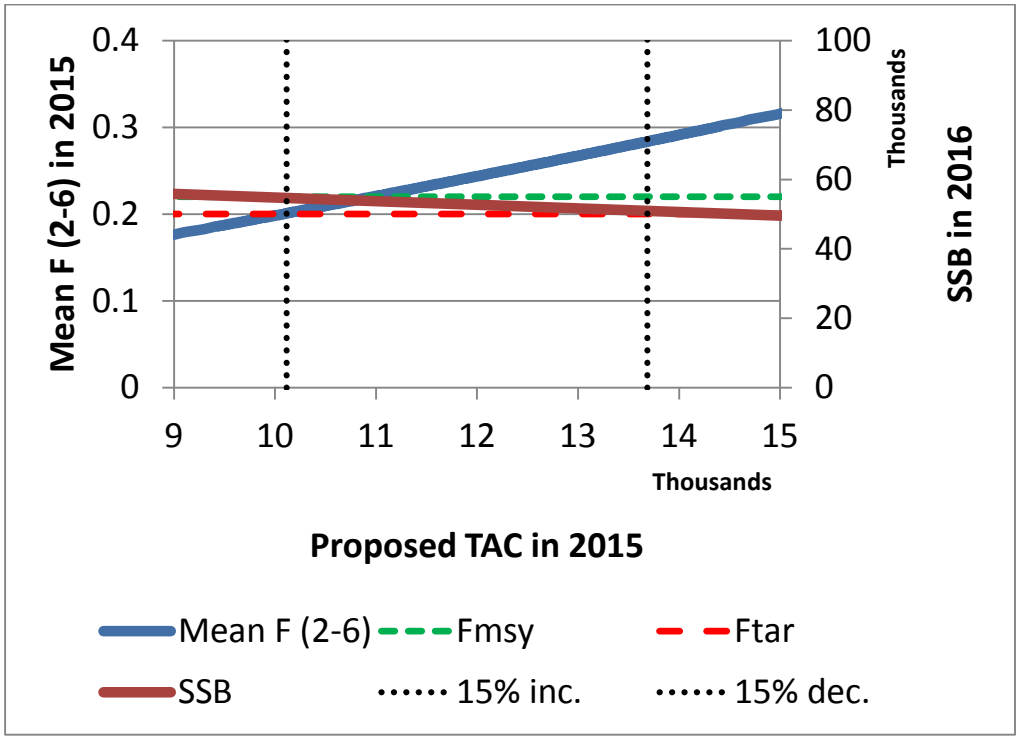


Figure 10.7.1 Sole in Sub-Area IV. Short term forecast.

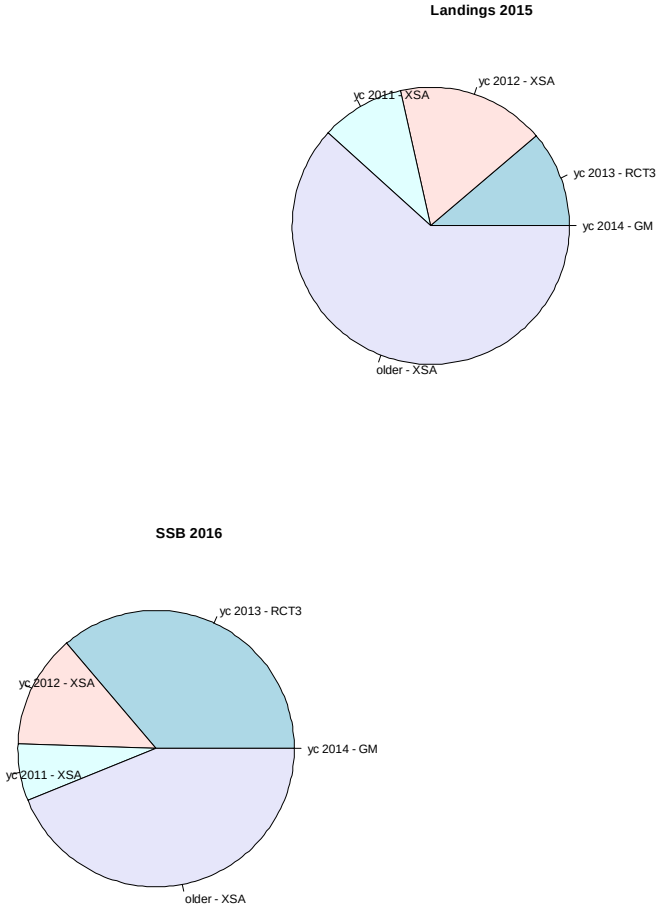


Figure 10.7.2 Sole in Sub-Area IV. Relative year class contribution to 2016 predicted SSB (right) and 2015 landings (left).

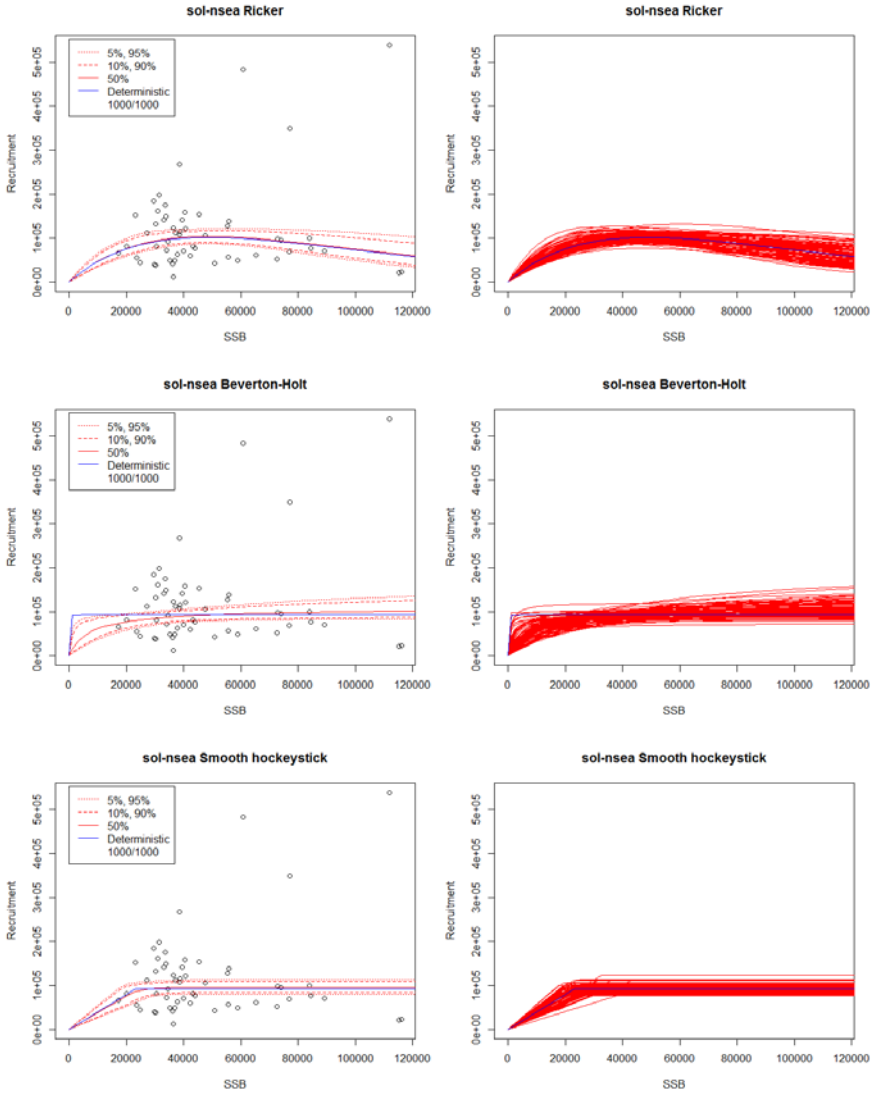


Figure 10.8.2 Sole in sub area IV: Fits of Ricker, Beverton-Hold and hockystick stock recruitment relationships.

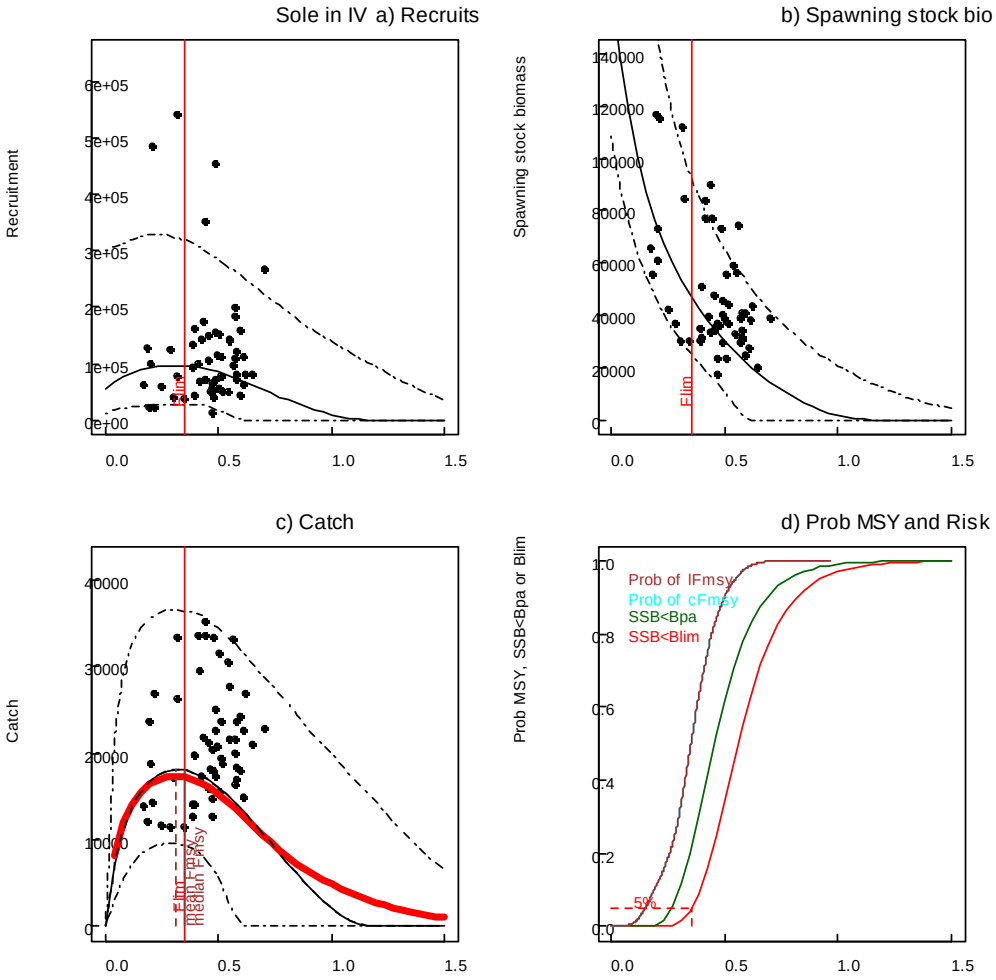


Fig 10.8.3 Sole in sub area IV: Output from Eqsim software.

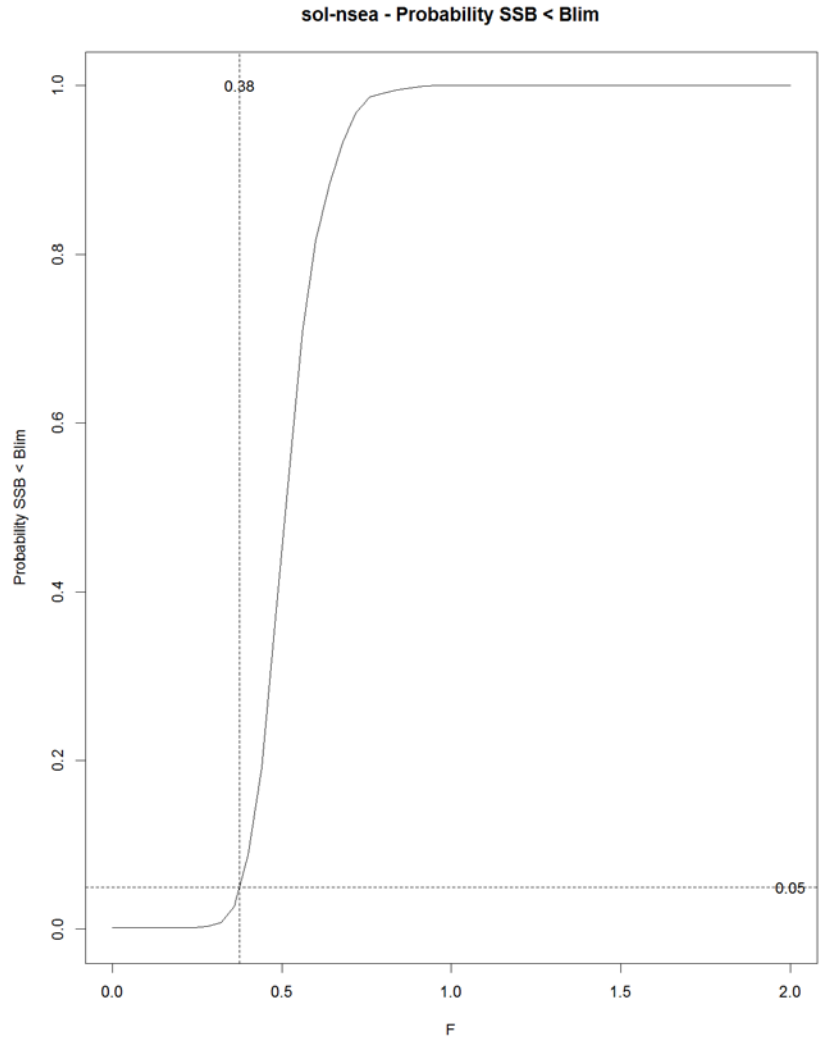


Figure 10.8.4. Sole in sub area IV: Long term probability of SSB<Blim for a given fishing mortality.

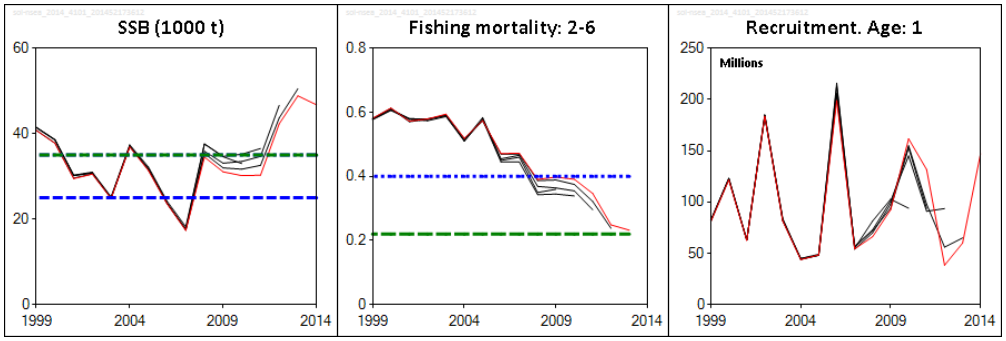


Figure 10.10.1 Sole in Subarea IV (North Sea). Historical assessment results (final year recruitment estimates included).

11 Saithe in Subareas IV, VI and Division IIIa

11.1 General

The assessment of saithe in Division IIIa and Subareas IV and VI is presented as an update assessment. The most recent benchmark was carried out in 2011. More details can be found in the Stock Annex.

11.1.1 Ecosystem aspects

No new information on ecosystem aspects was presented in 2014. A summary of available information, prepared during WKBENCH 2011, can be found in the Stock Annex.

11.1.2 Fisheries

Information on the North Sea saithe fishery can be found in the Stock Annex.

Beginning in 2009, changes in the fishing pattern of the three main commercial trawler fleets for saithe became apparent. The EU fleet has fallen under the effort regime of the EU cod management plan (1342/2008), which may have contributed to the southern shift in geographical distribution for the German fleet (Figure 11.1.1); this fleet has now returned to its original fishing pattern. The French trawl fleet also shifted southwards 2009–2011, but in 2012, returned to the traditional saithe fishing ground (Figure 11.1.2). French industry representatives noted increased competition over fishing grounds between trawlers and gillnetters in Division VI, particularly in 2009 and 2010, which may explain the shift for those years. The Norwegian trawler fleet shows a similar southerly shift 2009–2012 (Figure 11.1.3). Most of the catch and effort for the French and Norwegian trawler fleets was from the first and second quarters (Figures 11.1.4, 11.1.5).

In 2013, discarding by the EU fleet, based on sampled discards, was assumed to be 9400 t (12% of the total landings); discards are assumed to be zero from the Norwegian vessels. Norwegian trawlers are regulated by a total discard ban and restrictions on bycatch allowances. Furthermore, Norwegian vessels must leave the area when the boat quotas are reached and the fishery is closed when the seasonal quota is reached. The Skagerrak agreement, which previously regulated the fisheries in part of this area, has been terminated. Precautionary area closures where mixed fisheries are observed, off southern Norway and in northern Danish waters, have been problematic to enforce.

11.1.3 ICES Advice of 2014

The information in this section is taken from section 6.4.21 in the Advice summary sheet 2013.

Advice for 2014

ICES advises on the basis of the EU–Norway management plan that landings in 2014 should be no more than 85 581 tonnes for the whole assessment area. Discards are known to take place but cannot be quantified, therefore total catches cannot be calculated.

Management plan

The EU–Norway agreement management plan does not clearly state whether the SSB in the intermediate year or the SSB at the beginning or end of the TAC year should be used

to determine the status of the stock. ICES interprets this as being the SSB at the beginning of the intermediate year (2013).

Since SSB at the beginning of 2013 is below B_{pa}, paragraph 3 of the harvest control rule applies, resulting in a F of 0.29 and a TAC (landings) reduction of more than 15%. Therefore, the maximum TAC reduction of 15% is applied (paragraph 5), resulting in landings of no more than 85 581 t in 2014. This is expected to lead to an SSB of 176 099 t in 2015 which is below B_{pa}. Discards are known to take place but cannot be quantified, therefore total catches cannot be calculated.

11.2 Management

The EU-Norway management plan was reconsidered in February 2013, but no revision was implemented. The plan was previously evaluated by ICES (ICES 2012a) and considered to be consistent with the precautionary approach in the short term (< 4 years).

11.3 Data available

11.3.1 Catch

Preliminary official landings in 2013 were approximately 71 601 t in Subarea IV and Division IIIa and 8474 t in Subarea VI, which are 78% and 90% of the TACs, respectively (Table 11.3.1). The Working Group estimated landings for Subarea IV and Division IIIa as 71 825 t (79% of the TAC) and for Subarea VI, 8 062 t (85% of the TAC).

Seven countries reported discards in 2013. Discards for the French bottom trawl fleet were raised using the information gathered from the German bottom trawl fleet for areas IV and VI (all quarters). All unsampled discards, except Norwegian fleets, were raised using all discard sampling information (all fleets) for Division IIIafor the and combined Subareas IV and VI; Subareas IV and VI were combined due to the relatively low sampling coverage in Subarea VI. Large discards are observed for the Scottish trawlers, 5346 and 1297 t in Subareas IV and VI, respectively. Discard numbers have not been used in the current assessment; however, coverage of discards by the EU fleets ranged from 72% in Division IIIa to approximately 82% in Subareas IV and VI. Estimated discards for the EU fleet in 2013 were 9.4 kt.

11.3.2 Age compositions

International catch data was collated and catch-at-age was generated with InterCatch. Age composition in the landings was based on samples provided by Denmark, France, Scotland, Germany, and Norway. Unsampled catches (all fleets) were raised using the sampled data (all fleets) for each quarter and area. A quarterly basis was chosen for raising the unsampled data because different age-classes of saithe are specifically targeted at certain times of the year, e.g., the fisheries on the spawning aggregations, the fisheries on younger saithe nearshore. Catch weights by fleet, country, and quarter for sampled and unsampled catches for each area are given in Figures 11.3.1–11.3.3. Discards were raised, but not used in the 2014 assessment (Figure 11.3.4); the average discard amount for 2012-2013 was used to top-up the advice.

The age compositions of the landings are presented in Table 11.3.2. Strong year classes are visible in the landings-at-age over time; in recent years, larger year classes are appearing at age 4 and not at age 3 (Figure 11.3.5). The catch in 2013 was predominantly made up of the 2009 year class. Since the early 1990s, there have been few strong incoming year classes.

11.3.3 Weight at age

Weight-at-age from the landings for ages 3–10+ are presented in Table 11.3.3 and Figure 11.3.6. These are also used as stock weights. There has been a decreasing trend in mean weight from the mid-1990s for ages 4 and older. Weights-at-age for ages 8–10+ are increasing slightly. Weights-at-age for ages 3-5 have been relatively stable (with some variation) over the last decade.

11.3.4 Maturity and natural mortality

The following maturity ogive is used for all years:

Age	1	2	3	4	5	6	7+
Proportion mature	0.0	0.0	0.0	0.15	0.7	0.9	1.0

The maturity at age ogive was modelled during WKBENCH 2011, with age as a continuous variable and sampling year as an additional effect. The age at 50% maturity has varied since 1992 between age 7 (1996) and age 4 (2001), but the current fixed maturity ogive could not be rejected on purely statistical grounds. A yearly update of the maturity ogives may give a more accurate assessment of SSB; the implications for realised spawning potential are not known.

A natural mortality rate of 0.2 is used for all ages and years.

11.3.5 Catch, effort and research vessel data

Three commercial unstandardized CPUE indices and two fisheries-independent survey indices were considered for tuning of the assessment (Table 11.3.4).

The commercial unstandardized CPUE indices are:

- French demersal trawl CPUE, ages 3–9, 1990–2013 (“FRATRB_IV ”),
- German bottom trawl CPUE, ages 3–9, 1995–2013 (“GER_OTB_IV”),
- Norwegian bottom trawl CPUE, ages 3–9, 1993–2013 (“NORTRL_IV2”).

All three fleets typically fish along the northern/northeastern edge of the North Sea shelf. In 2009, the fleets shifted southward, as noted in Section 11.1.2. All fleets appear to have now largely returned to their original fishing grounds.

The surveys are:

- IBTS quarter 3, ages 3–5, 1992–2013 (“IBTS-Q3”),
- Norwegian acoustic saithe survey in the North Sea, run concurrently with the IBTS survey, ages 3–6, 1996–2013 (“NORACU”).

The NORACU survey did not take place in 2009 and when re-established, it was carried out differently than in previous years. Further work is planned to improve the consistency of the series, primarily in light of the changes referenced above.

11.4 Data analyses

The assessment of North Sea saithe was carried out using the FLR version of XSA (FLXSA 2.5) in R, version 2.15.3. An alternate assessment was run with a state-space stock assessment model (SAM; stockassessment.org). All input data were identical for both XSA and SAM. XSA was used to for the forecasts and the final model. Results of both assessments are presented.

11.4.1 Reviews of last year's assessment

Comments made in 2013 by the Internal Review Group are summarised below in italics, along with an explanation of how this WG addressed the comments.

The section is well written and all results are presented properly in figures and tables. However, the description of results in the text would benefit from including the most important results in the text, e.g. SSB_{2012}, F_{2012}.

Answer: Text was added to include the most important results.

Some of the distribution maps lack a legend. Would be nice to have uniform panels in figure.

Answer: Figures were standardized as much as possible, however, the maps are provided by several countries for the earlier years, so complete standardization was not possible.

11.4.2 Exploratory survey-based analyses

Log-abundance indices by cohort for the research survey indices are plotted in Figure 11.4.1 and show numbers-at-age for saithe ages 3 to 5 (IBTS) and 3 to 6 (NORACU) on the log-scale, linked by cohort. A strong year effect is apparent in all surveys in 2011 and 2013; this is reflected in the sharp increase in age 4 when compared to earlier cohorts. The NORACU and IBTS indices are similar until 2009, which is not surprising as these surveys occur concurrently.

Within-cohort correlations between ages for the two survey indices are presented in Figure 11.4.2. The catch numbers correlate well between cohorts for the immediate ages for the NORACU and IBTS-Q3 indices. The NORACU and IBTS-Q3 data are not independent; since 2008, data for both are based on the same age and length samples.

The two research surveys track similar trends until 2006 (Figures 11.4.3). As noted in section 11.3.5, NORACU was processed differently after 2009, which may explain differences in the last 3 years. A thorough review of this index is planned for the inter-benchmark in 2015.

11.4.3 Exploratory catch-at-age-based analyses

The catch curves for total catches are shown in Figure 11.4.4. The curves show that age 3 is only partially recruited to the fishery for the latter cohorts (after the mid 1990s), but fully recruited for many of the earlier cohorts. The catch curves in recent years are less steep than for earlier cohorts, which indicates that a change in exploitation occurred. This may be partially explained by declines in catches by the Norwegian purse seine fishery, which occurred in the early 1990s; purse seiners mainly target younger fish.

The catch-at-age for each of the commercial indices are plotted in Figure 11.4.5. For the trawl fleets, saithe are partially recruited to the fishery at age 3, but are not fully recruited until age 4, 5, or occasionally, age 6. This most likely reflects that these fisheries tend to occur on the spawning grounds and hence, are capturing older fish.

Within-cohort correlations between ages for the three commercial tuning indices are presented in Figures 11.4.6–11.4.8. For all indices, the catch numbers correlate well between cohorts for the older ages. For the younger ages (ages 3–4), the relationship is poor and breaks down quickly over time.

The three indices show relatively similar trends (Figure 11.4.9), but some differences are noted. The French index for age 8 shows a large discrepancy with the other two indices; however, this index is given less weight in the assessment. The Norwegian index for age

6 and 9 shows a large discrepancy with the other indices in 2010, but then mirrors the German index in 2011–2013.

11.4.4 Conclusions drawn from the exploratory analysis

All indices appear to track cohorts moderately well and are internally consistent. However, the NORACU and IBTS-Q3 indices after 2009 appear to be negatively correlated for ages 3 and 5 (Figure 11.4.10). The NORACU index is still under investigation and this relationship may not be present in the next assessment. For this assessment, no action was taken.

11.4.5 SAM Assessment

Settings used in the assessment are shown below; settings for SAM model are in parenthesis if different from XSA settings. SOP correction of the catches has been used since the 2011 assessment.

Year of assessment:	2011	2011 REOPENING	2012	2013	2014
Assessment model:	XSA	XSA	XSA	XSA (SAM)	XSA (SAM)
Fleets:	FRATRB_IV (ages 6-9, 1990 –2010)	FRATRB_IV (ages 3-9, 1990 –2010)	FRATRB_IV (ages 3-9, 1990–2011)	FRATRB_IV (ages 3-9, 1990–2012)	FRATRB_IV (ages 3-9, 1990–2013)
	GER_OTB_IV (ages 6-9, 1995 –2010)	GER_OTB_IV (ages 3-9, 1995 –2010)	GER_OTB_IV (ages 3-9, 1995–2011)	GER_OTB_IV (ages 3-9, 1995–2012)	GER_OTB_IV (ages 3-9, 1995–2013)
	NORTRL_IV2 (ages 6-9, 1993 –2010)	NORTRL_IV2 (ages 3-9, 1993 –2010)	NORTRL_IV2 (ages 3-9, 1993–2011)	NORTRL_IV2 (ages 3-9, 1993–2012)	NORTRL_IV2 (ages 3-9, 1993–2013)
	NORACU (ages 3-6, 1996 –2011)	NORACU (ages 3-6, 1996 –2010)	NORACU (ages 3-6, 1996–2011)	NORACU (ages 3-6, 1996–2012)	NORACU (ages 3-6, 1996–2013)
	IBTS-Q3 (ages 3-5, 1992 –2010)	IBTS-Q3 (ages 3-5, 1992–2010)	IBTS-Q3 (ages 3-5, 1992–2011)	IBTS-Q3 (ages 3-5, 1992–2012)	IBTS-Q3 (ages 3-5, 1992–2013)
	NORASS (ages 2-4, 2006 –2010)	NORASS (ages 2-4, 2006 –2010)			
Age range:	3-10+	3-10+	3-10+	3-10+	3-10+
Catch data:	1967–2010	1967–2010	1967–2011	1967–2012	1967–2013
Fbar:	3-6	3-6	3-6	3-6	3-6
Time series weights:	Tricubic over 20 years	Tricubic over 20 years	Tricubic over 20 years	Tricubic over 20 years; (NA)	Tricubic over 20 years; (NA)
Power model for ages:	No	No	No	No; (NA)	No; (NA)
Catchability plateau:	Age 7	Age 7	Age 7	Age 7	Age 7
Survivor est. shrunk towards the mean F:	5 years/ 3 ages	5 years/ 3 ages	5 years/ 3 ages	5 years/ 3 ages; (NA)	5 years/ 3 ages; (NA)

S.E. of mean (F-shrinkage):	1.0	1.0	1.0	1.0; (NA)	1.0; (NA)
Min. S.E. of population estimates:	0.3	0.3	0.3	0.3; (NA)	0.3; (NA)
Prior weighting:	No	No	No	No	No
Number of iterations before convergence:	53	60	60	47; (NA)	44; (NA)

Thirty-six parameters were estimated in the SAM model; the negative log-likelihood value was 719.82. Estimated catchabilities for the NORACU index were high (range 226–489), while IBTS Q3 ranged between 0.6-0.9, and all other indices were < 0.01. Estimated fishing mortality-at-age is given in Table 11.4.1 and estimated population numbers-at-age are in Table 11.4.2.

The log catchability residuals from the SAM-run are shown in Figure 11.4.11 and the retrospective analysis is in Figure 11.4.12.

The historic stock and fishery trends, including 95% confidence intervals, for the SAM assessment are in Figure 11.4.13 and Table 11.4.3.

11.4.6 Final assessment: XSA

Settings used in the XSA assessment are as in Section 11.4.5.

Outputs from the final run are given in Table 11.4.4 (diagnostics), Table 11.4.5 (fishing mortality-at-age), and Table 11.4.6 (population numbers-at-age).

The log catchability residuals from the final XSA-run are shown in Figure 11.4.14 and the retrospective analysis is in Figure 11.4.15. The residuals do not show any large patterns, although there are a few large, negative values in 2012 of the NORACU index; residuals are much less negative in the 2013 fishing year. The IBTS Q3 residuals in 2013 were moderately large and strictly positive, while the NORACU residuals were strictly negative showing that final XSA estimates are a compromise between both data sources. The retrospective analysis shows that F tends to be underestimated, while SSB and recruitment tend to be overestimated.

Recruitment estimates are lower and SSB estimates are higher for the XSA model compared to the SAM model. The XSA estimates are within the 95% confidence intervals generated by the SAM model. FLXSA estimates of recruitment and SSB were 61.407 million individuals and 186 306 t, respectively.

11.5 Historic Stock Trends

The historic stock and fishery trends from the final XSA assessment are presented in Figure 11.5.1 and Table 11.5.1. Fishing mortality has declined since the mid 1980s, but began increasing again in 2005. Currently, fishing mortality is at F_{MSY}. SSB increased from the early 1990s through 2005, but has since been steadily declining. SSB is currently below B_{pa} and MSY $B_{trigger}$. Recruitment has been highly variable, but also shows a decline since the mid 1990s. Recruitment is well below the geometric mean used in the assessment, which was for the period 2005-2013.

11.6 Recruitment estimates

There is currently no survey that provides an estimate of incoming recruitment. Previous forecasts used the years 1988-current assessment year to estimate the geometric mean; however, change-point analysis indicated that the geometric mean of the period 2005-2013 was significantly different than the mean 1988-2004. The WG decided to use the new period indicated by the change-point analysis.

The 2005–2013 geometric mean value (83 642) used in the short-term forecast is higher than the estimated recruitment for 2011 and 2013.

11.7 Short-term forecasts

A short-term forecast was carried out based on the FLXSA assessment.

Weight-at-age in the stock and catch were the mean values for the last 3 years. The exploitation pattern (selectivity pattern) was chosen as the mean exploitation pattern over the last three years. F was scaled to the F corresponding to the TAC in 2014. A TAC constraint for the intermediate year was chosen, i.e., the fishing mortality for 2014 was determined such that the landings in 2013 matched the TAC. Population numbers-at-age for ages 4 and older in 2014 were XSA survivor estimates, while numbers at age 3 were the geometric mean estimate of recruitment for the years 2005–2013. The short-term projection was run in FLR, using the FLSTF package (v. 1.99-1).

The input data for the short term forecast are given in Table 11.7.1.

The management options are given in Table 11.7.2. Assuming that the landings in 2014 are scaled to the TAC in 2014 results in an F_{2014} of 0.33 and a SSB in 2015 of 173 197 t, which is an 8% decline from the 2014 estimated SSB. Because estimated SSB in 2014 is below B_{pa}, paragraph 3 of the management plan stipulates that the TAC must not exceed the level that will result from a fishing mortality rate equal to 0.30-0.20*(200 000 – SSB)/94 000. Appling the sliding rule results in catches of no more than 81 490 t. If discard rates do not change from the average of the last 2 years (2012-2013), this implies landings of no more than 72 854 t, resulting in an SSB in 2016 of 178 867 t.

The contribution of recruitment of the 2008–2012 year classes to landings in 2015 and to SSB in 2016 are shown in Table 11.7.3 and Figure 11.7.1. The 2009 and 2011 year classes contribute the most to the forecasts. The 2009 year class was the most recent large year classes, evident as age 4 in the landings-at-age plot (Figure 11.3.5).

11.8 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

11.9 Biological reference points

The biological reference points were derived in 2006 and are:

$F_{0.1}$	0.10	F_{lim}	0.60	F_{max}	0.22	F_{MSY}	0.30
F_{pa}	0.40	F_{med}	0.35	F_{high}	>0.49		
B_{lim}	106 000 t	B_{pa}	200 000 t	MSY $B_{trigger}$	200 000 t		

These reference points refer to an F_{bar} for ages 3 to 6.

11.10 Estimation of F_{MSY}

The estimation of F_{MSY} values for Saithe was done during WGNSSK in 2010 with the Cefas ADMB module. The accepted assessment from 2009 was taken as basis for the calculations.

The analyses showed that F_{MSY} estimates are sensitive to the choice of the stock recruitment relationship and the part of the time series used as input. The hockey stick recruitment curve was chosen as being most appropriate. The median value of the bootstrap estimates was 0.3 and was chosen as F_{MSY}, however, there is considerable uncertainty around the estimate.

11.11 Quality of the assessment and forecast

This year's assessment of North Sea saithe was an update assessment. Similar issues as noted for previous assessments still hold true.

The poor reliability of the recruitment estimate is a major problem for the saithe assessment. There is no survey that adequately covers the recruiting age class.

The NORACU index is under investigation. Opposing trends are seen between the NORACU and IBTS-Q3 indices for ages 3 and 5 after 2009. The surveys take place at the same time, with the same vessel. These differences are under investigation.

The commercial CPUE indices may introduce biases into the assessment if changes in fishing patterns occur, as seen in 2009–2011. Furthermore, effort is estimated as hours trawling, which has the potential to introduce bias if the horsepower of the vessels has changed over time. Previous meetings of WGNSSK and the benchmark in 2011 concluded that this bias should be relatively minor. WGNSSK 2013 agreed that this should be investigated further in the inter-benchmark in 2015.

11.12 Status of the Stock

The general perception of the status of the saithe stock is more negative than last year. The spawning stock in 2013 is estimated to be below B_{pa} and MSY $B_{trigger}$.

11.13 Management Considerations

Saithe has had growing importance for both the Danish and Scottish fleets. The fishers' survey (Napier, 2012) shows a perception of an increasing stock which is not in accordance with the latest assessment. Reports from Norwegian fishers show concerns about increased landings from pelagic trawling and a possible change in exploitation pattern towards younger year classes. French and German industry representatives confirmed changes in fishing pattern for trawlers due to effort management and conflicts with gillnetters, especially in 2009 and 2010.

According to a RAC-meeting between scientist and fishers in Hanstholm in April 2012, the industry stated concern about the decline in stock weights after 2000. The fishing industry has also reported it is worried about conflicting data-sources and suggests that fishermen's knowledge should be used in the interpretation of the data.

Spawning stock biomass is below B_{pa} and recruitment estimates for the terminal year are uncertain. Advice can vary greatly depending on whether the stock is estimated to be above or below B_{pa} because of the restrictions within the harvest control rule and the sensitivity of the forecast to relatively small changes in the parameters. Recruitment is currently at a low level and it appears the strong recruitment pulses are more sporadic than in the past.

The reported landings, while relatively stable since the early 1990s, have been declining since 2010. Landings have been lower than the TAC for the past ten years. Reductions in the TAC in recent years has led to smaller differences between landings and TAC.

Bycatch of other demersal fish species does occur in the target trawl fishery for saithe. Saithe is also taken as unintentional bycatch in other fisheries, and discards may occur. Bycatch of saithe in all fisheries is presently estimated to be approximately 12 % of the official landings.

11.13.1 Evaluation of the Management plan

This assessment is run in terms with the management plan which is consistent with the precautionary approach in the short term conditional on the absence of major changes in the productivity and the absence of measurement and implementation error (ICES Advice 2008, Book 6, Paragraph 6.3.3.3). The EU–Norway management plan was reconsidered in February 2013, but no modification was implemented. It was previously evaluated by ICES (ICES, 2012a) and considered to be consistent with the precautionary approach in the short term (< 4 years).

11.14 References

ICES. 2012a. Report of the ICES Advisory Committee 2012. ICES Advice, 2012. Book 6, 447 pp.

ICES. 2012b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 27 April - 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:13.1346 pp.

ICES-WKBENCH, 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks. ICES CM 2011/ACOM:38

ICES, 2008. Report of the ICES Advisory Committee 2008. ICES Advice, 2008. Book 6, 326 pp.

Napier, I. R. 2012. Fishers' North Sea stock survey 2012. NAFC Marine Centre, Shetland, Scotland.

Table 11.3.1. Saithe in Subareas IV and VI and Division IIIa. Nominal landings (tonnes) of saithe, 2003-2013, as officially reported to ICES and estimated by the Working Group.

SAITHE IV and IIIa											
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
Belgium	45	22	28	16	18	7	27	15	2	1	3
Denmark	6954	7991	7498	7471	5458	8069	8802	8019	6325	5170	5690
Faroe Isl.	495	558	184	62	15	108	-	146	0	8	3
France	18001	13628	10768	15739	13043	15302	5445*	4582*	13856	14093	8484
Germany	8956	9589	12401	14390	12790	14141	13689	11192	10234	8007	9698
Greenland	1616	403	-	-	-	-	-	-	0	-	-
Ireland	0	1	-	0	-	81	81	-	0	0	0
Netherlands	11	3	40	28	5	3	17	3	24	34	168
Norway	61735	62783	67365	61268	45395	62055	57708	53031	46778	33028	35703
Poland	734	0	1100	-	-	1407	988	654	584	-	-
Russia	0	-	35	2	5	5	13	-	0	-	-
Sweden	1876	2249	2114	1695	1380	1639	1363	1545	1331	1305	1401
UK (E/W/NI)	1215	457	1190	9129**	9628**	11701**	12545**	11887**	10148**	7287**	10453**
UK (Scotland)	5829	5924	7703								
Total reported	107647	103608	110426	109800	87737	114518	100678	91074	89282	68933	71603
Unallocated	-5809	-3646	1117	7312	5881	-3085	4851	4026	422	952	222
ICES estimate	101658	99962	111543	117112	93618	111433	105529	95100	89704	69885	71825
TAC	165000	190000	145000	123250	135900	135900	125934	107000	93600	79320	91220

*Preliminary, **Scotland+E/W/NI combined

SAITHE VI											
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
Faroe Islands	2	34	21	76	32	23	-	24	5	6	25
France	3499	3053	3452	5782	3956	2617	2093	2003	2382	2612	3775
Germany	54	4	373	532	580	147	298	257	0	9	-
Ireland	170	95	168	243	322	208	208	519	359	341	313
Netherlands	-	-	-	-	-	1	-		0	0	0
Norway	28	16	20	28	377	78	68	249	160	47	715
Russia	6	6	25	7	2	50	4	2	0	-	-
Spain	6	2	3	-	-	-	-	-	0	-	-
UK (E/W/NI)	263	37	203	2748**	1419**	2887**	3501**	3168**	4399**	4549**	3646**
UK (Scotland)	1189	1563	4433								
Total reported	5217	4810	8698	9416	6688	6011	6172	6222	7305	7564	8474

Unallocated	33	-296	-2959	-848	98	1223	791	618	95	-357	-412
ICES estimate	5250	4514	5739	8568	6786	7234	6963	6840	7400	7207	8062
TAC	17119	20000	15044	12787	14100	14100	13066	11000	9570	8230	9464
*Preliminary	**Scotland+E/W/NI combined										

SAITHE IV, IIIa and VI

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*
ICES estimate	106908	104476	117282	125680	100404	118667	112492	101940	97104	77092	79887
TAC	182119	210000	160044	136037	150000	150000	139000	118000	103170	87550	100684

Table 11.3.2. Saithe in Subareas IV and VI and Division IIIa. Landed numbers (thousands) at age.

Year	3	4	5	6	7	8	9	10
1967	17330	16220	15531	2303	1594	292	198	183
1968	23223	21231	13184	6023	429	242	123	145
1969	30235	17681	11057	7609	5738	791	626	150
1970	37249	76661	15000	12128	3894	1792	318	267
1971	69808	57792	32737	4736	4248	2843	1874	774
1972	48075	66095	25317	21207	3672	2944	1641	1607
1973	54332	37698	26849	16061	8428	2000	1357	2381
1974	66938	33740	14123	20688	14666	5199	1477	1955
1975	56987	25864	10319	7566	13657	9357	3501	2687
1976	207823	53060	11696	6253	3976	5362	3586	3490
1977	27461	54967	14755	5490	3777	3447	3812	4701
1978	35059	27269	18062	3312	1138	1033	768	3484
1979	16332	14216	11182	8699	2805	733	540	2089
1980	17494	12341	9015	6718	5658	1150	509	2302
1981	26178	8339	6739	3675	3335	3396	657	2536
1982	31895	40587	9174	5978	2145	1454	982	1254
1983	28242	20604	26013	5678	4893	1494	1036	1327
1984	80933	32172	12957	13011	1657	1252	335	646
1985	134024	55605	13281	4765	3005	682	399	742
1986	55434	91223	15186	5381	2603	1456	445	900
1987	31220	97470	13990	3158	1811	1240	910	700
1988	32578	26408	35323	3828	1908	1104	776	680
1989	22128	30752	13187	10951	1557	739	419	488
1990	40808	19583	11322	4714	2776	745	281	364
1991	46117	29871	7467	3583	1716	953	367	458
1992	18404	33614	12753	3193	1524	696	518	422
1993	37823	20828	11845	3125	1568	1511	814	1026
1994	19958	40194	13034	4297	947	346	427	794
1995	26664	26034	14797	3774	3494	674	552	800
1996	11066	38861	11786	7731	3163	808	210	491
1997	15036	19299	30177	3676	2640	1012	291	288
1998	10363	31017	16367	16077	2231	1206	567	277
1999	9429	13872	26684	8389	10070	2346	891	657

2000 7064 17295 8940 12339 3159 3226 641 441

2001 16052 17646 22421 3349 3586 1772 1614 245

2002 19914 42331 8871 8899 2437 2976 1865 1623

2003 11661 20209 25759 6269 7061 1512 1979 1039

2004 5315 14987 17696 13412 3820 4104 1118 806

2005 13933 12508 16861 17796 11585 2838 2248 460

2006 9871 28211 12355 9364 11375 5958 1545 1432

2007 17486 7982 21443 7367 5639 5230 1800 975

2008 9692 24765 8119 17113 4561 3418 2407 1737

2009 9325 13046 16675 4970 10604 3600 2226 3191

2010 7355 8299 7842 6159 3281 4052 2153 3919

2011 9584 20747 5840 4362 2466 1500 2608 4450

2012 6608 10577 17833 3872 2007 1002 452 2884

2013 5024 25551 4964 7590 1858 1227 607 1638

Table 11.3.3. Saithe in Subareas IV and VI and Division IIIa. Landings weights at age (kg).

Year	3	4	5	6	7	8	9	10
1967	1.198	1.754	2.709	4.102	4.834	6.845	7.585	9.939
1968	0.993	1.283	1.544	2.337	3.138	3.438	4.765	5.751
1969	0.966	1.557	2.262	2.713	3.559	4.407	5.221	6.768
1970	0.941	1.440	2.058	2.718	3.599	4.462	5.686	6.844
1971	0.840	1.348	2.178	2.936	3.766	4.634	5.173	6.163
1972	0.808	1.196	1.961	2.368	3.794	4.227	4.630	6.325
1973	0.821	1.406	1.641	2.571	3.357	4.684	4.814	6.445
1974	0.861	1.561	2.383	2.753	3.429	4.498	5.713	7.857
1975	0.893	1.498	2.490	3.300	3.764	4.295	5.539	7.561
1976	0.703	1.309	2.261	3.071	4.036	4.384	5.113	7.149
1977	0.760	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.340	4.523	4.901	5.450	7.401
1979	1.107	1.623	2.238	3.095	4.051	5.275	6.308	7.956
1980	0.955	1.821	2.391	3.030	4.090	5.127	5.940	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.981	8.724
1982	1.086	1.575	2.530	3.220	4.207	5.126	5.905	8.824
1983	1.028	1.718	2.149	3.138	3.691	4.632	5.505	8.453
1984	0.795	1.614	2.296	2.690	3.896	4.664	6.183	8.473
1985	0.663	1.265	1.950	2.772	3.407	4.950	5.865	8.854
1986	0.694	1.035	1.794	2.431	3.572	4.209	5.650	8.218
1987	0.674	0.876	1.824	3.075	4.210	5.330	6.129	8.603
1988	0.779	0.981	1.386	2.791	4.024	5.254	6.322	8.649
1989	0.895	1.036	1.419	1.998	3.913	5.017	6.429	8.429
1990	0.844	1.195	1.582	2.247	3.241	4.857	6.313	8.414
1991	0.791	1.158	1.752	2.364	3.165	4.221	6.065	8.190
1992	0.964	1.189	1.607	2.242	3.668	4.330	5.412	7.045
1993	0.899	1.260	1.754	2.636	3.185	3.980	5.080	6.890
1994	0.944	1.119	1.601	2.434	3.617	4.787	6.548	8.326
1995	1.002	1.294	1.816	2.562	3.555	4.768	5.268	7.892
1996	0.967	1.188	1.807	2.368	2.952	4.706	6.094	8.384
1997	0.905	1.145	1.452	2.586	3.555	4.524	6.156	8.865
1998	0.892	0.966	1.392	1.744	2.948	3.883	4.995	7.227
1999	0.882	1.062	1.213	1.757	2.341	3.499	4.852	6.757

2000 1.094 1.199 1.638 1.793 2.761 3.283 5.082 7.944

2001 0.831 1.110 1.360 2.170 2.638 3.610 4.290 6.362

2002 0.861 0.918 1.415 1.873 2.446 3.322 4.190 4.004

2003 0.767 1.019 1.157 1.774 2.402 3.576 4.031 4.586

2004 0.964 1.116 1.382 1.740 2.722 3.411 4.712 6.109

2005 0.718 1.156 1.402 1.724 2.152 3.241 4.089 5.262

2006 0.917 1.025 1.384 1.784 2.133 2.647 3.885 5.492

2007 0.796 1.175 1.239 1.741 2.144 2.856 3.495 5.335

2008 0.952 1.176 1.532 1.770 2.457 3.028 3.600 4.600

2009 0.741 1.226 1.520 2.053 2.321 2.971 3.501 4.442

2010 0.981 1.429 1.935 2.554 3.066 3.477 3.927 4.937

2011 1.014 1.261 1.770 2.436 2.881 3.374 3.645 3.979

2012 0.996 1.321 1.391 2.215 3.158 3.495 4.281 4.071

2013 0.896 1.162 1.612 1.978 3.072 3.850 4.540 5.662

Table 11.3.4. Saithe in Subareas IV and VI and Division IIIa. Tuning indices considered for use in the 2014 assessment of saithe. Indices include three commercial unstandardized CPUE indices and three research surveys.

FRATRB_IV units= NA

	3	4	5	6	7	8	9
1990	21758	0.1553	0.1136	0.0646	0.01397	0.013328	0.001471	0.000643
1991	15248	0.0906	0.1664	0.0479	0.02440	0.008578	0.004394	0.000782
1992	7902	0.0907	0.1873	0.0630	0.00931	0.003037	0.000886	0.000727
1993	13527	0.2896	0.1666	0.0859	0.00766	0.000614	0.000639	0.000457
1994	14417	0.1228	0.2534	0.0958	0.03011	0.002698	0.000369	0.000188
1995	14632	0.2154	0.1150	0.0630	0.01542	0.004811	0.001646	0.000910
1996	16241	0.0551	0.2639	0.0648	0.03300	0.006627	0.001517	0.000933
1997	12903	0.0843	0.1484	0.2461	0.01473	0.006503	0.001281	0.001065
1998	13559	0.0590	0.1872	0.1379	0.10922	0.003854	0.001698	0.000766
1999	14588	0.0584	0.0846	0.1828	0.04251	0.027397	0.001660	0.000938
2000	8695	0.1023	0.2292	0.1195	0.13745	0.024701	0.020761	0.003652
2001	6366	0.1137	0.2104	0.3727	0.04241	0.022762	0.004014	0.004599
2002	11022	0.2972	0.6874	0.1107	0.11269	0.015905	0.013739	0.003714
2003	10536	0.1440	0.3071	0.2235	0.02509	0.030857	0.007642	0.010714
2004	5234	0.0854	0.1868	0.1951	0.09450	0.017689	0.006807	0.003778
2005	3015	0.1350	0.2191	0.2133	0.14209	0.069557	0.005202	0.004730
2006	5710	0.2945	0.5503	0.0966	0.02531	0.034901	0.006945	0.002319
2007	8255	0.5089	0.1261	0.3401	0.02917	0.012090	0.000372	NA
2008	7016	0.1252	0.2170	0.0350	0.13538	0.023503	0.004887	0.004749
2009	7093	0.0575	0.1684	0.1599	0.07619	0.017925	0.013590	0.005402
2010	6035	0.1096	0.1114	0.0937	0.03054	0.004563	0.013687	0.004643
2011	9985	0.1862	0.2348	0.0622	0.02210	0.006899	0.003955	0.004729
2012	11990	0.0506	0.1403	0.1956	0.06493	0.008559	0.000947	0.007561
2013	7632	0.0934	0.2375	0.0489	0.02744	0.005860	0.002447	0.001337

NORTRL_IV2 units= NA

	3	4	5	6	7	8	9
1993	24572	0.3107	0.1639	0.1171	0.0414	0.0214	0.01485	0.010256
1994	30628	0.1286	0.5256	0.1396	0.0302	0.0082	0.00235	0.006628
1995	32489	0.1338	0.2883	0.1666	0.0256	0.0506	0.00840	0.006248
1996	40400	0.0938	0.3572	0.1093	0.0684	0.0283	0.00468	0.000396
1997	36026	0.0803	0.1462	0.2731	0.0394	0.0248	0.00830	0.001999

1998 24510 0.0561 0.3378 0.2225 0.2310 0.0399 0.01995 0.009914

1999 21513 0.0378 0.1206 0.3193 0.1101 0.1674 0.05429 0.016083

2000 15520 0.0183 0.1049 0.1323 0.2745 0.0687 0.07751 0.014240

2001 23106 0.2081 0.2263 0.2819 0.0405 0.0534 0.02203 0.016879

2002 38114 0.1053 0.3165 0.0911 0.0990 0.0257 0.04282 0.027549

2003 41645 0.0391 0.1309 0.2510 0.0865 0.1064 0.01902 0.024109

2004 32726 0.0203 0.0818 0.1744 0.2010 0.0689 0.08067 0.020045

2005 34964 0.0344 0.0881 0.1481 0.2632 0.1989 0.04942 0.041014

2006 30190 0.0264 0.1363 0.1273 0.1527 0.2421 0.13163 0.026863

2007 26354 0.0593 0.0547 0.1777 0.1330 0.1007 0.11843 0.033657

2008 32550 0.0709 0.3181 0.1126 0.2567 0.0662 0.04974 0.037911

2009 29841 0.0359 0.1091 0.1989 0.0420 0.1787 0.05482 0.031266

2010 19341 0.0183 0.0538 0.0912 0.1348 0.0891 0.09441 0.054134

2011 26788 0.0542 0.2608 0.0425 0.0689 0.0276 0.02826 0.064059

2012 20784 0.1063 0.0298 0.1641 0.0332 0.0212 0.01588 0.002406

2013 20661 0.0331 0.3584 0.0235 0.0977 0.0285 0.01336 0.009099

GER_OTB_IV units= NA

	3	4	5	6	7	8	9
1995	21167	0.0547	0.1114	0.0638	0.0278	0.00718	0.00142	0.000756
1996	19064	0.0268	0.1661	0.0567	0.0271	0.01348	0.00776	0.002151
1997	21707	0.0376	0.1140	0.1675	0.0135	0.00751	0.00322	0.001106
1998	20153	0.0293	0.1362	0.0692	0.0881	0.01181	0.00496	0.001935
1999	18596	0.0153	0.0573	0.1217	0.0507	0.05458	0.00414	0.001936
2000	12223	0.0443	0.1788	0.0673	0.0995	0.01980	0.02659	0.003109
2001	11008	0.0810	0.1207	0.2105	0.0338	0.04833	0.02262	0.014081
2002	12789	0.0508	0.2860	0.0962	0.0860	0.00774	0.01095	0.005395
2003	14560	0.0343	0.0961	0.1806	0.0301	0.02692	0.00398	0.004945
2004	13708	0.0244	0.1488	0.1406	0.0787	0.01459	0.01714	0.003429
2005	11700	0.0371	0.0436	0.1387	0.1319	0.06726	0.01752	0.010171
2006	10815	0.0346	0.1456	0.0638	0.0618	0.06334	0.03236	0.013592
2007	12606	0.0743	0.0566	0.2231	0.0482	0.03213	0.03308	0.013882
2008	12871	0.0371	0.2448	0.0487	0.1291	0.02750	0.01709	0.017326
2009	16692	0.0215	0.0455	0.0757	0.0189	0.04242	0.01881	0.016235
2010	16046	0.0652	0.0695	0.0449	0.0275	0.00623	0.01508	0.010034
2011	13627	0.0413	0.1286	0.0593	0.0235	0.01695	0.00558	0.011448
2012	13735	0.0101	0.0465	0.1711	0.0236	0.01172	0.00830	0.002767

2013 13549 0.0176 0.0843 0.0368 0.0898 0.01683 0.00900 0.004428

NORACU units= NA

		3	4	5	6
1996	1	21480	29698	6125	4593
1997	1	22585	16188	24939	3002
1998	1	15180	48295	13540	11194
1999	1	16933	21109	27036	4399
2000	1	34551	82338	14213	13842
2001	1	72108	28764	17405	3870
2002	1	82501	163524	17479	4475
2003	1	67774	107730	41675	4581
2004	1	34153	43811	31636	6413
2005	1	48446	36560	27859	10174
2006	1	18909	58132	11378	7922
2007	1	77958	12070	32445	2384
2008	1	7122	18989	4180	10262
2009	1	NA	NA	NA	NA
2010	1	34953	35191	21222	6318
2011	1	18118	63591	6114	5455
2012	1	3232	1361	2460	354
2013	1	10023	12232	3028	2539

IBTS-Q3 units= NA

		3	4	5
1992	1	1.08	2.760	0.516
1993	1	7.96	2.781	1.129
1994	1	1.12	1.615	0.893
1995	1	13.96	2.501	1.559
1996	1	3.83	6.533	1.112
1997	1	3.76	3.351	7.461
1998	1	1.18	4.134	1.351
1999	1	2.09	1.907	3.155
2000	1	3.48	8.836	1.081
2001	1	21.61	6.206	3.959
2002	1	10.75	18.974	1.327

2003 1 19.27 23.802 13.402

2004 1 4.98 6.896 3.158

2005 1 8.89 6.870 4.994

2006 1 10.64 29.826 2.941

2007 1 34.02 5.593 11.763

2008 1 3.44 5.827 0.952

2009 1 1.35 1.703 0.568

2010 1 1.37 0.962 0.465

2011 1 4.49 8.424 1.064

2012 1 11.11 2.521 2.799

2013 1 14.90 16.493 1.807

Table 11.4.1. Saithe in Subareas IV and VI and Division IIIa. SAM: fishing mortalities at age.

Year \ Age	3	4	5	6	7	8	9+
1967	0.236	0.374	0.412	0.431	0.368	0.299	0.400
1968	0.243	0.392	0.404	0.401	0.332	0.279	0.380
1969	0.246	0.413	0.395	0.407	0.356	0.312	0.384
1970	0.272	0.459	0.413	0.416	0.354	0.315	0.358
1971	0.315	0.486	0.405	0.397	0.361	0.342	0.382
1972	0.361	0.510	0.398	0.407	0.376	0.362	0.380
1973	0.410	0.538	0.402	0.402	0.389	0.370	0.383
1974	0.451	0.563	0.422	0.418	0.416	0.388	0.384
1975	0.459	0.574	0.444	0.432	0.436	0.415	0.394
1976	0.479	0.598	0.481	0.452	0.440	0.422	0.390
1977	0.429	0.567	0.502	0.469	0.462	0.450	0.393
1978	0.412	0.535	0.490	0.443	0.448	0.432	0.369
1979	0.377	0.493	0.492	0.456	0.476	0.433	0.368
1980	0.363	0.475	0.505	0.483	0.492	0.455	0.397
1981	0.348	0.473	0.508	0.503	0.509	0.488	0.427
1982	0.368	0.526	0.556	0.542	0.527	0.490	0.421
1983	0.383	0.584	0.606	0.596	0.560	0.517	0.431
1984	0.416	0.677	0.647	0.614	0.534	0.501	0.398
1985	0.423	0.781	0.688	0.587	0.515	0.477	0.415
1986	0.388	0.848	0.736	0.585	0.514	0.475	0.460
1987	0.380	0.807	0.752	0.569	0.510	0.482	0.485
1988	0.372	0.751	0.765	0.587	0.522	0.495	0.488
1989	0.364	0.733	0.750	0.616	0.515	0.487	0.463
1990	0.356	0.709	0.736	0.607	0.514	0.473	0.446
1991	0.331	0.681	0.728	0.590	0.519	0.460	0.465
1992	0.282	0.628	0.721	0.593	0.536	0.473	0.486
1993	0.244	0.564	0.665	0.572	0.587	0.525	0.559
1994	0.212	0.530	0.635	0.532	0.580	0.505	0.576
1995	0.183	0.481	0.596	0.511	0.608	0.533	0.611
1996	0.162	0.420	0.558	0.507	0.577	0.522	0.566
1997	0.149	0.381	0.507	0.466	0.522	0.512	0.544
1998	0.140	0.354	0.478	0.437	0.464	0.499	0.541
1999	0.127	0.329	0.449	0.417	0.430	0.494	0.566

2000	0.114	0.298	0.415	0.388	0.386	0.430	0.514
2001	0.110	0.293	0.389	0.360	0.367	0.405	0.469
2002	0.114	0.282	0.363	0.353	0.386	0.416	0.513
2003	0.112	0.267	0.356	0.362	0.396	0.423	0.502
2004	0.110	0.262	0.349	0.361	0.397	0.426	0.465
2005	0.115	0.271	0.361	0.372	0.407	0.426	0.411
2006	0.119	0.275	0.372	0.380	0.413	0.433	0.387
2007	0.118	0.277	0.372	0.387	0.408	0.428	0.351
2008	0.121	0.293	0.398	0.399	0.410	0.412	0.352
2009	0.120	0.308	0.415	0.414	0.437	0.406	0.366
2010	0.110	0.311	0.405	0.417	0.446	0.405	0.380
2011	0.110	0.326	0.397	0.412	0.422	0.412	0.388
2012	0.104	0.356	0.404	0.404	0.400	0.396	0.366
2013	0.099	0.369	0.402	0.391	0.387	0.395	0.359

Table 11.4.2. Saithe in Subareas IV and VI and Division IIIa. SAM: Estimated population number-at-age.

Year \ Age	3	4	5	6	7	8	9	10+
1967	97734	63259	48146	6172	4483	1046	621	574
1968	112533	70615	41731	24441	2604	1784	494	551
1969	186839	66171	42617	24984	16868	2366	1621	539
1970	188339	184057	40741	31414	14916	8740	1368	1136
1971	265402	151600	105873	19191	16272	9935	6193	2111
1972	167544	177726	87291	62505	12247	9692	5927	5342
1973	163081	96858	95320	57526	31382	7429	5019	7431
1974	168552	82951	45342	63070	42447	18354	4857	7132
1975	175255	71611	34475	24173	38025	26239	11314	8112
1976	395142	102950	31288	18442	13179	19088	13123	11520
1977	102642	148747	37571	13558	9498	7982	11510	14568
1978	104402	65513	56897	13290	4621	3795	3217	12909
1979	66171	46351	32696	27806	7501	2497	1993	8674
1980	65447	37911	23671	18050	15642	3653	1566	7589
1981	122762	32112	21534	11090	9171	8250	1984	6473
1982	110525	98322	21519	14864	5927	4560	3470	4149
1983	108337	57412	56954	11632	9211	3257	2700	3882
1984	216858	67846	28739	26318	4656	3549	1304	2687
1985	317426	104297	29231	12729	9337	2166	1492	2399
1986	211082	145219	31320	12460	6737	4451	1231	2435
1987	109207	163081	33256	9645	5357	3555	2394	1913
1988	115151	59874	65056	10383	4684	2789	1943	1935
1989	81716	63895	26108	23389	4432	2083	1265	1576
1990	132191	42916	24343	10701	8308	2176	948	1268
1991	142486	63323	15943	9494	4895	3388	1110	1283
1992	85648	76650	24173	6964	4464	2357	1666	1293
1993	195048	57699	30031	7708	3071	2751	1655	2144
1994	114234	106298	29290	12250	2807	1167	1115	1989
1995	182773	70615	38025	11240	6572	1460	915	1708
1996	91126	131926	29673	17771	6871	2379	625	1188
1997	124119	69843	86077	11421	7022	2717	858	785
1998	81879	108554	44981	50111	6940	3464	1497	770
1999	83450	51431	74459	25185	29115	4577	1877	1351

2000	87291	85391	30394	42745	12685	13125	1991	1224
2001	203618	72911	72693	14328	17587	7212	6005	987
2002	177549	178796	37272	37086	7751	9464	4387	3867
2003	118302	104925	96375	20944	22181	4548	4916	3106
2004	68186	81064	72258	51896	13018	12623	2826	2705
2005	135808	53960	59042	58571	36498	8958	7004	1927
2006	90400	121905	39222	32370	34961	18086	5224	4650
2007	181317	43088	86509	24984	18854	15547	7743	4259
2008	91126	110194	25566	56840	16454	11227	9010	6816
2009	72330	50463	48776	14787	29792	11648	7699	10901
2010	97538	39656	26716	20018	8145	14219	7216	12765
2011	90672	87728	21696	14119	8365	4275	8279	13025
2012	76191	37160	55659	12320	7054	3780	1839	10515
2013	65973	79063	17096	28283	6929	4107	2204	6363

Table 11.4.3. Saithe in Subareas IV and VI and Division IIIa. SAM: Estimated recruitment, total stock biomass (TSB), spawning stock biomass (SSB), and average fishing mortality for ages 3 to 6 (F_{3-6}), 1967–2014. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	Recruits		Low	High	TSB	Low	High	SSB	Low	High	F36	Low	High
1967	97734	64714	147600	328404	262987	410093	132058	103431	168609	0.363	0.289	0.457	
1968	112533	78308	161716	442856	358606	546899	167376	131845	212484	0.360	0.292	0.445	
1969	186839	128343	271995	530195	431723	651127	226613	183223	280279	0.365	0.299	0.445	
1970	188339	131405	269941	719995	596269	869394	283509	233971	343536	0.390	0.325	0.469	
1971	265402	187104	376465	866312	724343	1036106	395142	324053	481826	0.401	0.336	0.478	
1972	167544	118960	235970	815862	689224	965767	433653	358261	524911	0.419	0.354	0.496	
1973	163081	115865	229537	786226	668405	924816	474967	391732	575888	0.438	0.372	0.516	
1974	168552	119186	238365	868046	740431	1017655	562980	465594	680736	0.463	0.393	0.546	
1975	175255	124896	245920	809361	689466	950105	528078	434180	642284	0.477	0.405	0.563	
1976	395142	272164	573687	825711	687556	991627	406769	332076	498261	0.503	0.425	0.595	
1977	102642	72837	144642	607435	512045	720595	344208	279439	423988	0.492	0.417	0.580	
1978	104402	74316	146667	492377	415218	583875	291268	235047	360937	0.470	0.400	0.551	
1979	66171	46643	93875	432787	366330	511299	265136	217389	323371	0.454	0.387	0.534	
1980	65447	46311	92490	396726	338979	464310	252963	209624	305263	0.456	0.389	0.535	
1981	122762	86253	174723	431922	366965	508377	242559	201267	292322	0.458	0.390	0.537	
1982	110525	78818	154988	482627	409919	568231	209819	176741	249087	0.498	0.429	0.578	
1983	108337	77278	151879	465562	397864	544778	230038	191591	276200	0.542	0.468	0.628	

1984	216858	153350	306668	484077	408390	573792	191760	161566	227597	0.589	0.506	0.685
1985	317426	220612	456726	507372	419142	614176	163898	139343	192780	0.620	0.530	0.724
1986	211082	150320	296404	453160	381689	538013	158895	135273	186642	0.639	0.544	0.751
1987	109207	78011	152879	379269	322447	446103	163244	139250	191372	0.627	0.537	0.731
1988	115151	82201	161309	330050	281838	386510	160492	134672	191262	0.619	0.532	0.719
1989	81716	58266	114602	272393	233610	317614	127134	107782	149962	0.616	0.530	0.716
1990	132191	94875	184182	279568	237085	329663	110525	94723	128964	0.602	0.518	0.699
1991	142486	102441	198186	283509	239237	335974	97831	84479	113293	0.583	0.501	0.678
1992	85648	61730	118834	272938	232349	320617	99608	86260	115023	0.556	0.477	0.648
1993	195048	141631	268611	365127	304220	438227	109974	94677	127742	0.511	0.439	0.595
1994	114234	83241	156765	343176	291169	404473	117125	101177	135587	0.477	0.410	0.556
1995	182773	136995	243848	420837	358230	494385	136626	118210	157911	0.443	0.380	0.516
1996	91126	68024	122074	385771	331217	449311	144206	125221	166071	0.412	0.353	0.481
1997	124119	92650	166279	396329	340665	461088	175606	149188	206703	0.376	0.321	0.440
1998	81879	61062	109794	374745	324183	433192	185165	157779	217304	0.352	0.300	0.413
1999	83450	61883	112533	364397	316280	419835	213203	181193	250867	0.330	0.281	0.389
2000	87291	64537	118066	396726	342891	459012	204025	174168	239001	0.304	0.257	0.360
2001	203618	151330	273972	467895	400453	546696	206282	175825	242016	0.288	0.243	0.342
2002	177549	132119	238599	489921	419151	572641	195048	166959	227863	0.278	0.234	0.330
2003	118302	87978	159080	421258	363159	488651	216425	184540	253820	0.274	0.231	0.326

2004	68186	50408	92235	413329	357132	478369	248451	211727	291544	0.271	0.228	0.321
2005	135808	101035	182550	454976	394584	524611	282660	240148	332698	0.280	0.237	0.331
2006	90400	67014	121947	475442	411533	549276	269952	229397	317678	0.286	0.242	0.338
2007	181317	134993	243536	449100	386438	521921	239666	203217	282651	0.289	0.244	0.341
2008	91126	67692	122673	461852	399024	534572	257301	217739	304050	0.303	0.256	0.358
2009	72330	53340	98082	389648	335558	452458	261189	219158	311282	0.314	0.265	0.373
2010	97538	71781	132537	422946	362826	493028	257816	213434	311426	0.311	0.261	0.370
2011	90672	66633	123382	413329	352247	485004	203414	167668	246781	0.311	0.260	0.372
2012	76191	55671	104274	319336	272062	374825	174033	143933	210427	0.317	0.262	0.384
2013	65973	45868	94891	316159	264608	377752	165711	134672	203903	0.316	0.254	0.392

Table 11.4.4. Saithe in Subareas IV and VI and Division IIIa. FLR XSA: Diagnostics

FLR XSA Diagnostics 2014-05-18 14:43:54

CPUE data from indices

Catch data for 47 years. 1967 to 2013. Ages 3 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	FRATRB_IV	3	9	1990	2013	0	1
2	NORTRL_IV2	3	9	1993	2013	0	1
3	GER_OTB_IV	3	9	1995	2013	0	1
4	NORACU	3	6	1996	2013	0.5	0.75
5	IBTS-Q3	3	5	1992	2013	0.5	0.75

Time series weights :

Tapered time weighting applied
Power = 3 over 20 years

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 7

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 5 years or the 3 oldest ages.

S.E. of the mean to which the estimates are shrunk = 1

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

age	year 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

age	year 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
3	0.061	0.085	0.188	0.191	0.174	0.209	0.068	0.226	0.074	0.095
4	0.194	0.198	0.247	0.229	0.453	0.374	0.291	0.277	0.419	0.450
5	0.228	0.348	0.307	0.301	0.386	0.637	0.405	0.343	0.408	0.354
6	0.288	0.378	0.332	0.303	0.420	0.433	0.513	0.415	0.402	0.303
7	0.294	0.433	0.445	0.342	0.312	0.502	0.575	0.398	0.341	0.342
8	0.416	0.372	0.416	0.378	0.359	0.435	0.362	0.569	0.277	0.361
9	0.625	0.423	0.356	0.211	0.299	0.420	0.508	0.421	0.331	0.270
10	0.625	0.423	0.356	0.211	0.299	0.420	0.508	0.421	0.331	0.270

XSA population number (NA)

year	age 3	4	5	6	7	8	9	10
2004	99833	94006	95798	59318	16553	13332	2658	1894
2005	189407	76927	63404	62421	36429	10096	7202	1461
2006	63528	142466	51665	36655	35003	19344	5698	5244
2007	111137	43081	91115	31120	21538	18365	10446	5625
2008	67137	75170	28049	55196	18813	12531	10304	7384
2009	54695	46197	39135	15618	29706	11276	7167	10189
2010	123933	36343	26019	16953	8290	14727	5975	10764
2011	52334	94813	22246	14206	8307	3819	8391	14195
2012	102456	34175	58854	12929	7684	4570	1769	11218
2013	61407	77904	18410	32050	7082	4475	2835	7599

Estimated population abundance at 1st Jan 2014

age

year 3 4 5 6 7 8 9 10

2014 0 45731 40664 10581 19373 4117 2554 1772

Fleet: FRATRB_IV

Log catchability residuals.

year

age 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

3 0.137 -0.562 -0.263 0.441 -0.068 -0.333 -1.009 -0.958 -0.452 -1.203 -0.243 -0.995 0.144 -0.179 -0.477 -0.648

4 0.041 0.158 0.082 0.039 0.124 -0.409 -0.572 -0.477 -0.606 -0.483 -0.364 0.011 0.338 -0.337 -0.431 -0.070

5 0.000 0.023 0.263 0.192 0.248 -0.437 -0.224 -0.075 0.024 0.006 0.477 0.623 -0.136 -0.254 -0.386 0.171

6 -0.390 0.197 -0.432 -0.367 0.315 -0.432 0.134 -0.655 0.143 -0.096 0.870 0.431 0.396 -0.735 -0.194 0.205

7 0.762 0.460 -0.650 -1.746 0.031 0.006 0.080 -0.058 -0.832 0.059 0.579 0.332 0.624 0.277 0.052 0.695

8 -0.375 0.353 -1.254 -1.522 -1.629 0.324 -0.142 -0.779 -0.726 -0.990 0.395 -0.755 0.367 0.481 -0.631 -0.642

9 -0.057 -0.368 -0.848 -1.262 -1.993 -0.066 0.607 0.240 -0.597 -0.559 0.558 -0.641 -0.258 0.774 0.484 -0.376

year

age 2006 2007 2008 2009 2010 2011 2012 2013

3 1.273 1.262 0.356 -0.202 -0.441 1.026 -1.020 0.115

4 0.258 -0.028 0.060 0.258 0.047 -0.173 0.397 0.114

5 -0.435 0.254 -0.804 0.493 0.265 -0.016 0.186 -0.062

6 -1.010 -0.717 0.298 0.992 0.031 -0.160 1.006 -0.807

7 0.051 -0.570 0.216 -0.426 -0.486 -0.153 0.115 -0.182

8 -0.983 -3.876 -0.927 0.236 -0.057 0.144 -1.597 -0.587

9 -0.885 NA -0.787 -0.240 -0.170 -0.530 1.455 -0.778

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8	9
Mean_Logq	-13.3670	-12.5069	-12.5123	-12.9223	-13.5641	-13.5641	-13.5641
S.E_Logq	0.6904	0.3017	0.3322	0.5614	0.5597	0.9596	0.7403

Fleet: NORTRL_IV2

Log catchability residuals.

year																
age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
3	1.551	1.018	0.230	0.563	0.034	0.538	-0.599	-0.924	0.649	0.147	-0.442	-0.876	-0.976	-0.099	0.153	0.827
4	0.536	1.367	1.024	0.245	0.022	0.498	0.386	-0.632	0.598	0.076	-0.676	-0.743	-0.467	-0.623	-0.349	0.957
5	0.547	0.670	0.581	0.343	0.074	0.548	0.609	0.624	0.389	-0.285	-0.093	-0.452	-0.148	-0.114	-0.350	0.410
6	0.587	-0.415	-0.658	0.130	-0.405	0.158	0.122	0.828	-0.349	-0.467	-0.231	-0.173	0.088	0.054	0.067	0.204
7	0.253	-0.410	0.806	-0.021	-0.273	-0.048	0.317	0.049	-0.367	-0.447	-0.037	-0.140	0.193	0.435	-0.002	-0.301
8	0.071	-1.330	0.401	-0.568	-0.463	0.185	0.946	0.160	-0.605	-0.049	-0.159	0.289	0.057	0.406	0.335	-0.159
9	0.296	0.017	0.308	-1.803	-0.683	0.411	0.730	0.366	-0.893	0.193	0.033	0.601	0.231	0.012	-0.435	-0.262

year					
age	2009	2010	2011	2012	2013
3	0.368	-1.190	0.833	0.762	0.116
4	0.338	-0.168	0.446	-0.637	1.039
5	0.757	0.283	-0.352	0.056	-0.751
6	-0.337	0.782	0.244	-0.398	-0.271
7	0.321	0.933	-0.320	-0.532	-0.154
8	0.078	0.322	0.558	-0.329	-0.443

9 -0.037 0.733 0.523 -1.243 -0.412

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8	9
Mean_Logq	-14.4069	-13.0208	-12.5575	-12.1887	-12.0117	-12.0117	-12.0117
S.E_Logq	0.7379	0.6483	0.4388	0.4089	0.3948	0.4965	0.6591

Fleet: GER_OTB_IV

Log catchability residuals.

year															
age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.361	-0.389	-0.422	0.192	-1.202	0.264	0.009	-0.279	-0.269	-0.388	-0.597	0.474	0.682	0.482	0.159	0.383
4	0.359	-0.235	0.059	-0.125	-0.074	0.186	0.255	0.261	-0.699	0.141	-0.885	-0.272	-0.030	0.980	-0.251	0.375
5	-0.095	-0.029	-0.131	-0.336	-0.071	0.233	0.382	0.053	-0.138	-0.383	0.071	-0.520	0.162	-0.143	0.075	-0.140
6	0.199	-0.021	-0.704	-0.030	0.122	0.588	0.245	0.167	-0.512	-0.335	0.171	-0.076	-0.174	0.292	-0.359	-0.033
7	-0.013	0.370	-0.333	-0.131	0.329	-0.062	0.666	-0.516	-0.278	-0.560	0.242	0.227	-0.012	-0.046	0.016	-0.594
8	-0.246	1.072	-0.276	-0.073	-0.495	0.223	0.554	-0.280	-0.590	-0.127	0.153	0.136	0.193	-0.094	0.142	-0.379
9	-0.671	1.022	-0.142	-0.090	-0.255	-0.023	0.058	-0.305	-0.418	-0.032	-0.030	0.464	-0.188	0.088	0.441	0.181

year			
age	2011	2012	2013
3	0.864	-1.286	-0.213
4	0.025	0.091	-0.123
5	0.266	0.382	-0.016
6	-0.058	0.035	0.420

7 0.326 0.010 0.454

8 0.068 0.155 0.296

9 -0.066 0.030 0.001

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	3	4	5	6	7	8	9
Mean_Logq	-14.7102	-13.3065	-12.8418	-12.9636	-13.1446	-13.1446	-13.1446
S.E_Logq	0.5783	0.4035	0.2438	0.3181	0.3540	0.3867	0.3615

Fleet: NORACU

Log catchability residuals.

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
3	-0.207	-0.532	-0.056	-0.703	0.412	0.289	0.608	0.810	0.343	0.067	0.283	1.142	-0.757	NA	0.154	0.458	-2.032
4	-0.658	-0.596	0.142	0.238	0.691	0.120	1.002	0.692	0.198	0.220	0.098	-0.289	-0.253	NA	0.990	0.614	-2.122
5	-0.168	0.030	0.103	0.512	0.746	-0.047	0.385	0.445	0.158	0.518	-0.199	0.278	-0.540	NA	1.172	0.045	-1.798
6	0.733	0.264	0.392	0.167	1.121	0.544	-0.326	0.071	-0.379	0.088	0.341	-0.714	0.245	NA	0.999	0.967	-1.681

age	2013
3	-0.376
4	-0.731
5	-0.461
6	-0.680

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	3	4	5	6
Mean_Logq	-1.2528	-0.7156	-0.9984	-1.5414
S.E_Logq	0.7369	0.7694	0.6445	0.7176

Fleet: IBTS-Q3

Log catchability residuals.

year																	
age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
3	-1.704	-0.148	-1.777	-0.093	-0.704	-1.098	-1.381	-1.569	-0.656	0.312	-0.202	0.781	-0.355	-0.400	0.936	1.541	
4	-0.525	-0.489	-1.332	-0.659	-0.736	-0.734	-0.880	-0.729	-0.104	0.023	0.285	0.619	-0.214	-0.015	0.867	0.379	
5	-0.338	-0.010	-0.292	-0.016	-0.175	0.523	-0.503	0.063	-0.130	0.172	-0.493	1.010	-0.447	0.498	0.148	0.963	

year						
age	2008	2009	2010	2011	2012	2013
3	-0.258	-0.969	-1.859	0.290	0.430	1.249
4	0.002	-0.790	-1.173	0.029	-0.069	1.005
5	-0.320	-1.014	-0.949	-0.004	0.031	0.722

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	3	4	5
Mean_Logq	-9.3885	-9.0601	-9.6058
S.E_Logq	0.9885	0.6285	0.5349

Terminal year survivor and F summaries:

Age 3 Year class = 2010

source survivors N scaledWts

FRATRB_IV 51295 1 0.165

NORTRL_IV2 51348 1 0.203

GER_OTB_IV 36954 1 0.262

NORACU 31404 1 0.143

IBTS-Q3 159421 1 0.103

fshk 27950 1 0.125

Age 4 Year class = 2009

source survivors N scaledWts

FRATRB_IV 40282 2 0.415

NORTRL_IV2 102262 2 0.131

GER_OTB_IV 24679 2 0.220

NORACU 10275 2 0.078

IBTS-Q3 95043 2 0.103

fshk 52489 1 0.052

Age 5 Year class = 2008

source survivors N scaledWts

FRATRB_IV 13345 3 0.316

NORTRL_IV2 6324 3 0.155

GER_OTB_IV 11395 3 0.339

NORACU 5292 3 0.066

IBTS-Q3 15622 3 0.092

fshk 8157 1 0.032

Age 6 Year class = 2007

source survivors N scaledWts

FRATRB_IV 16306 4 0.233

NORTRL_IV2 16190 4 0.214

GER_OTB_IV 27870 4 0.404

NORACU 10108 4 0.067

IBTS-Q3 15321 3 0.057

fshk 12436 1 0.025

Age 7 Year class = 2006

source survivors N scaledWts

FRATRB_IV 4233 5 0.260

NORTRL_IV2 3217 5 0.240

GER_OTB_IV 5308 5 0.397

NORACU 2422 3 0.038

IBTS-Q3 2336 3 0.038

fshk 3143 1 0.026

Age 8 Year class = 2005

source survivors N scaledWts

FRATRB_IV 2883 6 0.181

NORTRL_IV2 2056 6 0.282

GER_OTB_IV 2803 6 0.463

NORACU 5472 3 0.024

IBTS-Q3 1137 3 0.024

fshk 2235 1 0.026

Age 9 Year class = 2004

source survivors N scaledWts

FRATRB_IV 1432 7 0.148

NORTRL_IV2 1610 7 0.255

GER_OTB_IV 1969 7 0.547

NORACU 3903 3 0.012

IBTS-Q3 1215 3 0.012

fshk 1368 1 0.025

Table 11.4.5. Saithe in Subareas IV and VI and Division IIIa. XSA: Fishing mortality-at-age.

year	3	4	5	6	7	8	9	10
1967	0.163	0.263	0.378	0.484	0.416	0.260	0.389	0.389
1968	0.255	0.307	0.355	0.245	0.152	0.100	0.167	0.167
1969	0.118	0.314	0.260	0.357	0.391	0.464	0.407	0.407
1970	0.152	0.490	0.483	0.507	0.313	0.202	0.343	0.343
1971	0.268	0.373	0.400	0.274	0.332	0.397	0.336	0.336
1972	0.371	0.440	0.277	0.492	0.354	0.405	0.420	0.420
1973	0.499	0.563	0.320	0.284	0.369	0.332	0.330	0.330
1974	0.688	0.675	0.424	0.439	0.456	0.411	0.438	0.438
1975	0.427	0.629	0.446	0.424	0.587	0.597	0.541	0.541
1976	0.911	0.931	0.661	0.538	0.414	0.483	0.482	0.482
1977	0.297	0.655	0.737	0.771	0.747	0.784	0.775	0.775
1978	0.543	0.545	0.464	0.355	0.348	0.463	0.392	0.392
1979	0.265	0.442	0.450	0.426	0.582	0.398	0.472	0.472
1980	0.340	0.328	0.563	0.540	0.549	0.503	0.535	0.535
1981	0.183	0.268	0.299	0.472	0.569	0.768	0.609	0.609
1982	0.386	0.479	0.534	0.475	0.563	0.525	0.525	0.525
1983	0.306	0.465	0.656	0.762	0.936	1.030	0.919	0.919
1984	0.572	0.691	0.607	0.836	0.523	0.662	0.680	0.680
1985	0.644	1.044	0.697	0.470	0.460	0.424	0.455	0.455
1986	0.239	1.392	0.951	0.690	0.512	0.424	0.547	0.547
1987	0.361	0.864	0.835	0.517	0.525	0.493	0.516	0.516
1988	0.370	0.596	0.936	0.572	0.692	0.722	0.668	0.668
1989	0.374	0.726	0.687	0.885	0.484	0.639	0.675	0.675
1990	0.477	0.673	0.653	0.564	0.580	0.452	0.536	0.536
1991	0.459	0.790	0.593	0.441	0.411	0.400	0.420	0.420
1992	0.246	0.731	0.986	0.550	0.339	0.290	0.396	0.396
1993	0.320	0.486	0.622	0.700	0.580	0.672	0.656	0.656
1994	0.239	0.673	0.650	0.482	0.470	0.238	0.401	0.401
1995	0.139	0.563	0.565	0.391	0.956	0.738	0.740	0.740
1996	0.115	0.310	0.540	0.663	0.673	0.601	0.536	0.536
1997	0.108	0.301	0.422	0.319	0.498	0.471	0.451	0.451
1998	0.176	0.337	0.452	0.418	0.326	0.446	0.529	0.529
1999	0.076	0.377	0.546	0.442	0.507	0.684	0.707	0.707

2000 0.085 0.195 0.448 0.529 0.295 0.299 0.398 0.398

2001 0.082 0.316 0.417 0.299 0.284 0.268 0.239 0.239

2002 0.122 0.322 0.259 0.288 0.370 0.405 0.504 0.504

2003 0.106 0.175 0.331 0.295 0.392 0.415 0.521 0.521

2004 0.061 0.194 0.228 0.288 0.294 0.416 0.625 0.625

2005 0.085 0.198 0.348 0.378 0.433 0.372 0.423 0.423

2006 0.188 0.247 0.307 0.332 0.445 0.416 0.356 0.356

2007 0.191 0.229 0.301 0.303 0.342 0.378 0.211 0.211

2008 0.174 0.453 0.386 0.420 0.312 0.359 0.299 0.299

2009 0.209 0.374 0.637 0.433 0.502 0.435 0.420 0.420

2010 0.068 0.291 0.405 0.513 0.575 0.362 0.508 0.508

2011 0.226 0.277 0.343 0.415 0.398 0.569 0.421 0.421

2012 0.074 0.419 0.408 0.402 0.341 0.277 0.331 0.331

2013 0.095 0.450 0.354 0.303 0.342 0.361 0.270 0.270

Table 11.4.6. Saithe in Subareas IV and VI and Division IIIa. XSA: Estimated population number-at-age.

year	3	4	5	6	7	8	9	10
1967	127456	77470	54512	6638	5177	1407	680	621
1968	114114	88671	48750	30578	3351	2796	888	1041
1969	300689	72416	53388	27984	19585	2356	2070	490
1970	291836	218825	43291	33705	16026	10843	1213	1008
1971	327932	205231	109793	21871	16622	9598	7256	2974
1972	171373	205323	115736	60269	13622	9765	5286	5132
1973	152852	96808	108299	71849	30155	7830	5330	9288
1974	148741	75984	45149	64373	44292	17063	4601	6037
1975	181240	61210	31681	24186	33985	22993	9266	7036
1976	384114	96822	26712	16601	12956	15467	10359	9984
1977	118019	126440	31261	11287	7934	7009	7812	9495
1978	92456	71778	53784	12243	4273	3079	2620	11785
1979	77657	43974	34092	27691	7027	2469	1586	6075
1980	67153	48803	23139	17794	14801	3215	1358	6077
1981	172857	39151	28790	10788	8490	6998	1592	6076
1982	109994	117837	24509	17473	5507	3933	2657	3358
1983	118272	61196	59752	11765	8897	2568	1904	2400
1984	205300	71278	31460	25384	4495	2856	751	1428
1985	312017	94853	29247	14033	9010	2181	1206	2223
1986	288633	134188	27346	11929	7178	4658	1169	2336
1987	113903	186153	27322	8648	4898	3521	2496	1899
1988	116425	65007	64214	9710	4223	2371	1761	1522
1989	78398	65843	29329	20612	4487	1731	943	1085
1990	118953	44164	26082	12081	6967	2265	748	959
1991	138487	60466	18439	11110	5626	3193	1180	1461
1992	93424	71655	22477	8340	5853	3053	1751	1414
1993	152586	59837	28251	6862	3939	3413	1870	2327
1994	103741	90704	30144	12412	2791	1807	1427	2632
1995	226372	66877	37893	12887	6274	1428	1166	1667
1996	112546	161212	31198	17636	7136	1975	559	1294
1997	162979	82132	96826	14878	7443	2980	887	870
1998	71024	119831	49782	51970	8855	3705	1524	737
1999	142258	48773	70045	25948	28002	5231	1942	1414

2000 95717 107939 27380 33203 13654 13814 2160 1475
2001 225436 71975 72724 14328 16020 8321 8391 1269
2002 192200 170046 42961 39255 8700 9871 5209 4487
2003 127706 139342 100919 27147 24087 4918 5389 2800
2004 99833 94006 95798 59318 16553 13332 2658 1894
2005 189407 76927 63404 62421 36429 10096 7202 1461
2006 63528 142466 51665 36655 35003 19344 5698 5244
2007 111137 43081 91115 31120 21538 18365 10446 5625
2008 67137 75170 28049 55196 18813 12531 10304 7384
2009 54695 46197 39135 15618 29706 11276 7167 10189
2010 123933 36343 26019 16953 8290 14727 5975 10764
2011 52334 94813 22246 14206 8307 3819 8391 14195
2012 102456 34175 58854 12929 7684 4570 1769 11218
2013 61407 77904 18410 32050 7082 4475 2835 7599

Table 11.5.1. Saithe in Subareas IV and VI and Division IIIa. Historic stock and fishery trends, 1967–2013.

Year	Recruitment	SSB	Catch	Landings	TSB	Fbar3-6	Y/SSB
1967	127456	194228	113751	113751	509444	0.322	0.59
1968	114114	164413	88326	88326	404127	0.291	0.54
1969	300689	263979	130588	130588	694193	0.262	0.49
1970	291836	311949	234962	234962	890441	0.408	0.75
1971	327932	429606	265381	265381	1018391	0.329	0.62
1972	171373	474022	261877	261877	903522	0.395	0.55
1973	152852	534466	242499	242499	847459	0.416	0.45
1974	148741	554917	298351	298351	833756	0.556	0.54
1975	181240	472030	271584	271584	743383	0.482	0.58
1976	384114	351617	343967	343967	752450	0.76	0.98
1977	118019	263129	216395	216395	509448	0.615	0.82
1978	92456	268133	155141	155141	463900	0.477	0.58
1979	77657	241084	128360	128360	419194	0.396	0.53
1980	67153	235196	131908	131908	396848	0.443	0.56
1981	172857	241263	132278	132278	495293	0.306	0.55
1982	109994	210527	174351	174351	511914	0.469	0.83
1983	118272	214392	180044	180044	467507	0.548	0.84
1984	205300	176854	200834	200834	466301	0.677	1.14
1985	312017	161191	220869	220869	491143	0.714	1.37
1986	288633	152337	198596	198596	488432	0.818	1.3
1987	113903	154307	167514	167514	387346	0.644	1.09
1988	116425	149996	135172	135172	324265	0.619	0.9
1989	78398	117888	108877	108877	262669	0.668	0.92
1990	118953	107607	103800	103800	267954	0.592	0.96
1991	138487	107158	108048	108048	288537	0.571	1.01
1992	93424	109016	99742	99742	284220	0.628	0.91
1993	152586	113947	111491	111491	331942	0.532	0.98
1994	103741	126196	109622	109622	327874	0.511	0.87
1995	226372	139287	121810	121810	463680	0.414	0.87
1996	112546	150397	114997	114997	443063	0.407	0.76
1997	162979	200254	107327	107327	473600	0.287	0.54
1998	71024	200890	106123	106123	392469	0.346	0.53
1999	142258	211125	110716	110716	410732	0.361	0.52
2000	95717	210157	91322	91322	444303	0.314	0.43
2001	225436	225582	95042	95042	513672	0.278	0.42
2002	192200	226007	115395	115395	549809	0.248	0.51
2003	127706	256368	105569	105569	514878	0.227	0.41
2004	99833	315944	104237	104237	551425	0.193	0.33
2005	189407	320700	124532	124532	569725	0.252	0.39
2006	63528	307605	125681	125681	518007	0.269	0.41
2007	111137	300500	101202	101202	471261	0.256	0.34
2008	67137	286518	119305	119305	448267	0.358	0.42

2009	54695	251814	115747	115747	361586	0.413	0.46
2010	123933	235249	101940	101940	420400	0.319	0.43
2011	52334	200525	96217	96217	370480	0.315	0.48
2012	102456	183311	77447	77447	351187	0.326	0.42
2013	61407	186306	79684	79684	333520	0.301	0.43

Table 11.7.1. Saithe in Subareas IV and VI and Division IIIa. Input data for the short term forecast. Age 10 is a plus group.

Age	Year	F	Stock.n	Stock.wt	Landings.wt	Maturity	M
3	2014	0.139	83643	0.97	0.97	0	0.2
4	2014	0.403	45730	1.25	1.25	0.15	0.2
5	2014	0.389	40663	1.59	1.59	0.7	0.2
6	2014	0.394	10581	2.21	2.21	0.9	0.2
7	2014	0.381	19372	3.04	3.04	1	0.2
8	2014	0.425	4117	3.57	3.57	1	0.2
9	2014	0.360	2553	4.16	4.16	1	0.2
10	**2014**	**0.360**	**6520**	**4.57**	**4.57**	**1**	**0.2**

Table 11.7.2. Saithe in Subareas IV and VI and Division IIIa. Management option table. Basis: F (2014) = [TAC constraint] = 0.33; SSB (2015) = 173 197; R (2014) = GM (2005–2013) = 83.643 million; landings (2014) = TAC (2014) = 85 581.

Rationale	Landings 2015	Landings IIIa & IV 20151	Landings VI 20151	Basis	F 2015	SSB 2016	% SSB change 2	% TAC change 3
Management plan	72 854	66 006	6848	Management plan	0.28	178 867	3.2	-14.9
MSY approach	69 364	62 844	6520	FMSY* (SSB2015/Btrigger)	0.26	182 015	4.8	-18.9
Precautionary approach	49 533	44 877	4656	Bpa (F2013*0.51)	0.18	200 001	13.4	-42.1
Zero catch	0	0	0	F = 0	0.00	245 585	29.5	-100.0
Other options	78 185	70 836	7349	FMSY	0.30	174 070	0.5	-8.6
	84 932	76 948	7984	F2014	0.331	168 020	-3.1	-0.8
	85 581	77 536	8045	TAC2013	0.334	167 440	-3.4	0.0

[1] Landings split according to agreement: 90.6% in Subarea IV and Division IIIa West and 9.4% in Subarea VI.

[2] SSB 2016 relative to SSB 2015.

[3] Landings 2015 relative to TAC 2014.

Table 11.7.3. Saithe in Subareas IV and VI and Division IIIa. Stock number of recruits and their source for recent year-classes used in predictions, and relative (%) contributions to landings and SSB (by weight) of these year-classes.

Year-class	2008	2009	2010	2011	2012
Stock no. (thousands) of 3 years old	52334	102456	61407	83643	83643
Source	XSA	XSA	XSA	GM05-13	GM05-13
Status Quo F:					
% in 2013 landings	8.12	22.21	20.2	11.16	-
% in 2014 landings	6.02	17.45	13.76	26.52	11.18
% in 2013 SSB	11.14	23.98	4.53	0	-
% in 2014 SSB	10.24	25.91	16.08	6.44	0.00
% in 2015 SSB	6.95	22.54	16.45	21.64	6.56

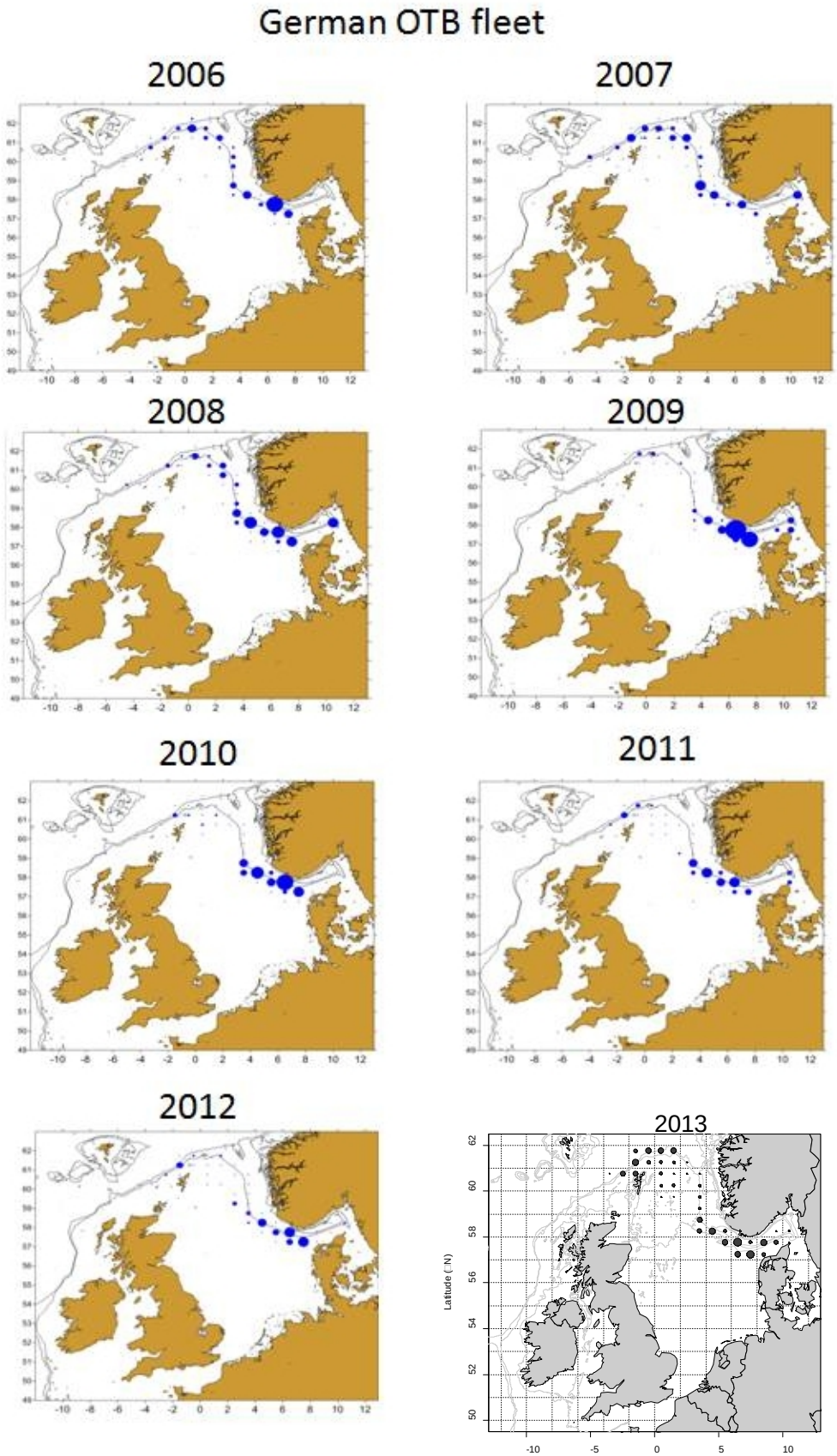


Figure 11.1.1. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of catch from the German trawl 2006–2013.

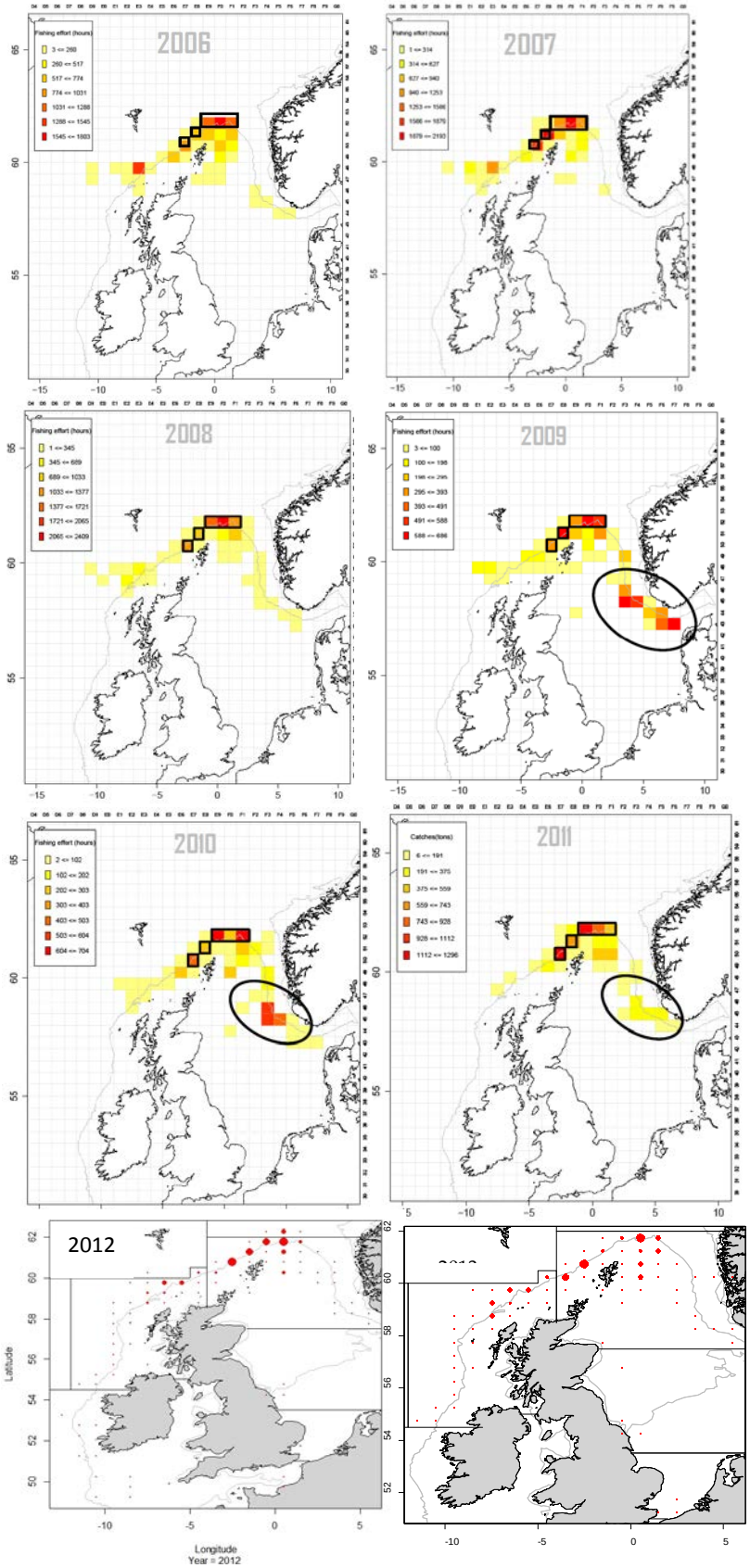


Figure 11.1.2. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of the French trawl fleet effort 2006–2011 and catches for 2012-2013.

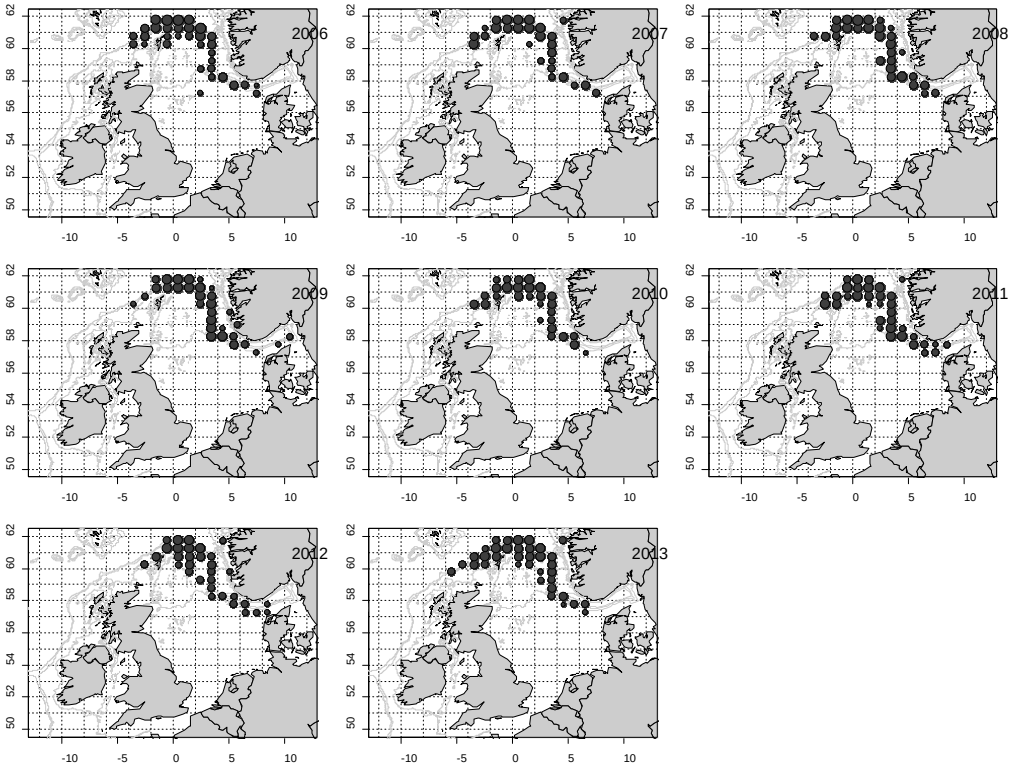


Figure 11.1.3. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of catch from the Norwegian trawl fleet 2006–2013.

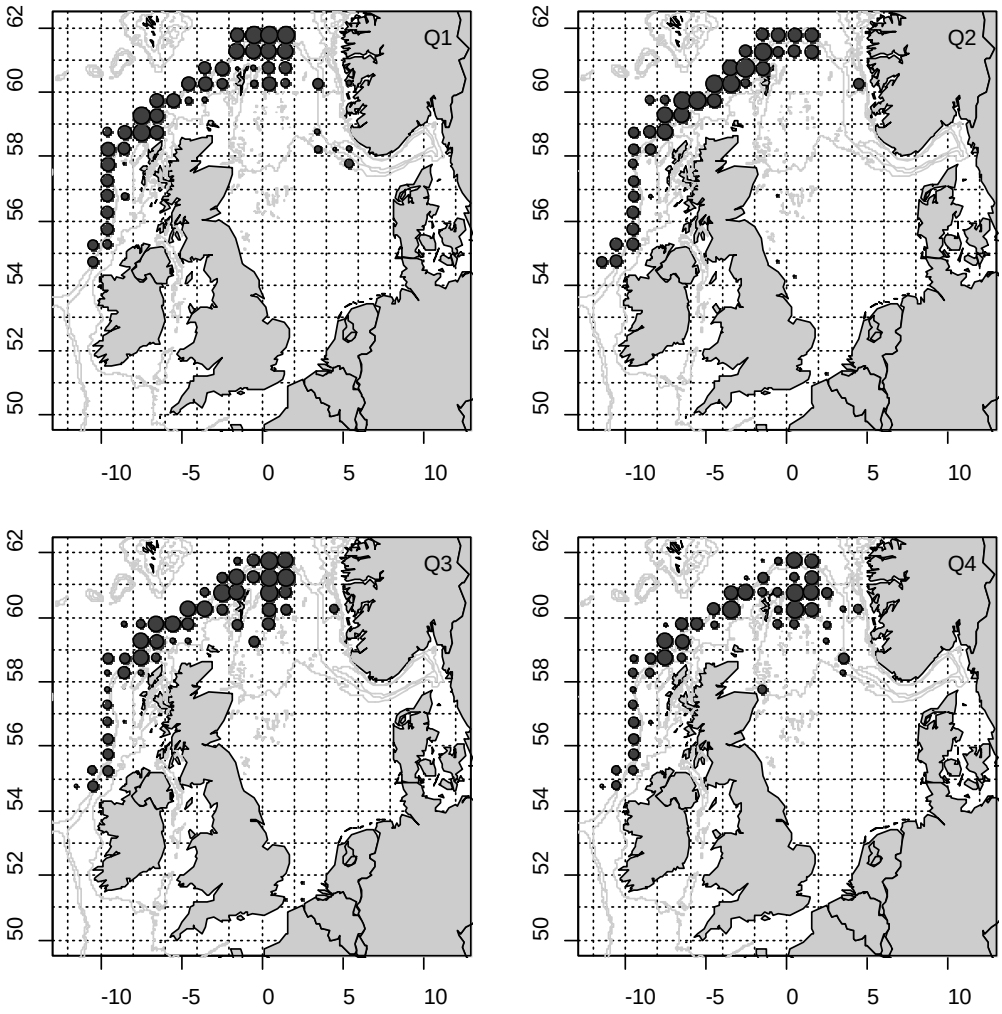


Figure 11.1.4. Saithe in Subareas IV and VI and Division IIIa. Quarterly spatial distribution of catches from the French trawl fleet in 2013.

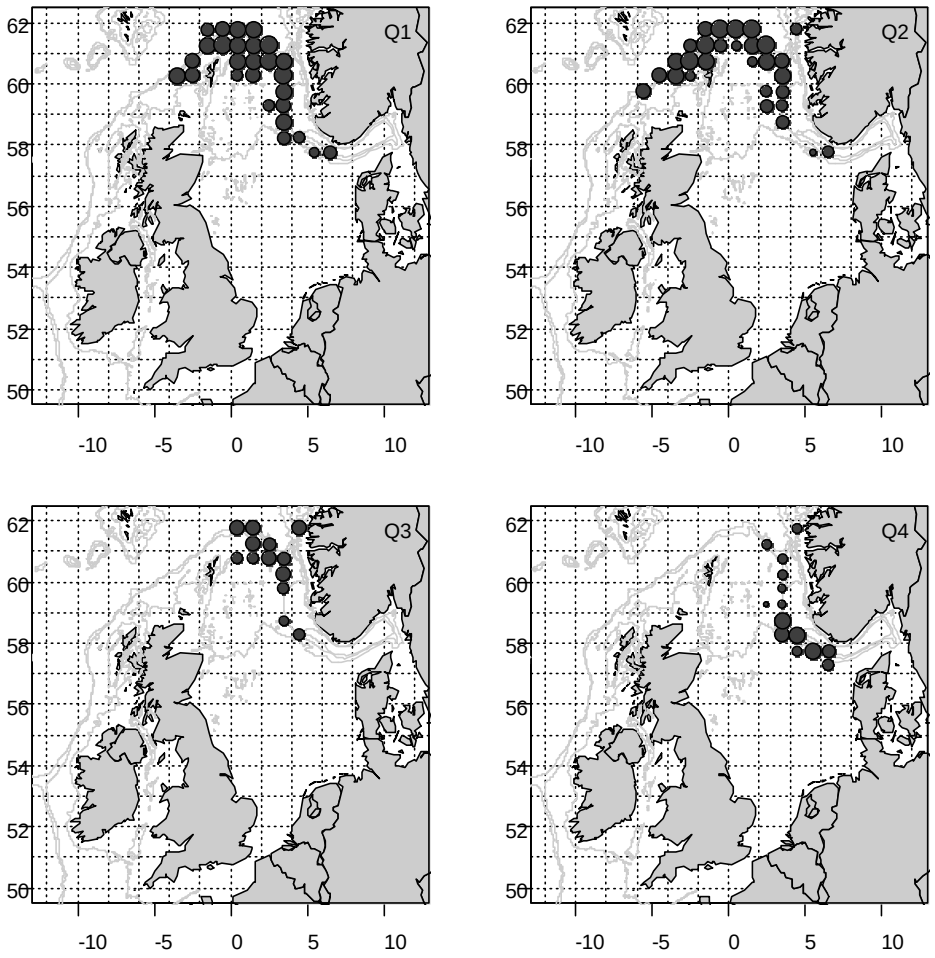


Figure 11.1.5. Saithe in Subareas IV and VI and Division IIIa. Quarterly spatial distribution of catches from the Norwegian trawl fleet in 2013.

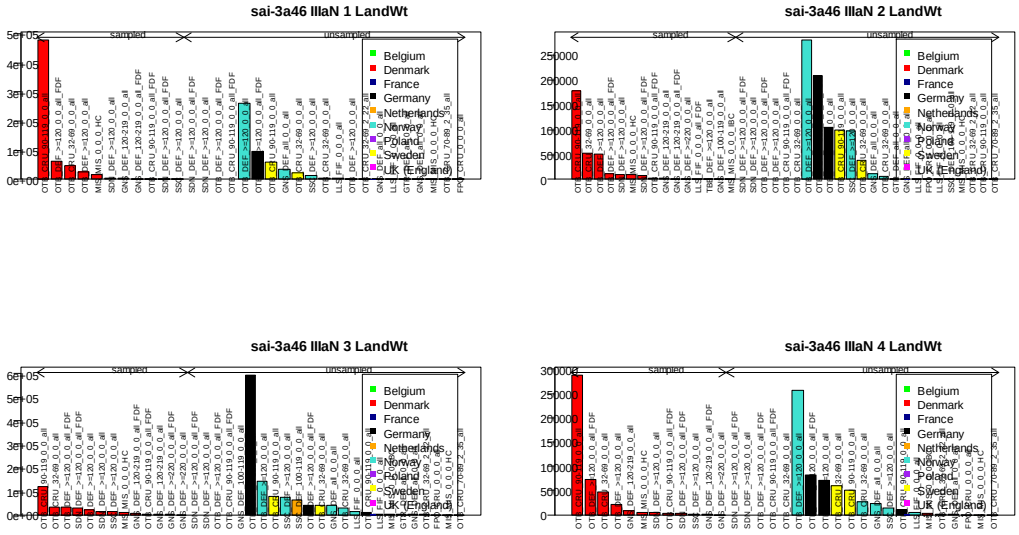


Figure 11.3.1. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet and quarter for saithe catches in Subdivsion IIIa.

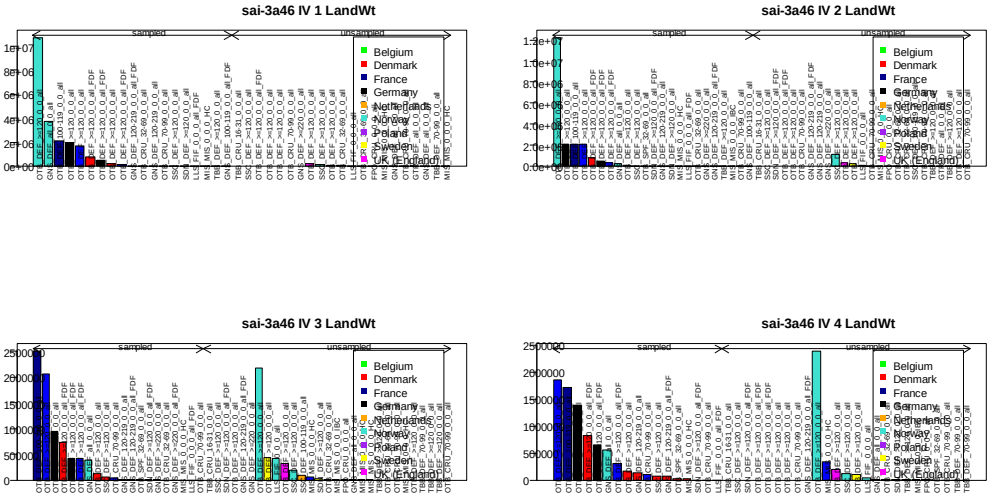


Figure 11.3.2. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet and quarter for saithe catches in Subarea IV.

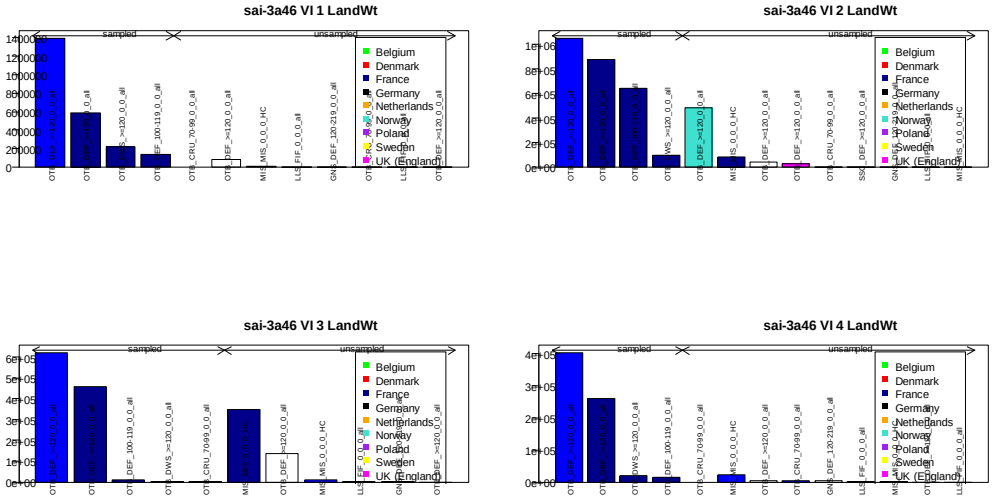


Figure 11.3.3. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet and quarter for saithe catches in Subarea VI.

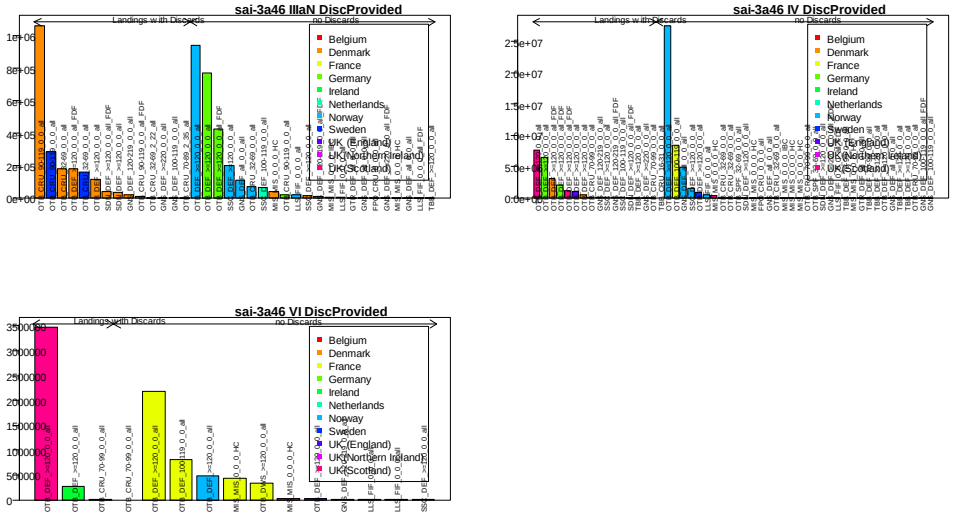


Figure 11.3.4. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled discards by fleet and area.

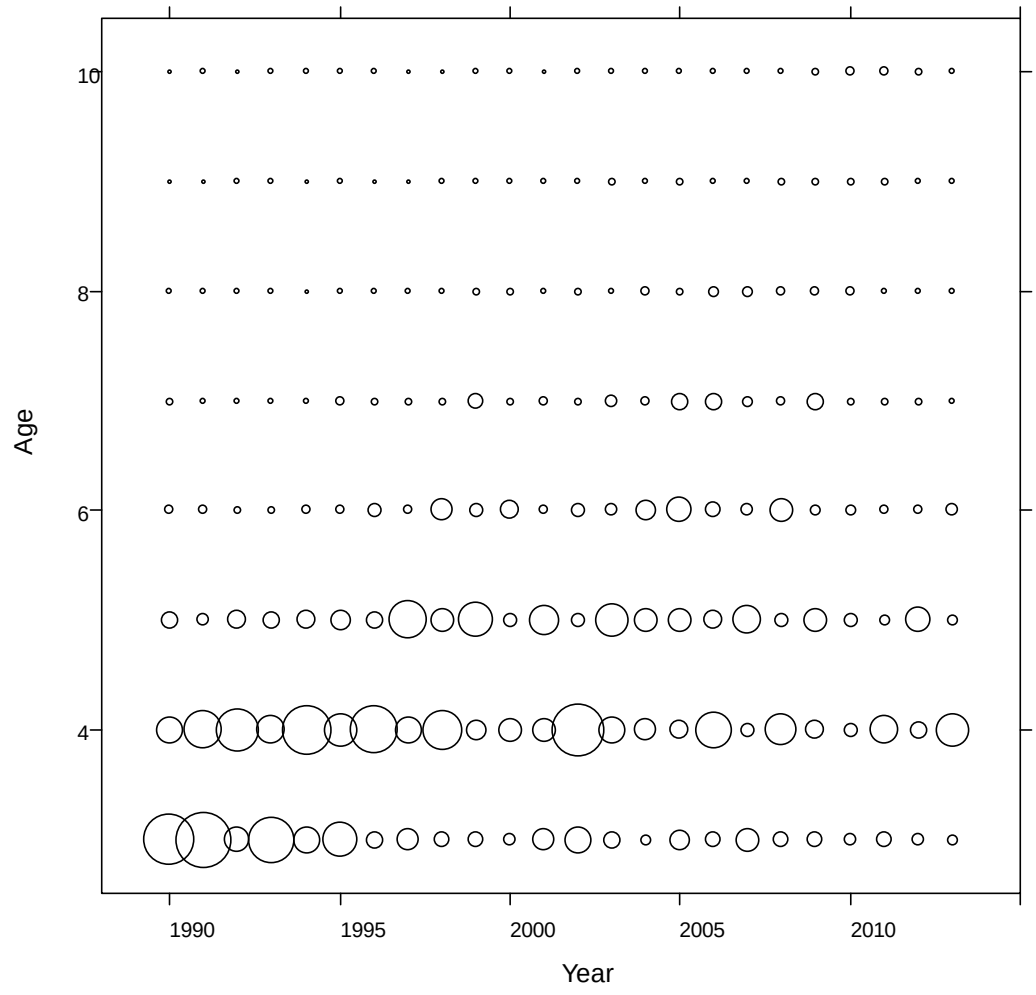


Figure 11.3.5. Saithe in Subareas IV and VI and Division IIIa. Landings-at-age for saithe ages 3–10+, 1990-2013. Smallest bubble corresponds to 210 000 individuals and largest to 46.117 million individuals.

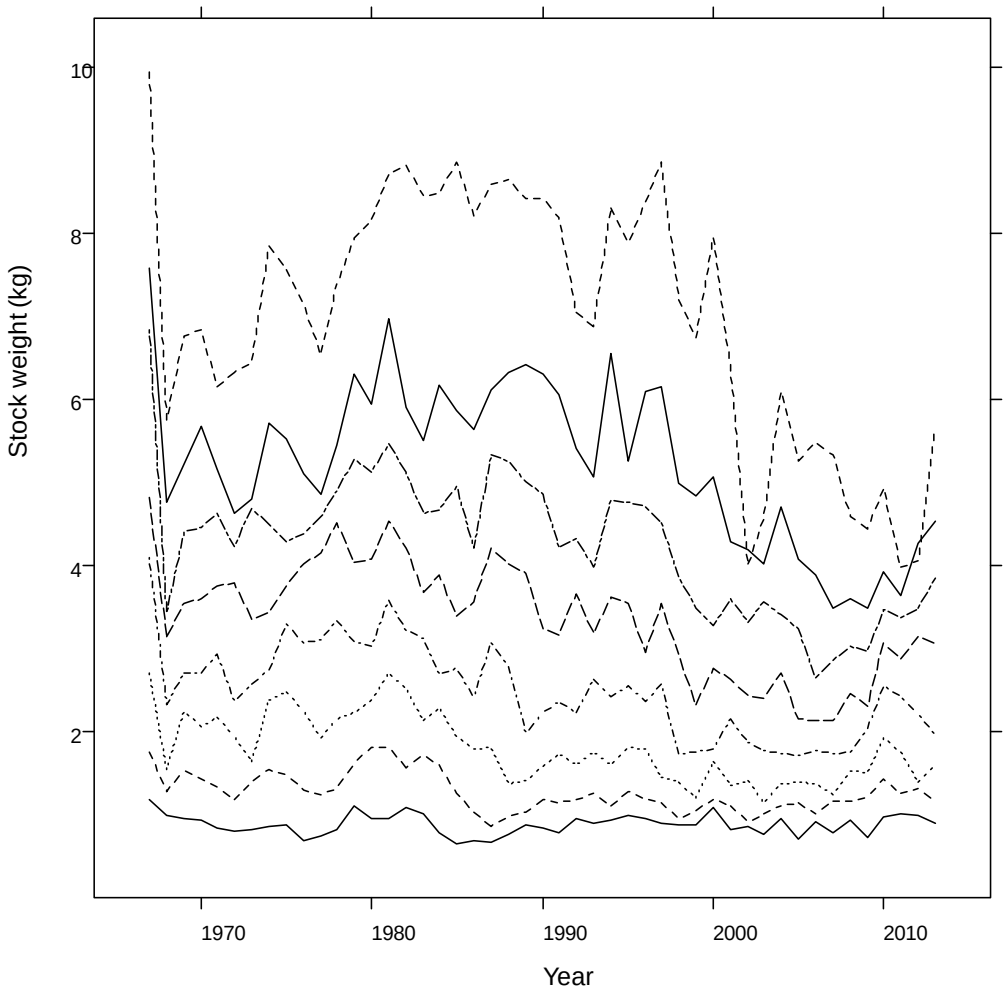


Figure 11.3.6. Saithe in Subareas IV and VI and Division IIIa. Landings weight-at-age (kg) for saithe ages 3–10+, 1967–2013. Landings weight-at-age are also stock weight-at-age in the assessment.

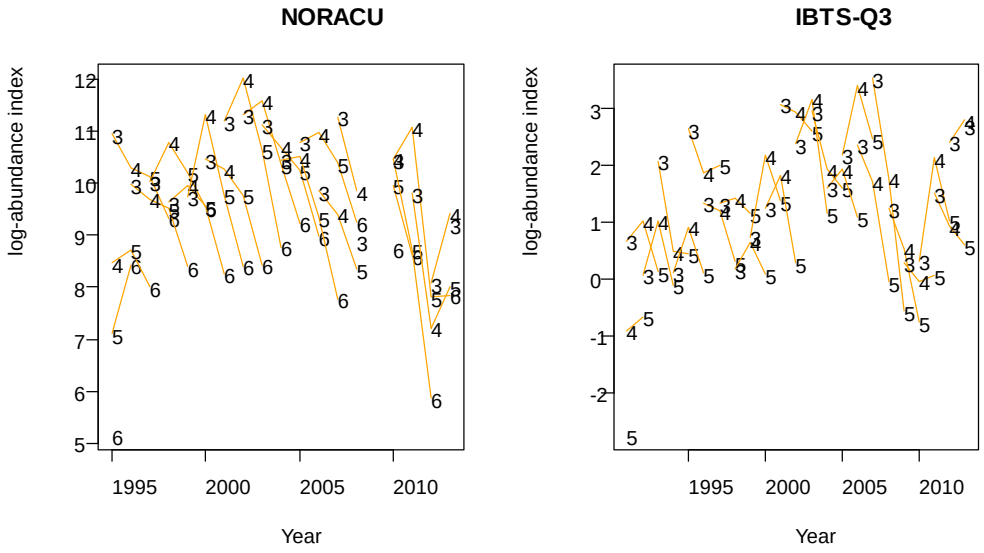


Figure 11.4.1. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the research survey indices for total catches for ages 3 to 6 (NORACU) and ages 3 to 5 (IBTS Q3).

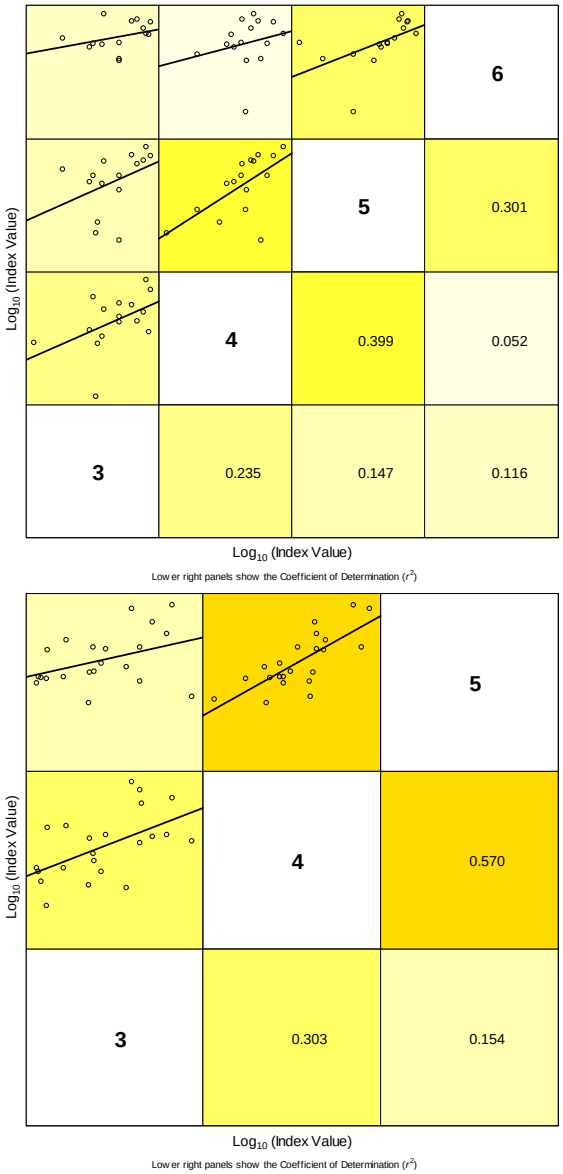


Figure 11.4.2. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the three research indices for ages 3 to 6 (NORACU) and 3 to 5 (IBTS, NORASS).

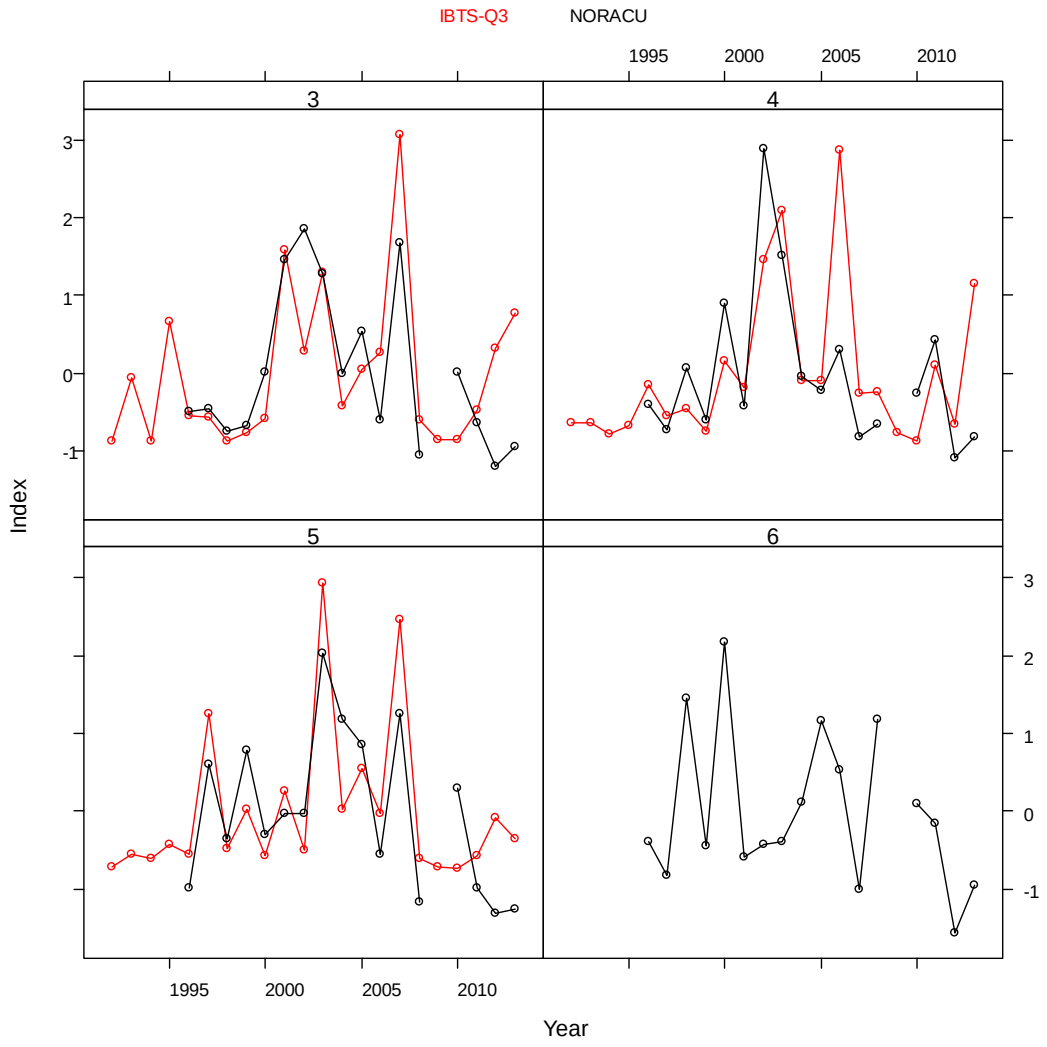


Figure 11.4.3. Saithe in Subareas IV and VI and Division IIIa. Standardised indices from the two research tuning series.

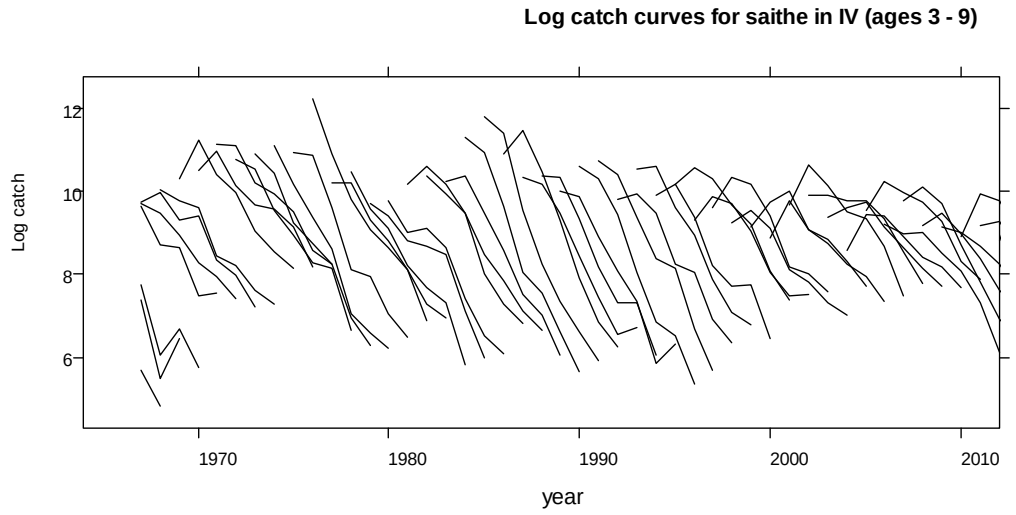


Figure 11.4.4. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort for total catches for ages 3 to 9.

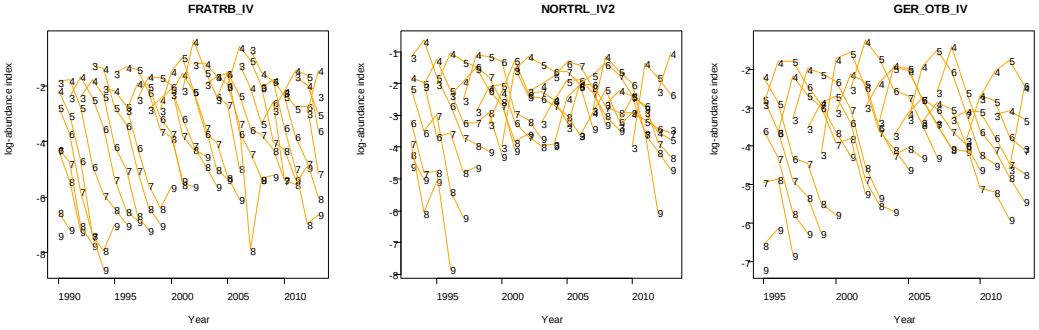


Figure 11.4.5. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the three commercial indices for ages 3 to 9.

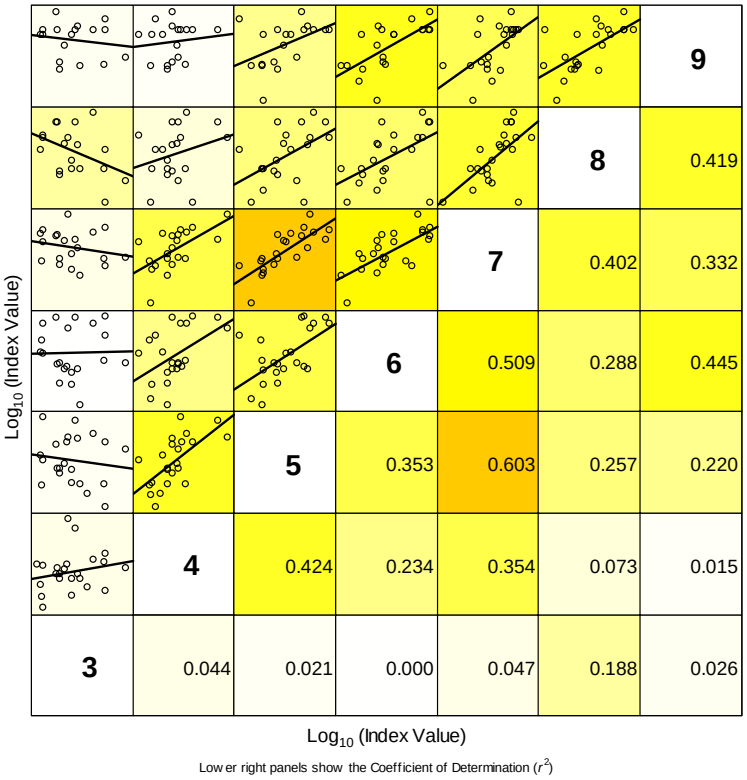


Figure 11.4.6. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the French unstandardized CPUE index. Straight line indicates a linear regression.

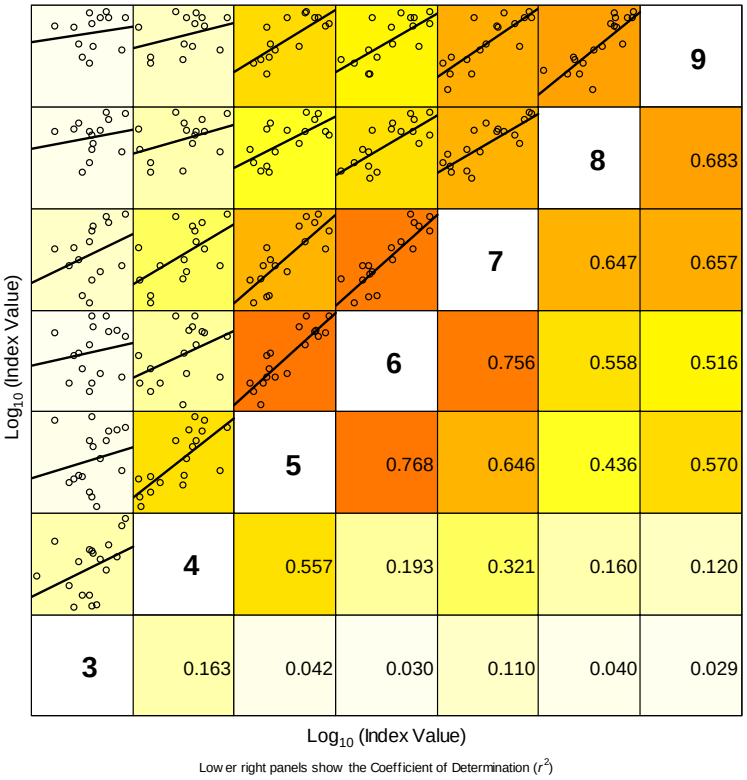


Figure 11.4.7. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the German unstandardized CPUE index. Straight line indicates a linear regression.

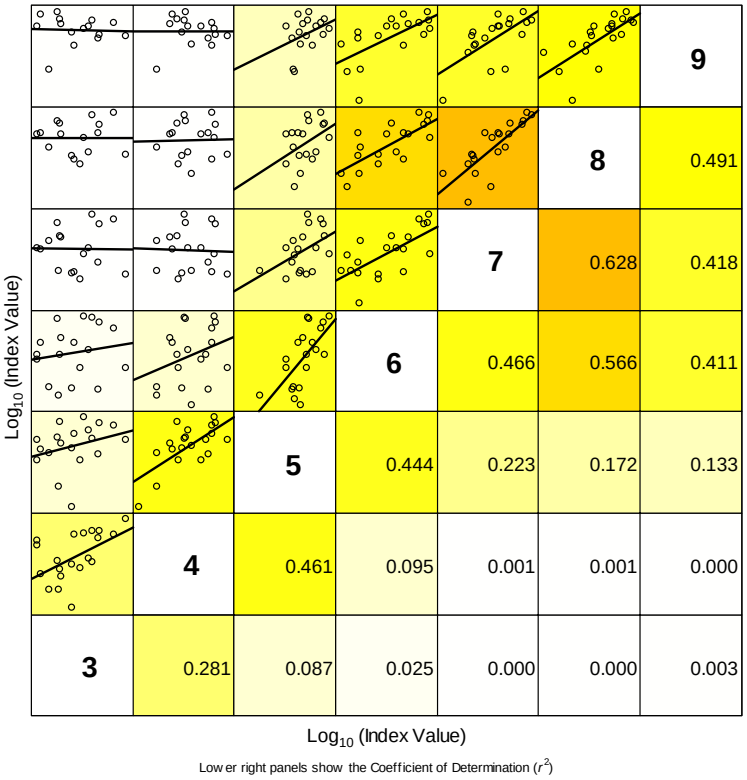


Figure 11.4.8. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the Norwegian unstandardized CPUE index. Straight line indicates a linear regression.

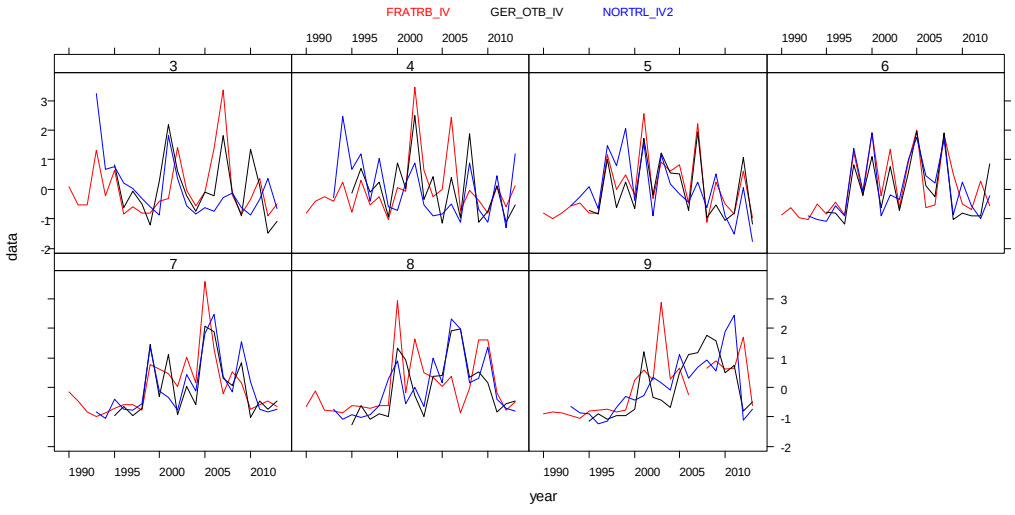


Figure 11.4.9. Saithe in Subareas IV and VI and Division IIIa. Standardised indices from the three commercial tuning series.

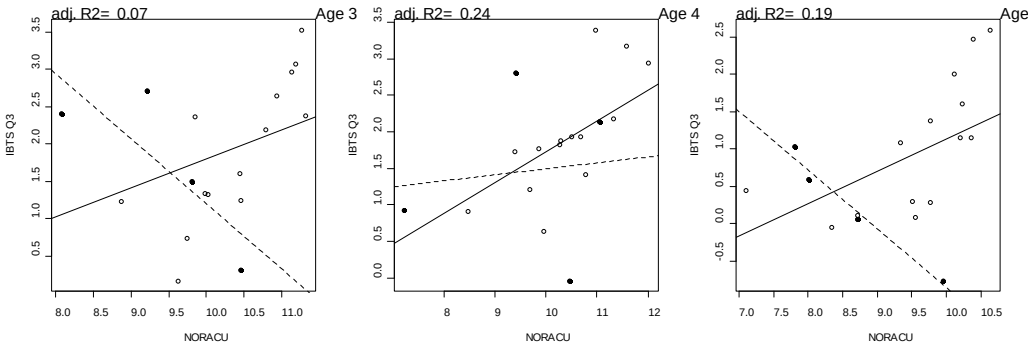


Figure 11.4.10. Saithe in Subareas IV and VI and Division IIIa. Relationship between NORACU and IBTS-Q3 indices for ages 3-5. Black points are the years 2010-2013; dashed lines are the relationship between the 2 surveys for 2010-2013.

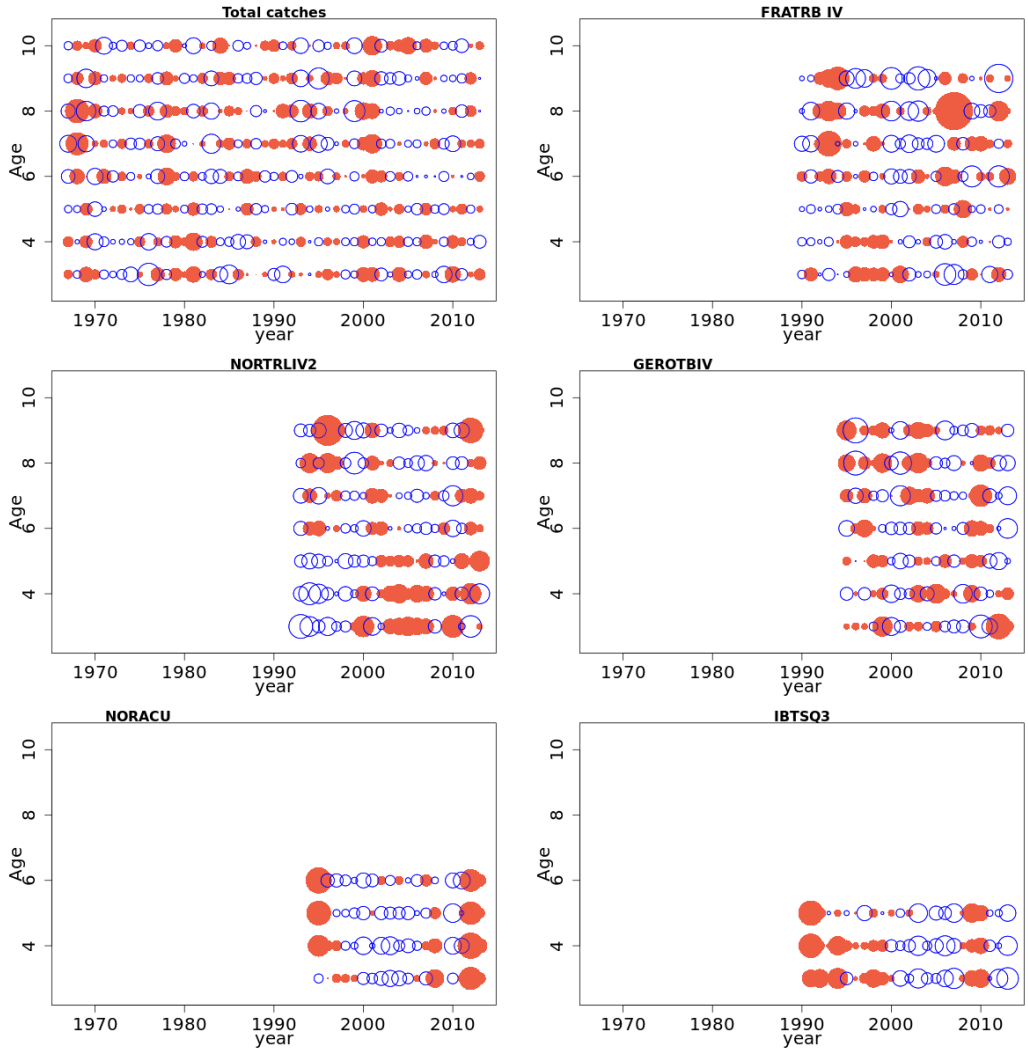


Figure 11.4.11. Saithe in Subareas IV and VI and Division IIIa. Normalized residuals from the SAM model. Blue circles indicate positive residuals and filled red circles indicate negative residuals.

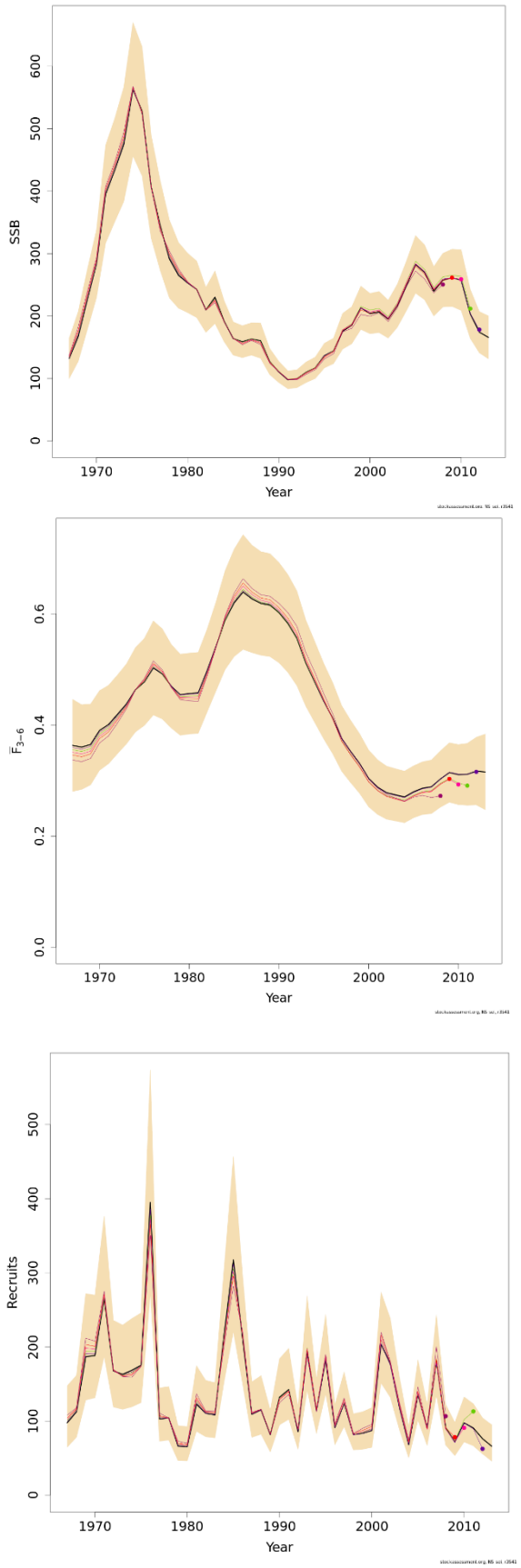
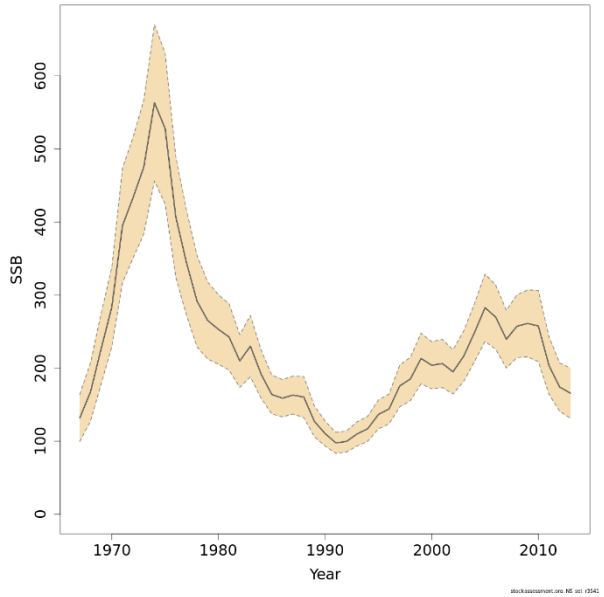
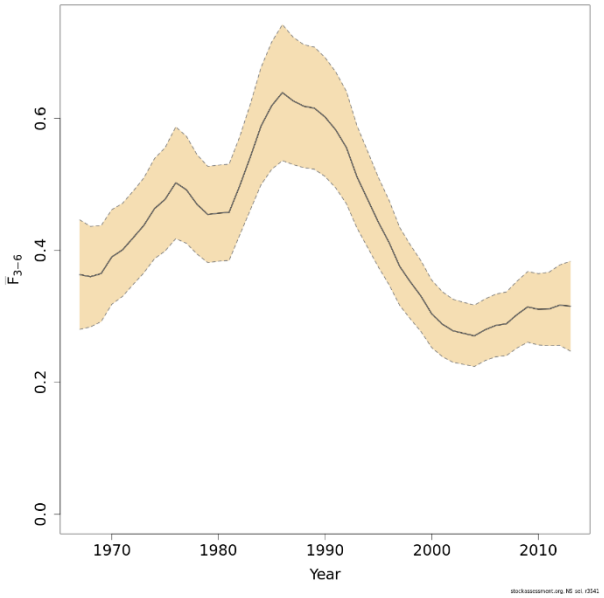


Figure 11.4.12. Saithe in Subareas IV and VI and Division IIIa. SAM model: Results of the retrospective analysis for SSB (top left), average fishing mortality (ages 3-6, top right), and recruitment (lower left).


SSB
0
100
200
300
400
500
600
1970
1980
1990
2000
2010
Year


F_{3-6}
0.0
0.2
0.4
0.6
1970
1980
1990
2000
2010
Year

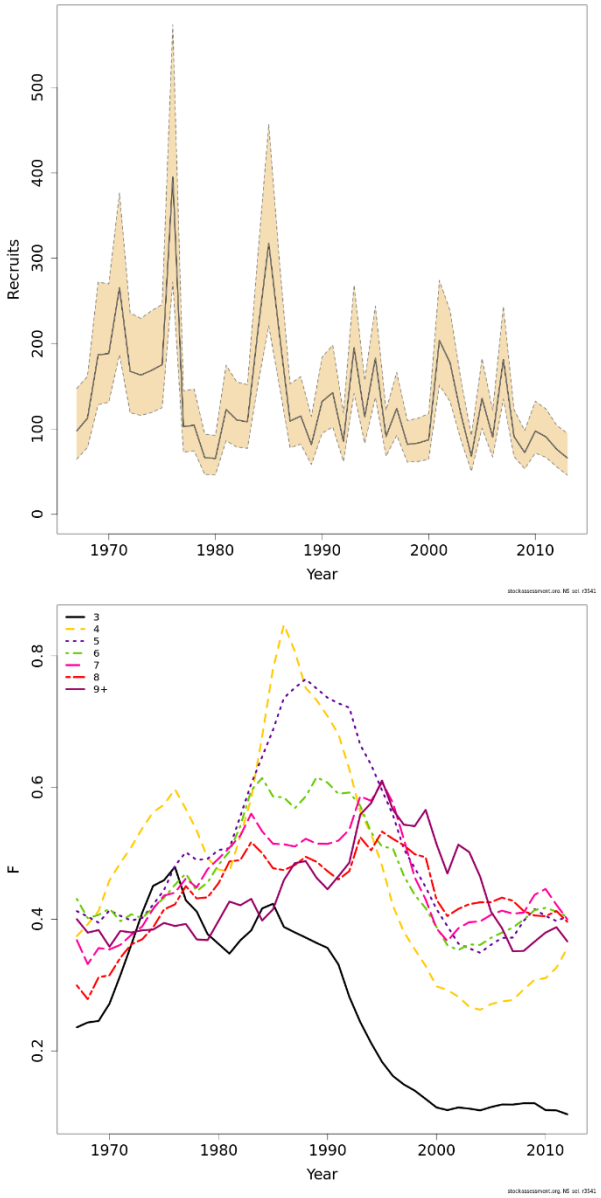


Figure 11.4.13. Saithe in Subareas IV and VI and Division IIIa. SAM model: Trends in SSB (top left), average F (ages 3–6, top right), recruitment (lower left), and fishing mortality-at-age (lower right).

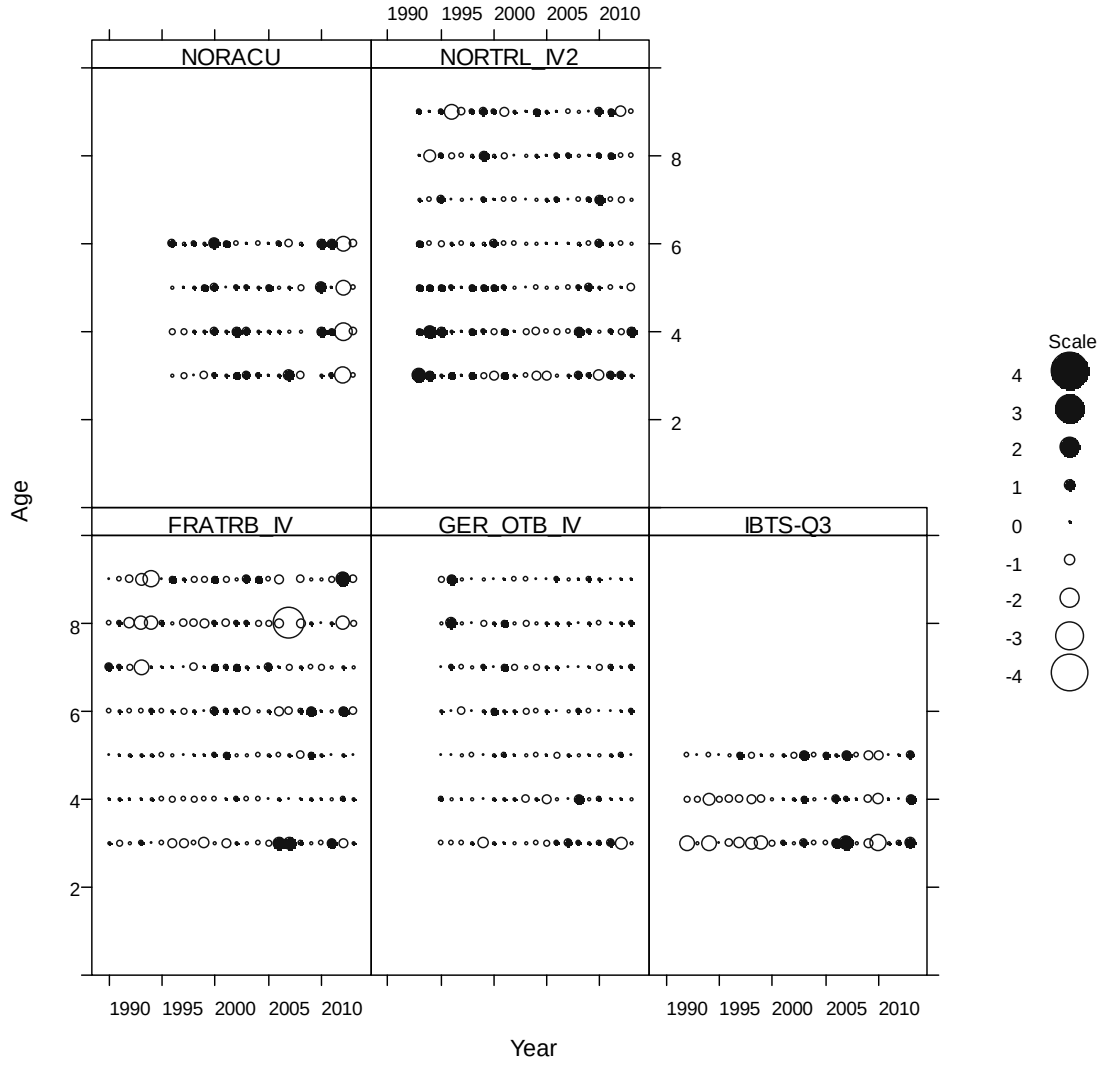


Figure 11.4.14. Saithe in Subareas IV and VI and Division IIIa. XSA: Log catchability residuals from the XSA shown for each tuning fleet.

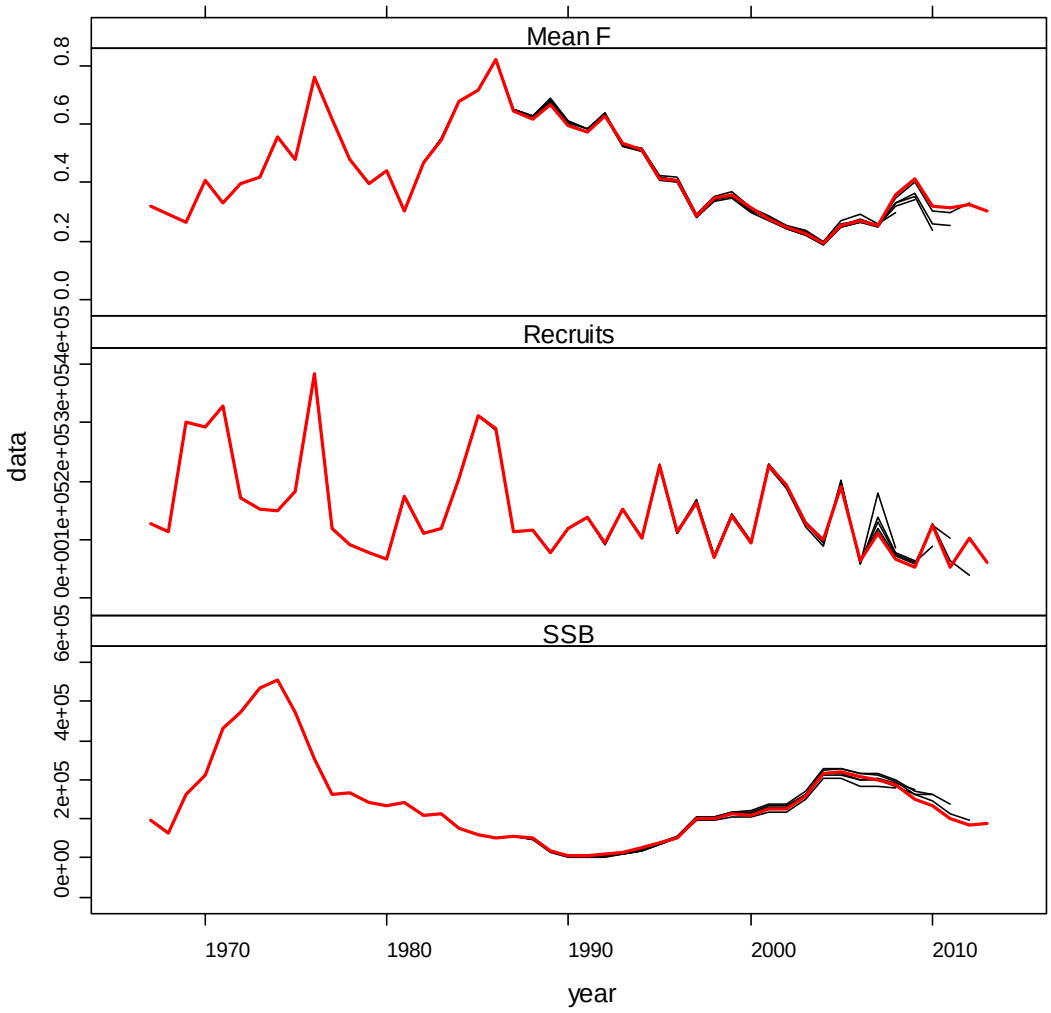


Figure 11.4.15. Saithe in Subareas IV and VI and Division IIIa. XSA: Retrospective plot.

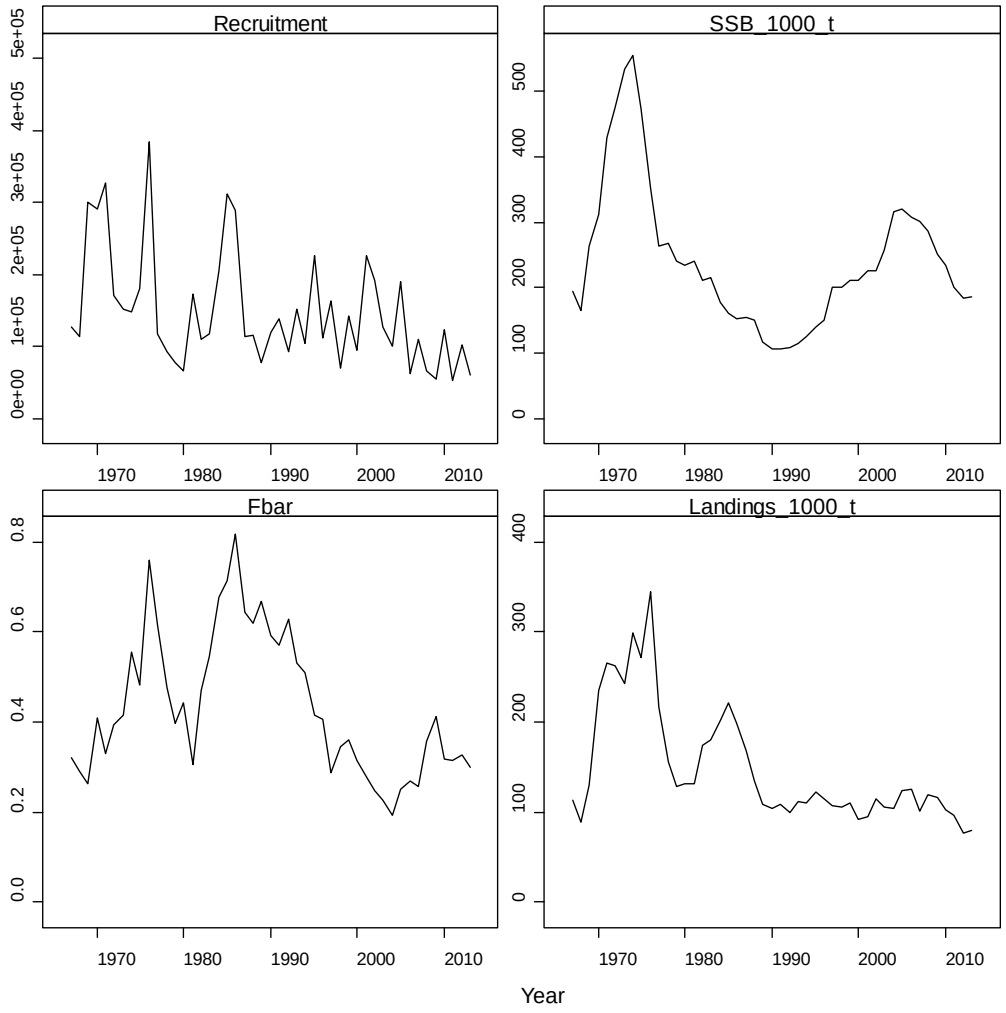


Figure 11.5.1. Saithe in Subareas IV and VI and Division IIIa. XSA: Stock summary of trends in recruitment, SSB, $F_{3\text{-}6}$ and landings.

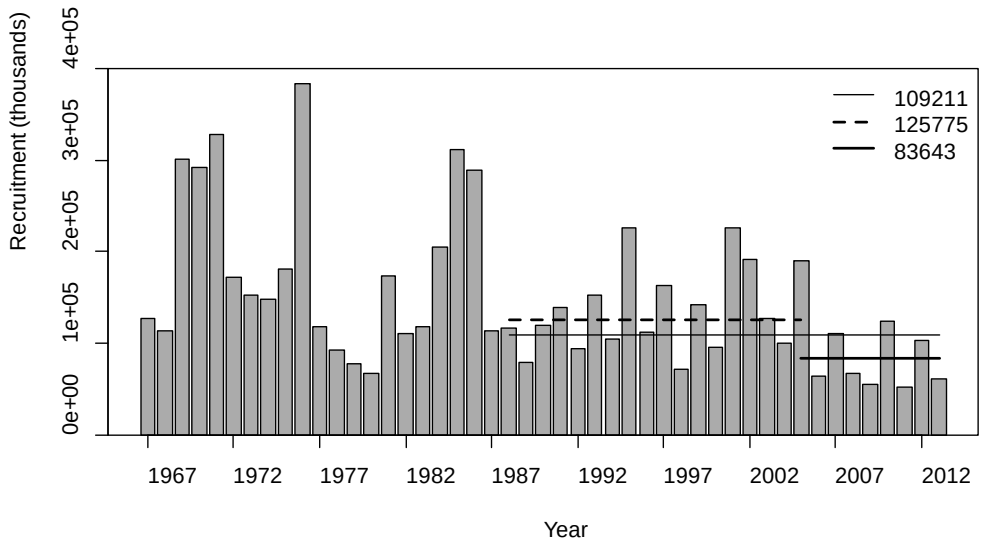


Figure 11.6.1. Saithe in Subareas IV and VI and Division IIIa. Recruitment time series showing the results of the change-point analysis (1988-2004, 125775 million; 2005-2013, 83643 million) compared to the 1988-2013 geometric mean recruitment (109211 million).

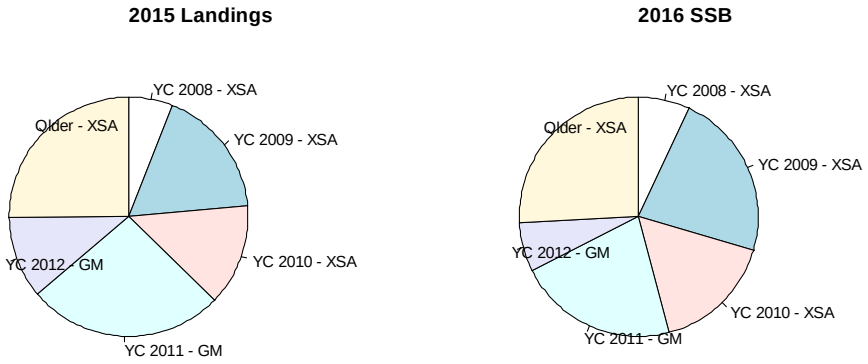


Figure 11.7.1. Saithe in Subareas IV and VI and Division IIIa. Contribution of recruitment of the 2008–2012 year classes to landings in 2015 and SSB in 2016. XSA and GM refers to how recruitment was estimated; GM is the geometric mean 2005–2013.

12 Whiting in Subarea IV and Divisions VIId and IIIa

12.1 Whiting in Division IIIa

12.1.1 General

12.1.1.1 Stock definition

There is a paucity of information on the population structure of whiting in Division IIIa (the Skagerrak-Kattegat area). No genetic surveys have been conducted, nor otolith based surveys. Tagging of whiting has previously been undertaken, yet these data need to be re-examined. Results from modelled survey data (SURBAR) are inconclusive regarding independent population dynamics in Division IIIa in comparison with the North Sea. The drop in landings in the beginning of the 1990s gives however an indication of local stock structure, as this reduction was not paralleled by any similar event in the North Sea.

12.1.1.2 Ecosystem aspect

No new information was presented at the Working Group. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.1.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the spatial distribution of the Swedish landings in 2013 using logbooks information. The plot is reported in Figure 12.1.1a and showed that higher landings were taken along the Swedish coastline than in the offshore Skagerrak. Spatial distribution of the all combined fisheries in 2012 by statistical rectangle is reported in Figure 12.1.1b. A summary of available information on fisheries is presented in the Stock Annex prepared at ICES-WKROUND (2009). Discards estimates are available since 2003. Information on derivation of discards is presented in the Stock Annex.

12.1.1.4 Data available

According to the WKLIFE categorisation of various levels of available data for assessment, whiting in Division IIIa can be considered to be a stock for which survey based indices are available, indicating trends. This survey data have been used for an exploratory assessment.

Total landings are shown in Table 12.1.1.

The WGNSSK in 2014 used IBTS indices per area (Skagerrak and Kattegat) and BITS indices (Kattegat) for plotting CPUE per quarter of fish of total length ≥ 22 cm, which corresponds to the 50% point of the maturity ogive of whiting in the North Sea. Plots of the IBTS Q1 and IBTS Q3 are shown in Figures 12.1.2 and BITS Q1 and Q4 in Figure 12.1.3. IBTS Q3 indicate high inter-annual variability in recruitment. The mean log age indices per age class for IBTS Q1 covering the years 1967-2011 and IBTS Q3 covering the years 1991-2013 are plotted in Figure 12.1.4.

12.1.2 Data analyses

12.1.2.1 Exploratory survey-based analysis

Based on the information provided by the IBTS mean age indices for Q1 and Q3 a SURBAR analysis was performed. The summary plot from this run is given is Figure 12.1.5 and indicated great uncertainties in all parameter values of relative spawning stock biomass (SSB), relative total biomass (TSB) and mean mortality (Z) with highly erratic patterns.

The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year are shown in Figure 12.1.6. For both IBTS Q1 and IBTS Q3 surveys the different plots indicated that internal consistency was virtually absent, impeding cohort analysis in the stock for the present. Log residual estimates per age class for IBTS Q1 and IBTS Q3 are shown in Figure 12.1.7.

The retrospective analysis plots for mean total mortality (Z) over ages 2 and 4, relative SSB, relative TSB, and relative recruitment reported in Figure 12.1.8, providing further evidence of great uncertainty based on the 90% CI.

12.1.2.2 Conclusions drawn from exploratory analysis

The lack of internal consistency in the available survey indices prevents analytical assessment. This internal inconsistency could be related to a) age reading problems, and/or b) a mixture of several stock components leading to unaccounted migrations. As the survey-based assessment cannot be used as a basis for advice, the stock is thus classified, according to the ICES rules for data limited stocks, as belonging to category 5.2.

12.1.2.3 Advice

Based on the ICES approach for data limited stocks, ICES advises that catches should be no more than 950 tonnes, and landings should be no more than 110 tonnes.

Table 12.1.1 Nominal landings (t) of Whiting from Division IIIa as supplied by the Study Group on Division IIIa Demersal Stocks (ICES 1992b) and updated by the Working Group, and WG estimate of Discards.

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
1975	19,018			57	611	4	19,690	
1976	17,870			48	1,002	48	18,968	
1977	18,116			46	975	41	19,178	
1978	48,102			58	899	32	49,091	
1979	16,971			63	1,033	16	18,083	
1980	21,070			65	1,516	3	22,654	
	Total consumption	Total industrial	Total					
1981	1,027	23,915	24,942	70	1,054	7	26,073	
1982	1,183	39,758	40,941	40	670	13	41,664	
1983	1,311	23,505	24,816	48	1,061	8	25,933	
1984	1,036	12,102	13,138	51	1,168	60	14,417	
1985	557	11,967	12,524	45	654	2	13,225	
1986	484	11,979	12,463	64	477	1	13,005	
1987	443	15,880	16,323	29	262	43	16,657	
1988	391	10,872	11,263	42	435	24	11,764	
1989	917	11,662	12,579	29	675	-	13,283	
1990	1,016	17,829	18,845	49	456	73	19,423	
1991	871	12,463	13,334	56	527	97	14,041	
1992	555	3,340	3,895	66	959	1	4,921	
1993	261	1,987	2,248	42	756	1	3,047	
1994	174	1,900	2,074	21	440	1	2,536	
1995	85	2,549	2,634	24	431	1	3,090	
1996	55	1,235	1,290	21	182	-	1,493	
1997	38	264	302	18	94	-	414	
1998	35	354	389	16	81	-	486	
1999	37	695	732	15	111	-	858	
2000	59	777	836	17	138	1	992	
2001	61	9701	1,0311	27	126	+	1,1841	
2002	101	9751	1,0761	23	127	1	1,2271	
2003	93	6541	7471	20	71.9	2	840.91	429
2004	93	1,1201	1,2131	17	74	1	1,3051	909
2005	49	9071	9561	13	73	0	1,0421	299
2006	591	2901	3491	n/a	85.92	n/a	434.92	331
2007	532	2782	3312	14	82	1	4282	561
2008	522	2882	3402	14	52	n/a	4062	241
009	12	1732	2442	10.3	33.82	-	88.12	128
2010	41	165	206	9.7	29.7	-	245.4	291
2011	40	44	84	8.3	20.4	0.2	112.9	94
2012	30	6.8	37	15.5	9.6	0.8	62.9	291
2013	29	102	131	8.4	14.5	1.0	155	1486

[1] **Values from 1992 updated by WGNSSK (2007).**

[2] **Values updated by WGNSSK (2011).**

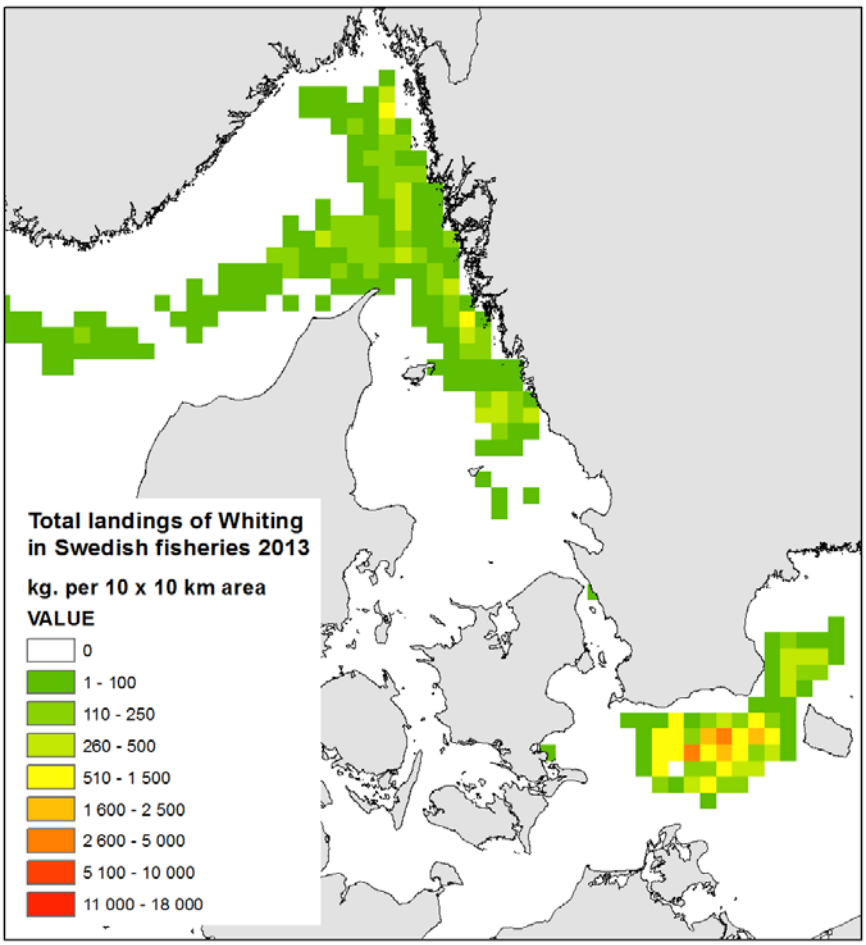


Figure 12.1.1a. Whiting in Division IIIa. Spatial distribution of the total landings of whiting IIIa in Swedish fisheries 2013 from logbooks information.

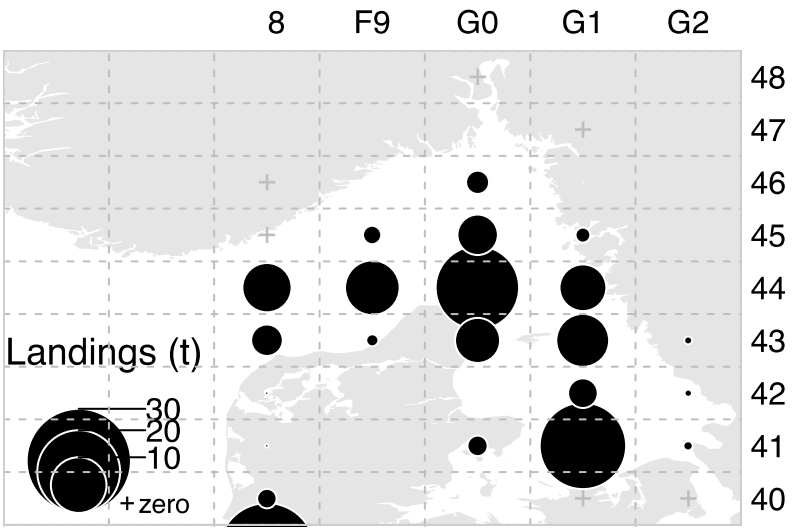


Figure 12.1.1b. Whiting in Division IIIa. Spatial distribution of the total landings of whiting IIIa by statistical rectangle for all combined fisheries in 2012.

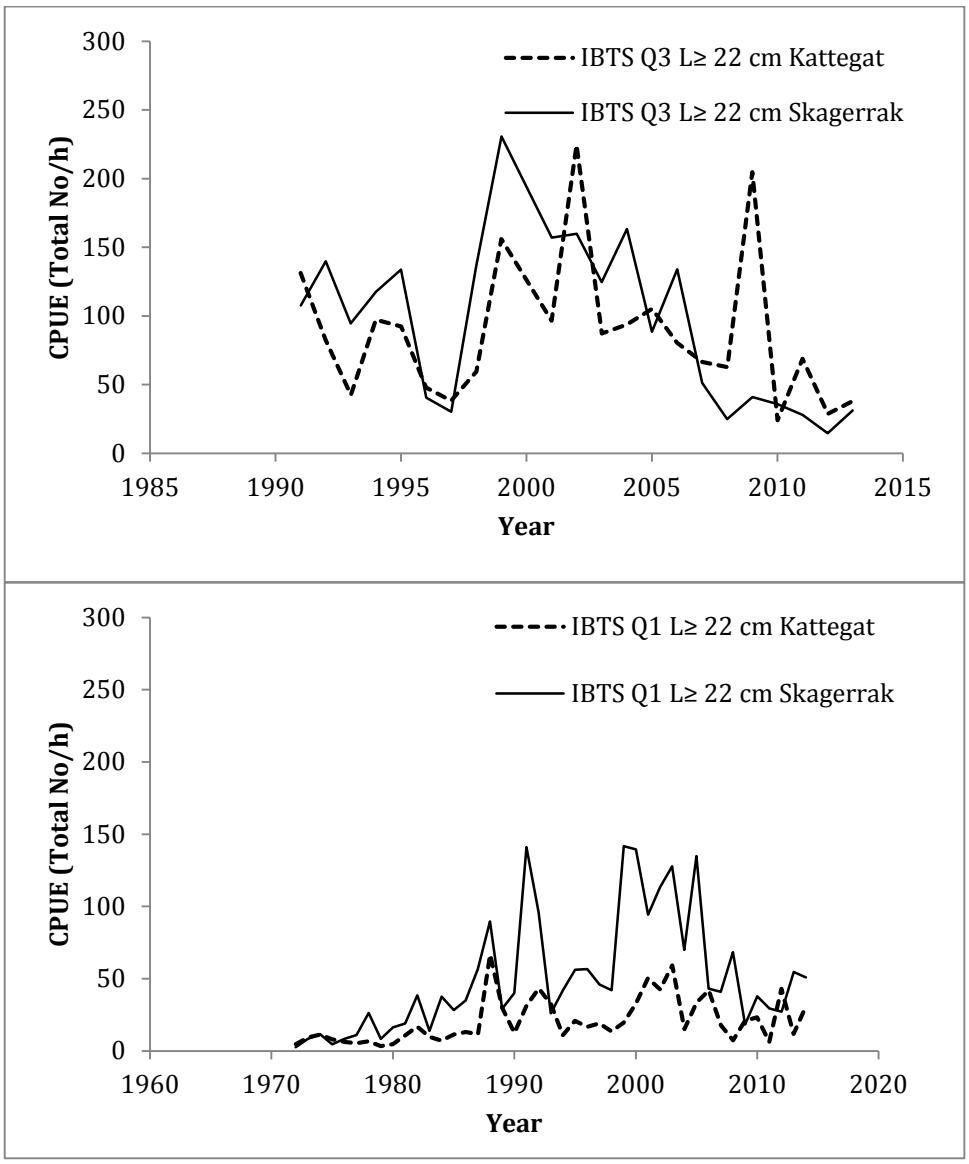


Figure 12.1.2. Whiting in Division IIIa (Skagerrak and Kattegat). IBTS CPUE per area Q1 covering the years 1967-2014 and Q3 covering the years 1991-2013.

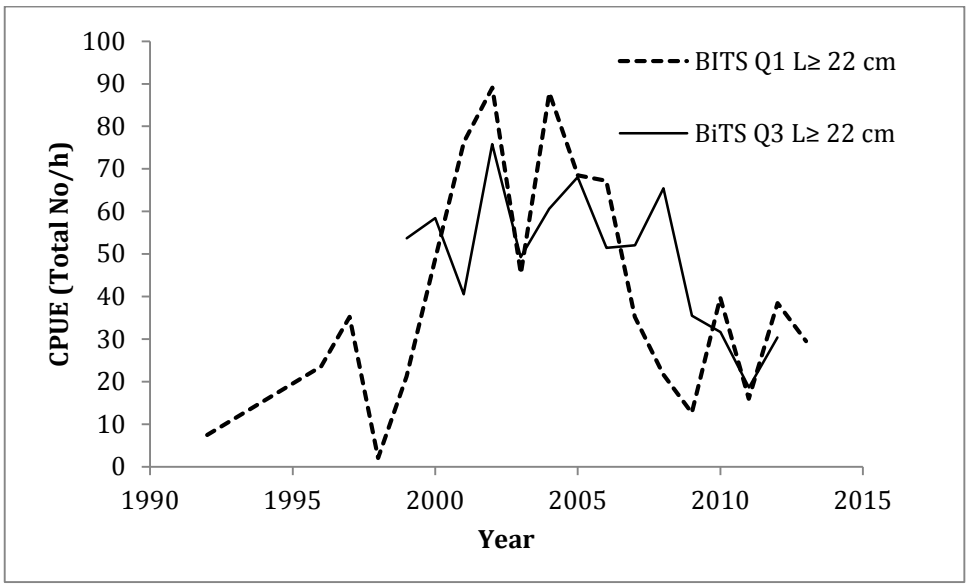


Figure 12.1.3. Whiting in Division IIIa S (Kattegat). BITS CPUE per Q1 and Q4 covering the years 1992-2013.

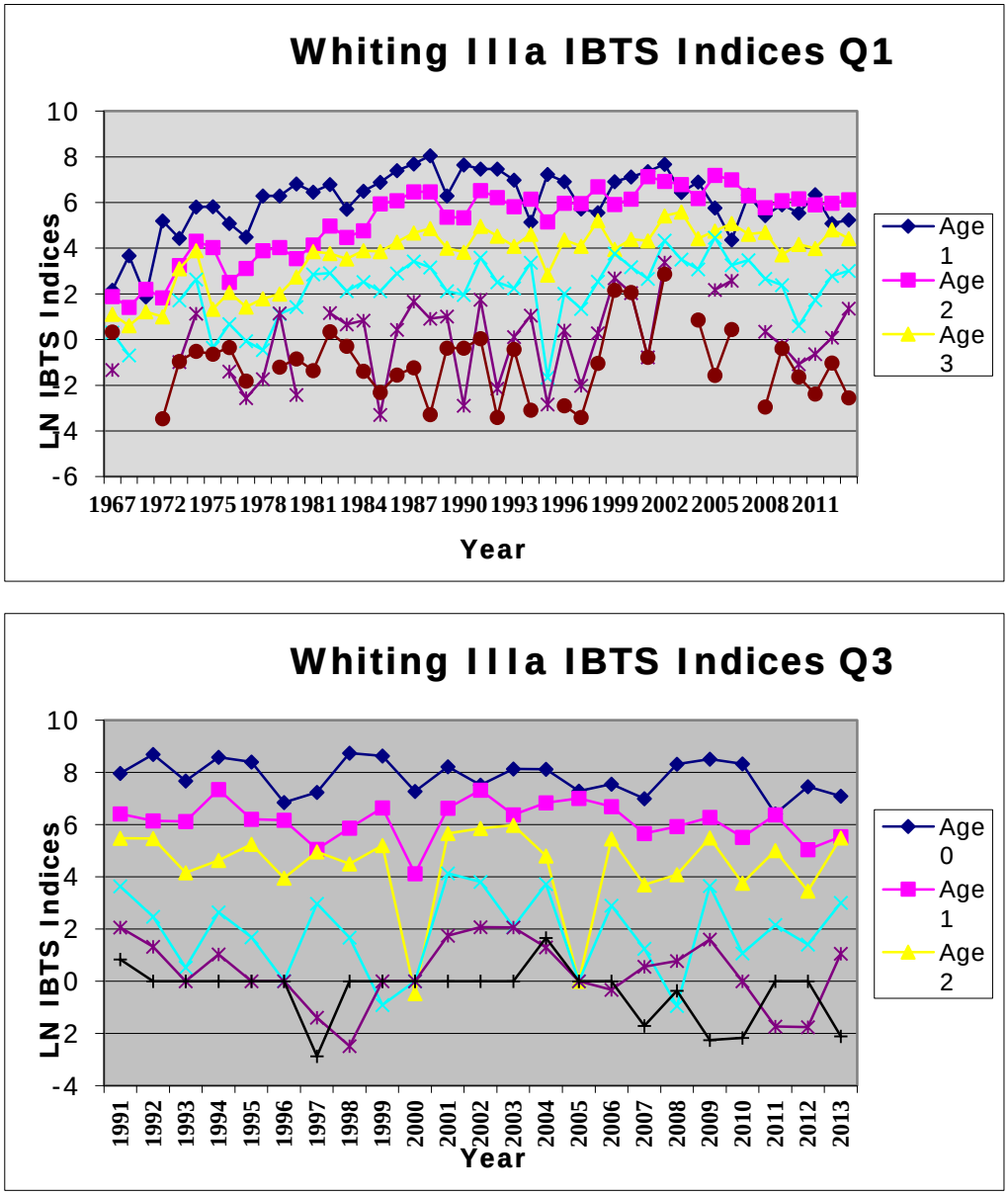


Figure 12.1.4. Whiting in Division IIIa. IBTS indices per age class for Q1 covering the years 1967-2014 and Q3 covering the years 1991-2013.

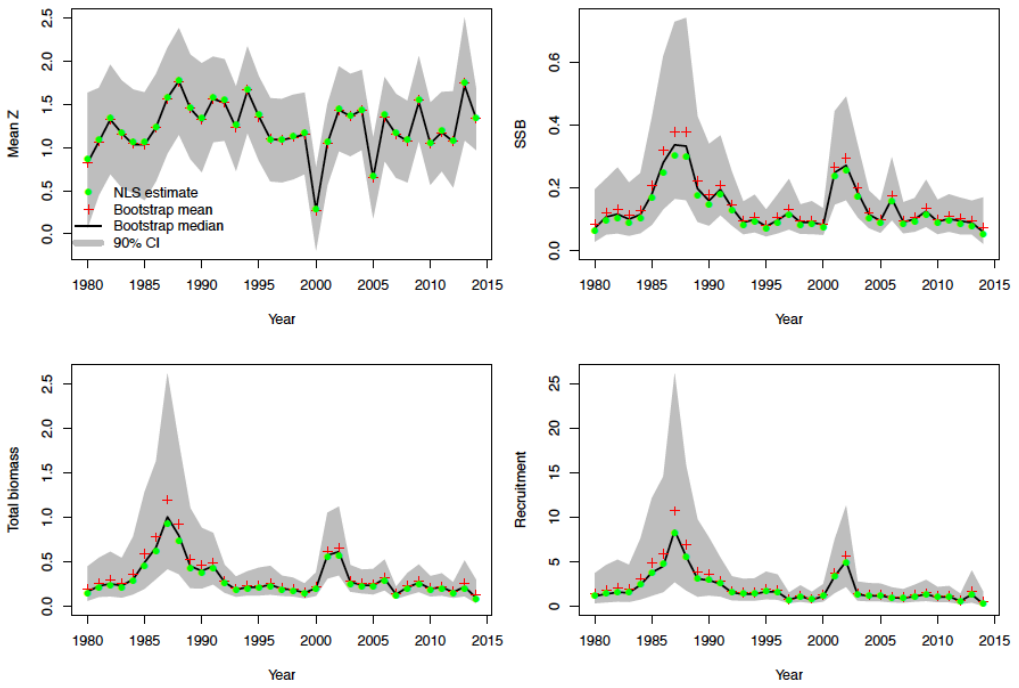


Figure 12.1.5. Whiting in Division IIIa. SURBAR analysis. Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

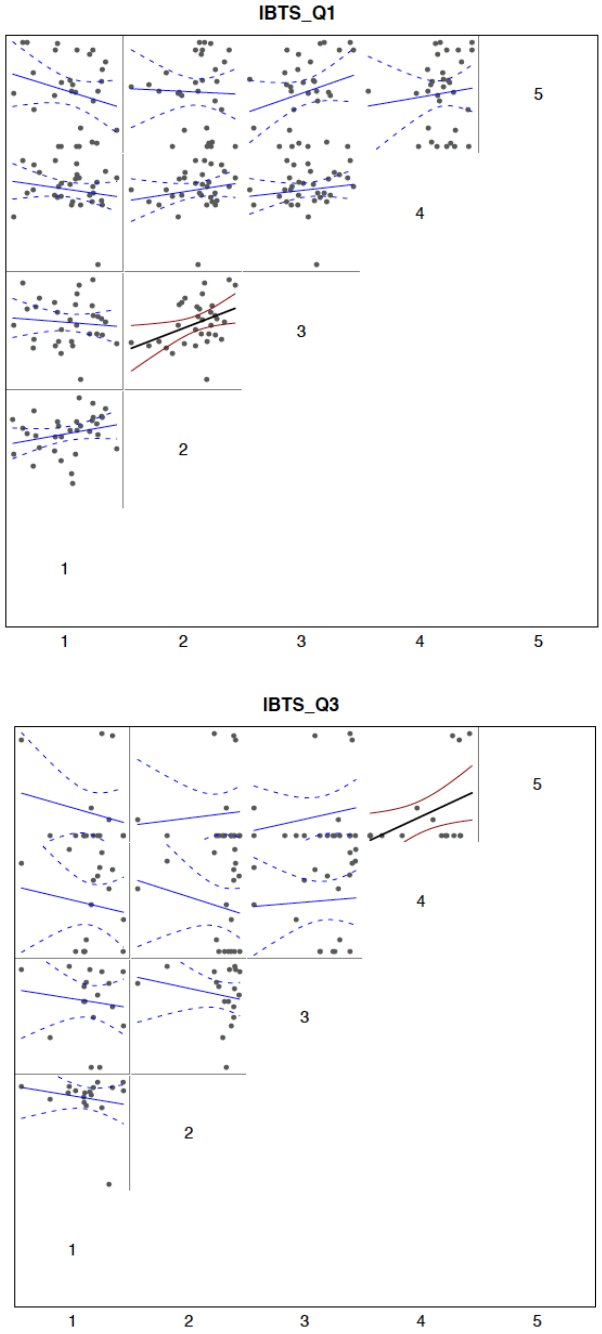


Figure 12.1.6 Whiting in Division IIIa. SURBAR analysis. IBTS indices per age class 1-5 for Q1 covering the years 1980-2014 and Q3 covering the years 1991-2013. The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year.

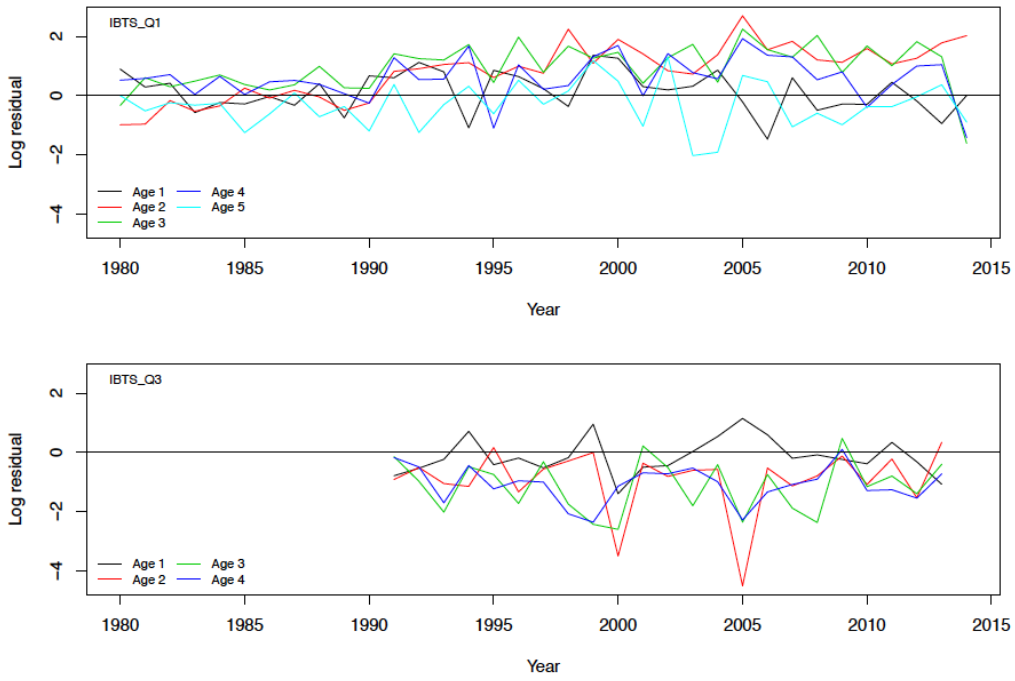


Figure 12.1.7 Whiting in Division IIIa. SURBAR analysis. Log residual estimates per age class for IBTS Q1 (upper line plots) and IBTS Q3 (lower line plots).

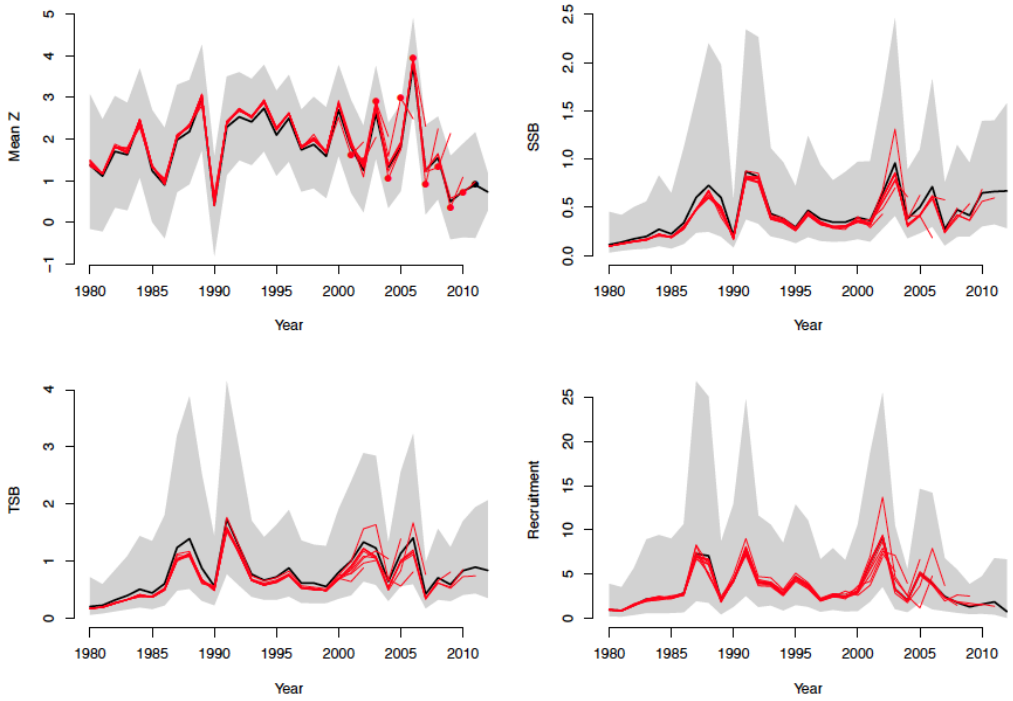


Figure 12.1.8. Whiting in Division IIIa. SURBAR analysis. Retrospective analysis plots for mean total mortality Z over ages 2 to 4, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment. The full time-series run is indicated by a black line, the retrospective runs by red lines. Shaded gray areas indicate the 90% CI. For mean Z, the second-last estimate for each analysis is marked with a point (as the last estimate for each analysis is based on a three year mean and is not directly based on data).

12.2 Whiting in Subarea IV and Divisions VIId

This Section contains the assessment relating to whiting in the North Sea (ICES Subarea IV) and eastern Channel (ICES Division VIId). The current assessment is formally classified as an update assessment. The most recent benchmark for this stock was conducted in January 2013.

Available information on whiting in Division IIIaN (Skagerrak) is presented in Section 12.1.

After the working group information became available that for this stock and year 2013, the Scottish discard weights, numbers-at-age, mean weights-at-age etc, were erroneously allocated to the wrong fleets, resulting in the wrong discard rates etc for those fleets, though the total discards for the Scottish fleets were correct. The effects were analysed in detail in a working paper (see Annex 8) and it was concluded that the overall discard estimates and age distirbutions etc were virtually not affected by this error. This happened because all the fleets concerned were used in the estimation of all missing discards, and the weighting factor in this discard estimation was landed weight. There was no need to re-run the assessment after the working group.

12.2.1 General

12.2.1.1 Stock definition

No new information was presented at the WG. A summary of available information on stock definition can be found in the Stock Annex prepared by ICES-WKROUND (2013).

12.2.1.2 Ecosystem aspects

No new information was presented at the WG. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared by ICES-WKROUND (2013).

12.2.2 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES-WKROUND (2013).

12.2.3 ICES advice

ICES advice for 2013

In June 2012, ICES concluded as follows:

ICES advises on the basis of precautionary considerations that landings should be no more than 26 000 t (human consumption for the combined area) in 2013. Management for Division VIId should be separated from the rest of Subarea VII. This advice was unchanged following the application of the update protocol in October 2012, after the autumn groundfish surveys of that year.

ICES advice for 2014

In November 2013, ICES concluded as follows:

ICES advises on the basis of precautionary considerations that landings should be no more than 31 553 tonnes (human consumption for the combined area in 2014). Management for Division VIId should be separated from the rest of Subarea VII.

12.2.4 Management

Management of whiting is by TAC and technical measures. The TACs for this stock are split between two areas: (i) Subarea IV and Division IIa (EU waters), and (ii) Divisions VIIb-k, since 1996 when the North Sea and eastern Channel whiting assessments were first combined into one.

The agreed TACs for whiting in Subarea IV and Division IIa (EU waters) were 17 056 t in 2012, and 18 932 t in 2013. In 2014 the TAC for Subarea IV and Division IIa (EU waters) is set at 16 092t. There is no separate TAC for Division VIId; landings from this Division are counted against the TAC for Divisions VIIb-k combined (20 668 t in 2014). There are no means to control how much of the Division VIIb-k TAC is taken from Division VIId. By comparison, a specific TAC for Division VIId was established for cod in 2009, and the same procedure for whiting may be appropriate (see Tables 12.1 and 12.2).

In previous years, the human consumption landings in Subarea IV and Division VIId were calculated as 70% and 30% of the combined area totals. Since 2006, the landings data have been collated separately for each area.

The minimum landing size for whiting in Subarea IV is 27 cm. The minimum mesh size for whiting in Division VIId is 80 mm, also with a 27 cm minimum landing size.

Whiting are a by-catch in some Nephrops fisheries that use a smaller mesh size, although landings are restricted through by-catch regulations. They are also caught in flatfish fisheries that use a smaller mesh size. Industrial fishing with small-meshed gear is permitted, subject to by-catch limits of protected species. Regulations also apply to the area of the Norway pout box, preventing industrial fishing with small meshes in an area where the by-catch limits are likely to be exceeded.

Conservation credit scheme

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). 185 closures were enforced in 2011, 173 in 2012, 166 in 2013 and in 2014, 35closures had been implemented by 16th May. The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it may also have an effect on the mortality of associated species such as haddock.

Studies tracking Scottish vessels during 2009-2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the net effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the whiting stock is still under investigation.

In 2013, 18 Scottish demersal whitefish vessels are participating in a trial Fully Documented Fishery (FDF) scheme, following trials in 2010, 2011 and 2012. Similar trials have been conducted during various periods by Denmark, England, Germany, Sweden

and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on whiting fisheries of an enforceable discard ban for cod, and in data collation for the whiting assessment it was assumed that FDF vessels would have similar whiting discard patterns as other vessels, but this remains to be verified. The Scottish FDF scheme for 2014 is planned to begin in June, along similar lines to previous years. At the time of writing, in May 2014, 23 vessels had applied to join the scheme, and it is likely that all will be admitted and will receive a 25% increase in cod quota and extra days at sea in return for landing all cod caught.

12.2.5 Data available

12.2.5.1 Catch

Since 2012, international data on landings and discards have been collated through the InterCatch system (see Section 1.2). The process proved to be slow and cumbersome in the first year, largely due to the definition of around 160 fleet components for which whiting discard rates and age compositions had to be inferred. However, extensive development work by ICES on grouping fleet allocations has greatly improved the efficiency of the system, and the members of WGNSSK would like to record their appreciation for this.

Figure 12.1 shows fleet-specific landings for whiting in Subarea IV and Division VIId, both for fleets sampled for age compositions in landings and for fleets which were not sampled. The Figure also shows the cumulative landings when sampled and unsampled fleets are ordered by landings yield. Sampled fleets comprise only around 78% of the overall landings. However, although the unsampled fleets provide considerable landings overall, there are many of them and none of them provide much more than 1% of the overall landings. It would therefore make little difference to the final data collation to segregate fleets on the basis of area, quarter or gear type before applying age compositions. Therefore, age compositions were applied without any splitting of fleets on the basis of area, quarter or gear type. For consistency, the same approach was taken for raising discard rates from sampled to unsampled fleets. Discard rates for unsampled whiting fleet components in Subarea IV and Division VIId were obtained from samples provided by Denmark, Germany, France and the UK (UKE and UKS).

Official reported landings and WG estimates of catch component yields are given in Tables 12.1 and 12.2 for the North Sea (Subarea IV) and Eastern Channel (Division VIId). Industrial bycatch is almost entirely due to the Danish sandeel, sprat and Norway pout fisheries.

WG estimates of weights and numbers for the defined catch components (total catch, landings, discards and industrial bycatch) are given in Tables 12.3 to 12.10. The estimated tonnages of the Subarea IV catch components remain among the lowest in the series, and whiting industrial by-catch also remains low (however higher than last year). For Division VIId, the total catch in 2013 represents a decrease from the preceding three years (it is the lowest observed in the last 3 years).

Figure 12.2 plots the trends in the commercial catch for each component. Recent years have seen these time-series stabilise to a certain extent, and there has been a slight increase in discards for ages 1-2 in 2013. In age 3 there was a slight decrease. (Figure 12.3).

12.2.5.2 Age compositions

Age compositions in the landings and discards were based on samples provided by France, UK(England), UK(Scotland) and Germany (for landings). For discards, other than the countries mentioned before, Denmark also provided age-length data. Limited sampling of the industrial bycatch component resulted in the 2006 data appearing as an outlier and the 2007 to 2010 data were deemed unreliable. This applies to both the age compositions and the estimates of mean weights at age. Thus the data for 2006 to 2010 were replaced with an estimate n^a,y given by:

$$\hat{n}_{a,y} = \hat{N}_y \hat{p}_{a,y}, \quad (12.1)$$

where p^a,y is the mean proportion at age over the years 1990 to 2005, and N^ y is estimated to give a sums of products correction (SOP) factor of 1 by

$$\hat{N}_y = \frac{\sum_a \hat{p}_{a,y} \hat{w}_{a,y}}{W_y}, \quad (12.2)$$

where Wy is the reported weight of industrial bycatch. Here w^ a,y have been estimated by taking the mean weights at age in the industrial bycatch over the period 1995 to 2005 (zero weights are taken as missing values).

For the industrial bycatch in 2011 and 2012, age compositions were inferred in Inter-Catch from correspond- ing age samples taken from small-mesh fisheries of France and the UK.

Total international catch numbers at age (Subarea IV and Division VIId combined) are presented in Table 12.3. Numbers for human consumption landings, discards, and industrial bycatch are given in Tables 12.4 to 12.6.

12.2.5.3 Weight at age

Mean weights at age (Subarea IV and Division VIId combined) in the catch are presented in Table 12.7. These are also used as stock weights. Mean weights at age (both areas combined) in human consumption landings are presented in Table 12.8, and for the discards and industrial by-catch in the North Sea in Tables 12.9 and 12.10 respectively. Weights-at-age are depicted graphically in Figure 12.4, which indicates an increasing trend (with annual fluctuations) in mean weight-at-age in the landings, discards and catch for all ages except age 1.

Unrepresentative sampling of industrial bycatch in 2006 to 2010 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values).

12.2.5.4 Maturity and natural mortality

Values for maturity remain unchanged from those used in recent assessments and are given in Table 12.11. Their origin is discussed in the Stock Annex.

Estimates of natural mortality (M) are taken from the latest key from of the SMS multispecies model (ICES-WGSAM 2012), and are given in Table 12.12 and Figure 12.5. As the update approach (agreed at ICES-WKROUND, 2013) is to use natural mortality

estimates from the latest SMS key run, the values in Table 12.12 are used in the assessment this year.

12.2.5.5 Research vessel data

Survey tuning indices used in the assessment are presented in Table 12.13. These are ages 1 to 5 from the IBTS-Q1 and IBTS-Q3 surveys, from 1990 to 2014 and 1991 to 2013 respectively. The report of the 2001 meeting of WGNSSK (ICES-WGNSSK 2002), and the ICES advice for 2002 (ICES-ACFM 2001) provide arguments for the exclusion of commercial CPUE tuning series from calibration of the catch-at-age analysis. Such arguments remain valid and only survey data have been considered for tuning purposes. All available tuning series are presented in the Stock Annex prepared at ICES-WKROUND (2013).

Survey distribution maps are given in Figures 12.6 and 12.7, for the first quarter of 2013 and 2014 respectively. These have been produced only for the Scottish components of the North Sea and Division VIa surveys, and so do not cover the full area of the current assessment. However, they do show a consistent distribution during 2013 and 2014, and they also demonstrate that the northern North Sea whiting stock is not spatially separate from the northern Division VIa stock. In figures 12.7.1 survey distribution maps for Ages 1-3+ for the first quarter (Q1) 2010-2013 and Q1 for 2014 are presented. These maps are based on the IBTS-Q1 survey in the North Sea and therefore cover the full area of the current assessment. Figure 12.7.2, the third quarter is represented (Q3) for Ages 1- 3+ for the years 2010 – 2013.

12.2.6 Data analyses

The benchmark meeting for whiting in Subarea IV and Division VIId was held in Galway and Aberdeen in early 2013 (ICES-WKROUND 2013). Analyses focused on a number of key issues: these are listed below, along with relevant recommendations for future work (and steps taken by WGNSSK to address them):

CCTV-based discard-rate estimation

Several participating countries have now installed CCTV cameras on a subset of vessels, and the issue is whether footage from these can be used to improve discard- rate estimation for assessments. The WKROUND meeting concluded that further work is needed to integrate CCTV with existing observer programmes, and work is ongoing to improve length measurements accordingly (new camera and annotation systems, automated image analysis, and length-based assessments).

Length of assessment time-series

Considerable effort was put into the evaluation of the pre-1990 catch and survey data which were previously used in the assessment, but which were removed in recent years due to discrepancies between catch and survey information. WKROUND found that pre-1990 catch data would need to be reduced by at least 75% for the FLXSA SSB estimates (catch-based) to resemble those from SURBAR (survey-based). It did not seem possible to resolve this discrepancy, and WKROUND concluded that 1990 should be retained as the starting point for the update assessment.

Natural mortality and multispecies interactions

Significant changes to the estimates of natural mortality (M) used in the assessment were made in 2012 (ICES-WGNSSK 2012), following a key run of the SMS multispecies model in 2011 (ICES-WGSAM 2012). The changes for whiting were mostly due to inclusion of harbour porpoise and seal predation. The WKROUND conclusion was that

the use of the latest M estimates from WGSAM should be continued. WKROUND also requested that time- varying survey-based estimates of maturity for North Sea whiting should be calculated, although this has not yet been addressed.

Stock identity

The issue of how to define stock units for whiting that are biologically relevant remains a difficult one to address. WKROUND evaluated the available evidence, and produced area-specific SURBAR analyses to determine whether estimated time-series of biomass and mortality were correlated between different areas. Although the northern North Sea appeared to be linked with the areas immediately to the south and with no others, the analysis was not sufficiently conclusive. There is some evidence for north-south split in the North Sea, and some evidence for links between Divisions IVa and VIa, but full stock determination is hindered by data availability. It would be very difficult to subdivide historical landings and discards time-series from all participating nations between any new areas. WKROUND concluded that the issue of stock identity needs to be considered as a matter of high priority, and as a parallel process with the existing data collation and assessment approach.

Assessment models

WKROUND concluded that the update assessment model should continue to be FLXSA, with supporting exploratory runs using SURBAR (and, time permitting, SAM). A full investigation of the appropriate SAM run settings was not possible due to lack of time, although WKROUND recommended that this be done in the near future (possibly as an inter-benchmark process). Time also did not permit the production of a SAM run at the 2013 WGNSSK meeting.

Fmsy estimation WKROUND concluded that no reliable estimate of Fmsy could be found for North Sea whiting using standard approaches, and that candidate fishing mortality and biomass reference points should be developed using meta-analytic (or other) methods. Furthermore, their utility should be tested as part of a future management strategy evaluation process.

12.2.6.1 Exploratory survey-based analyses

Figure 12.8 presents time-series of survey log CPUE at age, and suggests that while broad trends are captured in a consistent way by the two surveys, finer-scale details of year-class strength may not be.

Catch-curve analyses for the surveys are shown in Figures 12.9. These show consistent tracking of year classes (since catch curves are mostly smooth) and consistent selection with some recent exceptions. The catchability of the IBTS Q1 seems to have changed since 2007, underestimating the size of the 2006 yearclass at age 1. The 2007 to 2010 year classes also seem to have been underestimated at age 1. The IBTS-Q3 survey shows low mortality for the 2006 year class, and a potential under estimate of the 2007 yearclass at age 1; however, numbers at age 2 in the 2007 yearclass may well be an overestimate. There does not appear to be a problem estimating age 1 in the 2008 or subsequent yearclasses in the IBTS-Q3 survey.

The consistency within surveys is assessed using correlation plots in Figures 12.10 and 12.11. These indicate that the IBTS Q1 and Q3 surveys both show good internal consistency across all ages. The log CPUE plots by survey (Figure 12.12) support the conclusion of good internal consistency.

Figures 12.13 to 12.15 summarise the results of a SURBAR analysis using the available whiting surveys. These show a well-specified analysis in which the data agree broadly with the separability assumptions in the model and uncertainty bounds are fairly tight.

12.2.6.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 12.16 and show numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 2 for some cohorts. Also evident is the persistence of the 1999 to 2001 year classes in the catch and the recent low catches of the 2002–2010 year classes.

The negative gradients of log catches per cohort, averaged over ages 2-6 and interpreted here as a rough proxy for fishing mortality over those ages, are given in Figure 12.17. The gradients (since the 2002 year class) appear to be fluctuating around a mean level that is lower than the mean level before the 1998 year- class, which suggests that recent fishing mortality is likely to be lower than in the past.

Within cohort correlations between ages are presented in Figure 12.18. In general, catch numbers correlate well between cohorts with the relationship breaking down as cohorts are compared across increasing time gaps.

Single fleet XSA runs were conducted to compare trends in the catch data with trends in the survey data. These used the same procedure as this year's final assessment. Summary plots of these runs are presented in Figure 12.19. The population trends from each survey are consistent; however, the mean F estimates differ considerably throughout the time-series (apart from the last two years). Residual patterns (Figure 12.20) show that the 2006 yearclass has a large negative residual at age 1 for both surveys (and particularly IBTS Q1).

Finally, Figure 12.21 compares the SURBAR results with the final XSA assessment. The mean Z (total mortality) estimates show year-to-year variation, but the trends in all outputs are very similar.

12.2.6.3 Conclusions drawn from exploratory analyses

Catch curve analysis and correlation plots show that in general both surveys and catch data track cohorts well and are internally consistent. However, beginning with the 2006 year class, the IBTS Q1 appears to be underestimating the abundance of age 1 and 2 whiting. In previous assessments, this had implications for the estimation of recruitment at age 1 in 2007 and resulted in a considerable retrospective bias. This year's assessment does not generate such a bias (see Figure 12.25), which may indicate that consistency has improved.

12.2.6.4 Final assessment

The final assessment used an FLXSA model fitted to the combined landings, discard and industrial by-catch data for the period 1990–2013. This is the same procedure as last year and that agreed at WKROUND (ICES-WKROUND 2013). The settings are provided in the table below.

Catch-at-age data	1990-2013
	Ages 1-8+
Calibration period	1990-2013
Survey: IBTS Q1	1990-2014

Ages 1-5	
Survey: IBTS Q3	1991-2013
Ages 1-5	
Catchability independent of stock size from	Age 1
Catchability plateau	Age 4
Weighting	No taper weighting
Shrinkage	Last 3 years and 4 ages
Shrinkage SE	2.0
Minimum SE for survivors' estimates	0.3

Diagnostics for the final XSA run are given in Tables 12.14 to 12.17. Residual plots are presented in Figure 12.22. These show that the IBTS Q3 survey fits more closely to the model and the catch data, than the IBTS Q1 survey which demonstrated considerable year effects towards the end of the time series. This indicates that the model is effectively paying less attention to the Q1 survey than to the Q3 survey, and this is borne out by Figure 12.23 which shows the contribution of each tuning fleet to the estimation of survivors in the most recent year.

Fishing mortality estimates are presented in Table 12.18, estimated stock numbers in Table 12.19 and the assessment summary in Table 12.20 and Figure 12.24.

A retrospective analysis is shown in Figure 12.25. This shows a consistent bias in recruitment from 2006 to 2010. The largest revision in recruitment is for recruitment in 2008 (the 2007 year class) which coincides with large negative residuals and the flat catch curve in the IBTS-Q1 survey (Figure 12.9). This translates directly to a large revision of SSB in 2008. However, the last three retrospective runs are very consistent. This may indicate that previous data problems have been corrected, although it may be too early to say whether the retrospective bias has actually been eliminated.

12.2.7 Historical stock trends

Historical trends for catch, mean F, SSB and recruitment are presented in Figure 12.24. These show that mean F is declining and has reached the minimum of the post-1990 time-series, that SSB has stabilised after recent increases, and that recruitment is fluctuating around a recent low average. In the most recent year, landings, discards and industrial bycatch have also all remained at or around a recent average. The stock-recruitment plot in Figure 12.26 shows some evidence of a positive relationship between SSB and subsequent recruitment, although such evidence is not compelling.

12.2.8 Recruitment estimates

RCT3 input data are presented in Table 12.21, and RCT3 output is presented in Table 12.22. The RCT3 estimate of recruitment in at age 1 in 2014 (that is, the 2013 year-class) was 2613 million. The geometric mean of all recruitments excluding the most recent year is 3687 million. Following the approach taken last year, and subsequently formalised in the benchmark report (ICES-WKROUND 2013), the WG agreed to use the RCT3 estimates for recruitment in 2014, and the long-term geometric mean for recruitment in 2015 and beyond.

12.2.9 Short-term forecasts

A short-term forecast was carried out based on the final FLXSA assessment. FLXSA survivors from 2013 were used as input population numbers for ages 2 and older in 2014. Recruitment assumptions are detailed in the preceding section.

The exploitation pattern was chosen as the mean exploitation pattern over the years 2011–2013. A simple mean F would have led to bias in forecast F , given the recent changes in F_{2-6} , so this exploitation pattern was scaled to the mean F_{2-6} in 2013 for forecasts. Partial F at age for each catch component was estimated by splitting the forecast F at age using the mean proportion in the catch of each catch component over the years 2011–2013. The F at age used in the forecast is compared with the F at age estimates for 2011–2013 in Figure 12.27.

Mean weights at age are generally consistent over the recent period but there are trends at several ages (Figure 12.4). To avoid introducing bias, therefore, the 2013 estimates were used for the purposes of forecasting.

The inputs to the short-term forecast are given in Tables 12.23 to 12.25, and results are presented in Table 12.26. The MFDP program was used to carry out the forecasts. In the Stock Annex, it is stipulated that FLR should be used for this purpose, but there is no available function currently within FLR to account for industrial bycatch in forecasts and WGNSSK could not complete the coding required to address this in the time available.

No TAC constraint was applied in the intermediate year since it is not considered that fishing will stop when the TAC is reached.

Assuming mean F_{2014} to equal mean F_{2013}, results in human consumption landings in 2014 of 19367 t from a total catch of 28731 t, giving an SSB in 2015 of 230124 t. Carrying the same fishing mortality forward into 2015 (the status quo F option) would result in landings of 17576 t out of total catches of 28798 t, and would result in an SSB of 265533 t in 2016 (an increase of 15%). Applying the proposed target F (0.225) from the management plan to the stock in 2015 would generate landings of 20687 t out of total catches of 33954 t, and result in an SSB of 261330 t in 2016 (a 14% increase).

12.2.10 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting. After the considerable revisions in the 2012 assessment, caused by new estimates of natural mortality, the target F is no longer considered applicable. The management plan was re-evaluated in October 2013 (ICES, 2013d) and ICES advised that updating the target F from 0.3 to 0.15 within the current management plan is considered precautionary under the assumption that recruitment stays within a medium–low range.

12.2.11 Biological reference points

The precautionary fishing mortality and biomass reference points agreed by the EU and Norway (and unchanged since 1999) are as follows:

Blim = 225, 000t ; Bpa = 315, 000t ; Flim = 0.90; Fpa = 0.65.

Note that WGNSSK considers that these reference points are not applicable to the current assessment (see discussion in the following Section).

$F_{0.1}$ and F_{max} were estimated based on the F -at-age from the final XSA assessment in each year back to 1993. $F_{0.1}$ has been stable historically at around 0.4 but has been very

variable in recent years. Due to the shape of the yield per recruit (YPR) curve, a maximum is often not reached, and F_{max} has therefore not been defined for several years. The WG considers that YPR F reference points are not applicable to this stock since F_{max} is undefined in most years, and the estimate of $F_{0.1}$ is very variable in recent years (see ICES- WGNSSK, 2009; Section 12.8). A long-term average selection pattern could be used to stabilise $F_{0.1}$ or a long term average of $F_{0.1}$ could be interpreted as a sensible reference point. Note that the 2013 benchmark meeting (ICES-WKROUND 2013) attempted to calculate F_{msy} for North Sea whiting, but concluded that this value was inestimable using standard equilibrium considerations and would need to be determined as part of a management strategy evaluation.

12.2.12 Quality of the assessment

Previous meetings of WGNSSK and the benchmark workshop (ICES-WKROUND 2009, ICES-WKROUND 2013) have concluded that the historical survey data and commercial catch data contain different signals concerning the stock. Analyses by Working Group members and by the ICES Study Group on Stock Identity and Management Units of Whiting (ICES-SGSIMUW 2005) indicate that data since the early- to mid-1990s are sufficiently consistent to undertake a catch-at-age analysis calibrated against survey data from1990. This has been taken forward into prediction for catch option purposes. However, due to the lack of concordance in the data pre-dating the early 1990s, WGNSSK considers that it is not possible categorically to classify the current state of the stock with reference to precautionary reference points as the biomass reference points are derived from a consideration of the stock dynamics dating from a time when the commercial catch-at-age data and the survey data conflict. Precautionary reference points must be reconsidered following the ongoing management strategy evaluation.

The IBTS-Q1 survey is showing a step change in catchability of young fish (especially age 1). The reason for this is unclear, but it appears to have happened after the 2006 survey. This represents a model misspecification, as the current model (FLXSA) assumes constant catchability through time.

Due to the likely population structuring in the North Sea and Eastern Channel, it is probable that the overall stock estimates may not reflect trends in more localised areas.

Given the spatial structure of the whiting stock and of the fleets exploiting it, it is important to have data that covers all fleets. Considering that age 1 and age 2 whiting make up a large proportion of the total stock biomass, good information of the discarding practices of the major fleets is important.

The survey information for Division VIId were not available in a form that could be used by WGNSSK. Due to the recent changes in distribution of the stock, tuning information from this area would be extremely useful, and could improve the estimate of recruitment in the most recent year. However, previous analyses of the survey in Division VIId showed it did not track cohorts well (ICES-WKROUND 2009).

Age distributions and mean weights at age have been estimated for the industrial bycatch from 2006 to 2010. This was due to low sampling levels of the Danish industrial bycatch fisheries. Although the fishery only comprises around 0.03% by weight of the total catch, the bycatch of whiting is mostly young fish so comprises around 10% by number (excluding age 0). This means that, for these years, no cohort information was coming from the industrial component of the catch and this potentially reduces our ability to estimate the recruitment of some recent year classes.

The historical performance of the assessment is summarised in Figure 12.28.

12.2.13 Status of the stock

For North Sea whiting, SSB is estimated to be just above B(lim). As there have been no fishing mortality reference points defined, the status of the stock with respect to these is unknown. Nevertheless all indications are that the stock, at the level of the entire North Sea and Eastern Channel, was at an historical low level during 2005 to 2008 (relative to the period since 1990), and that the recent increase is in large part due to relatively improved perception of recruitment in 2008. Fishing mortality is currently fluctuating around a low level. Recruitment is varying around a recent mean, but that mean is low relative to the rest of the time series and whiting biomass is likely to decline in future (even with low fishing mortality rates) until the appearance of the next good year class. The Quality evaluation is set to be below recent average.

12.2.14 Management considerations

Between 2003 and 2007 the whiting stock produced the lowest recruitments in the series. Whiting recruitment (estimated largely from the IBTS-Q1 and IBTS-Q3 surveys) was underestimated substantially in 2007 and 2008 resulting in low forecasts of recruitment and recommendations of reduced TACs due to the perception of critically low recruitment. Subsequent recruitment is below the long-term average.

Whiting mature at age 2 and grow quickly at young ages; therefore an increase in SSB is seen the year immediately after a good recruitment. Managers should consider the age structure of the population as well as the SSB since at low stock sizes short term forecasts are highly sensitive to recruitment assumptions.

Catches of whiting have been declining since 1980 (from 224 000 t in 1980 to 25 440 t in 2012, including discards and industrial bycatch). Catch rates from localized fleets may not represent trends in the overall North Sea and English Channel population. The localized distribution of the population is known to be resulting in substantial differences in the quota uptake rate. This is likely to result in localized discarding problems that should be monitored carefully.

Whiting are caught in mixed demersal roundfish fisheries, fisheries targeting flatfish, the Nephrops fisheries, and the Norway pout fishery. The current minimum mesh-size in the targeted demersal roundfish fishery in the northern North Sea has resulted in reduced discards from that sector compared with the historical discard rates. Mortality may have increased on younger ages due to increased discarding in recent years as a result of recent changes in fleet dynamics of Nephrops fleets and small mesh fisheries in the southern North Sea. The bycatch of whiting in the Norway pout and sandeel fisheries is dependent on activity in that fishery, which has recently declined after strong reductions in the fisheries. Industrial bycatches are considered low in the forecast. A larger catch allocation for bycatch may be required if industrial effort increases.

Catches of whiting in the North Sea are also likely to be affected by the effort reduction seen in the targeted demersal roundfish and flatfish fisheries, although this will in part be offset by increases in the number of vessels switching to small mesh fisheries. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. WGMIXFISH monitors the consistency of the various single-species management plans and TAC advice under current effort schemes, in order to estimate the potential risks of quota over- and under

shooting for the different stocks, and it was demonstrated that the current basis for whiting advice was not consistent with other single-stock management objectives. It is recommended that the ongoing discussions about the whiting management plan takes into account such mixed-fisheries considerations before implementation.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear in the North Sea and Skagerrak, should be encouraged for whiting. There is a mismatch between quota allocations, derived from relative stability criteria, and the access of the various fisheries to the resource which has changed because of changes in the distribution of whiting.

ICES has developed a generic approach to evaluate whether new survey in-formation that becomes available in September forms a basis to update the advice. ICES will publish new advice in October 2014 if this is the case for this year.

12.3 References

ICES-ACFM (2001). Report of the ICES Advisory Committee on Fisheries Management.

ICES-SGSIMUW (2005). Report of the Study Group on Stock Identity and Management Units of Whiting, (SGSIMUW), 15–17 March 2005, Aberdeen. ICES CM 2005/G:03.

ICES-WGNSSK (2002). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2003/ACFM:02.

ICES-WGNSSK (2009). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Combined Spring and Autumn (WGNSSK), 6 - 12 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:10.

ICES-WGNSSK (2012). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2011/ACOM:13.

ICES-WGSAM (2012). Report of the Working Group on Multispecies Assessment Methods (WGSAM 2012). ICES CM 2012/ACOM:XXXX.

ICES-WKROUND (2009). Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND). ICES CM 2009/ACOM:32.

ICES-WKROUND (2013). Report of the Benchmark Workshop on Roundfish Stocks (WKROUND 2011). ICES CM 2013/ACOM:47.

ICES. 2013d. Joint EU–Norway request to evaluate the long-term management plan for whiting in the North Sea. In Report of the ICES Advisory Committee, 2013. ICES Advice 2013, Book 6, Section 6.3.5.2.

Needle, C. L. (2012). Fleet Dynamics in Fisheries Management Strategy Evaluations, PhD thesis, University of Strathclyde, Glasgow.

Needle, C. L. and Catarino, R. (2011). Evaluating the effect of real-time closures on cod targeting, ICES Journal of Marine Science 68(8): 1647–1655.

Table 12.1: Whiting in Subarea IV and Division VIId. Nominal landings (in tonnes) as officially reported to ICES, WG estimates of catch components, and TACs. Subarea IV.

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
belgium.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	536	454	270
denmark.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	105	105	96
france.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2527	3455	3314
germany.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	424	402	354
netherlands.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1884	2478	2425
norway.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	33	44	47
sweden.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	6	7
england.wales.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1782	1301	1322
scotland.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	17158	10589	7756
uk.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
total.landings.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	24453	18834	15591
unallocated.landings.iv	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	173	-426	721
wg.landings.iv	42180	46210	45210	46610	41870	40550	35550	30940	23690	25700	24280	19260	14870
wg.discards.iv	52270	30840	28470	41400	31840	28940	27130	16660	12480	22110	21931	16130	17144
wg.ibc.iv	51337	39755	25045	20723	17473	27379	5116	6213	3494	5038	9160	940	7270
wg.catch.iv	145787	116805	98725	108733	91183	96869	67796	53813	39664	52848	55371	36330	39284
tac.iv.iia	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	30000	29700	41000

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
belgium.iv	248	144	105	93	45	115	162	147	74	45	33	NA
denmark.iv	89	62	57	251	79	42	80	158	135	131	124	NA
france.iv	2675	1721	1261	2711	3312	3051	2304	2631	2546	1925	930	NA
germany.iv	334	296	149	252	76	76	125	156	111	25	44	NA
netherlands.iv	1442	977	805	702	618	656	718	615	514	471	495	NA
norway.iv	39	23	16	17	11	92	73	118	28	94	560	NA
sweden.iv	10	2	0	1	1	1	4	8	6	4	1	NA
england.wales.iv	680	1209	2560	3539	3048	1541	1397	NA	NA	NA	NA	NA
scotland.iv	5734	5057	3441	8093	9063	8850	7456	NA	NA	NA	NA	NA
uk.iv	NA	NA	NA	NA	NA	NA	NA	7841	8891	9862	11167	NA
total.landings.iv	11251	9491	8394	15659	16253	14424	12319	11527	12305	12547	13354	NA
unallocated.landings.iv	801	541	-2286	562	587	945	545	-754	-1000	-382	-2030	NA
wg.landings.iv	10450	8950	10680	15097	15666	13479	11774	12281	13305	12929	15384	NA
wg.discards.iv	26135	18142	10300	14018	5206	8356	5223	7853	8180	5929	4198	NA
wg.ibc.iv	2730	1210	890	2190	1240	0	1020	1350	1750	78	1655	NA
wg.catch.iv	39315	28302	21870	31305	22112	21835	18017	21484	23235	18936	21237	NA
tac.iv.iia	16000	16000	28500	23800	23800	17850	15173	12897	14832	17056	18932	16092

Table 12.2: Whiting in Subarea IV and Division VIId. Nominal landings (in tonnes) as officially reported to ICES, WG estimates of catch components, and TACs. Division VIId.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
belgium.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	65	75	58	67	46
france.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5875	6338	5172	6654	5006
netherland.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	14	67	19	175	132
england. wales.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	118	134	112	109	99
total. landings.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6072	6614	5361	7005	5283
unallocated. landings.viid	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1772	814	-439	1295	933
wg.landings.viid	3480	5720	5740	5210	6620	5390	4950	4620	4600	4430	4300	5800	5800	5710	4350
wg.discards.viid	3330	4220	4090	2970	3850	3240	3370	3000	3210	3570	4129	3109	1356	604	907
wg.catch.viid	6810	9940	9830	8180	10470	8630	8320	7620	7810	8000	8429	8909	7156	6314	5257
tac.viib.k	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	22000	21000	31700	31700	27000

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
belgium.viid	45	73	75	69	71	88	78	66	94	NA
france.viid	4638	3487	3135	2875	6266	5436	4438	3093	3041	NA
netherland.viid	128	117	118	162	112	270	282	437	650	NA
england.wales.viid	90	53	50	54	86	253	271	258	NA	NA
total.landings.viid	4901	3730	3378	3160	6535	5959	5069	3854	3785	NA
unallocated.landings. viid	111	287	124	-1311	-111	20	5	-249	-165	NA
wg.landings.viid	4790	3443	3254	4471	6646	5939	5064	4103	3950	NA
wg.discards.viid	2219	2291	1763	1943	2477	3727	3538	2446	1778	NA
wg.catch.viid	7009	5734	5017	6414	9123	9666	8602	6549	5728	NA
tac.viib.k	21600	19940	19940	19940	16949	14407	16568	19053	24500	20668

Table 12.3: Whiting in Subarea IV and Division VIId. Total catch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	687238	418910	313391	242370	90047	7563	7565	1851	253	11	9	4	0	0	0	0	277
1979	476383	615524	467537	218283	100975	29267	3111	1657	264	35	1	4	0	0	0	0	304
1980	332209	265359	416008	286077	90718	52969	10751	1152	689	58	14	5	1	0	0	0	767
1981	516869	162899	346343	266517	102295	27776	12297	3540	244	45	37	1	0	0	0	0	326
1982	101058	192640	114444	245246	88137	26796	6909	2082	400	53	26	4	1	0	0	0	484
1983	668604	205646	184746	118412	131508	37231	8688	1780	794	101	35	0	0	0	0	0	930
1984	157819	323408	175965	124886	49505	59817	13860	2964	410	182	21	0	0	0	0	0	613
1985	186723	203321	141716	82037	37847	14420	17445	3328	805	89	9	1	0	0	0	0	904
1986	225201	576731	167077	169577	46517	13367	3487	3975	497	71	0	1	0	0	0	0	569
1987	84863	267051	368229	122748	85240	11392	4556	928	929	98	7	0	0	0	0	0	1035
1988	416924	430344	307429	179502	39635	17901	2175	544	59	72	37	0	0	0	0	0	168
1989	87325	331672	173676	191942	78464	14367	5050	516	291	36	6	1	0	0	0	0	334
1990	289174	258102	501372	127966	84147	31102	1934	719	93	16	0	0	0	0	0	0	109
1991	1058000	135797	194921	184960	36290	25554	5339	526	249	17	1	0	0	0	0	0	268
1992	259390	230302	167478	87819	91081	11654	6634	2546	104	7	1	0	0	0	0	0	112
1993	628301	223425	172048	125599	46181	45300	3899	1501	682	56	15	0	0	0	0	0	754
1994	218286	191544	158369	97559	51040	18683	17905	1258	441	73	0	0	0	0	0	0	514
1995	1597900	148170	144023	112416	35649	15062	5117	4472	315	101	54	0	0	0	0	0	470
1996	96515	86318	118910	99644	48303	14088	4638	1281	897	166	24	6	2	0	0	0	1095
1997	19001	60946	80471	84336	41975	18304	3333	1012	304	135	16	0	0	0	0	0	456
1998	72289	92557	50361	43423	36295	17627	6343	1416	306	66	33	0	0	0	0	0	405
1999	76976	189162	95416	45920	33921	18271	7443	2021	565	95	12	0	0	0	0	0	672
2000	1970	82545	129582	63706	23913	16198	8758	4309	969	244	47	3	0	0	0	0	1264
2001	18011	52567	83086	52076	20799	9256	4826	2233	896	246	124	2	0	0	0	0	1268
2002	135848	51338	62462	84600	34659	8098	2048	1461	621	102	13	9	9	0	0	0	755
2003	60744	83680	111144	55866	41840	14218	2358	473	329	50	16	1	0	0	0	0	397
2004	34210	47967	23009	32557	30401	21755	8342	1351	197	93	12	1	4	0	0	0	307
2005	17621	47805	34627	12204	18146	14931	8979	3041	540	83	29	1	0	0	0	0	654
2006	15673	73908	42198	21651	8642	15077	11822	4618	1300	142	14	0	0	0	0	0	1457
2007	34038	39041	34001	24900	9905	4009	7657	5267	2559	476	82	0	0	0	0	0	3117
2008	5631	62164	28301	22741	13571	4305	1848	3954	2134	631	143	43	0	0	0	0	2951
2009	2362	19919	56301	14922	11605	5331	1409	613	1504	942	341	49	1	0	0	0	2837
2010	1224	26266	60426	24826	8016	5394	2867	518	650	567	239	54	1	0	0	0	1510
2011	612	32894	59451	27509	14825	3331	2179	1032	119	47	92	55	0	0	0	0	312
2012	1854	28438	29366	22034	17656	6541	2406	1215	330	86	52	18	55	0	5	0	546
2013	4979	19972	17442	30164	16063	11179	3598	781	366	132	3	0	0	0	0	0	501

Table 12.4: Whiting in Subarea IV and Division VIId. Landings numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0	14793	99836	155424	76829	6693	7202	1837	253	11	9	4	0	0	0	0	277
1979	8	8488	108548	144343	89093	26584	3011	1617	250	35	1	4	0	0	0	0	290
1980	0	3656	62405	152570	68422	41430	9911	1135	689	58	14	5	1	0	0	0	767
1981	6	4240	69211	104348	78253	23698	12036	3530	244	45	37	1	0	0	0	0	326
1982	0	10890	46703	124656	59393	21376	5664	2058	400	53	26	4	1	0	0	0	484
1983	1	10568	68640	67312	101342	31266	8330	1730	784	101	35	0	0	0	0	0	921
1984	0	14388	62693	99204	41277	51745	12735	2813	410	182	21	0	0	0	0	0	613
1985	1	2288	51194	57049	32340	12974	16361	3238	805	89	9	1	0	0	0	0	904
1986	29	12879	44500	111527	37287	11285	3379	3912	485	71	0	1	0	0	0	0	557
1987	22	11074	72372	70504	73742	10808	4506	928	899	98	7	0	0	0	0	0	1004
1988	0	7462	61360	94163	29147	16556	2158	544	56	72	37	0	0	0	0	0	164
1989	52	8636	28406	77009	44307	9249	3888	420	208	35	6	1	0	0	0	0	249
1990	23	6910	52533	43850	48537	16845	1341	605	91	16	0	0	0	0	0	0	107
1991	410	11565	42525	88974	25738	21261	4581	396	249	17	1	0	0	0	0	0	268
1992	298	9565	44697	47843	59208	9784	6099	1453	99	7	1	0	0	0	0	0	107
1993	720	5957	28935	63383	32819	33741	2932	1339	682	56	15	0	0	0	0	0	753
1994	77	17124	31351	45492	36289	13920	14407	914	366	73	0	0	0	0	0	0	439
1995	277	8829	28027	58046	27775	13652	4911	4359	308	101	54	0	0	0	0	0	463
1996	1015	12517	26611	47125	35828	11861	4396	1103	897	166	24	6	2	0	0	0	1095
1997	608	6511	23436	47717	31503	15615	2931	1010	289	135	15	0	0	0	0	0	439
1998	1202	17071	19828	24860	24473	14579	5395	1204	219	64	16	0	0	0	0	0	299
1999	68	16661	26669	25504	23465	14483	6554	1854	514	61	12	0	0	0	0	0	587
2000	0	15384	31808	28283	14241	11775	6618	3758	862	244	47	3	0	0	0	0	1157
2001	150	12260	28476	27293	17491	8633	4503	2091	877	246	124	2	0	0	0	0	1249
2002	0	2610	10346	30890	22353	6712	1710	1330	511	99	10	9	9	0	0	0	639
2003	20	403	11613	13990	18974	9513	1861	443	329	50	16	0	0	0	0	0	396
2004	0	3973	2812	9629	13302	11846	4409	747	174	84	12	1	4	0	0	0	274
2005	74	11009	10414	5669	10926	10283	5933	2343	321	78	29	1	0	0	0	0	429
2006	11	11055	11023	8494	5362	12259	10161	4118	1080	105	6	0	0	0	0	0	1192
2007	140	10378	14740	16491	7666	3310	6681	4227	2179	383	77	0	0	0	0	0	2638
2008	0	13234	12334	14120	9106	3564	1519	2505	1481	568	143	43	0	0	0	0	2235
2009	2	2462	31910	9615	9516	4318	1252	548	1156	876	304	49	1	0	0	0	2386
2010	9	3593	27147	15341	4885	4063	1746	363	391	489	230	54	1	0	0	0	1165
2011	0	4679	22858	14952	10821	2333	1484	729	114	42	76	48	0	0	0	0	280
2012	213	4872	13111	13014	11490	4726	1590	860	247	76	28	13	49	0	4	0	417
2013	7	2596	7176	17656	12699	9914	3208	705	328	122	3	0	0	0	0	0	453

Table 12.5: Whiting in Subarea IV and Division VIId. Discards numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	28587	52684	114965	37682	7154	255	110	0	0	0	0	0	0	0	0	0	0
1979	4577	473830	126724	31601	7322	1263	27	7	0	0	0	0	0	0	0	0	0
1980	3144	103203	250735	88399	14135	10795	786	0	0	0	0	0	0	0	0	0	0
1981	867	50407	96509	57403	7313	1285	149	10	0	0	0	0	0	0	0	0	0
1982	18639	53753	26922	52349	18230	2972	343	22	0	0	0	0	0	0	0	0	0
1983	71016	152488	85318	33325	23442	4309	295	25	9	0	0	0	0	0	0	0	9
1984	16724	200589	82563	16814	4437	4495	1034	151	0	0	0	0	0	0	0	0	0
1985	8497	154232	48791	15117	2985	761	801	65	0	0	0	0	0	0	0	0	0
1986	7966	404604	120492	43479	5242	627	108	63	12	0	0	0	0	0	0	0	12
1987	9978	158531	202154	34824	9776	582	49	0	31	0	0	0	0	0	0	0	31
1988	21321	65021	87197	51135	5877	846	16	0	3	0	0	0	0	0	0	0	3
1989	6898	150598	36712	61442	21267	3276	103	8	12	0	0	0	0	0	0	0	12
1990	147764	83152	241924	33084	23009	11665	246	85	0	0	0	0	0	0	0	0	0
1991	7208	81678	82053	75035	5176	1885	91	60	0	0	0	0	0	0	0	0	0
1992	7587	105838	63830	27659	23115	1231	355	1064	2	0	0	0	0	0	0	0	2
1993	48873	128248	104844	51054	9205	10727	521	131	0	0	0	0	0	0	0	0	0
1994	8352	96890	102020	37751	9867	2885	2338	7	0	0	0	0	0	0	0	0	0
1995	33363	53830	81783	50019	7136	1336	206	113	6	0	0	0	0	0	0	0	6
1996	4575	43126	86878	49817	11506	2205	240	179	0	0	0	0	0	0	0	0	0
1997	11525	26188	34948	32473	9398	2412	400	2	16	0	1	0	0	0	0	0	17
1998	6098	50703	24200	17053	11076	2987	936	213	87	2	18	0	0	0	0	0	106
1999	14762	96413	56365	15228	9016	3104	862	167	51	34	0	0	0	0	0	0	85
2000	1682	48162	81086	24082	3075	2311	1560	478	107	0	0	0	0	0	0	0	107
2001	17352	39826	52156	23055	2795	471	283	142	19	0	0	0	0	0	0	0	19
2002	1158	10597	33371	45125	10136	1182	218	131	110	3	3	0	0	0	0	0	116
2003	3584	65829	94497	39301	21654	4314	449	30	0	0	0	1	0	0	0	0	1
2004	10478	31169	15698	21879	16951	9909	3922	605	24	9	0	0	0	0	0	0	33
2005	5499	25753	23486	6041	7192	4616	2992	688	211	5	0	0	0	0	0	0	216
2006	15662	51961	25906	10935	2474	2595	1598	493	219	37	8	0	0	0	0	0	265
2007	2350	22508	16283	7153	1784	572	940	1037	380	93	5	0	0	0	0	0	478
2008	5631	48929	15967	8621	4465	741	328	1449	653	63	0	0	0	0	0	0	716
2009	2360	12411	21950	4277	1715	910	128	62	347	66	37	0	0	0	0	0	450
2010	1215	15988	30046	8121	2637	1194	1082	151	258	77	9	0	0	0	0	0	344
2011	612	28024	34431	11770	3314	866	641	274	5	3	9	5	0	0	0	0	22
2012	1635	23479	16165	8953	6112	1796	809	352	82	10	23	5	6	0	0	0	128
2013	4972	17154	9653	10997	2277	417	116	15	10								

Table 12.6: Whiting in Subarea IV and Division VIId. Industrial bycatch numbers at age (thousands). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	658651	351432	98590	49263	6064	616	252	14	0	0	0	0	0	0	0	0	0
1979	471798	133206	232266	42339	4561	1420	73	33	14	0	0	0	0	0	0	0	14
1980	329065	158500	102869	45108	8162	744	55	18	0	0	0	0	0	0	0	0	0
1981	515996	108252	180623	104766	16729	2793	112	0	0	0	0	0	0	0	0	0	0
1982	82418	127998	40818	68242	10514	2448	902	2	0	0	0	0	0	0	0	0	0
1983	597587	42591	30789	17774	6723	1656	63	25	0	0	0	0	0	0	0	0	0
1984	141095	108431	30709	8868	3790	3577	91	0	0	0	0	0	0	0	0	0	0
1985	178224	46801	41731	9871	2522	685	284	26	0	0	0	0	0	0	0	0	0
1986	217207	159249	2086	14572	3987	1456	0	0	0	0	0	0	0	0	0	0	0
1987	74863	97446	93704	17420	1722	1	0	0	0	0	0	0	0	0	0	0	0
1988	395603	357861	158872	34205	4611	500	0	0	0	0	0	0	0	0	0	0	0
1989	80375	172438	108558	53491	12890	1842	1060	89	71	2	0	0	0	0	0	0	72
1990	141387	168040	206916	51033	12601	2592	346	29	2	0	0	0	0	0	0	0	2
1991	1050381	42554	70343	20951	5376	2408	667	70	0	0	0	0	0	0	0	0	0
1992	251505	114899	58952	12318	8758	639	180	29	3	0	0	0	0	0	0	0	3
1993	578708	89219	38270	11162	4157	832	445	31	0	0	0	0	0	0	0	0	0
1994	209858	77530	24998	14316	4885	1878	1160	337	75	0	0	0	0	0	0	0	75
1995	1564260	85510	34213	4351	738	73	0	0	0	0	0	0	0	0	0	0	0
1996	90925	30675	5421	2702	970	21	2	0	0	0	0	0	0	0	0	0	0
1997	6868	28247	22087	4146	1074	276	2	0	0	0	0	0	0	0	0	0	0
1998	64989	24782	6334	1511	746	62	12	0	0	0	0	0	0	0	0	0	0
1999	62145	76088	12381	5188	1440	684	27	0	0	0	0	0	0	0	0	0	0
2000	288	19000	16688	11341	6597	2113	580	73	0	0	0	0	0	0	0	0	0
2001	510	481	2453	1728	514	152	40	0	0	0	0	0	0	0	0	0	0
2002	134690	38131	18745	8585	2170	205	120	0	0	0	0	0	0	0	0	0	0
2003	57140	17448	5034	2575	1213	390	49	0	0	0	0	0	0	0	0	0	0
2004	23732	12824	4499	1049	147	0	11	0	0	0	0	0	0	0	0	0	0
2005	12049	11043	726	494	28	32	54	10	8	0	0	0	0	0	0	0	8
2006	0	10892	5270	2222	806	223	63	7	1	0	0	0	0	0	0	0	1
2007	31548	6155	2978	1256	456	126	36	4	1	0	0	0	0	0	0	0	1
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	5046	2441	1030	374	103	29	3	1	0	0	0	0	0	0	0	1
2010	0	6685	3234	1364	495	137	39	4	1	0	0	0	0	0	0	0	1
2011	0	191	2162	787	691	132	54	30	0	1	7	2	0	0	0	0	11
2012	6	87	90	67	54	20	7	4	1	0	0	0	0	0	0	0	2
2013	1	222	614	1511	1087	848	275	60	28	10	0	0	0	0	0	0	0

Table 12.7: Whiting in Subarea IV and Division VIId. Total catch mean weights at age (kg). Age 8 is a plus-group. These estimates are also used as stock mean weights at age. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.010	0.074	0.182	0.234	0.322	0.427	0.428	0.466	0.615	0.702	1.539	0.589	0.000	0.000	0.000	0	0.649
1979	0.009	0.098	0.166	0.259	0.301	0.411	0.455	0.492	0.578	0.617	0.737	0.515	0.000	0.000	0.000	0	0.582
1980	0.013	0.075	0.176	0.252	0.328	0.337	0.458	0.458	0.568	0.539	0.790	0.688	1.711	0.000	0.000	0	0.572
1981	0.011	0.083	0.168	0.242	0.321	0.379	0.411	0.444	0.651	0.833	1.041	0.695	0.000	0.000	0.000	0	0.720
1982	0.029	0.061	0.184	0.253	0.314	0.376	0.478	0.504	0.702	0.772	1.141	0.853	1.081	0.000	0.000	0	0.736
1983	0.015	0.107	0.191	0.273	0.325	0.384	0.426	0.452	0.520	0.677	0.516	0.000	0.000	0.000	0.000	0	0.537
1984	0.020	0.089	0.188	0.271	0.337	0.382	0.391	0.463	0.575	0.514	0.871	0.000	0.000	0.000	0.000	0	0.567
1985	0.014	0.094	0.192	0.284	0.332	0.402	0.435	0.494	0.426	0.507	0.852	0.976	0.000	0.000	0.000	0	0.438
1986	0.015	0.105	0.183	0.255	0.318	0.378	0.475	0.468	0.540	1.226	0.990	0.535	0.000	0.000	0.000	0	0.626
1987	0.013	0.077	0.148	0.247	0.297	0.375	0.379	0.542	0.555	0.857	0.603	1.193	0.000	0.000	0.000	0	0.584
1988	0.013	0.054	0.146	0.223	0.301	0.346	0.423	0.506	0.854	0.585	0.648	0.000	0.000	0.000	0.000	0	0.694
1989	0.023	0.070	0.157	0.225	0.267	0.318	0.391	0.431	0.369	0.517	0.857	0.609	0.000	0.000	0.000	0	0.394
1990	0.016	0.084	0.137	0.210	0.252	0.279	0.411	0.498	0.636	0.351	0.918	0.000	0.000	0.000	0.000	0	0.594
1991	0.018	0.104	0.168	0.217	0.289	0.306	0.339	0.365	0.385	0.589	0.996	2.756	0.000	0.000	0.000	0	0.401
1992	0.013	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.480	0.763	1.728	0.000	0.000	0.000	0.000	0	0.506
1993	0.012	0.073	0.174	0.250	0.316	0.328	0.346	0.400	0.376	0.417	0.359	0.000	0.000	0.000	0.000	0	0.379

1994	0.013	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.438	0.392	0.499	0.000	0.000	0.000	0.000	0	0.431
1995	0.010	0.089	0.180	0.257	0.340	0.384	0.429	0.434	0.445	0.346	0.406	0.000	0.000	0.000	0.000	0	0.419
1996	0.018	0.094	0.167	0.235	0.302	0.388	0.407	0.431	0.439	0.404	0.376	0.398	0.287	0.000	0.000	0	0.432
1997	0.028	0.096	0.178	0.242	0.295	0.334	0.384	0.387	0.394	0.479	0.458	0.000	0.000	0.000	0.000	0	0.422
1998	0.018	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.335	0.495	0.433	0.600	0.000	0.000	0.000	0	0.369
1999	0.023	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.286	0.316	0.344	0.000	0.000	0.000	0.000	0	0.292
2000	0.034	0.117	0.182	0.238	0.287	0.286	0.276	0.275	0.268	0.264	0.280	0.321	0.000	0.000	0.000	0	0.268
2001	0.024	0.101	0.192	0.244	0.282	0.267	0.298	0.284	0.286	0.301	0.315	0.505	0.000	0.000	0.000	0	0.292
2002	0.010	0.069	0.155	0.218	0.273	0.303	0.350	0.343	0.327	0.412	0.288	0.231	0.304	0.643	0.000	0	0.336
2003	0.012	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.342	0.462	0.620	0.000	0.000	0.000	0.000	0	0.368
2004	0.031	0.111	0.150	0.213	0.253	0.286	0.285	0.286	0.347	0.351	0.352	1.463	0.337	0.000	0.000	0	0.350
2005	0.032	0.124	0.199	0.239	0.250	0.282	0.305	0.298	0.271	0.376	0.316	0.337	0.670	0.000	0.000	0	0.286
2006	0.093	0.131	0.180	0.231	0.274	0.288	0.360	0.345	0.318	0.299	0.289	0.000	0.000	0.000	0.000	0	0.316
2007	0.029	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.325	0.288	0.328	0.350	0.000	0.000	0.000	0	0.320
2008	0.027	0.104	0.218	0.282	0.315	0.402	0.407	0.317	0.359	0.337	0.334	0.433	0.000	0.000	0.000	0	0.354
2009	0.042	0.092	0.220	0.289	0.381	0.401	0.465	0.393	0.336	0.310	0.342	0.321	0.436	0.000	0.000	0	0.328
2010	0.022	0.088	0.226	0.305	0.376	0.448	0.422	0.458	0.380	0.376	0.351	0.355	0.272	0.000	0.000	0	0.373
2011	0.046	0.106	0.185	0.315	0.379	0.443	0.499	0.460	0.568	0.606	0.396	0.437	0.894	0.000	0.000	0	0.501

2012	0.021	0.087	0.193	0.279	0.385	0.398	0.413	0.421	0.443	0.583	0.225	0.478	0.618	0.489	0.288	0	0.462
2013	0.045	0.091	0.188	0.246	0.399	0.481	0.498	0.523	0.465	0.567	1.027	0	0	0	0	0	0.496

Table 12.8: Whiting in Subarea IV and Division VIId. Landings mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.000	0.185	0.233	0.250	0.334	0.426	0.434	0.466	0.615	0.702	1.539	0.589	0.000	0.000	0.000	0	0.649
1979	0.113	0.206	0.231	0.277	0.304	0.416	0.456	0.491	0.583	0.617	0.737	0.515	0.000	0.000	0.000	0	0.587
1980	0.000	0.204	0.239	0.273	0.335	0.358	0.473	0.457	0.568	0.539	0.790	0.688	1.711	0.000	0.000	0	0.572
1981	0.144	0.194	0.242	0.292	0.331	0.378	0.411	0.445	0.651	0.833	1.041	0.695	0.000	0.000	0.000	0	0.720
1982	0.000	0.186	0.230	0.282	0.340	0.396	0.461	0.507	0.702	0.772	1.141	0.853	1.081	0.000	0.000	0	0.736
1983	0.132	0.199	0.240	0.282	0.332	0.383	0.429	0.452	0.522	0.677	0.516	0.000	0.000	0.000	0.000	0	0.538
1984	0.000	0.194	0.231	0.279	0.346	0.391	0.403	0.472	0.575	0.514	0.871	0.000	0.000	0.000	0.000	0	0.567
1985	0.137	0.187	0.248	0.307	0.337	0.408	0.443	0.498	0.426	0.507	0.852	0.976	0.000	0.000	0.000	0	0.438
1986	0.131	0.189	0.230	0.279	0.327	0.376	0.484	0.472	0.546	1.226	0.990	0.535	0.000	0.000	0.000	0	0.632
1987	0.135	0.188	0.226	0.286	0.310	0.381	0.381	0.542	0.564	0.857	0.603	1.193	0.000	0.000	0.000	0	0.593
1988	0.117	0.194	0.226	0.256	0.328	0.351	0.425	0.506	0.887	0.585	0.648	0.000	0.000	0.000	0.000	0	0.702
1989	0.171	0.178	0.226	0.253	0.288	0.345	0.370	0.440	0.373	0.522	0.857	0.609	0.000	0.000	0.000	0	0.405
1990	0.167	0.206	0.222	0.263	0.296	0.337	0.455	0.533	0.640	0.351	0.918	0.000	0.000	0.000	0.000	0	0.597
1991	0.139	0.202	0.249	0.252	0.308	0.317	0.349	0.387	0.385	0.589	0.996	2.756	0.000	0.000	0.000	0	0.401
1992	0.145	0.194	0.246	0.289	0.306	0.340	0.356	0.383	0.473	0.763	1.728	0.000	0.000	0.000	0.000	0	0.501
1993	0.153	0.194	0.248	0.284	0.345	0.358	0.385	0.418	0.376	0.417	0.359	0.000	0.000	0.000	0.000	0	0.379
1994	0.132	0.182	0.248	0.297	0.346	0.392	0.382	0.412	0.414	0.392	0.499	0.000	0.000	0.000	0.000	0	0.410
1995	0.140	0.171	0.256	0.299	0.367	0.397	0.437	0.437	0.448	0.346	0.406	0.000	0.000	0.000	0.000	0	0.421
1996	0.143	0.169	0.222	0.274	0.329	0.408	0.415	0.452	0.439	0.404	0.376	0.398	0.287	0.000	0.000	0	0.432
1997	0.149	0.171	0.206	0.260	0.315	0.349	0.401	0.386	0.398	0.479	0.437	0.000	0.000	0.000	0.000	0	0.424
1998	0.138	0.164	0.208	0.259	0.304	0.331	0.361	0.348	0.392	0.504	0.603	0.600	0.000	0.000	0.000	0	0.427
1999	0.135	0.184	0.237	0.271	0.281	0.303	0.316	0.320	0.292	0.368	0.344	0.000	0.000	0.000	0.000	0	0.301
2000	0.000	0.166	0.227	0.272	0.299	0.292	0.313	0.276	0.269	0.264	0.280	0.321	0.000	0.000	0.000	0	0.269
2001	0.138	0.160	0.216	0.268	0.285	0.267	0.301	0.288	0.287	0.301	0.315	0.505	0.000	0.000	0.000	0	0.293
2002	0.000	0.183	0.214	0.260	0.293	0.313	0.364	0.350	0.325	0.390	0.311	0.231	0.304	0.643	0.000	0	0.333
2003	0.128	0.208	0.228	0.258	0.308	0.311	0.374	0.391	0.342	0.462	0.620	0.000	0.000	0.000	0.000	0	0.369
2004	0.000	0.210	0.216	0.242	0.290	0.326	0.330	0.334	0.366	0.351	0.352	1.463	0.337	0.000	0.000	0	0.363
2005	0.164	0.205	0.253	0.277	0.270	0.308	0.339	0.313	0.296	0.381	0.316	0.337	0.670	0.000	0.000	0	0.313
2006	0.133	0.217	0.254	0.285	0.295	0.298	0.377	0.353	0.334	0.306	0.290	0.000	0.000	0.000	0.000	0	0.331
2007	0.202	0.199	0.264	0.280	0.351	0.361	0.319	0.332	0.342	0.318	0.334	0.000	0.000	0.000	0.000	0	0.338
2008	0.000	0.223	0.265	0.324	0.356	0.431	0.424	0.359	0.389	0.339	0.334	0.433	0.000	0.000	0.000	0	0.374
2009	0.148	0.205	0.246	0.318	0.386	0.404	0.464	0.404	0.347	0.313	0.311	0.321	0.436	0.000	0.000	0	0.329
2010	0.359	0.221	0.255	0.331	0.416	0.470	0.479	0.541	0.439	0.374	0.337	0.355	0.272	0.000	0.000	0	0.388
2011	0.000	0.182	0.237	0.374	0.416	0.506	0.569	0.504	0.582	0.634	0.406	0.465	0.894	0.000	0.000	0	0.523
2012	0.021	0.135	0.236	0.337	0.468	0.443	0.501	0.478	0.478	0.584	0.256	0.514	0.621	0.489	0.288	0	0.498

2013	0.066	0.181	0.224	0.275	0.421	0.487	0.508	0.526	0.464	0.567	1.027	0	0	0	0	0	0.496

Table 12.9: Whiting in Subarea IV and Division VIId. Discards mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.036	0.145	0.158	0.185	0.209	0.222	0.239	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1979	0.080	0.104	0.158	0.191	0.189	0.234	0.265	0.295	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1980	0.030	0.107	0.166	0.202	0.244	0.253	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1981	0.071	0.131	0.164	0.197	0.230	0.289	0.252	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1982	0.047	0.091	0.182	0.211	0.225	0.241	0.244	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1983	0.036	0.114	0.167	0.235	0.264	0.290	0.317	0.277	0.365	0.000	0.000	0.000	0.000	0.000	0.000	0	0.365
1984	0.038	0.101	0.162	0.216	0.246	0.265	0.248	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1985	0.022	0.105	0.169	0.213	0.238	0.242	0.253	0.255	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1986	0.028	0.123	0.166	0.190	0.208	0.227	0.194	0.217	0.311	0.000	0.000	0.000	0.000	0.000	0.000	0	0.311
1987	0.016	0.090	0.149	0.206	0.205	0.263	0.257	0.000	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0	0.292
1988	0.030	0.063	0.146	0.181	0.210	0.219	0.235	0.000	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0	0.284
1989	0.033	0.083	0.164	0.191	0.213	0.227	0.241	0.351	0.221	0.000	0.000	0.000	0.000	0.000	0.000	0	0.221
1990	0.024	0.095	0.130	0.183	0.186	0.196	0.249	0.302	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1991	0.041	0.089	0.154	0.177	0.213	0.230	0.253	0.268	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1992	0.037	0.093	0.173	0.210	0.215	0.241	0.245	0.220	1.183	0.000	0.000	0.000	0.000	0.000	0.000	0	1.183
1993	0.023	0.087	0.160	0.205	0.237	0.235	0.225	0.213	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1994	0.040	0.090	0.151	0.203	0.230	0.244	0.254	0.332	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1995	0.032	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0	0.290
1996	0.031	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1997	0.031	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.320	0.601	0.773	0.000	0.000	0.000	0.000	0	0.352
1998	0.026	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.191	0.180	0.284	0.000	0.000	0.000	0.000	0	0.206
1999	0.062	0.100	0.166	0.197	0.201	0.225	0.231	0.212	0.231	0.220	0.000	0.000	0.000	0.000	0.000	0	0.227
2000	0.033	0.127	0.167	0.195	0.226	0.209	0.219	0.222	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0	0.264
2001	0.023	0.084	0.183	0.217	0.259	0.248	0.240	0.225	0.243	0.000	0.000	0.000	0.000	0.000	0.000	0	0.243
2002	0.039	0.130	0.167	0.196	0.224	0.224	0.225	0.272	0.334	1.120	0.217	0.000	0.000	0.000	0.000	0	0.352
2003	0.048	0.062	0.105	0.170	0.214	0.262	0.257	0.293	0.237	0.000	0.000	0.000	0.000	0.000	0.000	0	0.055
2004	0.079	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.204	0.351	0.000	0.000	0.000	0.000	0.000	0	0.245
2005	0.070	0.124	0.177	0.207	0.221	0.223	0.235	0.245	0.222	0.293	0.000	0.000	0.000	0.000	0.000	0	0.224
2006	0.093	0.131	0.161	0.193	0.229	0.233	0.247	0.273	0.239	0.279	0.289	0.000	0.000	0.000	0.000	0	0.246
2007	0.050	0.065	0.170	0.214	0.225	0.247	0.237	0.215	0.229	0.166	0.241	0.350	0.000	0.000	0.000	0	0.217
2008	0.027	0.072	0.181	0.213	0.230	0.265	0.328	0.244	0.291	0.317	0.057	0.000	0.000	0.000	0.000	0	0.293
2009	0.042	0.089	0.193	0.243	0.376	0.393	0.484	0.286	0.300	0.268	0.596	0.000	0.000	0.000	0.000	0	0.319
2010	0.019	0.075	0.211	0.272	0.319	0.384	0.330	0.254	0.290	0.390	0.730	0.000	0.000	0.000	0.000	0	0.323
2011	0.046	0.093	0.147	0.242	0.271	0.285	0.339	0.344	0.246	0.291	0.304	0.167	0.000	0.000	0.000	0	0.256
2012	0.021	0.076	0.155	0.184	0.204	0.254	0.211	0.252	0.313	0.574	0.183	0.374	0.580	0.489	0.288	0.000	0.325
2013	0.045	0.076	0.158	0.196	0.262	0.326	0.207	0.335	0.508	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.508

Table 12.10: Whiting in Subarea IV and Division VIId. Industrial bycatch mean weights at age (kg). Age 8 is a plus-group. Ages 1–8+ and years 1990–2013 are included in the final assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1978	0.009	0.059	0.158	0.220	0.295	0.529	0.351	0.449	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1979	0.008	0.069	0.141	0.249	0.428	0.477	0.467	0.605	0.482	0.000	0.000	0.000	0.000	0.000	0.000	0	0.482
1980	0.013	0.051	0.164	0.281	0.412	0.380	0.389	0.561	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0	1.000
1981	0.011	0.056	0.141	0.218	0.318	0.433	0.596	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0	0.800
1982	0.025	0.038	0.133	0.232	0.320	0.366	0.674	0.284	0.800	1.000	1.200	0.000	0.000	0.000	0.000	0	0.840
1983	0.012	0.058	0.148	0.311	0.431	0.651	0.565	0.602	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0	0.802
1984	0.018	0.053	0.173	0.289	0.343	0.390	0.228	0.600	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0	0.896
1985	0.014	0.054	0.150	0.263	0.382	0.454	0.504	0.584	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0	0.809
1986	0.014	0.054	0.150	0.262	0.381	0.455	0.500	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0	0.800
1987	0.012	0.043	0.085	0.173	0.262	0.400	0.500	0.600	0.800	1.000	0.000	0.000	0.000	0.000	0.000	0	0.822
1988	0.012	0.050	0.115	0.197	0.245	0.380	0.500	0.600	0.800	0.000	0.000	0.000	0.000	0.000	0.000	0	0.800
1989	0.022	0.053	0.137	0.224	0.285	0.344	0.482	0.396	0.385	0.401	0.000	0.000	0.000	0.000	0.000	0	0.385
1990	0.007	0.073	0.123	0.181	0.201	0.280	0.355	0.335	0.472	0.000	0.000	0.000	0.000	0.000	0.000	0	0.472
1991	0.018	0.105	0.136	0.215	0.272	0.265	0.279	0.322	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1992	0.012	0.068	0.151	0.235	0.244	0.364	0.219	0.256	0.282	0.000	0.000	0.000	0.000	0.000	0.000	0	0.282
1993	0.011	0.045	0.156	0.260	0.264	0.307	0.235	0.392	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1994	0.012	0.055	0.131	0.259	0.388	0.521	0.555	0.440	0.555	0.000	0.000	0.000	0.000	0.000	0.000	0	0.555
1995	0.009	0.072	0.160	0.312	0.373	0.511	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1996	0.016	0.064	0.151	0.239	0.233	0.347	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1997	0.012	0.051	0.145	0.252	0.321	0.348	0.588	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1998	0.015	0.049	0.115	0.220	0.304	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
1999	0.013	0.027	0.077	0.144	0.194	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2000	0.038	0.051	0.166	0.242	0.289	0.339	0.000	0.588	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2001	0.012	0.055	0.118	0.225	0.320	0.351	0.386	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2002	0.010	0.044	0.101	0.185	0.294	0.415	0.380	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2003	0.010	0.035	0.102	0.189	0.302	0.418	0.462	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2004	0.010	0.032	0.083	0.143	0.264	0.000	0.380	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2005	0.014	0.043	0.133	0.196	0.205	0.366	0.438	0.541	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0	0.530
2006	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.260	0.343	0.000	0.000	0.000	0.000	0	0.530
2007	0.027	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0	0.530
2008	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0	0.000
2009	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0	0.530
2010	0.000	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530	0.000	0.000	0.000	0.000	0.000	0.000	0	0.530
2011	0.000	0.188	0.242	0.305	0.321	0.371	0.464	0.436	0.628	0.421	0.393	0.480	0.000	0.000	0.000	0	0.419
2012	0.021	0.087	0.193	0.279	0.385	0.398	0.413	0.421	0.443	0.583	0.225	0.478	0.618	0.489	0.288	0	0.462
2013	0.066	0.181	0.224	0.275	0.421	0.487	0.508	0.526	0.464	0.567	1.027	0.000	0.000	0.000	0.000	0.000	0.496

Table 12.11: Whiting in Subarea IV and Division VIId. Estimated proportion mature at age as used in the assessment.

	age.1	age.2	age.3	age.4	age.5	age.6	age.7	age.8
Mat	0.11	0.92	1	1	1	1	1	1

Table 12.12: Whiting in Subarea IV and Division VIId. Natural mortality at age from ICES-WGSAM (2012).

	age.1	age.2	age.3	age.4	age.5	age.6	age.7	age.8
1990	1.563	0.790	0.572	0.540	0.522	0.513	0.509	0.447
1991	1.571	0.783	0.568	0.537	0.521	0.512	0.508	0.455
1992	1.582	0.779	0.564	0.534	0.520	0.512	0.508	0.463
1993	1.594	0.776	0.561	0.533	0.519	0.512	0.508	0.472
1994	1.610	0.775	0.559	0.532	0.520	0.513	0.509	0.482
1995	1.628	0.774	0.559	0.533	0.522	0.515	0.511	0.491
1996	1.647	0.773	0.559	0.534	0.524	0.518	0.514	0.499
1997	1.666	0.774	0.560	0.536	0.527	0.521	0.517	0.508
1998	1.685	0.775	0.562	0.538	0.531	0.524	0.521	0.515
1999	1.703	0.778	0.565	0.541	0.535	0.527	0.524	0.523
2000	1.721	0.782	0.568	0.545	0.539	0.531	0.529	0.531
2001	1.737	0.790	0.573	0.549	0.544	0.535	0.534	0.539
2002	1.749	0.801	0.578	0.555	0.549	0.540	0.540	0.547
2003	1.754	0.814	0.584	0.560	0.554	0.546	0.546	0.556
2004	1.751	0.828	0.589	0.565	0.559	0.551	0.553	0.564
2005	1.737	0.841	0.592	0.568	0.562	0.555	0.558	0.571
2006	1.715	0.854	0.593	0.570	0.563	0.557	0.562	0.577
2007	1.685	0.864	0.593	0.569	0.562	0.558	0.564	0.581
2008	1.650	0.873	0.591	0.566	0.560	0.556	0.565	0.584
2009	1.613	0.880	0.588	0.562	0.556	0.554	0.564	0.586
2010	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587
2011	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587
2012	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587
2013	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587

Table 12.13: Whiting in Subarea IV and Division VIId. Tuning series used in the assessment and forecast. Note that only years from 1990 onwards are used in the final assessment.

IBTS-Q1					
	age.1	age.2	age.3	age.4	age.5
1978	5.47181	2.62892	0.91937	0.21965	0.04185
1979	4.43922	2.30673	1.14262	0.33495	0.04952
1980	6.74975	4.03662	1.2504	0.25403	0.08786
1981	2.29666	4.63525	2.28459	0.45955	0.09138
1982	1.51516	2.17346	2.58135	0.68593	0.10148
1983	1.2662	1.25028	1.09999	0.76427	0.32203
1984	4.34487	1.77966	0.8898	0.30258	0.25363
1985	3.39177	3.62255	0.6585	0.18636	0.07144
1986	4.68744	2.68265	1.94648	0.32115	0.06597
1987	6.84898	5.61078	0.90439	0.45502	0.04903
1988	4.47989	8.65722	3.14309	0.3298	0.12608
1989	14.4608	5.38563	4.14762	1.099	0.12046
1990	5.18936	8.62354	1.98161	0.91605	0.16937
1991	10.07621	6.86445	4.79623	0.70946	0.37635
1992	9.07297	6.65714	2.40156	1.50832	0.12672
1993	10.75624	5.22811	2.44586	0.65488	0.59015
1994	7.21709	6.27406	1.81022	0.68082	0.11855
1995	6.7859	4.48484	2.39448	0.58074	0.11867
1996	5.02361	4.85968	2.44699	0.6974	0.23085
1997	2.87733	3.42212	1.62521	0.60426	0.18009
1998	5.43117	1.60695	1.25377	0.54046	0.15496
1999	6.7627	3.05445	0.94675	0.57451	0.25825
2000	7.4149	4.60697	1.57811	0.30714	0.12948
2001	6.48649	5.98388	2.99179	0.98318	0.25724
2002	5.57353	3.43308	2.63173	0.6328	0.20805
2003	1.31033	2.96405	2.36519	1.32585	0.48289
2004	1.84468	0.89595	1.72716	1.0016	0.49216
2005	1.12688	0.9792	0.45582	0.60167	0.39068
2006	1.84574	1.25265	0.45526	0.18403	0.27185
2007	0.64593	1.5045	0.66298	0.1772	0.07565
2008	2.68451	2.05826	0.6565	0.22111	0.07537
2009	2.11006	2.95618	0.93508	0.27189	0.11936
2010	3.26994	2.25541	2.43766	0.94942	0.2855
2011	1.84287	3.36844	1.56429	0.9265	0.19633
2012	2.31037	5.80934	1.17645	0.49447	0.32593
2013	0.53095	1.62999	2.42468	0.88558	0.26933
2014	2.05313	2.26241	1.05279	0.71413	0.2915

IBTS-Q3					
	age.1	age.2	age.3	age.4	age.5
1991	7.034	1.586	0.790	0.146	0.052
1992	6.009	2.961	0.725	0.575	0.103
1993	6.387	1.774	0.661	0.147	0.159
1994	6.776	2.195	0.747	0.195	0.047
1995	6.198	2.912	1.072	0.215	0.060
1996	5.457	2.782	1.294	0.340	0.069
1997	3.330	1.807	1.090	0.280	0.107
1998	3.306	1.502	0.528	0.310	0.112
1999	12.035	1.906	0.539	0.245	0.095
2000	9.417	3.269	0.641	0.136	0.065
2001	6.450	2.823	0.949	0.193	0.043
2002	7.321	2.374	1.251	0.340	0.053
2003	2.462	3.021	1.348	0.661	0.165
2004	1.507	0.591	0.664	0.458	0.272
2005	1.631	0.805	0.349	0.471	0.294
2006	1.728	0.850	0.319	0.132	0.229
2007	0.956	0.640	0.379	0.116	0.085
2008	3.627	0.689	0.310	0.138	0.041
2009	5.855	3.848	0.410	0.123	0.080
2010	2.236	1.466	0.565	0.131	0.063
2011	4.467	1.444	0.472	0.162	0.070
2012	2.585	1.946	0.574	0.200	0.106
2013	0.675	0.602	0.661	0.177	0.071

Table 12.14: Whiting in Subarea IV and Division VIId. FLXSA tuning diagnostics.

FLR XSA Diagnostics 2014-05-04 16:55:36

CPUE data from x.index

Catch data for 24 years. 1990 to 2013. Ages 1 to 8.

	fleet	first age	last age	first year	last year	alpha	beta
1	IBTS-Q1	1	5	1990	2013	0	0.25
2	IBTS-Q3	1	5	1991	2013	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 4

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 4 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

year

age 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

all 1 1 1 1 1 1 1 1 1 1

Fishing mortalities

year

age 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013

1 0.061 0.047 0.075 0.041 0.035 0.014 0.018 0.017 0.034 0.073

2 0.124 0.182 0.169 0.139 0.117 0.123 0.156 0.152 0.053 0.076

3 0.130 0.153 0.294 0.254 0.231 0.145 0.127 0.175 0.136 0.124

4 0.199 0.148 0.235 0.328 0.330 0.269 0.161 0.155 0.246 0.209

5 0.268 0.211 0.266 0.244 0.353 0.313 0.288 0.136 0.138 0.367

6 0.295 0.250 0.394 0.316 0.252 0.276 0.422 0.266 0.201 0.152

7 0.204 0.245 0.295 0.473 0.409 0.182 0.229 0.400 0.352 0.135

8 0.204 0.245 0.295 0.473 0.409 0.182 0.229 0.400 0.352 0.135

XSA population number (Thousand)

age

year 1 2 3 4 5 6 7 8

2004 1944928 299319 359485 223243 122408 43051 9650 2143

2005 2475535 317727 115601 175289 103972 53539 18483 3878

2006 2421506 415680 114227 54884 85643 47990 23933 7353

2007 2236667 404576 149451 47018 24550 37384 18541 10594

2008 4089046 397963 148394 64094 19168 10964 15611 11284

2009 3307736 757832 147960 65256 26158 7698 4887 22143

2010 3222901 650385 278050 71063 28426 10965 3356 9557

2011 4340978 655541 229154 136445 34608 12279 4143 1216

2012 1858168 884089 231904 107188 66879 17405 5422 2366

2013 624701 371903 345368 112809 47992 33556 8205 5168

Estimated population abundance at 1st Jan 2014

age

year 1 2 3 4 5 6 7 8

2014 0 120297 142022 169990 52418 19160 16609 4088

Fleet: IBTS-Q1

Log catchability residuals.

year

age 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1 0.010 0.647 0.599 0.612 0.267 0.303 0.349 0.067 0.362 0.093 -0.008 0.067 0.065 -0.282 0.047

2 -0.187 0.465 0.360 0.227 0.241 -0.035 0.146 0.149 -0.322 0.010 -0.042 -0.007 -0.344 -0.314 -0.332

3 0.013 0.097 0.262 0.154 -0.014 0.027 0.097 -0.233 -0.158 -0.168 0.095 0.223 -0.200 -0.088 -0.128

4 -0.030 0.261 -0.010 0.071 0.101 -0.016 -0.113 -0.245 -0.314 0.003 -0.257 0.672 -0.462 0.021 -0.074

5 -0.543 0.385 -0.415 0.067 -0.470 -0.433 0.061 -0.456 -0.657 -0.137 -0.471 0.579 -0.034 0.067 -0.176

year

age 2005 2006 2007 2008 2009 2010 2011 2012 2013

1 -0.690 -0.174 -1.152 -0.335 -0.371 0.089 -0.782 0.295 -0.081

2 -0.294 -0.317 -0.109 0.219 -0.061 -0.174 0.219 0.453 0.050

3 -0.322 -0.294 -0.192 -0.198 0.148 0.473 0.228 -0.073 0.250

4 -0.347 -0.360 -0.232 -0.320 -0.140 1.012 0.335 -0.041 0.486

5 -0.250 -0.412 -0.444 -0.188 -0.044 0.741 0.152 0.000 0.169

Mean log catchability and standard error of ages with catchability

independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-13.6979	-12.2703	-12.0296	-12.1468	-12.1468
S.E_Logq	0.4407	0.2558	0.2058	0.3485	0.3610

Fleet: IBTS-Q3

Log catchability residuals.

year

age 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

1 0.131 0.057 -0.041 0.077 0.088 0.312 0.101 -0.234 0.586 0.134 -0.031 0.254 0.312 -0.219 -0.397

2 -0.338 0.173 -0.211 -0.203 0.135 0.180 0.098 0.183 0.144 0.207 -0.209 -0.161 0.315 -0.163 0.131

3 -0.787 0.006 -0.150 0.069 0.166 0.386 0.276 -0.166 0.181 0.123 -0.096 -0.091 0.185 -0.268 0.240

4 -0.278 0.039 -0.335 -0.024 0.006 0.190 -0.025 0.099 0.163 -0.048 -0.015 -0.167 0.236 0.043 0.282

5 -0.386 0.383 -0.132 -0.187 0.002 -0.118 0.055 0.023 -0.113 -0.052 -0.168 -0.479 -0.104 0.161 0.370

year

age 2006 2007 2008 2009 2010 2011 2012 2013

1 -0.315 -0.866 -0.161 0.494 -0.464 -0.071 0.241 0.013

2 -0.084 -0.352 -0.271 0.813 0.026 0.001 -0.061 -0.355

3 0.251 0.130 -0.081 0.147 -0.177 -0.133 0.026 -0.238

4 0.228 0.310 0.174 -0.001 -0.090 -0.537 -0.028 -0.222

5 0.346 0.587 0.177 0.512 0.174 -0.024 -0.265 -0.191

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-12.7283	-12.3800	-12.4868	-12.6637	-12.6637
S.E_Logq	0.3250	0.2694	0.2495	0.2085	0.2774

Terminal year survivor and F summaries:

Age 1 Year class =2012

source
scaledWts survivors yrcls
IBTS-Q1 0.346 110889 2012
IBTS-Q3 0.635 121818 2012
fshk 0.019 351662 2012

Age 2 Year class =2011

source
scaledWts survivors yrcls
IBTS-Q1 0.494 149363 2011
IBTS-Q3 0.494 99613 2011
fshk 0.012 83802 2011

Age 3 Year class =2010

source
scaledWts survivors yrcls
IBTS-Q1 0.494 218322 2010
IBTS-Q3 0.494 133961 2010
fshk 0.013 139970 2010

Age 4 Year class =2009

source
scaledWts survivors yrcls
IBTS-Q1 0.409 85223 2009
IBTS-Q3 0.575 41973 2009
fshk 0.016 57716 2009

Age 5 Year class =2008

source
scaledWts survivors yrcls
IBTS-Q1 0.365 22680 2008
IBTS-Q3 0.615 15828 2008

fshk 0.020 40368 2008

Age 6 Year class =2007

source
scaledWts survivors yrcls
fshk 1 7710 2007

Age 7 Year class =2006

source
scaledWts survivors yrcls
fshk 1 2427 2006
> FLR XSA Diagnostics 2014-05-04 16:55:36

CPUE data from x.index

Catch data for 24 years. 1990 to 2013. Ages 1 to 8.

	fleet	first age	last age	first year	last year	alpha	beta
1	IBTS-Q1	1	5	1990	2013	0	0.25
2	IBTS-Q3	1	5	1991	2013	0.5	0.75

Time series weights :

Tapered time weighting not applied

Catchability analysis :

Catchability independent of size for all ages

Catchability independent of age for ages > 4

Terminal population estimation :

Survivor estimates shrunk towards the mean F
of the final 3 years or the 4 oldest ages.

S.E. of the mean to which the estimates are shrunk = 2

Minimum standard error for population
estimates derived from each fleet = 0.3

prior weighting not applied

Regression weights

age	year 2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	0.061	0.047	0.075	0.041	0.035	0.014	0.018	0.017	0.034	0.073
2	0.124	0.182	0.169	0.139	0.117	0.123	0.156	0.152	0.053	0.076
3	0.130	0.153	0.294	0.254	0.231	0.145	0.127	0.175	0.136	0.124
4	0.199	0.148	0.235	0.328	0.330	0.269	0.161	0.155	0.246	0.209
5	0.268	0.211	0.266	0.244	0.353	0.313	0.288	0.136	0.138	0.367
6	0.295	0.250	0.394	0.316	0.252	0.276	0.422	0.266	0.201	0.152
7	0.204	0.245	0.295	0.473	0.409	0.182	0.229	0.400	0.352	0.135
8	0.204	0.245	0.295	0.473	0.409	0.182	0.229	0.400	0.352	0.135

XSA population number (Thousand)

year	age 1	2	3	4	5	6	7	8
2004	1944928	299319	359485	223243	122408	43051	9650	2143
2005	2475535	317727	115601	175289	103972	53539	18483	3878
2006	2421506	415680	114227	54884	85643	47990	23933	7353
2007	2236667	404576	149451	47018	24550	37384	18541	10594

2008 4089046 397963 148394 64094 19168 10964 15611 11284

2009 3307736 757832 147960 65256 26158 7698 4887 22143

2010 3222901 650385 278050 71063 28426 10965 3356 9557

2011 4340978 655541 229154 136445 34608 12279 4143 1216

2012 1858168 884089 231904 107188 66879 17405 5422 2366

2013 624701 371903 345368 112809 47992 33556 8205 5168

Estimated population abundance at 1st Jan 2014

age

year 1 2 3 4 5 6 7 8

2014 0 120297 142022 169990 52418 19160 16609 4088

Fleet: IBTS-Q1

Log catchability residuals.

year

age 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

1 0.010 0.647 0.599 0.612 0.267 0.303 0.349 0.067 0.362 0.093 -0.008 0.067 0.065 -0.282 0.047

2 -0.187 0.465 0.360 0.227 0.241 -0.035 0.146 0.149 -0.322 0.010 -0.042 -0.007 -0.344 -0.314 -0.332

3 0.013 0.097 0.262 0.154 -0.014 0.027 0.097 -0.233 -0.158 -0.168 0.095 0.223 -0.200 -0.088 -0.128

4 -0.030 0.261 -0.010 0.071 0.101 -0.016 -0.113 -0.245 -0.314 0.003 -0.257 0.672 -0.462 0.021 -0.074

5 -0.543 0.385 -0.415 0.067 -0.470 -0.433 0.061 -0.456 -0.657 -0.137 -0.471 0.579 -0.034 0.067 -0.176

year

age 2005 2006 2007 2008 2009 2010 2011 2012 2013

1 -0.690 -0.174 -1.152 -0.335 -0.371 0.089 -0.782 0.295 -0.081

2 -0.294 -0.317 -0.109 0.219 -0.061 -0.174 0.219 0.453 0.050

3 -0.322 -0.294 -0.192 -0.198 0.148 0.473 0.228 -0.073 0.250

4 -0.347 -0.360 -0.232 -0.320 -0.140 1.012 0.335 -0.041 0.486

5 -0.250 -0.412 -0.444 -0.188 -0.044 0.741 0.152 0.000 0.169

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-13.6979	-12.2703	-12.0296	-12.1468	-12.1468
S.E_Logq	0.4407	0.2558	0.2058	0.3485	0.3610

Fleet: IBTS-Q3

Log catchability residuals.

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.131	0.057	-0.041	0.077	0.088	0.312	0.101	-0.234	0.586	0.134	-0.031	0.254	0.312	-0.219	-0.397
2	-0.338	0.173	-0.211	-0.203	0.135	0.180	0.098	0.183	0.144	0.207	-0.209	-0.161	0.315	-0.163	0.131
3	-0.787	0.006	-0.150	0.069	0.166	0.386	0.276	-0.166	0.181	0.123	-0.096	-0.091	0.185	-0.268	0.240
4	-0.278	0.039	-0.335	-0.024	0.006	0.190	-0.025	0.099	0.163	-0.048	-0.015	-0.167	0.236	0.043	0.282
5	-0.386	0.383	-0.132	-0.187	0.002	-0.118	0.055	0.023	-0.113	-0.052	-0.168	-0.479	-0.104	0.161	0.370

year

age	2006	2007	2008	2009	2010	2011	2012	2013
1	-0.315	-0.866	-0.161	0.494	-0.464	-0.071	0.241	0.013
2	-0.084	-0.352	-0.271	0.813	0.026	0.001	-0.061	-0.355
3	0.251	0.130	-0.081	0.147	-0.177	-0.133	0.026	-0.238
4	0.228	0.310	0.174	-0.001	-0.090	-0.537	-0.028	-0.222
5	0.346	0.587	0.177	0.512	0.174	-0.024	-0.265	-0.191

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1	2	3	4	5
Mean_Logq	-12.7283	-12.3800	-12.4868	-12.6637	-12.6637
S.E_Logq	0.3250	0.2694	0.2495	0.2085	0.2774

Terminal year survivor and F summaries:

Age 1 Year class =2012

source	scaledWts	survivors	yrcls
IBTS-Q1	0.346	110889	2012
IBTS-Q3	0.635	121818	2012
fshk	0.019	351662	2012

Age 2 Year class =2011

source	scaledWts	survivors	yrcls
IBTS-Q1	0.494	149363	2011
IBTS-Q3	0.494	99613	2011
fshk	0.012	83802	2011

Age 3 Year class =2010

source	scaledWts	survivors	yrcls
IBTS-Q1	0.494	218322	2010
IBTS-Q3	0.494	133961	2010
fshk	0.013	139970	2010

Age 4 Year class =2009

```
source
      scaledWts survivors yrcls
IBTS-Q1     0.409     85223  2009
IBTS-Q3     0.575     41973  2009
fshk        0.016     57716  2009

 Age 5 Year class =2008

source
      scaledWts survivors yrcls
IBTS-Q1     0.365     22680  2008
IBTS-Q3     0.615     15828  2008
fshk        0.020     40368  2008

 Age 6 Year class =2007

source
    scaledWts survivors yrcls
fshk         1      7710  2007

 Age 7 Year class =2006

source
    scaledWts survivors yrcls
fshk         1      2427  2006
>
```

Table 12.18: Whiting in Subarea IV and Division VIId. Final fishing mortality estimates from FLXSA.

	1	2	3	4	5	6	7	8+
1990	0.106	0.346	0.599	0.753	0.953	0.695	0.772	0.772
1991	0.054	0.320	0.357	0.519	0.868	0.614	0.606	0.606
1992	0.098	0.249	0.406	0.457	0.463	0.919	1.120	1.120
1993	0.081	0.289	0.534	0.609	0.670	0.400	0.839	0.839
1994	0.074	0.219	0.462	0.684	0.853	1.001	0.307	0.307
1995	0.063	0.210	0.412	0.463	0.674	0.965	1.265	1.265
1996	0.052	0.191	0.379	0.476	0.501	0.689	1.141	1.141
1997	0.049	0.183	0.343	0.409	0.498	0.301	0.451	0.451
1998	0.053	0.151	0.238	0.364	0.449	0.476	0.289	0.289
1999	0.068	0.215	0.343	0.453	0.474	0.521	0.397	0.397
2000	0.024	0.182	0.376	0.464	0.635	0.685	1.113	1.113
2001	0.019	0.090	0.172	0.302	0.500	0.602	0.557	0.557
2002	0.022	0.084	0.211	0.247	0.271	0.283	0.558	0.558
2003	0.110	0.187	0.171	0.230	0.223	0.171	0.140	0.140
2004	0.061	0.124	0.130	0.199	0.268	0.295	0.204	0.204
2005	0.047	0.182	0.153	0.148	0.211	0.250	0.245	0.245
2006	0.075	0.169	0.294	0.235	0.266	0.394	0.295	0.295
2007	0.041	0.139	0.254	0.328	0.244	0.316	0.473	0.473
2008	0.035	0.117	0.231	0.330	0.353	0.252	0.409	0.409
2009	0.014	0.123	0.145	0.269	0.313	0.276	0.182	0.182
2010	0.018	0.156	0.127	0.161	0.288	0.422	0.229	0.229
2011	0.017	0.152	0.175	0.155	0.136	0.266	0.400	0.400
2012	0.034	0.053	0.136	0.246	0.138	0.201	0.352	0.352
2013	0.073	0.076	0.124	0.209	0.367	0.152	0.135	0.135

Table 12.19: Whiting in Subarea IV and Division VIId. Final abundance estimates from FLXSA.

	1	2	3	4	5	6	7	8+
1990	5584149	2546314	378155	208295	65713	4991	1723	251
1991	5704990	1052057	817678	117243	57141	15023	1492	733
1992	5427698	1123537	348847	324057	40803	14251	4871	203
1993	6345393	1011735	402028	132180	120230	15280	3407	1634
1994	6016410	1187622	348779	134487	42219	36587	6137	2450
1995	5465481	1117116	439877	125605	39878	10695	8043	794
1996	3865863	1007755	417586	166612	46425	12067	2434	1963
1997	2941914	707044	384302	163452	60693	16648	3610	1577
1998	4143379	529559	271510	155762	63527	21760	7323	2047
1999	6777335	728550	209796	121987	63185	23844	8009	2587
2000	8198033	1153373	270106	84651	45118	23032	8360	2312
2001	6663282	1432160	439803	105068	30883	13948	6833	3741
2002	5744721	1151567	593827	208893	44860	10876	4477	2231

2003	1931222	978127	475086	269672	93709	19751	4774	3931
2004	1944928	299319	359485	223243	122408	43051	9650	2143
2005	2475535	317727	115601	175289	103972	53539	18483	3878
2006	2421506	415680	114227	54884	85643	47990	23933	7353
2007	2236667	404576	149451	47018	24550	37384	18541	10594
2008	4089046	397963	148394	64094	19168	10964	15611	11284
2009	3307736	757832	147960	65256	26158	7698	4887	22143
2010	3222901	650385	278050	71063	28426	10965	3356	9557
2011	4340978	655541	229154	136445	34608	12279	4143	1216
2012	1858168	884089	231904	107188	66879	17405	5422	2366
2013	624701	371903	345368	112809	47992	33556	8205	5168

Table 12.20: Whiting in Subarea IV and Division VIId. Final FLXSA summary table. Units are millions of individuals and tonnes.

	Recruitment	TSB	SSB	Catch	Landings	Discards	Bycatch	Yield/SSB	Mean F(2–6)
1990	5584149	968423	524844	152602	45662	55603	51337	0.087	0.669
1991	5704990	1003275	462904	126742	51929	35058	39755	0.112	0.536
1992	5427698	866712	440845	108555	50946	32564	25045	0.116	0.499
1993	6345393	828582	401788	116911	51818	44370	20723	0.129	0.5
1994	6016410	870664	404695	101650	48486	35692	17473	0.12	0.644
1995	5465481	866473	418412	105494	45938	32176	27379	0.11	0.545
1996	3865863	705751	368140	76123	40503	30505	5116	0.11	0.447
1997	2941914	577166	316721	61435	35563	19660	6213	0.112	0.347
1998	4143379	608335	267077	47475	28288	15693	3494	0.106	0.336
1999	6777335	764571	283716	60845	30130	25677	5038	0.106	0.401
2000	8198033	1277407	408632	63806	28583	26063	9160	0.07	0.468
2001	6663282	1104021	480286	45242	25061	19237	944	0.052	0.333
2002	5744721	780089	413955	46450	20675	18501	7275	0.05	0.219
2003	1931222	425197	317888	45640	16161	26745	2734	0.051	0.196
2004	1944928	444711	248839	33557	13295	19048	1214	0.053	0.203
2005	2475535	493830	215699	28883	15471	12525	888	0.072	0.189
2006	2421506	486756	197720	37038	18535	16310	2193	0.094	0.272
2007	2236667	384703	183693	27125	18915	6971	1239	0.103	0.256
2008	4089046	595576	209630	28247	17951	10296	0	0.086	0.256
2009	3307736	563243	277768	27139	18418	7705	1016	0.066	0.225
2010	3222901	563120	300127	31147	18224	11577	1346	0.061	0.231
2011	4340978	728881	310005	32626	18899	11977	1750	0.061	0.177
2012	1858168	469466	313706	25078	17032	7968	78	0.054	0.155
2013	624701	303278	247007	26965	19335	5976	1655	0.078	0.186
2014	2613817		204360						

Table 12.21: Whiting in Subarea IV and Division VIId. RCT3 input table.

Year Class	recruitmemt	IBTSq11	IBTSq22	IBTSq30	IBTSq31	IBTSq32	Year Class
1989	5584149	518.936	686.445	NA	NA	158.594	1989
1990	5704990	1007.621	665.714	NA	703.368	296.100	1990
1991	5427698	907.297	522.811	536.990	600.867	177.377	1991
1992	6345393	1075.624	627.406	1379.459	638.722	219.541	1992
1993	6016410	721.709	448.484	919.193	677.645	291.180	1993
1994	5465481	678.590	485.968	610.743	619.786	278.218	1994
1995	3865863	502.361	342.212	729.246	545.708	180.681	1995
1996	2941914	287.733	160.695	316.501	332.968	150.205	1996
1997	4143379	543.117	305.445	2062.670	330.600	190.645	1997
1998	6777335	676.270	460.697	2631.690	1203.503	326.943	1998
1999	8198033	741.490	598.388	2498.550	941.658	282.320	1999

2000	6663282	648.649	343.308	1968.070	645.003	237.372	2000
2001	5744721	557.353	296.405	3031.442	732.137	302.054	2001
2002	1931222	131.033	89.595	264.063	246.155	59.087	2002
2003	1944928	184.468	97.920	363.406	150.681	80.542	2003
2004	2475535	112.688	125.265	714.343	163.117	84.980	2004
2005	2421506	184.574	150.450	166.877	172.778	64.032	2005
2006	2236667	64.593	205.826	201.586	95.638	68.918	2006
2007	4089046	268.451	295.618	821.726	362.658	384.805	2007
2008	3307736	211.006	225.541	765.077	585.543	146.610	2008
2009	3222901	326.994	336.844	593.814	223.603	144.443	2009
2010	NA	184.287	580.934	509.938	446.718	194.624	2010
2011	NA	231.037	162.999	246.895	258.453	60.199	2011
2012	NA	53.095	226.241	307.402	67.488	NA	2012
2013	NA	205.313	NA	335.126	NA	NA	2013

Table 12.22: Whiting in Subarea IV and Division VIId. RCT3 output.

Analysis by RCT3 ver4.0	by	RCT3	ver4.0						
Whiting									
Data for 5 surveys over 25 years : 1989 - 2013									
Regression type = C									
Tapered time weighting not applied									
Survey weighting not applied									
Final estimates not shrunk towards mean									
Estimates with S.E.'S greater than that of mean included									
Minimum S.E. for any survey taken as .00									
Minimum of 3 points used for regression									
Forecast/Hindcast variance correction used.									
yearclass:2013									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.6368	11.44	0.2302	0.7999	21	5.325	14.83	0.2515	0.6936
IBTSq12	0.7963	10.68	0.2234	0.8093	21	NA	NA	NA	NA
IBTSq30	0.645	10.91	0.341	0.6581	19	5.815	14.66	0.3784	0.3064
IBTSq31	0.7306	10.82	0.2278	0.8078	20	NA	NA	NA	NA
IBTSq32	0.8866	10.67	0.2564	0.7632	21	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	21	NA	15.23	0.4486	0
	WAP	logWAP	int.se						
yearclass:2013	2613817	14.78	0.1898						

Table 12.23: Whiting in Subarea IV and Division VIId. Short-term forecast inputs for 2014.

MFDP version 1a

Run: 01

Time and date: 14:36 03/05/2014

Fbar age range (Total) : 2-6

Fbar age range Fleet 1 : 2-6

Fbar age range Fleet 2 : 2-6

2014

Age	N	M	Mat	PF	PM	SWt	
1	261381	71.57451	0.11	0	0	0.091	
2	120213.9576		0.88681	0.92	0	0	0.188
3	185318.738		0.58451	1	0	0	0.246
4	163027.2926		0.558	1	0	0	0.399
5	51736.95221		0.55171	1	0	0	0.481
6	20570.76423		0.55108	1	0	0	0.498
7	16994.91401		0.56214	1	0	0	0.523
8	5543.326763		0.58727	1	0	0	0.496

Catch

Age	Sel	CWt	DSel	DCWt	
1	0.006486183		0.181	0.037091958	0.076
2	0.041288944		0.224	0.055934332	0.158
3	0.089943056		0.275	0.062704462	0.196
4	0.160829023		0.421	0.052699663	0.262
5	0.173281204		0.487	0.042900736	0.326
6	0.166807138		0.508	0.04949462	0.207
7	0.251486932		0.526	0.062302139	0.335
8	0.277810695		0.496	0.035193004	0.508

IBC

Age	Sel	CWt
1	0	0.181
2	0.002	0.224
3	0.004	0.275

4	0.009	0.421
5	0.009	0.487
6	0.008	0.508
7	0.012	0.526
8	0.013	0.496

2015

Age	N	M	Mat	PF	PM	SWt	
1	3687668.507		1.57451	0.11	0	0	0.091
2	.	0.88681	0.92	0	0	0.188	
3	.	0.58451	1	0	0	0.246	
4	.	0.558	1	0	0	0.399	
5	.	0.55171	1	0	0	0.481	
6	.	0.55108	1	0	0	0.498	
7	.	0.56214	1	0	0	0.523	
8	.	0.58727	1	0	0	0.496	

Catch

Age	Sel	CWt	DSel	DCWt	
1	0.006486183		0.181	0.037091958	0.076
2	0.041288944		0.224	0.055934332	0.158
3	0.089943056		0.275	0.062704462	0.196
4	0.160829023		0.421	0.052699663	0.262
5	0.173281204		0.487	0.042900736	0.326
6	0.166807138		0.508	0.04949462	0.207
7	0.251486932		0.526	0.062302139	0.335
8	0.277810695		0.496	0.035193004	0.508

IBC

Age	Sel	CWt
1	0	0.181
2	0.002	0.224
3	0.004	0.275
4	0.009	0.421
5	0.009	0.487

6	0.008	0.508
7	0.012	0.526
8	0.013	0.496

2016

Age	N	M	Mat	PF	PM	SWt	
1	3687668.507		1.57451	0.11	0	0	0.091
2	.	0.88681	0.92	0	0	0.188	
3	.	0.58451	1	0	0	0.246	
4	.	0.558	1	0	0	0.399	
5	.	0.55171	1	0	0	0.481	
6	.	0.55108	1	0	0	0.498	
7	.	0.56214	1	0	0	0.523	
8	.	0.58727	1	0	0	0.496	

Catch

Age	Sel	CWt	DSel	DCWt	
1	0.006486183		0.181	0.037091958	0.076
2	0.041288944		0.224	0.055934332	0.158
3	0.089943056		0.275	0.062704462	0.196
4	0.160829023		0.421	0.052699663	0.262
5	0.173281204		0.487	0.042900736	0.326
6	0.166807138		0.508	0.04949462	0.207
7	0.251486932		0.526	0.062302139	0.335
8	0.277810695		0.496	0.035193004	0.508

IBC

Age	Sel	CWt
1	0	0.181
2	0.002	0.224
3	0.004	0.275
4	0.009	0.421
5	0.009	0.487
6	0.008	0.508
7	0.012	0.526

8 0.013 0.496

nput units are thousands and kg - output in tonnes

Table 12.24. Whiting in Subarea IV and Division VIId. MFDP output table for short-term forecasts.

2014																		
		Catch			Landings				Discards		IBC	Landings						
Biomass	SSB	FMult	FBar	Yield	FBar	IV+VIId Yield	IV yield	VIId yield	FBar	Yield	FMult	FBar	Yield			2014 TAC IV	16092	
417861	204360	1	0.1855	28731	0.1264	19367	15410	3957	0.0527	8447	1	0.0064	917					
2015														2016				
		Catch			Landings				Discards		IBC	Landings						
Biomass	SSB	FMult	FBar	Yield	FBar	IV+VIId Yield	IV yield	VIId yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	IV TAC change	SSB change	
536583	230124	0	0.0064	861	0	0	0	0	0	0	1	0.0064	861	599111	288960	-100%	26%	No HC fishery
.	230124	0.10	0.0243	3825	0.0126	1888	1502	386	0.0053	1083	1	0.0064	854	596554	286453	-91%	24%	
.	230124	0.20	0.0422	6749	0.0253	3746	2981	765	0.0105	2157	1	0.0064	846	594036	283985	-81%	23%	
.	230124	0.30	0.0601	9633	0.0379	5573	4434	1139	0.0158	3222	1	0.0064	838	591556	281554	-72%	22%	
.	230124	0.40	0.0781	12480	0.0506	7371	5865	1506	0.0211	4278	1	0.0064	831	589113	279161	-64%	21%	
.	230124	0.50	0.096	15290	0.0632	9141	7273	1868	0.0264	5325	1	0.0064	824	586707	276803	-55%	20%	0.5 * F(sq)
.	230124	0.60	0.1139	18062	0.0759	10882	8659	2223	0.0316	6364	1	0.0064	816	584335	274481	-46%	19%	
.	230124	0.70	0.1318	20798	0.0885	12595	10022	2573	0.0369	7394	1	0.0064	809	581999	272193	-38%	18%	
	230124	0.75	0.1408	21627	0.0948	13041	10376	2664	0.0396	7780	1	0.0064	807	581353	271568	-36%	18%	0.75 * Fsq
	230124	0.80	0.1500	22978.02	0.101332	13878.40591	11043	2835	0.042268	8296.158188	1	0.0064	803.4552	580206.33	270446.2061	-31%	-17%	
.	230124	0.90	0.1677	26166	0.1138	15942	12685	3257	0.0475	9429	1	0.0064	795	577429	267720	-21%	16%	
.	230124	1.00	0.1855	28798	0.1264	17576	13985	3591	0.0527	10434	1	0.0064	788	575194	265533	-13%	15%	F(sq)
	230124	1.01	0.1865	28317	0.1271	17190	13678	3512	0.0530	10337	1	0.0064	790	575675	266012	-15%	16%	15% TAC decrease (IV)
.	230124	1.10	0.2035	31396	0.1391	19184	15265	3919	0.058	11431	1	0.0064	781	572991	263378	-5%	14%	
	230124	1.19	0.2198	33205	0.1506	20224	16092	4132	0.0628	12204	1	0.0064	777	571524	261951	0%	14%	Rollover TAC
.	230124	1.20	0.2214	33963	0.1517	20768	16525	4243	0.0633	12420	1	0.0064	775	570820	261254	3%	14%	
	230124	1.22	0.2250	33954	0.1543	20687	16461	4227	0.0643	12491	1	0.0064	775	570890	261330	2%	14%	F(msy) proposed
	230124	1.25	0.2304	34738	0.1580	21174	16848	4326	0.0659	12791	1	0.0064	773	570224	260679	5%	13%	1.25 * F(sq)
.	230124	1.30	0.2394	36496	0.1644	22327	17765	4562	0.0686	13401	1	0.0064	768	568680	259161	10%	13%	
	230124	1.38	0.2532	38093	0.1741	23257	18506	4752	0.0726	14072	1	0.0064	764	567374	257890	15%	12%	15% TAC increase (IV)
.	230124	1.40	0.2572	38999	0.177	23862	18987	4875	0.0738	14375	1	0.0064	762	566570	257099	18%	12%	
.	230124	1.50	0.2751	41468	0.1896	25373	20189	5184	0.0791	15340	1	0.0064	755	564491	255066	25%	11%	
.	230124	1.60	0.2931	43909	0.2023	26861	21373	5488	0.0844	16299	1	0.0064	749	562441	253063	33%	10%	
	230124	1.64	0.3000	44929	0.2072	27496	21879	5618	0.0864	16687	1	0.0064	746	561573	252214	36%	10%	F(msy) previous proxy
.	230124	1.70	0.311	46320	0.2149	28327	22540	5787	0.0897	17250	1	0.0064	743	560419	251088	40%	9%	
.	230124	1.80	0.3289	48700	0.2276	29771	23689	6082	0.0949	18193	1	0.0064	736	558426	249142	47%	8%	
.	230124	1.90	0.3468	51052	0.2402	31192	24819	6373	0.1002	19130	1	0.0064	730	556461	247223	54%	7%	
.	230124	2.00	0.3648	53376	0.2529	32593	25934	6659	0.1055	20059	1	0.0064	724	554523	245331	61%	7%	

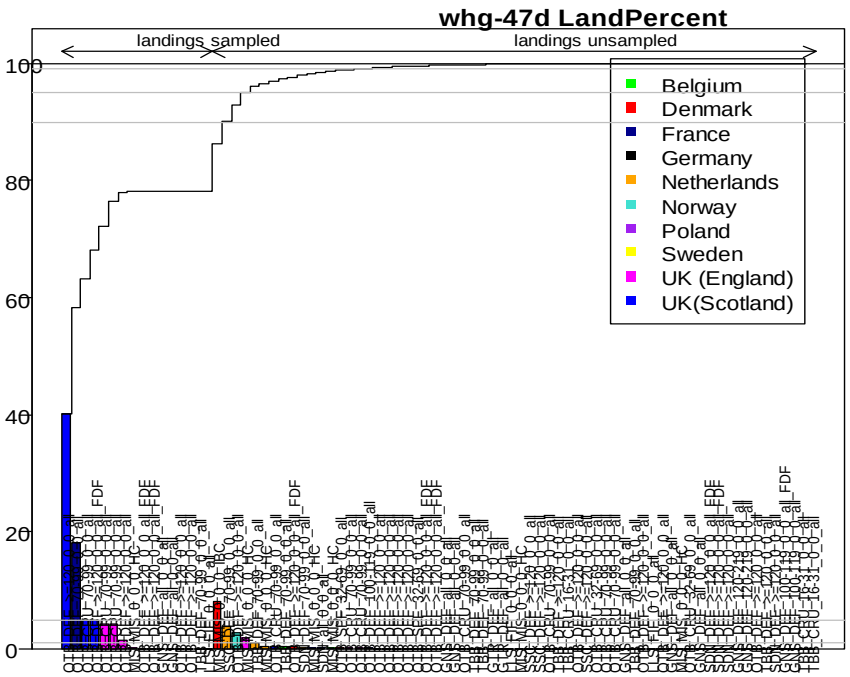


Figure 12.1: Whiting in Subarea IV and Division VIId. Reported landings for each sampled and unsampled fleet, along with cumulative landings for fleets in descending order of yield.



Figure 12.2: Whiting in Subarea IV and Division VIId. Yield by catch component.

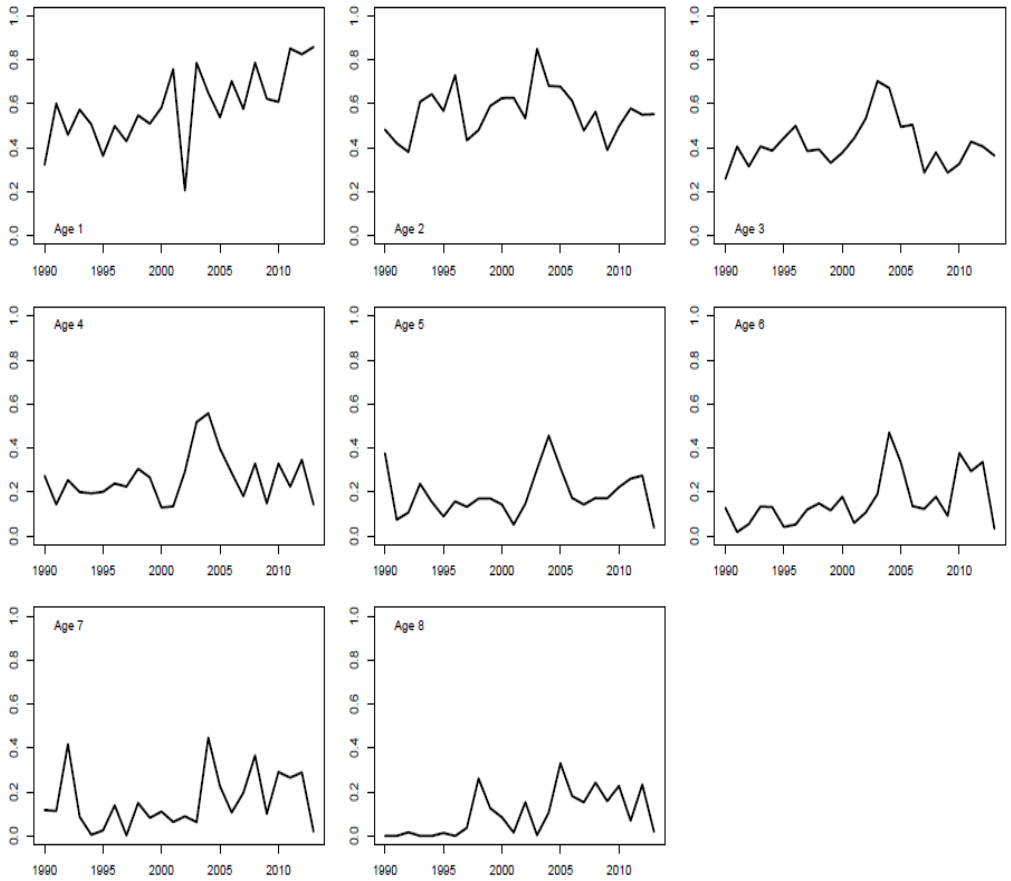


Figure 12.3: Whiting in Subarea IV and Division VIId. Proportion of total catch discarded, by age and year.

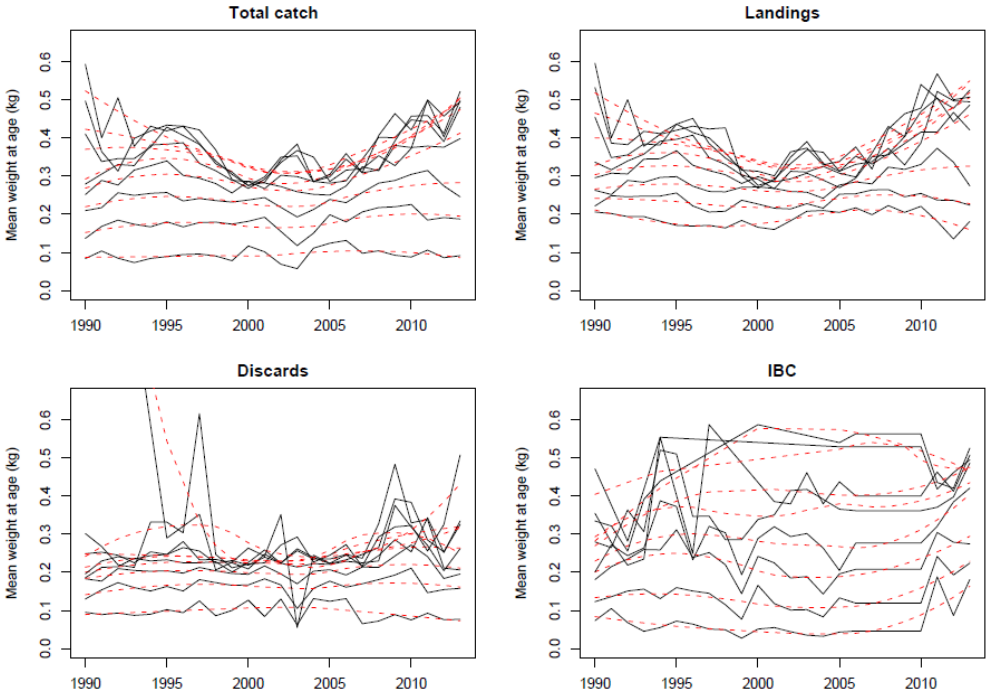


Figure 12.4: Whiting in Subarea IV and Division VIId. Mean weights-at-age (kg) by catch component. Catch mean weights are also used as stock mean weights. Red dotted line give loess smoothers through each time-series of mean weights-at-age.

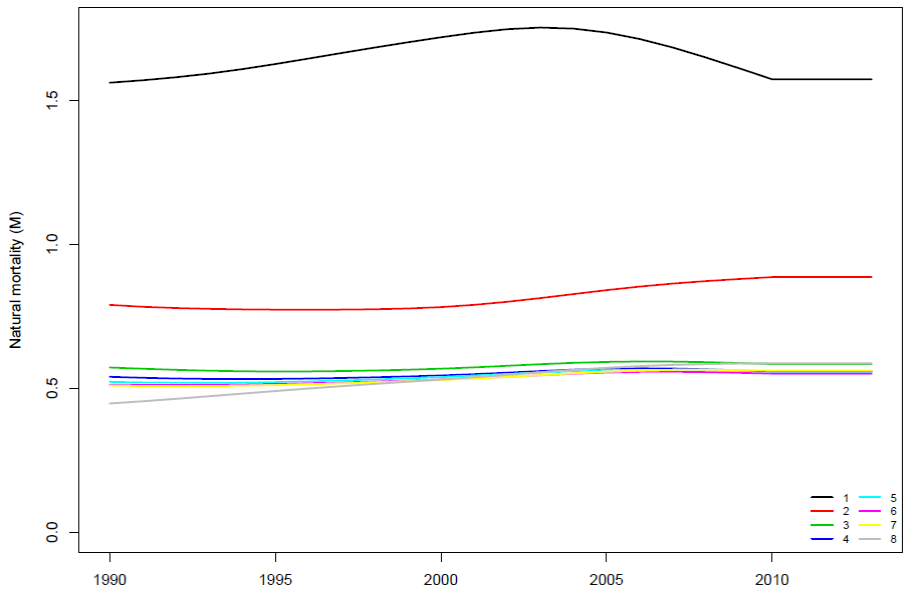


Figure 12.5: Whiting in Subarea IV and Division VIId. Natural mortality estimates from the 2012 SMS key run, used in this year's assessment.

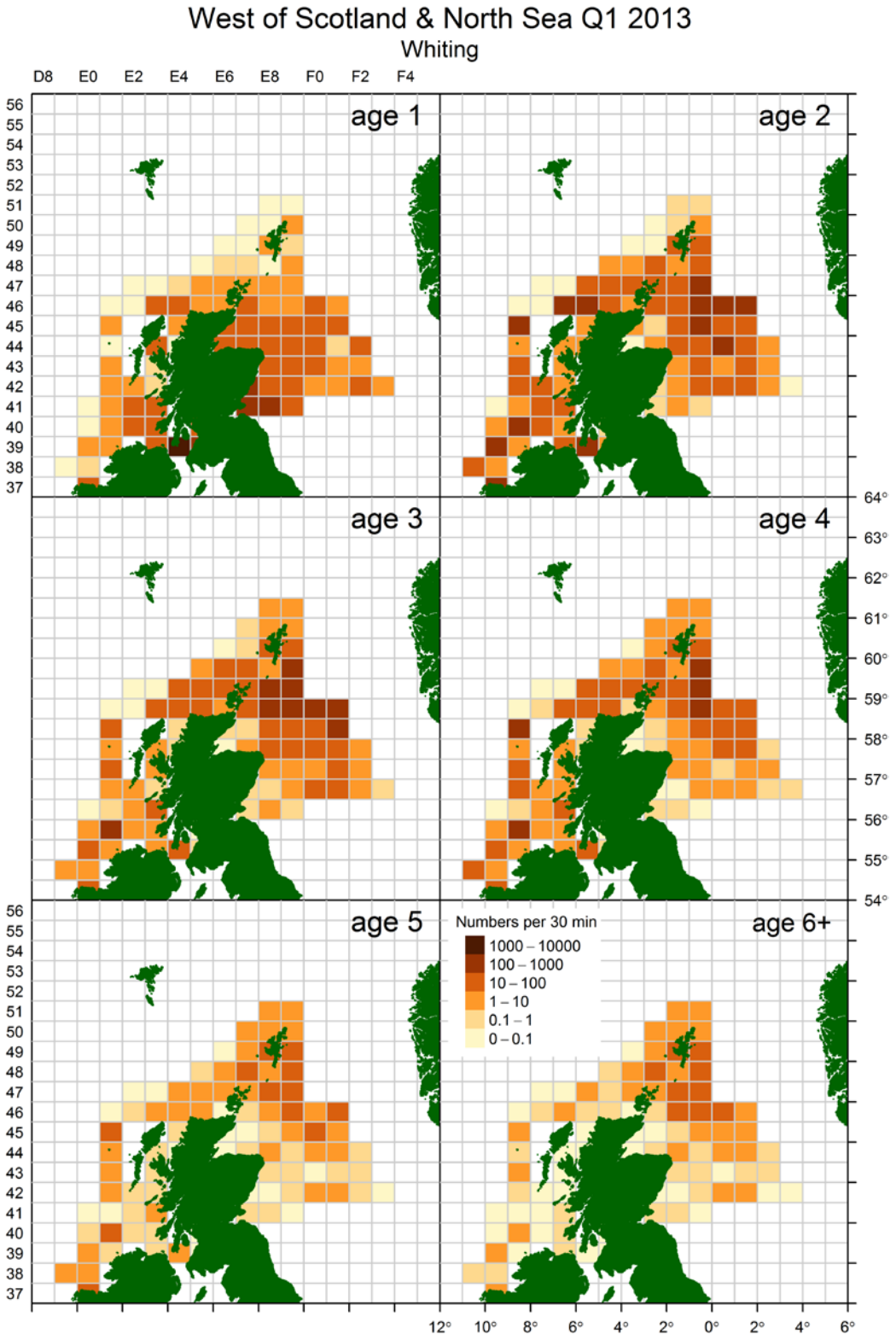


Figure 12.6: Whiting in Subarea IV and Division VIId. Survey distribution maps for Q1 2013. Colours indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the Scottish Q1 groundfish surveys in the North Sea (which forms part of the IBTS-Q1 survey) and Division VIa (which takes place a week later).

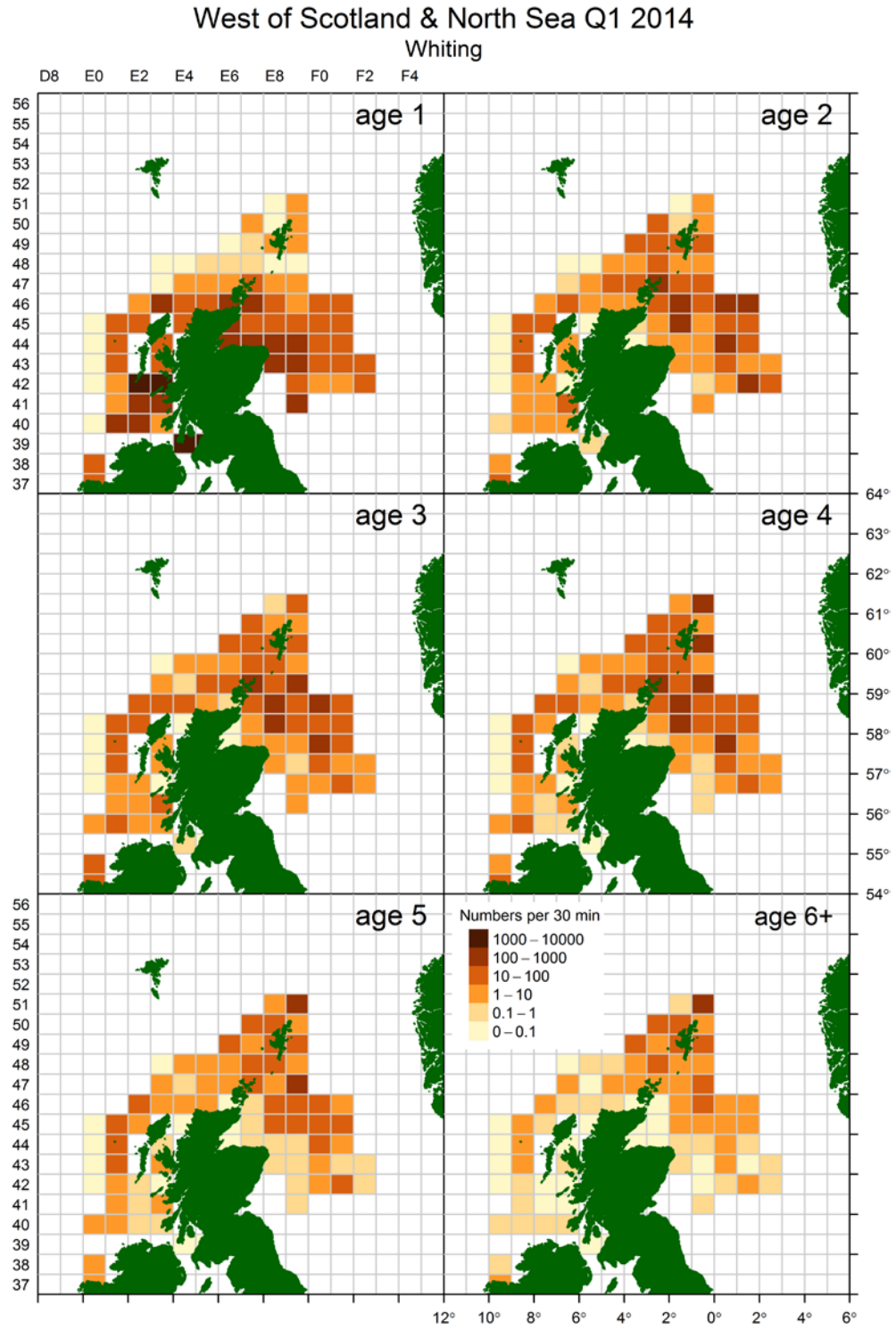


Figure 12.7: Whiting in Subarea IV and Division VIId. Survey distribution maps for Q1 2014. Colours indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the Scottish Q1 groundfish surveys in the North Sea (which forms part of the IBTS-Q1 survey) and Division VIa (which takes place a week later).

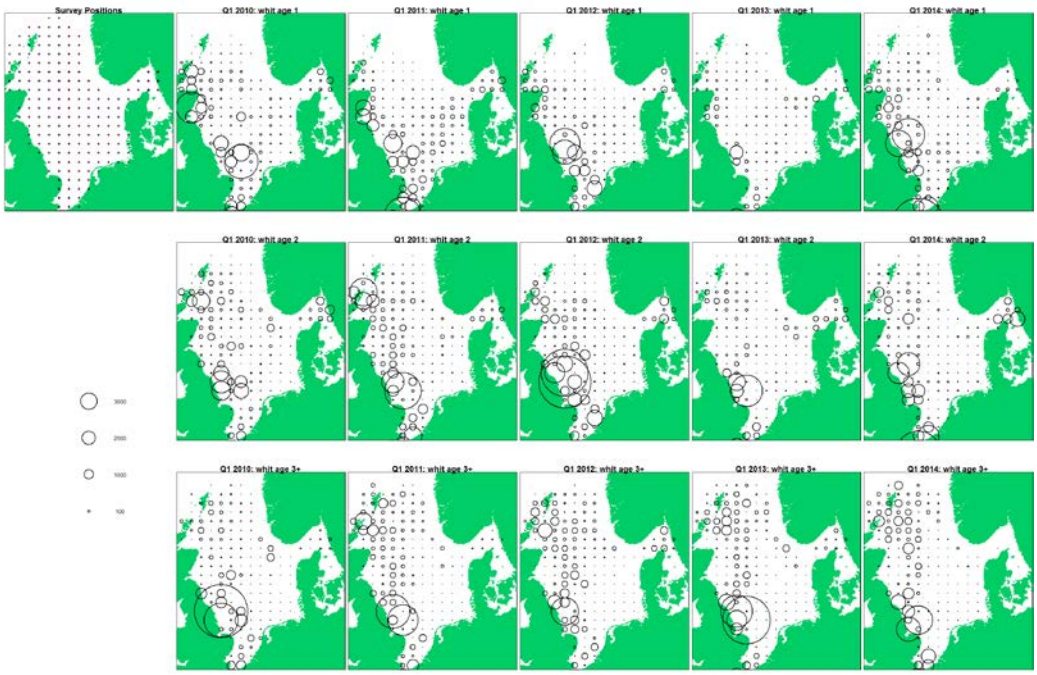


Figure 12.7.1: Whiting in Subarea IV and Division VIId. Survey distribution maps for Ages 1-3+ Q1 2010-2013 and Q1 for 2014. Size of the bubbles indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q1 survey in the North Sea.

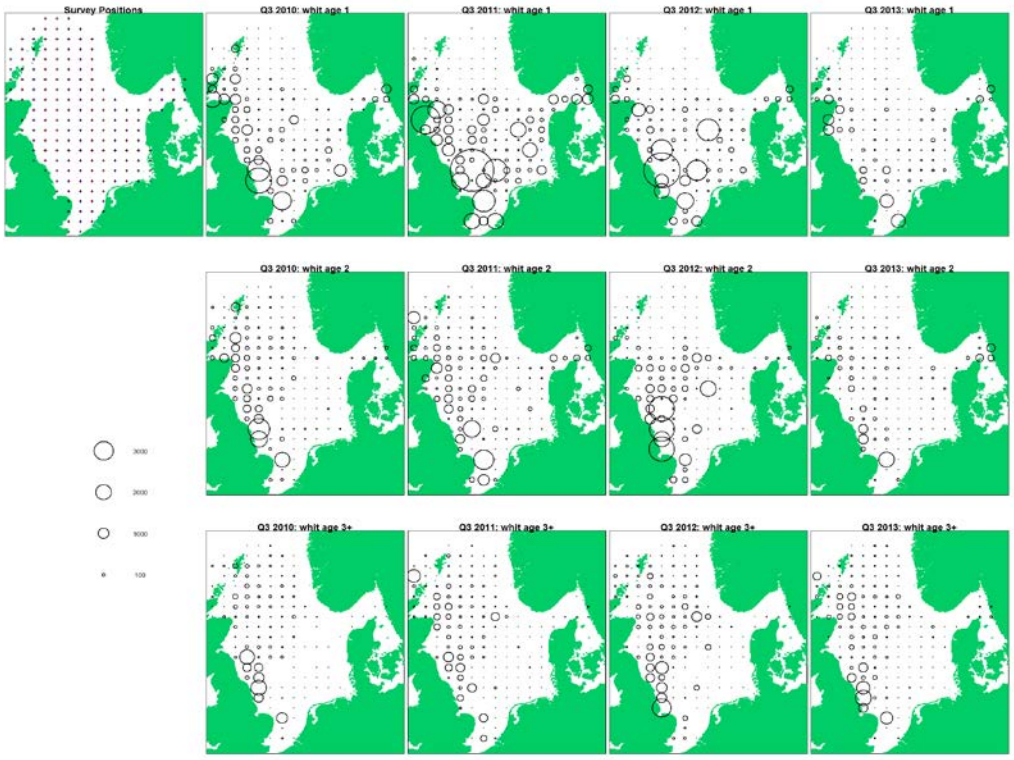


Figure 12.7.2 : Whiting in Subarea IV and Division VIId. Survey distribution maps for Ages 1-3+ Q3 2010-2013. Size of the bubbles indicate numbers caught per 30 minutes for each age (on a log10 scale). The maps are based on the IBTS-Q1 survey in the North Sea.

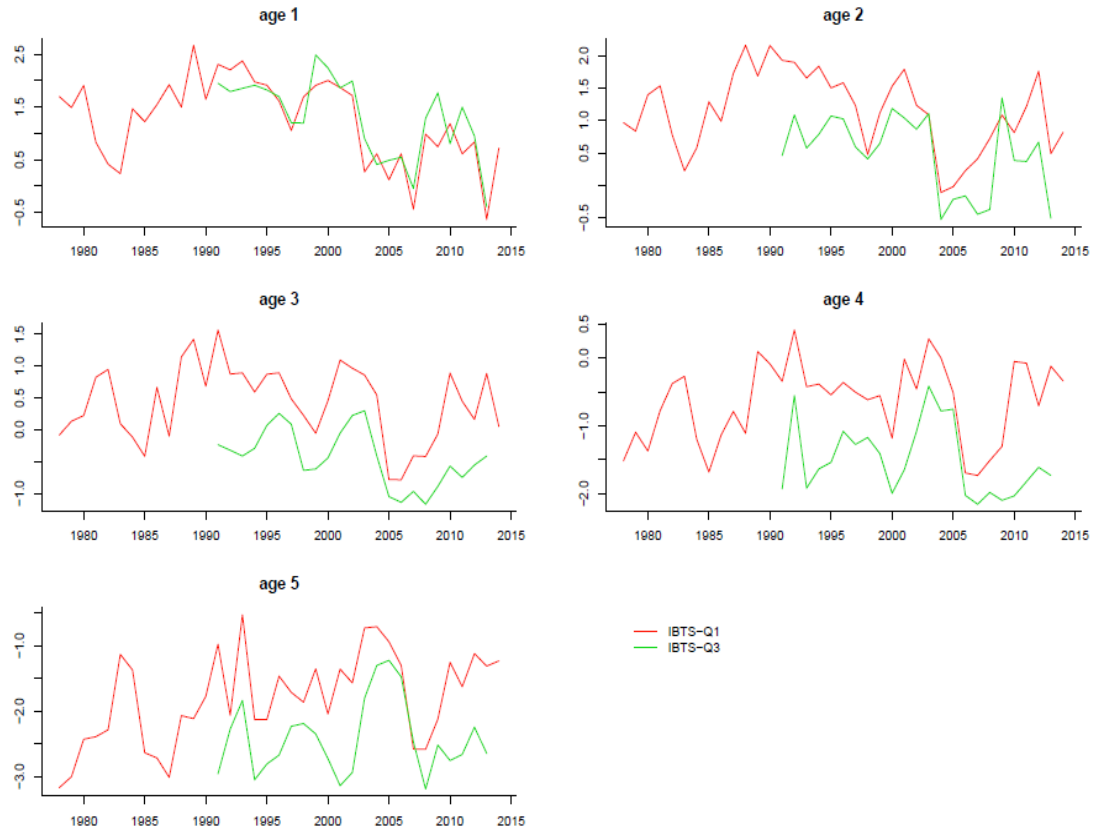


Figure 12.8: Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) at age.

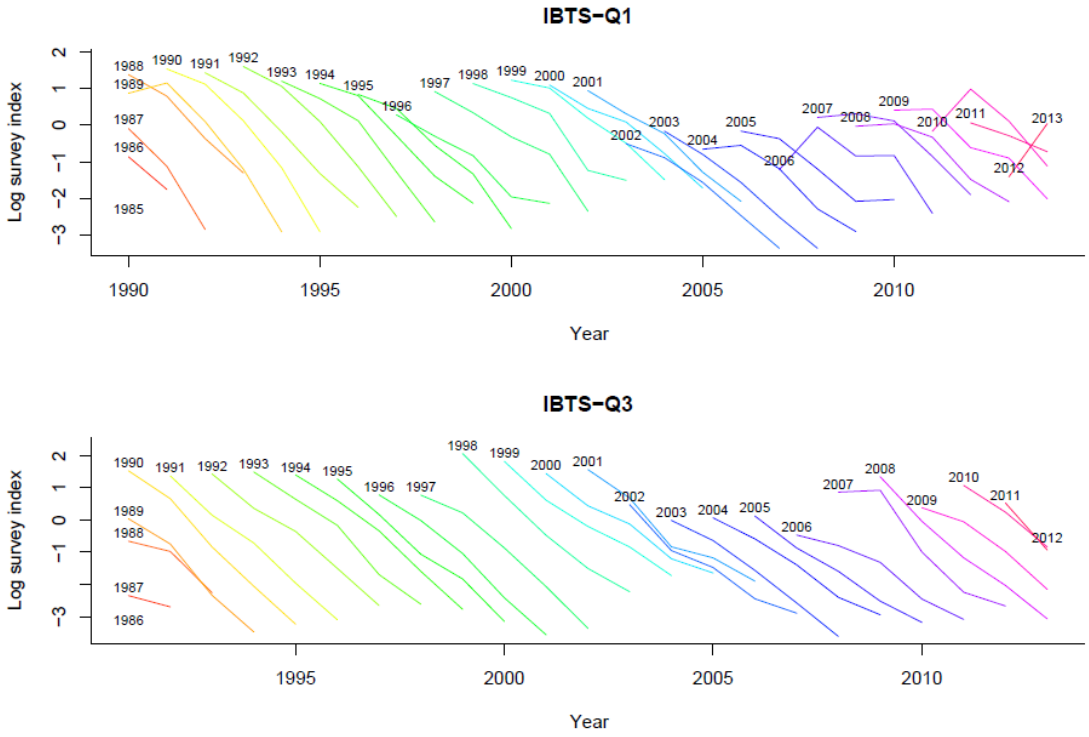


Figure 12.9: Whiting in Subarea IV and Division VIId. Log abundance indices by cohort for each of the two survey indices. The spawning year for each cohort is indicated at the start of each line.

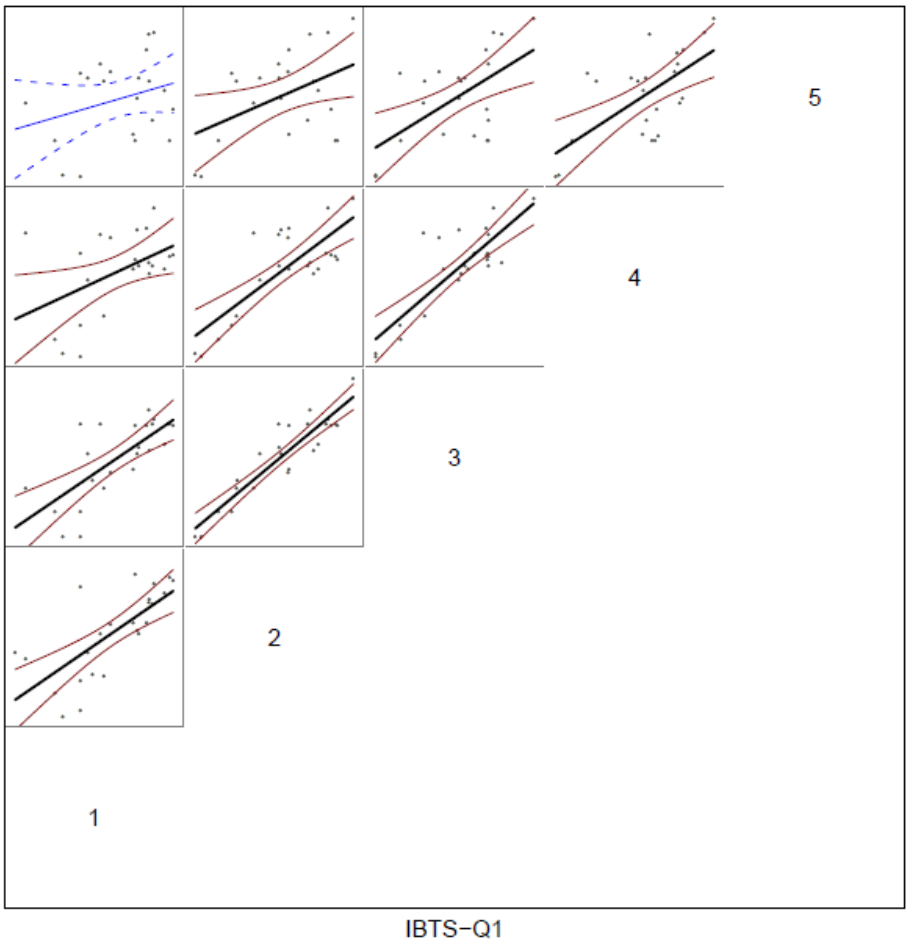


Figure 12.10: Within-survey correlations for the IBTS Q1 survey series, comparing index values at dif- ferent ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

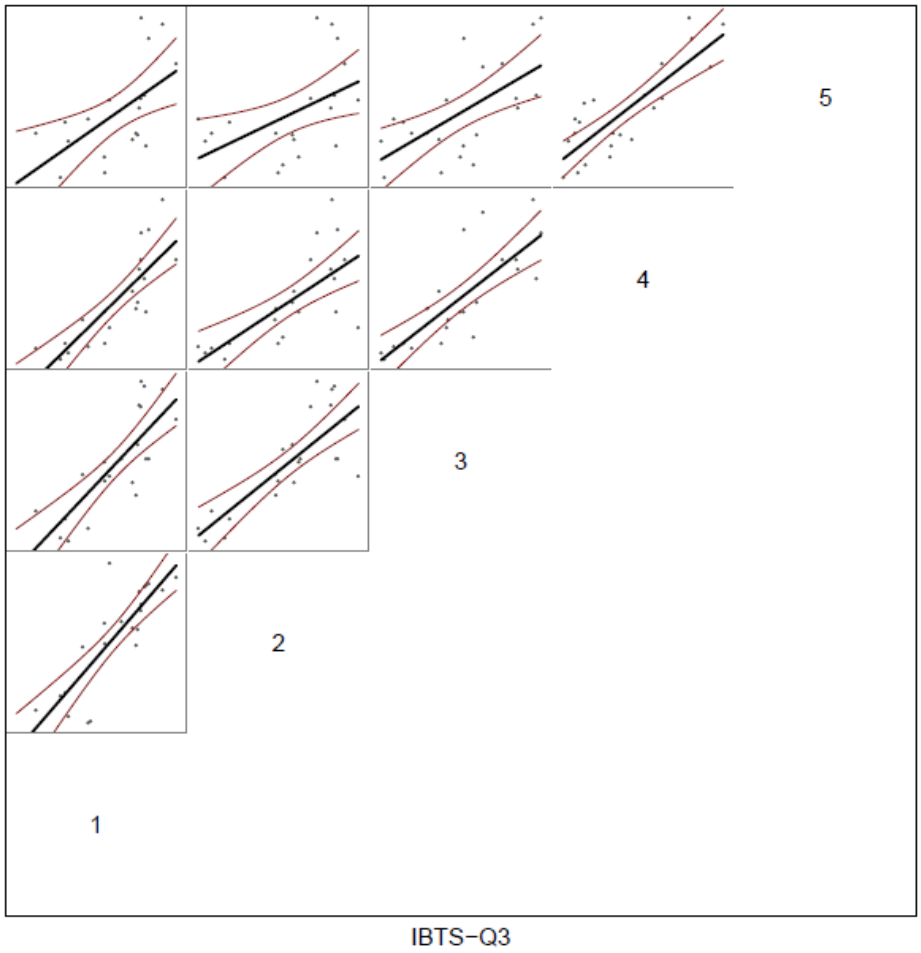


Figure 12.11: Within-survey correlations for the IBTS Q3 survey series, comparing index values at dif- ferent ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

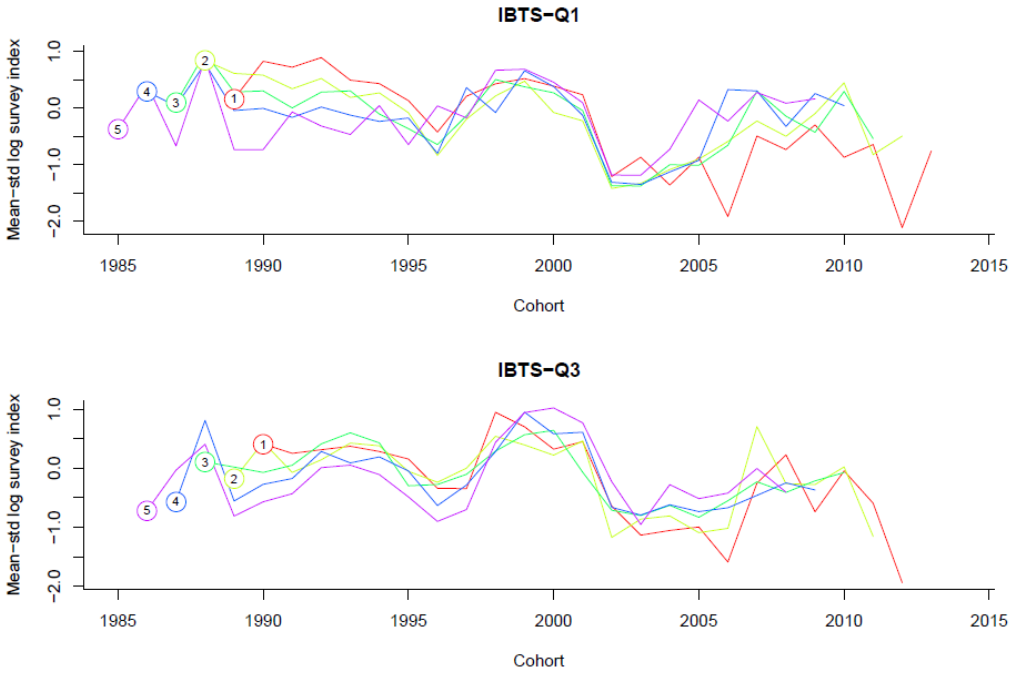


Figure 12.12: Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) for the IBTS Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

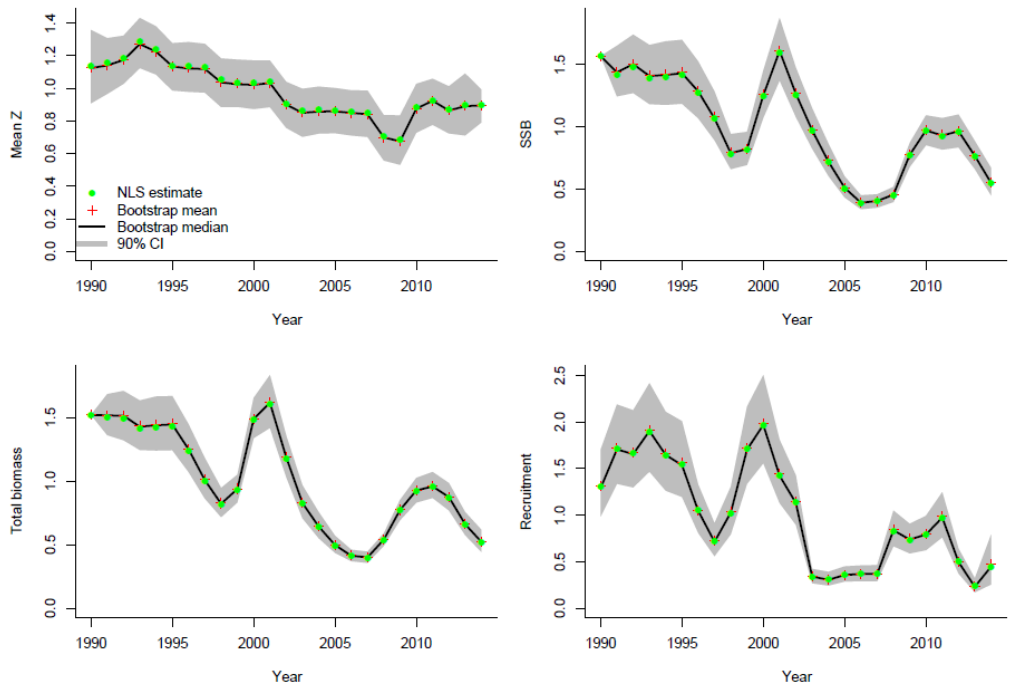


Figure 12.13: Whiting in Subarea IV and Division VIId. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

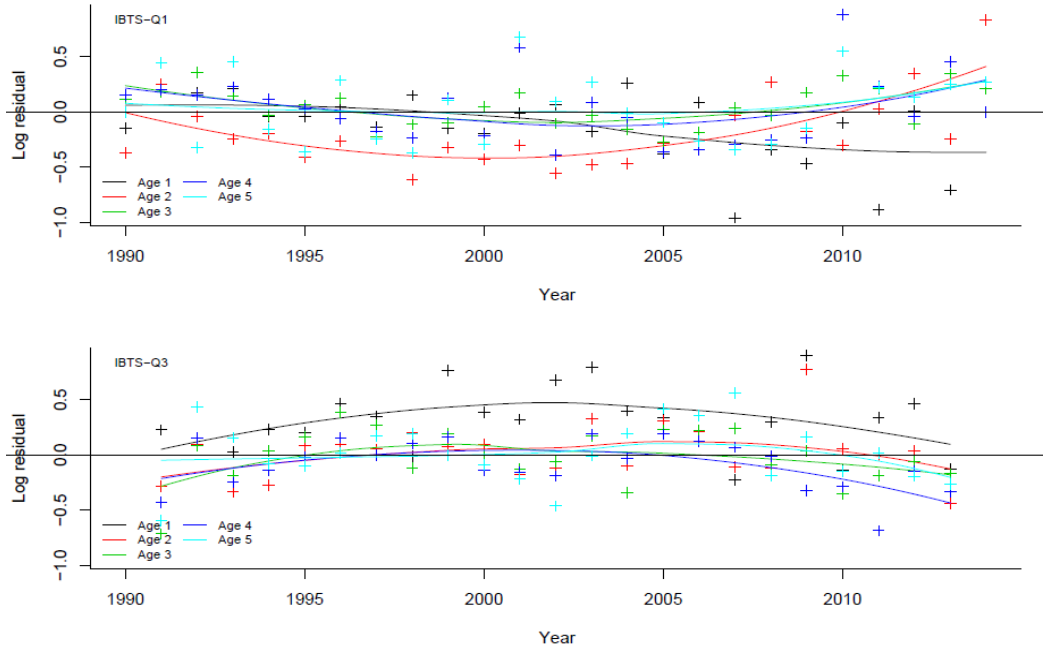


Figure 12.14: Whiting in Subarea IV and Division VIId. Log survey residuals from the SURBAR analysis. Ages are colour-coded, and a loess smoother (span = 2) has been fitted through each age time-series.

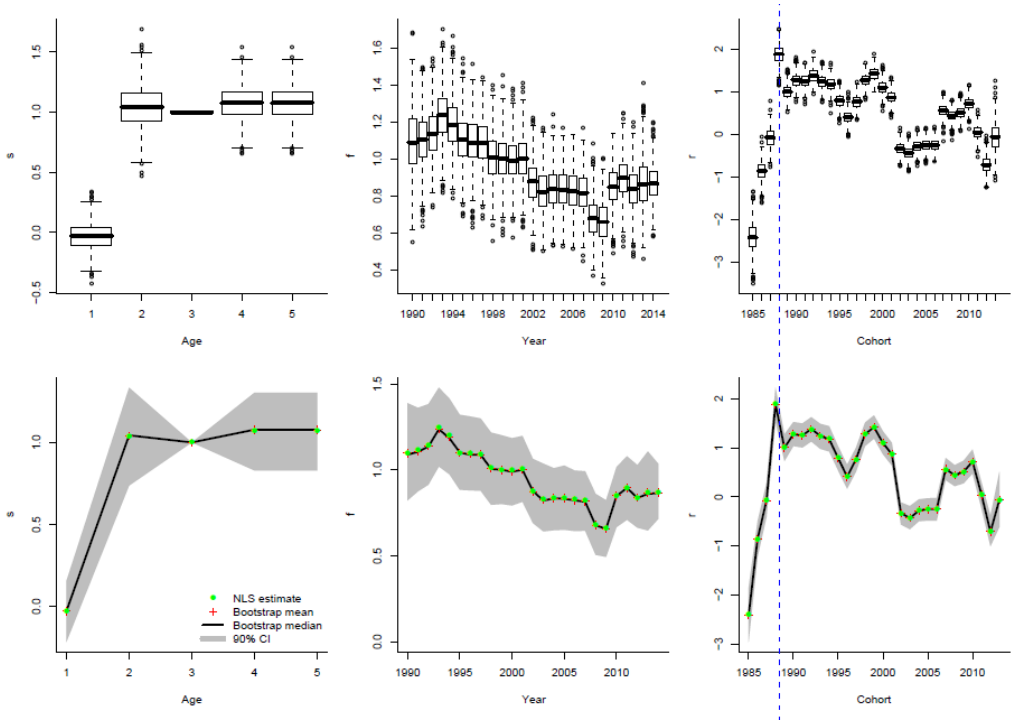


Figure 12.15: Whiting in Subarea IV and Division VIId. Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

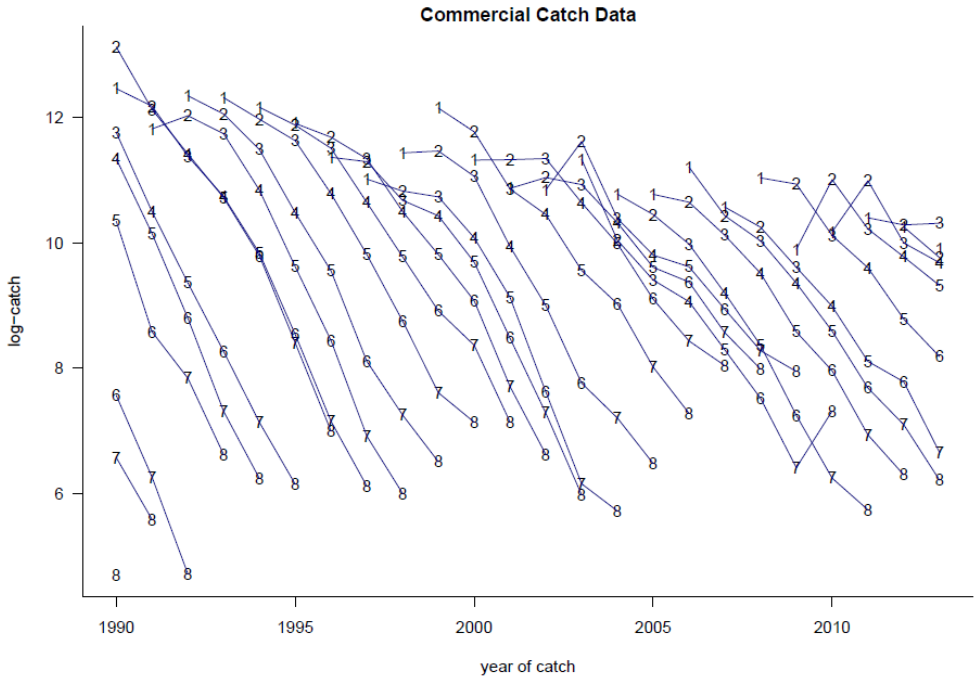


Figure 12.16: Whiting in Subarea IV and Division VIId. Log catch curves by cohort for total catches.

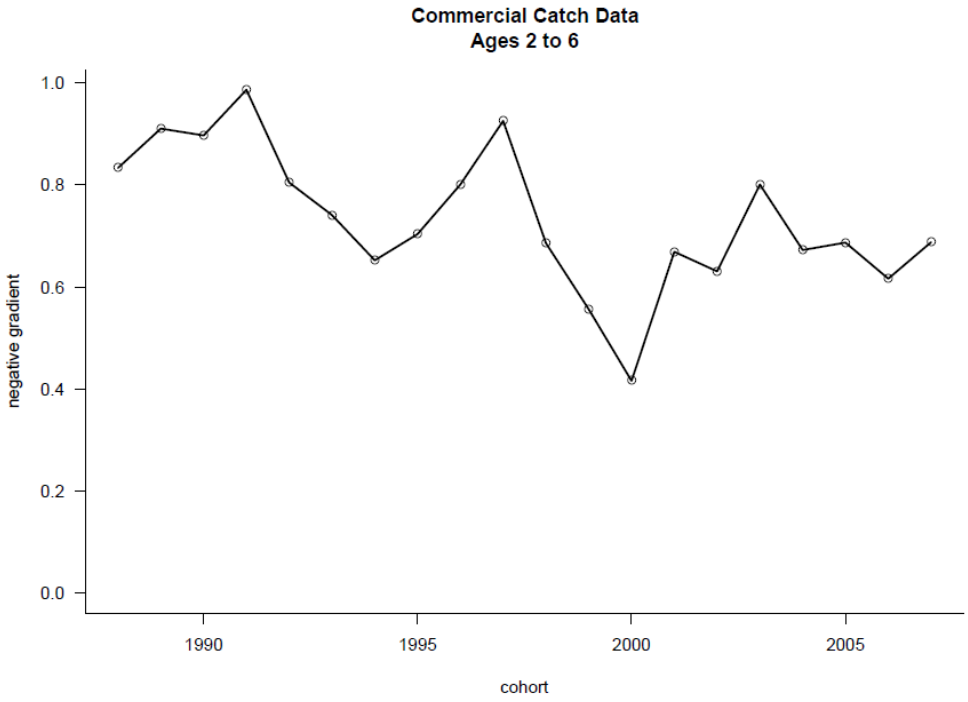


Figure 12.17: Whiting in Subarea IV and Division VIId. Negative gradients of log catches per cohort, averaged over ages 2-6. The x-axis represents the spawning year of each cohort.

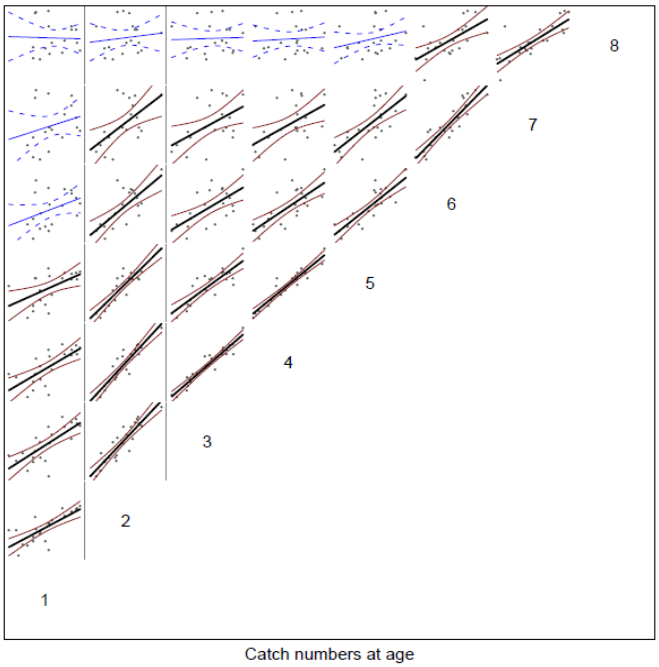


Figure 12.18: Whiting in Subarea IV and Division VIId. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

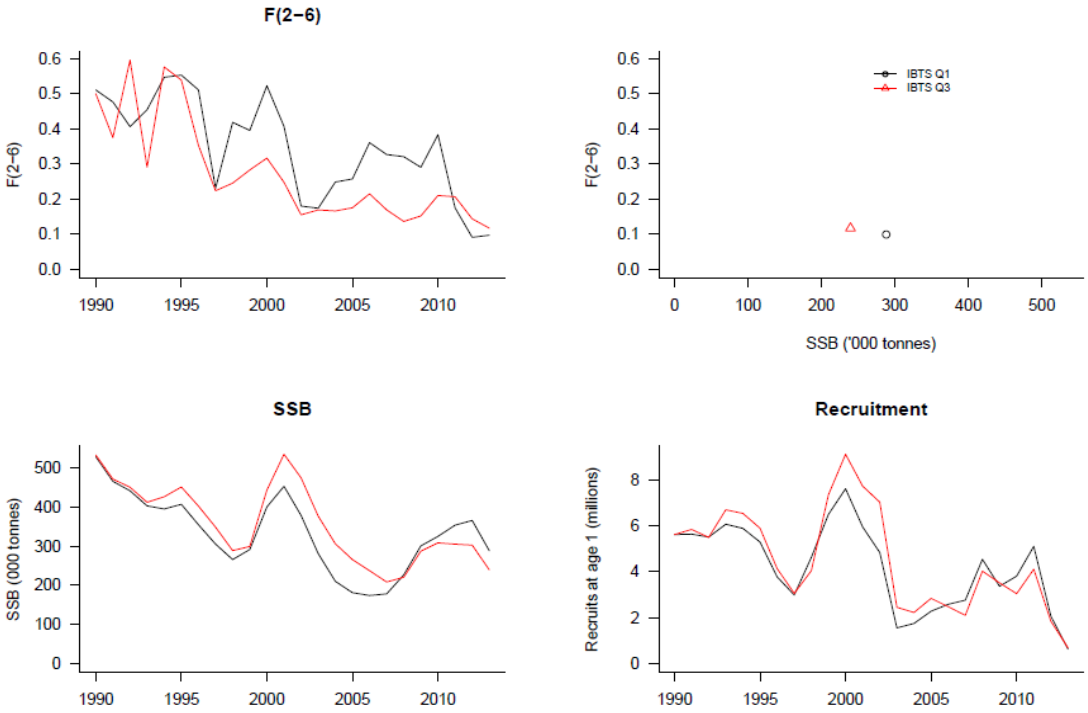


Figure 12.19: Whiting in Subarea IV and Division VIId. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2013) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

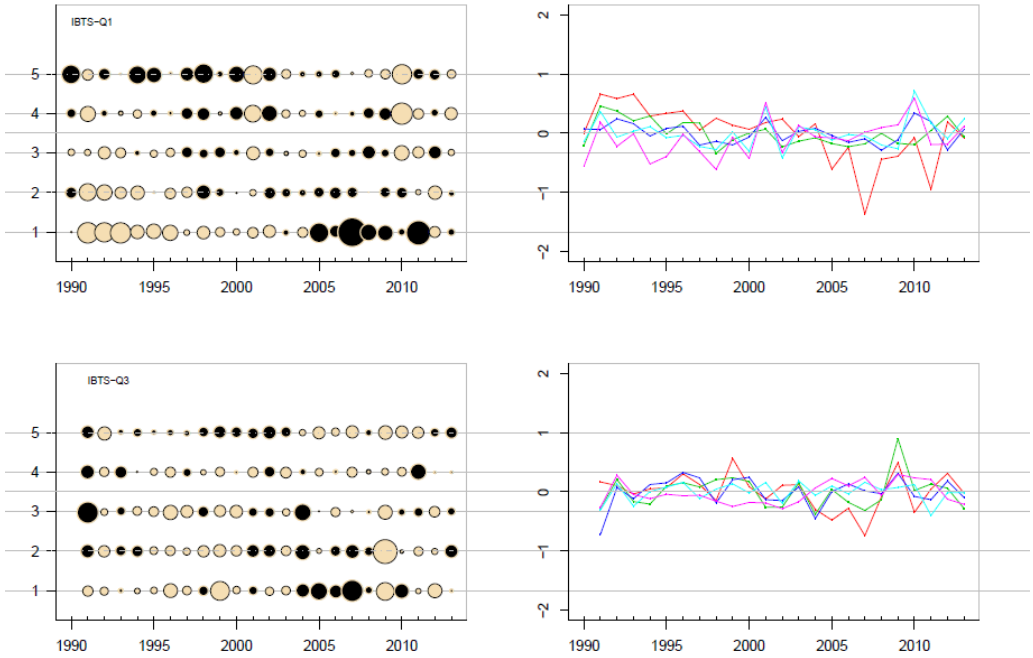


Figure 12.20: Whiting in Subarea IV and Division VIId. Log catchability residuals for single-fleet FLXSA assessments.

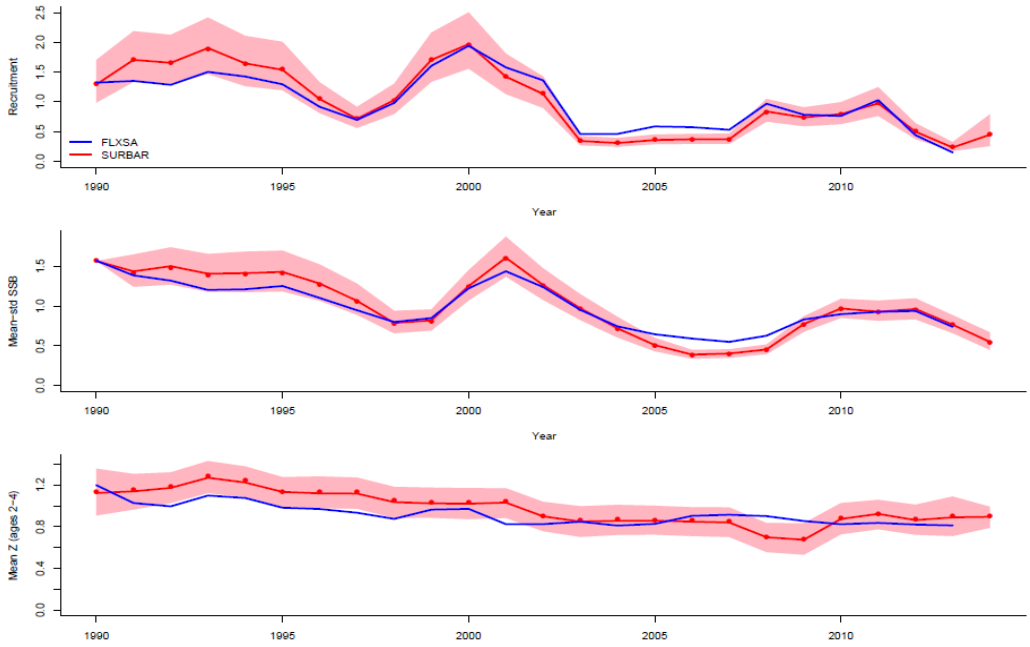


Figure 12.21: Whiting in Subarea IV and Division VIId. Comparisons of stock summary estimates from the final XSA (blue) and SURBAR (red) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models. The SURBAR estimates are plotted along with their 90% confidence bounds (shaded pink regions).

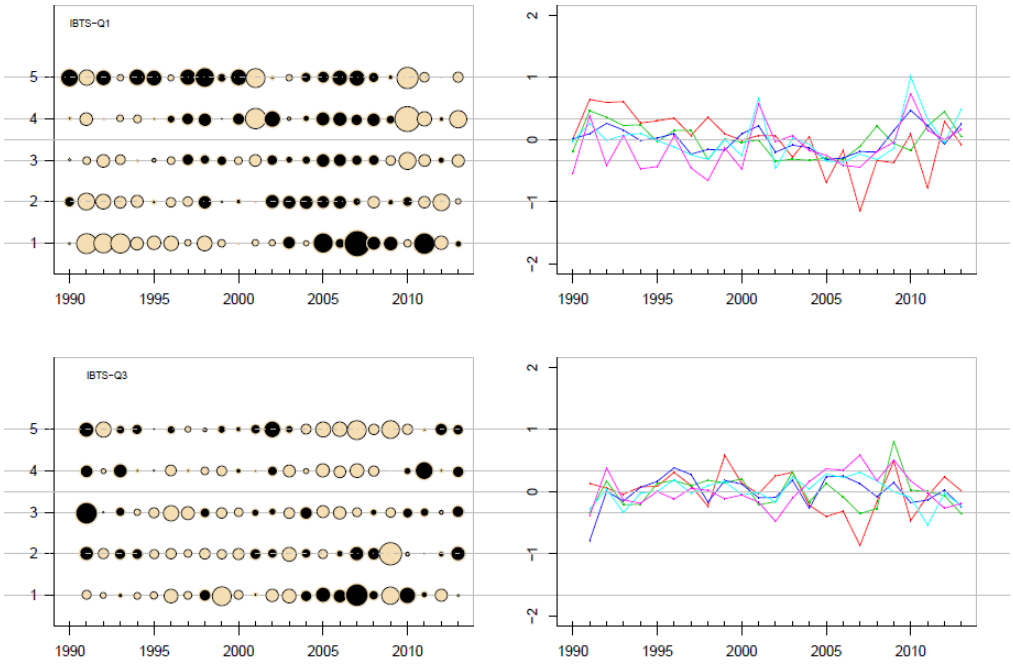


Figure 12.22: Whiting in Subarea IV and Division VIId. Log catchability residuals for final FLXSA assessment.

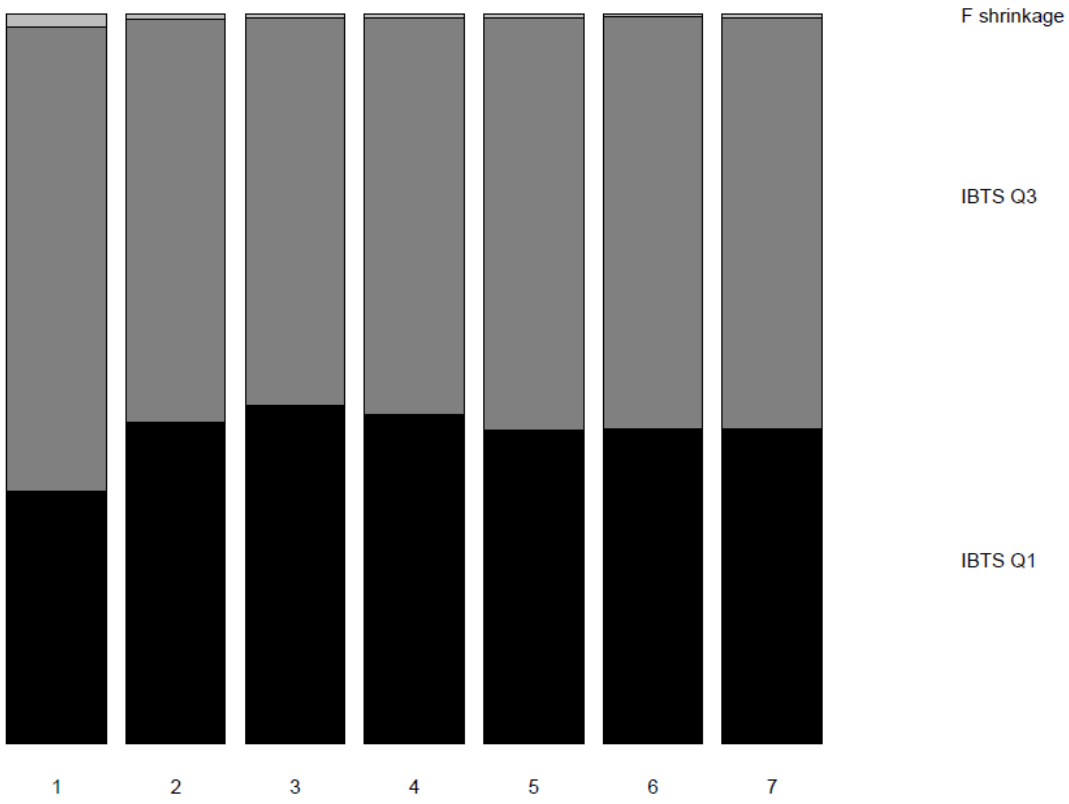


Figure 12.23: Whiting in Subarea IV and Division VIId. Contribution to survivors' estimates in final FLXSA assessment.

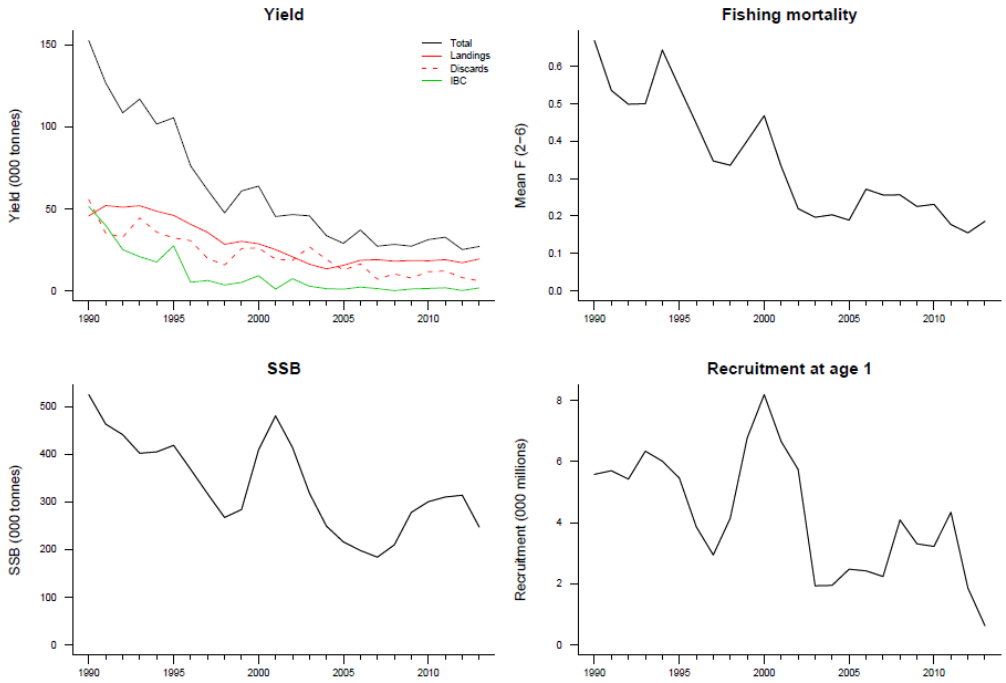


Figure 12.24: Whiting in Subarea IV and Division VIId. Summary plots for final FLXSA assessment.

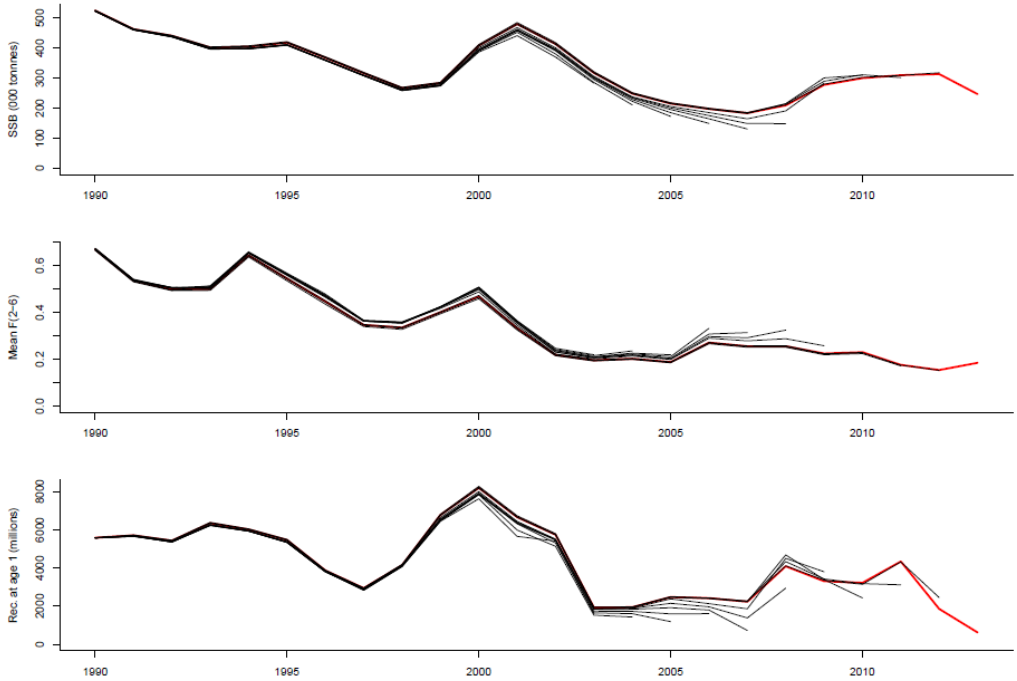


Figure 12.25: Whiting in Subarea IV and Division VIId. Retrospective plots for final FLXSA assessment.

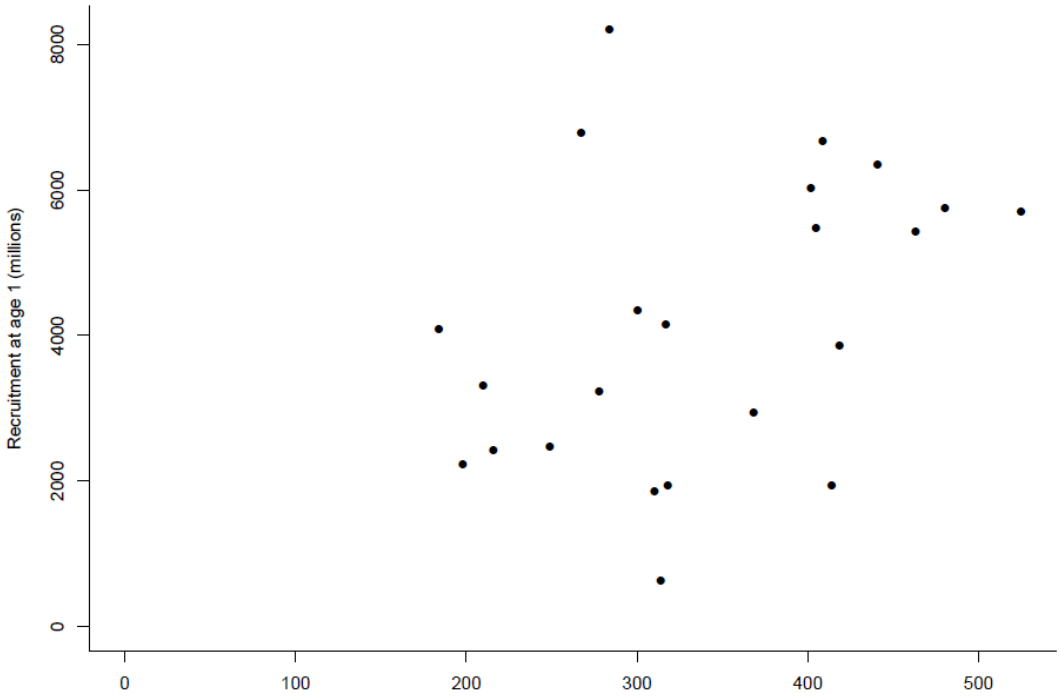


Figure 12.26: Whiting in Subarea IV and Division VIId. Stock-recruitment plot from final FLXSA assessment.

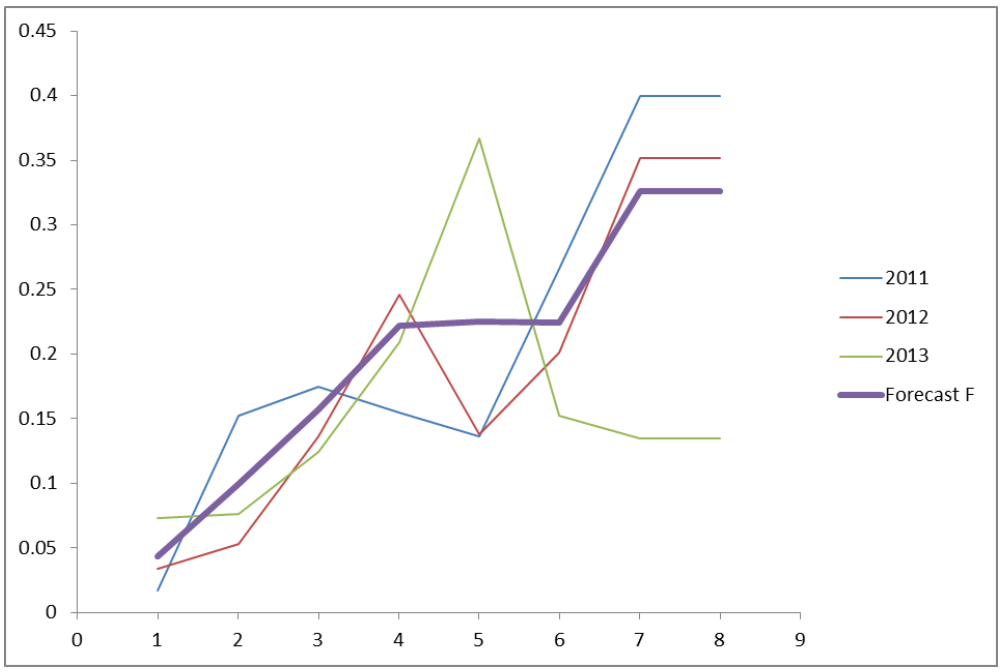


Figure 12.27: Whiting in Subarea IV and Division VIId. FLXSA F at age estimates for 2010-2012, along with scaled mean exploitation used for the forecast.

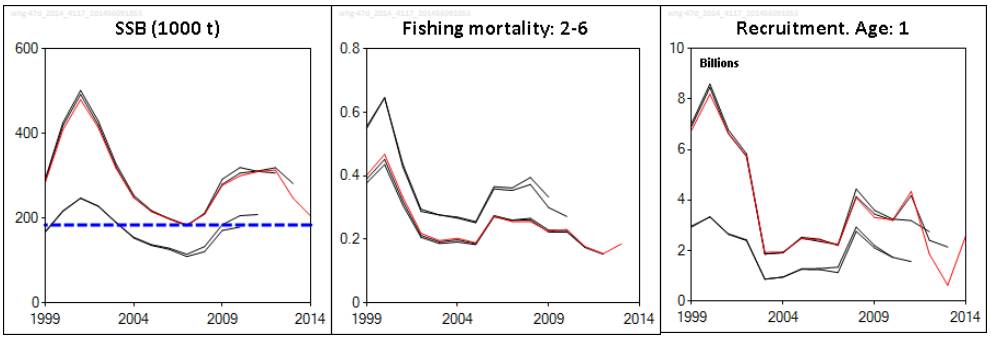


Figure 12.28: Whiting in Subarea IV and Division VIId. Historical assessment comparison plot.

13 Haddock in Subarea IV and Divisions IIIaW and VIa (North Sea, Skagerrak and West of Scotland)

Haddock in Subarea IV and Divisions IIIaW and VIa (referred to hereafter as Northern Shelf haddock) were previously assessed as two separate stocks: Subarea IV and Division IIIaW by WGNSSK, and Division VIa by WGCSE. The Benchmark Workshop for Northern Haddock Stocks (ICES-WKHAD 2014) met during early 2014, and concluded that the two notional haddock stocks should be assessed as one stock. This section therefore presents the first ICES assessment of Northern Shelf haddock. WKHAD also proposed a number of data changes and the use of a new stock assessment model, and these changes are also summarised throughout this Section. In brief, they are:

1. The assessment is now produced for the combined Northern Shelf stock.
2. The assessment model is now TSA, presented along with SAM and SURBAR exploratory runs.
3. Maturity is now knife-edged at age 3.
4. Time-varying natural mortality estimates from SMS runs are used.
5. The assessment is tuned using the North Sea IBTS Q1 and Q3 surveys.
6. The assessment now starts in 1972.

It should be noted that catch data problems were discovered and corrected several weeks after the WGNSSK meeting, during the subsequent ADGNS meeting. As a consequence, assessment data were recompiled and new versions of the assessment, forecast and advice were produced. This Section therefore reports the new assessment and forecast, generated in June 2014.

13.1 General

13.1.1 Ecosystem aspects

Ecosystem aspects are summarised in the Stock Annex.

13.1.2 Fisheries

A general description of the fishery (along with its historical development) is presented in the Stock Annex. Most of the information presented below and in the Stock Annex pertains to the Scottish fleet, which takes the largest proportion of the haddock stock. This fleet is not just confined to the Northern Shelf area, as vessels will sometimes operate in Divisions VIb (Rockall) and Vb (Faeroes).

Changes in fleet dynamics

There have been no decommissioning schemes affecting haddock fisheries since the major rounds in 2002 and 2004. A number of Scottish vessels have been taking up opportunities for oil support work during recent years with a view to saving quota and days at sea.

With the relatively limited cod and whiting quotas in recent years, many vessels have tended to concentrate more on the haddock fishery, with others taking the opportunity to move between the *Nephrops* and demersal fisheries (particularly during 2006 and 2007 – there may have been fewer boats changing focus in this way from 2008 to 2013). Accompanying the change in emphasis towards the haddock fishery, there has also

been a tendency to target smaller fish in response to market demand. Some trawlers operating in the east of the North Sea have used 130 mm mesh and this is likely to improve selectivity for haddock. Fish from the 2009 year-class now form the bulk of haddock catches, and discarding rates for this year-class fish declined during 20012 and 2013 as they grew beyond the minimum landings size. The decline may also have been due to other measures related to the Scottish Conservation Credits scheme (CCS; see Section 13.1.4).

Specific information on changes in the Scottish fleet during 2011-2013 was not provided to WGNSSK in 2014. It is difficult to reach a firm conclusion on the likely effect of recent fishery changes on haddock mortality. Changes in gear that were required to qualify for the Scottish CCS are likely to have reduced bycatch (and therefore discards) of haddock in the *Nephrops* fishery in particular. The inclusion of Scottish vessels in the CCS has been mandatory since the beginning of 2009, and compliance has been close to 100%. Cod avoidance under the real-time closures scheme (which is a component of the CCS) could also have moved vessels away from haddock concentrations, but the extent of this depends on how closely cod and haddock distributions are linked, and on how successful the avoidance strategies have been. On the other hand, vessels catching fewer cod may increase their exploitation of haddock in order to maintain economic viability. It is unclear what changes in fleet dynamics and fishing behaviour may be caused by the impending EU landings obligation, due to be implemented for the majority of fleets catching Northern Shelf haddock in January 2016.

In 2013, 18 Scottish demersal whitefish vessels participated in a Fully Documented Fishery (FDF) scheme, following trials during 2010-2012. Similar trials have been conducted during various periods by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land all cod caught. It is not clear what the impact would be on haddock fisheries of an enforceable discard ban for cod, and in data collation for the haddock assessment it was assumed that FDF vessels would have similar haddock discard patterns as other vessels, but this remains to be verified. It should be noted that the Scottish FDF schemes implemented to date have all been restricted to the North Sea: cod discarding from CCTV vessels has remained legal in Division VIa, and indeed has been mandatory for over-quota cod. The Scottish FDF scheme for 2014 is planned to begin in June, along similar lines to previous years. At the time of writing, 23 vessels had applied to join the scheme, and it is likely that all will be admitted and will receive a 25% increase in cod quota and extra days at sea in return for landing all cod caught.

Additional information provided by the fishing industry

Haddock are still the mainstay of the Scottish whitefish fleet, and have become increasingly so following cod-avoidance initiatives under the Scottish Conservation Credits scheme.

13.1.3 ICES advice

ICES advice for 2013

Subarea IV and Division IIIaW

In June 2012, ICES concluded the following:

Fishing mortality has been below F_{pa} and around F_{MSY} and SSB has been above MSY $B_{trigger}$ since 2001. Recruitment is characterized by occasional large year classes, the last of which was the strong 1999 year class. Apart from the 2005 and 2009 year classes which are about average,

recent recruitment has been poor. Following the ICES MSY framework implies fishing mortality to be increased to 0.3, resulting in human consumption landings of less than 49 000 t in 2013. This would be expected to lead to an SSB of 202 000 t in 2014. Following the management plan implies a TAC of 47 811 t in 2013, which is a TAC increase of 15% and is expected to lead to an F decrease of 8%.

Following the 2012 Q3 North Sea surveys for haddock (EngGFS-Q3 and ScoGFS-Q3), the application of the AGCREFA (ICES-AGCREFA 2008) update protocol indicated that updates to the advice were not required. The autumn indices suggested that the incoming year-class was rather weaker than had been assumed in the forecast produced in May 2012.

Division VIa

In September 2012, ICES concluded the following:

The 2009 year class is above the average in the recent period, but is below the long-term average. Nevertheless, this year class is the main contributor to the increase of the SSB in 2012 to above Blim. F has been above F_{pa} in most years since 1987 and has been declining since 1999. F is now below F_{MSY}. ICES advises on the basis of the MSY framework that landings in 2013 should be no more than 3100 t. Effective technical measures should be implemented to reduced high discard rates in the Nephrops fleet (TR2).

ICES advice for 2014

Subarea IV and Division IIIaW

In June 2013, ICES concluded the following:

Fishing mortality has been below F_{pa} and around the F_{MSY} proxy and SSB has been above MSY B trigger since 2001. Recruitment is characterized by occasional large year classes, the last of which was the strong 1999 year class. Apart from the 2005 and 2009 year classes which are about average, recent recruitment has been poor. ICES advises on the basis of the EU–Norway management plan that the TAC (Human Consumption landings) should be no more than 40 639 tonnes in 2014. If rates of discards and industrial bycatch do not change from the average of the last 3 years (2010–2012), this implies catches of no more than 45 318 tonnes.

Following the 2013 Q3 North Sea surveys for haddock (EngGFS-Q3 and ScoGFS-Q3), the application of the AGCREFA (ICES-AGCREFA 2008) update protocol indicated that updates to the advice were not required. The autumn indices suggested that the incoming year-class was slightly smaller (but not significantly so) than had been assumed in the forecast produced in May 2013.

Division VIa

In October 2013, ICES concluded the following:

The 2009 year class is above the average in the recent period, but is below the long-term average. Nevertheless, this year class is the main contributor to the increase of the SSB in 2012 to above B_{pa}. F has been above F_{pa} in most years since 1987 and has been declining since 1999. F has been below the F_{MSY} proxy since 2009. ICES advises on the basis of the MSY approach that catches should be no more than 6432 t. If discarding rates do not change from the average of the last three years, this corresponds to landings of no more than 3988 t. Effective technical measures should be implemented to reduce high discard rates in the Nephrops fleet (TR2).

13.1.4 Management

Subarea IV and Division IIIaW

North Sea haddock are jointly managed by the EU and Norway under an agreed management plan, the details of which are given in the Stock Annex. The plan was modified during 2008 to allow for limited quota banking-and-borrowing, following the meeting in June of the Norway-EC Working Group on Interannual Quota Flexibility and subsequent simulation analysis (Needle 2008a). The review and potential revision planned for 2009 was postponed until July 2010. Needle (2010) concluded that "a target F of 0.3 within the management plan gives the best combination of good long-term cumulative yield, and low risk of biomass falling below the precautionary level. This target F is also robust to worst-case assumptions about recruitment and the quality of stock assessments. The TAC constraint used does not appear to have a significant effect on the results." Following a review and evaluation process, ICES concurred with this view (ICES-ACOM 2010).

Annual management of the fishery operates through TACs for two discrete areas. The first is Subarea IV (and EU Waters of IIa). The 2012 and 2013 TACs for haddock in this area were 39166 t and 45040 t respectively. The second is Division IIIa (EU waters), for which the TACs for 2012 and 2013 were 2 409 t and 2 770 t respectively.

During 2008, 15 real-time closures (RTCs) were implemented under the Scottish Conservation Credits Scheme (CCS). In 2009, 144 RTCs were implemented, and the CCS was adopted by 439 Scottish and around 30 English and Welsh vessels. In 2010 there were 165 closures, and from July 2010 the area of each closure increased (from 50 square nautical miles to 225 square nautical miles). In more recent years, the following numbers of closures were implemented: 185 (2011), 173 (2012), and 166 (2013). In 2014, 35 closures had been implanted by 7th May. The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it will undoubtedly have an effect on the mortality of associated species such as haddock.

Studies tracking Scottish vessels during 2009-2010 concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters, although there was no significant effect during the second and fourth quarters; see Needle and Catarino (2011). In a subsequent analysis, Needle (2012) showed that the nett effect of RTCs appeared to be to attract vessels, although the movement towards RTCs may have been coincidental. However, the effect of these changes in behaviour on the haddock stock is still under investigation.

In early 2008, a one-net rule was introduced in Scotland as part of the CCS. This is likely to have improved the accuracy of reporting of landings to the correct mesh size range. However, Scottish seiners were granted a derogation from the one-net rule until the end of January 2009, and were allowed to carry two nets (e.g. 100-119 mm as well as 120+ mm). They were required to record landings from each net on a separate logsheet and to carry observers when requested (ICES-WGFTFB 2008).

The remaining technical conservation measures in place for the haddock fisheries in Subarea IV and Division VIa are summarised in the Stock Annex.

Division VIa

The TAC relating to this stock is in place for EU and international waters of ICES Divisions Vb and VIa. The agreed minimum landing size for haddock in Division VIa is 30 cm. There is no formal management plan currently in place although one has been evaluated and considered precautionary by ICES. Further regulations implemented for

the west of Scotland include technical measures associated with the cod recovery plan (EC regulation 1342/2008) and emergency measures introduced with EC regulation 43/2009. The EU Registration of Buyers and Sellers regulation has reduced bias in commercial landings data.

13.2 Data available

13.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 13.2.1, together with the corresponding WG estimates and the agreed international quota (listed as "total allowable catch" or TAC). Since 2012, international data on landings and discards have been collated through the InterCatch system (see Section 1.2). Figures 13.2.1 and 13.2.2 summarise the proportion of landings (in Subarea IV and Division IIIa, and Division VIa, respectively) for which samples have been provided. In both areas, while there are a large number of fleets for which landings have not been sampled, the overall contribution of these fleets to total landings is small and more than 90% of landings by weight have been sampled appropriately. Age compositions for the remaining landings have therefore been determined by averaging across the available sampling, without consideration of quarter, country or gear type. Similarly, discard observations are available (from Scotland and Denmark) for the fleets landing the vast majority of haddock, so discard rates for the remaining fleets have been inferred using simple averaging.

The full time series of landings, discards and industrial by-catch (IBC) is presented in Table 13.2.2. These data are illustrated further in Figure 13.2.3. The total landed yield of the international fishery has been relatively stable since 2007. The WG estimates (Table 13.2.2) suggest that haddock discarding (as a proportion of the total catch) decreased significantly during 2013, and is now the lowest in the time series at 6.5% by weight. This may be due in part to fleet behaviour changes related to cod avoidance measures, but also to the weak year-classes since 2009 (implying that the bulk of the catch is now large, mature fish that are less likely to be discarded). However, discards have declined for nearly all ages (Figure 13.2.4).

Subarea IV discard estimates are derived from data submitted by Belgium, Denmark, Germany, England and Scotland. As Scotland is the principal haddock fishing nation in that area, Scottish discard practices dominate the overall estimates. DCF regulations oblige only the UK (Scotland and England) to submit discard data for Subarea IV. Division IIIa discard estimates are derived from data submitted by Sweden and Denmark. Division VIa discard estimates are provided by Scotland, Ireland and Northern Ireland. Industrial bycatch (IBC) has declined considerably from the high levels observed until the late 1970s.

Discard estimates from 1972-1977 were not based directly on observations, but inferred from subsequent estimates of discard rates-at-age from the Scottish observer programme (see also ICES-WKHAD, 2014, and the Stock Annex). These data are therefore treated as missing in the TSA assessment (see below), with the exception of the 1972 value (as TSA requires a non-missing value at the start of the time-series). TSA estimates of discards for 1973-1977 are therefore extrapolated from later data.

Estimated discard rates can be calculated using video data from Scottish vessels carrying cameras (as part of the FDF scheme described in Section 13.1.2). Neither fish ages nor weights can be measured directly using video, but a method has been developed

in Scotland for estimating discard rates by measuring numbers and lengths of discarded fish and applying existing weight-length relationships to obtain a discarded weight, which can then be compared with the total landed weight. Figure 13.2.5 shows initial results for Q4 of 2012 and Q1-Q3 of 2013, for the North Sea and the West of Scotland, and for six species (cod, haddock, whiting, saithe, hake, monk). Haddock discard rates from all trips in both areas were low (less than 10%), and the mean rate (around 4%) was lower than the observer-based estimate used in the assessment presented here. The lack of age information currently impedes the use of these estimates in the ICES assessment process, but work is underway in Scotland and elsewhere to address this.

13.2.2 Age compositions

Total catch-at-age data are given in Table 13.2.3, while catch-at-age data for each catch component are given in Tables 13.2.4 to 13.2.6. The fishery in 2013 (landings for human consumption) was still strongly reliant on the 2005 and 2009 year-classes. The strong 1999 year-class has faded from the fishery, althogh the size of the plus-group has increased again with the aging of the 2005 year-class. In the past, vessels have seldom exhausted their quota in this fishery, and discarding behaviour is thought to be driven by a complicated mix of economic and other market-driven factors.

13.2.3 Weight at age

Weight-at-age for the total catch in the North Sea is given in Table 13.2.7. Weight-at-age in the total catch is a number-weighted average of weight-at-age in the human consumption landings, discards and industrial bycatch components. Weight-at-age in the stock is assumed to be the same as weight-at-age in the total catch. The mean weights-at-age for the separate catch components are given in Tables 13.2.8 to 13.2.10 and are illustrated in Figure 13.2.6: this shows the declining trend in weights-at–age for older ages, as well as some evidence for reduced growth rates for large year classes. Jaworski (2011) concluded that linear cohort-based growth models are the most appropriate method for characterising haddock growth, and these are used this year in the short-term forecast (Section 13.6).

13.2.4 Maturity and natural mortality

Maturity is assumed to be fixed over time and knife-edged at age 3 (that is, all fish aged 0-2 are assumed to be immature, all fish aged 3 and older are assumed to be mature). Natural mortality varies with age and year as shown in Figure 13.2.7 and Table 13.2.11. The basis for these estimates is described in the Stock Annex.

13.2.5 Catch, effort and research vessel data

The survey data available are summarised in the following table: data used in the final assessment are highlighted in bold.

Area	Country	Quarter	Code	Year range	Age range
Subarea IV	Scotland	Q3	ScoGFS Aberdeen Q3	1982-1997	0-8
Subarea IV	Scotland	Q3	ScoGFS Q3 GOV	1998-present	0-8
Subarea IV	England	Q3	EngGFS Q3 GRT	1977-1991	0-9

Subarea IV	England	Q3	EngGFS Q3 GOV	1992-present	0-9
Subarea IV and Division IIIa	International	Q1	IBTS Q1	1983-present	1-5
Subarea IV and Division IIIa	International	Q3	IBTS Q3	1991-present	0-5
Subarea VIa	Scotland	Q1	ScoGFS-WIBTS Q1	1985-2010	1-8
Subarea VIa	Scotland	Q1	New ScoGFS-WIBTS Q1	2011-present	1-8
Subarea VIa	Scotland	Q4	ScoGFS-WIBTS Q4	1996-2009	0-7
Subarea VIa	Scotland	Q4	New ScoGFS-WIBTS Q4	2011-present	0-7
Subarea VIa	Ireland	Q4	IGFS-WIBTS-Q4	1993-2002	0-8
Subarea VIa	Ireland	Q4	New IGFS-WIBTS-Q4	2003-present	0-8

The 2014 benchmark meeting (ICES-WKHAD 2014) concluded that only the North Sea IBTS Q1 and Q3 survey indices should be used to tune the Northern Shelf assessment. The West of Scotland surveys conducted by Scotland and Ireland covered too small a proportion of the overall stock area to be considered reliable indicators of overall stock dynamics, and the separate English and Scottish North Sea indices were only used previously because of the historical timing of the working group (WGNSSK met in October when IBTS Q3 was not yet available). ICES-WKHAD (2014) recommended that the IBTS working group consider whether the North Sea IBTS Q1 and West of Scotland ScoGFS Q1 indices could be combined, but this is for future consideration.

WGNSSK notes that less survey hauls than usual were conducted during the 2014 IBTS Q1 survey, due to bad weather. An increase in variability and uncertainty would thus be expected for the 2014 Q1 survey indices, and possible consequences of this are discussed further in Section 13.3.

Data used for the calibration of the assessment are presented in Table 13.2.12. Survey-based abundance distributions by age and year are given in Figures 13.2.8 (which plots the Scottish component of the North Sea IBTS Q1 survey along with the ScoGFS Q1 West of Scotland survey), 13.2.9 (North Sea IBTS Q1) and 13.2.10 (North Sea IBTS Q3). These demonstrate the concentration of North Sea haddock towards the north and west, and the relatively unbroken distribution across the north of Scotland. The moderately strong 2009 year-class is evident, as is the weakness of succeeding year-classes. Abundance trends in survey indices are shown in Figure 13.2.11. These indicate reasonably good consistency in stock signals from different surveys.

13.3 Data analyses

The assessment this year has been done using TSA (Fryer 2002) as the main assessment method. The results of SURBAR and SAM analyses are also shown, to corroborate (or otherwise) the update assessment.

13.3.1 Exploratory catch-at-age-based analyses

The catch-at-age data, in the form of log-catch curves linked by cohort (Figure 13.3.1), indicates partial recruitment to the fishery for most cohorts up to age 2. Gradients be-

tween consecutive values within a cohort have reduced considerably for recent cohorts, reflecting a reduction in fishing mortality. Recent catch curves have also lost much of the regularity of more historical catch curves, which may reflect the lower sample size available from reduced landings. Figure 13.3.2 plots the negative gradient of straight lines fitted to each cohort over the age range 2–4, which can be viewed as a rough proxy for average total mortality for ages 2–4 in the cohort. These negative gradients are also lower in recent cohorts, and the negative gradient measure for the 2009 cohort is the lowest in the time-series.

Cohort correlations in the catch-at-age matrix (plotted as log-numbers) are shown in Figure 13.3.3. These correlations show good consistency within cohorts up to the plus-group, verifying the ability of the catch-at-age data to track relative cohort strengths (although data for ages 0 and 1 are slightly more variable).

An exploratory SAM assessment was conducted, using the run settings stipulated in ICES-WKHAD (2014). The stock summary and residual plots from this run are given in Figure 13.3.4. The SAM assessment follows very similar trends to the final TSA assessment (see also Figure 13.3.10), although the variance on SAM estimates of SSB does tend to be higher than for TSA estimates (see Figure 13.3.11) and it is not yet clear why this should be.

13.3.2 Exploratory survey-based analyses

A SURBAR run (ICES-WKADSAM 2010, Needle 2014) was carried out using the same combination of tuning indices as in the TSA and SAM assessments. The summary plot from this run is given is Figure 13.3.5, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The SURBAR residual plot in Figure 13.3.6 indicates a potential problem with the final year values (2014) from the IBTS Q1 survey, which are nearly all positive: this implies a possible year-effect in the survey (and may be due in part to the low number of hauls in the 2014 Q1 survey: see also Section 13.2.5). This can also be seen in the plot of survey catch curves given in Figure 13.3.7, which shows increasing abundance in 4 of the 5 extant cohorts in the survey from 2013 to 2014. The plots of mean-standardised log survey indices by age and cohort (Figure 13.3.8) and the pairwise within-survey correlations (Figure 13.3.9) show that both surveys track year-class strength well through the population overall. The results are discussed further in Section 13.3.3 below.

13.3.3 Conclusions drawn from exploratory analyses

Mean-standardising SSB and recruitment estimates (using a common year-range for the mean) and generating TSA and SAM estimates of Z by adding F and M enables the comparison between TSA, SAM and SURBAR shown in Figure 13.3.10. SSB and recruitment estimates are very similar from the three models, although it is noticeable that the SURBAR estimates for large year-classes in particular tend to be higher. The mean Z time-series is slightly less consistent for SURBAR when compared with TSA and SAM, but the overall trends are not significantly different. Finally, Figure 13.3.11 compares the estimated coefficients of variation (CV = standard error / mean) for TSA, SAM and SURBAR estimates of SSB and mean Z. As mentioned above, the TSA SSB CV estimates tend to be lower than those for either SAM or SURBAR, although it is not yet clear why this should be. The estimated CVs on mean Z are quite consistent save for some noisy estimates in the SURBAR analysis. Overall, the SAM and SURBAR assessments concur with and support the final TSA assessment.

13.3.4 Final assessment

Table 13.3.1 gives the final TSA assessment settings, while Table 13.3.2 gives the corresponding parameter estimates from the completed run. A full description of the TSA method and the purpose of each parameter are given in the Stock Annex, and the ICES-WKHAD (2014) report. Note that, for assessment purposes, total catch is divided into human consumption landings (referred to as "landings") and a composite of discards and industrial bycatch (referred to as "discards" or "discards+bycatch"), as the selectivity characteristics of these latter components are similar.

The key difference with the run presented at the WKHAD meeting is caused by the additional year of IBTS Q1 survey data. As described above (Section 13.3.2), there is an apparent year-effect in the Q1 2014 survey with the survey indices for 4 out of the 5 available cohorts increasing between 2013 and 2014, rather than decreasing as expected. The implementation of TSA used here does not permit trends in survey catchability (survey parameter $\beta = 0.001$), so the survey data are interpreted as indicating a transient (yearly) change in catchability across all ages: specifically, that all the Q1 indices are roughly twice what they should be. In particular, the value at age 1 (24.077) is considered as actually representing an index value of around 10 to 15, which would be one of the lowest age-1 indices on record. Subsequently, this is used as evidence that the strength of the 2013 cohort at age-0 must have been very low. The Q3 index for the 2013 cohort at age-0 is not particularly low, but it is not very high either, so taken together the conclusion is that the 2013 recruitment must have been very poor. As TSA models recruitment normally rather than lognormally, the result without downweighting the age-1 2014 IBTS Q1 index is a negative recruitment estimate. It is known that the Q1 North Sea survey in 2014 was severely hampered by weather, and on the assumption that the 2014 survey data are less reliable than usual, the WG therefore applied heavy downweighting ($\omega = 25$) to the Q1 index at age-1 in 2014. The result of this is that the estimate of the 2013 year-class at age 0 reverts to close to the long term running mean estimated by TSA (see Figures 13.3.13 and 13.3.14). A number of exploratory runs with different values of ω were carried out, and there was very little impact on any of the results (apart from the final-year recruitment estimate). The decision to downweight this observation needs to be reconsidered in future years, as more information on the 2013 year-class becomes available.

The stock summary is given in Figure 13.3.12, with the stock-recruit plot in Figure 13.3.13 and the recruitment time-series in Figure 13.3.14. The latter plot shows that the underlying mean level of recruitment has declined from the early seventies until today, although the rate of this decline has slowed. Figure 13.3.15 summarises the observed and fitted discard+bycatch proportions by age, from which the decline in discard+bycatch rates across all ages in recent years can be seen. It should also be noted that TSA estimates a lower discard+bycatch rate than was observed in the most recent two years, and this could be an artefact of the survey year-effect discussed above.

Standardised prediction errors are given in Figures 13.3.16 (landings), 13.3.17 (discard+bycatch), 13.3.18 (IBTS Q1 survey) and 13.3.19 (IBTS Q3 survey). These are the principal diagnostic tools for time-series Kalman filter models like TSA, and indicate the discrepancy between the model prediction and observation as the model steps through the data from the start to the end. They are a useful guide to suggest observations which might need to be downweighted, but as TSA also includes a backwards smoothing step they cannot be considered to be residuals in the usual sense.

The time-series of observed and fitted values for total catch (Figure 13.3.20), the IBTS Q1 survey (Figure 13.3.21) and the IBTS Q3 survey (Figure 13.3.22) are more interpretable in that context. The estimate of total catch at age-0 prior to 1991 is based on quite noisy discard+bycatch data where they are available, or on model inference where they are not (1973-1977), so for the earlier period model fits are not necessarily very close to observations. The other notable feature is that total catch tends to be underestimated for larger year-class, whereas survey indices tend to be overestimated for these year-classes: the TSA model fit is a compromise between the two.

Figures 13.3.23 to 13.3.25 summarise the results of TSA retrospective analyses for Northern Shelf haddock. In common with previous FLXSA, SAM and SURBAR retrospective analyses from previous WGs for North Sea haddock, there is almost no retrospective noise or bias: at no time do the retrospective runs fall outside the approximate pointwise 95% confidence intervals of the full time-series assessment. It may be hypothesized that the strong population signals from occasional large year-classes provide sufficient data contrast to obviate against retrospective noise.

Fishing mortality estimates for the final TSA assessment are presented in Table 13.3.3, the stock numbers in Table 13.3.4, and the assessment summary in Table 13.3.5. Note that the observed values for catch, landings and "discards" (= discards + bycatch) in Table 13.3.5 are not identical to those in Table 13.2.1. To ensure numerical stability, TSA scales all fishery input data by 1.0e-4 before model fitting. The outputs are then rescaled by 1.0e4 to return to the correct scale, but this introduces a small amount of rounding error in the output. The outcomes are not affected.

13.4 Historical Stock Trends

The historical stock and fishery trends are presented in Figure 13.3.12.

Landings yields have stabilised since 2000, partly due (in the most recent years) to the limitation of inter-annual TAC variation to ±15% in the EU-Norway management plan for the North Sea. Discards have fluctuated in the same period due to the appearance and subsequent growth of the 1999, 2005 and 2009 year-classes, while industrial bycatch (IBC) is now at a very low level for haddock (see also Figure 13.2.3).

Estimated fishing mortality for 2008 to 2013 appeared to have stabilised at or just above 0.2, and is well below the North Sea management plan target of 0.3 in 2013. Fluctuations around the target-F rate of the management plan are an expected consequence of the lag between data collection and management action, and should not be taken to indicate that the plan is not working. The 2006-2008 and 2010-2013 year-classes are estimated to have been weak, and the fishery has been sustained in recent years by the 2005 and 2009 year-classes. The final TSA assessment indicates the beneficial impact on SSB of the above-average 2009 year-class, but the lack of a strong subsequent year-class suggests that this rise may only be temporary (see Section 13.6)

13.5 Recruitment estimates

Following the Stock Annex, recruits in the intermediate year (IY = 2014) and in the quota year (IY + 1 = 2015) will be based on the TSA estimate of forecasted recruits at age 0 in the intermediate year, as this ensures consistency between assessment and forecast. There are no other indications of incoming year-class strength available to the WG, as the IBTS Q3 survey has not yet taken place at the time of the WG meeting (May).

The following table summarises the recruitment, age 1 and age 2 assumptions for the short term forecast.

Year class	Age in 2014	TSA estimate (millions)	TSA forecast (millions)
2012	2	133	
2013	1	478	
2014	0		2745
2015	Age 0 in 2015		2745
2016	Age 0 in 2016		2745

13.6 Short-term forecasts

Weights-at-age

Mean weights-at-age are forecast using the method proposed by Jaworski (2011) and discussed by ICES-WKHAD (2014). The method is also summarised in the Stock Annex, and involves fitting straight lines to cohort-based weight estimates and extrapolating forward in time.

The outcomes are summarized in Figures 13.6.1 (total catch), 13.6.2 (landings) and 13.6.3 (discards). There is insufficient data to allow for cohort-based modeling of weights-at-age in the industrial bycatch component, so simple three-year (2011-2013) means by age are used for all forecast years.

Fishing mortality

ICES-WKHAD (2014) concluded that fishing mortality estimates for the intermediate year should be taken to be the same as the final year, considering that F is smoothed within the TSA model. Where this results in landings that overshoot the TAC, a TAC constraint should be considered: however, this is not the case for the 2014 intermediate year.

Given the choice of fishing-mortality rates discussed above, partial fishing mortality values were obtained for each catch component (human consumption, discards and bycatch) by using the relative contribution (averaged over 2011-2013) of each component to the total catch.

Splitting catch forecasts between management units

The haddock assessment presented in this section is for the combined Northern Shelf stock, following the conclusion from ICES-WKHAD (2014) that this was biologically appropriate. However, catch advice is still required for the extant management units. ICES-WKHAD (2014) proposed a survey-based method for splitting forecast catch into sub-units on the basis of a time-smoothed survey-based estimate of the proportion of the fishable stock in each area in each year. This is summarised in the Stock Annex, but in brief:

1) Generate a recalculated survey index based on IBTS Q1 but only including sampling areas 8-9 (Skaggerak). This is the survey for Division IIIa.

2) Generate a second survey index, also based on IBTS Q1 but including only sampling areas 1-7. This is the survey for Subarea IV.

3) The survey for Division VIa is the Scottish West Coast Q1 groundfish index (ScoGFS-WIBTS Q1 (new)).

4) For each of the three last years, and for each of the three surveys, calculate a survey-based estimate of biomass at age by multiplying the survey index at age (mean numbers caught per hour per stat square across the survey area) by the appropriate weight at age, and then by the number of stat squares

covered by the survey . Sum across ages to estimate total exploitable biomass (ages 1-5 in the surveys are assumed to be fully exploitable). Calculate the mean over the three years.

5) Express each mean biomass as a proportion of the total across all three surveys. These mean proportions then give the ratio by which the Northern Shelf catch advice should be split be-tween the three areas.

A further complication for the 2014 meeting was that ICES were not able to generate area-specific IBTS indices in time for the analysis to be carried out. These were therefore produced using the approach outlined in Needle (WP). Using this method, the stock proportions in each of the management units were estimated to be:

SUBAREA IV (NORTH SEA)	78.68%
Division IIIaW (Skagerrak)	1.84%
Division VIa (West of Scotland)	19.47%

These proportions were applied to the landings forecast for the Northern Shelf to generate the area-specific landings forecasts given in Table 13.6.2.

Forecast results

The inputs to the short-term forecast (conducted using the MFDP program) are presented in Table 13.6.1. Results for the short-term forecasts are presented in Table 13.6.2.

Yield and biomass estimates for the beginning of 2014 are presented in both Table 13.3.5 (TSA outputs) and Table 13.6.2 (short-term forecast outputs), and are around 10%-15% lower in the TSA outputs than in the short-term forecast outputs. The reason for this is that, in generating estimates for 2014, TSA assumes a simple three-year average for weights-at-age in total catch, landings, discards, and stock. Conversely, the short-term forecast follows the Stock Annex and uses linear cohort-based models to forecast weights-at-age. For this particular year, the average ratio when comparing both estimates of mean weights-at-age for fish aged 3 and older (to which the cohort-based forecast model can be applied) is around 85%-90%. This is why the values in Table 13.3.5 are around 10%-15% lower than those in Table 13.6.2, and it is the latter that correctly follow the procedure laid out in the Stock Annex.

Assuming TSA-smoothed F in both 2014 and 2015, SSB is expected to decrease to 164 257 t in 2015, before falling again in 2016 to 138 916 t. In this case, human consumption yield in 2015 would be around 21 762 t (Subarea IV), 510 t (Division IIIa), and 5 386 t (Division VIa), with associated Northern Shelf discards of 3 553 t.

Several alternative options have been highlighted in Table 13.6.2. Among these are a forecast with total fishing mortality fixed to the level specified in the EU-Norway North Sea management plan (F = 0.3), a revised estimate of F_{msy} = 0.35 (see Section 13.7), and forecasts using a range of multipliers of F_{sq} as the basis. Under the management plan, the 2015 landings yield of 32 667 t (Subarea IV), 766 t (Division IIIa), and 8 085 t (Division VIa), and discards of 5 502 t lead to SSB in 2016 of 124 446 t. The trend in SSB for the near future is likely to be downwards, however, and even with continued low F, further strong year-classes will be needed to increase SSB again.

13.7 MSY estimation and medium-term forecasts

No specific medium-term forecasts have been carried out for this stock. However, management simulations over the medium-term period have been performed for North Sea

haddock (Needle 2008a, b) and West of Scotland haddock (Needle 2010), as discussed briefly in Section 13.1.4 above.

13.8 Biological reference points

Extensive work on estimation of F_{msy} was carried out during the 2014 meeting, using the EqSIM software (see ICES WGMG 2013; Annex 8). Figure 13.8.1 summarises the output from this analysis, which indicates that an appropriate value of F_{msy} for Northern Shelf haddock would be around 0.35. This is slightly higher than the previous proxy (0.3), although the stock and assessment changes recommended by ICES-WKHAD (2014) have been considerable and it would be unlikely for F_{msy} estimate to be exactly the same. The new F_{msy} estimate is in accordance with the precautionary criteria (that is, initial evaluations indicate that it is likely to lead to a >95% probability of remaining above B_{lim} when applying the ICES F_{msy} harvest control rule, although further work is required to confirm).

EqSIM was also used to fit a segmented regression model to the Northern Shelf haddock stock-recruit data (see Figure 13.8.2). This indicated a likely changepoint at around 63 000 t. Applying the previously-used methodology to generate a B_{pa} estimate results in $B_{pa} = 1.4 * B_{lim} = 88\ 000$ t. ICES-WKHAD (2014) had suggested B_{loss} as an estimate for B_{lim}, but WGNSSK considered that this resulted in a value that was too low.

13.9 Quality of the assessment

Survey data are consistent both within and between surveys, and the catch data are internally consistent. Trends in mortality from catch data and survey indices are similar. There is very little retrospective bias. However, the stock estimates from the current and previous assessments cannot be compared in this case, as the Northern Shelf haddock stock has not previously been assessed.

The assumed stock identity is the principal change in the current assessment following the benchmark (ICES-WKHAD 2014), although as the Division VIa subunit is a relatively small component of the overall stock, its addition does not in itself lead to substantial revisions of stock perceptions. However, when combined with changes to the surveys used, along with the natural mortality and maturity assumptions, the new assessment indicates greater variation in SSB and recruitment through time (although without an overall trend). Fishing morality estimates have remained relatively similar.

The survey-based method used in this section for splitting catch advice into management subunits is novel, and the implications of its use have not been thoroughly tested. It is also unclear how to present management plan advice when the extant management plans are for subareas of the full assessment area.

13.10 Status of the Stock

Fishing mortality is now estimated to have remained at a low level in 2013 and now around the historical minimum. This is below the mortality rate recommended in the North Sea management plan (0.3) and the most recent estimate of F_{msy} (0.35). Discards have decreased again significantly in 2013, and the discard rate is now the lowest observed. Spawning stock biomass is predicted to decrease in the near future, but will still remain above the proposed B_{pa} (88 kt). The 2010-2013 year-classes were estimated to be weak, following the relatively strong 2009 year-class.

13.11 Management Considerations

In 2006 the EU and Norway agreed a revised management plan for haddock in the North Sea and Skagerrak, which states that every effort will be made to maintain a minimum level of SSB greater than 100 000 t (B_{lim}). Furthermore, fishing will be restricted on the basis of a TAC consistent with a fishing mortality rate of no more than 0.30 for appropriate age groups, along with a limitation on interannual TAC variability of ±15%. Following a minor revision in 2008, interannual quota flexibility ("banking and borrowing") of up to ±10% is permitted (although this facility has not yet been used). The stipulations of the management plan have been adhered to by the EU and Norway since its implementation in January 2007. In Division VIa, a similar plan was formulated by member states and the EU and accepted as being precautionary by ICES following evaluation, but it has never been implemented. An estimate of F_{may} for Northern Shelf haddock has been produced by WGNSSK in 2014, so the MSY framework is also available. It is not yet clear which management approach will be used for the combined Northern Shelf stock. The survey-based proposal for splitting catch advice into management subunits has also not yet been agreed by fishery managers. ICES have also proposed estimates for B_{pa} and B_{lim}, and these have yet to be considered more widely in the management context.

Considering the Northern Shelf as a whole, fishing mortality declined significantly in the early 2000s and has fluctuated around a low level since. The current estimate is well below the proposed F_{msy}. Spawning stock biomass is estimated to have reached a historical peak in 2002 with the growth of the large 1999 year-class, but declined again rapidly and is now driven strongly by occasional large year-classes. The last of these occurred in 2005 and 2009: other recent cohorts have been extremely weak. SSB is likely to decline further in the future, even with low fishing mortality, until the next large year-class emerges.

Keeping fishing mortality close to the target level would be preferable to encourage the sustainable exploitation of the 2009 year-class. Estimated discard rates are now the lowest ever, which may be due partly to the lack of small fish in the population, and partly due to an increased awareness of discard problems following public campaigns and (particularly) the installation of CCTV monitoring cameras on a number of vessels. However, discard rates do remain high in certain small-mesh fisheries (such as the TR2 *Nephrops* fleets in Division VIa). Further improvements to gear selectivity measures, allowing for the release of small fish, would be highly beneficial not only for the haddock stock, but also for the survival of juveniles of other species that occur in mixed fisheries along with haddock. Similar considerations also apply to spatial management approaches (such as real-time closures), and other measures intended to reduce unwanted bycatch and discarding of various species (such as the Scottish Conservation Credits scheme; see Section 13.1.4).

Haddock is a specific target for some fleets, but is also caught as part of a mixed fishery catching cod, whiting and *Nephrops*. It is important to consider both the species-specific assessments of these species for effective management, as well as the latest developments in the mixed fisheries approach. This is not straightforward when stocks are managed via a series of single-species, single-area management plans that do not incorporate mixed-stocks considerations. However, a reduction in effort on one stock may lead to a reduction or an increase in effort on another and the implications of any change need to be considered carefully.

13.12 References

Fernandes, P. G., Coull, K., Davis, C., Clark, P., Catarino, R., Bailey, N., Fryer, R. and Pout, A. (2011). Observations of discards in the Scottish mixed demersal trawl fishery. *ICES Journal of Marine Science*, 68(8), 1734–1742. doi:10.1093/icesjms/fsr131.

ICES-ACOM (2010). Report of the ICES Advisory Committee, 2010. ICES Advice, 2010. Books 1-11.

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA), 20–22 August 2008, Copenhagen, Denmark. ICES CM 2008/ACOM:60. 30 pp.

ICES-WKADSAM (2010). Report of the Workshop on Reviews of Recent Advances in Stock Assessment Models World-wide: "Around the World in AD Models". ICES CM 2010/SSGSUE:10.

Jaworski, A. (2011). Evaluation of methods for predicting mean weight-at-age: an application in forecasting yield of four haddock (*Melanogrammus aeglefinus*) stocks in the Northeast Atlantic. *Fisheries Research*, doi:10.1016/j.fishres.2011.01.017.

Millar, C. P. and Fryer, R. J. (2005). Revised estimates of annual discards-at-age for cod, haddock, whiting and saithe in ICES Sub-Area IV and Division VIa. *Fisheries Research Services Internal Report* No. 15/05. Marine Laboratory, Aberdeen, Scotland. 22 pp.

Needle, C. L. (2008a). Evaluation of interannual quota flexibility for North Sea haddock: Final report. Working paper for the ICES Advisory Committee (ACOM), September 2008.

Needle, C. L. (2008b). Management strategy evaluation for North Sea haddock. *Fisheries Research*, 94(2): 141–150.

Needle, C. L. (2010). An evaluation of a proposed management plan for haddock in Division VIa (2nd edition). Working paper to ICES ACOM.

Needle, C. L. (2012). Fleet Dynamics in Fisheries Management Strategy Evaluations, PhD thesis, University of Strathclyde, Glasgow.

Needle, C. L. and Catarino, R. (2011). Evaluating the effect of real-time closures on cod targeting, ICES Journal of Marine Science 68(8): 1647–1655. doi:10.1093/icesjms/fsrXXX.

Needle, C. L. (in prep). Using self-testing to validate the SURBAR survey-based assessment model. Submitted to *ICES Journal of Marine Science.*

Table 13.2.1. Haddock in Subarea IV, Division IIIaW and Division VIa. Nominal landings (tonnes) during 2006–2013, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2013 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota. Note that the United Kingdom did not provide official landings for 2012.

Division IIIa								
Country	2006	2007	2008	2009	2010	2011	2012	2013
DE	186	206	87	105	65	102	120	90
DK	1001	1054	1052	1263	1139	1661	1916	1456
NL	0	0	0	0	1	0	0	5
NO	113	152	170	121	81	125	239	223
PT	30	37	0	0	0	0	0	0
SE	246	278	276	166	126	198	210	217
UK	0	0	0	0	0	0	0	3

Subarea IV								
Country	2006	2007	2008	2009	2010	2011	2012	2013
BE	106	178	112	108	78	106	78	78
DE	726	727	393	657	634	575	548	677
DK	759	645	501	552	725	697	947	1283
ES	0	0	0	0	0	0	0	0
FO	4	0	3	32	5	0	0	0
FR	444	498	448	135	276	320	175	177
GL	5	8	0	4	0	0	0	0
IE	0	0	0	0	0	0	0	0
IS	0	0	0	0	0	0	0	0
NL	33	55	29	24	41	71	191	172
NO	1798	1706	1482	1278	1126	1195	1069	1661
PL	8	8	16	0	0	0	0	0
PT	76	0	0	0	0	0	0	0
SE	100	130	83	141	90	128	103	113
UK	32390	26717	27365	28393	24983	23343	0	32993

Division VIa								
Country	2006	2007	2008	2009	2010	2011	2012	2013
DE	7	0	1	0	1	0	0	
ES	44	5	10	21	28	36	15	
FO	1	2	0	0	0	0	0	
FR	291	211	151	136	89	73	32	51
IE	526	759	879	297	396	290	845	746
NO	17	16	28	18	9	4	0	6
UK	4947	2780	1776	2380	2415	1364	0	3878

Northern Shelf								
	2006	2007	2008	2009	2010	2011	2012	2013
Official landings	43858	36172	34862	35831	32308	30288	6488	43830

WG landings	43334	34672	33058	35590	31940	36570	38162	43681
WG discards	23094	32651	14503	12326	13071	13067	5032	3038
WG IBC	535	48	199	52	431	24	1	54
WG total catch	66962	67371	47759	47968	45442	49661	43195	46772
TAC IV	51850	54640	46444	42110	35794	34057	39000	45041
TAC IIIa	3189	3360	2856	2590	2201	2100	2095	2770
TAC VIa	7810	7200	6120	3520	2670	2005	6015	4211
Total TAC	62849	65200	55420	48220	40665	38162	47110	52022
WG quota uptake	69%	53%	60%	74%	79%	96%	81%	84%

Table 13.2.2. Haddock in Subarea IV, Division IIIaW and Division VIa. Working Group estimates of catch components by weight (000 tonnes). *Note that Subarea IV and Division IIIaW data are collated together from 2013 onwards, and are listed here only in the Subarea IV section.

	Subarea IV				Division IIIa			Division VIa			Combined			
Year	Landings	Discards	IBC	Total	Landings	Discards	Total	Landings	Discards	Total	Landings	Discards	IBC	Total
1965	161.7	62.3	74.6	298.6	0.7		0.7	32.5	3.4	35.9	194.9	65.7	74.6	335.2
1966	225.6	73.5	46.7	345.8	0.6		0.6	29.9	0.7	30.6	256.1	74.2	46.7	377.0
1967	147.4	78.2	20.7	246.3	0.4		0.4	20.3	7.4	27.7	168.1	85.6	20.7	274.4
1968	105.4	161.8	34.2	301.4	0.4		0.4	20.5	25.3	45.8	126.3	187.1	34.2	347.6
1969	331.1	260.1	338.4	929.5	0.5		0.5	26.3	25.2	51.5	357.9	285.3	338.4	981.6
1970	524.1	101.3	179.7	805.1	0.7		0.7	34.1	6.2	40.3	558.9	107.5	179.7	846.1
1971	235.5	177.8	31.5	444.8	2		2	46.3	12.2	58.5	283.8	190.0	31.5	505.3
1972	193	128	29.6	350.5	2.6		2.6	41.1	16.4	57.5	236.7	144.4	29.6	410.7
1973	178.7	114.7	11.3	304.7	2.9		2.9	28.8	11.4	40.2	210.4	126.1	11.3	347.8
1974	149.6	166.4	47.5	363.5	3.5		3.5	18.0	15.4	33.3	171.1	181.8	47.5	400.3
1975	146.6	260.4	41.5	448.4	4.8		4.8	13.7	33.0	46.6	165.1	293.4	41.5	499.9
1976	165.7	154.5	48.2	368.3	7		7	18.8	15.3	34.1	191.5	169.8	48.2	409.5
1977	137.3	44.4	35	216.7	7.8		7.8	19.3	4.4	23.7	164.4	48.8	35	248.2
1978	85.8	76.8	10.9	173.5	5.9		5.9	17.2	1.1	18.3	108.9	77.9	10.9	197.7
1979	83.1	41.7	16.2	141	4		4	14.8	6.5	21.3	101.9	48.2	16.2	166.3
1980	98.6	94.6	22.5	215.7	6.4		6.4	12.8	4.8	17.5	117.8	99.4	22.5	239.6
1981	129.6	60.1	17	206.7	6.6		6.6	18.2	7.1	25.3	154.4	67.2	17	238.6
1982	165.8	40.6	19.4	225.8	7.5		7.5	29.6	7.7	37.3	202.9	48.3	19.4	270.6
1983	159.3	66	12.9	238.2	6		6	29.4	3.4	32.8	194.7	69.4	12.9	277.0
1984	128.2	75.3	10.1	213.6	5.4		5.4	30.0	8.1	38.1	163.6	83.4	10.1	257.1

1985	158.6	85.2	6	249.8	5.6		5.6	24.4	10.7	35.1	188.6	95.9	6	290.5
1986	165.6	52.2	2.6	220.4	2.7		2.7	19.6	5.2	24.7	187.9	57.4	2.6	247.8
1987	108	59.1	4.4	171.6	2.3		2.3	27.0	11.1	38.1	137.3	70.2	4.4	211.9
1988	105.1	62.1	4	171.2	1.9		1.9	21.1	5.0	26.1	128.1	67.1	4	199.2
1989	76.2	25.7	2.4	104.2	2.3		2.3	16.7	2.5	19.2	95.2	28.2	2.4	125.8
1990	51.5	32.6	2.6	86.6	2.3		2.3	10.1	0.8	11.0	63.9	33.4	2.6	100.0
1991	44.7	40.2	5.4	90.2	3.1		3.1	10.6	4.8	15.3	58.4	45.0	5.4	108.7
1992	70.2	47.9	10.9	129.1	2.6		2.6	11.3	3.5	14.9	84.1	51.4	10.9	146.5
1993	79.6	79.6	10.8	169.9	2.6		2.6	19.1	7.0	26.1	101.3	86.6	10.8	198.7
1994	80.9	65.4	3.6	149.8	1.2		1.2	14.2	5.0	19.2	96.3	70.4	3.6	170.3
1995	75.3	57.4	7.7	140.4	2.2		2.2	12.4	7.7	20.0	89.9	65.1	7.7	162.6
1996	76	72.5	5	153.5	3.1		3.1	13.5	7.8	21.3	92.6	80.3	5	177.9
1997	79.1	52.1	6.7	137.9	3.4		3.4	12.9	7.5	20.4	95.4	59.6	6.7	161.7
1998	77.3	45.2	5.1	127.6	3.8		3.8	14.4	7.0	21.4	95.5	52.2	5.1	152.8
1999	64.2	42.6	3.8	110.7	1.4		1.4	10.4	3.9	14.3	76.0	46.5	3.8	126.3
2000	46.1	48.8	8.1	103	1.5		1.5	7.0	6.3	13.2	54.6	55.1	8.1	117.7
2001	39	118.3	7.9	165.2	1.9		1.9	6.7	8.5	15.2	47.6	126.8	7.9	182.3
2002	54.2	45.9	3.7	103.8	4.1		4.1	7.1	9.4	16.5	65.4	55.3	3.7	124.4
2003	40.1	23.5	1.1	64.8	1.8	0.2	2	5.3	4.5	9.8	47.2	28.2	1.1	76.5
2004	47.3	15.4	0.6	63.2	1.4	0.1	1.6	3.2	4.5	7.7	51.9	20.0	0.6	72.5
2005	47.6	8.4	0.2	56.2	0.8	0.2	1	3.1	3.8	6.9	51.5	12.4	0.2	64.1
2006	36.1	16.9	0.5	53.6	1.5	1	2.5	5.7	5.2	10.9	43.3	23.1	0.5	66.9
2007	29.4	27.8	0	57.3	1.5	0.8	2.3	3.7	4.0	7.8	34.6	32.6	0	67.3
2008	28.9	12.5	0.2	41.6	1.4	0.6	2	2.8	1.3	4.1	33.1	14.4	0.2	47.7
2009	31.3	10	0.1	41.3	1.5	0.6	2.1	2.8	1.8	4.6	35.6	12.4	0.1	48.1

2010	27.8	9.5	0.4	37.7	1.3	0.6	1.9	2.9	2.9	5.8	32.0	13.0	0.4	45.4
2011	26.3	10.2	0	36.5	9.9	1.7	11.6	1.7	1.5	3.3	37.9	13.4	0	51.4
2012	30.3	3.7	1.2	35.0	2.6	0.7	3.4	5.1	0.5	5.6	38.0	4.9	1.2	44.1
2013*	38.9	2.0	0.1	41.0				4.7	1.1	5.8	43.7	3.0	0.1	46.8

Table 13.2.3. Haddock in Subarea IV, Division IIIaW and Division VIa. Numbers at age data (thousands) for total catch. Ages 0-7 and 8+ and years 1972-2013 are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	8+
1965	650218	368560	16491	721514	36301	4954	2245	626	118	97	47	0	0	0	0	0	262
1966	1672925	1007517	26186	7536	459941	11903	1109	633	222	90	23	2	0	0	0	0	337
1967	345371	856339	108401	5814	3850	202830	2843	223	231	61	34	0	0	0	0	0	326
1968	11133	1226448	477603	22671	2303	3210	60034	1052	84	22	5	0	0	0	0	0	111
1969	75301	20554	3736629	313593	9029	2678	2894	23704	392	32	7	0	0	0	0	0	431
1970	941790	272467	218881	2003201	60200	1350	1285	401	6539	81	13	19	0	0	0	0	6652
1971	337277	1881729	74866	50845	480381	10916	589	201	167	1767	176	3	5	0	0	0	2119
1972	255110	696714	671965	43309	23547	211817	4067	241	53	27	475	11	0	0	0	0	566
1973	79461	412305	587335	260080	6450	5689	72652	1406	140	34	234	49	5	0	0	0	462
1974	665110	1283252	187149	342628	60523	1956	1795	22380	345	57	63	4	7	4	0	0	480
1975	51796	2276937	673960	62175	112242	17691	1078	718	6168	339	70	11	0	8	0	0	6596
1976	171400	192030	1127520	225532	11538	32677	5864	228	84	1863	64	3	5	0	0	0	2019
1977	119506	263702	109480	426291	45756	4984	6757	1608	163	40	460	8	0	1	0	0	672
1978	281785	223294	130963	31141	144703	11791	1582	2322	740	122	33	275	16	2	0	0	1188
1979	844410	261156	220200	45487	7978	38097	3069	377	629	181	57	13	52	3	0	0	935
1980	374573	439674	374310	80225	11364	2040	11143	827	143	168	96	34	9	7	1	0	457
1981	645352	116229	430149	180553	17044	2225	497	3320	164	78	26	32	5	1	4	0	311
1982	275508	217834	89989	390347	49835	4275	820	551	1072	60	28	8	2	2	0	0	1172
1983	513034	148158	222772	83199	166812	20055	2365	338	255	385	93	21	4	4	0	0	763
1984	95862	483045	139887	143821	29321	56077	6238	967	127	84	185	19	5	1	1	0	423
1985	127003	161400	441785	80605	41508	7082	18393	1929	296	56	29	144	9	0	0	1	535

1986	45703	137091	144075	328016	29497	10595	1686	4421	581	156	56	47	37	16	4	1	898
1987	10249	253236	259369	56407	92705	6214	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	16679	33092	424014	96795	17161	27728	2030	874	368	1076	95	21	12	13	17	1	1603
1989	19587	51743	43162	216359	21015	4189	7671	763	285	170	469	69	8	3	2	1	1007
1990	19286	82571	78881	17811	60888	4373	1104	1839	254	100	54	13	12	1	4	2	439
1991	128703	188087	101425	24822	4706	17618	1388	684	1024	171	65	11	11	1	2	2	1287
1992	277933	166550	255051	43257	7162	1486	6376	611	337	401	149	22	6	2	0	0	918
1993	136841	302610	269220	123469	11822	1986	669	2050	215	210	188	84	4	4	0	0	706
1994	89104	91674	339428	106673	35056	3381	601	366	746	132	48	36	26	5	0	0	992
1995	200151	336460	119210	182969	33802	9237	898	161	155	151	21	8	6	2	1	0	345
1996	167032	46797	505401	73987	66245	11159	4058	1080	75	72	37	9	8	3	1	0	205
1997	36954	162449	107657	251339	18037	18288	2762	937	121	16	18	5	4	4	2	0	170
1998	21919	88387	224037	60861	128348	7110	4590	850	263	60	7	8	3	2	1	1	345
1999	90634	69455	119094	110046	28510	45221	2700	2047	438	53	8	3	3	2	0	0	507
2000	12630	397390	110381	61263	33137	7254	9935	765	367	53	13	2	1	1	0	0	438
2001	3518	95086	633162	34548	12078	5573	2094	1611	257	89	28	3	4	0	0	0	382
2002	50927	36063	99685	372036	7812	2801	1615	729	603	283	25	8	5	0	0	0	923
2003	7082	13136	15234	48729	127241	2166	786	339	144	100	48	5	1	0	0	0	299
2004	3758	25698	24627	8958	38784	97827	1010	248	82	42	37	12	1	0	0	0	174
2005	8779	17695	24596	15085	5446	27745	61457	371	132	38	11	8	4	1	0	0	193
2006	3229	122537	30995	20657	11284	6078	16415	32978	156	56	20	7	4	1	0	0	243
2007	2046	20565	171600	16796	8187	4782	2237	6876	7254	75	8	14	3	1	0	0	7355
2008	3780	15005	31864	75341	4757	2050	1516	566	1432	2570	5	8	1	1	0	0	4017
2009	10483	11042	15303	20764	78513	1860	845	567	239	276	569	6	2	0	0	0	1092
2010	2930	108139	17377	17834	11301	38134	853	416	160	83	85	148	9	0	0	3	488

2011	3003	6082	66355	17091	14138	11495	23124	677	282	95	17	5	60	0	0	0	459
2012	1319	3389	5260	66109	5388	3670	2416	7900	157	178	68	44	57	24	4	0	532
2013	1199	11340	4275	4815	68536	2266	1533	878	3878	37	7	8	2	2	2	0	3935

Table 13.2.4. Haddock in Subarea IV, Division IIIaW and Division VIa. Numbers at age data (thousands) for landings. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	0	13354	233966	35440	22165	210167	4054	241	53	27	475	11	0	0	0	0	566
1973	0	7277	211018	209961	6085	5459	72528	1406	140	34	234	49	5	0	0	0	462
1974	0	25699	55734	236624	53054	1868	1679	22156	345	57	63	4	7	4	0	0	480
1975	0	28773	211495	41030	93617	17406	1073	718	6163	339	70	11	0	8	0	0	6591
1976	0	3045	246027	155162	11292	29594	5846	228	84	1863	64	3	5	0	0	0	2019
1977	0	8934	33058	278741	42737	4737	6516	1608	163	40	460	8	0	1	0	0	672
1978	0	13913	55636	26119	123655	11479	1496	2317	740	122	33	275	16	2	0	0	1187
1979	0	16077	120456	38247	7752	37353	3052	377	629	181	57	13	52	3	0	0	935
1980	0	11487	154765	67241	9978	1985	11057	820	143	166	96	34	9	7	1	0	456
1981	0	1959	174018	128102	16447	2219	494	3320	164	78	26	32	5	1	4	0	311
1982	0	7623	40161	282492	45732	3811	820	551	1072	60	28	8	2	2	0	0	1172
1983	0	7669	114118	57151	152477	19147	2201	338	255	385	93	21	4	4	0	0	763
1984	0	22842	80349	115405	27331	52226	6238	967	127	84	185	19	5	1	1	0	423
1985	0	3059	267559	75242	40846	6858	18360	1929	296	56	29	144	9	0	0	1	535
1986	0	12735	67173	287995	29371	10587	1685	4421	581	156	56	47	37	16	4	1	898
1987	0	11150	120584	46970	89772	6212	3993	1187	2596	462	56	65	35	32	17	8	3271
1988	0	2371	167090	83798	16114	27515	2030	874	344	1076	95	21	12	13	17	1	1579
1989	0	5446	17801	146467	19506	4130	7549	752	283	170	467	69	8	3	2	1	1003
1990	0	6279	46366	15680	54465	4117	1054	1761	250	100	54	13	12	1	4	2	435
1991	0	21627	57480	23058	4646	17468	1388	684	1024	171	65	11	11	1	2	2	1287
1992	0	3544	128147	38838	7038	1483	6354	611	337	401	149	22	6	2	0	0	918
1993	0	3232	92828	102781	11570	1976	669	2028	215	210	188	84	4	4	0	0	706

1994	0	1484	75783	85391	32827	3345	600	366	746	132	48	36	26	5	0	0	992
1995	0	2410	32846	114437	31198	9038	898	161	155	151	21	8	6	2	1	0	345
1996	0	1179	84349	41653	55794	11123	4058	1080	75	72	37	9	8	3	1	0	205
1997	0	2292	26774	140099	16153	17846	2762	937	121	16	18	5	4	4	2	0	170
1998	0	2167	45449	42411	106125	6959	4579	850	263	60	7	8	3	2	1	1	345
1999	0	1340	31357	60351	26260	42494	2648	2047	438	53	8	3	3	2	0	0	507
2000	0	5508	32823	34517	27247	6927	9734	765	367	53	13	2	1	1	0	0	438
2001	0	855	75731	17938	10929	5321	2094	1609	256	89	28	3	4	0	0	0	381
2002	0	816	14893	124903	6330	2710	1615	618	603	283	25	8	5	0	0	0	923
2003	0	53	2119	16076	81868	2141	777	339	144	100	48	5	1	0	0	0	299
2004	0	495	3142	4906	23978	77262	996	239	82	42	37	12	1	0	0	0	174
2005	0	788	5777	8878	4178	22915	56760	370	131	38	11	8	4	1	0	0	192
2006	0	2129	10416	11780	8602	5209	14745	30350	149	54	20	7	3	1	0	0	234
2007	0	1146	28873	11204	7361	4684	2199	6773	7183	75	8	14	3	1	0	0	7284
2008	0	299	6472	50965	4461	1986	1378	563	1402	2566	5	8	1	1	0	0	3983
2009	0	486	4605	9666	61972	1775	793	521	239	276	566	6	2	0	0	0	1088
2010	0	1089	5150	12597	10176	35718	828	416	146	83	85	147	9	0	0	3	473
2011	0	224	16505	15260	13321	11383	22889	677	282	95	16	5	60	0	0	0	458
2012	0	261	3286	52091	4884	3660	2408	7885	157	178	68	44	57	24	4	0	532
2013	39	1403	2557	4360	65938	2236	1519	865	3846	36	6	8	2	2	2	0	3902

Table 13.2.5. Haddock in Subarea IV, Division IIIaW and Division VIa. Numbers-at-age data (thousands) for discards. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	18446	444794	380988	6846	1236	1212	13	0	0	0	0	0	0	0	0	0	0
1973	38129	287558	363916	50108	354	33	123	0	0	0	0	0	0	0	0	0	0
1974	88456	982287	99148	59143	2869	6	4	0	0	0	0	0	0	0	0	0	0
1975	7479	1653310	377845	16385	13423	143	0	0	0	0	0	0	0	0	0	0	0
1976	6418	122012	698428	41183	200	137	0	0	0	0	0	0	0	0	0	0	0
1977	16364	107748	47070	79922	664	9	0	0	0	0	0	0	0	0	0	0	0
1978	1193	83683	63997	4214	19568	248	80	0	0	0	0	0	0	0	0	0	0
1979	4795	119245	82074	5734	142	365	0	0	0	0	0	0	0	0	0	0	0
1980	258	146751	197725	4726	96	0	0	0	0	0	0	0	0	0	0	0	0
1981	442	15023	225773	47838	157	1	0	0	0	0	0	0	0	0	0	0	0
1982	505	36063	35089	94315	2293	0	0	0	0	0	0	0	0	0	0	0	0
1983	24327	76672	94323	20914	12092	905	164	0	0	0	0	0	0	0	0	0	0
1984	3275	361946	48893	23714	1623	3317	0	0	0	0	0	0	0	0	0	0	0
1985	4924	146668	156400	3624	115	1	16	0	0	0	0	0	0	0	0	0	0
1986	13007	84333	75071	39219	23	1	0	0	0	0	0	0	0	0	0	0	0
1987	1996	159860	134988	9142	2795	2	0	0	0	0	0	0	0	0	0	0	0
1988	7399	27412	244105	10535	427	10	0	0	24	0	0	0	0	0	0	0	24
1989	10673	43756	23611	67102	1048	23	35	0	2	0	2	0	0	0	0	0	4
1990	16290	69073	30530	1772	4932	28	25	0	0	0	0	0	0	0	0	0	0
1991	11794	143967	40697	1163	17	107	0	0	0	0	0	0	0	0	0	0	0
1992	36231	82605	115933	4063	97	0	6	0	0	0	0	0	0	0	0	0	0
1993	12346	191714	163172	17474	170	1	0	3	0	0	0	0	0	0	0	0	0

1994	19197	75840	254112	20271	2069	30	0	0	0	0	0	0	0	0	0	0	0
1995	2118	231490	84163	67644	2539	199	0	0	0	0	0	0	0	0	0	0	0
1996	22563	35010	413599	28996	10344	36	0	0	0	0	0	0	0	0	0	0	0
1997	15260	114893	69948	106789	1700	425	0	0	0	0	0	0	0	0	0	0	0
1998	2936	77065	162251	15801	20732	88	11	0	0	0	0	0	0	0	0	0	0
1999	20814	57336	83205	46764	1905	2561	49	0	0	0	0	0	0	0	0	0	0
2000	8472	320463	55818	24661	5703	321	201	0	0	0	0	0	0	0	0	0	0
2001	1531	71284	521655	6483	1115	244	0	2	1	0	0	0	0	0	0	0	1
2002	1120	21358	80304	243495	978	64	0	111	0	0	0	0	0	0	0	0	0
2003	2937	7101	11014	31369	43849	13	9	0	0	0	0	0	0	0	0	0	0
2004	3758	24613	21221	3967	14548	19811	5	4	0	0	0	0	0	0	0	0	0
2005	8779	16730	18722	6181	1258	4826	4496	1	1	0	0	0	0	0	0	0	1
2006	3229	118636	19862	8636	2634	823	1596	2520	6	1	1	0	0	0	0	0	8
2007	2045	19393	142509	5585	826	97	38	103	71	0	0	0	0	0	0	0	71
2008	3768	14623	25111	24195	243	46	134	2	30	4	0	0	0	0	0	0	34
2009	10468	10521	10601	11050	16522	79	50	46	0	1	4	0	0	0	0	0	5
2010	2930	102881	11872	5201	1125	2415	25	0	14	0	0	1	0	0	0	0	15
2011	3002	5858	49830	1817	806	105	224	0	0	0	1	1	0	0	0	0	2
2012	1319	3128	1973	14017	503	11	7	15	0	0	0	0	0	0	0	0	0
2013	1160	9930	1714	449	2518	26	12	11	27	0	1	0	0	0	0	0	28

Table 13.2.6. Haddock in Subarea IV, Division IIIaW and Division VIa. Numbers-at-age data (thousands) for IBC. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	236664	238566	57010	1023	146	439	0	0	0	0	0	0	0	0	0	0	0
1973	41332	117470	12402	11	11	196	0	0	0	0	0	0	0	0	0	0	0
1974	576654	275266	32266	46862	4600	82	112	224	0	0	0	0	0	0	0	0	0
1975	44317	594854	84620	4761	5203	141	5	0	5	0	0	0	0	0	0	0	5
1976	164982	66973	183064	29188	46	2946	17	0	0	0	0	0	0	0	0	0	0
1977	103142	147019	29352	67628	2355	238	240	0	0	0	0	0	0	0	0	0	0
1978	280592	125698	11330	809	1480	64	6	5	0	0	0	0	0	0	0	0	0
1979	839615	125834	17671	1507	84	379	16	0	0	0	0	0	0	0	0	0	0
1980	374315	281436	21820	8258	1291	54	86	7	0	1	0	0	0	0	0	0	1
1981	644910	99247	30358	4613	440	6	2	0	0	0	0	0	0	0	0	0	0
1982	275002	174147	14740	13540	1810	464	0	0	0	0	0	0	0	0	0	0	0
1983	488707	63818	14331	5134	2242	3	0	0	0	0	0	0	0	0	0	0	0
1984	92587	98257	10644	4702	368	535	0	0	0	0	0	0	0	0	0	0	0
1985	122078	11672	17826	1739	547	223	17	0	0	0	0	0	0	0	0	0	0
1986	32696	40023	1831	802	103	7	0	0	0	0	0	0	0	0	0	0	0
1987	8253	82226	3797	295	138	0	0	0	0	0	0	0	0	0	0	0	0
1988	9280	3309	12819	2462	620	202	0	0	0	0	0	0	0	0	0	0	0
1989	8914	2541	1751	2789	460	37	86	10	0	0	0	0	0	0	0	0	0
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	0	0	0	0	0	0	0	0	0	0	0
1992	241702	80402	10971	356	27	3	17	0	0	0	0	0	0	0	0	0	0
1993	124495	107664	13220	3214	82	9	0	18	0	0	0	0	0	0	0	0	0

1994	69907	14349	9534	1011	160	7	1	0	0	0	0	0	0	0	0	0	0
1995	198032	102560	2201	888	65	0	0	0	0	0	0	0	0	0	0	0	0
1996	144469	10608	7453	3338	107	0	0	0	0	0	0	0	0	0	0	0	0
1997	21694	45264	10935	4451	184	17	0	0	0	0	0	0	0	0	0	0	0
1998	18983	9155	16337	2649	1490	63	0	0	0	0	0	0	0	0	0	0	0
1999	69820	10780	4531	2932	344	166	3	0	0	0	0	0	0	0	0	0	0
2000	4158	71419	21740	2085	186	5	0	0	0	0	0	0	0	0	0	0	0
2001	1987	22946	35776	10127	35	8	0	0	0	0	0	0	0	0	0	0	0
2002	49807	13889	4489	3638	504	27	0	0	0	0	0	0	0	0	0	0	0
2003	4145	5983	2101	1285	1524	12	0	0	0	0	0	0	0	0	0	0	0
2004	0	590	265	84	258	753	8	4	0	0	0	0	0	0	0	0	0
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	0	1
2007	1	27	218	6	1	0	0	0	0	0	0	0	0	0	0	0	0
2008	12	82	280	180	52	18	4	1	0	0	0	0	0	0	0	0	0
2009	15	36	97	48	19	6	2	0	0	0	0	0	0	0	0	0	0
2010	0	4169	355	36	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	19	14	11	7	12	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	6	4	6	80	3	2	1	4	0	0	0	0	0	0	0	4

Table 13.2.7. Haddock in Subarea IV, Division IIIaW and Division VIa. Mean weight at age data (kg) for total catch. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	0.025	0.117	0.242	0.383	0.503	0.585	0.987	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000	1.692
1973	0.043	0.118	0.239	0.369	0.577	0.612	0.648	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000	1.660
1974	0.025	0.130	0.226	0.339	0.537	0.868	0.828	0.863	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000	1.502
1975	0.023	0.105	0.240	0.353	0.442	0.678	1.190	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000	1.076
1976	0.014	0.129	0.224	0.394	0.505	0.578	0.916	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000	1.300
1977	0.020	0.111	0.238	0.339	0.585	0.611	0.787	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000	1.584
1978	0.011	0.104	0.254	0.396	0.424	0.706	0.784	0.921	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000	1.446
1979	0.009	0.093	0.287	0.416	0.611	0.669	0.931	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000	1.418
1980	0.012	0.081	0.276	0.464	0.693	0.985	0.909	1.264	1.511	1.501	1.676	3.104	1.050	2.134	2.921	0.000	1.664
1981	0.009	0.060	0.264	0.445	0.726	1.055	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000	1.612
1982	0.010	0.075	0.286	0.423	0.760	1.109	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000	1.522
1983	0.011	0.132	0.304	0.431	0.611	0.905	1.211	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000	1.555
1984	0.010	0.142	0.303	0.461	0.646	0.736	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000	1.848
1985	0.010	0.148	0.297	0.466	0.649	0.835	0.934	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139	1.846
1986	0.023	0.124	0.261	0.406	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894	1.653
1987	0.010	0.125	0.264	0.405	0.594	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638	1.339
1988	0.042	0.163	0.232	0.411	0.581	0.731	1.203	1.363	1.281	0.974	1.633	2.163	2.547	3.139	3.435	2.863	1.156
1989	0.036	0.201	0.282	0.367	0.590	0.770	0.935	1.259	1.586	1.507	1.034	1.534	2.431	2.559	2.307	0.980	1.322
1990	0.040	0.187	0.313	0.421	0.506	0.795	0.995	1.179	1.494	1.898	2.519	2.259	2.188	0.562	1.852	4.731	1.768
1991	0.030	0.175	0.308	0.454	0.575	0.644	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888	1.418
1992	0.019	0.102	0.306	0.466	0.717	0.923	0.903	1.382	1.514	1.813	2.014	2.064	2.441	1.781	0.000	0.000	1.746
1993	0.010	0.110	0.282	0.454	0.661	0.876	1.053	1.062	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000	1.646

1994	0.018	0.121	0.247	0.435	0.599	0.846	1.240	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000	1.439
1995	0.012	0.107	0.290	0.369	0.581	0.773	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000	1.368
1996	0.022	0.125	0.241	0.382	0.484	0.746	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000	1.617
1997	0.029	0.138	0.280	0.360	0.585	0.635	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782	1.548
1998	0.027	0.153	0.255	0.396	0.444	0.665	0.777	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509	1.210
1999	0.025	0.166	0.250	0.356	0.477	0.510	0.736	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220	0.914
2000	0.052	0.121	0.256	0.355	0.480	0.605	0.655	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843	1.084
2001	0.029	0.110	0.219	0.321	0.466	0.658	0.735	0.945	1.690	1.148	1.725	2.923	1.286	2.534	1.239	3.425	1.573
2002	0.017	0.108	0.254	0.311	0.527	0.703	0.829	0.818	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000	1.508
2003	0.024	0.082	0.221	0.327	0.400	0.681	0.758	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092	1.535
2004	0.039	0.139	0.239	0.378	0.395	0.440	0.687	0.926	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000	1.506
2005	0.054	0.161	0.271	0.364	0.494	0.479	0.522	0.925	1.054	1.373	1.847	2.750	2.545	2.309	3.431	0.000	1.263
2006	0.042	0.126	0.283	0.352	0.442	0.507	0.538	0.550	1.048	1.395	2.031	2.525	1.835	3.531	5.271	2.581	1.276
2007	0.042	0.159	0.227	0.408	0.479	0.538	0.657	0.700	0.744	0.902	2.272	0.971	1.712	2.348	4.244	0.000	0.749
2008	0.030	0.170	0.256	0.365	0.593	0.662	0.714	0.928	0.924	0.879	1.689	1.970	0.988	0.224	3.792	3.024	0.898
2009	0.048	0.174	0.305	0.323	0.388	0.677	0.799	0.839	1.308	1.319	1.025	1.045	1.150	3.091	2.115	0.000	1.162
2010	0.016	0.078	0.288	0.412	0.455	0.466	0.710	0.899	1.269	1.431	1.366	1.420	2.766	2.214	2.677	2.588	1.396
2011	0.017	0.140	0.260	0.399	0.434	0.467	0.533	0.661	0.864	0.559	1.484	1.788	1.593	0.000	0.000	0.000	0.930
2012	0.035	0.160	0.439	0.408	0.576	0.706	0.711	0.654	1.279	0.895	1.564	2.223	2.121	2.134	2.368	0.000	1.402
2013	0.034	0.174	0.431	0.600	0.487	0.727	0.853	0.797	0.757	1.084	1.844	2.194	2.599	1.810	2.512	0.000	0.767

Table 13.2.8. Haddock in Subarea IV, Division IIIaW and Division VIa. Mean weight at age data (kg) for landings. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	0.000	0.243	0.325	0.415	0.518	0.587	0.989	1.380	1.967	1.979	1.618	2.861	0.000	0.000	0.000	0.000	1.692
1973	0.000	0.228	0.310	0.400	0.596	0.621	0.649	1.044	1.378	2.658	1.603	1.988	2.123	0.000	0.000	0.000	1.660
1974	0.000	0.268	0.314	0.381	0.567	0.882	0.866	0.867	1.377	1.704	1.854	4.057	1.927	0.890	0.000	0.000	1.502
1975	0.000	0.254	0.336	0.400	0.476	0.683	1.193	1.077	1.031	1.564	2.188	2.764	0.000	3.318	0.000	0.000	1.076
1976	0.000	0.243	0.331	0.452	0.509	0.601	0.917	1.829	1.656	1.247	2.296	2.425	1.679	0.000	0.000	0.000	1.300
1977	0.000	0.272	0.344	0.381	0.595	0.625	0.800	1.160	1.715	1.971	1.490	2.067	0.000	3.898	0.000	0.000	1.584
1978	0.000	0.257	0.333	0.427	0.456	0.717	0.812	0.922	1.350	1.995	1.990	1.329	2.182	4.475	0.000	0.000	1.446
1979	0.000	0.262	0.348	0.447	0.620	0.675	0.932	1.241	1.320	1.453	2.505	1.575	1.233	1.580	0.000	0.000	1.418
1980	0.000	0.274	0.347	0.501	0.706	0.992	0.907	1.261	1.511	1.499	1.676	3.104	1.050	2.134	2.921	0.000	1.664
1981	0.000	0.334	0.364	0.503	0.734	1.056	1.222	1.195	1.545	1.672	1.531	1.515	2.982	4.273	1.896	0.000	1.612
1982	0.000	0.299	0.349	0.478	0.788	1.153	1.415	1.578	1.466	2.136	2.122	1.877	1.886	3.179	0.000	0.000	1.522
1983	0.000	0.320	0.375	0.464	0.624	0.914	1.242	1.191	1.630	1.460	1.449	1.972	2.853	4.689	0.000	0.000	1.555
1984	0.000	0.280	0.350	0.493	0.666	0.764	1.077	1.205	1.821	2.030	1.732	1.951	2.422	2.822	4.995	0.000	1.848
1985	0.000	0.279	0.348	0.478	0.651	0.844	0.935	1.344	1.638	2.097	2.109	2.061	2.555	2.471	2.721	4.139	1.846
1986	0.000	0.277	0.348	0.428	0.600	0.848	1.195	1.098	1.524	1.356	2.178	2.366	2.498	2.993	2.778	2.894	1.653
1987	0.000	0.265	0.335	0.440	0.603	0.974	1.215	1.322	1.260	1.358	1.870	2.132	2.609	2.450	2.768	2.638	1.339
1988	0.000	0.236	0.322	0.437	0.594	0.732	1.203	1.363	1.370	0.974	1.633	2.163	2.547	3.139	3.435	2.863	1.173
1989	0.000	0.319	0.356	0.413	0.602	0.769	0.934	1.256	1.579	1.507	1.025	1.534	2.431	2.559	2.307	0.980	1.316
1990	0.000	0.260	0.372	0.439	0.525	0.796	1.015	1.196	1.504	1.898	2.519	2.259	2.188	0.562	1.852	4.731	1.776
1991	0.000	0.269	0.363	0.462	0.576	0.645	0.959	1.136	1.313	1.701	2.163	2.012	1.622	1.070	1.208	2.888	1.418
1992	0.000	0.287	0.367	0.486	0.723	0.924	0.904	1.382	1.515	1.813	2.014	2.064	2.441	1.781	0.000	0.000	1.747
1993	0.000	0.293	0.372	0.484	0.666	0.878	1.053	1.067	1.545	1.460	1.830	1.894	2.155	2.460	0.000	0.000	1.646

1994	0.000	0.269	0.378	0.473	0.617	0.851	1.241	1.274	1.289	1.573	2.060	2.070	2.834	2.403	2.523	0.000	1.439
1995	0.000	0.316	0.400	0.424	0.600	0.782	1.058	1.418	1.261	1.320	1.889	2.491	1.713	1.699	2.243	0.000	1.368
1996	0.000	0.326	0.364	0.471	0.519	0.747	0.847	0.825	1.616	1.538	1.433	1.830	2.358	2.636	3.433	0.000	1.617
1997	0.000	0.344	0.410	0.418	0.615	0.641	0.923	0.997	1.293	2.196	1.961	2.058	2.757	2.270	2.867	2.782	1.548
1998	0.000	0.271	0.370	0.441	0.470	0.670	0.778	1.041	1.109	1.251	2.373	2.334	1.656	2.433	2.085	2.509	1.210
1999	0.000	0.297	0.349	0.422	0.490	0.523	0.746	0.798	0.826	1.305	1.533	2.478	2.086	2.698	2.904	2.220	0.914
2000	0.000	0.334	0.368	0.421	0.515	0.617	0.663	1.033	0.973	1.529	1.911	2.323	2.365	2.310	3.595	1.843	1.084
2001	0.000	0.379	0.352	0.448	0.483	0.675	0.735	0.946	1.695	1.148	1.725	2.923	1.286	2.534	1.239	3.425	1.576
2002	0.000	0.427	0.446	0.397	0.569	0.713	0.829	0.901	1.279	1.945	1.798	1.839	2.352	2.762	0.000	0.000	1.508
2003	0.000	0.283	0.377	0.464	0.441	0.684	0.759	1.110	1.281	1.612	2.022	2.219	2.506	2.606	1.981	3.092	1.535
2004	0.000	0.366	0.383	0.474	0.454	0.468	0.688	0.932	1.184	1.602	1.753	2.605	2.170	0.000	0.000	0.000	1.506
2005	0.000	0.399	0.399	0.428	0.548	0.516	0.536	0.926	1.056	1.373	1.847	2.750	2.545	2.309	3.431	0.000	1.265
2006	0.000	0.392	0.386	0.418	0.493	0.546	0.574	0.583	1.093	1.431	2.109	2.643	1.926	3.592	5.292	2.709	1.326
2007	0.000	0.379	0.385	0.466	0.497	0.542	0.662	0.705	0.748	0.902	2.272	0.971	1.712	2.348	4.244	0.000	0.752
2008	0.000	0.357	0.408	0.414	0.607	0.668	0.754	0.931	0.935	0.879	1.703	1.970	0.988	0.224	3.792	3.024	0.902
2009	0.000	0.443	0.434	0.410	0.416	0.691	0.830	0.882	1.309	1.321	1.029	1.045	1.150	3.091	2.115	0.000	1.165
2010	0.000	0.278	0.473	0.457	0.471	0.476	0.721	0.899	1.364	1.431	1.366	1.420	2.766	2.214	2.677	2.588	1.429
2011	0.016	0.266	0.358	0.411	0.442	0.468	0.535	0.661	0.864	0.559	1.456	1.698	1.593	0.000	0.000	0.000	0.925
2012	0.000	0.358	0.525	0.445	0.606	0.707	0.712	0.654	1.279	0.895	1.564	2.223	2.121	2.134	2.368	0.000	1.402
2013	0.036	0.359	0.556	0.624	0.492	0.729	0.850	0.800	0.756	1.084	1.803	2.194	2.599	1.810	2.512	0.000	0.766

Table 13.2.9. Haddock in Subarea IV, Division IIIaW and Division VIa. Mean weight at age data (kg) for discards. Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	0.045	0.140	0.207	0.239	0.261	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.051	0.135	0.201	0.237	0.263	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.046	0.146	0.201	0.234	0.259	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.041	0.126	0.201	0.257	0.275	0.348	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1976	0.053	0.172	0.198	0.239	0.291	0.337	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.062	0.191	0.198	0.220	0.306	0.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1978	0.042	0.175	0.199	0.222	0.225	0.265	0.284	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1979	0.037	0.128	0.221	0.245	0.259	0.314	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1980	0.051	0.147	0.232	0.276	0.325	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1981	0.074	0.160	0.199	0.296	0.621	0.727	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1982	0.055	0.194	0.247	0.265	0.289	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1983	0.066	0.184	0.237	0.343	0.458	0.711	0.792	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.047	0.160	0.245	0.315	0.309	0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.040	0.154	0.221	0.271	0.356	0.423	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.057	0.140	0.185	0.246	0.337	0.329	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.026	0.160	0.201	0.227	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.072	0.167	0.172	0.239	0.256	0.352	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.054	0.188	0.229	0.266	0.336	0.708	0.844	0.000	2.572	0.000	3.048	0.000	0.000	0.000	0.000	0.000	2.810
1990	0.047	0.189	0.229	0.248	0.264	0.290	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.059	0.179	0.238	0.341	0.464	0.480	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.136	0.246	0.282	0.345	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.028	0.139	0.237	0.287	0.355	0.369	0.000	0.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1994	0.042	0.130	0.212	0.273	0.310	0.304	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.044	0.132	0.250	0.276	0.356	0.384	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.047	0.133	0.218	0.279	0.297	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.060	0.159	0.250	0.286	0.322	0.374	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.075	0.159	0.232	0.293	0.317	0.391	0.428	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.047	0.182	0.217	0.273	0.308	0.304	0.227	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.049	0.129	0.245	0.278	0.316	0.355	0.292	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.049	0.115	0.206	0.300	0.301	0.300	0.000	0.411	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.416
2002	0.044	0.125	0.223	0.267	0.334	0.382	0.000	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.042	0.124	0.223	0.261	0.327	0.536	0.630	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.039	0.135	0.218	0.263	0.299	0.330	0.639	0.650	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.054	0.150	0.232	0.273	0.318	0.301	0.342	0.499	0.493	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.493
2006	0.042	0.121	0.231	0.265	0.279	0.274	0.217	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.042	0.146	0.195	0.291	0.314	0.358	0.375	0.356	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.368
2008	0.030	0.166	0.217	0.262	0.365	0.456	0.317	0.454	0.427	0.596	0.321	0.000	0.000	0.000	0.000	0.000	0.448
2009	0.048	0.162	0.250	0.248	0.282	0.394	0.315	0.357	0.366	0.409	0.452	0.000	0.000	0.000	0.000	0.000	0.442
2010	0.016	0.076	0.209	0.303	0.307	0.315	0.350	0.523	0.284	0.000	0.000	1.445	0.000	0.000	0.000	0.000	0.340
2011	0.017	0.135	0.227	0.297	0.310	0.352	0.351	0.000	0.000	0.000	2.027	2.215	0.000	0.000	0.000	0.000	2.128
2012	0.035	0.143	0.295	0.271	0.286	0.406	0.353	0.392	0.633	0.488	0.316	0.000	0.000	0.000	0.000	0.000	0.515
2013	0.034	0.148	0.244	0.365	0.351	0.521	1.269	0.558	0.840	1.184	2.105	1.923	2.925	1.810	2.512	0.000	0.883

Table 13.2.10. Haddock in Subarea IV, Division IIIaW and Division VIa. Mean weight at age data (kg) for industrial bycatch (IBC). Ages 0-7 and 8+ are used in the assessment.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	8+
1972	0.023	0.067	0.136	0.255	0.288	0.231	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1973	0.035	0.068	0.141	0.246	0.327	0.396	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1974	0.022	0.058	0.150	0.260	0.359	0.579	0.277	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1975	0.020	0.039	0.173	0.275	0.267	0.413	0.585	0.000	0.585	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.585
1976	0.012	0.046	0.181	0.304	0.473	0.360	0.725	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1977	0.013	0.042	0.184	0.307	0.490	0.352	0.442	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.317
1978	0.011	0.040	0.174	0.286	0.372	0.473	0.411	0.456	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.345
1979	0.009	0.039	0.177	0.285	0.384	0.461	0.735	1.234	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.333
1980	0.012	0.039	0.176	0.268	0.623	0.722	1.102	1.591	0.000	1.796	0.000	0.000	0.000	0.000	0.000	0.000	1.796
1981	0.009	0.040	0.176	0.371	0.467	0.858	1.200	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.346
1982	0.010	0.040	0.206	0.379	0.636	0.751	1.225	1.233	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1983	0.008	0.047	0.173	0.428	0.584	1.006	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.318
1984	0.009	0.045	0.211	0.414	0.626	0.751	1.225	1.234	1.315	1.319	1.400	1.400	0.000	0.000	0.000	0.000	1.356
1985	0.009	0.043	0.186	0.371	0.550	0.563	0.565	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.319
1986	0.010	0.040	0.186	0.375	0.626	1.259	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.328
1987	0.006	0.038	0.258	0.442	0.908	1.171	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1988	0.018	0.077	0.196	0.274	0.455	0.549	1.225	1.234	1.315	1.319	1.400	0.000	0.000	0.000	0.000	0.000	1.330
1989	0.015	0.165	0.251	0.347	0.670	0.923	1.065	1.492	1.315	0.000	1.400	0.000	0.000	0.000	0.000	0.000	1.329
1990	0.005	0.104	0.229	0.506	0.609	0.842	0.829	0.796	0.956	1.319	0.000	0.000	0.000	0.000	0.000	0.000	0.956
1991	0.027	0.058	0.206	0.357	0.472	0.477	1.225	1.234	1.315	1.319	0.000	0.000	0.000	0.000	0.000	0.000	1.316
1992	0.015	0.059	0.217	0.422	0.552	0.615	0.548	1.234	0.621	0.820	0.000	0.000	0.000	0.000	0.000	0.000	0.659
1993	0.008	0.053	0.206	0.399	0.521	0.578	1.225	0.582	1.315	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.315

1994	0.011	0.055	0.155	0.435	0.595	0.698	0.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.012	0.045	0.193	0.285	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1996	0.018	0.077	0.136	0.162	0.264	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.007	0.076	0.149	0.309	0.419	0.601	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.020	0.075	0.166	0.291	0.351	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1999	0.018	0.064	0.177	0.304	0.416	0.309	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.058	0.070	0.113	0.176	0.370	0.203	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.014	0.086	0.133	0.110	0.353	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2002	0.016	0.064	0.178	0.283	0.374	0.431	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.012	0.031	0.056	0.231	0.326	0.339	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2004	0.000	0.116	0.183	0.255	0.276	0.446	0.539	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.000	0.107	0.187	0.239	0.268	0.287	0.598	0.619	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.000	0.127	0.232	0.273	0.273	0.280	0.283	0.286	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.287
2007	0.035	0.141	0.192	0.290	0.315	0.370	0.427	0.342	0.368	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.368
2008	0.042	0.146	0.291	0.388	0.454	0.526	0.414	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2009	0.047	0.180	0.252	0.247	0.279	0.410	0.417	0.413	0.400	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.400
2010	0.000	0.080	0.244	0.310	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2011	0.016	0.316	0.324	0.350	0.367	0.443	0.460	0.493	0.589	0.385	0.000	1.331	1.624	0.000	0.000	0.000	0.424
2012	0.451	0.762	1.045	1.498	1.854	2.098	2.188	2.317	2.541	2.173	2.324	2.121	2.452	2.368	0.000	0.000	2.234
2013	0.047	0.289	0.522	0.604	0.484	0.723	0.844	0.786	0.721	1.042	2.020	2.304	2.233	1.810	2.512	0.000	0.731

Table 13.2.11. Haddock in Subarea IV, Division IIIaW and Division VIa. Estimates of natural mortality from the most recent key run of SMS (ICES-WGSAM 2011).

Age	0	1	2	3	4	5	6	7
1972	1.658	1.791	0.808	0.648	0.528	0.460	0.391	0.356
1973	1.664	1.792	0.824	0.654	0.531	0.460	0.391	0.358
1974	1.676	1.784	0.832	0.656	0.532	0.459	0.390	0.357
1975	1.692	1.770	0.834	0.655	0.530	0.455	0.386	0.354
1976	1.710	1.752	0.829	0.652	0.524	0.450	0.381	0.350
1977	1.727	1.733	0.818	0.646	0.515	0.443	0.373	0.345
1978	1.740	1.711	0.803	0.637	0.503	0.434	0.365	0.338
1979	1.750	1.686	0.785	0.627	0.489	0.423	0.356	0.331
1980	1.756	1.658	0.764	0.615	0.473	0.411	0.346	0.324
1981	1.758	1.626	0.741	0.602	0.457	0.399	0.337	0.316
1982	1.757	1.589	0.716	0.589	0.442	0.387	0.327	0.308
1983	1.755	1.547	0.691	0.575	0.428	0.376	0.319	0.300
1984	1.754	1.503	0.666	0.562	0.417	0.366	0.312	0.292
1985	1.753	1.460	0.641	0.549	0.408	0.357	0.306	0.285
1986	1.751	1.420	0.618	0.537	0.401	0.349	0.301	0.279
1987	1.747	1.386	0.597	0.524	0.396	0.342	0.298	0.273
1988	1.739	1.359	0.577	0.512	0.393	0.337	0.296	0.269
1989	1.725	1.339	0.558	0.500	0.391	0.333	0.295	0.266
1990	1.707	1.325	0.541	0.488	0.391	0.329	0.294	0.264
1991	1.685	1.319	0.526	0.477	0.390	0.326	0.294	0.263
1992	1.662	1.319	0.512	0.467	0.390	0.323	0.294	0.262
1993	1.642	1.324	0.501	0.458	0.391	0.321	0.293	0.262
1994	1.625	1.334	0.492	0.451	0.391	0.319	0.293	0.262
1995	1.612	1.346	0.485	0.444	0.389	0.318	0.293	0.262
1996	1.603	1.361	0.480	0.437	0.387	0.317	0.293	0.262
1997	1.599	1.376	0.476	0.430	0.382	0.316	0.293	0.262
1998	1.597	1.391	0.473	0.423	0.376	0.315	0.292	0.261
1999	1.598	1.407	0.472	0.416	0.369	0.314	0.292	0.260
2000	1.600	1.424	0.472	0.408	0.362	0.312	0.291	0.258
2001	1.600	1.445	0.474	0.401	0.356	0.312	0.291	0.257
2002	1.596	1.465	0.478	0.395	0.351	0.312	0.291	0.257
2003	1.584	1.484	0.484	0.391	0.346	0.313	0.291	0.257
2004	1.565	1.495	0.491	0.387	0.343	0.314	0.292	0.258
2005	1.539	1.497	0.499	0.385	0.341	0.315	0.293	0.258
2006	1.510	1.487	0.508	0.383	0.340	0.317	0.294	0.259
2007	1.479	1.467	0.517	0.382	0.339	0.319	0.295	0.259
2008	1.448	1.439	0.526	0.382	0.339	0.322	0.295	0.259
2009	1.417	1.405	0.535	0.381	0.340	0.325	0.296	0.258
2010	1.388	1.369	0.544	0.380	0.341	0.328	0.296	0.257
2011	1.388	1.369	0.544	0.380	0.341	0.328	0.296	0.257
2012	1.388	1.369	0.544	0.380	0.341	0.328	0.296	0.257
2013	1.388	1.369	0.544	0.380	0.341	0.328	0.296	0.257

Table 13.2.12. Haddock in Subarea IV, Division IIIaW and Division VIa. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS Q1					
1983	2014				
1	1	0.00	0.25		
1	5				
100	302.278	403.079	89.463	116.447	13.182
100	1072.285	221.275	127.770	20.410	20.900
100	230.968	833.257	107.598	32.317	3.575
100	573.023	266.912	303.546	17.888	6.490
100	912.559	328.062	45.201	58.262	4.345
100	101.691	677.641	97.149	12.684	13.965
100	219.705	98.091	274.788	16.653	2.113
100	217.448	139.114	32.997	50.367	3.163
100	680.231	134.076	25.032	4.260	8.476
100	1141.396	331.044	17.035	3.026	0.664
100	1242.121	519.521	152.384	8.848	1.076
100	227.919	491.051	97.656	23.308	1.566
100	1355.485	201.069	176.165	24.354	5.286
100	267.411	813.268	65.869	46.691	7.734
100	849.943	353.882	466.731	24.987	15.238
100	357.597	420.926	103.531	112.632	8.758
100	211.139	222.907	127.064	48.217	36.650
100	3482.017	96.075	43.255	24.163	11.804
100	894.651	2255.213	47.899	10.962	7.218
100	57.312	473.628	1309.589	9.179	6.886
100	89.991	39.267	241.529	532.024	5.354
100	71.847	79.595	35.460	173.607	329.990
100	69.697	60.984	33.156	10.397	59.114
100	1156.650	48.553	27.917	8.629	4.865
100	109.110	963.377	36.579	15.513	3.193
100	60.037	106.460	239.285	14.780	1.553
100	74.749	140.033	102.910	135.628	2.520
100	686.078	72.371	68.139	51.618	91.088
100	45.647	777.833	100.329	35.751	47.355
100	14.099	65.061	386.286	20.773	14.789
100	58.261	23.680	33.043	94.244	6.634
100	24.077	104.211	17.956	50.078	126.081

Table 13.2.12. (cont.) Haddock in Subarea IV, Division IIIaW and Division VIa. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

North Sea IBTS Q3						
1991	2013					
1	1	0.50	0.75			
0	5					
100	718.479	233.550	22.921	2.842	0.507	1.561
100	2741.140	595.235	189.015	10.529	1.583	0.396
100	577.382	605.990	140.146	37.604	2.360	0.372
100	1781.191	195.331	262.643	32.423	8.383	0.381
100	520.855	1019.607	106.642	97.383	8.060	3.131
100	627.502	247.469	428.471	30.426	20.215	2.649
100	195.255	347.567	123.793	149.048	6.672	5.282
100	276.401	257.140	164.853	53.690	42.660	3.093
100	6904.561	176.461	94.108	47.947	13.268	9.904
100	1092.830	2511.127	44.361	19.494	10.290	4.276
100	34.751	360.531	1100.248	30.305	6.377	3.653
100	138.204	49.504	223.792	583.061	10.079	2.601
100	163.924	69.356	31.171	199.252	368.656	2.942
100	184.090	64.677	41.951	9.900	79.211	175.486
100	1410.156	68.254	47.877	16.219	9.281	33.228
100	194.481	553.438	27.042	11.599	3.592	3.324
100	112.464	149.622	385.798	10.403	5.376	1.132
100	126.531	86.978	90.222	175.485	5.253	2.266
100	909.349	77.692	79.989	38.131	73.976	1.643
100	30.244	562.845	59.557	35.232	22.419	44.887
100	30.649	77.884	342.306	26.916	11.956	8.817
100	68.712	32.008	40.528	132.702	7.153	4.410
100	85.976	64.277	8.075	4.836	115.866	0.657

Table 13.3.1. Haddock in Subarea IV, Division IIIaW and Division VIa. TSA final assessment: Model settings. ω is a multiplier on the permitted variance of the estimated value: a higher setting for ω indicates greater downweighting of that value in the overall assessment.

Landings	Ages	0–8+
	Years	1972-2013
Discards	Ages	0-8+
	Years	1972, 1978-2013
Industrial bycatch	Ages	0-8+
	Years	1972, 1978-2013
Survey: NS IBTS Q1	Ages	1-5
	Years	1983-2014
Survey: NS IBTS Q3	Ages	0-5
	Years	1991-2013
Maturity		Knife-edge at age 3 (interim measure)
Natural mortality		Age- and time-varying from North Sea SMS key runs
Catch weights		Catch abundance-weighted average of North Sea and West of Scotland catch weights
Stock weights		Set equal to catch weights (interim measure)
Large year-classes ($\lambda = 5$)		1974, 1979, 1999, 2005, 2009
Age-dependent F variability		$H(a) = (2,1,1,1,1,1,1,1,1)$
F plateau		$a_m = 5$
Measurement-error multiplier for landings		$B_{landings}(a) = (*, 2, 1, 1, 1, 1, 1, 2, 2)$
Measurement-error multiplier for discards+bycatch		$B_{discards}(a) = (2, 1, 1, 1, 2, 2, *, *, *)$
Downweighted landings outliers		1996, age 7 (ω = 3)
Downweighted discards+bycatch outliers		1982, age 5; 2012, age 2 (ω = 3 for both)
Downweighted survey outliers		NS IBST Q1: 2011, age 5 (ω = 3); 2014, age 1 (ω = 25)

Table 13.3.2. Haddock in Subarea IV, Division IIIaW and Division VIa. TSA final assessment: Parameter estimates.

	estimate	lower.bound	upper.bound	active	on.bound
F age 0	0.0338	0.010	0.100	TRUE	FALSE
F age 1	0.0810	0.050	0.150	TRUE	FALSE
F age 2	0.6855	0.600	1.000	TRUE	FALSE
F age 5	1.0444	0.800	1.200	TRUE	FALSE
sd F	0.1193	0.050	0.150	TRUE	FALSE
sd U	0.0712	0.010	0.100	TRUE	FALSE
sd V	0.1007	0.030	0.140	TRUE	FALSE
sd Y	0.1620	0.100	0.250	TRUE	FALSE
cv landings	0.2154	0.100	0.250	TRUE	FALSE
cv discards	0.2725	0.150	0.350	TRUE	FALSE
log mean recruitment at start	8.0652	7.000	8.200	TRUE	FALSE
sd of random walk	0.0961	0.020	0.150	TRUE	FALSE
recruitment cv	0.3910	0.300	0.500	TRUE	FALSE
discards sd transitory	0.2400	0.150	0.350	TRUE	FALSE
discards sd persistent	0.4429	0.250	0.500	TRUE	FALSE
NSQ1 selection age 1	0.2163	0.100	0.300	TRUE	FALSE
NSQ1 selection age 2	0.6010	0.400	0.700	TRUE	FALSE
NSQ1 selection age 3	0.6572	0.500	0.800	TRUE	FALSE
NSQ1 selection age 4	0.5143	0.400	0.700	TRUE	FALSE
NSQ1 selection age 5	0.4608	0.400	0.700	TRUE	FALSE
NSQ1 sigma	0.1746	0.100	0.300	TRUE	FALSE
NSQ1 eta	0.3331	0.250	0.500	TRUE	FALSE
NSQ1 omega	0.1494	0.050	0.250	TRUE	FALSE
NSQ1 beta	0.0010	0.001	0.100	FALSE	TRUE
NSQ3 selection age 0	0.1604	0.050	0.400	TRUE	FALSE
NSQ3 selection age 1	0.3125	0.200	0.500	TRUE	FALSE
NSQ3 selection age 2	0.4782	0.200	0.600	TRUE	FALSE
NSQ3 selection age 3	0.4467	0.200	0.600	TRUE	FALSE
NSQ3 selection age 4	0.3967	0.200	0.600	TRUE	FALSE
NSQ3 selection age 5	0.3532	0.200	0.600	TRUE	FALSE
NSQ3 sigma	0.2228	0.100	0.400	TRUE	FALSE
NSQ3 eta	0.0997	0.050	0.300	TRUE	FALSE
NSQ3 omega	0.1553	0.010	0.200	TRUE	FALSE
NSQ3 beta	0.0010	0.001	0.150	FALSE	TRUE

Table 13.3.3. Haddock in Subarea IV, Division IIIaW and Division VIa. Estimates of fishing mortality at age from the final TSA assessment. Estimates refer to the full year (January – December) except for age 0, for which the mortality rate given refers to the second half-year only (July – December).

	0	1	2	3	4	5	6	7	8	Mean F(2–4)
1972	0.030	0.072	0.566	0.797	0.820	0.823	0.869	0.863	0.845	0.728
1973	0.027	0.081	0.515	0.738	0.751	0.794	0.844	0.829	0.846	0.668
1974	0.025	0.088	0.510	0.645	0.740	0.693	0.757	0.775	0.765	0.632
1975	0.027	0.078	0.564	0.746	0.820	0.823	0.895	0.868	0.867	0.710
1976	0.026	0.079	0.500	0.793	0.780	0.895	0.869	0.855	0.859	0.691
1977	0.024	0.084	0.501	0.694	0.870	0.839	0.846	0.834	0.833	0.688
1978	0.020	0.099	0.528	0.764	0.891	0.898	0.906	0.889	0.900	0.728
1979	0.022	0.077	0.527	0.805	0.825	0.844	0.841	0.835	0.837	0.719
1980	0.024	0.069	0.407	0.792	0.864	0.716	0.793	0.765	0.764	0.688
1981	0.022	0.069	0.304	0.662	0.722	0.629	0.538	0.630	0.611	0.563
1982	0.017	0.071	0.322	0.534	0.620	0.548	0.583	0.612	0.577	0.492
1983	0.016	0.081	0.385	0.724	0.740	0.754	0.706	0.691	0.696	0.617
1984	0.018	0.116	0.439	0.816	0.931	0.728	0.770	0.759	0.753	0.729
1985	0.018	0.108	0.425	0.788	0.887	0.751	0.742	0.721	0.730	0.700
1986	0.013	0.101	0.541	0.767	0.920	0.698	0.648	0.665	0.688	0.743
1987	0.018	0.077	0.648	0.897	0.859	0.770	0.791	0.783	0.776	0.802
1988	0.017	0.103	0.518	0.990	0.965	0.797	0.777	0.767	0.791	0.824
1989	0.015	0.108	0.585	0.879	0.983	0.770	0.777	0.775	0.780	0.816
1990	0.012	0.102	0.634	0.842	0.856	0.755	0.688	0.695	0.708	0.777
1991	0.013	0.140	0.647	0.902	0.860	0.729	0.732	0.748	0.730	0.803
1992	0.014	0.092	0.568	0.843	0.893	0.671	0.773	0.728	0.749	0.768
1993	0.016	0.113	0.707	0.889	0.905	0.892	0.880	0.882	0.902	0.833
1994	0.011	0.102	0.598	0.922	0.875	0.926	0.921	0.940	0.906	0.799
1995	0.015	0.080	0.528	0.820	0.889	0.807	0.888	0.863	0.863	0.746
1996	0.013	0.079	0.476	0.818	0.935	0.946	0.992	0.932	0.936	0.743
1997	0.010	0.096	0.447	0.613	0.744	0.898	0.862	0.854	0.859	0.602
1998	0.010	0.113	0.546	0.635	0.810	0.850	0.877	0.886	0.886	0.664
1999	0.008	0.107	0.604	0.853	0.874	1.090	1.027	1.032	1.027	0.777
2000	0.008	0.069	0.608	0.870	0.933	0.905	0.976	0.957	0.945	0.804
2001	0.008	0.061	0.339	0.631	0.700	0.722	0.718	0.718	0.722	0.557
2002	0.007	0.085	0.246	0.338	0.498	0.519	0.526	0.526	0.530	0.360
2003	0.004	0.047	0.204	0.232	0.284	0.362	0.357	0.359	0.360	0.240
2004	0.003	0.050	0.204	0.250	0.281	0.336	0.320	0.329	0.329	0.245
2005	0.003	0.054	0.249	0.339	0.318	0.384	0.390	0.381	0.380	0.302
2006	0.004	0.047	0.357	0.522	0.562	0.642	0.553	0.598	0.555	0.480
2007	0.004	0.049	0.242	0.477	0.523	0.553	0.556	0.538	0.542	0.414
2008	0.003	0.037	0.163	0.263	0.368	0.363	0.379	0.367	0.374	0.265
2009	0.002	0.033	0.120	0.215	0.279	0.278	0.271	0.277	0.277	0.205
2010	0.003	0.036	0.133	0.235	0.264	0.275	0.257	0.266	0.266	0.211
2011	0.003	0.034	0.126	0.294	0.361	0.338	0.317	0.305	0.297	0.260
2012	0.002	0.029	0.110	0.184	0.255	0.215	0.209	0.214	0.210	0.183

2013	0.002	0.039	0.110	0.168	0.255	0.186	0.183	0.189	0.191	0.178
2014	0.002	0.031	0.111	0.187	0.261	0.203	0.203	0.203	0.203	0.186

Table 13.3.4. Haddock in Subarea IV, Division IIIaW and Division VIa. Estimates of stock numbers at age from the final TSA assessment. Estimates refer to January 1st, except for age 0 for estimates refer to July 1st. *Estimated survivors.

	0	1	2	3	4	5	6	7	8+
1972	16979460	19098984	2192760	94438	50417	460860	8020	498	1266
1973	57545334	3144392	2971375	555761	22525	13325	127405	2306	548
1974	134801453	10583850	487640	778471	13992	6396	3829	37551	892
1975	10038319	24799025	1625190	139283	20707	38887	1902	1196	1234
1976	11830949	1810317	3906278	403936	35192	54881	11109	544	4361
1977	21699039	2085491	282639	1048982	95943	9951	14817	3352	1636
1978	48110825	3761132	328802	79684	292178	24928	3033	4908	1773
1979	97369284	8269983	612028	86580	19632	73264	6180	843	1964
1980	17293588	16571708	1416171	165996	20609	5692	21614	1988	971
1981	28321673	2925071	2956995	435171	41671	5712	1910	7370	1099
1982	16306697	4813141	541692	970851	120141	13350	2077	700	3282
1983	50605010	2786568	916581	196628	314905	41834	5330	858	1737
1984	11791117	8585393	548612	314607	54311	97680	13657	1939	1000
1985	17298465	2054356	1695317	182177	79818	14263	30368	4385	957
1986	31994479	2955774	429899	582621	48511	22233	4765	10632	1961
1987	3109421	5452262	647484	135191	158354	13071	7644	1752	4622
1988	3163944	539908	1260776	185897	33095	45023	4350	2618	2309
1989	4975424	720404	131206	421303	41421	8666	14493	1495	1749
1990	17315746	943591	169283	41715	107538	10650	2946	5084	1194
1991	19184776	3093065	226923	48726	11069	31547	3714	1136	2487
1992	29203852	3508319	718181	71392	12636	3081	10293	1285	1269
1993	8916765	5466855	854853	244567	18630	3454	1102	3545	955
1994	34661961	1701170	1294673	253190	64146	5128	1048	352	1496
1995	9773076	6750332	405312	435623	64698	18102	1491	321	606
1996	13164863	1925891	1620583	147800	123882	18054	5866	470	318
1997	7108791	2618830	456625	622929	42378	33272	5166	1664	249
1998	5165405	1423729	599855	181574	220338	13818	9923	1655	641
1999	90105491	1037004	314102	211744	62999	67430	4314	3091	744

2000	17429764	18076625	227242	102446	56523	17784	16209	1159	1068
2001	1740314	3491785	4064778	77170	27670	14938	5172	4471	669
2002	2634459	447595	775410	1803318	27024	9506	5204	1868	1908
2003	2635056	531158	95054	376023	867964	11431	4096	2265	1710
2004	2576169	576745	115120	47922	202036	462805	5752	2113	2116
2005	26711412	537104	123101	57413	25448	108144	240868	3052	2278
2006	5228484	5713562	113949	58260	27800	13226	53531	119614	2685
2007	3645805	1149956	1232031	48211	23607	11291	5064	22638	50022
2008	2724273	827328	252587	577599	20439	9920	4728	2151	32434
2009	17275664	638347	188836	126743	302958	10075	5010	2421	18726
2010	1478236	4178691	151510	98250	69919	163215	5527	2852	12701
2011	732351	386496	1025921	77059	53193	38276	89494	3187	9417
2012	2319278	196125	95095	525833	39083	26322	19697	48645	7415
2013	2178465	577702	48516	49400	299700	21513	15313	11919	35253
2014*	3484267	542711	141388	25282	28620	165494	12886	9510	30828

Table 13.3.5. Haddock in Subarea IV, Division IIIaW and Division VIa. Stock summary table. For each value, both estimates (EST) and standard errors (SE) are given. *TSA model fits or projections. Catches, landings, "discards" (= discards + industrial bycatch), SSB and TSB are all in tonnes – recruitment is in thousands.

	catch	catch.est	catch.se	landings	landings.est	landings.se	discards	discards.est	discards.se	meanF.est	meanF.se	SSB.est	SSB.se	TSB.est	TSB.se	recruit.est	recruit.se
1972	408150	397680	37700	233290	230260	25350	173900	167420	25080	0.728	0.059	341880	30850	3531590	340290	16979460	3886080
1973	344570	373140	47850	206810	196920	21410	137200	176220	40380	0.668	0.063	312110	24310	3867760	403080	57545330	8016410
1974	397030	282850	35330	167410	162330	17650	229500	120520	27290	0.632	0.064	381360	32450	5226920	597920	134801450	20452350
1975	494390	309620	45250	159640	157050	15710	334010	152570	38770	0.710	0.074	183900	12800	3408720	426010	10038320	2643730
1976	402050	369560	61300	181760	203770	27210	217730	165790	51330	0.691	0.074	225490	21950	1503560	173330	11830950	2333210
1977	240290	216250	31310	155750	173700	26340	83730	42550	12480	0.688	0.076	436060	48650	1168800	102390	21699040	2953550
1978	146660	134530	15060	102220	98330	12380	43760	36200	6260	0.728	0.071	182530	18710	1186420	77080	48110820	3662310
1979	149130	135480	14730	97390	81130	9760	51380	54350	8330	0.719	0.070	106700	13130	1927780	99310	97369280	7291400
1980	202620	194820	18670	110830	104360	12260	91260	90460	12930	0.688	0.064	120660	13360	2061360	113340	17293590	1650510
1981	226560	245280	24580	147670	152700	19460	78660	92580	14460	0.563	0.052	242840	17570	1453890	71340	28321670	2461040
1982	256280	222800	18630	195360	174980	17160	60730	47820	6790	0.492	0.042	525700	27120	1199860	49030	16306700	1355190
1983	253310	224130	17670	187960	169950	14480	64450	54180	7670	0.617	0.048	325460	17570	1527670	61050	50605010	3073890
1984	247210	239630	20440	157630	150840	12620	89060	88790	13690	0.729	0.055	270850	16380	1774120	82350	11791120	1077500
1985	247400	230870	19260	182550	168370	16540	64380	62500	10060	0.700	0.054	184630	9760	1163470	48860	17298470	1445160
1986	223840	191290	15680	184520	148490	14100	38740	42800	5490	0.743	0.055	305120	18730	1516750	62240	31994480	1888890
1987	195050	177730	14190	133890	123010	11040	60050	54720	7610	0.802	0.060	179340	10770	1062900	47820	3109420	514370
1988	179910	168690	14600	124800	118670	12660	53730	50030	7760	0.824	0.063	140010	9850	653400	63210	3163940	1270550
1989	127670	119070	10810	91930	83740	10060	34870	35330	4930	0.816	0.063	203470	12780	563670	35110	4975420	672060
1990	86730	76400	7060	61190	54840	5410	25160	21560	3220	0.777	0.060	91520	6260	1013590	50750	17315750	1076160
1991	97210	97500	10040	54730	51930	5300	41990	45560	7200	0.803	0.064	57170	4240	1243890	56900	19184780	1321420
1992	135090	125680	11070	80480	72940	8720	53420	52740	7230	0.768	0.055	58460	3570	1190940	53090	29203850	2021920
1993	180230	204200	17810	97870	112260	12660	81510	91940	12110	0.833	0.058	132850	8550	1064440	51700	8916760	767570
1994	169500	215590	20290	94710	124570	14840	74300	91020	12820	0.799	0.059	156800	11780	1306340	54850	34661960	2048250
1995	168830	174430	16190	89580	99990	11920	79040	74440	9500	0.746	0.058	215210	15060	1172310	52090	9773080	723780
1996	204700	201830	18270	92420	93250	10050	112060	108580	14320	0.743	0.055	135760	7870	1058610	44560	13164860	1040600

1997	170050	167100	14640	95340	94420	11000	74600	72680	9070	0.602	0.050	276950	15690	972360	44640	7108790	626070
1998	161960	150100	13280	95390	87810	8550	66460	62290	8350	0.664	0.054	189130	10830	699390	34080	5165400	478710
1999	123450	122660	10910	75870	70930	7120	47450	51730	6510	0.777	0.062	146140	9690	2649440	139570	90105490	5360640
2000	126880	149290	18780	54360	50470	5270	72390	98820	16570	0.804	0.065	87250	6800	3239040	149960	17429760	993520
2001	173530	256070	32490	47380	90640	16030	125980	165430	26820	0.557	0.050	56570	4240	1384820	65530	1740310	521270
2002	155160	188130	21220	64780	97090	15800	89750	91040	13890	0.360	0.036	590480	34350	881780	39190	2634460	202960
2003	74410	107210	12730	46990	81870	11450	27150	25340	5470	0.240	0.025	486170	25650	613980	28240	2635060	317590
2004	72510	80280	8700	51760	64700	8050	20590	15590	3230	0.245	0.025	310640	18290	518680	22820	2576170	203350
2005	64120	70500	7080	51440	59650	6410	12570	10850	1490	0.302	0.030	216730	15580	1778440	88000	26711410	1543880
2006	66960	78850	8030	43190	55270	6190	23620	23580	3710	0.480	0.043	137510	12170	1109270	49420	5228480	300370
2007	67440	88740	9360	34570	51640	6490	32750	37100	5700	0.414	0.039	93640	10400	709280	28680	3645810	219980
2008	47730	65470	7110	30750	47200	6110	14690	18270	2850	0.265	0.028	264580	16430	551620	23530	2724270	190530
2009	47940	47290	4930	34610	36880	4280	12370	10410	1580	0.205	0.022	193100	12420	1191640	67020	17275660	1251440
2010	45410	44860	4220	31460	34370	3390	13470	10480	1570	0.211	0.024	172400	11360	565620	30970	1478240	262050
2011	49680	55990	5370	36390	38350	3670	13080	17640	3150	0.260	0.030	130320	9140	463620	27620	732350	159980
2012	43200	50630	5710	37620	45020	5320	5030	5610	1130	0.183	0.024	311850	22210	466150	32890	2319280	362340
2013	46780	45110	5300	43610	41590	5000	3090	3520	880	0.178	0.025	240840	19380	436330	46250	2178470	883630
2014*	NA	34230	7680	NA	31130	7070	NA	3100	1030	0.186	0.048	178440	17970	417330	67590	3484270	1609540

Table 13.6.1. Haddock in Subarea IV, Division IIIaW and Division VIa. Short-term forecast input.

MFDP version 1a						
Run: 01						
Time and date: 17:07 03/05/2014						
Fbar age range (Total) : 2-4						
Fbar age range Fleet 1 : 2-4						
Fbar age range Fleet 2 : 2-4						
2014						
Age	N	M	Mat	PF	PM	SWt
0	3484267	1.39	0	0	0	0.029
1	542711	1.37	0	0	0	0.153
2	141388	0.54	0	0	0	0.379
3	25282	0.38	1	0	0	0.627
4	28620	0.34	1	0	0	0.62
5	165494	0.33	1	0	0	0.689
6	12886	0.3	1	0	0	0.831
7	9510	0.26	1	0	0	0.855
8	30828	0.23	1	0	0	0.985
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0.026	0.002	0.029		
1	0.002	0.328	0.029	0.153		
2	0.054	0.48	0.057	0.379		
3	0.161	0.97	0.026	0.361		
4	0.244	0.829	0.016	0.504		
5	0.201	0.575	0.002	0.435		
6	0.201	0.744	0.001	0.542		
7	0.202	0.868	0.001	0.995		
8	0.202	0.913	0.001	0.577		
IBC						
Age	Sel	CWt				
0	0	0.1714				
1	0	0.4557				
2	0	0.6302				
3	0	0.8172				
4	0	0.9016				
5	0	1.0879				
6	0	1.164				
7	0	1.1985				
8	0	1.2837				

Table 13.6.1 (cont). Haddock in Subarea IV, Division IIIaW and Division VIa. Short-term forecast input.

2015						
Age	N	M	Mat	PF	PM	SWt
0	3484270	1.39	0	0	0	0.029
1	.	1.37	0	0	0	0.153
2	.	1	0	0	0	0
3	.	0	1	0	0	0
4	.	0.34	1	0	0	1
5	.	0.33	1	0	0	1
6	.	0.3	1	0	0	1
7	.	0.26	1	0	0	1
8	.	0.23	1	0	0	1

Catch				
Age	Sel	CWt	DSel	DCWt
0	0	0.026	0.002	0
1	0.002	0.328	0.029	0
2	0.054	0.48	0.057	0
3	0.161	0.493	0.026	0
4	0.244	1.24	0.016	0
5	0.201	1.008	0.002	1
6	0.201	0.648	0.001	1
7	0.202	0.814	0.001	1
8	0.202	1.011	0.001	1

IBC		
Age	Sel	CWt
0	0	0.1714
1	0	0.4557
2	0	0.6302
3	0	0.8172
4	0	0.9016
5	0	1.0879
6	0	1.164
7	0	1.1985
8	0	1.2837

Table 13.6.1 (cont). Haddock in Subarea IV, Division IIIaW and Division VIa. Short-term forecast input.

2016						
Age	N	M	Mat	PF	PM	SWt
0	3484270	1.39	0	0	0	0
1	.	1.37	0	0	0	0
2	.	0.54	0	0	0	0
3	.	0.38	1	0	0	0
4	.	0.34	1	0	0	1
5	.	0.33	1	0	0	1
6	.	0.3	1	0	0	1
7	.	0.26	1	0	0	1
8	.	0.23	1	0	0	1

Catch				
Age	Sel	CWt	DSel	DCWt
0	0	0.026	0.002	0
1	0.002	0.328	0.029	0.153
2	0.054	0.48	0.057	0.379
3	0.161	0.493	0.026	0.405
4	0.244	0.513	0.016	0.529
5	0.201	1.51	0.002	0.588
6	0.201	1.187	0.001	0.746
7	0.202	0.721	0.001	0.595
8	0.202	0.887	0.001	0.714

IBC		
Age	Sel	CWt
0	0	0.1714
1	0	0.4557
2	0	0.6302
3	0	0.8172
4	0	0.9016
5	0	1.0879
6	0	1.164
7	0	1.1985
8	0	1.2837

Input units are thousands and kg - output in tonnes

Table 13.6.2. Haddock in Subarea IV, Division IIIaW and Division VIa. Short-term forecast output. A number of management options are highlighted.

MFDP version 1a

Run: 01

Time and date: 17:07 03/05/2014

Fbar age range (Total) : 2-4

Fbar age range Fleet 1 : 2-4

Fbar age range Fleet 2 : 2-4

2014

		Catch			Landings					Discards		IBC	Landings	
Biomass	SSB	FMult	FBar	Yield	FBar	NoSh yield	IV yield	IIIa yield	VIa yield	FBar	Yield	FMult	FBar	Yield
434491	196826	1	0.186	36686	0.153	32543	25606	600	6337	0.033	4143	1	0.000	0.000

2015 2016

		Catch			Landings					Discards		IBC	Landings							
Biomass	SSB	FMult	FBar	Yield	FBar	NoSh yield	IV yield	IIIa yield	VIa yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	IV TAC change	IIIa TAC change	VIa TAC change	SSB change	
454703	170473	0	0.000	0	0	0	0	0	0	0	0	1	0.000	0	495328	178092	-100%	-100%	-100%	4%	No HC fishery
.	170473	0.1	0.019	3598	0.0153	3075	2419	57	599	0.0033	523	1	0.000	0	491739	174788	-94%	-98%	-85%	3%	
.	170473	0.2	0.037	7136	0.0306	6094	4795	112	1187	0.0066	1042	1	0.000	0	488215	171548	-87%	-95%	-70%	1%	
.	170473	0.3	0.056	10614	0.0459	9057	7126	167	1764	0.0099	1557	1	0.000	0	484754	168370	-81%	-93%	-56%	-1%	
.	170473	0.4	0.074	14033	0.0612	11965	9414	221	2330	0.0132	2068	1	0.000	0	481356	165254	-75%	-91%	-42%	-3%	
.	170473	0.5	0.093	17395	0.0765	14820	11661	273	2886	0.0165	2575	1	0.000	0	478018	162198	-70%	-88%	-28%	-5%	
.	170473	0.6	0.112	20701	0.0918	17623	13866	325	3432	0.0198	3078	1	0.000	0	474740	159201	-64%	-86%	-14%	-7%	
.	170473	0.7	0.130	23950	0.1071	20374	16031	376	3967	0.0231	3576	1	0.000	0	471521	156261	-58%	-84%	-1%	-8%	
.	170473	0.8	0.149	27145	0.1224	23074	18155	426	4493	0.0264	4071	1	0.000	0	468359	153378	-53%	-82%	13%	-10%	
.	170473	0.9	0.167	30287	0.1377	25725	20241	475	5009	0.0297	4562	1	0.000	0	465253	150551	-47%	-80%	26%	-12%	
.	170473	1	0.186	33377	0.153	28328	22289	523	5516	0.033	5049	1	0.000	0	462203	147778	-42%	-78%	38%	-13%	Fsq
.	170473	1.1	0.205	36416	0.1683	30883	24299	570	6014	0.0363	5533	1	0.000	0	459207	145059	-37%	-76%	51%	-15%	
.	170473	1.2	0.223	39403	0.1836	33391	26273	616	6502	0.0396	6012	1	0.000	0	456263	142391	-31%	-74%	63%	-16%	
.	170473	1.3	0.242	42342	0.1989	35854	28211	661	6982	0.0429	6488	1	0.000	0	453372	139775	-26%	-72%	75%	-18%	
.	170473	1.4	0.260	45233	0.2142	38272	30113	706	7453	0.0462	6961	1	0.000	0	450531	137209	-21%	-70%	87%	-20%	
.	170473	1.5	0.279	48075	0.2295	40646	31981	750	7915	0.0495	7429	1	0.000	0	447741	134693	-16%	-68%	98%	-21%	
.	170473	1.6	0.298	50872	0.2448	42977	33815	793	8369	0.0528	7895	1	0.000	0	445000	132224	-12%	-66%	110%	-22%	
.	170473	1.7	0.316	53622	0.2601	45266	35616	835	8815	0.0561	8356	1	0.000	0	442306	129803	-7%	-65%	121%	-24%	
.	170473	1.8	0.335	56327	0.2754	47513	37384	876	9252	0.0594	8814	1	0.000	0	439660	127428	-2%	-63%	132%	-25%	

.	170473	1.9	0.353	58989	0.2907	49720	39121	917	9682	0.0627	9269	1	0.000	0	437060	125099	2%	-61%	143%	-27%	
.	170473	2	0.372	61608	0.306	51887	40826	957	10104	0.066	9721	1	0.000	0	434505	122814	7%	-59%	153%	-28%	
	170473	0.75	0.140	24748	0.115	20982	16509	387	4086	0.025	3766	1	0.000	0	470784	155652	-57%	-84%	2%	-9%	0.75 * F(sq)
	170473	0.81	0.150	26483	0.123	22444	17659	414	4370	0.027	4040	1	0.000	0	469071	154095	-54%	-82%	10%	-10%	New F(target) proposal
	170473	1.25	0.233	40121	0.191	33927	26695	626	6607	0.041	6194	1	0.000	0	455609	141863	-30%	-73%	66%	-17%	1.25 * F(sq)
	170473	1.54	0.286	48943	0.235	41358	32541	763	8054	0.051	7585	1	0.000	0	446899	133946	-15%	-68%	102%	-21%	15% TAC decrease (IV)
	170473	2.10	0.390	66275	0.321	55955	44027	1032	10896	0.069	10320	1	0.000	0	429789	118395	15%	-56%	173%	-31%	15% TAC increase (IV)
	170473	1.61	0.300	51280	0.247	43322	34087	799	8436	0.053	7957	1	0.000	0	444595	131855	-11%	-66%	112%	-23%	MP target F
	170473	1.82	0.338	57609	0.278	48656	38284	897	9475	0.060	8952	1	0.000	0	438344	126170	0%	-62%	138%	-26%	Rollover TAC (IV)
	170473	1.88	0.350	59545	0.288	50282	39563	927	9791	0.062	9263	1	0.000	0	436436	124442	3%	-61%	146%	-27%	New F(msy) estimate
Input units are thousands and kg - output in tonnes																					

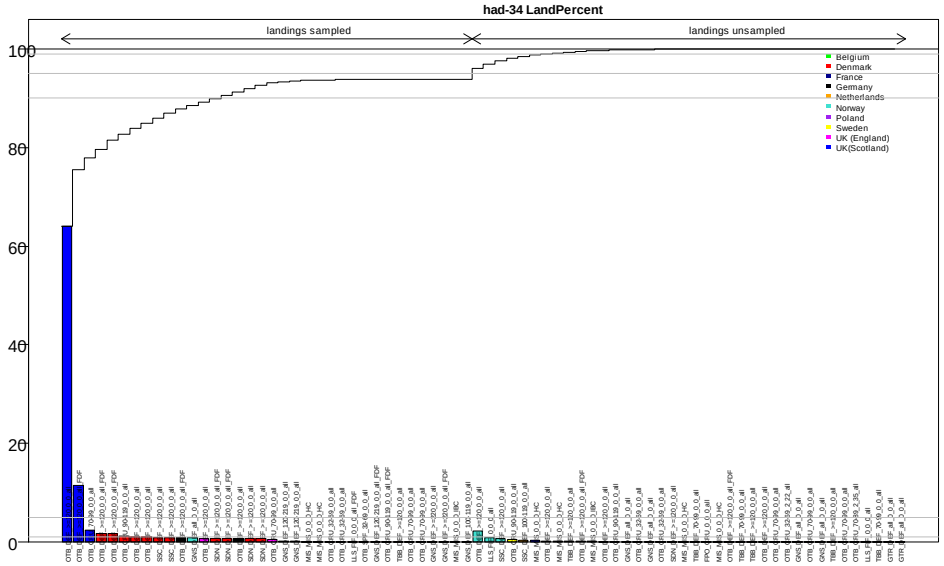


Figure 13.2.1: Haddock in Subarea IV, Division IIIaW and Division VIa. Reported landings for each sampled and unsampled fleet in Subarea IV and Division IIIaW, along with cumulative landings for fleets in descending order of yield.

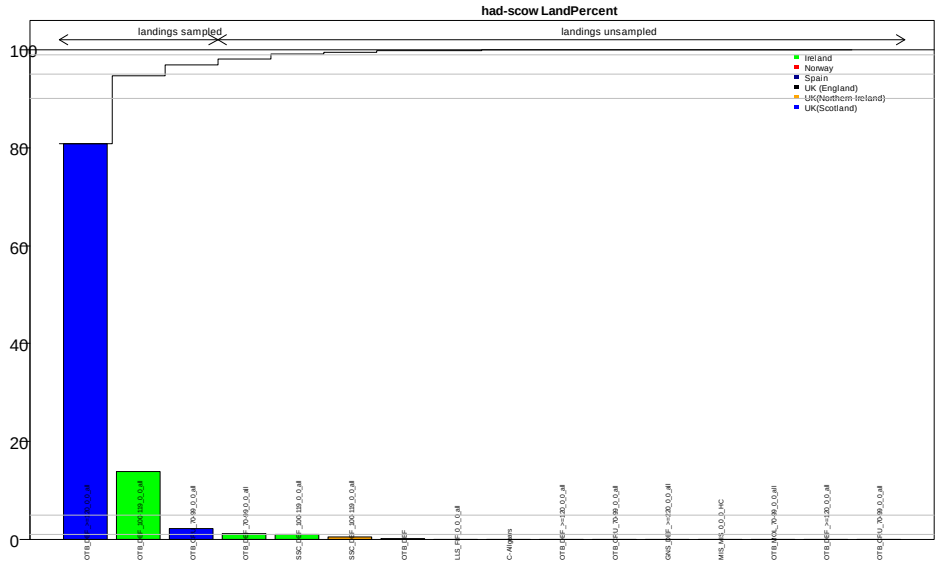


Figure 13.2.2: Haddock in Subarea IV, Division IIIaW and Division VIa. Reported landings for each sampled and unsampled fleet in Division VIa, along with cumulative landings for fleets in descending order of yield.

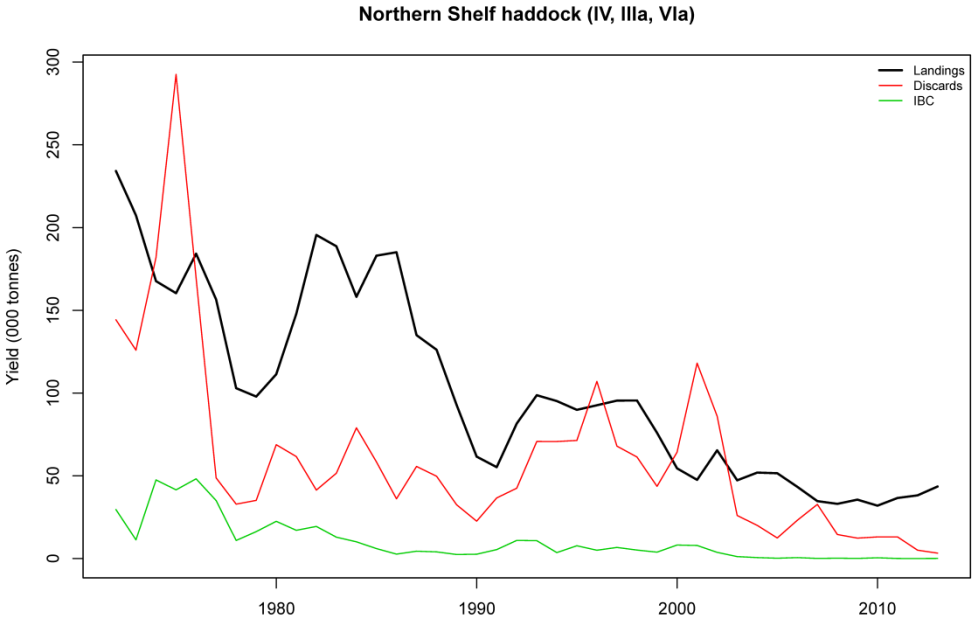


Figure 13.2.3. Haddock in Subarea IV, Division IIIaW and Division VIa. Yield by catch component.

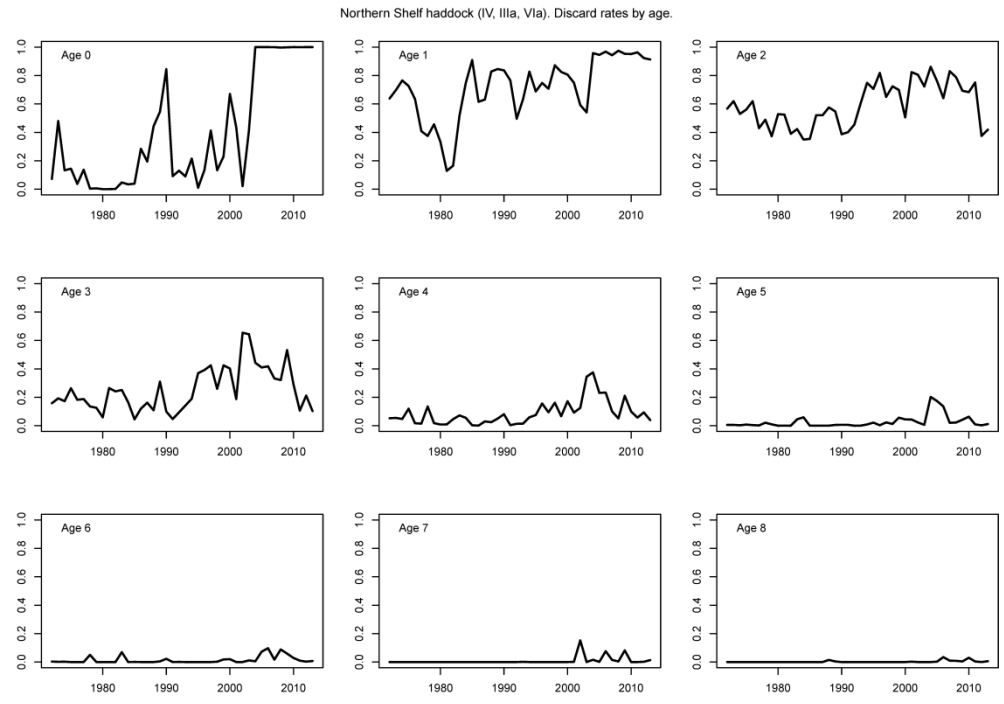


Figure 13.2.4. Haddock in Subarea IV and Divisions IIIa. Proportion of total catch discarded, by age and year.

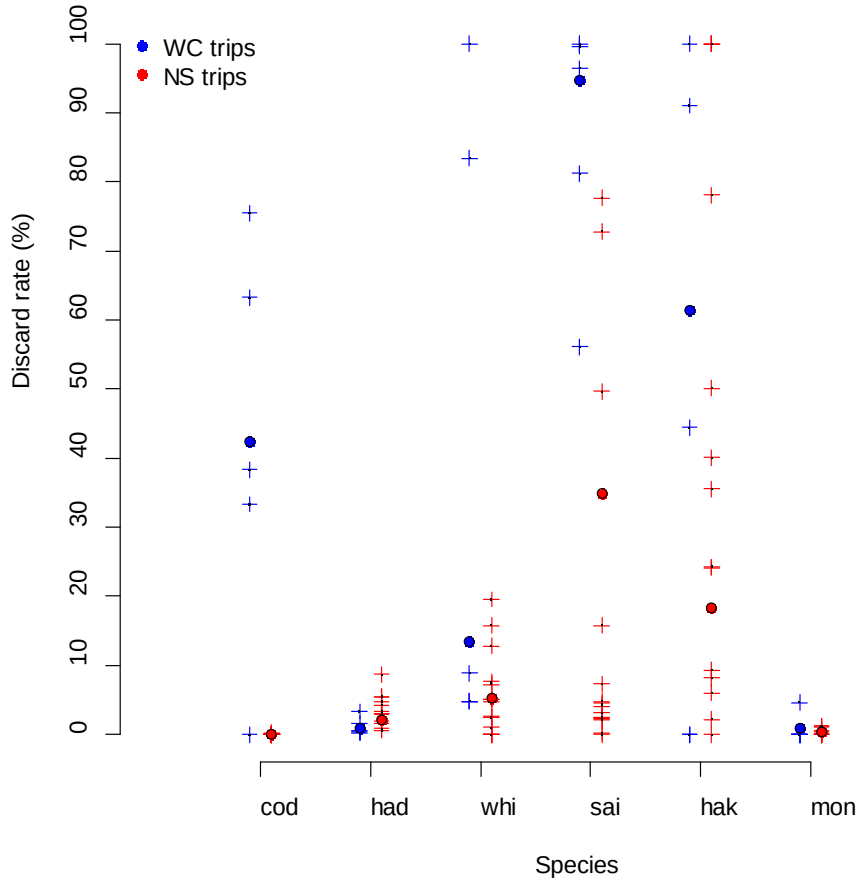


Figure 13.2.5. Haddock in Subarea IV, Division IIIaW and Division VIa. Estimates of discard rates from Scottish CCTV sampling during Q4 2012 and Q1-3 2013. Rates are shown for two areas (North Sea in blue, West of Scotland in red) and for six species (cod, haddock, whiting, saithe, hake and monk). Crosses give the discard rates (by weight) for each trip, while the averages for each species and area is given by filled circles.

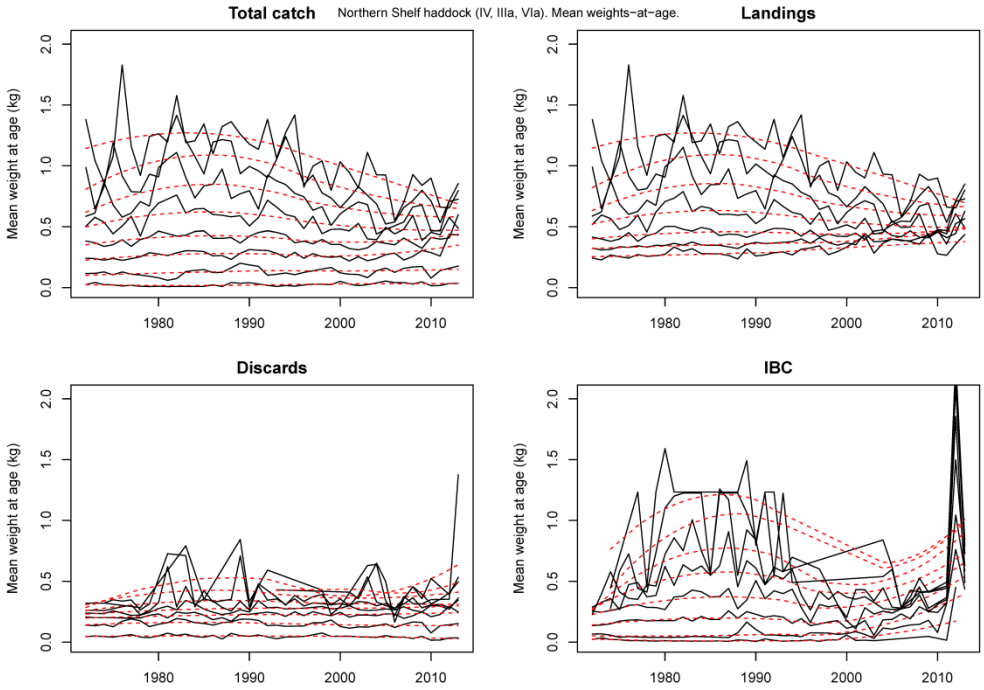


Figure 13.2.6. Haddock in Subarea IV, Division IIIaW and Division VIa. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

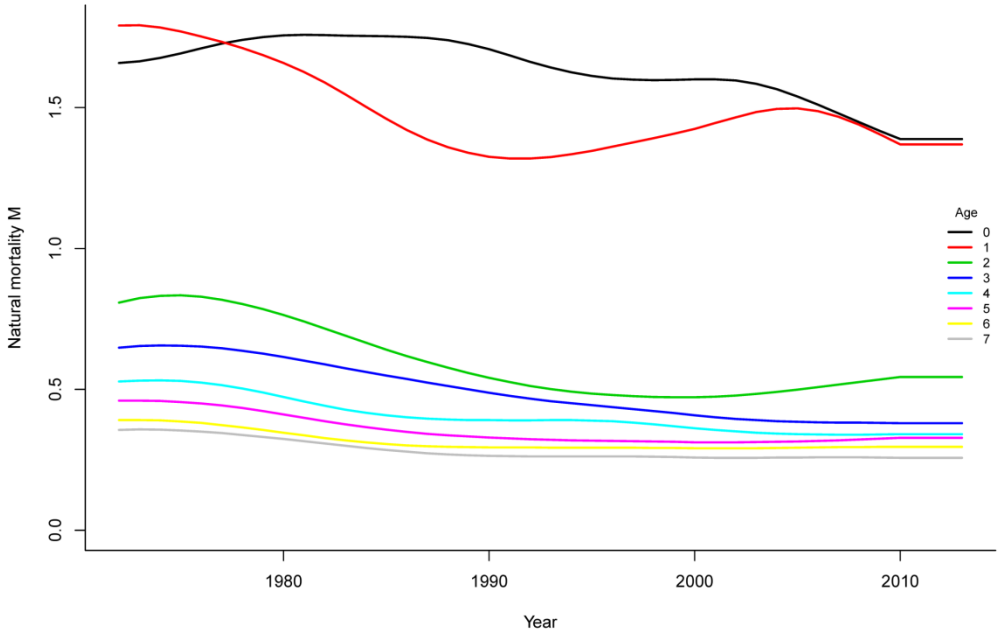


Figure 13.2.7. Haddock in Subarea IV, Division IIIaW and Division VIa. Time series of estimated natural mortality at age, from ICES-WGSAM (2011).

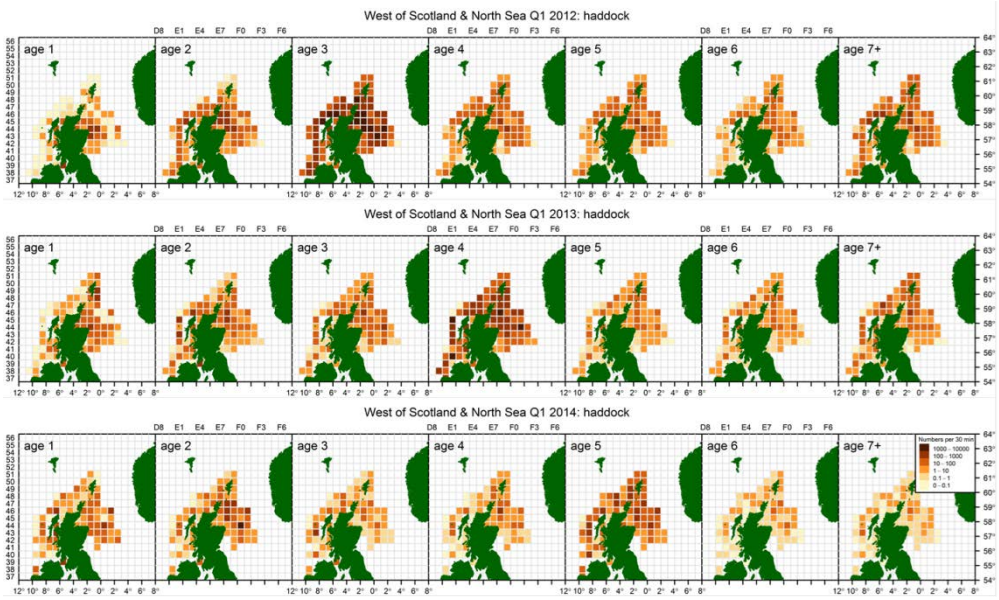


Figure 13.2.8. Haddock in Subarea IV, Division IIIaW and Division VIa. Survey distributions by age for the Scottish component of the IBTS Q1 survey (North Sea) and the Scottish West Coast Q1 survey (West of Scotland).

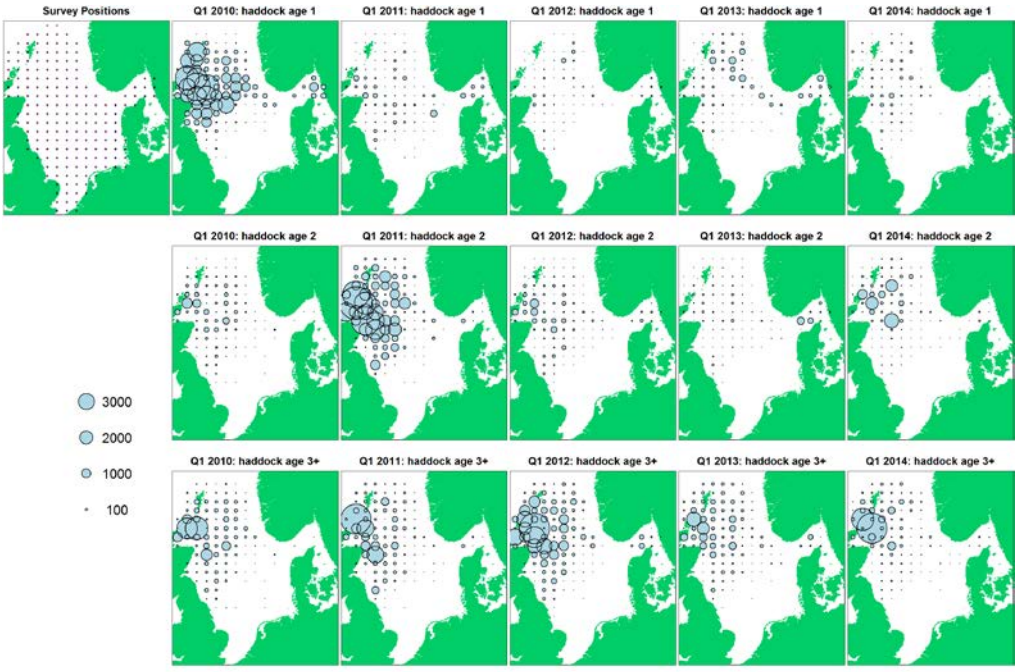


Figure 13.2.9. Haddock in Subarea IV, Division IIIaW and Division VIa. Survey distributions by age for the international IBTS Q1 survey (North Sea).



Figure 13.2.10. Haddock in Subarea IV, Division IIIaW and Division VIa. Survey distributions by age for the international IBTS Q3 survey (North Sea).

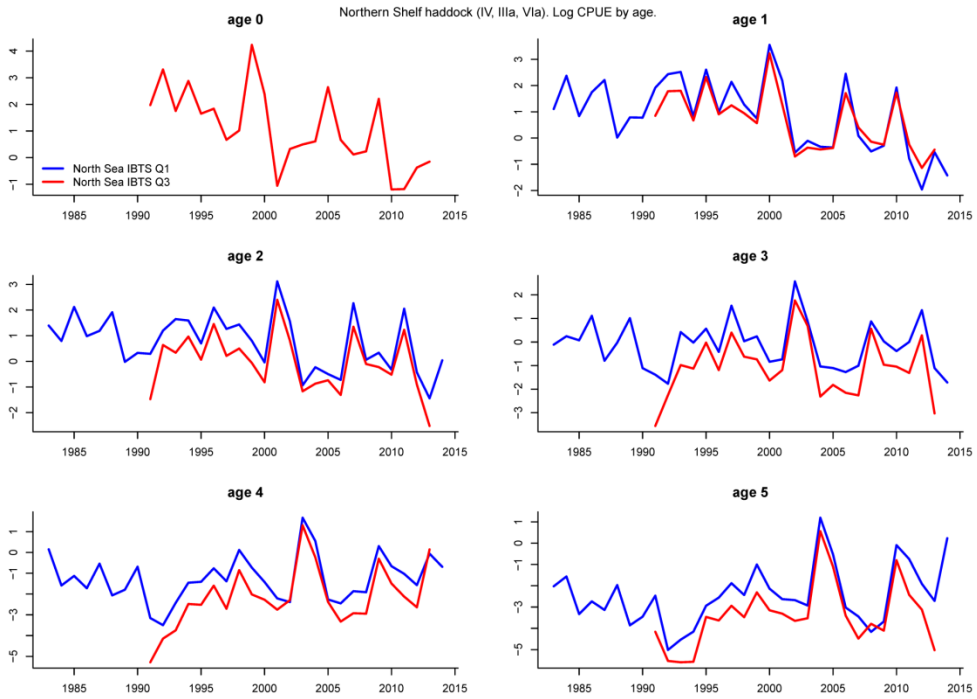


Figure 13.2.11. Haddock in Subarea IV, Division IIIaW and Division VIa. Survey log CPUE (catch per unit effort) at age.

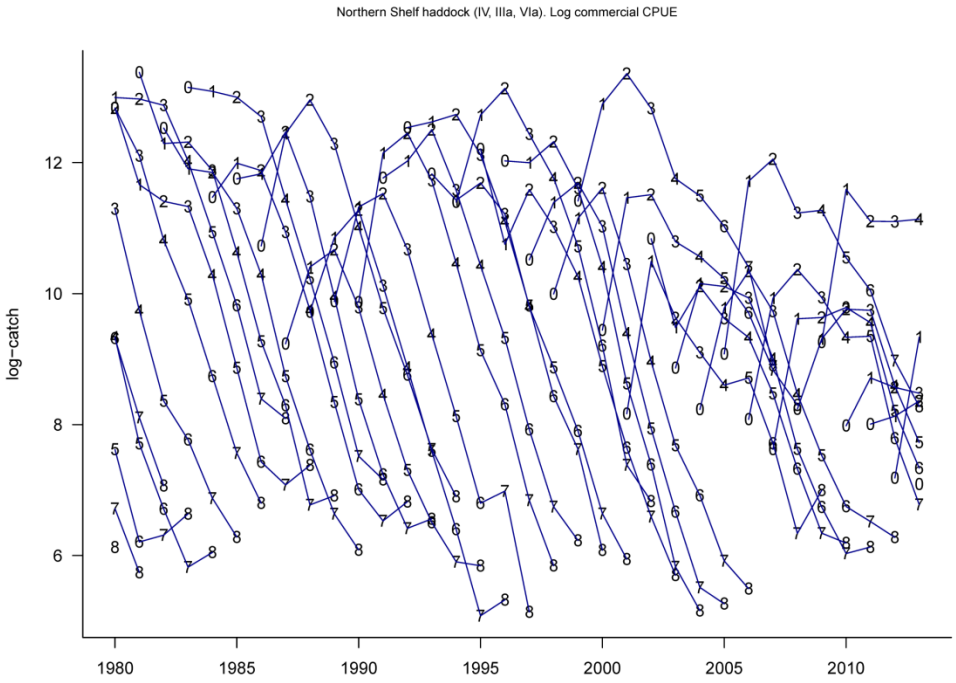


Figure 13.3.1. Haddock in Subarea IV, Division IIIaW and Division VIa. Log catch curves by cohort for total catches.

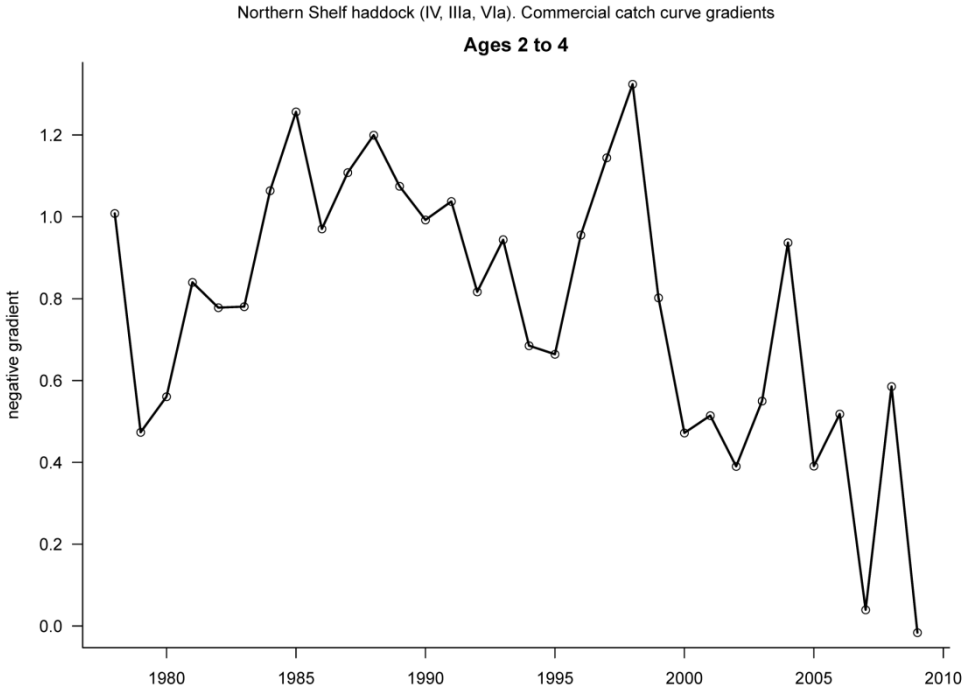


Figure 13.3.2. Haddock in Subarea IV, Division IIIaW and Division VIa. Negative gradients of log catches per cohort, averaged over ages 2-4. The x-axis represents the spawning year of each cohort.

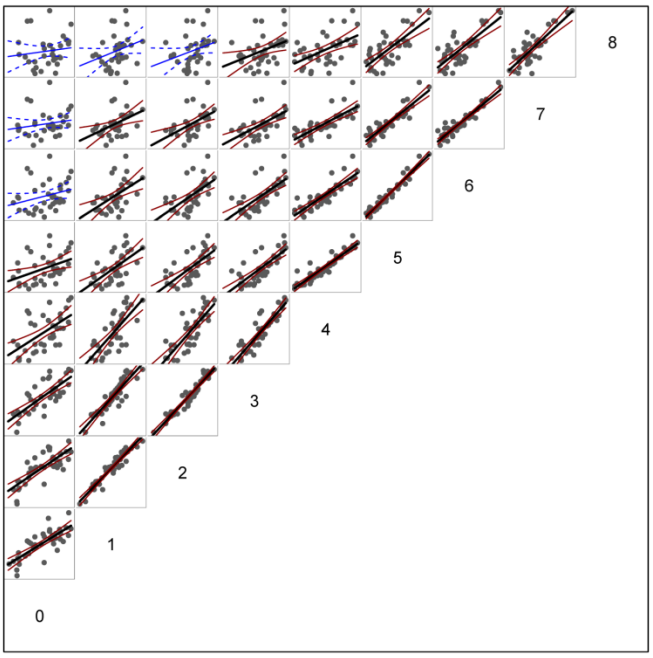


Figure 13.3.3. Haddock in Subarea IV, Division IIIaW and Division VIa. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) represents a significant ($p < 0.05$) regression, while a thin line (and blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

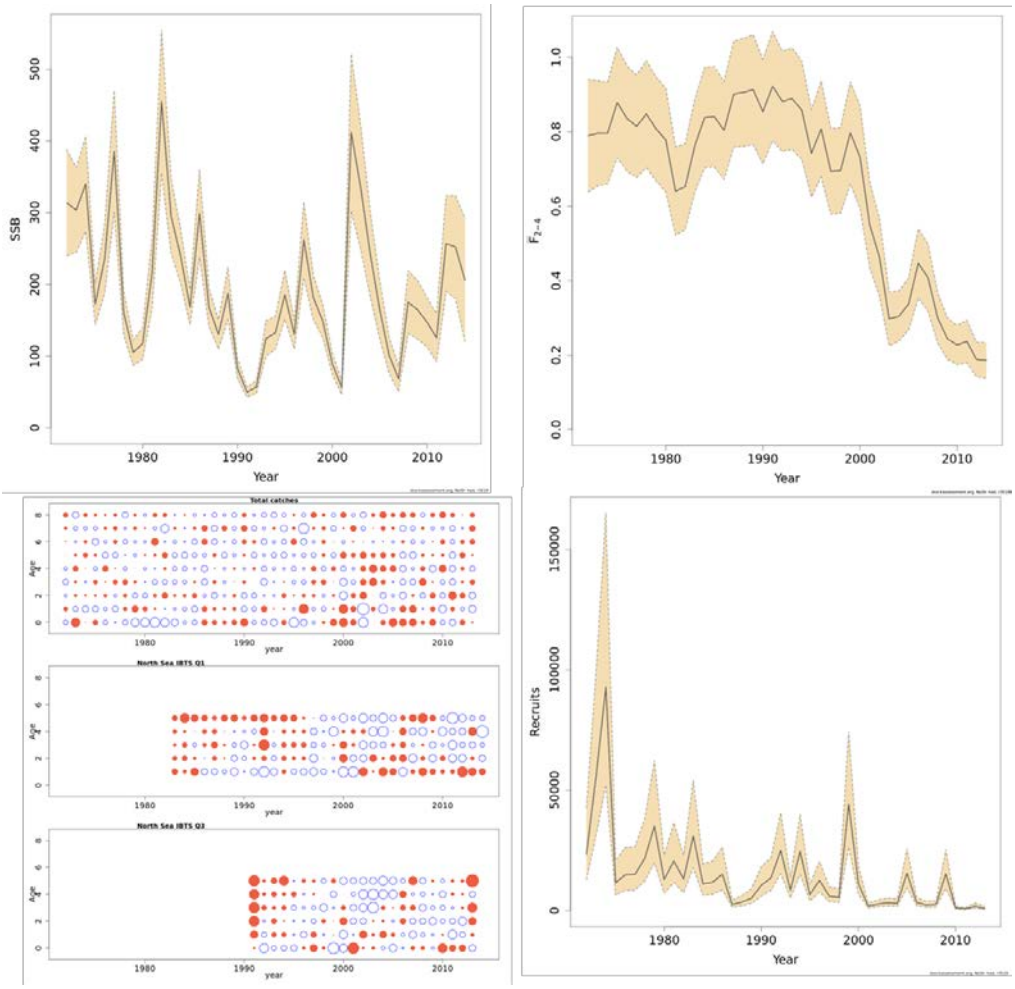


Figure 13.3.4. Haddock in Subarea IV, Division IIIaW and Division VIa. Summary plots from an exploratory SAM assessment. Time-series of estimated SSB (top left), mean F(2-4) (top right) and recruitment (bottom right) are shown with approximate pointwise 95% confidence intervals. Model residuals (botton left) are depicted with a clear blue circle for a positive residual, and a solid red circle for a negative residual.

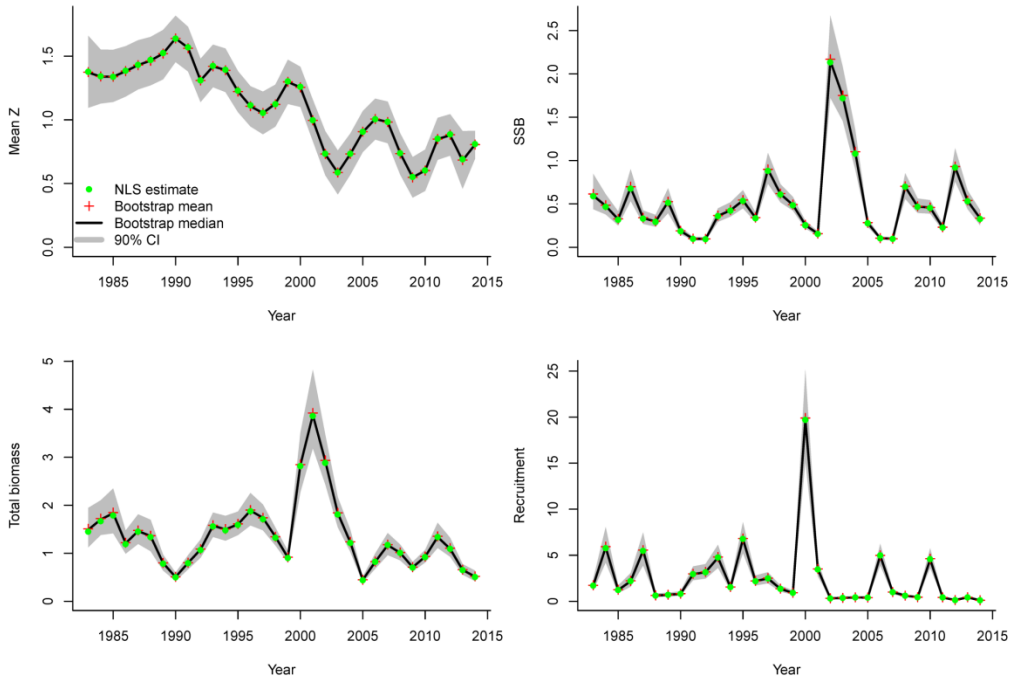


Figure 13.3.5. **Haddock in Subarea IV, Division IIIaW and Division VIa. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.**

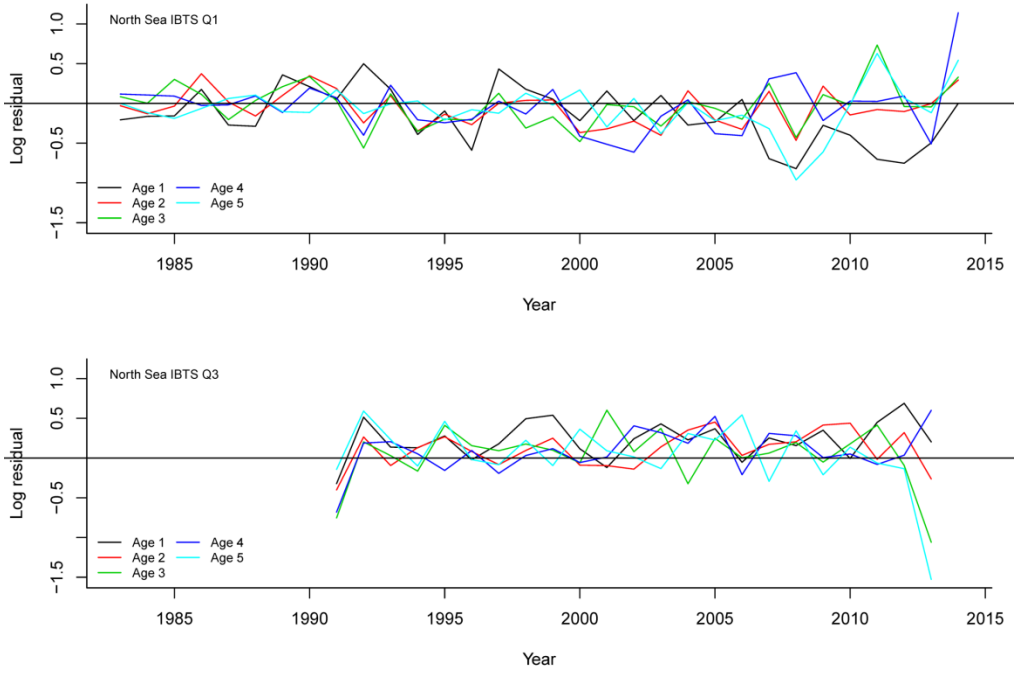


Figure 13.3.6. **Haddock in Subarea IV, Division IIIaW and Division VIa. Log residuals by age from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3).**

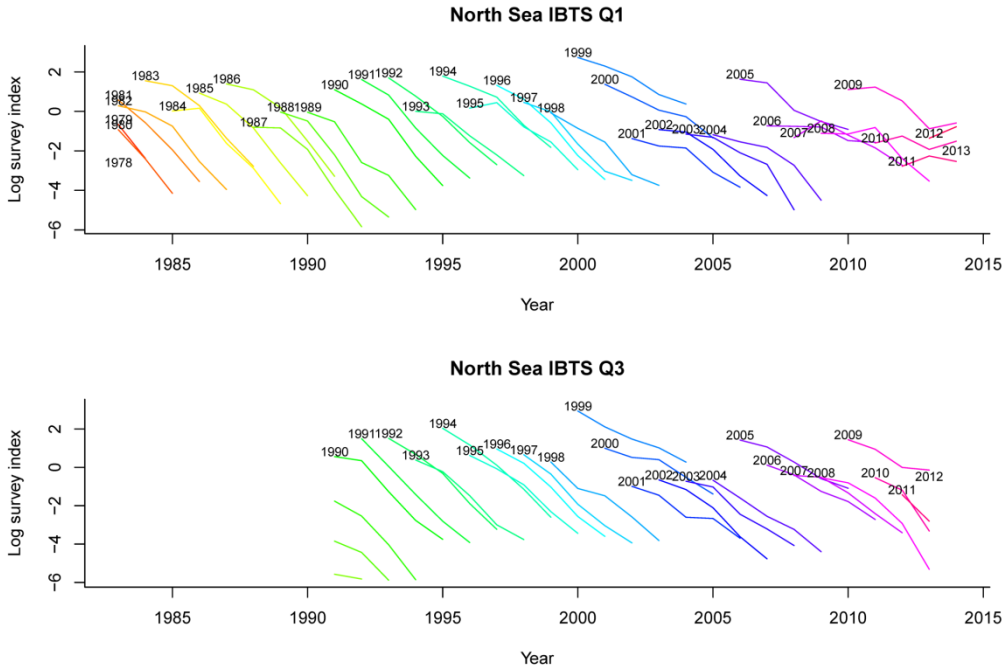


Figure 13.3.7. **Haddock in Subarea IV, Division IIIaW and Division VIa. Log abundance indices by cohort (survey "catch curves") for each of the survey indices.**

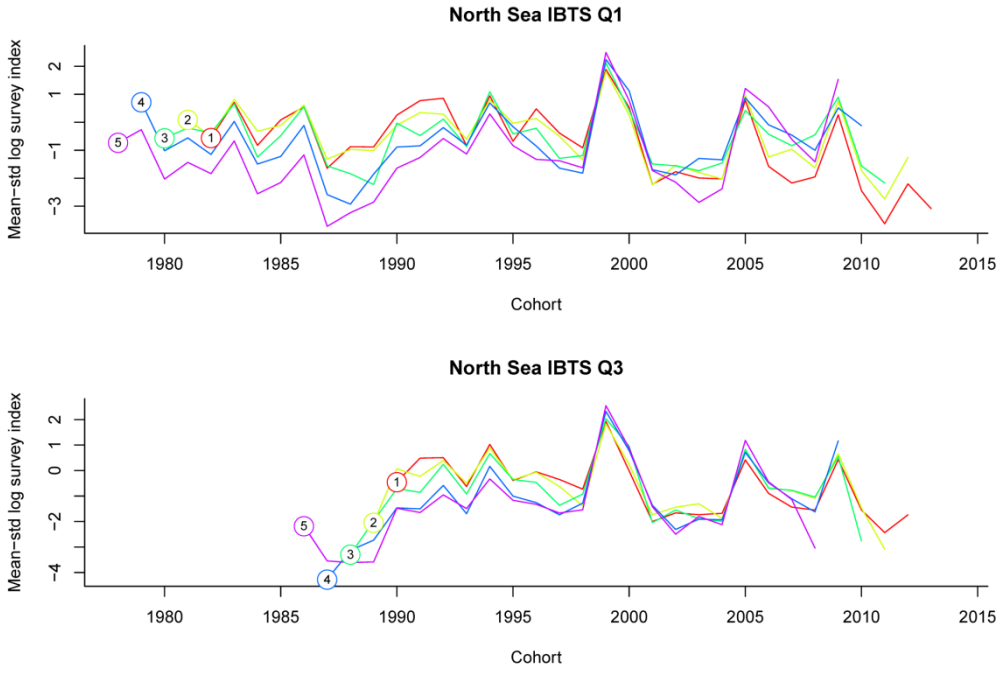


Figure 13.3.8. **Haddock in Subarea IV, Division IIIaW and Division VIa. Mean-standardised log abundance indices by age and cohort for each of the survey indices. The age represented by each line is indicated by a circled number at the start of the line.**

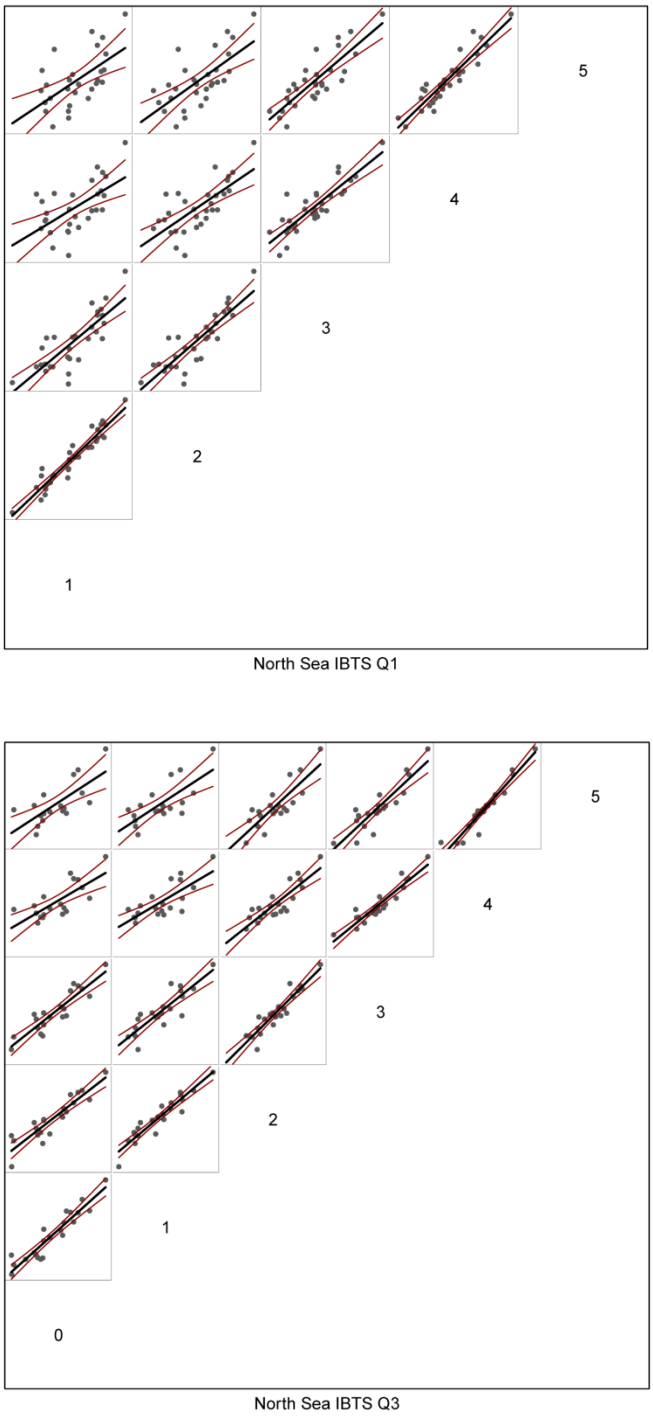


Figure 13.3.9. Haddock in Subarea IV, Division IIIaW and Division VIa. Within-survey correlations for the IBTS Q1 (upper) and Q3 (lower) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

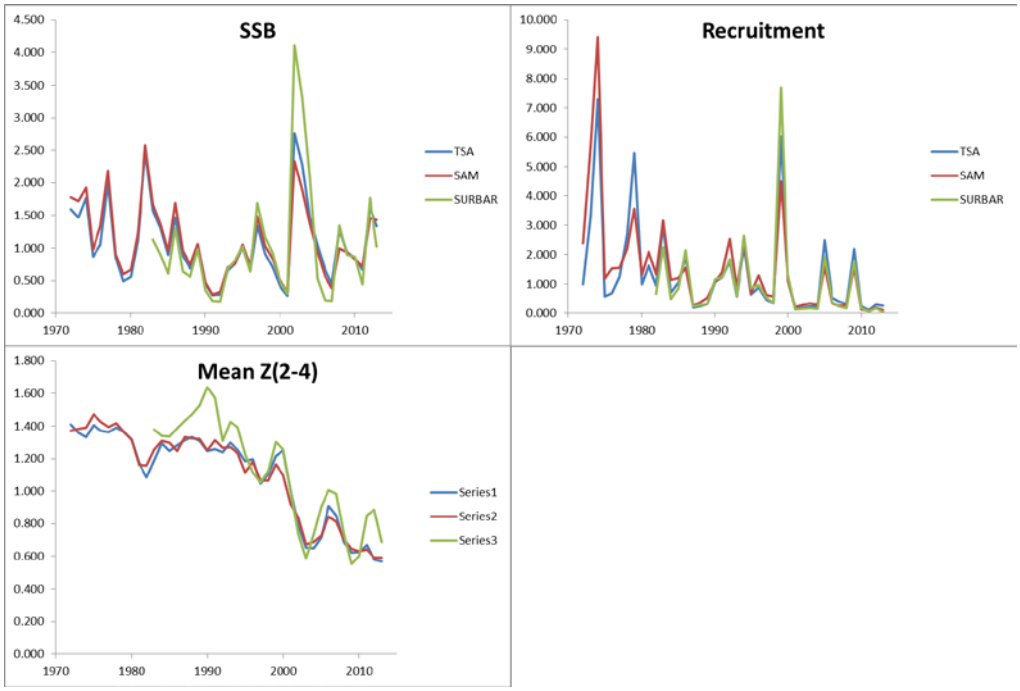


Figure 13.3.10. Haddock in Subarea IV, Division IIIaW and Division VIa. Comparisons of stock summary estimates from TSA (blue), SAM (red) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models, and a composite Z estimate has been made for TSA and SAM by adding natural and fishing mortality estimates. Top: SSB. Middle: mean Z(2-4). Bottom: recruitment. Note: these plots were produced by WGNSSK in April 2014, and therefore do not reflect the updated TSA assessment generated in June 2014. However, the comparison between TSA, SAM and SURBAR will be very similar using the later data.

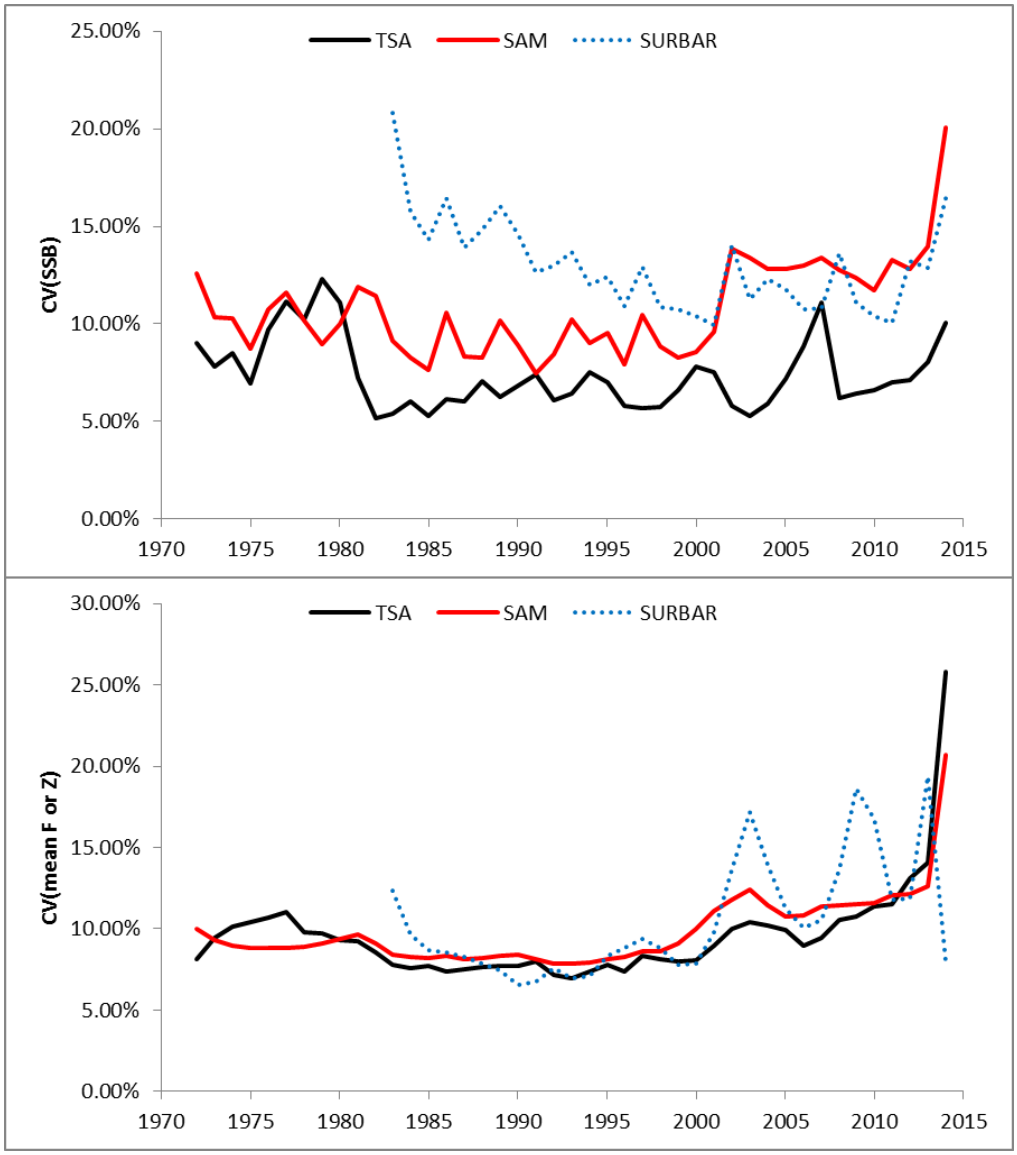


Figure 13.3.11. Haddock in Subarea IV, Division IIIaW and Division VIa. Comparisons of CVs on mean F (or Z) estimates (lower) and SSB estimates (upper) stock summary estimates from TSA (black), SAM (red) and SURBAR (dotted blue) models. x-axis gives the year. Note: these plots were produced by WGNSSK in April 2014, and therefore do not reflect the updated TSA assessment generated in June 2014. However, the comparison between TSA, SAM and SURBAR will be very similar using the later data.

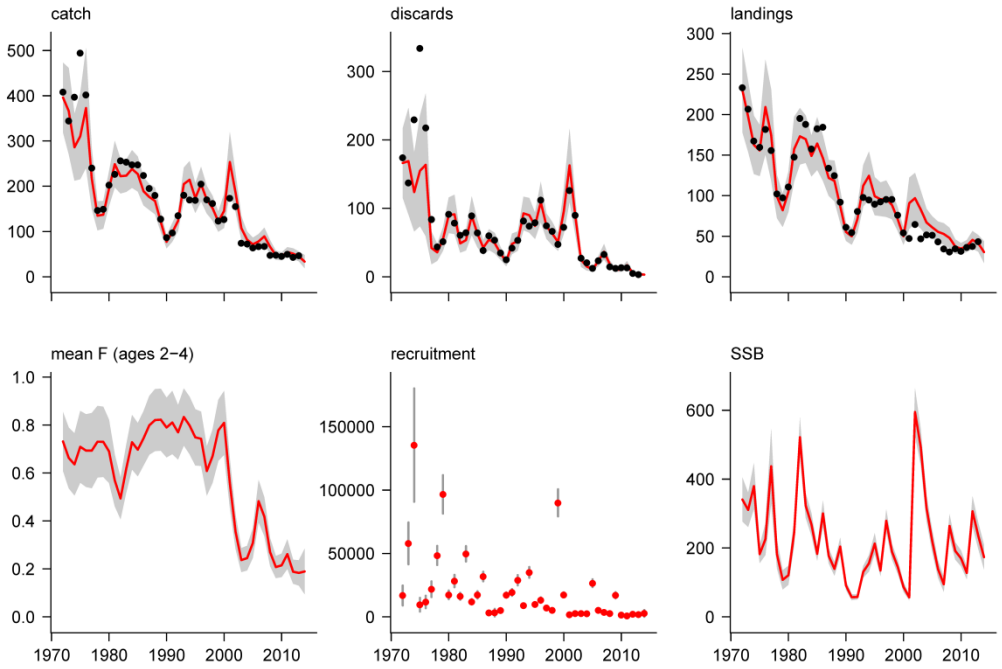


Figure 13.3.12. Haddock in Subarea IV, Division IIIaW and Division VIa. Stock summary from final TSA assessment. Red lines (or points) give best estimates, grey bands (or lines) give approximate pointwise 95% confidence intervals, and black points give observed values (for catch, landings and discards+IBC).

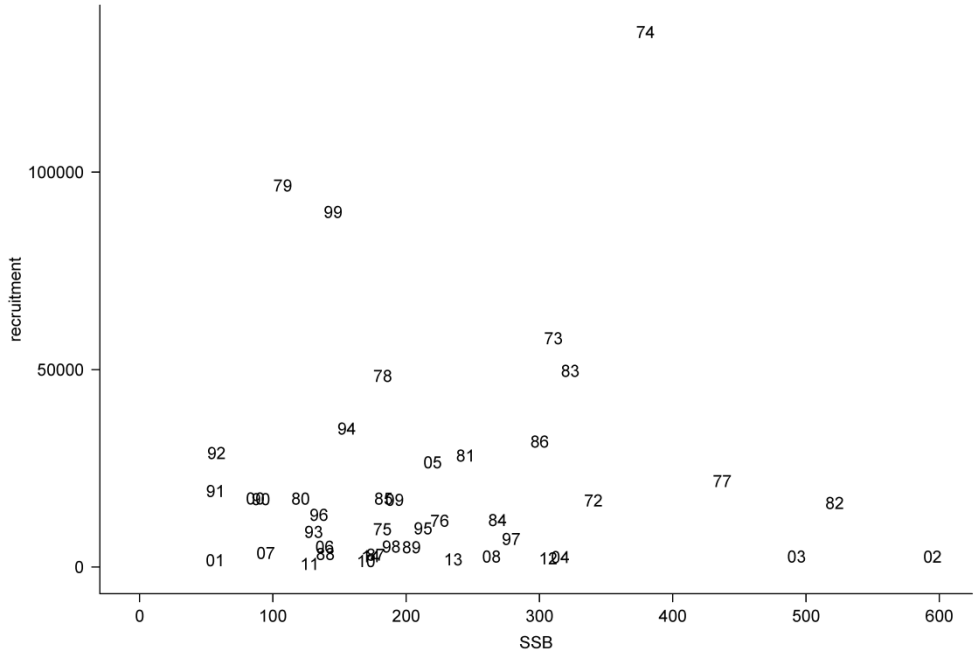


Figure 13.3.13. Haddock in Subarea IV, Division IIIaW and Division VIa. Stock-recruitment estimates from the final TSA assessment. Points are labelled by year-class

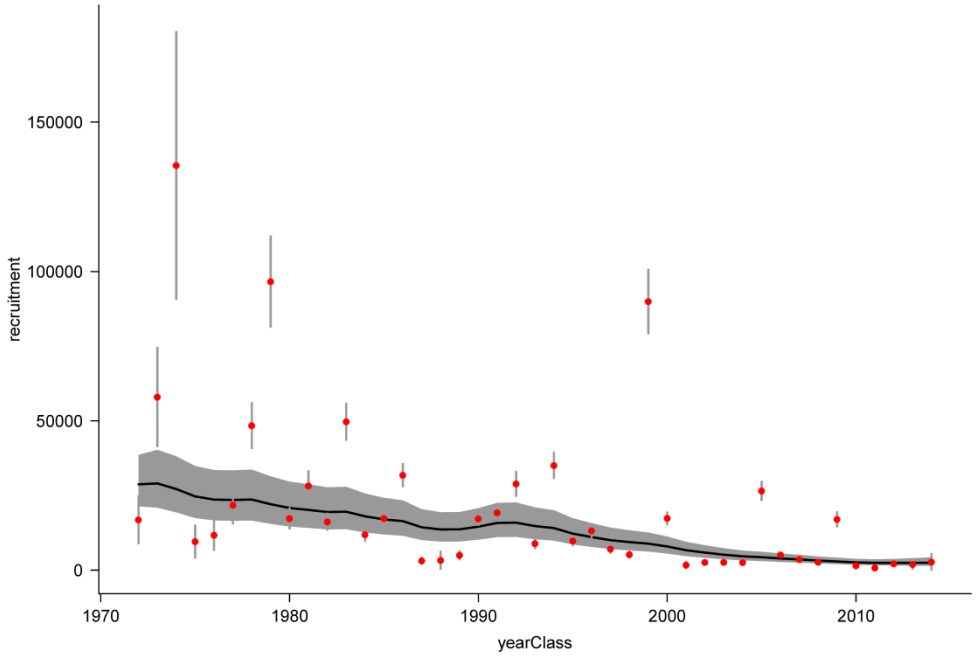


Figure 13.3.14. Haddock in Subarea IV, Division IIIaW and Division VIa. Estimated recruitment time-series from the final TSA assessment. Red points give estimated values with grey bars indicating approximate pointwise 95% confidence intervals. The black line (also with 95% CI) shows the underlying random-walk recruitment model estimated by TSA.

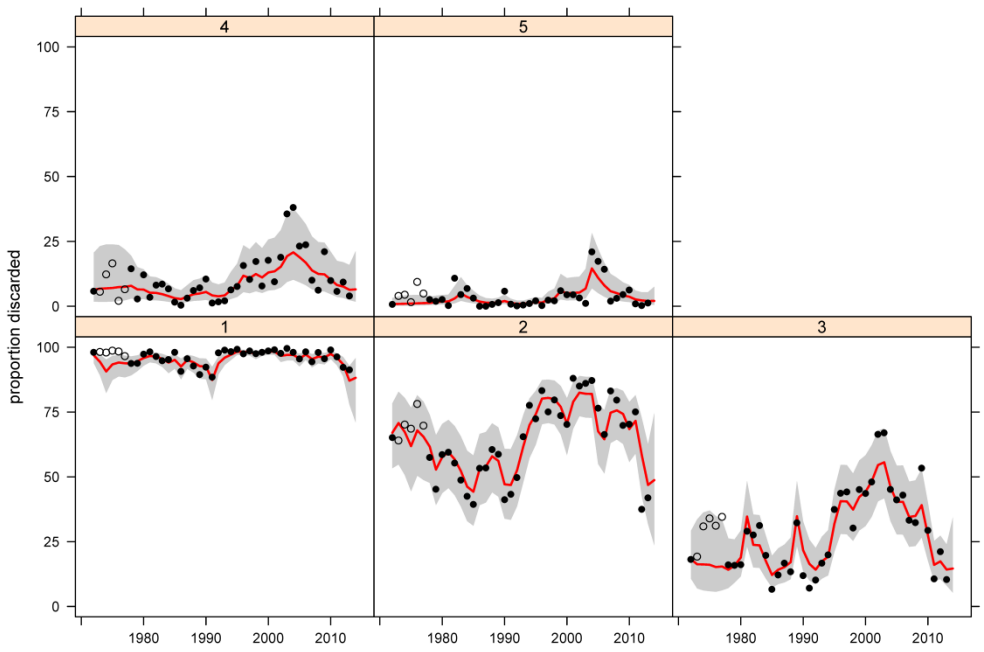


Figure 13.3.15. Haddock in Subarea IV, Division IIIaW and Division VIa. Observed (points) and fitted (red lines with 95% CI indicated by grey bands) for the proportion discarded by age. Here "discards" is shorthand for combined discards + industrial bycatch. The open points for the years 1973-1977 indicate that these values are treated as missing in the TSA estimation. All haddock of age 0 are assumed to be either discarded or caught as industrial bycatch.

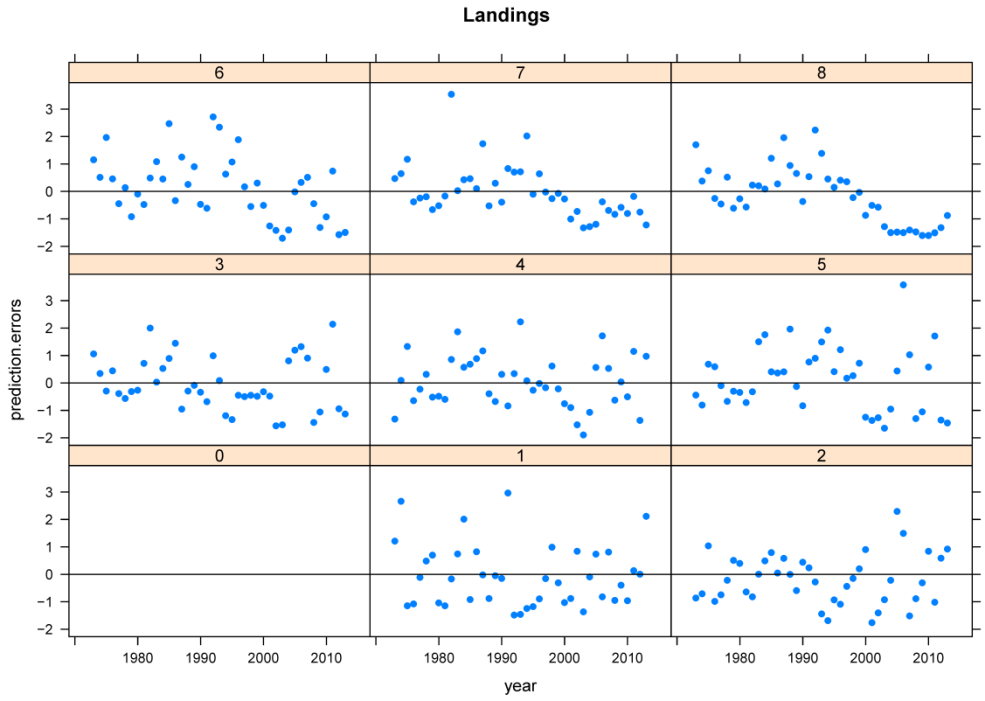


Figure 13.3.16. Haddock in Subarea IV, Division IIIaW and Division VIa. Standardised TSA landings prediction errors by age.

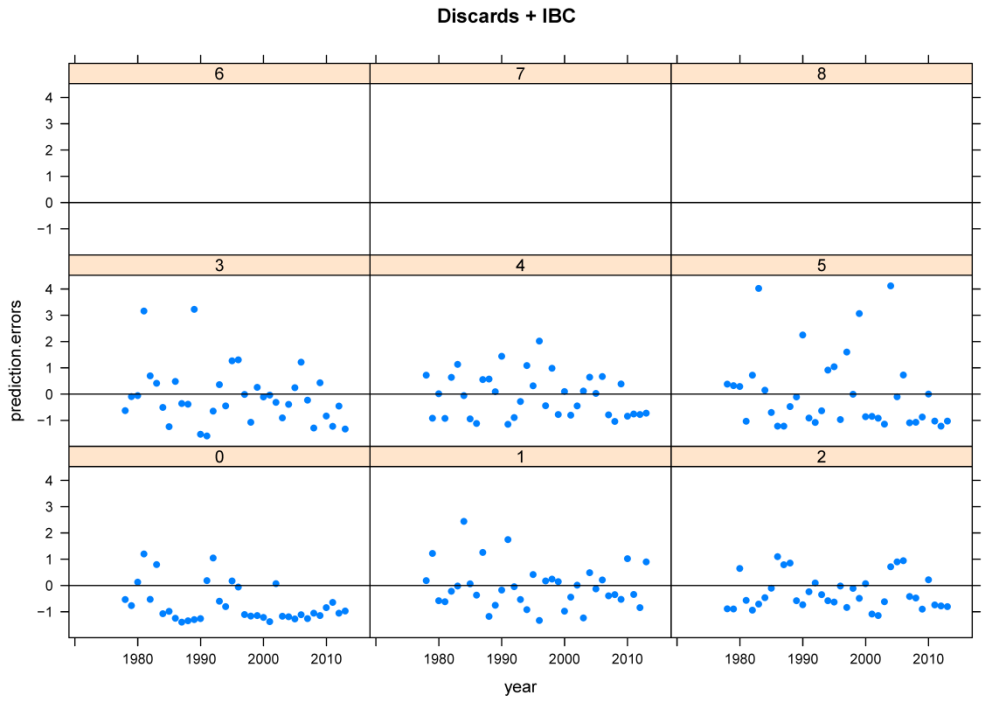


Figure 13.3.17. Haddock in Subarea IV, Division IIIaW and Division VIa. Standardised TSA discards + IBC prediction errors by age.

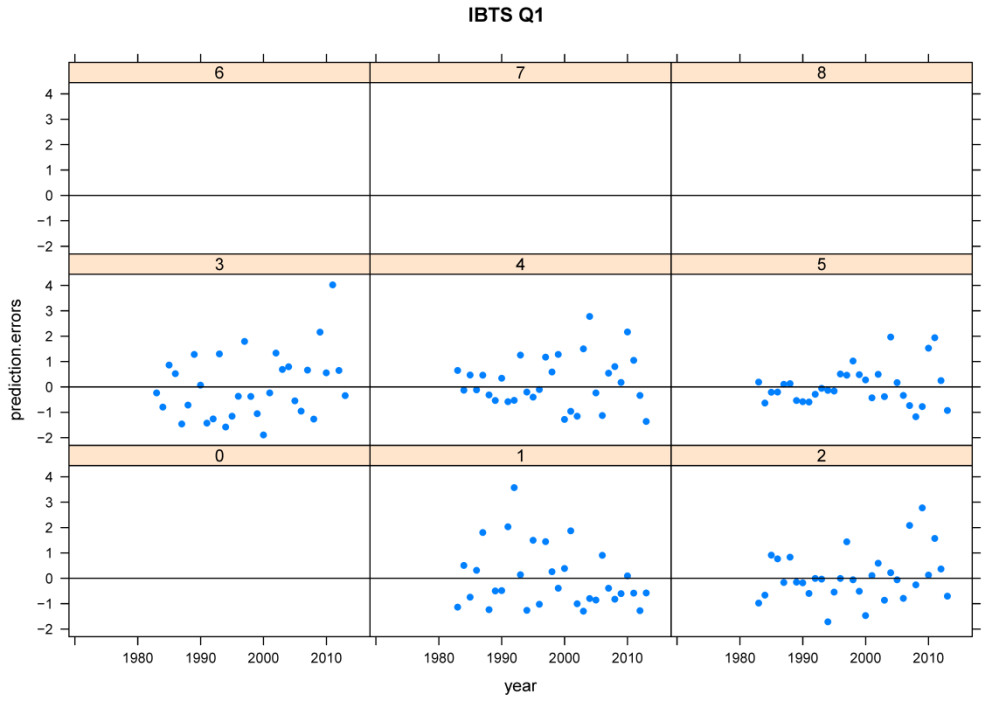


Figure 13.3.18. Haddock in Subarea IV, Division IIIaW and Division VIa. Standardised TSA prediction errors by age for the IBTS Q1 survey index.

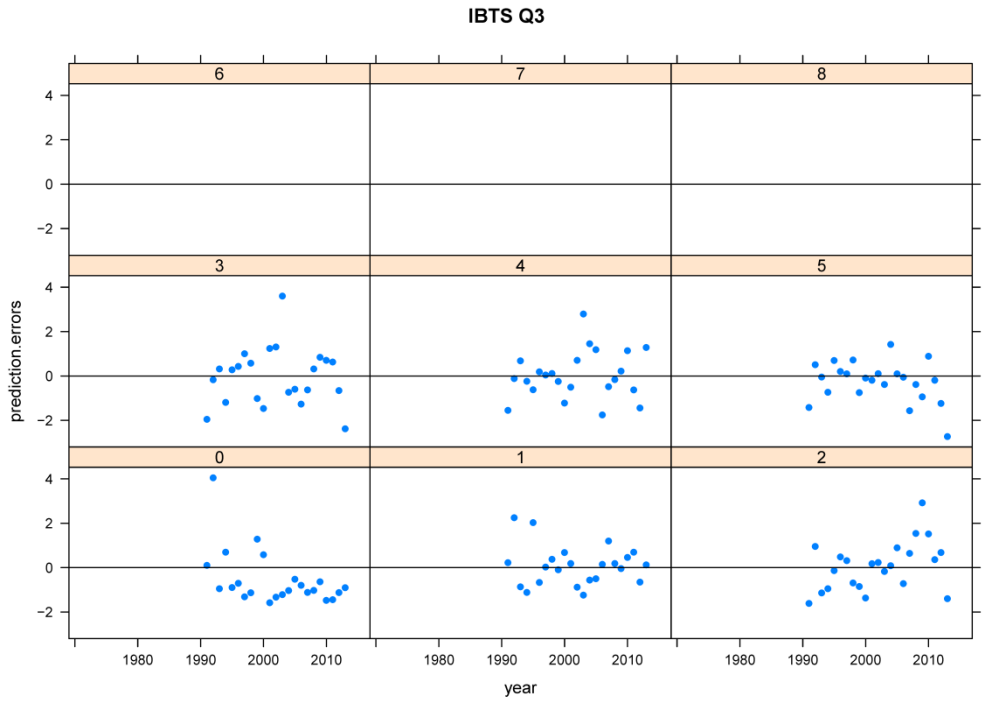


Figure 13.3.19. Haddock in Subarea IV, Division IIIaW and Division VIa. Standardised TSA prediction errors by age for the IBTS Q3 survey index.

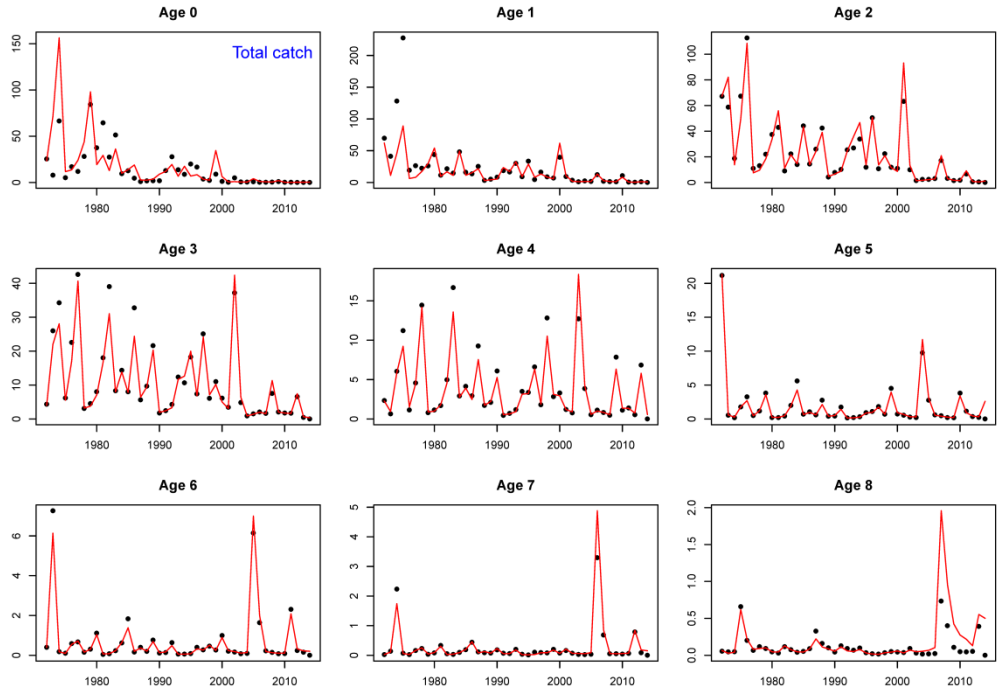


Figure 13.3.20. **Haddock in Subarea IV, Division IIIaW and Division VIa. Time-series of observed (points) and fitted (lines) values for total catch, by age.**

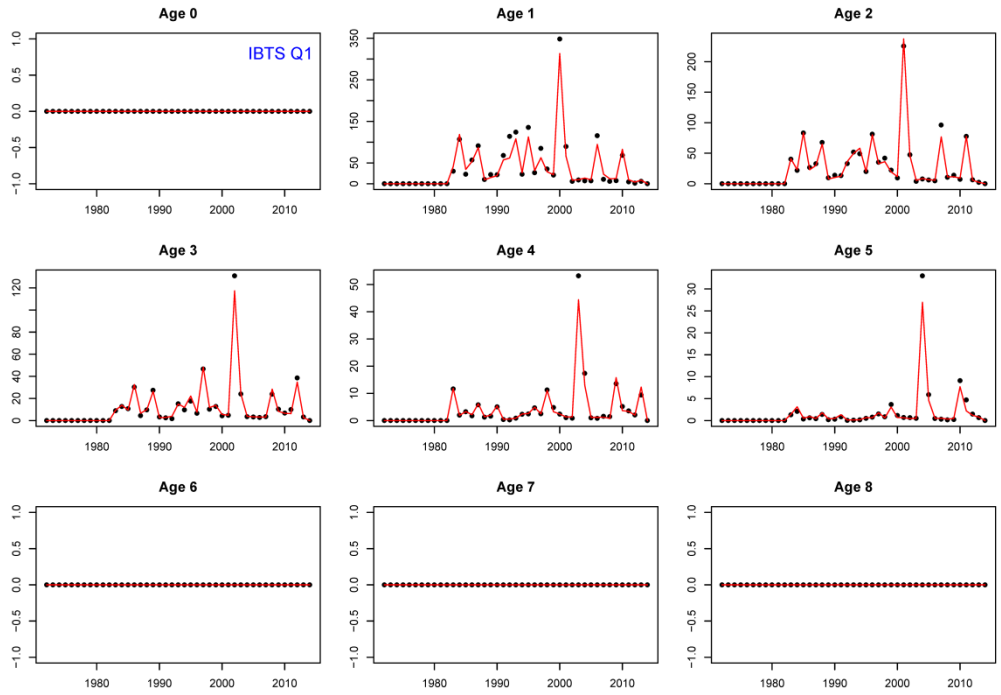


Figure 13.3.21. **Haddock in Subarea IV, Division IIIaW and Division VIa. Time-series of observed (points) and fitted (lines) values for the IBTS Q1 survey index, by age.**

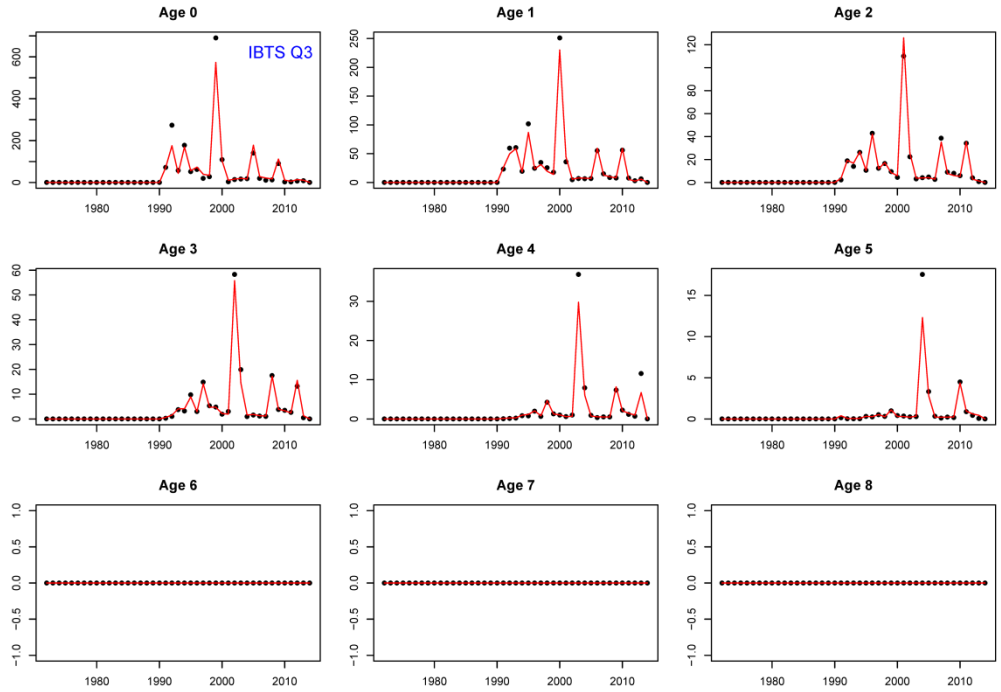


Figure 13.3.22. Haddock in Subarea IV, Division IIIaW and Division VIa. Time-series of observed (points) and fitted (lines) values for the IBTS Q3 survey index, by age.

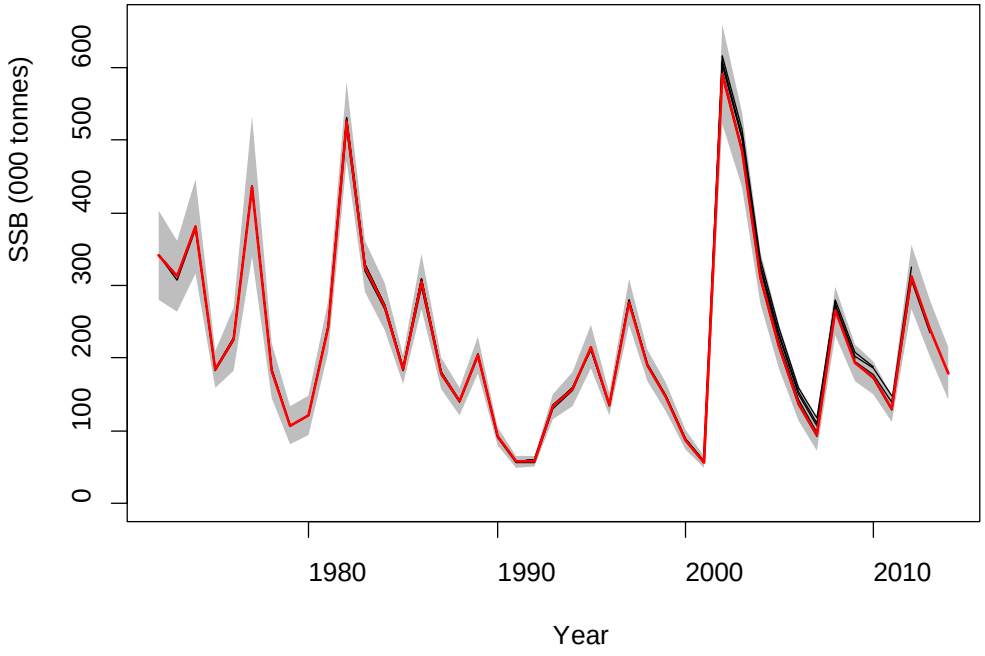


Figure 13.3.23. Haddock in Subarea IV, Division IIIaW and Division VIa. Five-year retrospective plots for SSB in the final TSA assessment. The red line gives the full time-series estimates with the grey band indicating the approximate pointwise 95% confidence interval, while the black lines show the median estimate from retrospective plots. Note: time did not permit new retrospective runs to be produced in June 2014. This plot was produced by WGNSSK in April 2014, and therefore does not reflect the updated TSA assessment generated in June 2014. However, the retrospective performance of the new run is likely to be very similar.

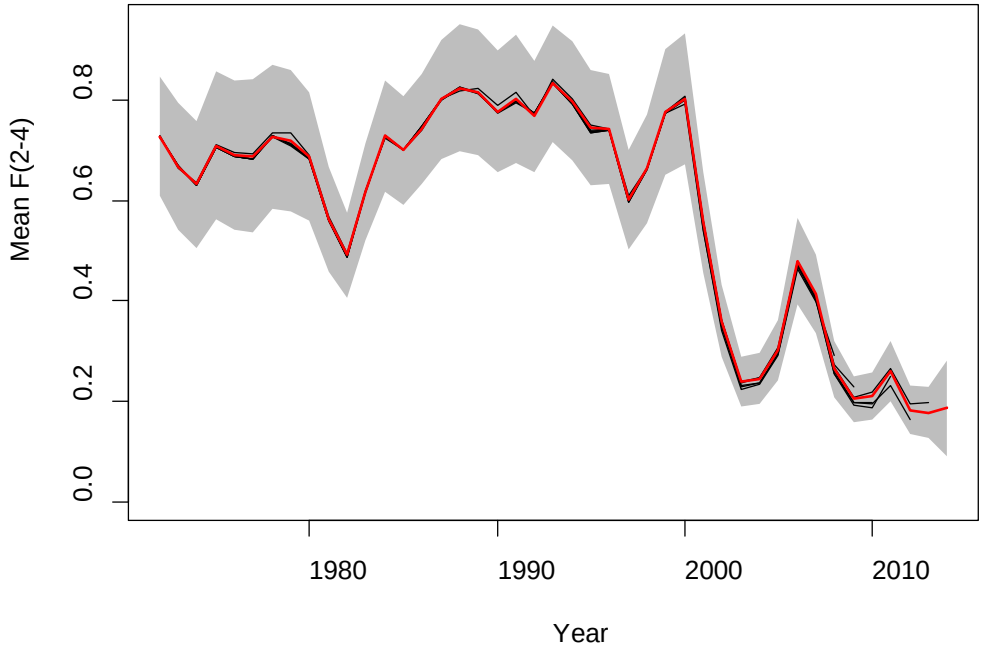


Figure 13.3.24. Haddock in Subarea IV, Division IIIaW and Division VIa. Five-year retrospective plots for mean F(2-4) in the final TSA assessment. The red line gives the full time-series estimates with the grey band indicating the approximate pointwise 95% confidence interval, while the black lines show the median estimate from retrospective plots. Note: time did not permit new retrospective runs to be produced in June 2014. This plot was produced by WGNSSK in April 2014, and therefore does not reflect the updated TSA assessment generated in June 2014. However, the retrospective performance of the new run is likely to be very similar.

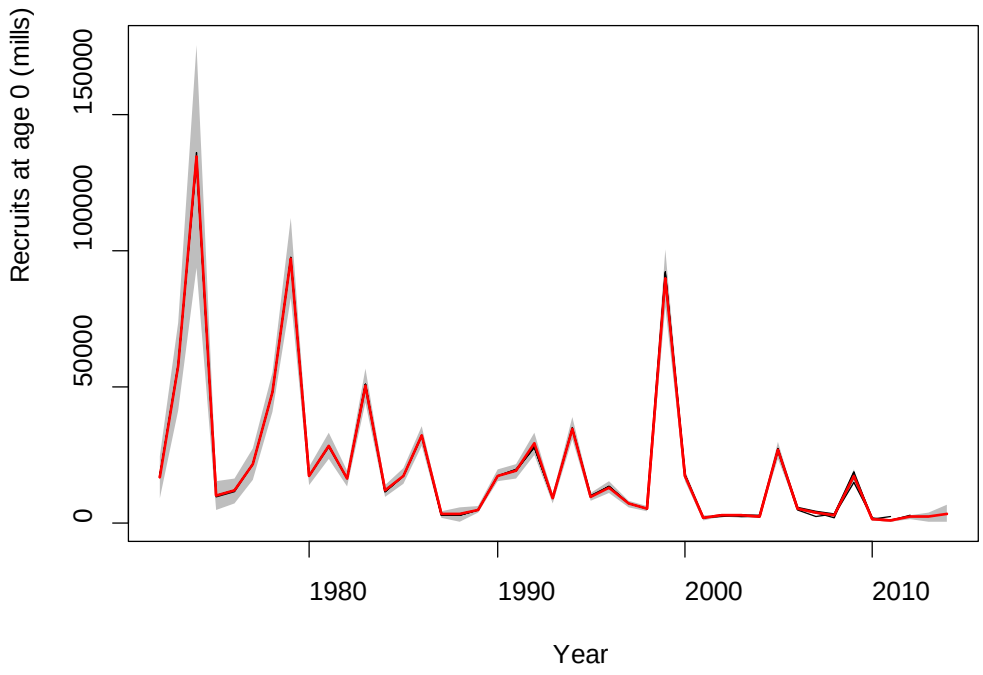


Figure 13.3.25. Haddock in Subarea IV, Division IIIaW and Division VIa. Five-year retrospective plots for recruitment at age 0 in the final TSA assessment. The red line gives the full time-series estimates with the grey band indicating the approximate pointwise 95% confidence interval, while the black lines show the median estimate from retrospective plots. Note: time did not permit new retrospective runs to be produced in June 2014. This plot was produced by WGNSSK in April 2014, and therefore does not reflect the updated TSA assessment generated in June 2014. However, the retrospective performance of the new run is likely to be very similar.

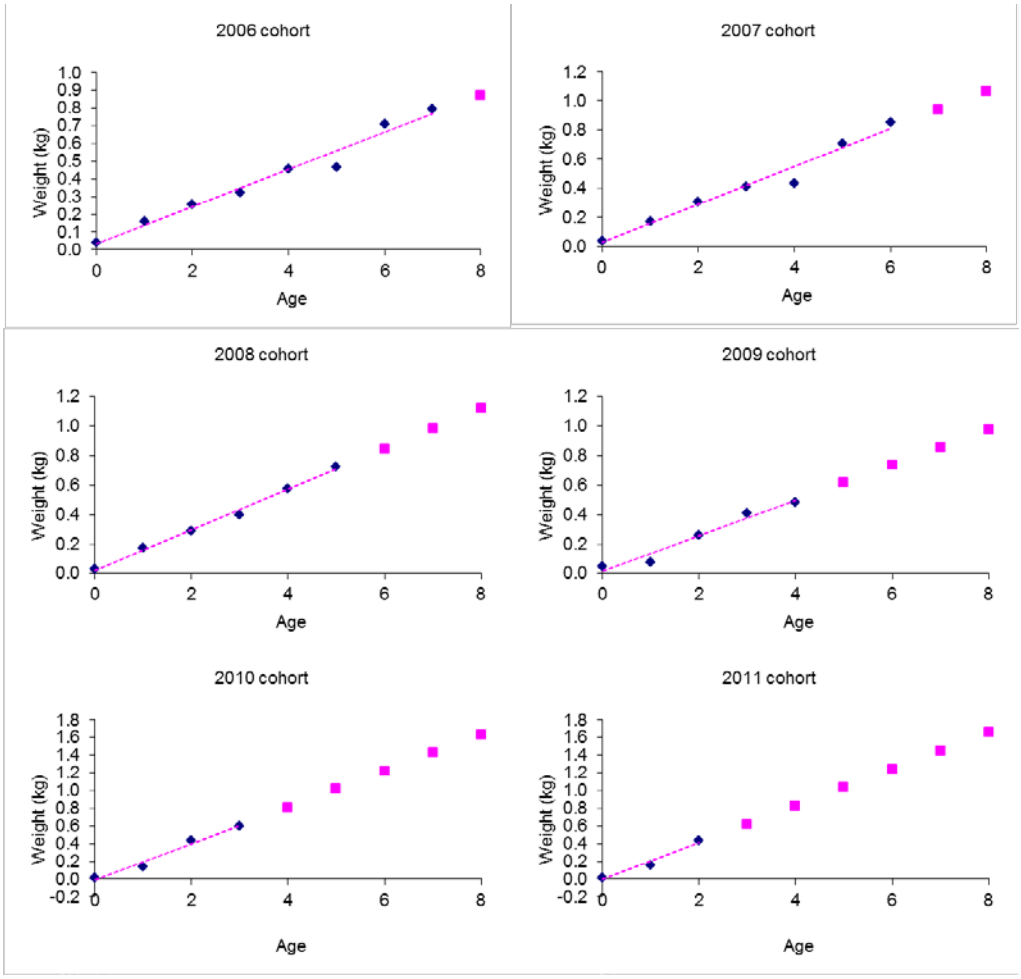


Figure 13.6.1. Haddock in Subarea IV, Division IIIaW and Division VIa. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski 2011). Cohorts 2006-2011 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

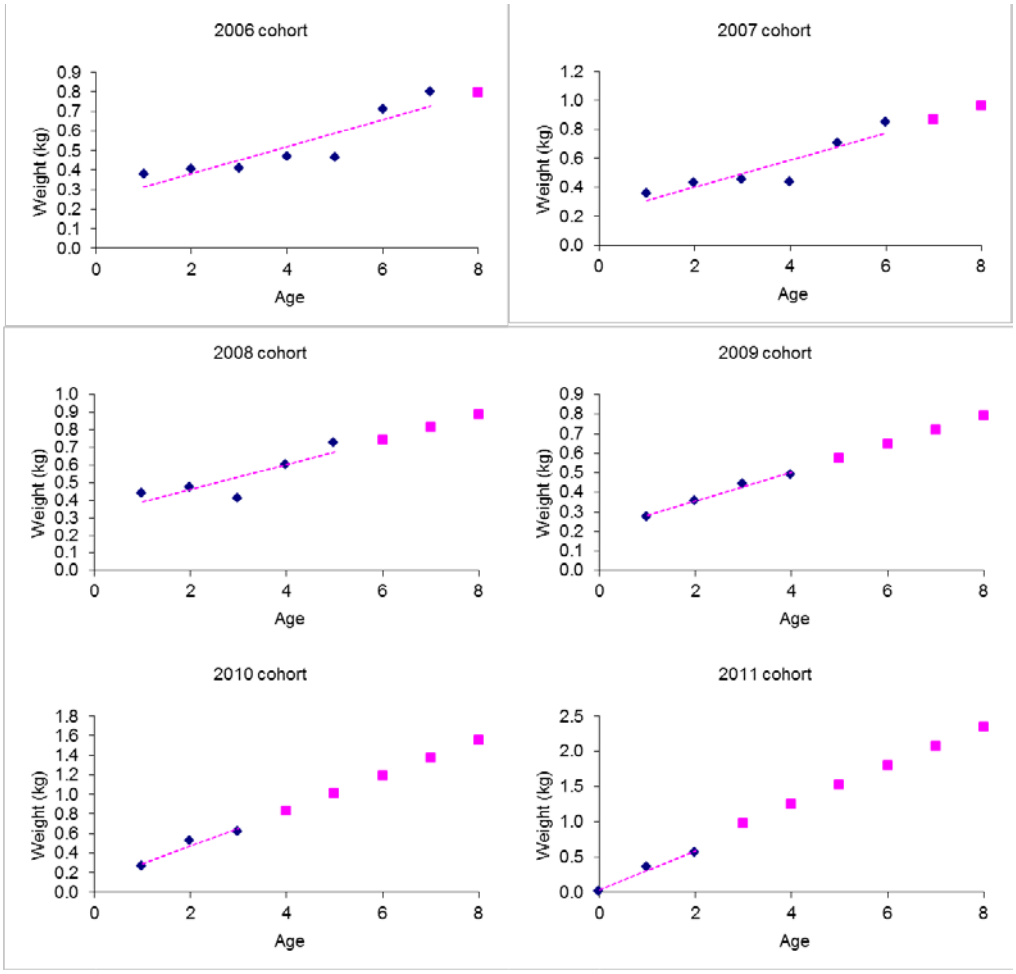


Figure 13.6.2. **Haddock in Subarea IV, Division IIIaW and Division VIa. Results of growth modelling for landings weights using cohort-based linear models (Jaworski 2011). Cohorts 2006-2011 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.**

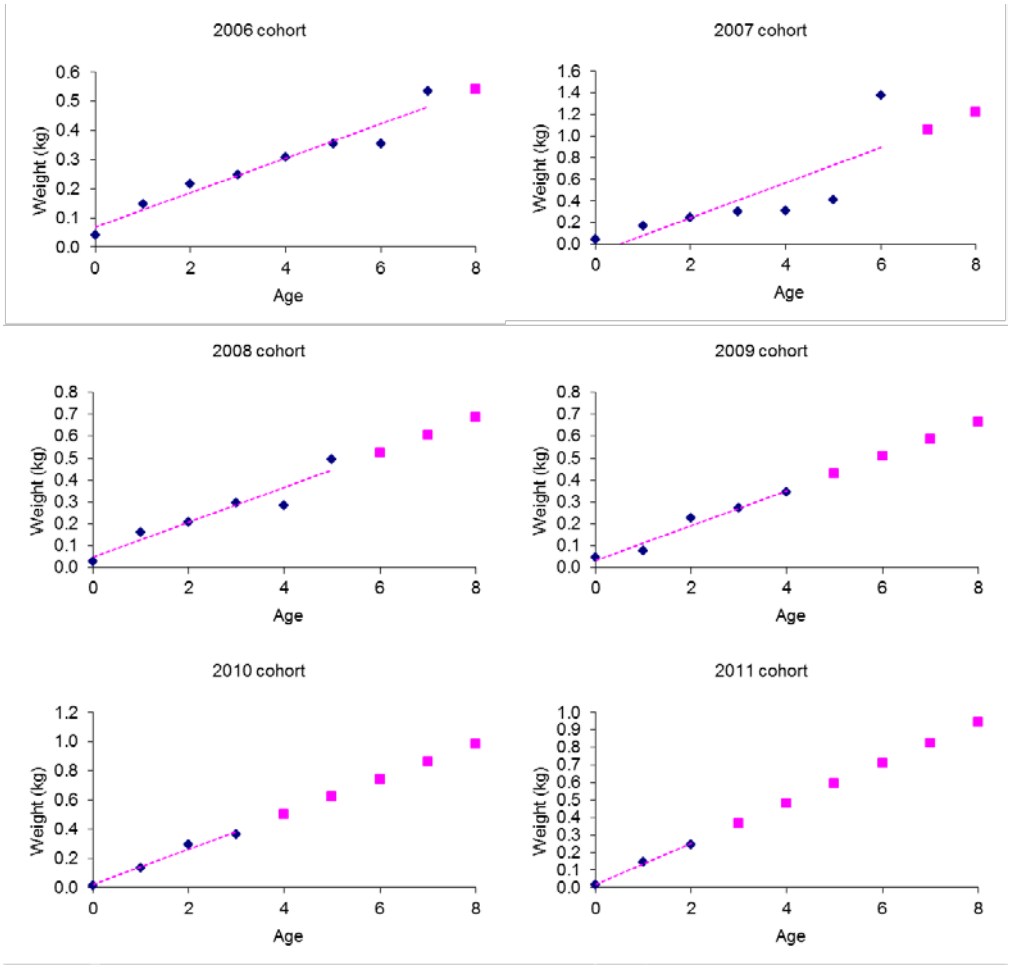


Figure 13.6.3. Haddock in Subarea IV, Division IIIaW and Division VIa. Results of growth modelling for discard weights using cohort-based linear models (Jaworski 2011). Cohorts 2006-2011 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages

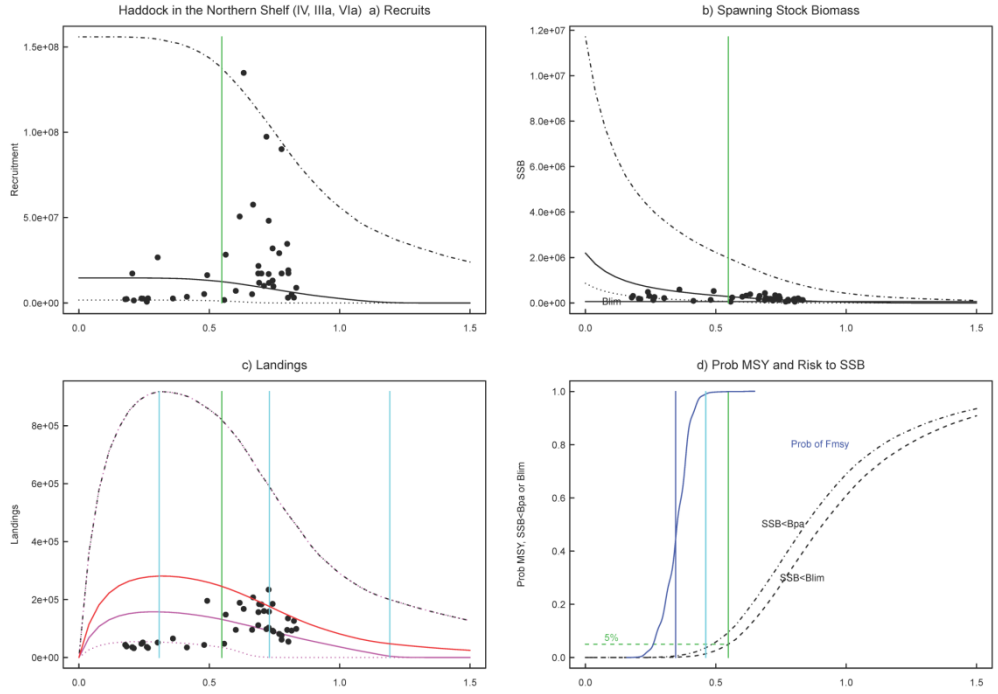


Figure 13.8.1. Haddock in Subarea IV, Division IIIaW and Division VIa. Results of EqSIM evaluation of F(msy).

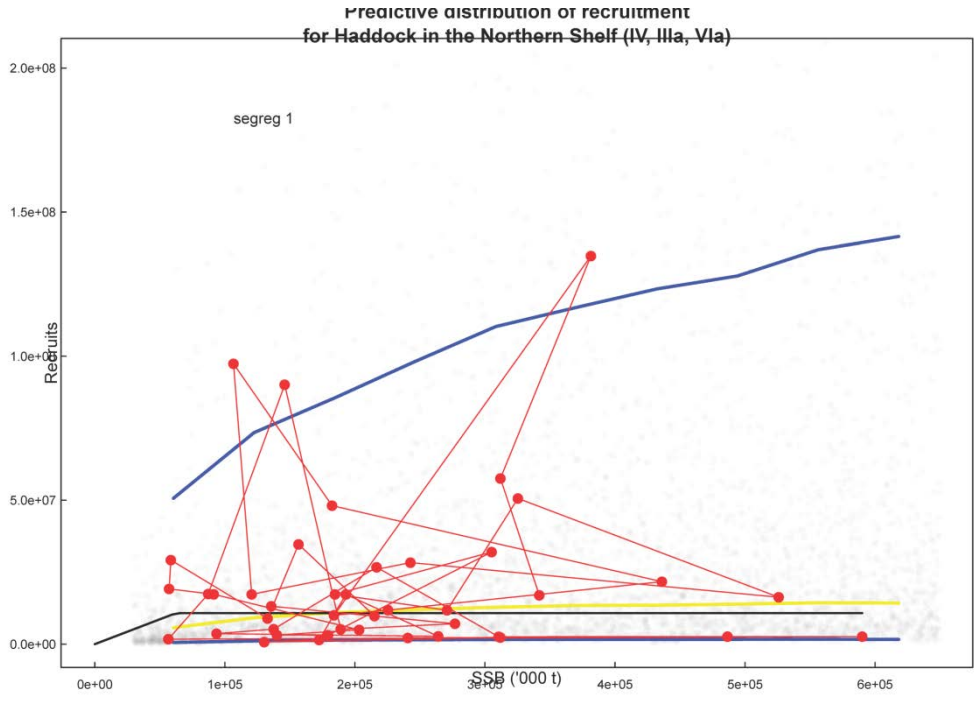


Figure 13.8.2. Haddock in Subarea IV, Division IIIaW and Division VIa. Segmented regression model fit to stock-recruit scatterplot, showing an estimated changepoint at 62 436 tonnes.

14 Cod

This assessment relates to the cod stock in the North Sea (Sub-area IV), the Skagerrak (the northern section of Division IIIa) and the eastern Channel (Division VIId). This assessment is an update from last year.

A stock annex (within Annex 3 to this report) records more detail and references historic information on the stock definition, ecosystem aspects and the fisheries. This report section records only recent developments and new information presented to WGNSSK.

14.1 General

14.1.1 Stock definition

A summary of available information on stock definition can be found in the Stock Annex.

14.1.2 Ecosystem aspects

The North Sea is characterised by episodic changes in productivity of key components of the ecosystem. Phytoplankton, zooplankton, demersal and pelagic fish have all exhibited such cycles in variability. Managers should expect long-term change, and ensure that management plans have the potential to respond to new circumstances. Examples of these changes include the gadoid outburst in the 1970s. The contracted range of the North Sea cod stock can be linked to reduced abundance as well as environmental factors. A summary of available information on ecosystem aspects is presented in the Stock Annex.

14.1.3 Fisheries

Cod are caught by virtually all the demersal gears in Sub-area IV and Divisions IIIa (Skagerrak) and VIId, including beam trawls, otter trawls, seine nets, gill nets and lines. Most of these gears take a mixture of species. In some of them, cod are considered to be a by-catch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, some of the fixed gear fisheries). The main gears landing cod in the EU are primarily TR1 (mainly operated by Scotland, Denmark and Germany), but also GN1 (mainly Denmark), BT1 (mainly Belgium), BT2 (mainly Netherlands), and TR2. The overall effort by demersal trawls/seines has shown a reduction since 2003, especially in the North Sea. The effort by larger mesh (TR1) had remained relatively stable over the previous cod plan (2004-2009) but has been declining since the full implementation of the new cod plan in 2010 (STECF, 2013). A summary of historic information on the directed and by-catch cod fisheries and past and current technical measures used for the management of cod is presented in the Stock Annex.

Technical Conservation Measures

In 2009 a new system of effort management, by setting effort ceilings (kilowatt-days), was introduced in accordance with the new cod management plan (EC 1342/2008). The number of kw-days utilized was estimated for the different metiers of the national fleets during a reference period selected by each nation (2004-2006 or 2005-2007). From these reference values, the effort in the primary métiers catching cod (with discard and

bycatch taken into account) will be reduced in direct proportion to reductions in fishing mortality until the new cod management plan target fishing mortality of 0.4 is achieved for levels of SSB at or above B_{pa}. EC 1342/2008 specifies that the reductions in effort shall be applied to metiers using Otter Trawls, Danish Seines or similar gears with mesh size 80 mm and larger and Gill Nets. However, if certain national fleet segments can provide proof that they use highly selective gears and/or that their catches per fishing trip comprise less than 5% cod, the reductions will not pertain. National fleet segments with less than 1.5% cod catches can apply to be excluded from the effort management regime completely. There has been no reduction in effort ceiling in 2013 and 2014 compared to 2012.

In 2008, Scotland introduced a voluntary programme known as "Conservation Credits", which involved seasonal closures, real-time closures (RTCs) and various selective gear options. This was designed to reduce mortality and discarding of cod. The scheme was incentivised by rewarding participating skippers with additional days at sea. The real-time closures system (15 were implemented in 2008) discouraged vessels from operating in areas of high cod abundance. In 2009, the number of closures implemented was increased substantially (to 144 for all areas subject to the cod management plan) and made mandatory, with up to 12 being implemented at any one time. Closures are determined by landings per unit effort, based on fine scale VMS data and daily logbook records and also by onboard inspections. Based on new in-year information on cod movement from tagging, the dimensions of the RTCs were increased by just over four times (from 50 square nautical miles to 225) from July 2010. The use of more species and size selective gears (some trialled by the Marine Laboratory in Aberdeen) formed a further series of options within the scheme. These included the 'Orkney trawl, the use of nets with 130mm codends and larger meshes in the square meshed panels of Nephrops trawls. The scheme has delivered a total of 165, 185, 173 and 166 closures in 2010, 2011, 2012 and 2013, respectively. ICES notes that from the initial year of operation (2008) cod discarding rates in Scotland have decreased from 62% to 24% in 2011 and 2012, but have increased again to 31% in 2013; it is hypothesised that the increase in 2013 may be due in part to FDF (fully documented fisheries) vessels putting upward pressure on the lease price of cod, resulting in non-FDF vessels increasing the amount of cod they discard because they are unwilling to pay an above-market price for cod quota.

The expansion of the closed-circuit TV (CCTV, 20% of landings in 2013) and FDF programmes in 2010–2013 in Scotland, Denmark, Germany, and England is expected to have contributed to the reduction of cod mortality. Under this scheme, UK vessels are not permitted to discard any cod, while Danish and German vessels are still permitted to discard undersized cod. In the Netherlands, five vessels have participated in a pilot project during 2012, extended to 11 vessels in 2013. For these nations, all cod caught are counted against the quota. Some of the fleets in this programme have shown a noticeable increase in smaller fish in the landings, which could imply that less highgrading occurs.

Changes in national fleet dynamics

The ICES WGFTFB report now only provides a description of changes in EU fishing fleets and effort relevant to assessment working groups every second year; there is no such information in the latest ICES-WGFTFB (2013) report.

Fisheries Science Partnerships

Up until recently, a number of collaborative studies (Fisheries-Science Partnerships) provided useful information to WGNSSK on the distribution, relative abundance and

size/age composition of cod and other species, as well as comparisons with the IBTS surveys and investigations into the effect of seabed type on catch rates. The WG regrets that these programmes have now come to an end due to funding constraints. The WG would welcome and encourage other studies of this nature, particularly on a regional basis, as they enhance the ability of the group to interpret information and analyses, and enhance the quality of management advice that the group can provide. Information on past Fisheries-Science Partnerships can be found in the Stock Annex.

The North Sea Stock Survey

Comparison between the fishers' North Sea stock survey (Napier, 2012; Figure 14.17) and the IBTS survey data has shown in previous years that the time-series are broadly in agreement in recording a stable overall stock abundance until 2003–2005, followed by a more recent increase. Because of the inherent spatial variation, the IBTS surveys have more variability, but exhibit similar trends in the same areas as the fishers' survey, showing significant increases in stock abundance in the north and west, and less in the south, with a leveling off/decrease in these southern areas in 2011–2012. The fishers' North Sea stock survey was not available for 2013.

14.1.4 Management

Management of cod is by TAC and technical measures. The agreed TACs for Cod in Division IIIa (Skagerrak), VIId and Sub-area IV were as follows:

TAC(000t)	2006	2007	2008	2009	2010	2011	2012	2013	2014
IIIa (Skagerrak)	3.3	2.9	3.2	4.1	4.8	3.8	3.8	3.8	4.0
IIa + IV	23.2	20.0	22.2	28.8	33.6	26.8	26.5	26.5	27.8
VIId				1.7	2.0	1.6	1.5	1.5	1.6

There was no TAC for cod set for Division VIId alone until 2009. Before 2009, landings from Division VIId were counted against the overall TAC agreed for ICES Divisions VII b-k.

For 2009 Council Regulation (EC) N°43/2009 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. (see section 2.1.2 for more details). For 2010-2014, Council Regulations (EC) N°53/2010, N°57/2011, N°44/2012, N°40/2013 and N°432/2014 respectively have updated Council Regulation (EC) N°43/2009 with new allocates, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

EU Cod Recovery plans

A Cod Recovery Plan which detailed the process of setting TACs for the North Sea cod was in place until 2008. Details of it are given in EC 423/2004 and previous working group reports. ICES considered the recovery plan as not consistent with the precautionary approach because it did not result in a closure of the fisheries for cod at a time of very low stock abundance and until an initial recovery of the cod SSB had been proven.

In April 2008, the European Commission adopted a proposal to amend the cod recovery plan, based on input from stakeholders, and on scientific advice from both ICES and STECF that current measures have been inadequate to reduce fishing pressure on cod to enable stock recovery. The main changes proposed were replacing targets in terms of biomass levels with new targets expressed as optimum fishing rates intended to provide high sustainable yield, and introducing a new system of effort management by setting effort ceilings (kilowatt-days) for groups of vessels or fleet segments to be managed at a national level by Member States. The new system was intended to be simpler, more flexible and more efficient than the previous one, allowing effort reductions to be proportionate to targeted reductions in fishing mortality for the segments that contribute the most to cod mortality, while for other segments effort will be frozen at the average level for 2005-2007.

In December 2008 the European Commission and Norway agreed on a new cod management plan that aimed to be consistent with the precautionary approach and was intended to achieve sustainable fisheries and high yield, leading to a target fishing mortality of 0.4. In addition to the EU-Norway agreement, the EU has implemented effort restrictions, reducing KW-days available to EU vessels in the main métiers catching cod in direct proportion to reductions in fishing mortality until the long-term phase of the plan is reached, for which the target F is 0.4 if SSB is above B_{pa}. Details of European Commission plan are given in EC 1342/2008.

A joint ICES–STECF group met during 2011 to conduct a historical evaluation of the effectiveness of these plans (ICES-WKROUNDMP, 2011; Kraak *et al*., 2013), and concluded that for North Sea cod, although there has been a gradual reduction in F and discards in recent years, the plans have not controlled F as envisaged, and that following the current regime is unlikely to deliver F_{msy} by 2015. However, there have been positive contributions under Article 13c of the EC plan towards achieving the cod plan targets. The EC plan is currently subject to deliberation between the European Commission, Council and Parliament.

The HCR for setting TAC for the North Sea cod stock are as follows:

Article 7: Procedure for setting TACs for cod stocks in the Kattegat the west of Scotland and the Irish Sea

1. Each year, the Council shall decide on the TAC for the following year for each of the cod stocks in the Kattegat, the west of Scotland and the Irish Sea. The TAC shall be calculated by deducting the following quantities from the total removals of cod that are forecast by STECF as corresponding to the fishing mortality rates referred to in paragraphs 2 and 3:

(a) a quantity of fish equivalent to the expected discards of cod from the stock concerned;

(b) as appropriate a quantity corresponding to other sources of cod mortality caused by fishing to be fixed on the basis of a proposal from the Commission.

4. [assumed to apply to North Sea cod as well] When giving its advice in accordance with paragraphs 2 and 3, STECF shall assume that in the year prior to the year of application of the TAC the stock is fished with an adjustment in fishing mortality equal to the reduction in maximum allowable fishing effort that applies in that year.

Article 8: Procedure for setting TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel

1. Each year, the Council shall decide on the TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel. The TACs shall be calculated by applying the reduction rules set out in Article 7 paragraph 1(a) and (b).

2. The TACs shall initially be calculated in accordance with paragraphs 3 and 5. From the year where the TACs resulting from the application of paragraphs 3 and 5 would be lower than the TACs resulting from the application of paragraphs 4 and 5, the TACs shall be calculated according to the paragraphs 4 and 5.

3. Initially, the TACs shall not exceed a level corresponding to a fishing mortality which is a fraction of the estimate of fishing mortality on appropriate age groups in 2008 as follows: 75 % for the TACs in 2009, 65 % for the TACs in 2010, and applying successive decrements of 10 % for the following years.

4. Subsequently, if the size of the stock on 1 January of the year prior to the year of application of the TACs is:

(a) above the precautionary spawning biomass level, the TACs shall correspond to a fishing mortality rate of 0,4 on appropriate age groups;

*(b) between the minimum spawning biomass level and the precautionary spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate on appropriate age groups equal to the following formula: 0,4 – (0,2 * (Precautionary spawning biomass level – spawning biomass) / (Precautionary spawning biomass level – minimum spawning biomass level))*

(c) at or below the limit spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate of 0,2 on appropriate age groups.

5. Notwithstanding paragraphs 3 and 4, the Council shall not set the TACs for 2010 and subsequent years at a level that is more than 20 % below or above the TACs established in the previous year.

6. Where the cod stock referred to in paragraph 1 has been exploited at a fishing mortality rate close to 0,4 during three successive years, the Commission shall evaluate the application of this Article and, where appropriate, propose relevant measures to amend it in order to ensure exploitation at maximum sustainable yield.

Article 9: Procedure for setting TACs in poor data conditions

Where, due to lack of sufficiently accurate and representative information, STECF is not able to give advice allowing the Council to set the TACs in accordance with Articles 7 or 8, the Council shall decide as follows:

(a) where STECF advises that the catches of cod should be reduced to the lowest possible level, the TACs shall be set according to a 25 % reduction compared to the TAC in the previous year;

(b) in all other cases the TACs shall be set according to a 15 % reduction compared to the TAC in the previous year, unless STECF advises that this is not appropriate.

Article 10: Adaptation of measures

1. When the target fishing mortality rate in Article 5(2) has been reached or in the event that STECF advises that this target, or the minimum and precautionary spawning biomass levels in Article 6 or the levels of fishing mortality rates given in Article 7(2) are no longer appropriate in order to maintain a low risk of stock depletion and a maximum sustainable yield, the Council shall decide on new values for these levels.

2. In the event that STECF advises that any of the cod stocks is failing to recover properly, the Council shall take a decision which:

(a) sets the TAC for the relevant stock at a level lower than that provided for in Articles 7, 8 and 9;

(b) sets the maximum allowable fishing effort at a level lower than that provided for in Article 12;

(c) establishes associated conditions as appropriate.

14.2 Data available

14.2.1 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given for each area separately and combined in Table 14.1.

The availability of discard rate estimates and age compositions has improved since 2011.

The landings estimate for 2013 is 31.1 thousand tonnes, split as follows for the separate areas (thousand tonnes):

	TAC	Landings	Discards
IIIa-Skagerrak	4.0	4.4	2.0
IV	27.8	25.8	8.5
VIId	1.6	0.9	0.1
Total	33.4	31.1	10.5

WG estimates of discards are also shown in the above table.

Discard numbers-at-age have in the past been estimated for areas IV and VIId by applying the Scottish discard ogives to the international landings-at-age. For 2006, Denmark was excluded from this calculation as they provided their own discard estimates. For 2007-2010, Scottish, Danish, German and England & Wales discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in sub-area IV to account for missing discards. Discard numbers-at-age for IIIa-Skagerrak were based on observer sampling estimates. For 2006-2009, Danish and Swedish discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in Division IIIa-Skagerrak to account for missing discards. Raising for IIIa-Skagerrak was similar in 2010, but with the inclusion of German discard estimates. Discard raising for 2011-2013 was performed in Intercatch, with the different nations providing information by quarter and métier. The provision of discard information has improved in 2011-13, with Belgium providing discard information (tonnage and age composition) from 2011 and The Netherlands from 2012 for IV, and Belgium and France from 2011 for VIId. Figure 14.1a plots reported landings and estimated discards used in the assessment. Discard ratio sampling coverage by area and season for 2013 is provided in Table 14.2e, along with the contributions to total landings and discards from each area prior to raising.

For cod in IV, IIIa-Skagerrak and VIId, ICES first raised concerns about the mis-reporting and non-reporting of landings in the early 1990s, particularly when TACs became

intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid-1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3 000t of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment.

For 1999 and 2000, the WG has no *a priori* reason to believe that there was significant under-reporting of landings. However, the substantial reduction in fishing effort implied by the 2001, 2002 and 2003 TACs is likely to have resulted in an increase in unreported catch in those years. Anecdotal information from the fisheries in some countries indicated that this may indeed have been the case, but the extent of the alleged under-reporting of catch varies considerably.

Marine Scotland-Compliance, a department in the Scottish government responsible for monitoring the Scottish fishing industry, operated a system intended to detect unreported or otherwise illegal fish landings (known as "blackfish"). Records show that blackfish landings have declined significantly since 2003, and is likely to be extremely low since 2006 (ICES-WKCOD, 2011). While the UK Registration of Buyers and Sellers regulation, introduced towards the end of 2005, may have had an important impact on the declining levels of blackfish landings, it is unlikely to be solely responsible, with other factors including large-scale decommissioning, and the development of targeting and monitoring systems that has substantially increased the pressure on the fleet.

The Danish Fisheries Directorate expressed the view that there is no indication of a lack of reporting of cod of any significance for vessels of ten meters and more. This view is based both on the analysis of six indicators of missing reports of landed cod, and a calculation of the difference between the total quantity of cod registered in logbooks and cod registered in sales receipts for Danish vessels over ten meters per quarter over the period 2008–2010, which has been shown to vary between approx. 0.5% and 2.5% (ICES-WKCOD, 2011).

Since the WG has no basis to judge the overall extent of under-reported catch over time, it has no alternative but to use its best estimates of landings, which in general are in line with the officially reported landings. An attempt is made to incorporate a catch multiplier to the sum of reported landings and discards data in the assessment of this stock for the period 1993-2005, but the figures shown in Table 14.2c and Figure 14.1a nevertheless comprise the input values to the assessment.

Age compositions

Age compositions were provided by all nations apart from the Netherlands for 2013 data. The sampling coverage for landings and discards age compositions for 2013 are reported in Table 14.2e.

Landings in numbers at age for age groups 1-11+ and 1963-2013 are given in Table 14.2a. SOP values are shown (but are not applied). These data form the basis for the catch at age analysis but do not include industrial fishery by-catches landed for reduction purposes. By-catch estimates are available for the total Danish small-meshed fishery in Division IIIa and Sub-area IV (see section 2.1.6) and separately for the Skagerrak (Table 14.1). During the last five years, an average of 72% of the international landings in number were accounted for by juvenile cod aged 1-3; this averages rises to 87% when

considering landings and discards combined. In 2013, age 1 cod comprised 28% of the total catch by number, age 2, 37% and age 3, 16%.

Discard numbers-at-age are shown in Table 14.2b. The proportions of the estimated numbers discarded for ages 1-4 are plotted in Figure 14.1b, The proportion of the estimated total discards by weight are shown in Figure 14.1c, and by number in Figure 14.1d. Estimated proportion of total numbers caught that were discarded (Figure 14.1d) has varied between 35 and 55% from 1995 to 2005, but has shown an increase to above 70% in 2006-8, due to the stronger 2005 year class entering the fishery (estimated to be almost the size of the 1999 year class), and a mismatch between the TAC and effort. The total numbers discarded has decreased to around 55% in 2010-13. Historically, the proportion of numbers discarded at age 1 has fluctuated around 80% with no decline apparent after the introduction of the 120mm mesh in 2002. Since 2006, it has been above 90%, except for a brief decrease to 82% in 2011 and 88% in 2013. At ages 2 to 4 discard proportions increased to a maximum around 2007-9, but have subsequently declined, although all have increased again in 2012 and 2013 to give 69% for age 2, 22% for age 3 and 14% for 4 year old cod in 2013. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 14.2c. Landings, discards and total catch numbers at age are given by season in Table 14.2d for 2013. Reported landings, estimated discards and total catch (sum of landings and discards), given in tonnage, are shown in Table 14.4.

Intercatch

Intercatch was used for estimation of landings, discards and total catch at age and mean weight at age in 2013, and an update performed for 2012 (due to new uploads by Norway and UK-E&W). Data co-ordinators from each nation were tasked to input data for 2013 into Intercatch, disaggregated to quarter and métier. Allocations of discard ratios and age compositions for unsampled strata were then performed in order to obtain the data required for the assessment. This is the third year that Intercatch is used for this purpose for North Sea cod. The raising procedure for 2012 and 2013 data was simplified compared to that used for 2011 data, making use of helpful improvements to Intercatch functionality. The approach used for discard ratio allocations was to do it by area (IIIaN, IV and VIId) and treat FDF métiers separately, giving six broad categories. Annual discards were first matched to quarterly landings. Then, within each of these six categories, ignoring country and season, where métiers had some samples these were pooled and allocated to unsampled records within that métier. At the end of this process, any remaining métiers were allocated an all-samples pooled discard ratio for the given category. A similar approach was used for allocating age compositions, except that there were 12 broad categories because discards were treated separately to landings.

The new uploads of Norwegian 2012 data into Intercatch this year differed from the original data uploaded last year in that, whereas the original upload was under a single métier, the new upload was spread across several metiers; this had an impact on discard estimates for 2012 because discard ratio allocations for Norway were no longer based on a single stratum, but used several metiers with differing discard ratios. The result of this change, coupled with the new UK-E&W uploads for 2012, was that the total discard weight for 2012 was reduced from 9 555t used last year to 8 792t this year. Swedish 2013 data uploads had to deal with the problem of a closure of fishing for cod, accompanied by a landings ban, for most of the fourth quarter, with no observer trips on which to base discard estimates for two métiers generating most of the cod discards.

However, the fishery remained opened for other species, so given that a similar closure and landings ban happened during 2012 (this time with observer coverage of métiers discarding cod), it was decided to borrow discard rates (using other target species) and the accompanying age structures from the fourth quarter in 2012.

Intercatch is discussed in section 1.2, and all results are available on the WGNSSK sharepoint. Further work is ongoing on analysing the Intercatch data (cf ICES WGMIXFISH meeting during 2014).

14.2.2 Weight at age

Mean weight at age data for landings, discards and catch, are given in Tables 14.3a-c. Landings, discards and catch mean weights at age are given by season in Table 14.3d for 2013. Total catch mean weight values were also used as stock mean weights. Long-term trends in mean catch weight at age for ages 1-9 are plotted in Figure 14.2, which indicates that there have been short-term trends in mean weight at age and that the decline noted during the 90's at ages 3-5 now seems to have been reversed, most likely as a result of high-grading. Ages 1 and 2 show little absolute variation over the long-term.

14.2.3 Maturity and natural mortality

Values for maturity are given in Table 14.5a; they are applied to all years and are unchanged from those used in recent assessments.

Table 14.5b shows estimates of M, based on multi species considerations adopted for the update assessment. ICES-WKROUND (2009) noted that as new stomach data (e.g. on seal predation) become available, a revision of more recent M2 values to reflect the current status of the food web, should be considered. Estimates of natural mortality, derived from multi-species analyses, have been updated to account for improved knowledge of predation on cod by other species (mainly seals, harbour porpoises and gurnards) and cannibalism; this update occurred in 2011 with the new key run (ICES-WGSAM, 2011).

14.2.4 Catch, effort and research vessel data

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable as it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed. The WG has previously argued that, although they are in general agreement with the survey information, commercial CPUE tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES-WGNSSK 2001), and also changes in gear design and usage, as discussed by ICES-WGFTFB (2006, 2007). Therefore, although the commercial fleet series are available, only survey and combined commercial landings and discard information are analysed within the assessment presented.

ICES-WKCOD (2011) analysed UK commercial landings per unit of effort (days fishing) to the northeast and west of Shetland compared to the south and east. Analyses were conducted by gear type and vessel length. Landings per unit of effort (lpue) do not contain discard information or allow for reductions in catch/landings rates result-

ing from changes in fisher behaviour as part of the Scottish Conservation Credits programme; recent values are therefore likely to be underestimates of the catches and potential catch rates. Vessels from 19–23 m had a slightly greater increase in their catch rates to the north and west of Shetland, by a factor of 4 compared to 3.5 in the east. When catch rates were averaged across other vessel lengths and across all vessels, the WKCOD analysis could not identify differing rates of increase to either side of the Shetlands but did demonstrate that all vessels have had strong increases in lpue around the Shetlands in recent years.

Two survey series are available for use within this assessment:

Quarter 1 international bottom-trawl survey (IBTS Q1): ages 1–6+, covering the period 1976–2014. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

Quarter 3 international bottom-trawl survey (IBTS Q3): ages 0–6+, covering the period 1991–2013. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.

An analysis of IBTSQ1 data by Rindorf and Vinther (WD4 in ICES-WGNSSK, 2007) illustrated the increased importance of recruitment from the Skagerrak. The survey indices from IBTSQ1 and Q3 available for use in the stock assessment have in the past only included catch rates from the three most easterly rectangles of Skagerrak. ICES-WKROUND (2009) compared the standard and extended area IBTS indices for IBTS Q1 and Q3. The indices showed minor changes for the ages used in the assessment at the time (1–5 for IBTS Q1 and 1–4 for IBTS Q3) when the indices were extended. The largest changes occured at the younger ages, particularly for age 0 in IBTS Q3, which has never been used in the assessment. Correspondence between WGNSSK and the IBTSWG during spring 2009 discussed the addition of the suggested areas to the calculation of the extended index. Some of the rectangles were not covered by surveys each year and a modified list was agreed (Figure 14.3c).

Initial difficulties with the calculation of the extended indices was encountered during 2009 and 2010, related to the misallocation of age-length keys, which meant that it was not used in the assessment for these years, but these problems have now been resolved and the use of the extended index was supported by ICES-WKCOD (2011). During the WKCOD meeting, the survey indices that include station to west of Shetland were compiled. A comparison between the survey indices based on the extended area (Skagerrak and southern North Sea) and those including the survey stations west of Shetland (Figure 14.3a) showed only minor differences. The extended index was used for the first time in 2011, and continues to be used in the assessment presented this year.

Maps showing the IBTS distribution of cod are presented in Figures 14.3a-b (ages 1-3+). The recent dominant effect of the size and distribution of the 1996 and, to a lesser extent, the 1999, 2005 and 2009 year-classes are clearly apparent from these charts. Fish of older ages continued to decline until 2006 due to the very weak 2000, 2002 and 2004 year classes, but have subsequently begun to increase, especially in the north and west. The abundance of 3+ fish is still at a low level compared to historic levels but is increasing. The 2010 year class appears to be weak (Figure 14.3a and b).

Both surveys have been used in assessments up to 2010, but there have been conflicting residual trends for the most recent survey data points, and when applied independently, the two surveys have resulted in divergent trends in population estimates, with the IBTS Q1 survey indicating declining or stable mortality rates in recent years, but the IBTS Q3 survey rapidly increasing mortality rates for the same period (ICES-

WGNSSK, 2010). This led to studies, presented to ICES-WKCOD (2011) that looked into the distribution of cod in the surveys and the possibility of catchability changes.

Darby and Parker-Humphreys (2010) reviewed maps of the spatial distribution of the IBTS Q1 and Q3 surveys in recent years to establish whether there have been any significant changes that could account for the differences in the fishing mortality trends derived from the separate indices. They found a relatively stable pattern of catches over time for all ages in the IBTS Q1 survey, and although the distribution of cod in the IBTS Q3 survey remained relatively unchanged until around 2003/4, 2+ cod became increasingly concentrated in the northern region of the survey area. Catch rates in the southern region of the IBTS Q3 survey area were found to be very low or zero – although this has been true for ages 4 and 5 throughout the time series, it has also become so for ages 2 and 3 since 2003/4. In a subsequent study, Darby and Parker-Humphreys (WD3 in ICES-WKCOD, 2011) demonstrated that recent catch rates in the south are making less of a contribution to the IBTS survey index in Q3 than Q1. Reasons for the change in distribution recorded by the IBTS Q3 survey are unknown. Either cod have changed their migration behaviour and are moving from the south in greater proportions, or they have changed their local behaviour in the summer months and are becoming less catchable to the survey.

Rindorf and Vinther (WD1 in ICES-WKCOD, 2011) and Darby and Parker-Humphreys (WD3 in ICES-WKCOD, 2011) both examined the relative catchability changes in the catches of the IBTS Q1 and Q3 surveys, the former through an examination of catch curves, and the latter through a comparison of catch rates; both studies demonstrated that the catchability of the IBTS Q3 survey seems to have increased in recent years. The conflict between the IBTS Q1 and Q3 surveys was not fully resolved at the WKCOD meeting. It was concluded that until the reasons for the discrepancy have been resolved, the Q1 survey is considered more likely to reflect the actual stock trends in recent years, because of suspected changes in catchability/availability of cod in the Q3 survey in relation to recent changes in the fish distribution in the latter part of the year. WKCOD recommended that further investigation would most appropriately be addressed within a dedicated study group on improving the use of survey data for assessment and advice. The lack of Norwegian participation in the 2009 IBTS Q3 survey also raised concerns (ICES-WGNSSK, 2010), with an analysis highlighting the sensitivity of the survey index to the inclusion/exclusion of the Norwegian data. These issues will be investigated as part of the benchmark meeting planned for early 2015.

The current assessment uses only the IBTS Q1 survey for calibration. The actual survey data used are shown in Table 14.6.

14.3 Data analyses

14.3.1 Assessment audit

The assessment audit for North Sea cod was completed and no significant issues found. Additional checks on the forecast are carried out during the ICES WGMIXFISH meeting in 2014.

14.3.2 Exploratory survey-based analyses

Survey abundance indices are plotted in log-mean standardised form by year and cohort in Figure 14.4a for the IBTS Q1 survey, together with log-abundance curves and associated negative gradients for the age range 2-4. Similar plots are shown for the IBTS

Q3 survey in Figure 14.4b. The log-mean standardised curves indicate no obvious year effects (top-left plots), and tracks cohort signals well (top right). The log abundance curves for each survey series indicate consistent gradients (bottom left), with less steep gradients in recent years (bottom right).

Figures 14.5a and b show within-survey consistency (in cohort strength) for the IBTS Q1 and Q3 surveys, while Figure 14.5c shows between-survey consistency (for each age) for the two surveys. These show generally good consistency, justifying their use for survey tuning. Correlations deteriorate for age 5 for the IBTS Q3 survey.

The SURBAR survey analysis model was fitted to the survey data for the IBTS Q1. The summary plots are presented in Figures 14.6.

Biomass –Spawning stock biomass reached the lowest level in the time series in 2005-6 caused by a series of poor recruitments coupled with high fishing mortality and discard rates at the youngest ages, but SSB has subsequently increased again because of the stronger 2005 and 2009 year classes. This increase can also be seen in the time series for total stock biomass. SSB shows a dip in 2011 as the contribution of the 2005 year class diminishes, and while the 2009 year class is largely still immature.

Total mortality –Trends in recent years indicate a gradual decline in total mortality.

Recruitment –The IBTS Q1 survey indicates that the recruiting years classes since 1996 have been relatively weak, but that the 2005, 2009 and 2011 year classes are among the highest of the recent low values. The variation recorded in year class strength at age 1 is substantially higher than that recorded subsequently at ages 2 and 3, indicating that the high rates of discarding (90%) and high mortality rates at this age are resulting in reduced contributions from one year old fish to the stock and catches. The 2010-2014 data from the IBTS Q1 indicate that the 2009 and, to a lesser extent, the 2011 year classes may be around the level of the 2005 year class, but that the 2010 year class is very weak, and 2012 and 2013 year classes moderate to weak relative to year classes since 1997.

14.3.3 Exploratory catch-at-age-based analyses

Catch-at-age matrix

The total catch-at-age matrix (Table 14.2c) is expressed as numbers at age, and proportions-at-age, standardised over time in Figure 14.7. It shows clearly the contribution of the 1996 and 1999 year classes to catches in recent years, with the larger 1996 year class disappearing more rapidly from the catches compared to the 1999 year class. It also shows the greater proportion of older fish in the catches at the start of the time series relative to recent years. The 2005 year class features strongly in the catch in the most recent period. The catch at age 1 of the 2009 year class is below average, indicating that this year class was not be discarded to the same extent that earlier larger year classes at this age (e.g. the 1996, 1999 and 2005 year classes).

Catch curve cohort trends

The top panel of Figure 14.8 presents the log catch curve plot for the catch at age data. Through time there is an increase in the slope of the cohort plots indicating faster removal rates or high total mortality. In the most recent years there has been a gradual decrease in the slope at the youngest ages – a sign of decreased mortality rates. The bottom panel plots the negative slope of a regression fitted to the ages 2-4, the age range used as the reference for mortality trends. The decrease in the negative slope indicates that total mortality rates at the ages comprising the dominant ages within the fishery are declining.

Assessment models

SAM is a state-space model (Nielsen and Berg, 2014). Recruitment is modelled from a stock–recruitment relationship, with random variability estimated around it. Starting from recruitment, each cohort's abundance decreases over time following the usual exponential equation involving natural and fishing mortality. Instead of assuming catches to be known without error and simply subtracting those, SAM assumes that catches include observation noise, and that the survival process along cohorts is a random process. This has the consequence that estimated F-at-age paths display less interannual variability with SAM than with deterministic assessment models, because part of the observed fluctuations in catch-at-age are arising from observation noise instead of from changes in F.

SAM puts random distributions on the fishing mortalities F(y,a), where (y,a) denotes year and age. SAM considers a random walk over time for log [F(y,a)], for each age, allowing for correlation in the increments of the different ages. It has observation equations for both survey indices-at-age and observed catch-at-age, so catch-at-age data are never considered to be known without error. Additionally, in order to deal with the uncertain overall catch levels from 1993, SAM estimates annual catch multipliers for a period after 1993.

SAM is considered more appropriate than VPA approaches such as B-Adapt, because the additional variability/uncertainty considered in various components of SAM seems realistic and gives rise to results that are less reactive to noise in the catch or survey data or to potential changes in survey catchability. As previously mentioned, the fact that SAM considers random variability of the annual survival process along cohorts separately from fishing mortality produces smoother estimated F paths over time. Because the current management regime for the North Sea cod stock is strongly focused on F estimates in the final assessment year, it is important that these estimates do not change too suddenly in response to some data values which may end up just representing noise. Additionally, SAM utilizes the age structure of the observed catch even in years when the overall catch value is considered biased. SAM was considered by the most recent benchmark of North Sea cod (ICES-WKCOD, 2011) to be the most appropriate modelling approach for the stock assessment.

Only the IBTS Q1 survey is currently used as a tuning index given:

- the conflicting signals between IBTS Q1 and Q3 in recent years;
- the IBTS Q1 survey is considered to more likely reflect actual stock trends in recent years, because of suspected changes in catchability/availability of cod in the IBTS Q3 survey in relation to recent changes in the fish distribution in latter part of the year;
- external information suggesting that the bias in landings in particular (and potentially in discards estimates in recent years) have declined compared with earlier period were not supported by a declining trend in the catch multiplier when IBTS Q3 survey was included in the assessment.

The annual catch multiplicative factors were estimated for every year from 1993 to 2005, as part of the assessment. Given that information from national authorities indicates that the level of catch misreporting has been decreasing and is likely to have become negligible since about 2006, the issue of whether the catch multiplicative factor should be set equal to 1, instead of estimated, from 2006 onwards, was discussed during WKCOD. It was initially decided to continue estimating the catch multiplier from 2006 onwards, because information from national authorities about misreporting refers

only to landings rather than to the whole catch, and because discarding is known to be very substantial, with some concerns about the quality of the discards estimates (e.g. suggestions that crews may discard less when an observer is on board). However, recent assessments (which estimated a catch multiplier after 2005) had developed a worrying retrospective pattern in F, which has become worse recently (ICES-WGNSSK, 2013). It was therefore decided to present an assessment estimating the catch multiplier for 1993-2005 as the final assessment last year, which was accepted and formed the basis for advice. This year, an update to this is presented, but an assessment estimating catch multipliers for 1993-2013 is also presented as a sensitivity check, as follows:

a. A SAM updated assessment run that estimates the catch multiplier for the period 1993-2005.

b. A SAM sensitivity run, with the catch multiplier for the extended period of 1993-2013.

Figures 14.9a-b show these two assessment runs, with (a) comparing this year's update run with the final assessment last year (in light lines), and (b) comparing the sensitivity run to the update assessment given in (a) (the latter shown in light lines in (b)). The main difference is in a downward revision in SSB, and recruitment in the recent time period, and a larger decline in F in recent years for a compared to b.

Normalised residual plots are shown in Figures 14.10a-b for SAM runs a (update run) and b (sensitivity run: catch multiplier 1993-2013), indicating no serious model misspecification for either model run, although a likelihood ratio test (assuming $2(L_b - L_a) \sim \chi^2_{df=\dim_b - \dim_a}$, where $L_{a/b}$ represents the negative log-likelihood for run a/b) reveals a P value of less than 0.00001, implying a significant improvement in the model fit when estimating catch multipliers for 1993-2013 (the sensitivity run b) compared to only estimating them for 1993-2005 (the updated run a). However, the decision last year to move to the shortened catch multiplier configuration was based on other considerations as well. For example, multi-year retrospective runs for SSB, Fbar (2-4) and recruitment are shown in Figure 14.11 for the update run a and sensitivity run b, with run b showing a strong retrospective pattern in F (with some retrospective endpoints lying outside the 95% confidence limits for the full data set). This retrospective pattern is coupled with estimates of the catch multiplier that are increasing and now significantly larger than 1; these recent catch multipliers cannot be justified on the basis of any other information for this stock, particularly as catch information for this stock has vastly improved in recent years (see Section 14.2.1). A further concern is that as more years are added, the proportion of the time series where catches are "trusted" (i.e. no catch multiplier is needed) becomes smaller, and as a result the estimation of the catch multiplier becomes less reliable. The downward revision in SSB and upward revision in Fbar (2-4) for the update run a are caused by the addition of the 2013 data, and it is not obvious from the exploratory survey and catch-at-age analyses presented earlier why this is happening, but on the whole these revisions are within the 95% confidence limits for the full data set. Update run a is therefore put forward as the final assessment run. A summary of the SAM final assessment run (catch multiplier estimated for 1993-2005 only) in terms of population trends is provided in Figure 14.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into ages is shown in Figure 14.13.

14.3.4 Final assessment

The SAM update run a (catch multipler estimated for 1993-2005 only) is accepted as the final assessment. The data used in the assessment are given in Tables 14.2-3 and

14.5-6, and the model configuration in Table 14.7a. Model fitting diagnostics, parameter estimates and associated correlation matrix are given in Table 14.7b, while normalised residual plots and retrospective runs are shown in Figures 14.10a and 14.11a respectively. Estimates of fishing mortality at age, stock numbers at age and total removals at age are given in Tables 14.8-10 respectively, while a summary table for estimates of recruitment (age 1), TSB, SSB, total removals and Fbar (2-4) are given in Table 14.11a (along with 95% confidence bounds), and estimates of landings, discards, catch, the catch multiplier and total removals (combining all these components) are given in Table 14.11b (and can be compared to the corresponding data in Table 14.4). Table 14.11c provides estimates of the catch multiplier along with 95% confidence bounds. Summary plots of the final assessment in terms of population trends is provided in Figure 14.12, and the mean fishing mortality split into landings and discards, using landings fraction, and split into age is shown in Figure 14.13. A comparison with last year's assessment is provided in Figure 14.14.

14.4 Historic Stock Trends

The historic stock and fishery trends are presented in Figures 14.12-13 and Table 14.11a-c.

Recruitment has fluctuated at a relatively low level since 1998. The 1996 year class was the last large year class that contributed to the fishery, and subsequent year classes have been the lowest in the time series apart from the 1999, 2005 and 2009 year classes. The 2006-8, and 2010-12 year classes are estimated to be weak.

Fishing mortality increased until the early 1980's, remained high until 2000 after which it has declined, and is now well below F_{pa} and around 0.4, the target for the management plan when SSB>B_{pa}.

SSB declined steadily during the 1970's and 80's. There was a small increase in SSB following improved recruitment coupled with a slight dip in fishing mortality in the early 1990s, but with low recruitment since 1998 and continued high mortality rates, SSB continued to decline. SSB is estimated to have increased in recent years from the lowest level in the time series in 2006. TSB estimates have been increasing for longer than SSB because of the 2005 year class, but has not experience as rapid an improvement as SSB because of continued low recruitment.

Figure 14.15 indicates that the age structure in the population is gradually improving (number of fish aged 5 and older in the population appears to be increasing), and the survival of fish to age 5 is at its highest level in the time series.

The North Sea Fishers' Survey (Figure 14.17) indicates that perceptions of cod abundance in recent years has been of a general increase throughout the North Sea, apart from a flattening off/decrease in the southernmost areas in 2011-2012; these perceptions are consistent with the stronger 2005 and 2009 year classes entering the fishery.

14.5 Recruitment estimates

Estimates of recruitment were sampled from the 1997-2012 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005 and 2009 year classes. These re-sampled recruitments are only used for SAM forecasts in order to evaluate future stock dynamics.

14.6 MSY estimation

MSY estimation was conducted in 2010, and repeated during the ICES-WKMSYREF2 (2014) meeting. The choice of the proxy F_{max} as a provisional candidate for F_{MSY} was based on the clear peak at F= 0.19 in the yield per recruit analysis (2010 advice). Extensive simulations and investigations of the productivity of the stock provide a range of possible candidate values (F_{MSY} = 0.16 to 0.42). The estimate of F_{MSY} is strongly dependent on the choice of stock-recruitment model. F_{max} was judged to be the most appropriate candidate for a provisional F_{MSY} (2010 advice).

The more recent study (ICES-WKMSYREF2, 2014) used several stocks, including four cod stocks, to compare MSY-based reference points from two software packages available to ICES WGs. Using estimates and data from ICES-WGNSSK (2013) and optimising for landings (consistent with previous analyses), the two packages derived F_{MSY} estimates of 0.22 and 0.23 respectively for North Sea cod. Following the guidelines from ICES-WKMSYREF2 (2014) (applying the ICES MSY rule and accounting for assessment and advice error), the fishing mortalities associated with a 5% probability of SSB falling below B_{lim} were estimated to be considerably higher than these potential F_{MSY} candidates.

As part of the ICES-WKMSYREF2 (2014) study, the sensitivity to different assumptions on productivity regimes and levels of natural mortality was also investigated for North Sea cod. Sensitivity to productivity regimes was explored by comparing results for the full stock-recruit data set with those for a data set truncated to stock-recruit data from 1991 onwards only, following what is believed to have been a regime shift at the end of the 1980s. Estimates of F_{MSY} were insensitive to this assumption, but yields and SSB were substantially lower. Sensitivity to alternative values for M was explored by comparing the current assumption (final year values from the latest key run; ICES-WGSAM, 2011) with those based on the average for 1963-1980 (period with high cod stock) and those based on a hybrid version (combining canabalism at 1963-1980 levels with higher seal mortality observed more recently). These M scenarios were combined with the productivity regime scenarios, but estimates of F_{MSY} remained insensitive to all scenarios tested (although, as before, SSB and yield were affected, both being reduced under the higher M scenarios). These results are in contrast to the multispecies simulations carried out by ICES-WGSAM (2012) to evaluate F_{MSY} in a multispecies context, where F_{MSY} for North Sea cod was shifted towards higher values due to density-dependent rates of cannibalism.

Although the F where the probability of falling below B_{lim} reaches 5% (given the ICES MSY rule and assessment/advice error) was lower for the sensitivity tests (truncated time series and alternative values for natural mortality), it was still far above potential F_{MSY} reference points. Thus the values for F_{MSY} appear to be very robust to precautionary considerations.

The estimate of F_{MSY} used in advice remains 0.19 until further investigations are carried out leading to the planned benchmark in 2015, and final decisions made by ACOM on how to determine ranges around F_{MSY}.

14.7 Short-term forecasts

Due to the uncertainty in the final year estimates of fishing mortality, the WG agrees that a standard (deterministic) short-term forecast is not appropriate for this stock. Therefore, stochastic projections are performed, from which short-term projections are

extracted. The stochastic projections are carried out by starting at the final year's estimates, and the covariance matrix of those estimates. 1000 samples are generated from the estimated distribution of the final year's estimates. Those 1000 replicates are then simulated forward according to the model (assumptions given in the Stock Annex) and subject to different scenarios.

For North Sea cod, there is the perception that short-term forecasts in a given year tend to be more optimistic than realised values in subsequent years, as observed in the data and estimated by the assessment. In order to explore this perception, forecast assumptions in last year's report were compared to observed data/model estimates in the current report, and these are shown in Figures 14.16a and b. For selection and mean weights (two top rows of plots in Figure 14.16a), the forecast assumes three year averages, which underestimated selection at older ages but matched the weights well when compared to realised values (left); the average of the curves in the two top right plots represent the corresponding forecast assumption for this year. For landings fraction (bottom row of plots in Figure 14.16a), used to split catch into landings and discards, the most recent year is used in the forecast because it is difficult to anticipate what discard ratios will be in the forecast period. The bottom left plot compares the forecast assumption two years ago, and the right plot that of last year to the subsequent realised values; the forecast two years ago underestimated age 1 discards, while last year's forecast underestimated discarding of fish aged 4 and older.

Forecast assumptions related to recruitment, fishing mortality (2-4) and the resultant SSB are shown in Figure 14.16b (solid curve representing last year's assessment estimates [highlighted with stars] and forecast, with corresponding 50 and 95% confidence limits shown as hashed and dotted curves, and diamonds representing this year's assessment estimates with error bars indicating 95% confidence limits; the grey vertical line indicates the intermediate year in last year's forecast). It is clear from the top plot of Figure 14.16b that last year's intermediate year recruitment assumption, when compared to this year's corresponding realised estimate, was too optimistic. In addition, it was discovered that this intermediate year recruitment assumption used the actual assessment estimate – this was in error as this estimate is uncertain and generally replaced by recruitment re-sampled (with replacement) from the recruitments estimated for 1998-2012 for the purpose of the forecast, and should have been of the level and spread indicated by the solid and broken curves from 2014 onwards in the top plot of Figure 14.16b. As a comparison, the 2014 estimate of recruitment in this year's assessment (top plot, Figure 14.16b) is high and very uncertain, and is replaced in this year's forecast by re-sampled values from recruitments estimated for 1998-2013. Using the correct intermediate year recruitment assumption, 2014 landings in last year's forecast would have been 2-3% lower, and SSB in 2015 3- 4% lower. The more pessimistic "realised" SSBs from this year's assessment (bottom plot, Figure 14.16b) are a combination of the too-optimistic intermediate year recruitment in last year's forecast and the downward revision of SSB and upward revision of F in this year's assessment (Figure 14.14).

To explore the fishing mortality assumption for the intermediate year (2014) in this year's forecast, several candidates are shown in Figure 14.16c. They all result in a narrow spread of possible F(2-4) assumptions for 2014, and it was decided to produce a single forecast table based on the final assessment and the management plan assumption of no cut in F (option A), because there has been no reduction in effort ceiling in 2013 and 2014 compared to 2012. A number of scenarios were considered as follows [note, $B_{trigger} = B_{pa}$]:

1. Management plan: the Longterm Phase of the plan, applying the sliding rule (paragraph 4 of Article 8 of EC 1342/2008), ensuring that TAC (2015) is within 20% of TAC (2014)
2. MSY framework: Fbar (2015) = $F_{MSY} \times SSB_{2015}/B_{trigger}$
3. Zero catch: Fbar (2015) = 0
4. MSY: Fbar (2015) = F_{MSY}
5. Lower TAC constraint: Fbar (2015) such that TAC (2015) = 0.8×TAC (2014)
6. Rollover TAC: Fbar (2015) such that TAC (2015) = TAC (2014)
7. Rollover TAC + 5%: Fbar (2015) such that TAC (2015) = 1.05×TAC (2014)
8. Rollover TAC + 10%: Fbar (2015) such that TAC (2015) = 1.1×TAC (2014)
9. Rollover TAC + 15%: Fbar (2015) such that TAC (2015) = 1.15×TAC (2014)
10. Upper TAC constraint: Fbar (2015) such that TAC (2015) = 1.2×TAC (2014)
11. Status quo – constant F: Fbar (2015) = Fbar (2014)

Forecasts for the SAM final run and associated scenarios are given in Table 14.12.

Recovery Phase or Longterm Phase?

The management plan switches to the Longterm Phase only once the TAC derived from applying the Longterm Phase calculation (paragraph 4 and 5 of Article 8 of EC 1342/2008) is greater than the TAC derived from applying the Recovery Phase calculations (paragraph 3 and 5 of Article 8 of EC 1342/2008) – see Section 14.1.4 for the relevant extracts from EC 1342/2008. The switchover occurred last year, and the management plan now operates in the Longterm Phase.

14.8 Medium-term forecasts

Medium-term projections are not carried out for this stock.

14.9 Biological reference points

The Precautionary Approach reference points for cod in IV, IIIa (Skagerrak) and VIId have been unchanged since 1998. They are, together with Management Plan and MSY reference points:

	Type	Value	Technical basis
Management Plan	SSBMP	150 000 t	= Bpa
	FMP	0.4	Mortality rate when SSB > SSBMP.
MSY Approach	MSY Btrigger	150 000 t	The default option of Bpa
	FMSY	0.19	Fmax 2010, within the range of fishing mortalities consistent with FMSY (0.16–0.42).
Precautionary approach	Blim	70 000 t	Bloss (~1995)
	Bpa	150 000 t	Bpa = Previous MBAL and signs of impaired recruitment below 150 000 t.
	Flim	0.86	Flim = Floss (~1995).
	Fpa	0.65	Fpa = Approx. 5th percentile of Floss, implying an equilibrium biomass > Bpa.

(unchanged since: 2011)

Yield and spawning biomass per Recruit F-reference points:

	Fish Mort	Yield/R	SSB/R
	Ages 2-4		
Average 2007-2009	0.70	0.34	0.45
Fmax	0.19	0.62	3.36
F0.1	0.13	0.59	4.73
Fmed	0.84	0.28	0.30

Estimated by ICES in 2010, based on the assessment performed in 2009 (ICES-WGNSSK 2009).

WKCOD recommended that the reference points are not revised in the short term until the SAM assessment model has been finalised (ICES-WKCOD, 2011). Revised M estimates from WGSAM (ICES-WGSAM, 2011) and changes to the model configuration also necessitate re-estimation of reference points, and these will be considered in the forthcoming benchmark (planned for 2015).

14.10 Quality of the assessment

The quality of the commercial landings and catch-at-age data for this stock deteriorated in the 1990s following reductions in the TAC without associated control of fishing effort. The WG considers the international landings figures from 1993 onwards to have inaccuracies that lead to retrospective underestimation of fishing mortality and over estimation of spawning stock biomass and other problems with an analytical assessment. The mismatch between reported and actual landings is assumed to be negligible since 2006.

Prior to 2006 estimates of discards for areas IV and VIId are taken from the Scottish discard sampling program and the average proportions across gears applied to raise the landings data from other areas. If the gear and fishery characteristics differ, this could introduce bias. This bias is likely to introduce sensitivity to the estimates of the youngest age classes (1 and 2) and will not affect estimates of SSB. For 2006, Scottish discard sampling was used to raise all landings data apart from Danish landings, because Danish discard data were provided. For 2007-2010, a combination of Scottish, Danish, German and England and Wales discard estimates was used to raise landings from countries that did not provide discard estimates. Although discard estimates were provided by Denmark for years prior to 2006, and by Germany and England and Wales for years prior to 2007, these have not been used as it was not possible to rework earlier discard estimates. The provision of discard rate estimates and age compositions has improved substantially since 2011.

Comparing the assessment this year with last year gives the following (Figure 14.14): historical SSB trends are similar; the stock is still well below B_{pa}, but is now in the vicinity of B_{lim}; fishing mortality continues to decline, and is now around the management plan target of 0.4, but still above F_{msy}; there is a slight downward revision in SSB and recruitment and upward revision in fishing mortality compared to last year.

The estimated CVs for observed catch-at-age 1, survey index-at-age 1 and the stock–recruitment relationship are all very large: 74%, 64% and 50%, respectively. These large CVs suggest that these three sources of information are to a large extent ignored in the SAM recruitment estimation, which might therefore be more influenced by age 2 abun-

dance estimates and model assumptions about F-at-age 1. The CV of the survival process is assumed to be the same for all ages (estimated at 10%) and this might have an impact on recruitment estimates (and, hence, age 1 catch and survey residuals) because it constraints the changes permitted between abundance at ages 1 and 2 of a cohort. These issues seem of interest in future model explorations.

Finally, the high correlation (0.81) estimated for the increments of log[F(y,a)] across ages suggests that the model might react a bit slowly if different changes in selectivity start to happen for different ages (for example, as a consequence of discard reduction policies). Annual assessment results should be monitored closely, via retrospective analyses and other model diagnostics.

The current SAM assessment model was adopted by WKCOD as a basis for assessments for an interim period (~two years), while additional analyses are carried out with the aim of providing a more suitable long-term solution (ICES-WKCOD, 2011). WKCOD considered that the development of a model structure that models discard and landings separately is required due to the differing levels of noise associated with each data set. Such further model development was presented to the WG in 2012, and did not show improved model fits. The SAM assessment as adopted by WKCOD has a general tendency to over-estimate F, a tendency that has worsened (i.e. estimates from truncated datasets lying outside the confidence bounds for the full data set) since the introduction in the 2012 assessment of M estimates from the most recent multispecies M key run. This retrospective pattern is coupled with estimates of the catch multiplier that are increasing and now significantly larger than one; these recent catch multipliers cannot be justified on the basis of any other information for this stock, particularly as catch information for this stock has vastly improved in recent years. Given these concerns, the WG can no longer justify the SAM assessment as adopted by WKCOD, and instead last year put forward a SAM assessment that estimates the catch multiplier for the period 1993-2005 only, because 2006 is the year that catch reporting is believed to have been substantially improved compared to earlier years, partially due to buyers and sellers legislation coming into force in the UK (ICES-WKCOD, 2011). WKCOD recommended that the reference points are not revised in the short term until the assessment model has been finalised. Given that a benchmark is planned for this stock in the near future (2015), revised reference points for the current assessment model should be considered during that process.

The indication that SSB in 2006 was at or around a historical low, and is now increasing, and that recent recruitments are at a relatively low level is consistent between model fits (SAM, SURBAR) and within and between survey indices (IBTS Q1 and Q3), which also confirm a higher 2005 and 2009 year class compared to recent years. The IBTS Q3 survey is currently not included in the assessment because of the conflicting trends between the IBTS Q1 and Q3 indices, possibly resulting from changes in the catchability/availability of cod in Q3 related to recent changes in fish distribution. Similar issues are becoming evident in the IBTS Q1 index (model underestimates towards end of time series, indicating conflicts between fishery-dependent and -independent data), although the lower number of hauls in the IBTS Q1 survey for 2014 should also be noted. The re-inclusion of the IBTS Q3 survey is envisaged in future once a detailed investigation is carried out; such investigations of both surveys are intended to form part of the forthcoming benchmark process (2015).

The SAM model estimates the quantity of additional "unaccounted removals" that would be required to be added or removed from the catch-at-age data in order to remove any persistent trends in survey catchability. The unaccounted removals figures

given by SAM could potentially include components due to increased natural mortality and discarding as well as misreported landings.

Values for natural mortality have been updated in 2012, following the key run conducted by WGSAM (ICES-WGSAM, 2011); they are smoothed annual model estimates from a multi-species VPA. The maturity-at-age estimates are constant by year at values that were estimated using the International Bottom trawl Survey series 1981-1985. These values were derived for the North Sea.

14.11 Status of the Stock

There has been a gradual improvement of the status of the stock in the last few years. SSB has increased from the historical low in 2006, and is now in the vicinity of B_{lim}. This increasing trend is expected to continue in the short term under current fishing mortality levels, because of improved survival of incoming year classes.

Fishing mortality has declined from 2000, and is now well below F_{pa}, and around the target for the management plan when SSB>B_{pa}, but still estimated to be above the level that achieves the long-term objective of maximum yield.

Recruitment of 1 year old cod has varied considerably since the 1960s, but since 1998, average recruitment has been lower than any other time. The 2009 year class is stronger, just below the level of the 2005 year class, but the 2010-12 year class appears to be weak. Recent sharp increases in the rate of discarding have been reversed, although there is some indication of a gradual increase again at ages 2-4.

14.12 Management Considerations

The stock has begun to recover from the low levels to which it was reduced in early 2000, at which recruitment was impaired and the biological dynamics of the stock difficult to predict. Fishing mortality rates have been reduced from 2000 and in combination with the stronger 2005 and 2009 year classes, the stock has increased since 2006. The reduction in fishing mortality, now well below F_{pa}, is allowing the recent series of poor recruitments to make an improved contribution to the stock. The low average age of the spawning stock reduces its reproductive capacity as first-time spawners reproduce less successfully than older fish, a factor that has contributed to the continued low recruitment.

There may have been some difficulties with the effectiveness of the cod recovery plans; despite the objective to reduce fishing mortality and to increase the SSB by combined TAC control and effort management, estimated total removals have until recently been much higher than intended. The situation has been improving, however, and fishing mortality is now well below F_{pa} and in the vicinity of the management plan target when SSB>B_{pa}. Discarding currently contributes around a quarter of the total catch by weight, a substantial improvement compared to recent years (when the average was almost half of the total). There have been considerable efforts to reduce discards by some countries, and the impact of these reductions are starting to be felt (e.g. reduced discarding leading to improved survival of incoming year classes).

Cod is caught by a large variety of gears and together with many other species. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. However, a reduction in effort

on one stock may lead to a reduction or an increase in effort on another, and the implications of any change need to be considered carefully. The ICES WGMIXFISH Group monitors the consistency of the various single-species management plans under current effort schemes, in order to estimate the potential risks of quota over- and undershooting for the different stocks.

Surveys indicate that the year classes have been depleting faster than one would expect from the catches, and point to unaccounted removals. There is no documented information on the source of these unaccounted removals; while it is assumed that these removals originate mostly from fishing activities, changes in natural mortality may also have an influence. Plausible fishery-based contributions to these unaccounted removals are discards (undersized cod, highgrading and over-quota catches) that do not count against quota, and mis- and under-reporting of catches. The recorded landings from 1993-2005 fluctuated between 50% and 112% of the estimated total removals (average: 82%), indicating that the management system has not been effective in controlling the catches in the past. However, WKCOD noted that incidence of underreporting of landings in the Scottish fleet fishing for cod has declined significantly since 2003, and is likely to be extremely low since 2006. Furthermore, based on several indicators (including comparisons between the total quantity of cod registered in logbooks and those registered in sales receipts), the Danish Directorate of Fisheries estimates that the placement of illegal fish on the market does not occur on a large scale (ICES-WKCOD, 2011).

There is a need to reduce fishing induced mortality on North Sea cod further, particularly for younger ages, in order to allow more fish to reach maturity and increase the probability of good recruitment. Incidence of discarding remain high, with the proportion of fish discarded by number in 2013 being 88% of 1 year old (compared to 93% in 2012), 69% of 2 year old (66% in 2012), 22% of 3 year old (22% in 2012) and 14% of 4 year old cod (7% in 2012).

Because the fishery is at present so dependent on incoming year classes, fishing mortalities on these year classes remain high, and only a small proportion of 2 year olds currently survive to maturity. At the same time, the unbalanced age structure of the stock reduces its reproductive capacity even if a sufficient SSB were reached, as first-time spawners reproduce less successfully than older fish. Both factors are believed to have contributed to the reduction in recruitment of cod. However, there are indications that, although still low, survival to age 5 is improving, and is currently at the highest level in the time series.

The recruitment of the relatively more abundant year classes to the fishery may have no beneficial effect on the stock if they are caught and heavily discarded. In 2006, the 2005 year class comprised 62% of the total catch by number (aged 1), in 2007 it comprised 55% (aged 2), in 2008 33% (aged 3), in 2009 11% (aged 4) and in 2010 4% (aged 5). The equivalent figures for the 2009 year class were 33% in 2010 (aged 1), 54% in 2011 (aged 2), 27% in 2012 (aged 3) and 12% in 2013 (aged 4). The last substantial year class to enter the fishery was the 1996 year class. This year class was a prominent feature in all surveys, was heavily exploited and discarded by the fishery at ages 1-5, and disappeared relatively quickly from the fishery.

The availability of discard rate estimates and age compositions has improved since 2011.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear such as the now widespread use of sorting grids in the Skagerrak, should be encouraged.

The reported landings in 2013 were 31.1 thousand tonnes and the estimated discards in 2013 were 10.5 thousand tonnes, giving a total of 41.6 thousand tonnes. Cod are taken by towed gears in mixed demersal fisheries, which include haddock, whiting, Nephrops, plaice, and sole. They are also taken in directed fisheries using fixed gears.

Cod catch in Division VIId is managed by a TAC for Divisions VIIb-k,VIII, IX, X, and CECAF 34.1.1, (i.e. the TAC covers a small proportion of the North Sea cod stock together with cod in Divisions VIIe-k). Division VIId was allocated a separate TAC from 2009 onwards which was adjusted in line with the revision to the North Sea TAC.

14.13 References

Darby, C. and M. Parker-Humphreys. 2010. A review of the IBTS cod survey data with particular reference to its use in the North Sea cod stock assessment. Document presented to WGNSSK by correspondence meeting in September 2010.

ICES-WGFTFB. 2006. Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 3–7 April 2006, Izmir, Turkey. ICES CM 2006/FTC:06, Ref. ACFM. 180 pp.

ICES-WGFTFB. 2007. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 23–27 April 2007, Dublin, Ireland. ICES CM 2007/FTC:06. 197 pp.

ICES-WGFTFB. 2013. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 6-10 May 2013, Bangkok, Thailand. ICES CM 2013/SSGESST:11: 116 pp.

ICES-WGNSSK 2001. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 19-28 June 2001, Hamburg, Germany. ICES CM 2002/ACFM:01.

ICES-WGNSSK 2007. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak – Combined Spring and Autumn (WGNSSK), 1-8 May 2007, ICES Headquarters and September 2007 by correspondence. ICES CM 2007/ACFM:18&30: 960.

ICES-WGNSSK. 2009. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Spring and Autumn (WGNSSK), 6-12 May, ICES Copenhagen, and September 2009, by correspondence. ICES CM 2009\ACOM:10: 1028pp.

ICES-WGNSSK. 2010. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5 -11 May 2010, ICES Headquarters, Copenhagen. ICES CM 2010/ACOM:13. 1058 pp.

ICES-WGNSSK. 2013. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:13. 1435 pp.

ICES-WGSAM. 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 10–14 October 2011, Woods Hole, USA. ICES CM 2011/SSGSUE:10. 229 pp.

ICES-WGSAM. 2012. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 22-26 October 2012, Venice, Italy. ICES CM 2012/SSGSUE:10. 145 pp.

ICES-WKCOD 2011. Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011), 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51: 94pp.

ICES-WKMSYREF2. 2014. Report of the Workshop to consider reference points for all stocks (WKMSYREF2), 8-10 January 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:47. 91 pp.

ICES-WKROUND. 2009. Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND), January 16–23 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:32: 259pp.

ICES-WKROUNDMP. 2011. Report of the Joint ICES-STECF Workshop on management plan evaluations for roundfish stocks (WKROUNDMP/EWG 11-01), 28 February - 4 March 2011, ICES Headquarters, Copenhagen. . 67 pp.

Kraak, S.B.M., Bailey, N., Cardinale, M., Darby, C., De Oliveira, J.A.A., Eero, M., Graham, N., Holmes, S., Jakobsen, T., Kempf, A., Kirkegaard, E., Powell, J., Scott, R.D., Simmonds, E.J., Ulrich, C., Vanhee, W., and M. Vinther. 2013. Lessons for fisheries management from the EU cod recovery plan. Marine Policy, 37: 200–213.

Napier, I. R. 2012. Fishers' North Sea stock survey 2012. NAFC Marine Centre, University of the Highlands and Islands: 116pp. [Accessed online, 16/05/2013: www.nsss.eu.]

Nielsen, A., and Berg, C.W. 2014. Estimation of time-varying selectivity in stock assessments using state-space models. Fisheries Research, 158: 96-101.

STECF. 2013. Evaluation of Fishing Effort Regimes in European Waters - Part 1 (STECF-13-06). 2013. Publications Office of the European Union, Luxembourg, EUR 26901EN, JRC 83567: 691 pp.

Table 14.1 Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1994-2013 as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Belgium	2,648	4,827	3,458	4,642	5,799	3,882	3,304	2,470	2,616	1,482
Denmark	19,243	24,067	23,573	21,870	23,002	19,697	14,000	8,358	9,022	4,676
Faroe Islands	80	219	44	40	102	96	-	9	34	36
France	1,868	3,040	1,934	3,451	2,934	.	1,222	717	1,777	620
Germany	5,974	9,457	8,344	5,179	8,045	3,386	1,740	1,810	2,018	2,048
Greenland	.	.	.	.	.	.	.	.	.	.
Netherlands	6,512	11,199	9,271	11,807	14,676	9,068	5,995	3,574	4,707	2,305
Norway	7,707	7,111	5,869	5,814	5,823	7,432	6,410	4,369	5,217	4,417
Poland	-	-	18	31	25	19	18	18	39	35
Sweden	630	709	617	832	540	625	640	661	463	252
UK (E/W/NI)	13,941	14,991	15,930	13,413	17,745	10,344	6,543	4,087	3,112	2,213
UK (Scotland)	28,854	35,848	35,349	32,344	35,633	23,017	21,009	15,640	15,416	7,852
Total Nominal Catch	87,457	111,468	104,407	99,423	114,324	77,566	60,881	41,713	44,421	25,936
Unallocated landings	7,066	8,555	2,161	2,746	7,779	826	-1,114	-740	-121	-89
WG estimate of total landings	**94,523**	**120,023**	**106,568**	**102,169**	**122,103**	**78,392**	**59,767**	**40,973**	**44,300**	**25,847**
Agreed TAC	**102,000**	**120,000**	**130,000**	**115,000**	**140,000**	**132,400**	**81,000**	**48,600**	**49,300**	**27,300**

Division VIId										
Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Belgium	228	377	321	310	239	172	110	93	51	54
Denmark	9	-	-	-	-	-	-	-	-	-
France	2,338	3,261	2,808	6,387	7,788	.	3,084	1,677	1,361	1,730
Netherlands	-	-	-	-	19	3	4	17	6	36
UK (E/W/NI)	312	336	414	478	618	454	385	249	145	121
UK (Scotland)	<0.5	<0.5	4	3	1	-	-	-	-	-
Total Nominal Catch	2,887	3,974	3,547	7,178	8,665	629	3,583	2,036	1,563	1,941
Unallocated landings	-37	-10	-44	-135	-85	6,229	-1,258	-463	1,534	-707
WG estimate of total landings	**2,850**	**3,964**	**3,503**	**7,043**	**8,580**	**6,858**	**2,325**	**1,573**	**3,097**	**1,234**

Division IIIa (Skagerrak)**										
Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Denmark	11,921	15,888	14,573	12,159	12,339	8,682	7,656	5,870	5,511	3,054
Germany	399	285	259	81	54	54	54	32	83	49
Norway	850	1,039	1,046	1,323	1,293	1,146	926	762	645	825
Sweden	1,834	2,483	1,986	2,173	1,900	1,909	1,293	1,035	897	510
Others	71	134	-	-	-	-	-	-	-	27
Norwegian coast *	760	846	748	911	976	788	624	846	.	.
Danish industrial by-catch *	666	749	676	205	97	62	99	687	.	.
Total Nominal Catch	15,075	19,829	17,864	15,736	15,586	11,791	9,929	7,699	7,136	4,465
Unallocated landings	-1,814	-7,720	-1,615	-790	-255	-817	-652	-613	332	-674
WG estimate of total landings	**13,261**	**12,109**	**16,249**	**14,946**	**15,331**	**10,974**	**9,277**	**7,086**	**7,468**	**3,791**
Agreed TAC	**15,500**	**20,000**	**23,000**	**16,100**	**20,000**	**19,000**	**11,600**	**7,000**	**7,100**	**3,900**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total Nominal Catch	105,419	135,271	125,818	122,337	138,575	89,986	74,393	51,448	53,120	32,342
Unallocated landings	5,215	825	502	1,821	7,439	6,239	-3,024	-1,816	1,745	-1,470
WG estimate of total landings	**110,634**	**136,096**	**126,320**	**124,158**	**146,014**	**96,225**	**71,369**	**49,632**	**54,865**	**30,872**

** Skaggerak/Kattegat split derived from national statistics

* The Danish industrial by-catch and the Norwegian coast catches are not included in the (WG estimate of) total landings of Division IIIa

. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IIIa (Skagerrak) landings not included in the assessment										
Country	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Norwegian coast *	760	846	748	911	976	788	624	846	.	.
Danish industrial by-catch *	666	749	676	205	97	62	99	687	.	.
Total	**1,426**	**1,595**	**1,424**	**1,116**	**1,073**	**850**	**723**	**1,533**	**.**	**.**

Table 14.1 cont. Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1994-2013 as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	1,627	1,722	1,309	1,009	894	946	666	653	862	1,075
Denmark	5,889	6,291	5,105	3,430	3,831	4,402	5,686	4,863	4,803	4,536
Faroe Islands	37	34	3	-	16	45	32	.	.	0
France	294	664	354	659	573	950	781	619	368	286
Germany	2,213	2,648	2,537	1,899	1,736	2,374	2,844	2,211	2,385	1,921
Greenland	.	35	23	17	17	11	.	.	.	0
Netherlands	1,726	1,660	1,585	1,523	1,896	2,649	2,657	1,928	1,955	1,344
Norway	3,223	2,900	2,749	3,057	4,128	4,234	4,496	4,898	4,614	4,060
Poland	-	-	-	1	2	3	.	2	.	0
Sweden	240	319	309	387	439	378	363	315	471	332
UK (E/W/NI)	1,890	1,270	1,491	1,587	1,546	2,384	2,553			
UK (Scotland)	6,650	4,936	6,857	6,511	7,185	9,052	11,568			
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12,310	12,187	12,782
Others	.	.	786	.	.	.	.	.	.	0
Norwegian indust by-catch *	.	.	48	101	22	4	201	1	.	.
Danish industrial by-catch *	.	.	34	18	46	76	11	0	0	34
Total Nominal Catch	23,789	22,479	23,108	20,080	22,263	27,428	31,646	27,799	27,645	26,336
Unallocated landings	-240	1,391	-1,012	-336	-68	-1,800	-346	-71	-987	-552
WG estimate of total landings	**23,549**	**23,870**	**22,096**	**19,744**	**22,195**	**25,628**	**31,300**	**27,728**	**26,658**	**25,784**
Agreed TAC	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**	**26,842**	**26,475**	**26,475**

Division VIId

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Belgium	47	51	80	84	154	73	57	56	40	52
Denmark	-	-	-	.	.	.	.	.	.	.
France	810	986	1,124	1,743	1,326	1,779	1,606	1,078	885	742
Netherlands	14	9	9	59	30	35	45	51	40	38
UK (E/W/NI)	103	184	267	175	144	134	127			
UK (Scotland)	-	-	1	12	7	3	1			
UK (conbined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	126	99	100
Total Nominal Catch	974	1,230	1,481	2,073	1,661	2,024	1,836	1,311	1,064	932
Unallocated landings	-167	-197	-353	-331	-307	-777	-44	-93	0	-34
WG estimate of total landings	**807**	**1,033**	**1,128**	**1,742**	**1,354**	**1,247**	**1,792**	**1,218**	**1,064**	**898**
Agreed TAC						**1,678**	**1,955**	**1,564**	**1,543**	**1,543**

Division IIIa (Skagerrak)**

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Denmark	3,009	2,984	2,478	2,228	2,552	3,023	3,289	3,118	3,177	3,057
Germany	99	86	84	67	52	55	56	60	78	69
Norway	856	759	628	681	779	440	375	421	587	573
Sweden	495	488	372	370	365	459	458	518	520	501
Others	24	21	373	385	13	2	26	0	0	33
Norwegian coast *	720	759	524	494	498	342	369	342	467	378
Danish industrial by-catch *	10	18	9	.	-	1	0	0	0	26
Total Nominal Catch	4,483	4,338	3,935	3,731	3,761	3,979	4,204	4,117	4,362	4,233
Unallocated landings	-696	-533	-569	-784	-463	-101	-116	-192	-60	177
WG estimate of total landings	**3,787**	**3,805**	**3,366**	**2,947**	**3,298**	**3,878**	**4,089**	**3,925**	**4,302**	**4,410**
Agreed TAC	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**	**3,835**	**3,783**	**3,783**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total Nominal Catch	29,246	28,047	28,524	25,884	27,685	33,431	37,686	33,227	33,071	31,501
Unallocated landings	-1,103	661	-1,934	-1,451	-838	-2,678	-506	-356	-1,047	-409
WG estimate of total landings	**28,143**	**28,708**	**26,590**	**24,433**	**26,847**	**30,753**	**37,180**	**32,871**	**32,023**	**31,092**

** Skaggerak/Kattegat split derived from national statistics

* The Danish and Norwegian industrial by-catch and the Norwegian coast catches are not included in the (WG estimate of) total landings

. Magnitude not available - Magnitude known to be nil <0.5 Magnitude less than half the unit used in the table n/a Not applicable

Division IV and IIIa (Skagerrak) landings not included in the assessment

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Norwegian coast *	720	759	524	494	498	342	369	342	467	378
Norwegian indust by-catch *	.	.	48	101	22	4	201	1	.	.
Danish industrial by-catch *	10	18	43	18	46	77	11	0	0	60
Total	**730**	**777**	**615**	**613**	**566**	**423**	**582**	**343**	**467**	**438**

Table 14.2a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Landings numbers at age (Thousands).

Landings numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	3214	5029	15813	18224	10803	5829	2947	54493	44824	3832	25966
2	42591	22486	51888	62516	70895	83836	22674	33917	155345	187686	31755
3	7030	20104	17645	29845	32693	42586	31578	18488	17219	48126	54931
4	3536	4306	9182	6184	11261	12392	13710	13339	6754	5682	14072
5	2788	1917	2387	3379	3271	6076	4565	6297	7101	2726	2206
6	1213	1818	950	1278	1974	1414	2895	1763	2700	3201	1109
7	81	599	658	477	888	870	588	961	893	1680	1060
8	492	118	298	370	355	309	422	209	458	612	489
9	14	94	51	126	138	151	147	186	228	390	80
10	6	12	75	56	40	111	46	98	77	113	58
+gp	0	4	8	83	17	24	78	40	94	18	162
TOTALNUM	60965	56486	98957	122538	132335	153600	79651	129791	235691	254064	131888
TONSLAND	116457	126041	181036	221336	252977	288368	200760	226124	328098	353976	239051
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	15562	33378	5724	75413	29731	34837	62605	20279	66777	25733	64751
2	58920	47143	100283	51118	175727	91697	104708	189007	65299	129632	66428
3	11404	18944	18574	25621	17258	44653	35056	34821	60411	21662	31276
4	15824	4663	6741	4615	9440	4035	12316	9019	9567	11900	4264
5	4624	7563	1741	2294	3003	3395	1965	4118	3476	2830	3436
6	961	2067	3071	836	1108	712	1273	785	2065	1258	1019
7	438	449	924	1144	410	398	495	604	428	595	437
8	395	196	131	371	405	140	197	134	236	181	244
9	332	229	67	263	153	158	74	65	78	90	60
10	81	95	63	26	36	42	55	37	27	28	45
+gp	189	63	43	96	44	17	25	21	16	23	20
TOTALNUM	108729	114791	137361	161797	237314	180085	218770	258889	208380	193932	171978
TONSLAND	214279	205245	234169	209154	297022	269973	293644	335497	303251	259287	228286
SOPCOF %	100	100	100	100	100	101	100	100	99	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	8845	100239	24915	21480	22239	11738	13466	27668	4783	15557	15717
2	118047	32437	128282	55330	36358	54290	23456	32059	55272	25279	63586
3	18995	34109	9800	43955	18193	11906	16776	8682	11360	21144	12943
4	7823	5814	8723	3134	9866	4339	3310	5007	3190	3083	5301
5	1377	2993	1534	2557	1002	2468	1390	1060	1577	870	802
6	1265	604	1075	655	1036	310	1053	491	435	519	286
7	373	556	235	295	251	310	225	329	204	142	151
8	173	171	215	66	140	54	139	52	108	58	42
9	79	69	55	63	27	60	28	40	18	32	15
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	10	9	13	16	5
TOTALNUM	157022	177058	174895	127577	89153	85496	59857	75415	76970	66706	98861
TONSLAND	214629	204053	216212	184240	139936	125314	102478	114020	121749	110634	136096
SOPCOF %	100	101	100	100	100	99	100	99	99	99	98

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4938	23769	1255	5941	8294	2220	7192	400	1589	1502	1906
2	36805	29194	81737	9731	23033	20832	7870	9615	4083	8210	4931
3	23364	18646	16958	32224	6472	6200	13252	3511	4949	2865	4447
4	3169	6499	5967	4034	6697	1142	2519	2660	1965	1628	1015
5	1860	1238	2402	1446	1021	1080	366	449	988	474	471
6	399	700	509	626	385	144	349	66	150	392	151
7	162	153	236	223	139	84	51	49	43	44	116
8	88	47	41	91	40	27	31	13	23	11	22
9	43	14	16	14	18	14	13	7	8	8	4
10	4	15	4	10	5	6	5	3	3	2	2
+gp	8	10	12	2	1	1	0	1	0	0	0
TOTALNUM	70837	80285	109137	54342	46105	31750	31649	16774	13800	15135	13064
TONSLAND	126320	124158	146014	96225	71371	49694	54865	30872	28188	28708	26590
SOPCOF %	100	100	100	100	100	100	100	102	100	100	103

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013
1	1241	556	620	904	994	569	807
2	6852	3400	4403	5175	5218	2364	2757
3	2443	4293	2763	4450	3830	5505	3090
4	1532	1064	2693	1567	1492	1995	2605
5	307	697	547	1281	602	647	912
6	114	170	245	238	579	245	198
7	39	70	52	87	68	137	86
8	36	30	29	19	25	16	40
9	6	21	20	9	5	4	6
10	1	4	7	5	10	4	1
+gp	0	3	2	3	2	1	1
TOTALNUM	12573	10307	11381	13737	12824	11486	10503
TONSLAND	24433	26847	30753	37180	32871	32799	31092
SOPCOF %	100	99	100	101	100	100	100

Table 14.2b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Discard numbers at age (Thousands).

Discards numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	16231	8089	98414	108921	50467	31272	2515	53225	260226	38442	86349
2	20003	6199	6632	22236	24861	23073	10331	8700	37412	59641	17475
3	33	116	90	71	160	198	113	153	47	178	247
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	36267	14404	105136	131229	75489	54542	12959	62078	297686	98261	104071
TONSDISC	12247	4731	29251	38109	23438	17575	4816	17928	84392	33848	30190
SOPCOF %	100	101	100	100	100	100	101	101	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	124777	137341	227925	474377	29043	584603	1189692	156878	183476	55478	540795
2	15958	16296	83630	48189	78477	5302	17751	34559	8448	11237	12594
3	71	0	193	466	0	0	0	80	99	25	5
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	140807	153637	311747	523032	107520	589904	1207444	191516	192022	66740	553394
TONSDISC	39807	37060	72840	139820	32583	163279	295449	57897	54501	22101	151923
SOPCOF %	100	100	100	100	100	100	100	101	100	102	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	63659	565753	24732	15461	178265	34194	48110	104321	34112	324703	45425
2	36780	5784	62194	17179	8751	48699	8495	10065	29119	17012	44083
3	115	305	0	218	492	79	454	2	12	162	30
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	100555	571842	86927	32858	187508	82972	57059	114388	63242	341877	89539
TONSDISC	31503	139081	27839	10714	62119	27022	18552	36920	21860	99578	32188
SOPCOF %	100	100	100	101	100	100	101	100	100	100	100

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	14451	87308	15608	31550	37981	5600	13373	8511	11865	11290	26690
2	23376	13892	91140	5737	5650	33946	2622	9976	4661	5673	5563
3	774	41	1514	8437	0	773	1972	1118	1158	108	804
4	0	0	0	0	0	0	0	69	0	19	53
5	0	0	0	0	0	0	0	11	0	4	12
6	0	0	0	0	0	0	0	2	0	3	2
7	0	0	0	0	0	0	0	1	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0
+gp	0	0	0	0	0	0	0	0	0	0	0
TOTALNUM	38601	101241	108262	45725	43631	40319	17967	19688	17684	17097	33126
TONSDISC	14255	33616	40480	14180	13713	13871	5706	6372	5849	6272	8050
SOPCOF %	100	100	100	102	100	100	100	101	102	103	102

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013
1	14622	8384	8600	9443	4391	7949	6182
2	20183	9165	7020	6829	10166	4545	6213
3	1506	7474	1435	1192	882	1541	886
4	371	149	586	52	98	148	415
5	49	21	34	22	11	5	87
6	25	13	16	0	7	2	41
7	0	0	8	0	1	1	16
8	2	3	0	0	1	0	0
9	0	0	0	0	0	0	0
10	0	0	2	0	0	0	0
+gp	0	0	0	0	0	0	0
TOTALNUM	36757	25210	17701	17538	15558	14190	13841
TONSDISC	23636	21814	14022	9982	9485	8792	10540
SOPCOF %	100	100	101	100	100	100	100

Table 14.2c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch numbers at age (Thousands).

Catch numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	19445	13118	114228	127146	61270	37101	5462	107718	305050	42274	112315
2	62594	28685	58520	84752	95756	106909	33005	42617	192757	247327	49230
3	7063	20220	17735	29916	32854	42784	31691	18640	17266	48304	55178
4	3536	4306	9182	6184	11261	12392	13710	13339	6754	5682	14072
5	2788	1917	2387	3379	3271	6076	4565	6297	7101	2726	2206
6	1213	1818	950	1278	1974	1414	2895	1763	2700	3201	1109
7	81	599	658	477	888	870	588	961	893	1680	1060
8	492	118	298	370	355	309	422	209	458	612	489
9	14	94	51	126	138	151	147	186	228	390	80
10	6	12	75	56	40	111	46	98	77	113	58
+gp	0	4	8	83	17	24	78	40	94	18	162
TOTALNUM	97232	70890	204093	253767	207823	208142	92610	191868	533377	352326	235958
TONSLAND	128704	130771	210287	259445	276416	305943	205576	244053	412490	387824	269241
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	140339	170719	233649	549790	58774	619440	1252297	177157	250252	81211	605546
2	74878	63439	183912	99307	254204	96999	122460	223566	73747	140869	79022
3	11476	18944	18766	26087	17258	44653	35056	34901	60510	21687	31281
4	15824	4663	6741	4615	9440	4035	12316	9019	9567	11900	4264
5	4624	7563	1741	2294	3003	3395	1965	4118	3476	2830	3436
6	961	2067	3071	836	1108	712	1273	785	2065	1258	1019
7	438	449	924	1144	410	398	495	604	428	595	437
8	395	196	131	371	405	140	197	134	236	181	244
9	332	229	67	263	153	158	74	65	78	90	60
10	81	95	63	26	36	42	55	37	27	28	45
+gp	189	63	43	96	44	17	25	21	16	23	20
TOTALNUM	249535	268428	449108	684830	344834	769989	1426214	450405	400402	260672	725372
TONSLAND	254086	242304	307009	348974	329605	433252	589093	393394	357752	281388	380209
SOPCOF %	100	100	100	100	100	101	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	72504	665992	49647	36942	200504	45932	61576	131989	38896	340260	61143
2	154827	38221	190476	72509	45109	102988	31950	42124	84390	42291	107670
3	19111	34413	9800	44172	18685	11985	17230	8684	11372	21306	12974
4	7823	5814	8723	3134	9866	4339	3310	5007	3190	3083	5301
5	1377	2993	1534	2557	1002	2468	1390	1060	1577	870	802
6	1265	604	1075	655	1036	310	1053	491	435	519	286
7	373	556	235	295	251	310	225	329	204	142	151
8	173	171	215	66	140	54	139	52	108	58	42
9	79	69	55	63	27	60	28	40	18	32	15
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	10	9	13	16	5
TOTALNUM	257577	748900	261822	160435	276661	168468	116916	189803	140212	408583	188400
TONSLAND	246131	343134	244052	194954	202055	152336	121030	150940	143609	210212	168283
SOPCOF %	100	101	100	100	100	100	100	99	100	100	99

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	19389	111077	16864	37491	46275	7820	20565	8911	13454	12792	28596
2	60181	43085	172877	15468	28683	54778	10492	19591	8744	13883	10495
3	24138	18687	18472	40662	6472	6972	15223	4629	6107	2973	5251
4	3169	6499	5967	4034	6697	1142	2519	2728	1965	1646	1068
5	1860	1238	2402	1446	1021	1080	366	460	988	478	483
6	399	700	509	626	385	144	349	68	150	394	153
7	162	153	236	223	139	84	51	50	43	44	117
8	88	47	41	91	40	27	31	13	23	11	22
9	43	14	16	14	18	14	13	7	8	8	4
10	4	15	4	10	5	6	5	3	3	2	2
+gp	8	10	12	2	1	1	0	1	0	0	0
TOTALNUM	109438	181526	217400	100066	89736	72069	49615	36462	31485	32232	46191
TONSLAND	140575	157774	186494	110405	85084	63565	60571	37244	34037	34980	34640
SOPCOF %	100	100	100	101	100	100	100	102	100	100	103

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013
1	15862	8940	9220	10347	5385	8518	6989
2	27035	12565	11423	12004	15383	6909	8970
3	3949	11767	4198	5642	4713	7045	3977
4	1903	1212	3280	1618	1590	2143	3020
5	356	718	581	1303	613	652	999
6	139	183	261	238	586	246	240
7	39	71	60	87	69	138	102
8	38	33	29	19	26	16	40
9	6	21	20	9	5	4	6
10	1	4	9	5	10	4	2
+gp	0	3	2	3	2	1	1
TOTALNUM	49330	35517	29083	31275	28382	25676	24345
TONSLAND	48069	48661	44775	47163	42357	41591	41632
SOPCOF %	100	100	100	101	100	100	100

Table 14.2d Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Landings, discards and catch numbers at age (Thousands) by season (quarter or annual, depending on data stratification) from Intercatch for 2013.

Landings numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	100	26	241	396	45	807
2	384	394	905	1043	31	2757
3	639	676	886	880	9	3090
4	766	718	595	520	5	2605
5	185	293	290	143	0	912
6	50	58	57	33	1	198
7	20	30	23	13	0	86
8	3	19	12	5	0	40
9	3	1	1	0	0	6
10	0	1	0	0	0	1
+gp	0	0	0	0	0	1
TOTALNUM	2150	2218	3010	3034	92	10503

Discards numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	464	617	1365	1498	2239	6182
2	1347	1066	1056	637	2107	6213
3	100	142	119	120	405	886
4	29	38	52	48	248	415
5	4	5	10	9	59	87
6	2	2	5	4	28	41
7	1	1	2	2	11	16
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	1945	1871	2609	2318	5098	13841

Catch numbers at age (thousands)

Age/Season	Q1	Q2	Q3	Q4	annual	TOTALNUM
1	563	643	1605	1894	2284	6989
2	1731	1461	1961	1680	2138	8970
3	739	819	1005	1001	414	3977
4	795	757	647	568	253	3020
5	189	298	300	152	60	999
6	51	60	62	37	29	240
7	20	31	25	14	11	102
8	3	19	12	5	0	40
9	3	1	1	0	0	6
10	0	1	0	0	0	2
+gp	0	0	0	0	0	1
TOTALNUM	4095	4089	5619	5352	5190	24345

Table 14.2e Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Sampling coverage for discard ratio, landings age composition and discards age composition by area and season (quarter or annual, depending on data stratification) for 2013, calculated as the weight in each area-season-métier stratum covered by the relavant sampling, then summed over métiers and expressed as a proportion of the total for the area-season (note the country dimension is not used). Also provided is the contribution of landings and discards in each area (by weight) to the total for that catch category (before raising is conducted).

Discard ratio coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	95%	85%	80%	88%	100%
IIIaN	84%	80%	74%	77%	-
VIId	75%	81%	89%	78%	100%

Landings age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	98%	95%	87%	96%	100%
IIIaN	100%	95%	88%	94%	-
VIId	78%	83%	89%	87%	100%

Discards age composition coverage

Area/Season	Q1	Q2	Q3	Q4	annual
IV	99%	91%	100%	18%	97%
IIIaN	98%	86%	98%	99%	-
VIId	100%	100%	100%	100%	100%

Contribution to total (before raising)

Area/Type	Landings	Discards
IV	83%	83%
IIIaN	14%	16%
VIId	3%	1%

Table 14.3a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Landings weights at age (kg).

Landings weights at age (kg)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.538	0.496	0.581	0.579	0.590	0.640	0.544	0.626	0.579	0.616	0.559
2	1.004	0.863	0.965	0.994	1.035	0.973	0.921	0.961	0.941	0.836	0.869
3	2.657	2.377	2.304	2.442	2.404	2.223	2.133	2.041	2.193	2.086	1.919
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.594	0.619	0.568	0.541	0.573	0.550	0.550	0.723	0.589	0.632	0.594
2	1.039	0.899	1.029	0.948	0.937	0.936	1.003	0.837	0.962	0.919	1.007
3	2.217	2.348	2.470	2.160	2.001	2.411	1.948	2.190	1.858	1.835	2.156
4	4.156	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972
5	6.174	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190
6	8.333	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362
7	9.889	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317
8	10.791	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352
9	12.175	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505
10	12.425	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408
+gp	13.731	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.590	0.583	0.635	0.585	0.673	0.737	0.670	0.699	0.699	0.677	0.721
2	0.932	0.856	0.976	0.881	1.052	0.976	1.078	1.146	1.065	1.075	1.021
3	2.141	1.834	1.955	1.982	1.846	2.176	2.038	2.546	2.479	2.201	2.210
4	4.164	3.504	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293
5	6.324	6.230	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220
6	8.430	8.140	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980
7	10.362	9.896	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282
8	12.074	11.940	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743
9	13.072	12.951	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107
10	14.443	13.859	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052
+gp	16.588	14.707	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.699	0.656	0.542	0.640	0.611	0.725	0.758	0.608	0.700	0.828	0.750
2	1.117	0.960	0.922	0.935	1.021	1.004	1.082	1.174	0.997	1.190	1.161
3	2.147	2.120	1.724	1.663	1.747	2.303	1.916	1.849	2.014	1.978	2.192
4	4.034	3.821	3.495	3.305	3.216	3.663	3.857	3.256	3.096	3.690	3.731
5	6.637	6.228	5.387	5.726	4.903	5.871	5.372	5.186	5.172	5.060	5.660
6	8.494	8.394	7.563	7.403	7.488	7.333	7.991	7.395	7.426	7.551	6.882
7	9.729	9.979	9.628	8.582	9.636	9.264	9.627	8.703	8.675	9.607	8.896
8	11.080	11.424	10.643	10.365	10.671	10.081	10.403	12.178	9.797	11.229	10.639
9	12.264	12.300	11.499	11.600	10.894	12.062	10.963	12.846	11.684	11.501	12.216
10	12.756	12.761	13.085	12.330	11.414	12.009	12.816	10.771	13.058	13.333	9.212
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.842	17.494	14.140	15.340	10.773

AGE/YEAR	2007	2008	2009	2010	2011	2012	2013
1	0.805	0.801	0.717	0.803	0.722	0.903	0.784
2	1.161	1.503	1.33	1.287	1.301	1.346	1.224
3	2.376	2.511	2.671	2.712	2.520	2.361	2.485
4	4.046	4.026	4.109	4.233	4.365	4.210	4.203
5	5.523	5.777	5.996	6.06	6.256	6.392	6.157
6	8.197	7.164	7.511	7.694	7.721	8.151	8.219
7	8.986	9.358	8.152	9.235	9.236	9.180	9.790
8	9.777	10.909	10.291	10.312	9.637	11.699	9.395
9	12.358	11.596	9.999	10.801	11.497	12.574	11.412
10	13.725	15.278	11.886	11.462	15.756	11.271	12.070
+gp	9.482	13.653	13.597	10.522	12.421	16.932	21.986

Table 14.3b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Discard weights at age (kg).

Discards weights at age (kg)

AGE/YEAI	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.270	0.270	0.269	0.269	0.269	0.269	0.268	0.268	0.268	0.268	0.268
2	0.393	0.393	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
3	0.505	0.508	0.506	0.509	0.506	0.505	0.504	0.505	0.508	0.507	0.507
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.268	0.227	0.189	0.255	0.287	0.276	0.242	0.279	0.274	0.297	0.270
2	0.392	0.359	0.354	0.382	0.309	0.361	0.411	0.396	0.489	0.458	0.469
3	0.508	0.000	0.412	0.376	0.000	0.000	0.000	0.517	0.593	0.534	0.509
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.276	0.242	0.237	0.300	0.326	0.260	0.315	0.314	0.274	0.287	0.316
2	0.376	0.365	0.353	0.339	0.431	0.371	0.366	0.408	0.429	0.362	0.404
3	0.652	0.437	0.000	0.463	0.484	0.526	0.395	2.309	0.705	0.483	0.553
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

AGE/YEAI	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.342	0.313	0.358	0.257	0.298	0.232	0.294	0.259	0.293	0.284	0.179
2	0.380	0.453	0.375	0.389	0.422	0.361	0.420	0.344	0.384	0.468	0.426
3	0.515	0.616	0.481	0.422	0.000	0.406	0.340	0.540	0.427	1.084	0.751
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.675	0.000	4.099	1.300
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.272	0.000	4.501	2.862
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.849	0.000	8.197	4.663
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.585	0.000	0.000	10.895
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.033	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
+gp	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.771	0.000	0.000	0.000

AGE/YEAI	2007	2008	2009	2010	2011	2012	2013
1	0.231	0.299	0.366	0.244	0.248	0.266	0.336
2	0.762	0.683	0.84	0.831	0.595	0.644	0.787
3	1.881	1.660	1.689	1.484	2.005	1.994	1.478
4	4.136	2.459	3.339	3.169	4.119	3.924	3.389
5	6.141	2.848	6.769	5.414	5.709	6.157	4.049
6	9.724	8.051	7.951	5.291	6.781	8.607	8.419
7	1.735	1.239	13.127	6.378	8.254	9.790	7.086
8	12.032	0.576	1.967	3.119	6.623	0.000	0.000
9	0.000	0.000	0.000	0.000	11.6	0.000	0.000
10	0.000	0.000	12.014	0.000	15.17	16.370	16.370
+gp	0.500	0.500	0.000	0.000	12.3576	0.000	0.000

Table 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch weights at age (kg), also assumed to represent stock weights at age.

Catch weights at age (kg)

AGE/YEAI	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.314	0.357	0.313	0.314	0.326	0.328	0.416	0.449	0.313	0.300	0.335
2	0.808	0.762	0.900	0.836	0.868	0.847	0.755	0.845	0.834	0.729	0.700
3	2.647	2.367	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.912
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886

AGE/YEAI	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.304	0.304	0.199	0.295	0.432	0.291	0.258	0.329	0.358	0.403	0.304
2	0.901	0.760	0.722	0.673	0.743	0.905	0.917	0.769	0.908	0.882	0.921
3	2.206	2.348	2.449	2.128	2.001	2.411	1.948	2.186	1.856	1.833	2.156
4	4.156	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972
5	6.174	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190
6	8.333	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362
7	9.889	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317
8	10.791	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352
9	12.175	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505
10	12.425	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408
+gp	13.731	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472

AGE/YEAI	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.314	0.293	0.437	0.466	0.364	0.382	0.392	0.395	0.327	0.305	0.420
2	0.800	0.782	0.773	0.753	0.931	0.690	0.889	0.970	0.845	0.788	0.768
3	2.132	1.822	1.955	1.974	1.810	2.165	1.994	2.545	2.478	2.188	2.207
4	4.164	3.504	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293
5	6.324	6.230	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220
6	8.430	8.140	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980
7	10.362	9.896	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282
8	12.074	11.940	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743
9	13.072	12.951	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107
10	14.443	13.859	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052
+gp	16.588	14.707	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954

AGE/YEAI	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.433	0.386	0.372	0.317	0.354	0.372	0.456	0.275	0.341	0.348	0.217
2	0.831	0.797	0.633	0.732	0.903	0.605	0.916	0.752	0.671	0.895	0.771
3	2.095	2.117	1.622	1.405	1.747	2.093	1.712	1.533	1.713	1.945	1.972
4	4.034	3.821	3.495	3.305	3.216	3.663	3.857	3.191	3.096	3.695	3.610
5	6.637	6.228	5.387	5.726	4.903	5.871	5.372	5.113	5.172	5.055	5.590
6	8.494	8.394	7.563	7.403	7.488	7.333	7.991	7.270	7.426	7.555	6.848
7	9.729	9.979	9.628	8.582	9.636	9.264	9.627	8.630	8.675	9.607	8.911
8	11.080	11.424	10.643	10.365	10.671	10.081	10.403	12.056	9.797	11.229	10.639
9	12.264	12.300	11.499	11.600	10.894	12.062	10.963	12.846	11.684	11.501	12.216
10	12.756	12.761	13.085	12.330	11.414	12.009	12.816	10.771	13.058	13.333	9.212
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.842	17.351	14.140	15.340	10.773

AGE/YEAI	2007	2008	2009	2010	2011	2012	2013
1	0.276	0.330	0.390	0.293	0.335	0.308	0.388
2	0.863	0.904	1.029	1.028	0.835	0.884	0.921
3	2.187	1.971	2.335	2.453	2.424	2.281	2.260
4	4.064	3.834	3.972	4.199	4.349	4.190	4.091
5	5.607	5.692	6.041	6.049	6.245	6.390	5.975
6	8.467	7.228	7.538	7.692	7.710	8.155	8.254
7	8.917	9.321	8.795	9.234	9.216	9.183	9.357
8	9.902	9.879	10.212	10.311	9.495	11.699	9.395
9	12.358	11.596	9.999	10.801	11.499	12.574	11.412
10	13.725	15.278	11.915	11.462	15.754	11.556	12.654
+gp	8.154	13.295	13.597	10.522	12.421	16.932	21.986

Table 14.3d Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Landings, discards and catch weights at age (kg) by season (quarter or annual, depending on data stratification) from Intercatch for 2013 (note differences in the +gp values between Tables 14.3a-c and Table 14.3d is due to rounding error alone).

Landings weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.895	0.764	0.601	0.860	0.868	0.784
2	1.157	1.057	1.174	1.343	1.637	1.224
3	2.061	2.151	2.706	2.813	3.649	2.485
4	3.818	3.890	4.648	4.676	5.573	4.203
5	5.741	5.699	6.545	6.843	8.708	6.157
6	7.348	7.862	8.482	9.683	9.111	8.219
7	9.688	9.458	10.156	10.072	10.633	9.790
8	9.381	8.486	10.341	10.603	0.000	9.395
9	9.016	13.919	15.362	13.276	0.000	11.412
10	16.187	9.018	17.517	15.685	0.000	12.070
+gp	26.775	15.308	21.938	31.292	0.000	21.978

Discards weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.247	0.271	0.312	0.327	0.393	0.336
2	0.488	0.601	0.773	0.846	1.060	0.787
3	0.988	0.981	1.378	1.291	1.859	1.478
4	4.017	3.101	3.442	3.263	3.373	3.389
5	4.056	4.066	4.046	4.245	4.018	4.049
6	8.421	8.419	8.418	8.509	8.406	8.419
7	7.086	7.086	7.086	7.086	7.086	7.086
8	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000
10	16.370	16.370	16.370	16.370	0.000	16.370
+gp	0.000	0.000	0.000	0.000	0.000	0.000

Catch weights at age (kg)

Age/Season	Q1	Q2	Q3	Q4	annual	total
1	0.362	0.291	0.355	0.439	0.402	0.388
2	0.637	0.724	0.958	1.155	1.068	0.921
3	1.916	1.947	2.549	2.630	1.899	2.260
4	3.825	3.850	4.551	4.557	3.420	4.091
5	5.709	5.674	6.459	6.691	4.042	5.975
6	7.384	7.882	8.477	9.550	8.430	8.254
7	9.601	9.393	9.918	9.736	7.098	9.357
8	9.381	8.486	10.341	10.603	0.000	9.395
9	9.016	13.919	15.362	13.276	0.000	11.412
10	16.193	9.140	17.410	16.177	0.000	12.654
+gp	26.775	15.308	21.938	31.292	0.000	21.978

Table 14.4 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Reported landings, estimated discards and total catch (landings + discards) in tonnes.

year	landings	discards	catch
1963	116457	12247	128704
1964	126041	4731	130771
1965	181036	29251	210287
1966	221336	38109	259445
1967	252977	23438	276416
1968	288368	17575	305943
1969	200760	4816	205576
1970	226124	17928	244053
1971	328098	84392	412490
1972	353976	33848	387824
1973	239051	30190	269241
1974	214279	39807	254086
1975	205245	37060	242304
1976	234169	72840	307009
1977	209154	139820	348974
1978	297022	32583	329605
1979	269973	163279	433252
1980	293644	295449	589093
1981	335497	57897	393394
1982	303251	54501	357752
1983	259287	22101	281388
1984	228286	151923	380209
1985	214629	31503	246131
1986	204053	139081	343134
1987	216212	27839	244052
1988	184240	10714	194954
1989	139936	62119	202055
1990	125314	27022	152336
1991	102478	18552	121030
1992	114020	36920	150940
1993	121749	21860	143609
1994	110634	99578	210212
1995	136096	32188	168283
1996	126320	14255	140575
1997	124158	33616	157774
1998	146014	40480	186494
1999	96225	14180	110405
2000	71371	13713	85084
2001	49694	13871	63565
2002	54865	5706	60571
2003	30872	6372	37244
2004	28188	5849	34037
2005	28708	6272	34980
2006	26590	8050	34640
2007	24433	23636	48069
2008	26847	21814	48661
2009	30753	14022	44775
2010	37180	9982	47163
2011	32871	9485	42357
2012	32799	8792	41591
2013	31092	10540	41632

Table 14.5a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Proportion mature by age-group.

Age group	Proportion mature
1	0.01
2	0.05
3	0.23
4	0.62
5	0.86
6	1.0
7+	1.0

Table 14.5b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Natural mortality by age-group.

	Age						
	1	2	3	4	5	6	7+
1963	1.107	0.789	0.233	0.202	0.2	0.2	0.2
1964	1.147	0.804	0.241	0.202	0.2	0.2	0.2
1965	1.184	0.819	0.248	0.202	0.2	0.2	0.2
1966	1.217	0.831	0.254	0.202	0.2	0.2	0.2
1967	1.242	0.839	0.261	0.202	0.2	0.2	0.2
1968	1.260	0.843	0.266	0.202	0.2	0.2	0.2
1969	1.273	0.844	0.271	0.202	0.2	0.2	0.2
1970	1.282	0.842	0.275	0.202	0.2	0.2	0.2
1971	1.287	0.838	0.277	0.201	0.2	0.2	0.2
1972	1.290	0.832	0.279	0.201	0.2	0.2	0.2
1973	1.291	0.826	0.280	0.201	0.2	0.2	0.2
1974	1.292	0.819	0.280	0.200	0.2	0.2	0.2
1975	1.293	0.811	0.280	0.200	0.2	0.2	0.2
1976	1.296	0.803	0.280	0.200	0.2	0.2	0.2
1977	1.301	0.795	0.282	0.200	0.2	0.2	0.2
1978	1.306	0.787	0.284	0.200	0.2	0.2	0.2
1979	1.311	0.779	0.286	0.200	0.2	0.2	0.2
1980	1.314	0.771	0.290	0.200	0.2	0.2	0.2
1981	1.314	0.762	0.293	0.200	0.2	0.2	0.2
1982	1.310	0.754	0.296	0.200	0.2	0.2	0.2
1983	1.301	0.746	0.298	0.201	0.2	0.2	0.2
1984	1.287	0.738	0.300	0.201	0.2	0.2	0.2
1985	1.269	0.730	0.300	0.201	0.2	0.2	0.2
1986	1.248	0.724	0.300	0.201	0.2	0.2	0.2
1987	1.226	0.719	0.299	0.202	0.2	0.2	0.2
1988	1.204	0.716	0.297	0.202	0.2	0.2	0.2
1989	1.183	0.715	0.296	0.202	0.2	0.2	0.2
1990	1.164	0.715	0.295	0.202	0.2	0.2	0.2
1991	1.149	0.716	0.295	0.202	0.2	0.2	0.2
1992	1.135	0.717	0.297	0.202	0.2	0.2	0.2
1993	1.124	0.716	0.302	0.203	0.2	0.2	0.2
1994	1.113	0.714	0.309	0.204	0.2	0.2	0.2
1995	1.102	0.711	0.319	0.205	0.2	0.2	0.2
1996	1.090	0.705	0.331	0.207	0.2	0.2	0.2
1997	1.077	0.698	0.346	0.209	0.2	0.2	0.2
1998	1.064	0.691	0.363	0.211	0.2	0.2	0.2
1999	1.051	0.683	0.381	0.214	0.2	0.2	0.2
2000	1.040	0.678	0.400	0.217	0.2	0.2	0.2
2001	1.032	0.676	0.417	0.220	0.2	0.2	0.2
2002	1.028	0.676	0.434	0.223	0.2	0.2	0.2
2003	1.027	0.679	0.449	0.225	0.2	0.2	0.2
2004	1.029	0.684	0.462	0.227	0.2	0.2	0.2
2005	1.032	0.688	0.472	0.229	0.2	0.2	0.2
2006	1.036	0.692	0.480	0.230	0.2	0.2	0.2
2007	1.038	0.695	0.484	0.231	0.2	0.2	0.2
2008	1.039	0.696	0.487	0.232	0.2	0.2	0.2
2009	1.039	0.697	0.489	0.232	0.2	0.2	0.2
2010	1.038	0.698	0.490	0.233	0.2	0.2	0.2
2011*	1.038	0.698	0.490	0.233	0.2	0.2	0.2
2012*	1.038	0.698	0.490	0.233	0.2	0.2	0.2
2013*	1.038	0.698	0.490	0.233	0.2	0.2	0.2

***A new key run was performed in 2011 with data up to 2010 (ICES-WGSAM 2011), so 2011-13 M-values are assumed equal to 2010.**

Table 14.6 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Survey tuning CPUE. Data used in the assessment are highlighted in bold text.

North Sea/Skagerrak/Eastern Channel Cod, Tuning data for standard survey. Updated 26 April 14

101							
IBTS_Q1_ext							
1983	2014						
1	1	0	0.25				
1	5						year
1	**5.696**	**17.403**	**2.997**	**2.05**	**0.793**	1.275	1983
1	**17.107**	**9.913**	**4.375**	**0.93**	**0.995**	0.82	1984
1	**1.096**	**20.221**	**4.562**	**3.649**	**0.768**	1.103	1985
1	**18.112**	**3.793**	**7.787**	**2.756**	**1.368**	0.981	1986
1	**9.626**	**33.252**	**1.845**	**2.032**	**0.659**	0.792	1987
1	**6.99**	**7.737**	**7.96**	**0.702**	**0.865**	1.072	1988
1	**14.953**	**6.776**	**5.877**	**2.668**	**0.412**	0.944	1989
1	**4.606**	**15.376**	**2.141**	**1.046**	**0.965**	0.596	1990
1	**2.688**	**5.061**	**4.757**	**1.042**	**0.551**	0.773	1991
1	**16.439**	**4.821**	**1.364**	**1.023**	**0.312**	0.445	1992
1	**13.619**	**20.429**	**2.4**	**0.807**	**0.693**	0.356	1993
1	**14.856**	**4.51**	**3.015**	**0.86**	**0.486**	0.498	1994
1	**12.798**	**27.878**	**3.461**	**1.363**	**0.306**	0.348	1995
1	**4.384**	**9.512**	**6.368**	**0.796**	**0.663**	0.397	1996
1	**38.005**	**7.597**	**2.67**	**1.142**	**0.455**	0.392	1997
1	**2.951**	**27.555**	**2.309**	**1.087**	**0.552**	0.401	1998
1	**3.304**	**1.878**	**8.104**	**0.804**	**0.452**	0.509	1999
1	**6.639**	**5.537**	**0.889**	**2.152**	**0.436**	0.591	2000
1	**3.378**	**9.316**	**1.891**	**0.293**	**0.41**	0.251	2001
1	**11.491**	**4.24**	**4.54**	**0.671**	**0.143**	0.23	2002
1	**0.756**	**4.168**	**1.301**	**1.415**	**0.48**	0.205	2003
1	**11.544**	**3.227**	**1.575**	**0.46**	**0.556**	0.276	2004
1	**2.731**	**3.283**	**0.94**	**0.665**	**0.229**	0.435	2005
1	**9.061**	**1.777**	**1.408**	**0.313**	**0.173**	0.295	2006
1	**3.636**	**8.109**	**1.365**	**0.461**	**0.331**	0.353	2007
1	**3.62**	**2.279**	**3.09**	**0.721**	**0.464**	0.189	2008
1	**2.171**	**3.526**	**1.172**	**0.986**	**0.327**	0.272	2009
1	**5.811**	**4.655**	**1.882**	**0.651**	**0.537**	0.231	2010
1	**1.098**	**7.059**	**1.952**	**0.746**	**0.417**	0.408	2011
1	**5.162**	**3.443**	**4.791**	**1.302**	**0.477**	0.21	2012
1	**2.753**	**5.758**	**1.916**	**1.632**	**0.874**	0.335	2013
1	**3.897**	**4.957**	**2.323**	**0.924**	**0.893**	0.451	2014

Table 14.7a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run model specification (model.cfg file).

```
# Min Age (should not be modified unless data is modified accordingly)
1
# Max Age (should not be modified unless data is modified accordingly)
7
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality STATES
# Rows represent fleets.
# Columns represent ages.
1       2       3       4       5       6       6
0       0       0       0       0       0       0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
1
# Coupling of catchability PARAMETERS
0       0       0       0       0       0       0
1       2       3       4       5       0       0
# Coupling of power law model EXPONENTS (if used)
0       0       0       0       0       0       0
0       0       0       0       0       0       0
# Coupling of fishing mortality RW VARIANCES
1       1       1       1       1       1       1
0       0       0       0       0       0       0
# Coupling of log N RW VARIANCES
1       2       2       2       2       2       2
# Coupling of OBSERVATION VARIANCES
1       2       3       3       3       3       3
4       5       5       5       5       0       0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
2
# Years in which catch data are to be scaled by an estimated parameter
# first the number of years
13
```

```
# Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
# Them the model config lines years cols ages
 1  1  1  1  1  1  1
 2  2  2  2  2  2  2
 3  3  3  3  3  3  3
 4  4  4  4  4  4  4
 5  5  5  5  5  5  5
 6  6  6  6  6  6  6
 7  7  7  7  7  7  7
 8  8  8  8  8  8  8
 9  9  9  9  9  9  9
10 10 10 10 10 10 10
11 11 11 11 11 11 11
12 12 12 12 12 12 12
13 13 13 13 13 13 13
# Define Fbar range
2       4
```

Table 14.7b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run model fitting diagnostics, parameter estimates and correlation matrix (.par and .cor files)

Number of parameters = 29 Objective function value = 122.760 Maximum gradient component = 0.0121998

The logarithm of the determinant of the hessian = 134.083

index	name	value	std.dev	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	log survey q 1	-10.807	0.12028	1																												
2	log survey q 2	-9.3446	0.05635	0.16	1																											
3	log survey q 3	-8.89	0.0542	0.12	0.26	1																										
4	log survey q 4	-8.6325	0.05487	0.11	0.24	0.28	1																									
5	log survey q 5	-8.2573	0.05599	0.11	0.24	0.27	0.3	1																								
6	log sigF	-2.4477	0.13741	-0.1	-0.1	-0.2	-0.2	-0.2	1																							
7	log sigR	-0.697	0.11313	-0	-0	-0	-0	-0	-0	1																						
8	log sigN	-2.2613	0.17484	-0	-0.1	-0.1	-0.1	-0.1	-0.1	0.23	1																					
9	log sigC1	-0.303	0.11405	0	0.01	0.02	0.02	0.02	-0	-0.1	-0.1	1																				
10	log sigC2	-1.5258	0.16306	0.02	0.05	0.05	0.06	0.06	-0	-0.2	-0.3	0.16	1																			
11	log sigC3+	-2.4795	0.16237	0.01	0.02	0.03	0.04	0.03	-0	-0.1	-0.6	0.07	0.11	1																		
12	log sigS1	-0.4537	0.13248	0.01	0.03	0.03	0.03	0.04	-0	-0	-0.1	-0	0.02	0.05	1																	
13	log sigS2+	-1.368	0.07491	0.05	0.1	0.11	0.13	0.14	-0.1	-0.1	-0.2	0.04	0.12	0.1	0.04	1																
14	rec_loga	1.7849	0.13599	-0.1	-0.1	-0	0.01	0.01	-0	-0	0.01	0.02	0.03	-0	-0	-0	1															
15	rec_logb	-14.284	1.6371	-0	-0	0	0.01	0.01	-0	-0	0.02	0.03	0.04	-0	-0	-0	0.83	1														
16	rho	0.80801	0.08836	-0.1	-0.1	-0.1	-0.1	-0.2	0.39	0	0.15	0.12	0.1	0.05	-0	-0.2	0.02	0.04	1													
17	log Cmult 93	-0.1027	0.09061	-0.1	-0.2	-0.2	-0.2	-0.2	0.04	-0	0.06	-0	-0	-0	-0	-0	-0	-0	0.05	1												
18	log Cmult 94	-0.0238	0.10078	-0.1	-0.2	-0.2	-0.2	-0.2	0.04	0	0.02	0.02	-0	-0	-0	-0	-0	-0	0.06	0.44	1											
19	log Cmult 95	0.09578	0.10405	-0.1	-0.2	-0.2	-0.2	-0.2	0.1	0.02	0.03	0	0.03	-0	-0	-0	-0	-0	0.09	0.23	0.49	1										
20	log Cmult 96	-0.0706	0.10568	-0.1	-0.2	-0.3	-0.3	-0.3	0.14	0.04	0.1	-0	-0	-0.1	-0	-0.1	-0	-0	0.11	0.13	0.26	0.5	1									
21	log Cmult 97	-0.1798	0.10422	-0.1	-0.2	-0.2	-0.2	-0.2	0.09	0.05	0.02	-0	-0	0	-0	-0.1	0	0	0.07	0.08	0.14	0.26	0.49	1								
22	log Cmult 98	-0.3579	0.10467	-0.1	-0.2	-0.2	-0.3	-0.3	0.12	0.03	0.02	-0	-0	-0	-0	-0.1	0	0	0.08	0.07	0.09	0.15	0.26	0.5	1							
23	log Cmult 99	-0.2676	0.10674	-0.1	-0.2	-0.3	-0.3	-0.3	0.18	0.03	0.08	-0	-0.1	-0	-0	-0.1	-0	-0	0.11	0.08	0.09	0.11	0.17	0.27	0.5	1						
24	log Cmult 00	-0.0827	0.10549	-0.1	-0.2	-0.2	-0.3	-0.3	0.14	0.01	0.02	-0	-0	0.01	-0	-0.1	-0	-0	0.09	0.08	0.09	0.1	0.12	0.15	0.26	0.5	1					
25	log Cmult 01	0.28519	0.10426	-0.1	-0.2	-0.2	-0.2	-0.2	0.03	0.02	0.01	-0	0.01	-0	-0	-0	-0	-0	0.02	0.08	0.1	0.1	0.1	0.1	0.13	0.24	0.48	1				
26	log Cmult 02	0.11707	0.10606	-0.1	-0.2	-0.2	-0.2	-0.2	0.07	0.06	0.04	-0	-0.1	0.03	-0	-0.1	-0	-0	0.05	0.09	0.11	0.11	0.12	0.11	0.11	0.16	0.26	0.49	1			
27	log Cmult 03	0.52176	0.10634	-0.1	-0.2	-0.3	-0.3	-0.3	0.16	0.03	0.05	0	0.01	-0	-0	-0.1	0.01	0	0.12	0.09	0.11	0.14	0.14	0.12	0.11	0.13	0.16	0.26	0.49	1		
28	log Cmult 04	0.18077	0.10502	-0.1	-0.2	-0.2	-0.2	-0.2	0.19	0.02	0.07	-0	-0.1	-0	-0	-0.1	0	-0	0.14	0.09	0.11	0.13	0.14	0.12	0.12	0.13	0.12	0.14	0.27	0.51	1	
29	log Cmult 05	0.16289	0.09416	-0.1	-0.2	-0.2	-0.2	-0.2	0.19	-0	0.04	-0	-0	-0	-0	-0.1	-0	-0	0.13	0.07	0.09	0.1	0.12	0.1	0.1	0.11	0.09	0.08	0.14	0.26	0.48	1

Table 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated fishing mortality at age.

Fishing mortality (F) at age

Year\Age	1	2	3	4	5	6	7+	Fbar 2-4
1963	0.115	0.448	0.513	0.474	0.450	0.486	0.486	0.478
1964	0.122	0.470	0.556	0.502	0.479	0.507	0.507	0.509
1965	0.129	0.494	0.598	0.531	0.504	0.521	0.521	0.541
1966	0.133	0.512	0.619	0.539	0.517	0.532	0.532	0.557
1967	0.146	0.561	0.676	0.584	0.569	0.580	0.580	0.607
1968	0.153	0.594	0.707	0.615	0.598	0.599	0.599	0.639
1969	0.150	0.583	0.680	0.593	0.581	0.576	0.576	0.619
1970	0.153	0.605	0.695	0.597	0.586	0.566	0.566	0.632
1971	0.172	0.690	0.769	0.661	0.644	0.622	0.622	0.707
1972	0.191	0.776	0.841	0.722	0.697	0.694	0.694	0.780
1973	0.187	0.764	0.804	0.696	0.667	0.660	0.660	0.755
1974	0.185	0.756	0.772	0.668	0.646	0.646	0.646	0.732
1975	0.196	0.805	0.814	0.699	0.677	0.674	0.674	0.773
1976	0.205	0.850	0.855	0.718	0.699	0.693	0.693	0.808
1977	0.204	0.841	0.849	0.695	0.696	0.684	0.684	0.795
1978	0.222	0.899	0.941	0.760	0.770	0.728	0.728	0.867
1979	0.205	0.805	0.881	0.699	0.698	0.654	0.654	0.795
1980	0.221	0.855	0.960	0.766	0.737	0.711	0.711	0.860
1981	0.227	0.869	0.997	0.799	0.743	0.735	0.735	0.888
1982	0.253	0.962	1.129	0.911	0.831	0.835	0.835	1.001
1983	0.249	0.943	1.106	0.909	0.820	0.824	0.824	0.986
1984	0.234	0.883	1.020	0.859	0.772	0.781	0.781	0.921
1985	0.225	0.850	0.971	0.837	0.745	0.758	0.758	0.886
1986	0.239	0.900	1.031	0.911	0.800	0.820	0.820	0.947
1987	0.237	0.897	1.022	0.919	0.795	0.829	0.829	0.946
1988	0.237	0.898	1.041	0.933	0.809	0.828	0.828	0.957
1989	0.243	0.923	1.065	0.970	0.844	0.859	0.859	0.986
1990	0.226	0.864	0.984	0.908	0.794	0.800	0.800	0.919
1991	0.231	0.878	1.004	0.940	0.831	0.851	0.851	0.941
1992	0.224	0.848	0.977	0.928	0.821	0.837	0.837	0.918
1993	0.221	0.834	0.985	0.928	0.825	0.837	0.837	0.916
1994	0.219	0.816	0.997	0.929	0.827	0.836	0.836	0.914
1995	0.221	0.824	1.034	0.950	0.856	0.853	0.853	0.936
1996	0.225	0.826	1.065	0.977	0.906	0.909	0.909	0.956
1997	0.223	0.803	1.061	0.997	0.930	0.920	0.920	0.954
1998	0.227	0.800	1.081	1.037	0.981	0.938	0.938	0.973
1999	0.233	0.800	1.113	1.088	1.038	0.999	0.999	1.000
2000	0.233	0.791	1.090	1.116	1.080	1.009	1.009	0.999
2001	0.222	0.750	1.021	1.078	1.047	0.984	0.984	0.950
2002	0.216	0.719	0.986	1.060	1.028	0.979	0.979	0.922
2003	0.213	0.714	0.968	1.052	1.022	0.971	0.971	0.911
2004	0.206	0.687	0.932	1.030	0.980	0.971	0.971	0.883
2005	0.194	0.642	0.867	0.962	0.935	0.935	0.935	0.824
2006	0.168	0.552	0.752	0.817	0.813	0.818	0.818	0.707
2007	0.149	0.487	0.676	0.719	0.721	0.731	0.731	0.627
2008	0.155	0.503	0.707	0.733	0.764	0.798	0.798	0.648
2009	0.149	0.481	0.675	0.712	0.748	0.800	0.800	0.623
2010	0.144	0.457	0.645	0.688	0.726	0.785	0.785	0.597
2011	0.127	0.399	0.556	0.607	0.647	0.7	0.7	0.521
2012	0.108	0.338	0.474	0.521	0.559	0.585	0.585	0.444
2013	0.097	0.301	0.425	0.467	0.5	0.514	0.514	0.398

Table 14.9 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated population numbers at age. [Note, the recruitment value in the final year relies on a single data point only, and is therefore considerd preliminary only, and is ignored for projections.]

Stock numbers at age (start of year) (thousands)

Year\Age	1	2	3	4	5	6	7+	Total
1963	461390	193687	21393	10377	8641	3341	1657	700486
1964	841549	137173	53370	11681	5363	4691	2338	1056165
1965	1065548	243775	40905	23179	6414	2643	3165	1385629
1966	1370930	286359	69703	16736	9887	3365	2947	1759927
1967	1268062	357539	73865	29144	7963	4822	3325	1744720
1968	654744	320937	91309	28141	14338	3515	3607	1116591
1969	600189	155749	76420	33928	11354	6724	3159	887523
1970	1835817	145801	39935	32209	15308	4760	4084	2077914
1971	2383308	445521	35277	14967	15537	6787	4191	2905588
1972	588893	563544	94372	12276	6100	6712	5481	1277378
1973	876770	129703	111636	29584	4978	2517	4539	1159727
1974	810981	195830	25694	37049	11038	2160	3167	1085919
1975	1390258	180412	39656	9669	16285	4605	2281	1643166
1976	857692	314268	35954	13751	3960	6810	2769	1235204
1977	2115919	185535	55659	11208	5286	1739	4036	2379382
1978	1255444	476870	32991	18822	5240	2264	2277	1793908
1979	1431166	281532	85391	9346	7209	1794	1786	1818224
1980	2264807	312075	61759	25185	4038	2814	1697	2672375
1981	884697	492377	61945	17926	9167	1638	1830	1469580
1982	1376425	186652	95798	17055	6712	3783	1446	1687871
1983	795718	290106	34201	21322	5455	2443	1821	1151066
1984	1380560	171613	54502	8112	6816	2022	1586	1625211
1985	367692	303458	35383	15519	2903	2635	1381	728971
1986	1644587	83034	60901	10432	5690	1162	1635	1807441
1987	646288	381933	17625	15621	3226	2023	1042	1067758
1988	446860	151903	73497	5323	5031	1251	980	684845
1989	743408	105556	31920	17510	1826	1901	837	902958
1990	320296	177549	21140	7949	5084	641	943	533602
1991	348363	78276	33057	6024	2640	1931	688	470979
1992	719276	87904	16110	8784	1982	936	876	835868
1993	392778	186279	18817	5008	2789	737	623	607031
1994	832343	101013	37347	5340	1680	978	477	979178
1995	484077	222348	23506	10112	1712	621	502	742878
1996	349759	128798	41856	5646	3149	642	463	530313
1997	920802	95703	27447	9501	1861	1027	360	1056701
1998	148153	256017	21952	6891	2808	645	421	436887
1999	264607	39340	53477	5186	1953	821	398	365782
2000	478303	73644	9965	10433	1449	597	340	574731
2001	181680	138968	17538	2407	2439	357	294	343683
2002	224583	51792	33024	4514	682	667	197	315459
2003	110084	63323	14263	7923	1272	204	240	197309
2004	171785	31634	14613	3671	2221	332	150	224406
2005	114691	48146	7764	3442	1001	762	142	175948
2006	295670	32728	12549	2133	946	303	281	344610
2007	123748	90039	9647	3829	808	323	195	228589
2008	147414	36938	26930	2900	1461	350	239	216232
2009	156843	44445	10874	7341	1180	520	228	221431
2010	235155	48002	13815	3548	2770	460	253	304003
2011	125367	72548	14866	4031	1417	1118	247	219594
2012	183689	39222	24125	5781	1647	595	448	255507
2013	197996	57354	14211	9036	2804	697	433	282531
2014	285501	63768	20785	5687	4375	1393	553	382062

Table 14.10 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated total removals at age (including catches due to unaccounted mortality)

Total removals at age (thousands)

Year\Age	1	2	3	4	5	6	7+
1963	30746	49821	7739	3572	2860	1175	583
1964	58273	36436	20444	4209	1865	1706	850
1965	76596	67104	16513	8722	2320	981	1175
1966	100238	80652	28788	6374	3648	1270	1112
1967	99898	107904	32429	11781	3163	1943	1340
1968	53734	101144	41246	11836	5907	1450	1488
1969	47930	48378	33530	13883	4581	2694	1265
1970	149447	46649	17752	13246	6216	1881	1614
1971	215712	157661	16825	6632	6760	2878	1777
1972	58835	217445	47729	5786	2808	3079	2514
1973	85837	49637	54776	13599	2221	1115	2011
1974	78229	74608	12276	16540	4813	941	1380
1975	141521	72049	19628	4457	7343	2069	1025
1976	91090	130758	18382	6459	1825	3120	1268
1977	222949	76795	28314	5149	2430	790	1833
1978	142886	207254	17895	9198	2583	1074	1080
1979	150799	113789	44374	4311	3320	789	786
1980	255582	131755	33843	12379	1931	1313	792
1981	102201	210976	34707	9057	4410	782	874
1982	176363	85837	57659	9380	3480	1969	752
1983	100720	132085	20332	11707	2803	1260	939
1984	166043	74997	30847	4298	3365	1006	789
1985	42912	129677	19453	8084	1399	1284	673
1986	204475	36968	34700	5734	2876	598	841
1987	80330	169838	9995	8632	1625	1048	540
1988	56106	67650	42159	2969	2563	647	507
1989	96298	47892	18570	10001	957	1007	444
1990	39085	77165	11738	4361	2559	324	477
1991	43656	34358	18575	3376	1369	1017	362
1992	88098	37666	8899	4884	1019	488	456
1993	47801	78976	10423	2784	1439	384	325
1994	100509	42214	20789	2968	869	509	248
1995	59249	93639	13322	5697	905	327	265
1996	43774	54491	24031	3234	1727	353	254
1997	115174	39775	15632	5503	1037	568	199
1998	18869	106415	12558	4082	1617	361	236
1999	34721	16413	30900	3156	1163	478	232
2000	62957	30510	5647	6430	883	349	199
2001	22992	55503	9493	1453	1460	206	170
2002	27786	20083	17385	2695	404	383	113
2003	13455	24392	7379	4706	751	117	137
2004	20361	11828	7348	2152	1278	190	86
2005	12832	17100	3710	1935	559	426	79
2006	28828	10334	5425	1080	483	155	144
2007	10779	25750	3858	1777	381	154	93
2008	13295	10827	11109	1364	716	177	120
2009	13704	12562	4338	3384	570	263	115
2010	19796	13007	5330	1594	1311	230	126
2011	9370	17560	5126	1656	618	516	114
2012	11838	8257	7342	2114	645	241	182
2013	11471	10936	3958	3034	1008	256	159

Table 14.11a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated stock and management metrics, together with the lower and upper bounds of the point-wise 95% confidence intervals.

Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), total removals (including catches due to unaccounted mortality) and average fishing mortality for ages 2 to 4 (Fbar 2-4).

	Recruits age 1			TSB			SSB			Total removals					
Year	('000)	Low	High	(tons)	Low	High	(tons)	Low	High	(tons)	Low	High	Fbar 2-4	Low	High
1963	461390	340639	624946	514525	457740	578355	152970	137859	169738	123871	110140	139315	0.478	0.423	0.541
1964	841549	627375	1128839	684196	594758	787084	165215	150107	181842	151903	136993	168437	0.509	0.455	0.569
1965	1065548	798875	1421240	861991	757581	980790	204638	186924	224031	202197	180830	226089	0.541	0.486	0.603
1966	1370930	1027727	1828744	1048635	918440	1197286	227521	208875	247832	247459	221908	275951	0.557	0.501	0.619
1967	1268062	948560	1695181	1134837	1001202	1286310	251702	231636	273506	297747	266206	333026	0.607	0.547	0.673
1968	654744	486202	881711	943168	852827	1043080	261974	241386	284318	300439	271783	332117	0.639	0.577	0.708
1969	600189	447056	805775	801307	718601	893533	258849	238152	281344	237994	217862	259986	0.619	0.558	0.686
1970	1835817	1371341	2457610	1331744	1109578	1598394	274306	252050	298528	265667	233653	302068	0.632	0.572	0.699
1971	2383308	1778392	3193985	1465929	1246839	1723518	276509	254935	299909	353274	307104	406386	0.707	0.642	0.779
1972	588893	439073	789836	980679	876649	1097053	240867	222283	261005	366590	321909	417473	0.780	0.707	0.859
1973	876770	654823	1173944	800507	710963	901328	212352	196466	229522	259627	236320	285232	0.755	0.685	0.831
1974	810981	605167	1086791	755398	673393	847390	232118	213612	252226	239905	215678	266854	0.732	0.665	0.807
1975	1390258	1026638	1882667	863717	739925	1008219	213203	196514	231309	239187	212980	268619	0.773	0.702	0.850
1976	857692	631567	1164777	663312	587842	748470	182956	169118	197926	239426	209665	273412	0.808	0.733	0.890
1977	2115919	1563098	2864258	1013581	836994	1227424	160974	149253	173616	244507	210688	283754	0.795	0.722	0.876
1978	1255444	931787	1691523	1120180	952645	1317178	160653	149476	172665	327748	278103	386255	0.867	0.789	0.953
1979	1431166	1065186	1922890	1001491	871708	1150595	166708	155172	179102	310519	273798	352165	0.795	0.723	0.874
1980	2264807	1677407	3057903	1170568	995322	1376670	181861	169282	195376	339422	295094	390409	0.860	0.786	0.942
1981	884697	658566	1188473	986580	869528	1119389	194269	181258	208214	361132	314800	414284	0.888	0.813	0.971
1982	1376425	1034574	1831233	1006511	867761	1167445	187400	175354	200273	336718	298436	379910	1.001	0.917	1.092
1983	795718	601968	1051828	797311	697426	911501	152207	142209	162909	278730	244610	317610	0.986	0.905	1.075
1984	1380560	1042133	1828890	804519	689317	938975	129962	121582	138920	241108	212481	273592	0.921	0.843	1.005
1985	367692	275929	489970	554599	496228	619836	124617	116514	133284	219696	192821	250317	0.886	0.811	0.968
1986	1644587	1239403	2182235	756910	630572	908562	114005	106747	121757	204025	177424	234615	0.947	0.870	1.032
1987	646288	489784	852800	717839	623201	826848	106724	99783	114147	242316	207227	283348	0.946	0.869	1.030
1988	446860	338690	589577	535523	473663	605463	98617	92263	105408	196025	175608	218817	0.957	0.879	1.042
1989	743408	558360	989782	523347	448106	611222	92226	86070	98823	166875	147481	188819	0.986	0.905	1.074
1990	320296	242826	422481	366590	325285	413141	77964	72838	83451	133119	117461	150865	0.919	0.841	1.003
1991	348363	263856	459935	334703	295014	379732	71325	66909	76032	118421	106416	131780	0.941	0.863	1.025
1992	719276	544716	949775	476870	402023	565653	67373	63097	71939	129962	113134	149294	0.918	0.842	1.000
1993	392778	298051	517611	386157	340257	438250	62131	58317	66195	136762	119129	157005	0.916	0.840	0.998
1994	832343	622974	1112077	464167	394178	546583	63640	59736	67800	135808	119689	154099	0.914	0.839	0.996
1995	484077	367515	637609	492870	427858	567760	71111	66530	76008	163081	141310	188206	0.936	0.858	1.020
1996	349759	265285	461132	400312	354122	452527	69494	65213	74056	144784	129305	162117	0.956	0.878	1.041
1997	920802	693745	1222172	550180	456729	662751	65710	61653	70033	143631	123942	166447	0.954	0.878	1.036
1998	148153	111369	197087	301040	265556	341267	53906	50517	57522	122884	106127	142288	0.973	0.896	1.056
1999	264607	200242	349661	225934	201127	253802	49613	46470	52968	89232	80816	98525	1.001	0.920	1.088
2000	478303	362573	630974	301643	256114	355266	43827	40827	47047	89322	77609	102802	0.999	0.920	1.084
2001	181680	136146	242443	217075	192544	244732	36607	34325	39041	79063	69800	89556	0.949	0.875	1.030
2002	224583	169038	298379	234920	205651	268354	37684	35275	40259	77575	69246	86906	0.922	0.848	1.002
2003	110084	83420	145272	135402	122369	149822	32827	30554	35269	54394	48901	60503	0.911	0.838	0.991
2004	171785	130215	226627	131531	115286	150066	28226	26405	30173	42959	38731	47648	0.883	0.810	0.963
2005	114691	87263	150741	123130	109607	138322	25489	23826	27268	40987	36511	46011	0.824	0.754	0.901
2006	295670	224556	389306	131795	114352	151898	21595	20175	23114	33928	30269	38029	0.707	0.644	0.775
2007	123748	94217	162534	157787	139823	178059	27255	25334	29322	45207	39531	51698	0.627	0.568	0.692
2008	147414	112149	193769	159373	143005	177613	33356	30846	36071	47858	43394	52782	0.648	0.588	0.714
2009	156843	119176	206414	174730	155381	196490	39066	35968	42430	48388	43632	53661	0.623	0.561	0.691
2010	235155	178218	310283	189662	167241	215089	40579	36990	44516	49861	44899	55372	0.597	0.532	0.669
2011	125367	94165	166908	176134	155838	199073	41316	36929	46224	46397	41709	51613	0.521	0.454	0.597
2012	183689	132204	255225	190232	164312	220242	48194	41811	55553	44400	40451	48735	0.444	0.373	0.53
2013	197996	127066	308519	225483	185060	274735	57989	48247	69697	45524	40496	51177	0.398	0.318	0.498
2014							68528	53469	87828						

Table 14.11b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated landings, discards, catch (=landings + discards) and total removals in tonnes. Landings and discards are derived by applying the landing fraction from landings and discards data to the SAM estimate of catch (after removing unaccounted mortality), while total removals are the SAM estimate of catch, including a catch multiplier incorporated from 1993 to 2005 only.

Year	Landings	Discards	Catch	Catch multiplier	Total Removals
1963	110747	13204	123871		123871
1964	138968	12856	151903		151903
1965	181317	20775	202197		202197
1966	215993	31414	247459		247459
1967	264607	33190	297747		297747
1968	279568	20835	300439		300439
1969	226160	11912	237994		237994
1970	242074	23600	265667		265667
1971	292143	61329	353274		353274
1972	331705	34996	366590		366590
1973	234920	24711	259627		259627
1974	215130	24909	239905		239905
1975	206695	32500	239187		239187
1976	201592	37911	239426		239426
1977	180773	63513	244507		244507
1978	287506	40015	327748		327748
1979	269144	41523	310519		310519
1980	272665	66636	339422		339422
1981	322868	38216	361132		361132
1982	296262	40296	336718		336718
1983	253470	25286	278730		278730
1984	195634	45661	241108		241108
1985	197798	22049	219696		219696
1986	159851	44223	204025		204025
1987	213203	29057	242316		242316
1988	183506	12574	196025		196025
1989	134861	32145	166875		166875
1990	111972	21142	133119		133119
1991	104089	14281	118421		118421
1992	104402	25540	129962		129962
1993	125832	25686	151554	0.90	136762
1994	104489	34573	139084	0.98	135808
1995	121445	26721	148185	1.10	163081
1996	134273	21033	155380	0.93	144784
1997	131115	40898	171928	0.84	143631
1998	136071	39733	175770	0.70	122884
1999	100171	16444	116615	0.77	89232
2000	77552	19481	97023	0.92	89322
2001	46949	12529	59445	1.33	79063
2002	61755	7282	69005	1.12	77575
2003	27126	5165	32281	1.68	54394
2004	28947	6909	35855	1.20	42959
2005	29089	5753	34826	1.18	40987
2006	26030	7899	33928		33928
2007	23435	21755	45207		45207
2008	26476	21410	47858		47858
2009	32209	16163	48388		48388
2010	37347	12509	49861		49861
2011	35137	11273	46397		46397
2012	34132	10265	44400		44400
2013	32598	12939	45524		45524

Table 14.11c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimated catch multipliers, together with the lower and upper bounds of the point-wise 95% confidence intervals.

Year Catch multiplier

year	Catch multiplier	Low	High
1993	0.90	0.75	1.08
1994	0.98	0.80	1.19
1995	1.10	0.89	1.36
1996	0.93	0.75	1.15
1997	0.84	0.68	1.03
1998	0.70	0.57	0.86
1999	0.77	0.62	0.95
2000	0.92	0.75	1.14
2001	1.33	1.08	1.64
2002	1.12	0.91	1.39
2003	1.68	1.36	2.08
2004	1.20	0.97	1.48
2005	1.18	0.97	1.42

Table 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch options based on the SAM final run. Units are '000t (SSB, landings, discards, unaccounted) or millions (recruitment). [See Figure 14.16c for intermediate year F assumptions, shown as option A (no cut).]

Basis

Management Plan assumption: F(2014) = F(2013) =	**0.40**
Recruitment resampled from 1998-2013 =	**177**
SSB(2015) =	**80.569**
HC landings (2014) =	**38.955**
Discards (2014) =	**14.178**

Rationale	Catch (2015)	Landings (2015)	Discards (2015)	Basis	Ftotal (2015)	F land (2015)	F disc (2015)	SSB (2016)	%SSB change	%TAC change	Ftotal (2016)	Ftotal (2017)	Catch (2016)	Catch (2017)	Landings (2016)	Landings (2017)	Discards (2016)	Discards (2017)	SSB (2017)	SSB (2018)	%change SSB 17:15	%change SSB 18:15
Management Plan	35.486	26.713	8.773	Longterm phase	0.22	0.15	0.07	109.1	35	-20	0.21	0.21	41.4	48.7	32.1	38.5	9.3	10.3	139.0	165.4	73	105
MSY approach	17.220	12.986	4.234	FMSY *SSB2015/Btrigger	0.10	0.07	0.03	124.7	55	-61	0.16	0.21	35.5	56.0	27.9	44.8	7.6	11.1	165.6	190.6	106	137
Zero Catch	0.000	0.000	0.000	F=0	0.00	0.00	0.00	139.7	73	-100	0	0	0.0	0.0	0.0	0.0	0.0	0.0	217.3	310.1	170	285
MSY	30.710	23.117	7.593	FMSY	0.19	0.13	0.06	113.1	40	-31	0.19	0.19	38.9	46.5	30.3	36.9	8.7	9.6	146.6	176.5	82	119
TAC constraint	35.486	26.713	8.773	TAC2014 - 20%	0.22	0.15	0.07	109.1	35	-20	0.4	0.4	71.5	71.3	55.2	54.9	16.3	16.4	113.2	112.2	40	39
TAC constraint	44.433	33.391	11.042	TAC2014	0.29	0.20	0.09	101.7	26	0	0.24	0.19	43.2	42.6	33.4	33.4	9.8	9.2	127.5	156.8	58	95
TAC constraint	46.651	35.061	11.590	TAC2014 + 5%	0.31	0.21	0.10	100.0	24	5	0.25	0.21	45.4	44.9	35.1	35.1	10.4	9.8	123.0	149.0	53	85
TAC constraint	48.898	36.730	12.168	TAC2014 + 10%	0.32	0.22	0.10	98.2	22	10	0.27	0.23	47.6	47.1	36.7	36.7	10.9	10.4	118.5	141.4	47	75
TAC constraint	51.183	38.400	12.783	TAC2014 + 15%	0.34	0.24	0.10	96.2	19	15	0.29	0.25	49.9	49.4	38.4	38.4	11.5	11.0	114.1	134.0	42	66
TAC constraint	53.444	40.069	13.375	TAC2014 + 20%	0.36	0.25	0.11	94.3	17	20	0.32	0.28	52.2	51.9	40.1	40.1	12.1	11.8	109.6	126.3	36	57
Status quo	58.502	43.804	14.698	Fsq	0.40	0.28	0.12	90.2	12	31	0.40	0.40	61.6	63.8	46.8	48.5	14.8	15.3	96.3	98.8	19	23

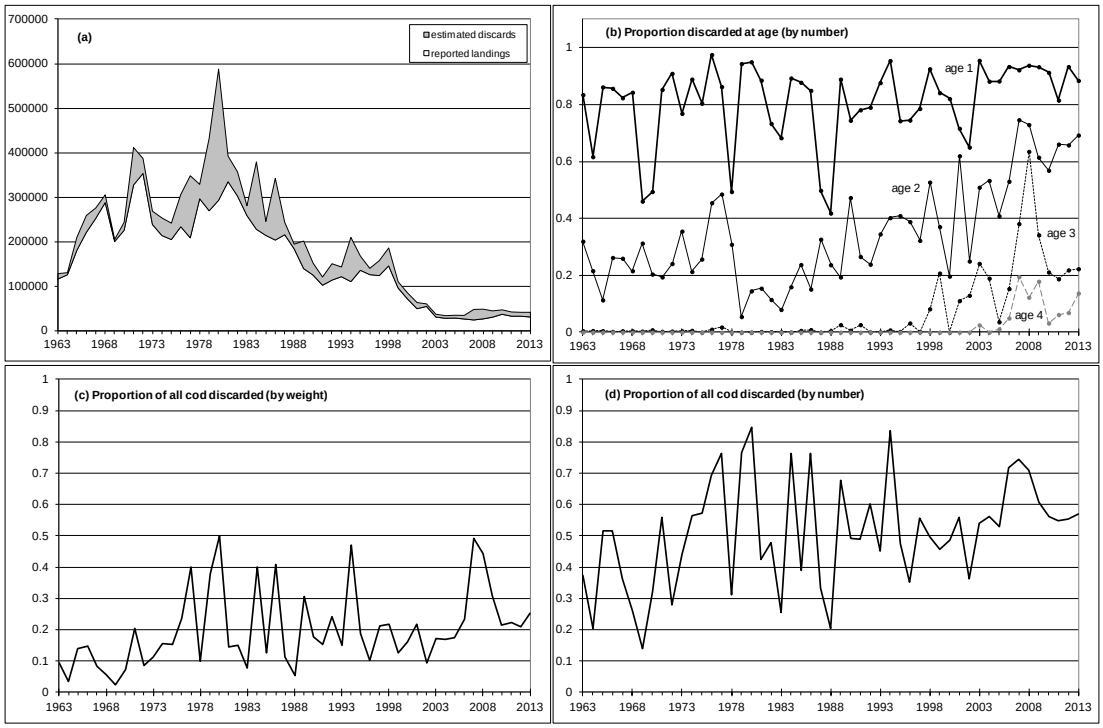


Figure 14.1 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: (a) stacked area plot of reported landings and estimated discards (in tons); (b) proportion of total numbers caught at age that are discarded; (c) proportion of total weight caught that is discarded; (d) and proportion of the total numbers caught that are discarded.

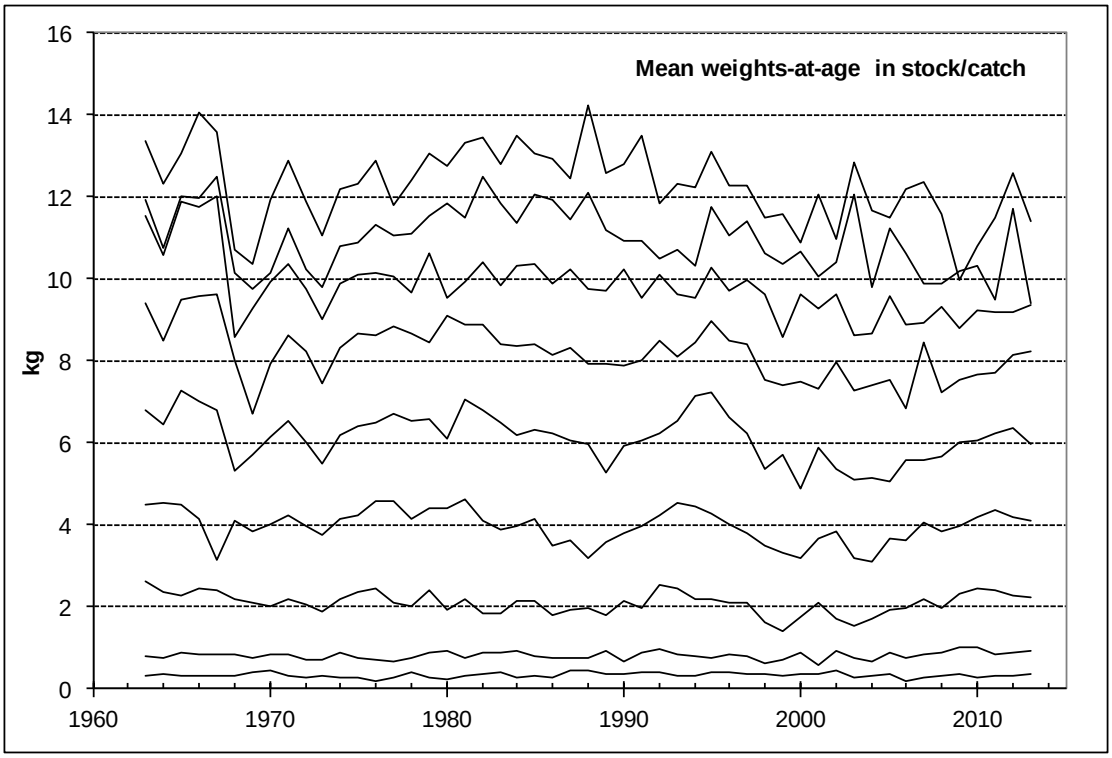


Figure 14.2 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: Mean weight at age in the catch for ages 1-9.



Figure 14.3a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1995-2014 in the North Sea.

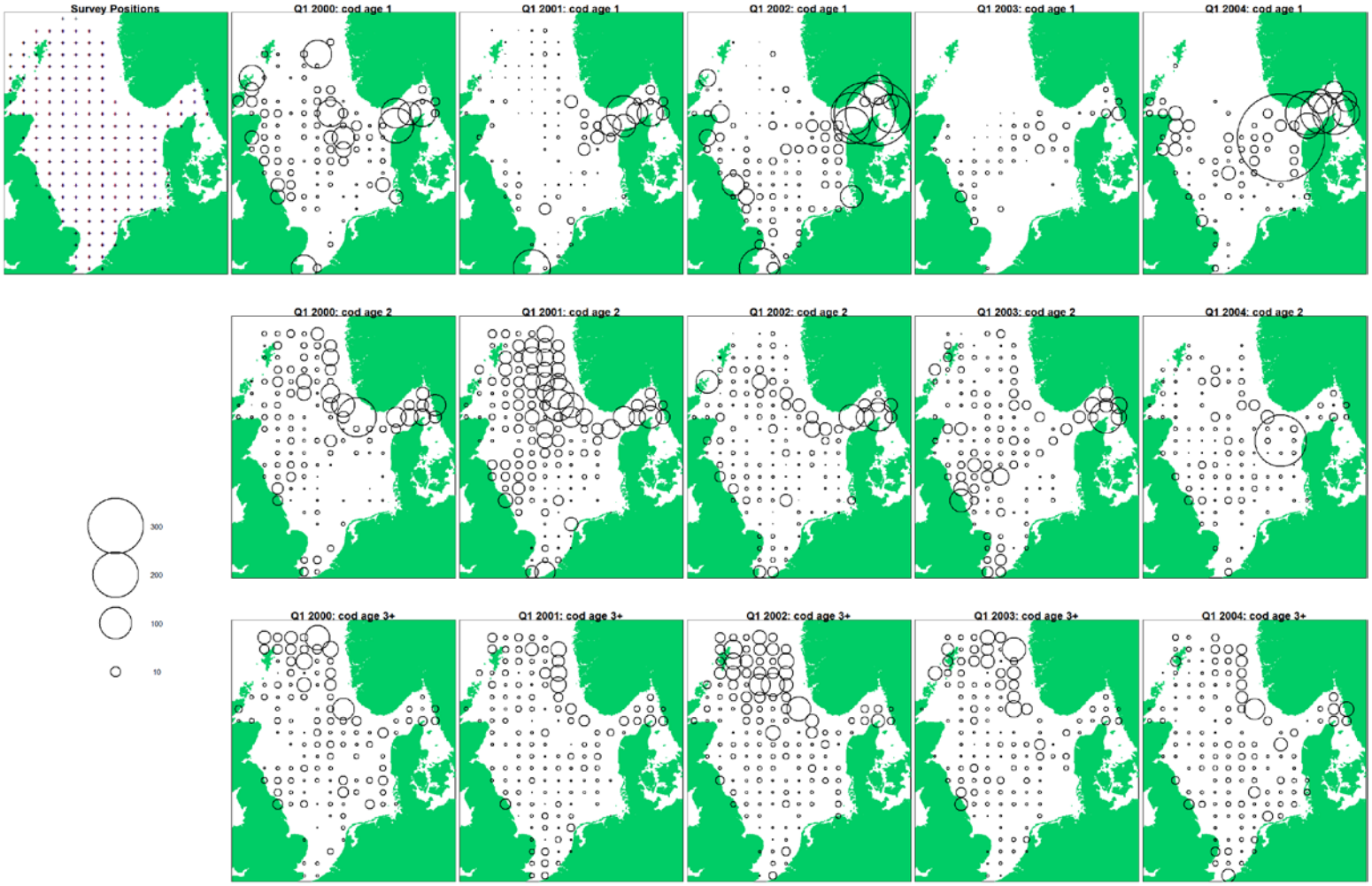


Figure 14.3a contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1995-2014 in the North Sea.



Figure 14.3a contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1995-2014 in the North Sea.



Figure 14.3a contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1995-2014 in the North Sea.



Figure 14.3b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1995-2013 in the North Sea.



Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1995-2013 in the North Sea.

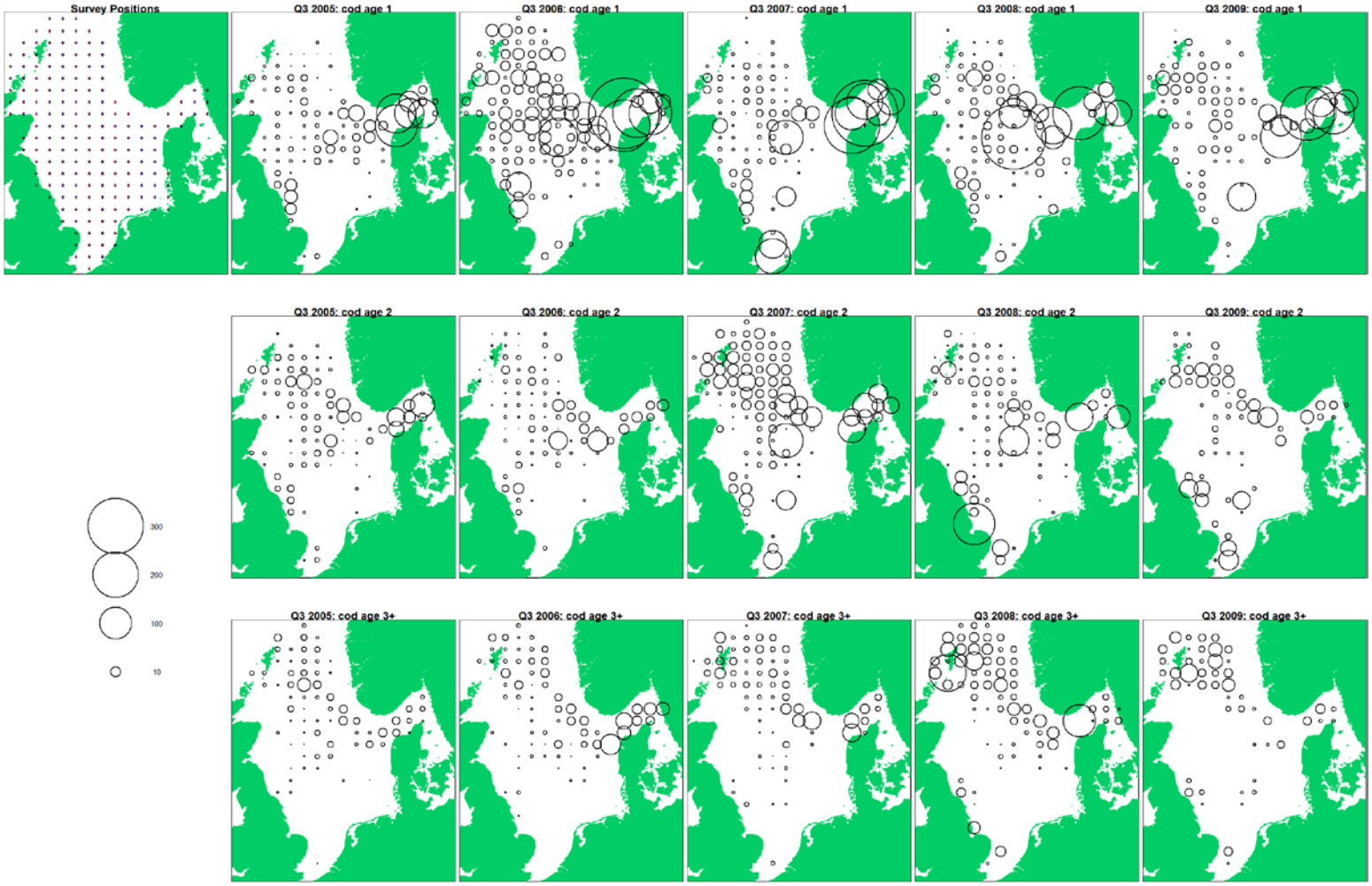


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1995-2013 in the North Sea.

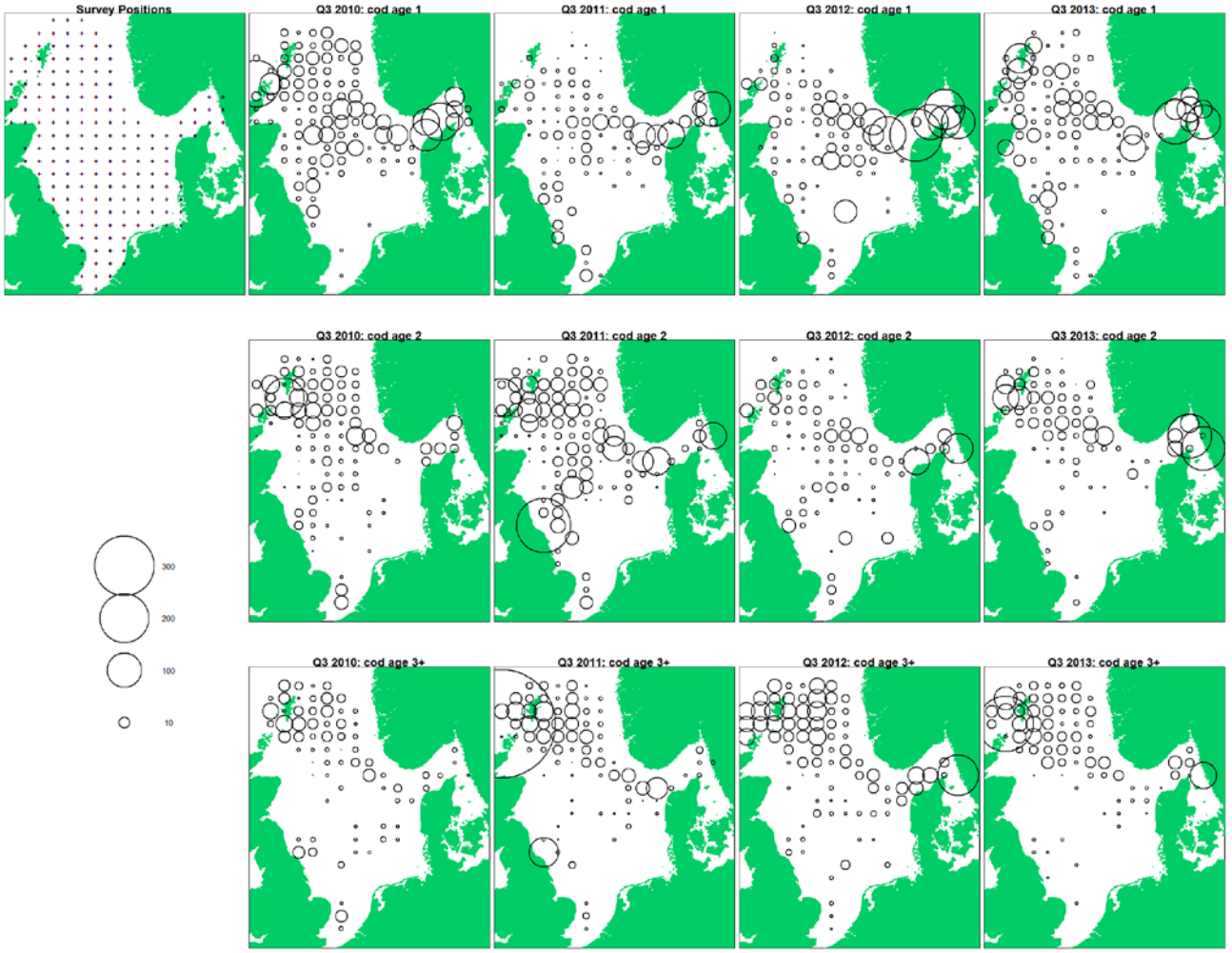


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1995-2013 in the North Sea.

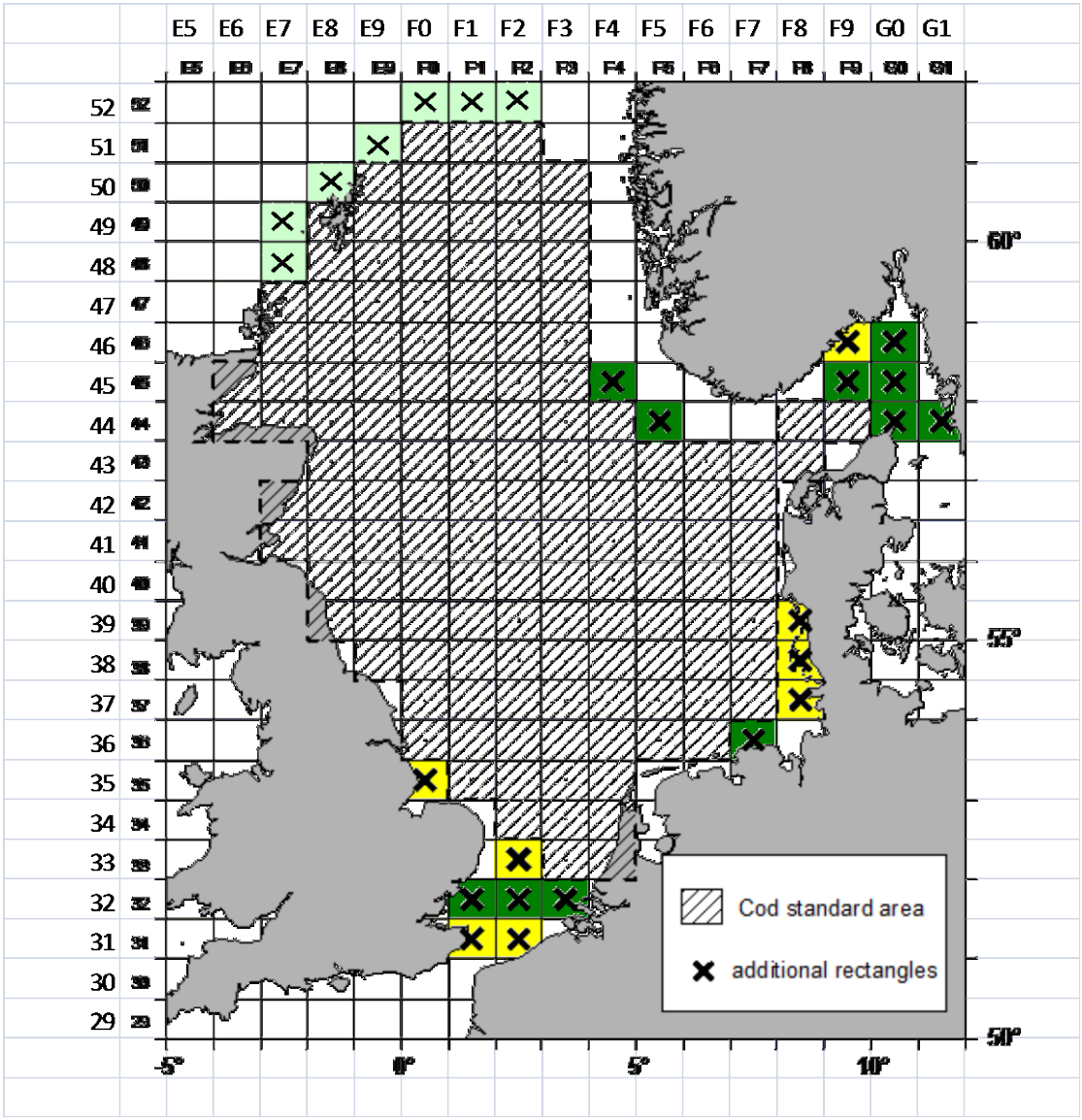


Figure 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Extension of cod standard area used for the revision of IBTS indices. Crosses indicate suggested extensions to the survey (ICES-WKROUND, 2009; ICES-WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate data is available; yellow squares indicate where intermittent coverage does not allow inclusion and the IBTS WG considered should be omitted; light green squares indicate the recommended extension around Shetland (ICES-WKCOD, 2011).

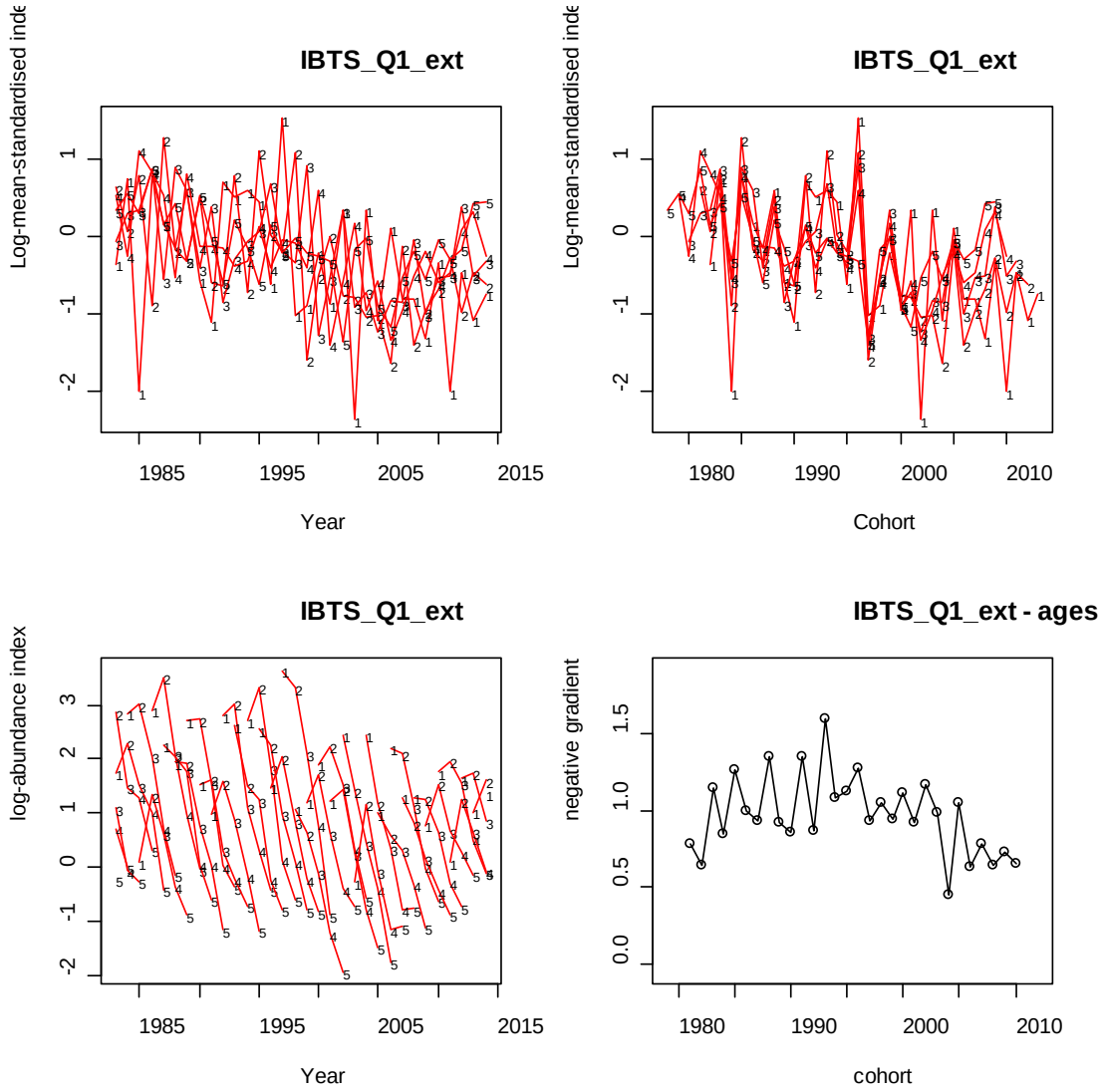


Figure 14.4a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ1 extended area groundfish survey.

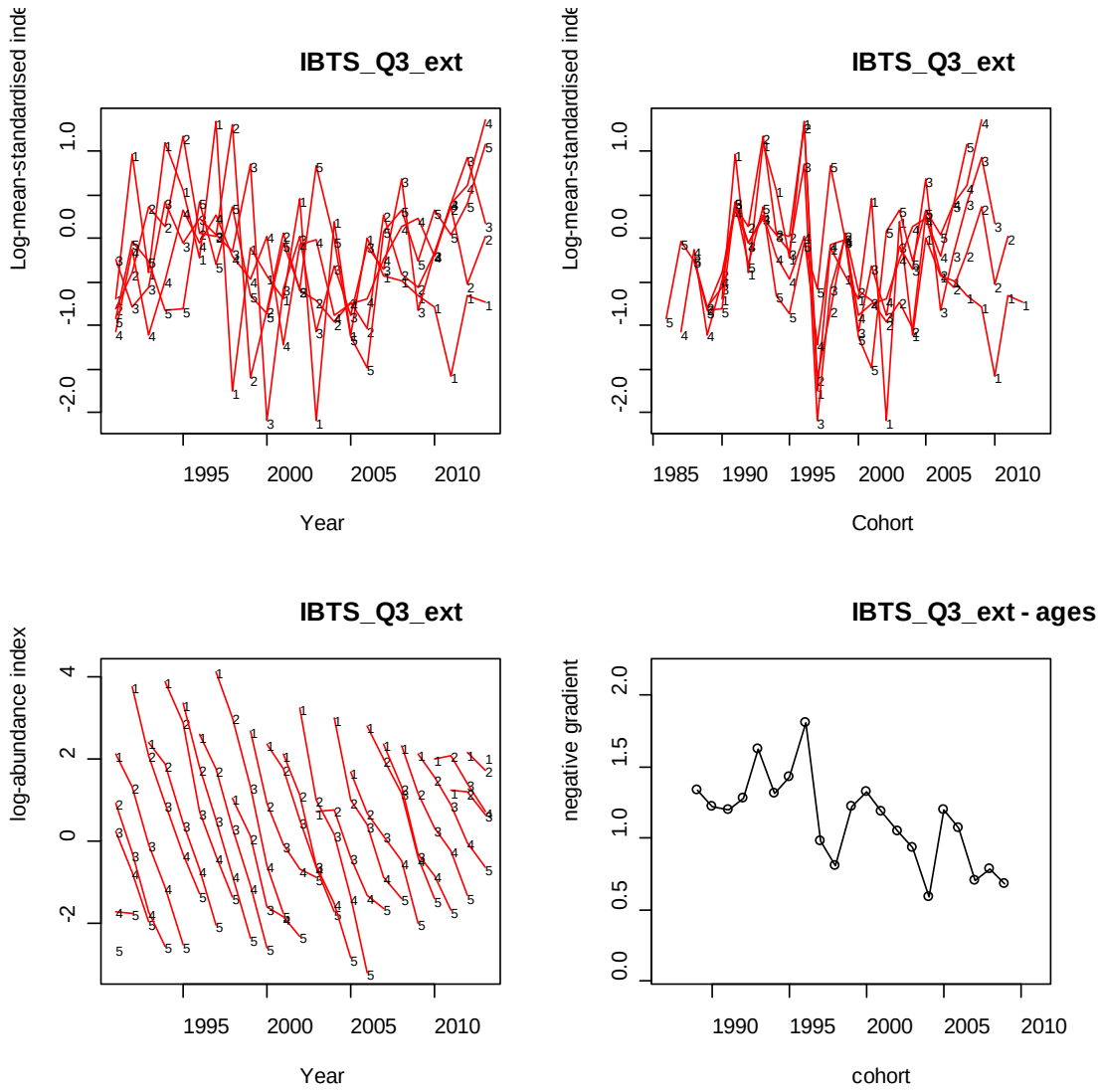


Figure 14.4b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ3 extended area groundfish survey.

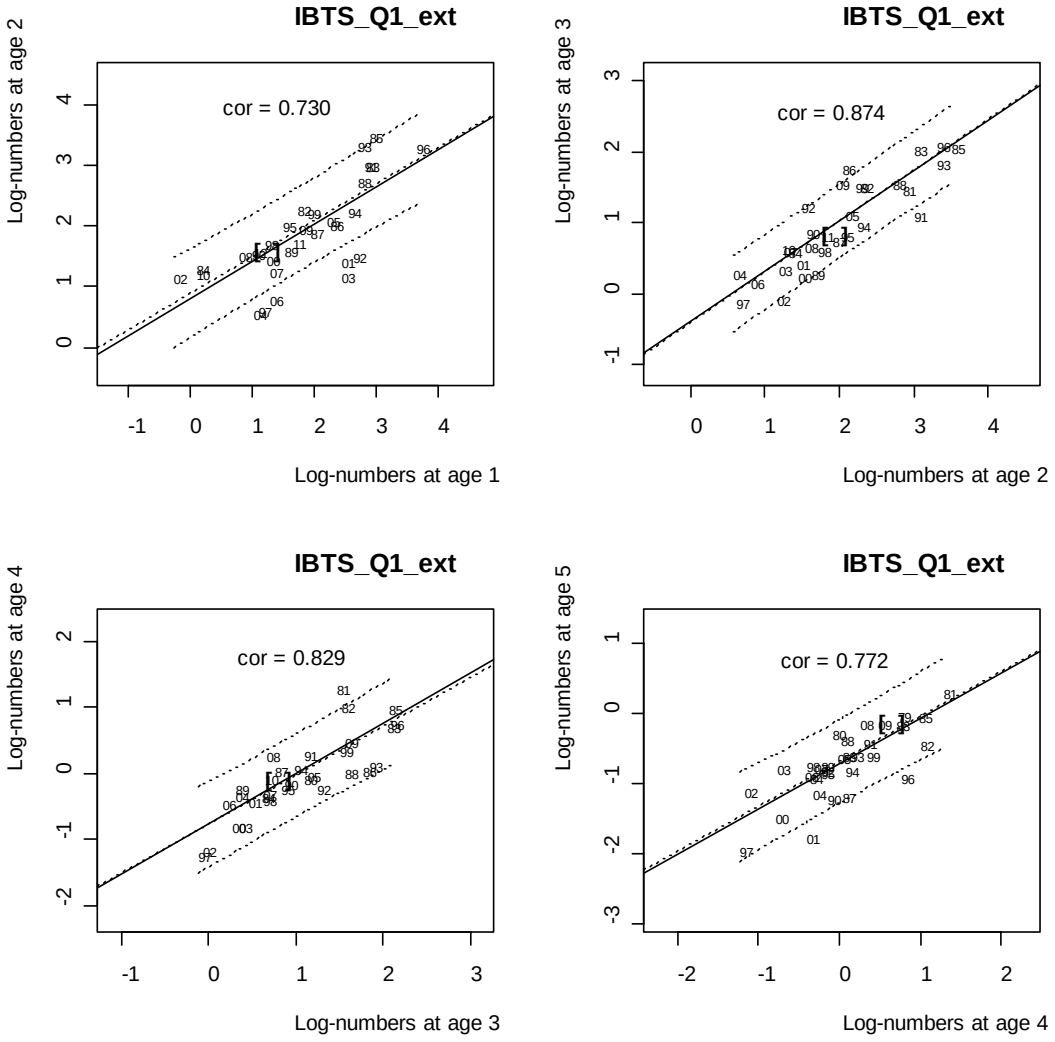


Figure 14.5a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ1 for the period 1983-2014. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in square brackets.

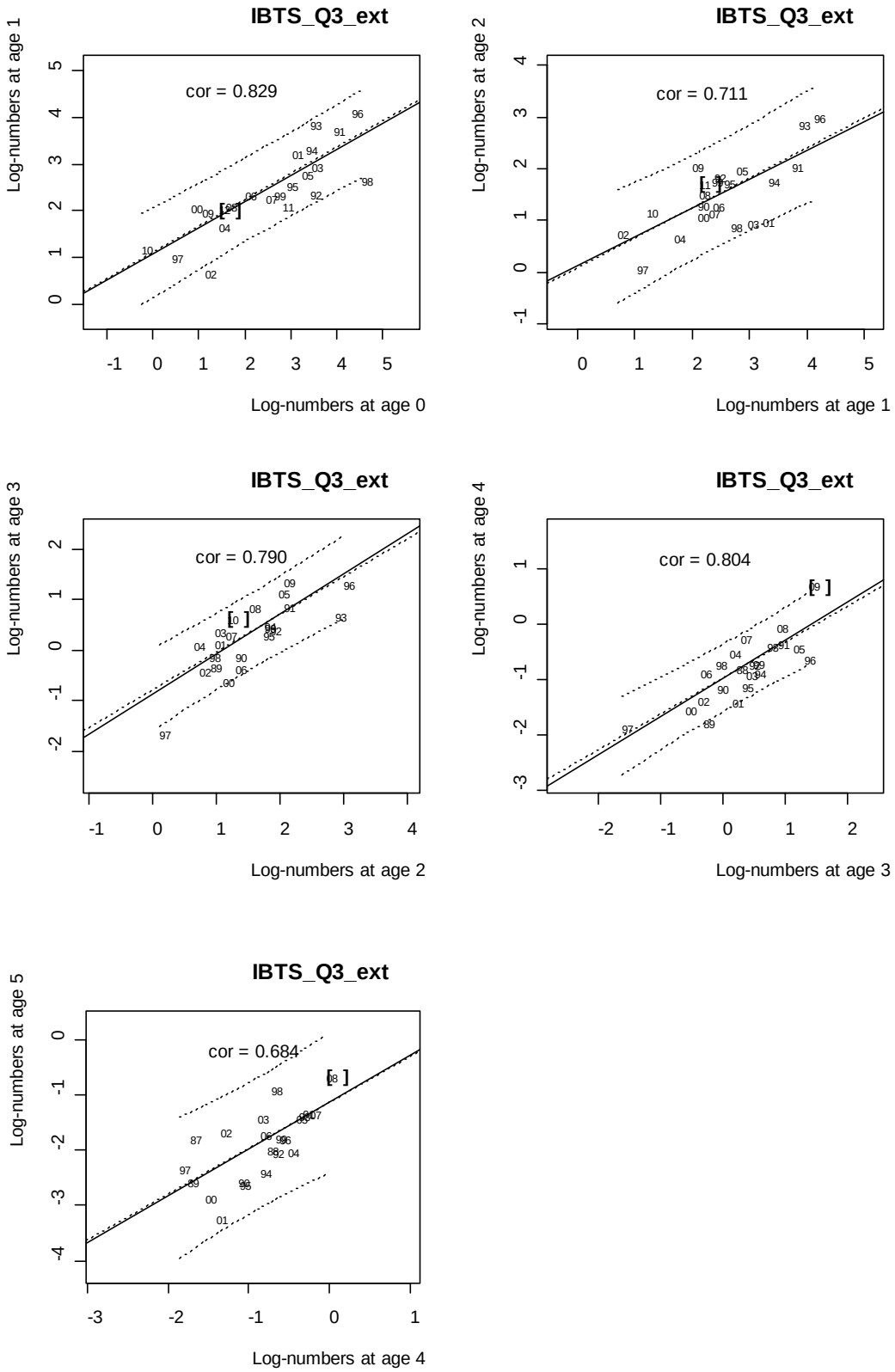


Figure 14.5b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ3 for the period 1991-2013. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, and "cor" denotes the correlation coefficient. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data point appears in square brackets.

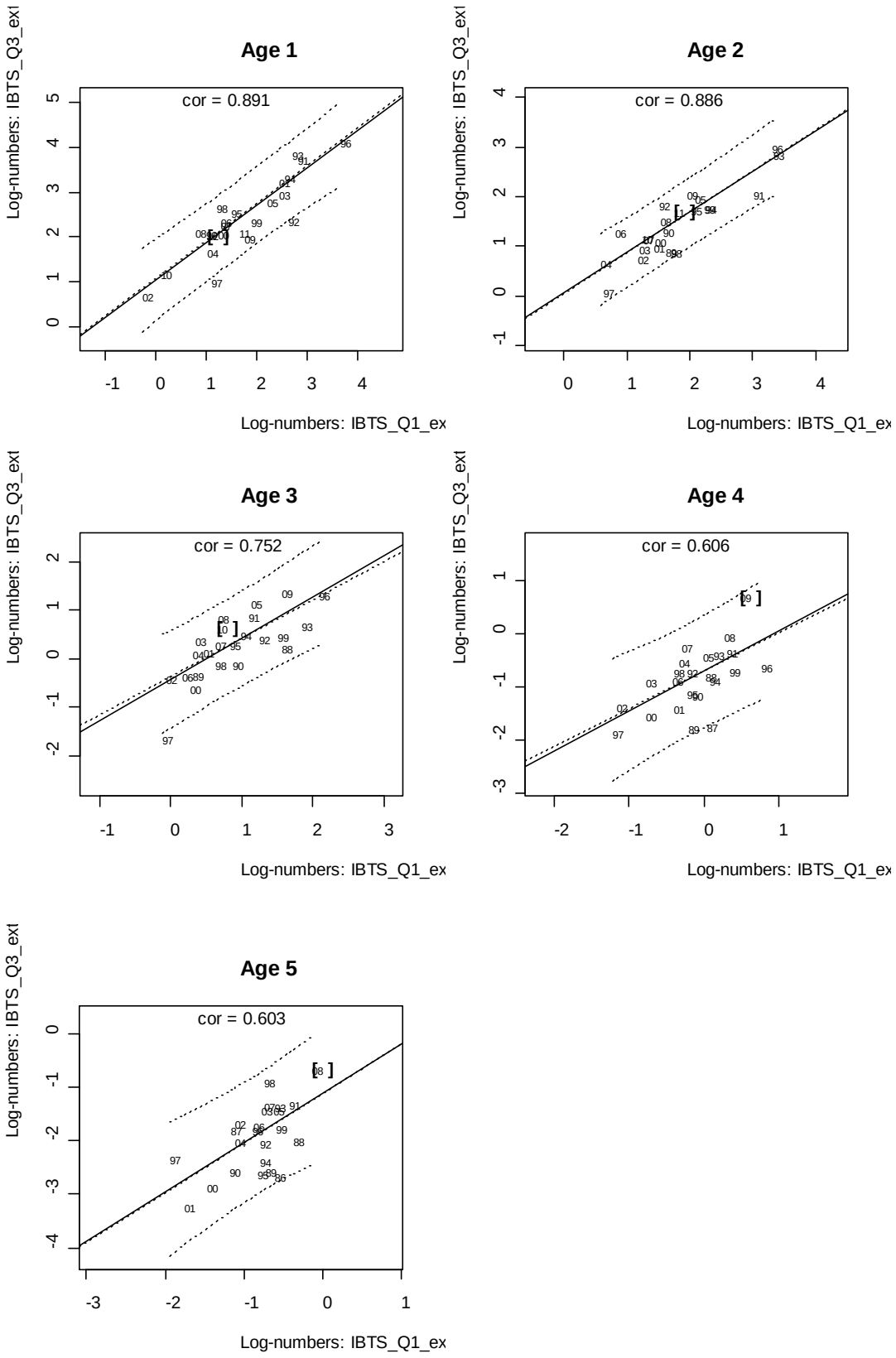


Figure 14.5c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Between-survey correlations for IBTSQ1 and Q3 surveys for the period 1991-2013. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear regression line. The pair of broken lines on either side of the solid line indicate prediction intervals. The most recent data appear in square brackets.

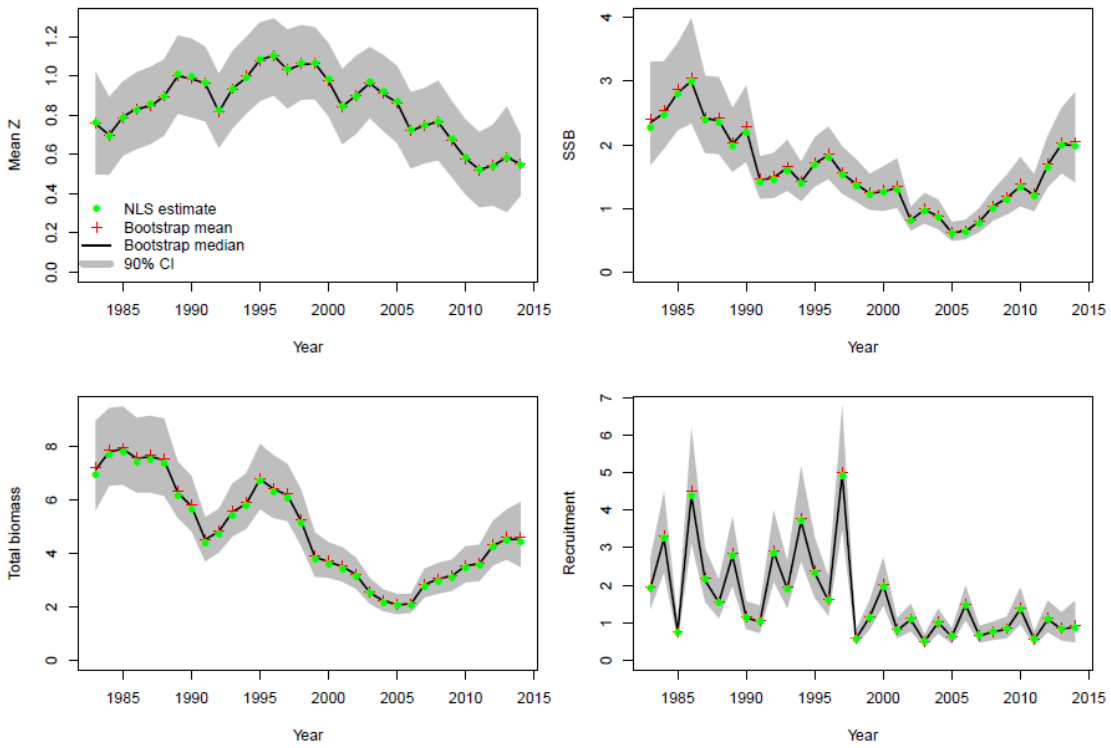


Figure 14.6 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Surbar summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for the IBTSQ1 survey. The smoothing parameter [illegible] to 3, and reference age at 3. Broken lines are 95% confidence bounds.

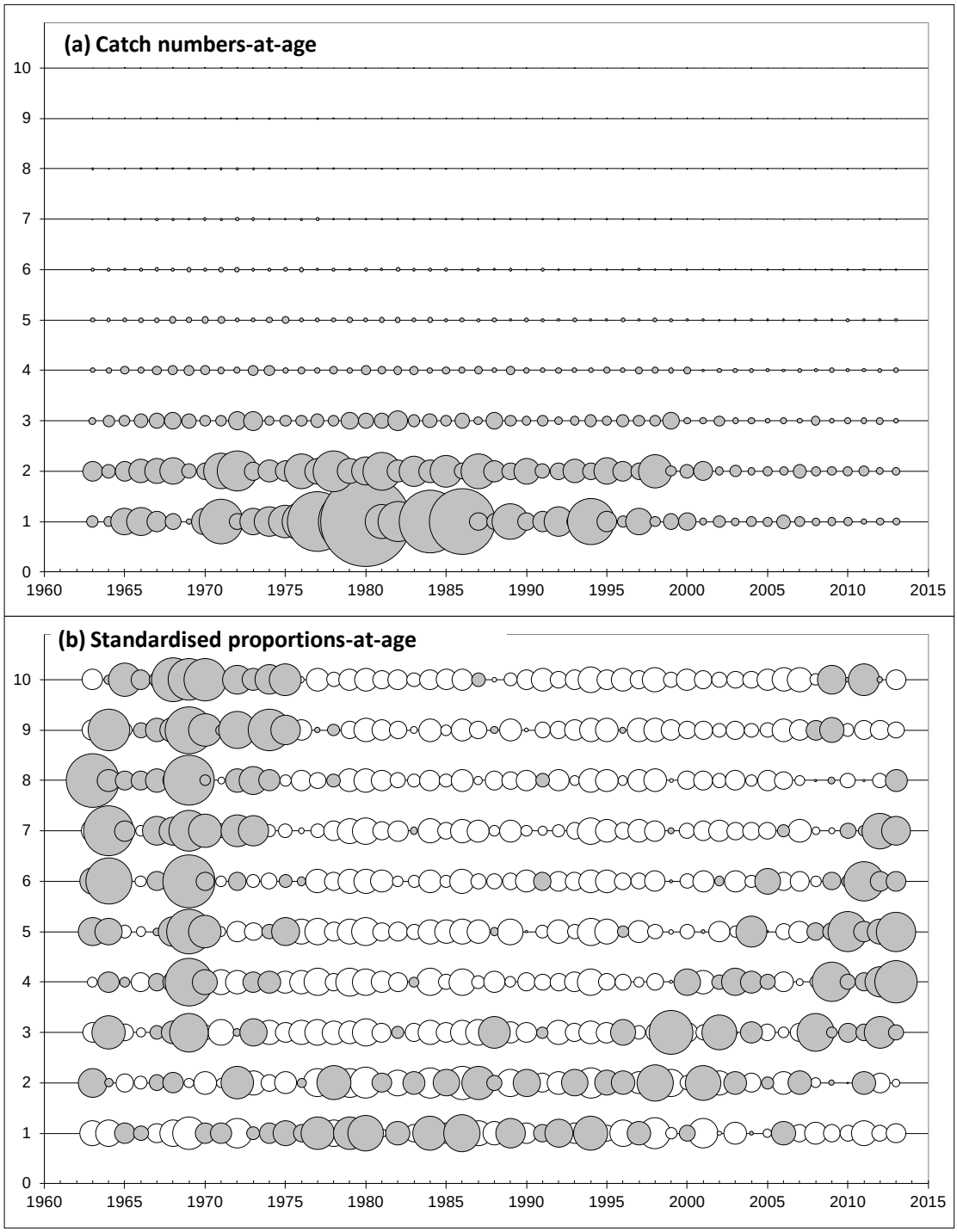


Figure 14.7 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

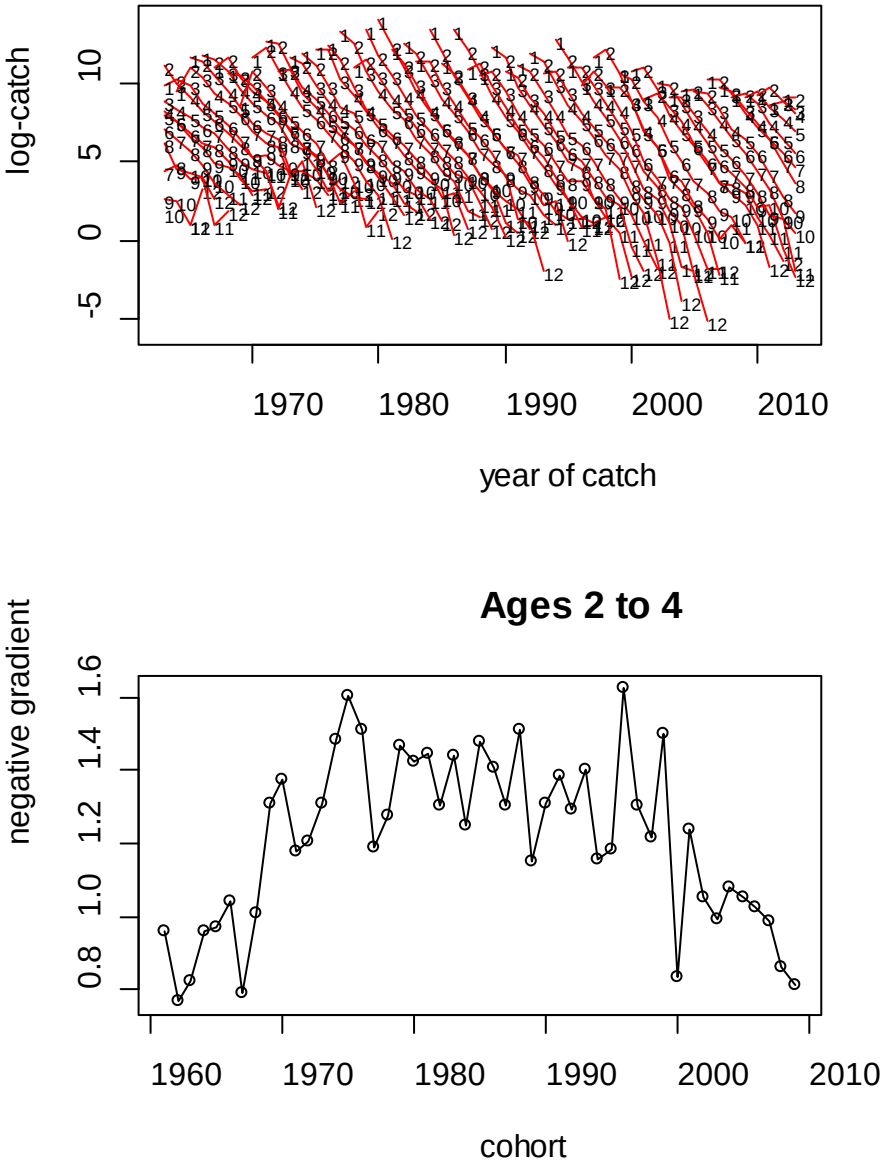


Figure 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2-4.

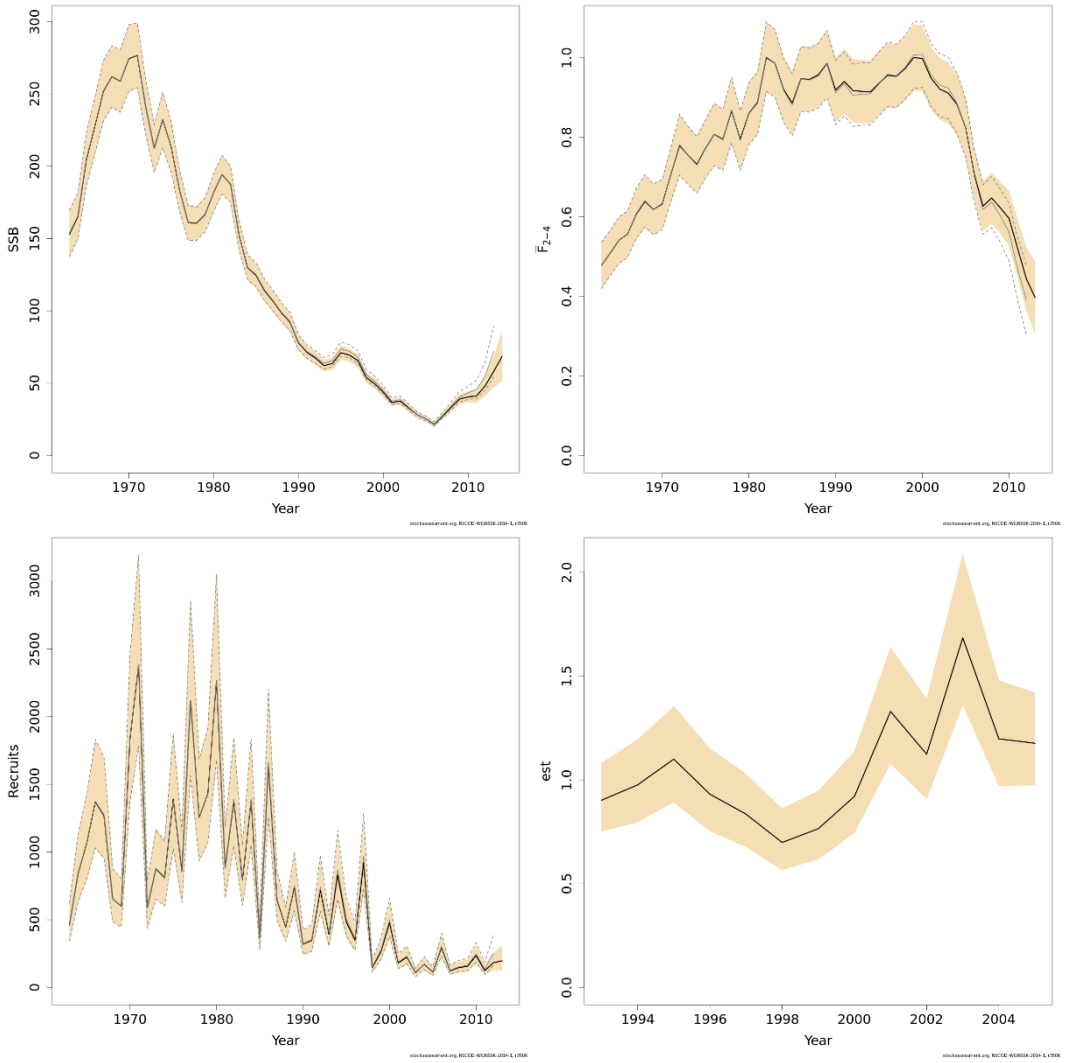


Figure 14.9a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM update run (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The final SAM assessment for last year (2013) is plotted in light grey for the SSB, F and recruitment plots for comparison.

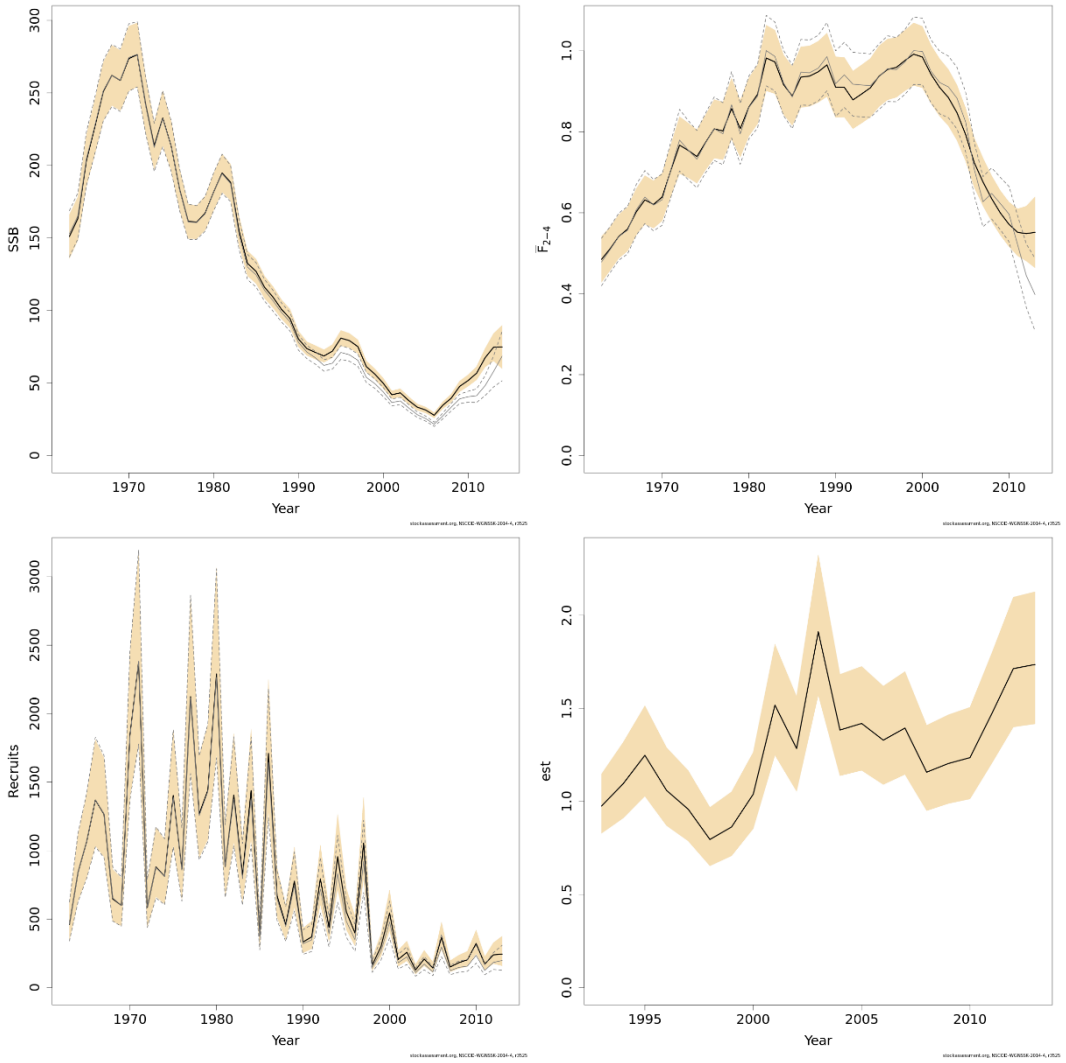


Figure 14.9b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM sensitivity run (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals), where the catch multiplier is estimated for 1993-2013. The update SAM assessment given in Figure 14.9a is plotted in light grey for the SSB, F and recruitment plots for comparison.

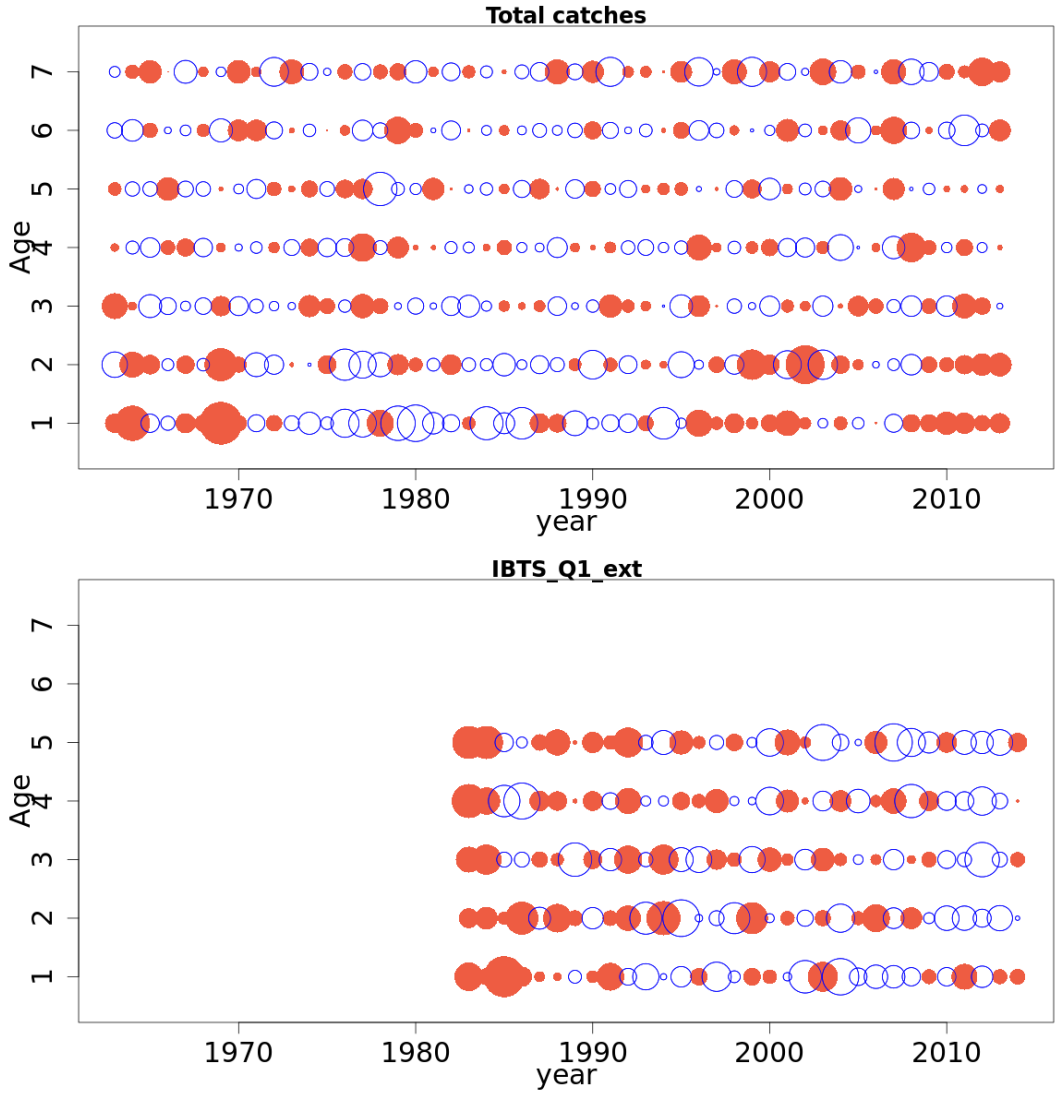


Figure 14.10a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the SAM updated run, for total catch and IBTSQ1. Empty circles indicate a positive residual and filled circles negative residual.

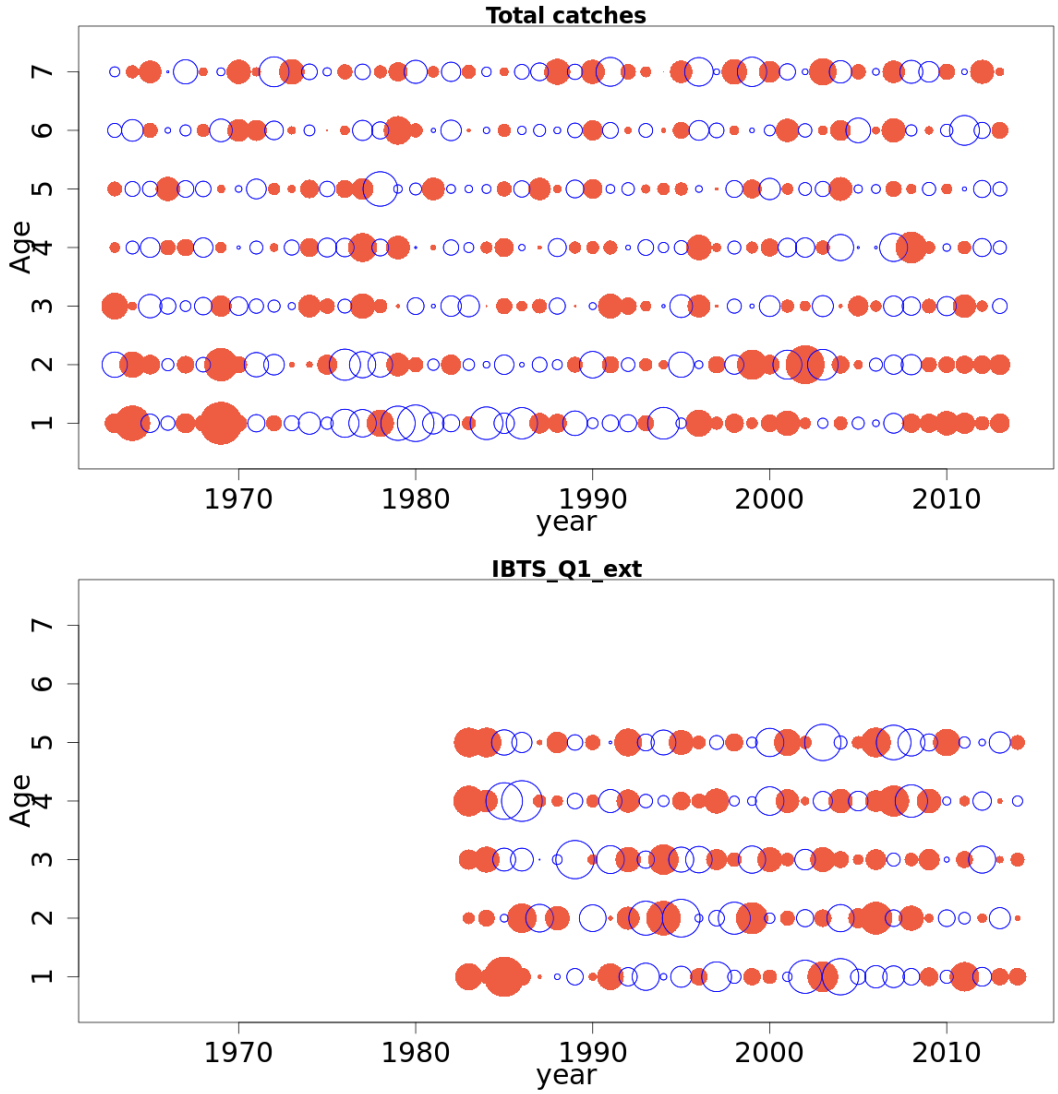


Figure 14.10b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the SAM sensitivity run, for total catch and IBTSQ1, where the catch multiplier is estimated for 1993-2013. Empty circles indicate a positive residual and filled circles negative residual.

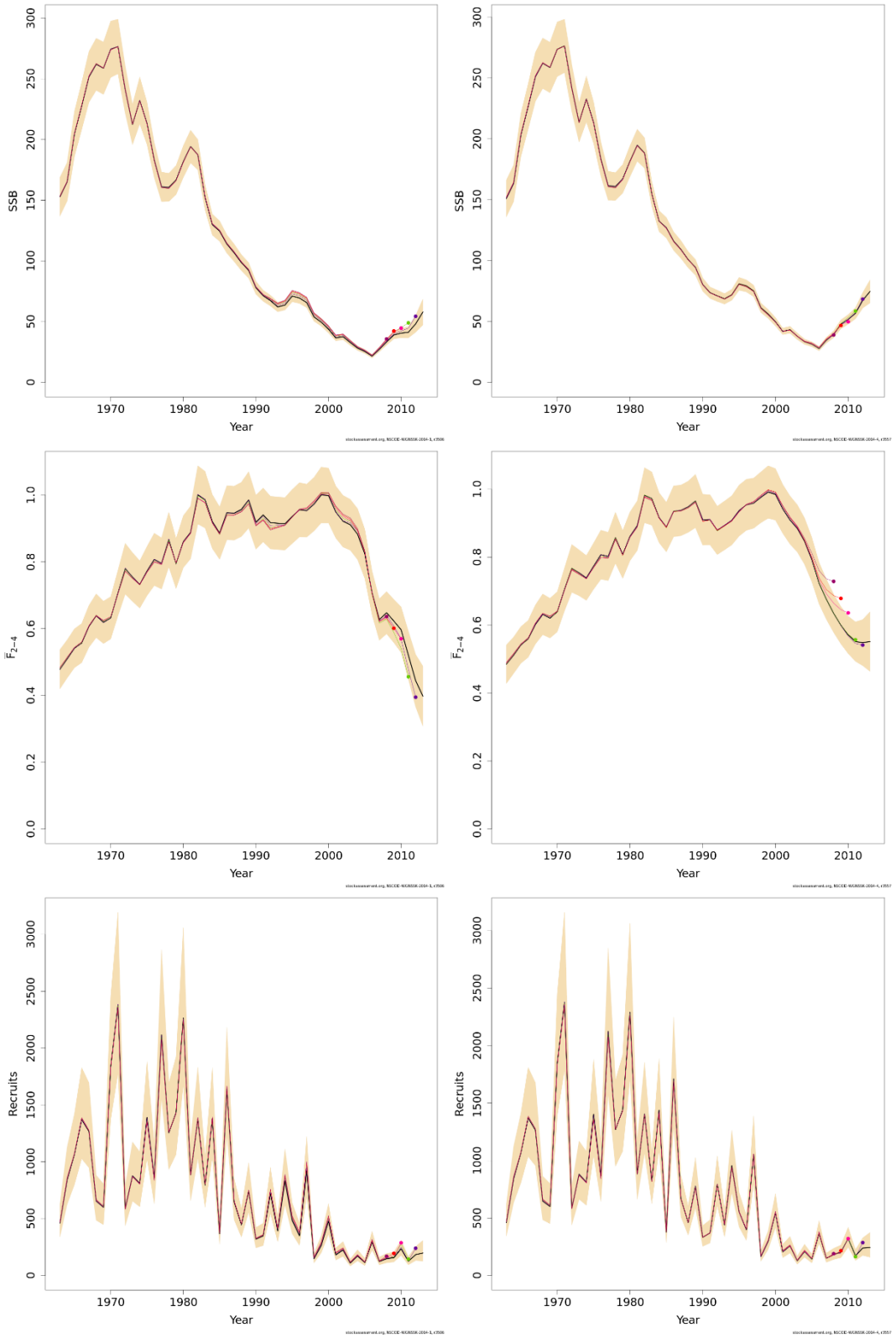


Figure 14.11 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Retrospective estimates (6 years) from (a) the SAM update run and (b) the SAM sensitivity run (catch multiplier estimated for 1993-2013). Estimated yearly SSB (top), average fishing mortality (middle) and recruitment age 1 (bottom), together with corresponding point-wise 95% confidence intervals.

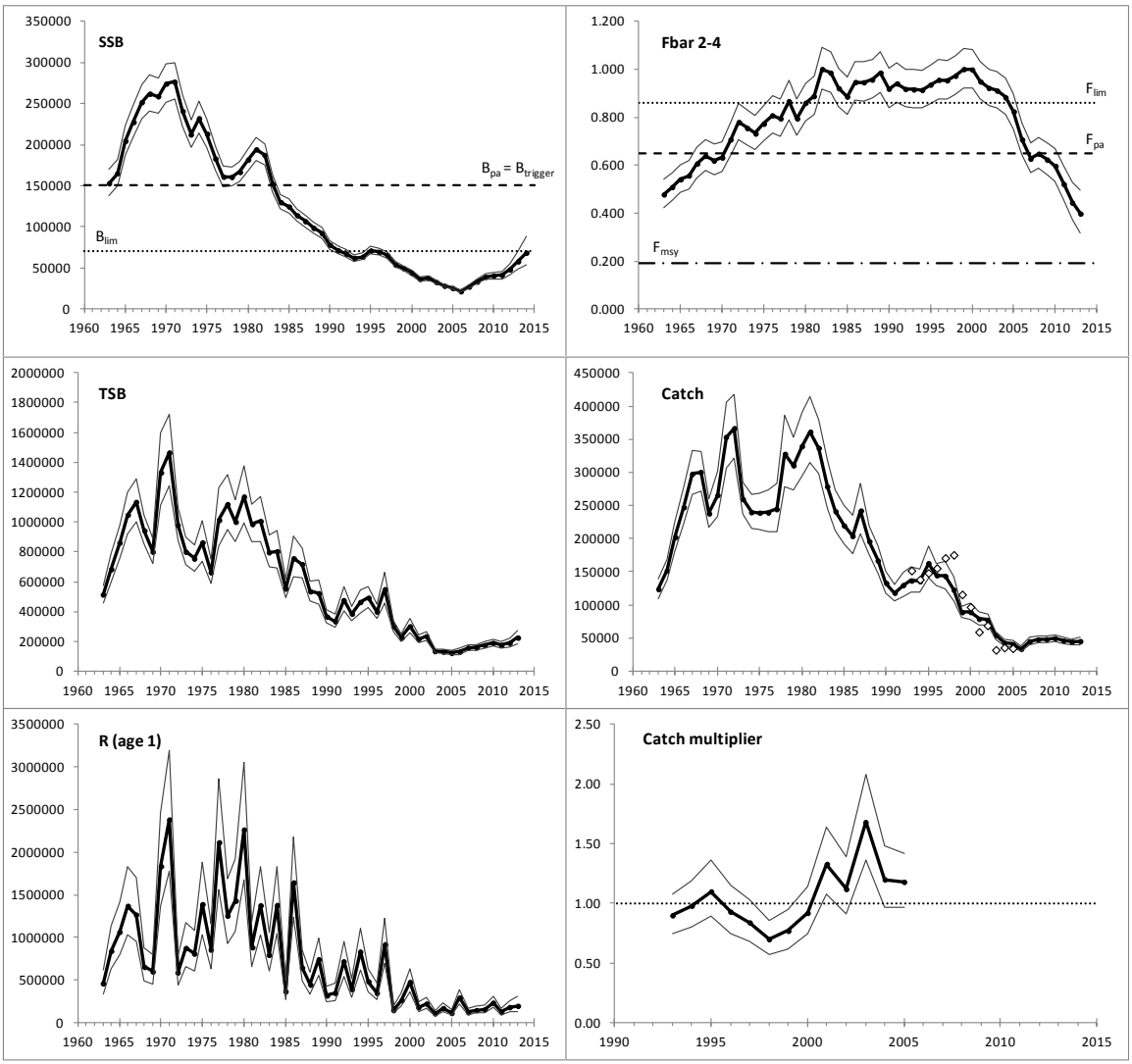


Figure 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Clockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2-4 (F(2-4)), from the SAM final run (catch multiplier estimated for 1993-2005 only). The heavy lines represent the point-wise estimate, and the light lines point-wise 95% confidence intervals. The open diamonds given in the catch plot represent model estimates of the total catch excluding unaccounted mortality, while the solid lines represent the total catch including unaccounted mortality for 1993-2005. The horizontal broken lines in the SSB plot indicate Blim=70 000t and Bpa=150 000t, and those in the F(2-4) plot Fpa=0.65 and Flim=0.86. The horizontal broken line in the catch multiplier plot indicates a multiplier of 1. Catch, SSB and TSB are in tons, and R in thousands.

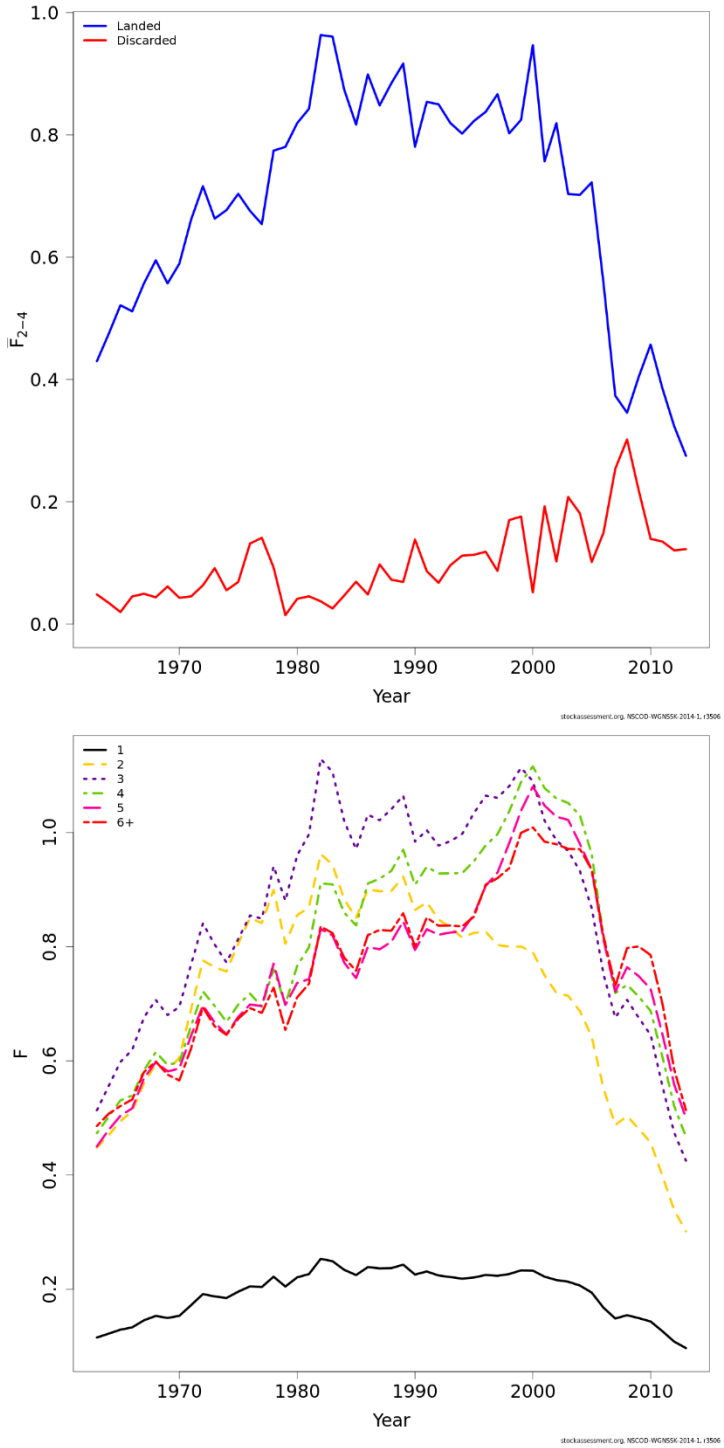


Figure 14.13 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2-4 (shown in Figure 14.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

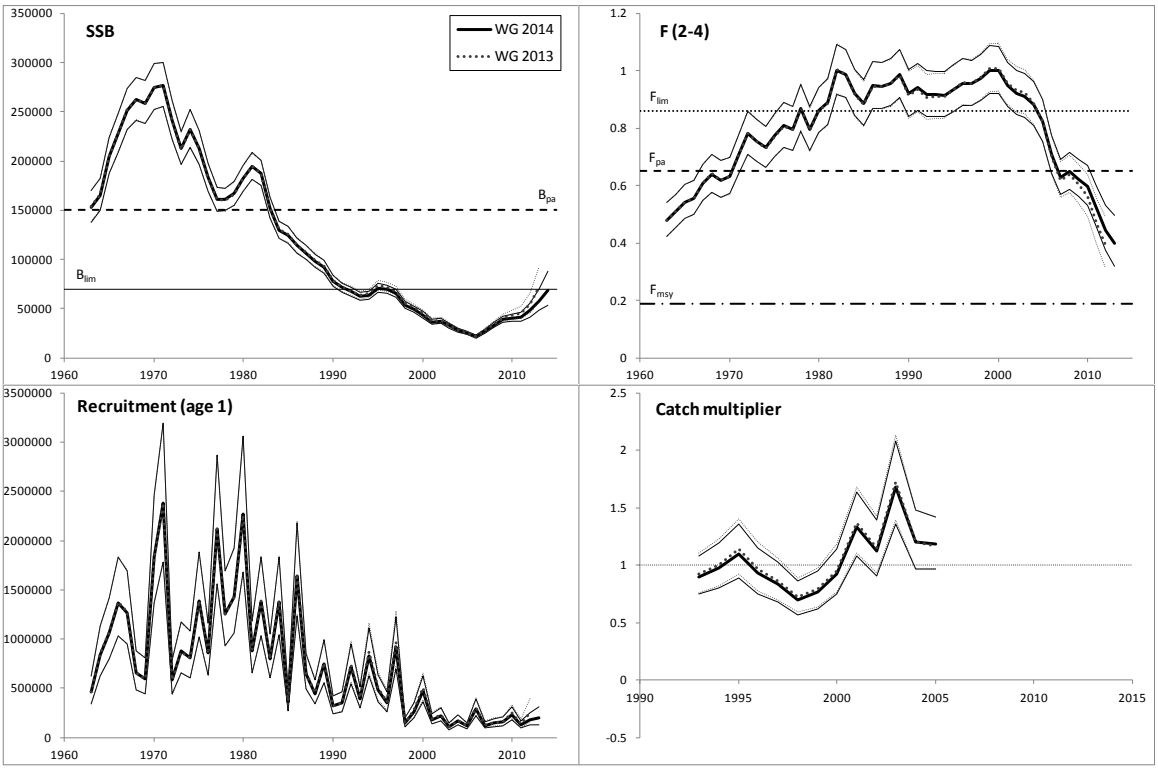


Figure 14.14 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Comparison of final SAM assessment for 2014 with the final SAM assessment for 2013. Plots are as described in Figure 14.12.

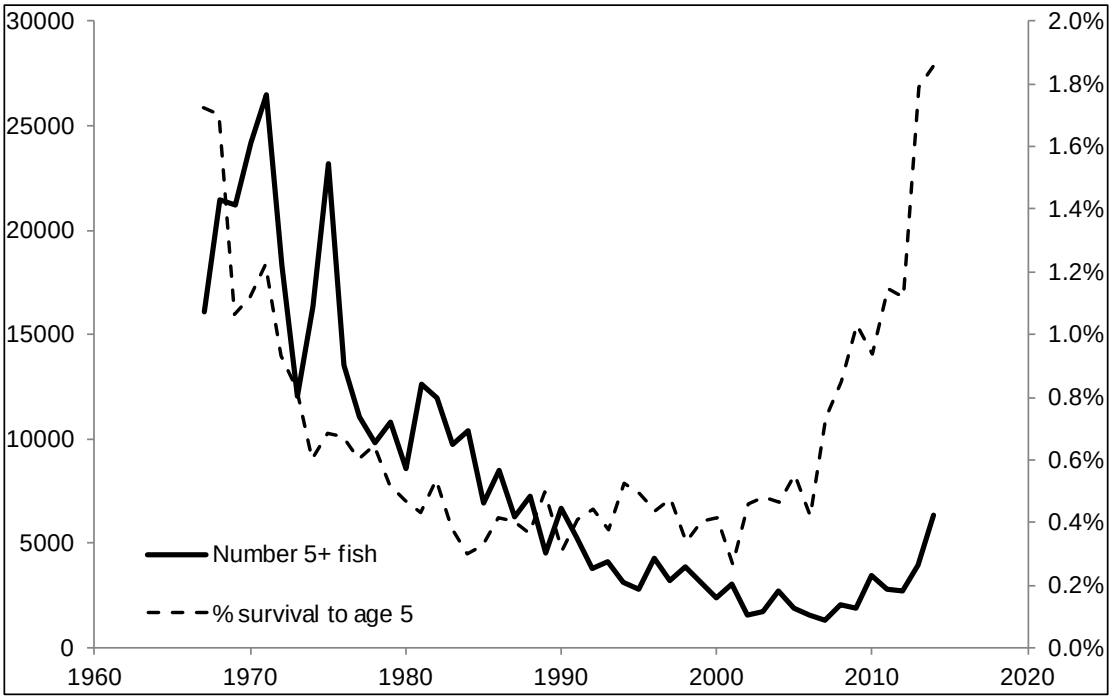


Figure 14.15 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimates (from the SAM final assessment) of the number of 5 year old and older cod in the population (solid line; thousands) and the percentage of 1 year olds by number that have survived to age 5 in the given year (hashed line).

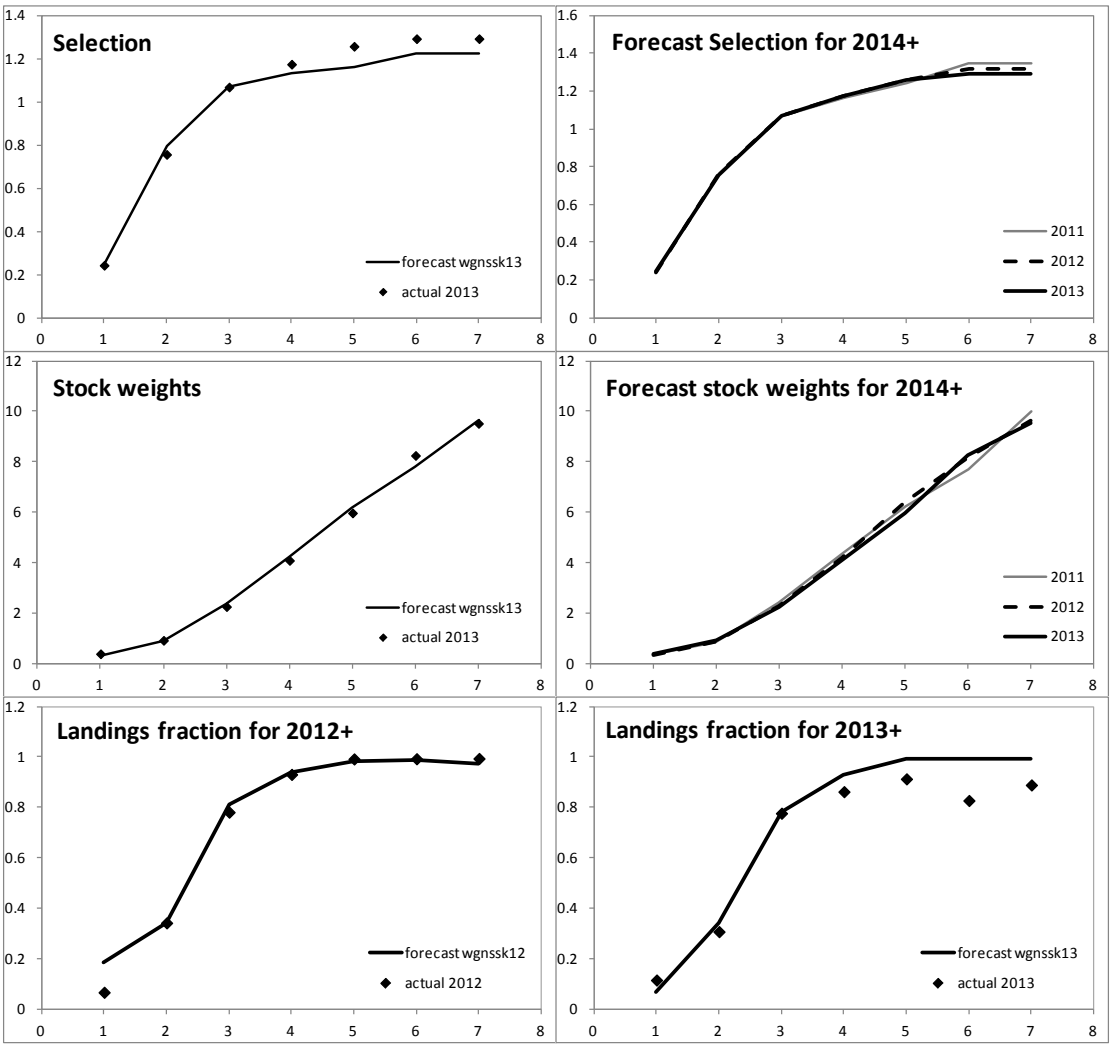


Figure 14.16a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Exploration of the forecast assumptions made during last year's meeting together with values used for this year's forecast. In the first (selection) and second (stock weights) row of plots, the left column compares last year's forecast assumptions with the actual data/estimates in the final assessment this year, while the right hand column indicates the values that are used to calculate 3-year averages for the forecast this year. The bottom row of plots compares the landings fraction assumptions used in the forecasts (last year and the year before) with the corresponding actual data used in the assessment in the year following the forecast; the forecast assumption for the landings fraction only uses the most recent year of data (and not a 3-year average), so that the actual 2013 values for the landings fraction (bottom left plot) are used in this year's forecast as the assumed landings fraction for 2014+.

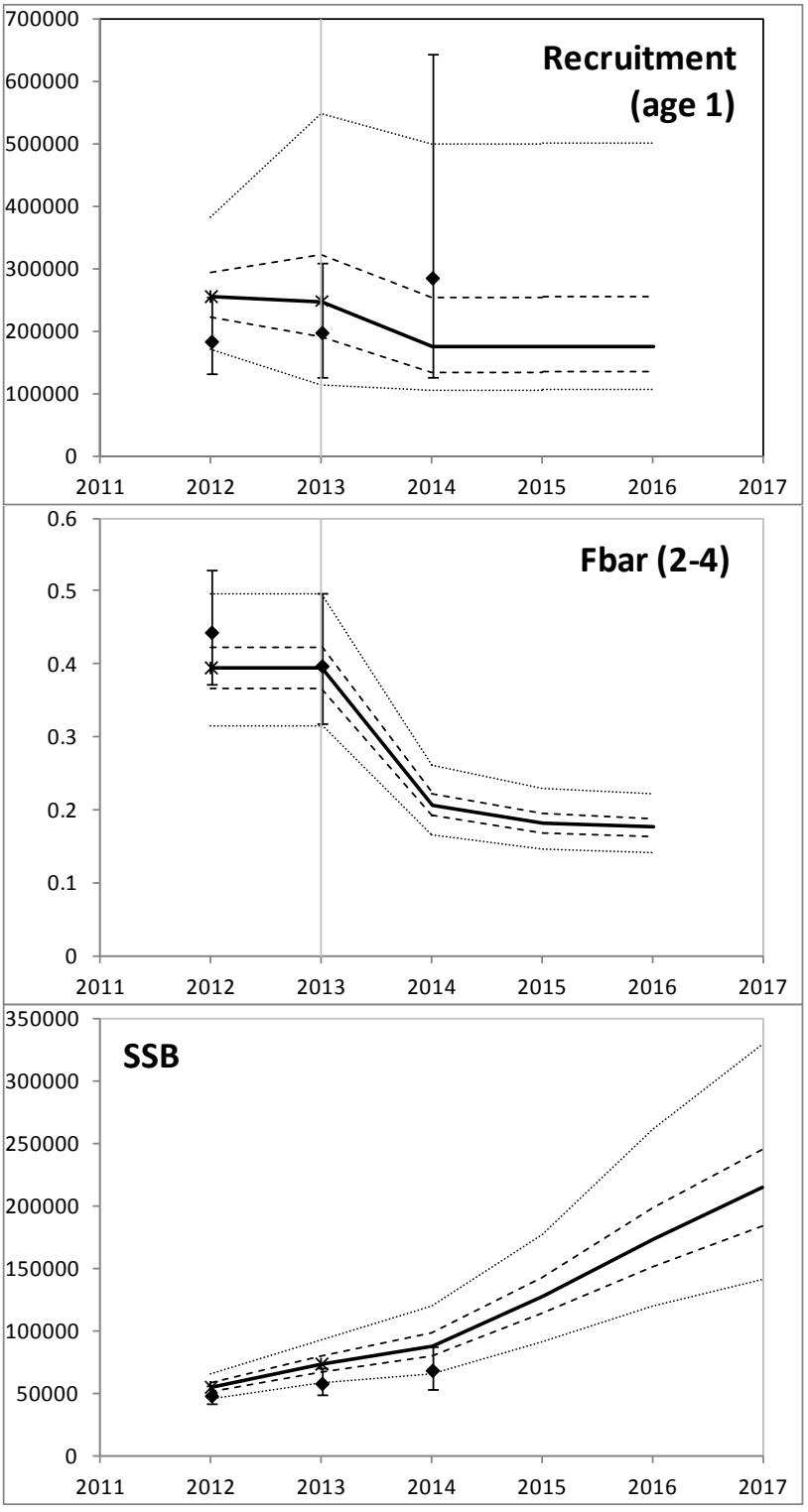


Figure 14.16b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Exploration of the forecast assumptions made during last year's meeting together with estimates from this year's assessment for recruitment (age 1), mean fishing mortality (ages 2-4), and spawning stock biomass. The solid bold lines with corresponding hashed 50% and 95% point-wise confidence bounds are the combined assessment estimates (highlighted with stars) and forecast projections, while the diamonds with 95% point-wise confidence bounds (shown as error bars) are estimates from the final assessment this year. The vertical grey line in the two top plots indicates the intermediate year of the forecast made last year. The fishing mortality assumptions follow the management plan.

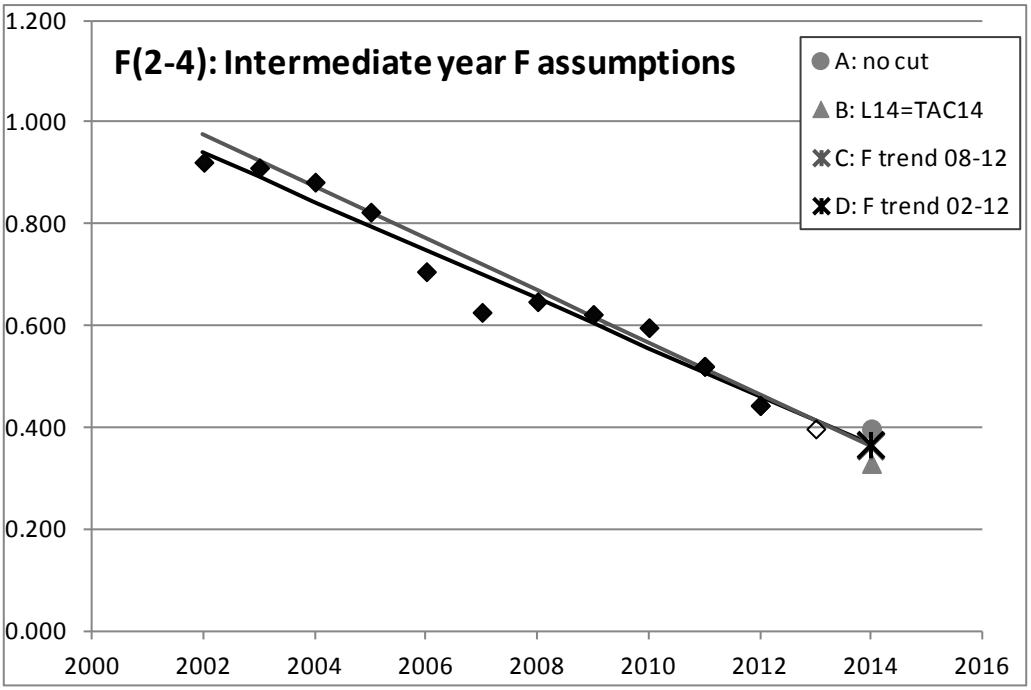


Figure 14.16c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Intermediate year F(2-4) options (relative to F in 2013) for the stochastic projections, corresponding to the Catch Options table (Table 14.12) associated with the SAM final run. A: no cut in F; B: Landings in 2014 correspond to the TAC set for 2014; C: extrapolate from the trend in F over 2008-2012; D: extrapolate from the trend in F over 2002-2012. Table 14.12 is based on option A.

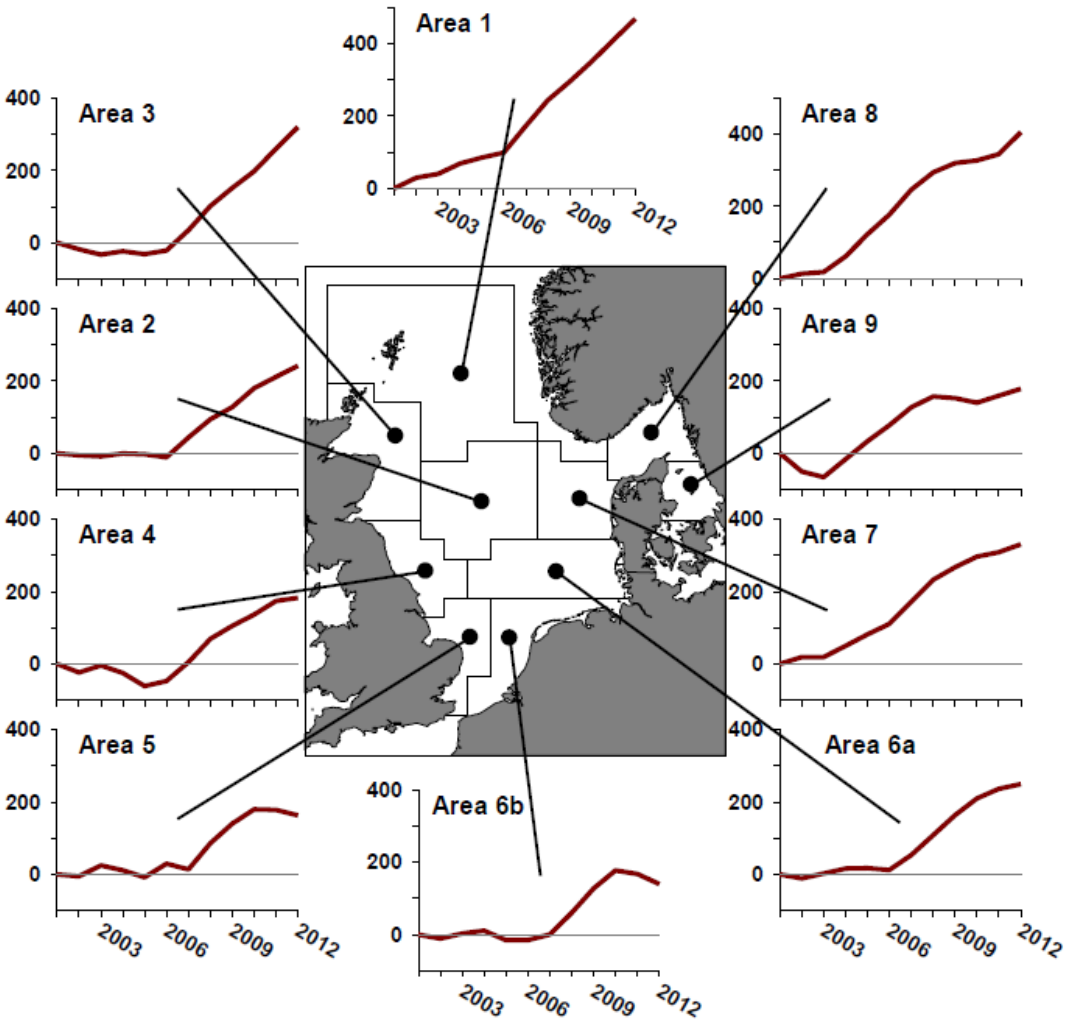


Figure 14.17 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. The North Sea Stock Survey fishers perception of the change abundance of North Sea cod since 2003 (Napier 2012).

15 Pollack in the North Sea and Skagerrak (Subarea IV and Division IIIa)

15.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at >35cm, at 3-4years of age and growth after age 3 is about 7 cm per year (Heino et al. 2012). Feeding is mainly on fish, and incidentally on crustaceans and cephalopods.

15.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including VIId and IIIa). In the ICES advice, it was, however, decided to include VIId Pollack in the Celtic Seas Ecoregion.

15.3 Management

For IV and IIIa there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

15.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2013 in Division IIIa (Skagerrak/Kattegat) and Subarea IV (North Sea) are shown in Tables 15.1 and 15.2. Figure 15.1 shows total landings in Subarea IV and Division IIIa from 1977–2013. Two periods with high landings can be seen, and over the entire period total landings for both areas have declined. In Division IIIa landings have been low but stable since 2000, while in Area IV landings have fluctuated over the same period and stabilised the last three years. Swedish fishers targeted pollack from the 1940s until mid-1980s when landings sometimes amounted to over 1000 tonnes. From the 1980s pollack started to decline severely and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast.

Nowadays, no fishery is targeting pollack, and it is mainly, possibly exclusively, a bycatch in various commercial fisheries. Norwegian catches peak in the months of March

and April, and this may be associated with spawning aggregations. In Norway the most important gears are gillnets, shrimp (*Pandalus*) trawls, and otter trawls, responsible for 67%, 13%, and 8% of the catches respectively. In 2013, 57% of the total landings were caught with gillnet and 27% with otter trawls in Division IIIa. In Subarea IV 30% of the total landings were made with gillnets and 54% with otter trawls. The geographical distribution of Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower.

Pollack is also frequently caught in recreational fisheries. Regularly collected data about these catches are not available to the working group. Norwegian recreational fishing data collected in 2009 suggests that catches of pollack south of 62^0 north may range between 13 – 30 tonnes (Vølstad et al. 2011)

15.5 Survey data / recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the cpue was much higher in the 1970s. They are distributed mainly over the northern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat. Time series of abundance (average number per hour) in the IBTS are shown for Subarea IV and Division IIIa separately, for quarter 1 (from 1977 onwards) and quarter 3 (from 1996 onwards) (Figure 15.2). The catches are small, and rather irregular, and no clear patterns emerge in III and IV.

15.5.1 Biological sampling

There has been some collection of length data in Subarea IV and Division IIIa by Norway in the most recent years. Preliminary analysis of this data indicates that length ranges of pollack caught in gill net fisheries differ with meshsize and location. The majority of fish caught in western Norwegian fjords had a size range of 60-80 cm (Figure 15.4) compared to 50-70 cm in the Skagerrak (Figure 15.5).

15.5.2 Analysis of stock trends

In previous years the study by Cardinale et al. (2012), which analysed the spatial distribution and stock trends for the period 1906–2007, based on IBTS Q1 and commercial catches, was used to assess the stock for Division IIIa (Skagerrak and Kattegat). However, during routine IBTS surveys in Area IV and Area III, pollack catches seem rather irregular and with no clear pattern. A spatial analysis of Norwegian fisheries data from 2013, showing total Pollack catches by ICES rectangle, indicates that the surveys do not cover the geographic distribution of the species adequately in both area IV and subdivision IIIa (Figure 15.3). The surveys are therefore not very well suited for monitoring this species and trends in standardised CPUE are not a reliable indicator for the status of the stock.

15.5.3 Data requirements

In order to get a better understanding of growth and maturity WGNEW recommended that the collection of otoliths and maturity should be continued during these surveys for a few years. WGNSSK recommends also that the Norwegian biological data from commercial catches should be processed.

15.6 References

Cardinale, M., H. Svedäng, V. Bartolino, L. Maiorano, M. Casini and H. Linderholm, 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. J. Appl. Ichthyol. 28(2): 200-208

Council Regulation (EU) No 850/1998. Conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

ICES 2012. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

Heino, M., Svåsand, T., Nordeide, J. T., Otterå, H., 2012. Seasonal dynamics of growth and mortality suggest contrasting population structure and ecology for cod, pollack, and saithe in a Norwegian fjord. – ICES Journal of Marine Science 69: 537–546

Vølstad, J. H., Korsbrekke, K., Nedreaas, K. H., Nilsen, M., Nilsson, G. N., Pennington, M., Subbey, S.,Wienerroither, R., 2011. Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery. ICES Journal of Marine Science. 68: 1785–1791

Table 15.1. Pollack. Landings by country in Division IIIa as officially reported to ICES.

	ICES Division IIIa							
	Belgium	Denmark	Germany	Netherl.	Norway	Sweden	UK	Total
1977	10	1764	4	3	449	706		2936
1978	1	2077	4		556	794		3432
1979	13	1898	<0.5		824	1066		3801
1980	13	1860			987	1584	<0.5	4444
1981	5	1661			839	1187	1	3693
1982	1	1272			575	417	<0.5	2265
1983	2	972			438	288		1700
1984	2	930	<0.5		371	276		1579
1985	-	824	<0.5		350	356		1530
1986	4	759	<0.5		374	271		1408
1987	6	665			342	246		1259
1988	4	494			350	136		984
1989	3	554			313	152		1022
1990	8	1842	<0.5		246	253		2349
1991	2	1824			324	281		2431
1992	8	1228			391	320		1947
1993	6	1130	1		364	442		1943
1994	5	645	<0.5		276	238		1164
1995	10	497			322	271		1100
1996		680			309	273		1262
1997		364	<0.5		302	178		844
1998		299			330	105		734
1999		192			342	88		622
2000		199			268	33		500
2001		201	1		253	46		501
2002		228	3		202	44		477
2003		168	3	1	236	17		425
2004		140	2	4	179	34		359
2005		160	5	7	173	153		498
2006		103	10	3	178	36		330
2007		172	9		245	38		464
2008		161	5		247	33		446
2009		206	7		220	38	<0.5	471
2010		313	8	1	195	35		552
2011		193	7		168	28		395
2012		200	7		170	37		414
2013		209	3		172	35		420*

***Preliminary**

Table 15.2. Pollack. Landings by country in Subarea IV as officially reported to ICES.

	ICES Subarea IV										
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
1977	121	275		75	142	38	419	9	0	442	1521
1978	102	249		98	154	21	492	2	0	471	1589
1979	62	333		72	64	8	563	11	31	429	1573
1980	82	407		66	58	2	1095		38	355	2103
1981	59	500		173	21	2	1261		12	362	2390
1982	46	431		59	40	1	1169	33	23	270	2072
1983	58	481		79	44	1	1081		57	300	2101
1984	52	402		108	37	0	880	2	106	315	1902
1985	14	308		69	23	0	686		51	363	1514
1986	44	550		45	21	0	602		67	362	1691
1987	21	427		988	21	0	471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273		0	21	4	568		37	269	1203
1990	44	924		0	34	3	651		126	366	2148
1991	31	1464		0	48	4	887		153	684	3271
1992	49	794		18	59	7	1051		141	1310	3429
1993	46	1161		8	161	19	1429		217	1561	4602
1994	42	635		12	55	14	845		113	872	2588
1995	56	532	1	7	84	18	1203		175	1525	3601
1996	13	366		4	99	13	909		82	945	2431
1997	20	272	1	1	115	11	733		82	1185	2420
1998	21	265		7	44	5	567		75	780	1764
1999	21	288		0	62	5	768		72	636	1852
2000	45	291		24	38	5	880		91	877	2251
2001	36	156		6	40	1	860		63	809	1971
2002	27	234		6	112	0	879		68	711	2037
2003	13	191		9	82	1	971		36	837	2140
2004	28	162		5	57	0	517		16	612	1397
2005	26	173		3	128	3	511		46	477	1367
2006	18	152		4	80	1	545		12	587	1399
2007	18	192		130	137	2	754		43	905	2181
2008	15	150		129	114	1	840		46	999	2294
2009	13	121	2	6	50	1	668		32	658	1551
2010	12	163		10	129	0	599		32	540	1485
2011	12	106	0	10	67	0	580	0	35	489	1299
2012	17	123	0	3	102	1	430		42	443*	1161*
2013	16	127	0	0	66	0	371	0	28	458*	1086*

*** Preliminary**

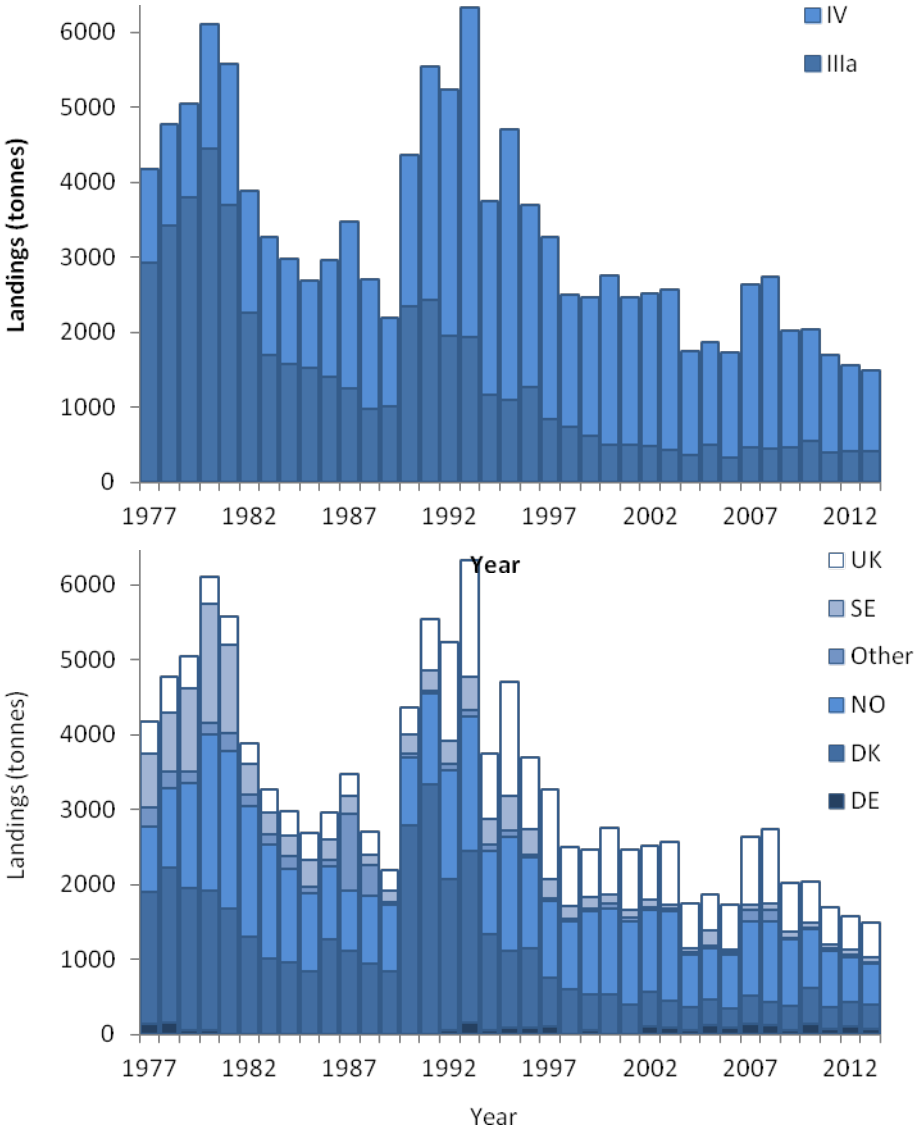


Figure 15.1. Pollack. Total landings of pollack in Division IIIa and Subarea IV (top) and by country (bottom) as officially reported to ICES.

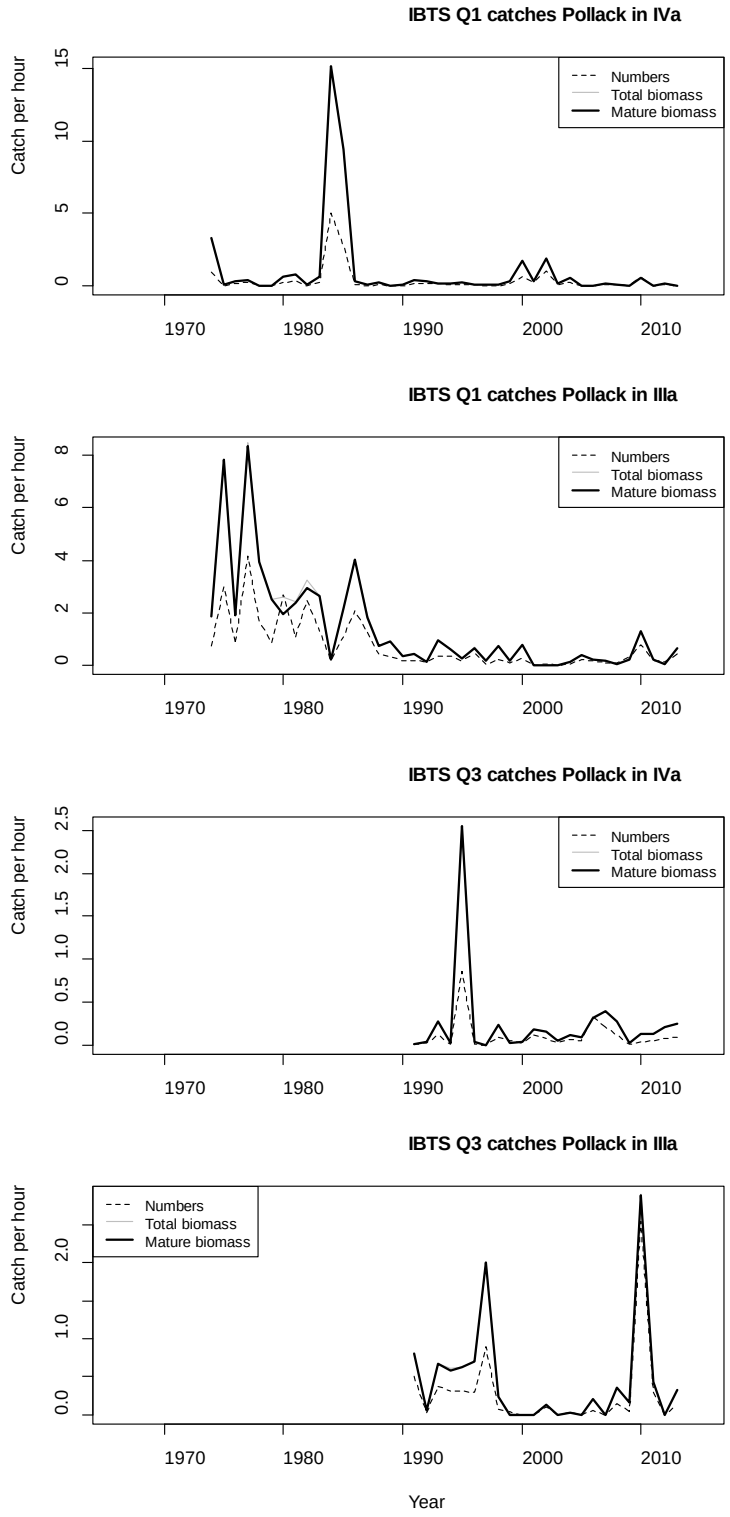


Figure 15.2. Time series of catches of pollack in the IBTS Q1 and Q3 surveys in the North Sea and in the Skagerrak, shown as numbers and weight (kg) caught per hour with the GOV-trawl. Data from Datras.

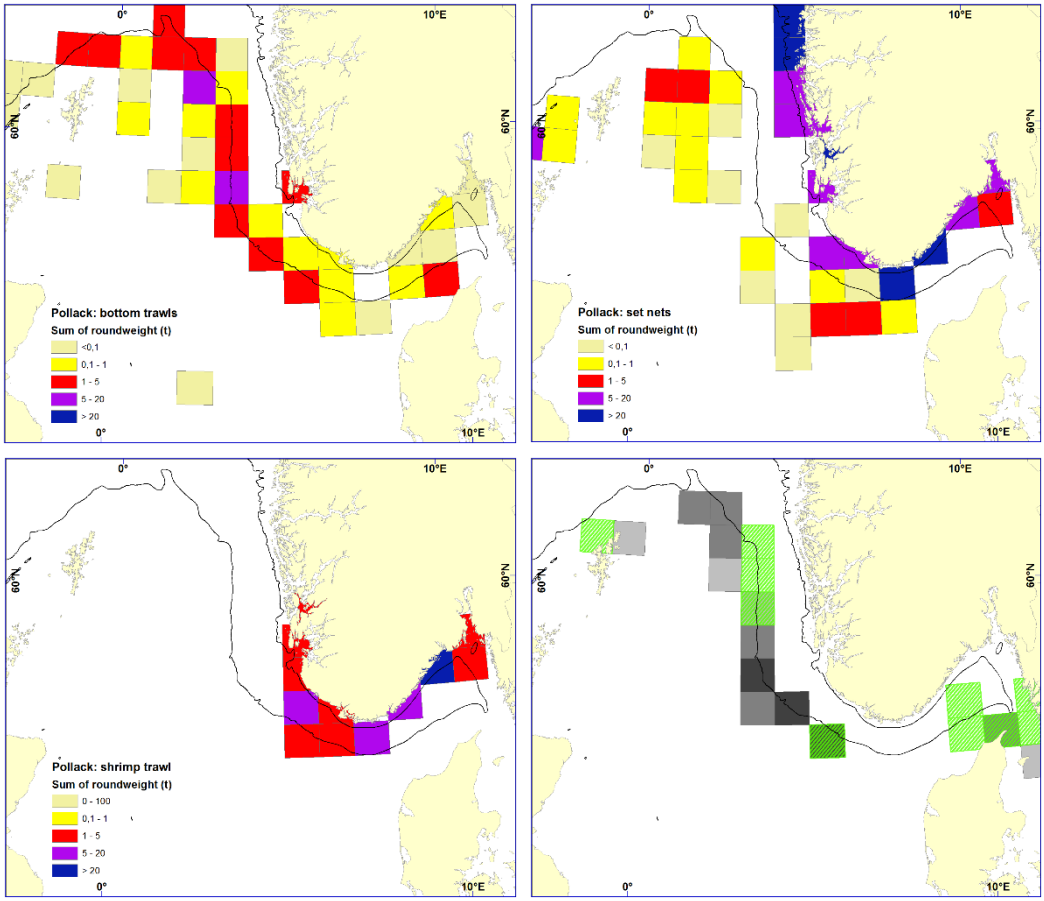


Figure 15.3 Distribution of total pollack catches (Norwegian landings) for 2013 aggregated by fishing gear (bottom trawls, set nets, shrimp trawls), and pollack catches from IBTS surveys in 2012 (grey) and 2013 (green).

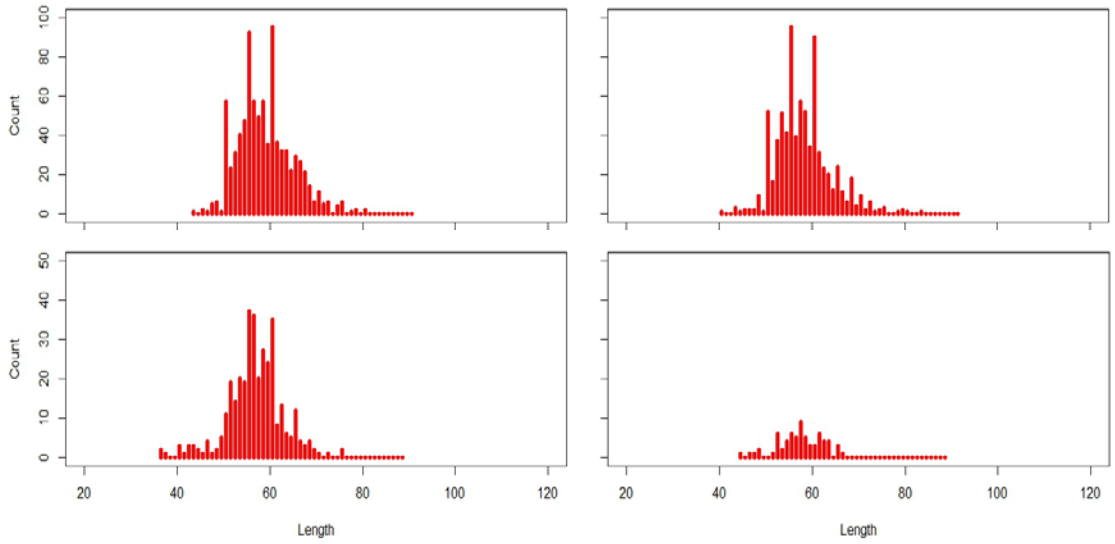


Figure 15.4 Length distributions of pollack sampled by the Norwegian reference fleet in the period 2010 – 2013, Area IIIa . The data is aggregated for gillnets with a 63mm meshsize.

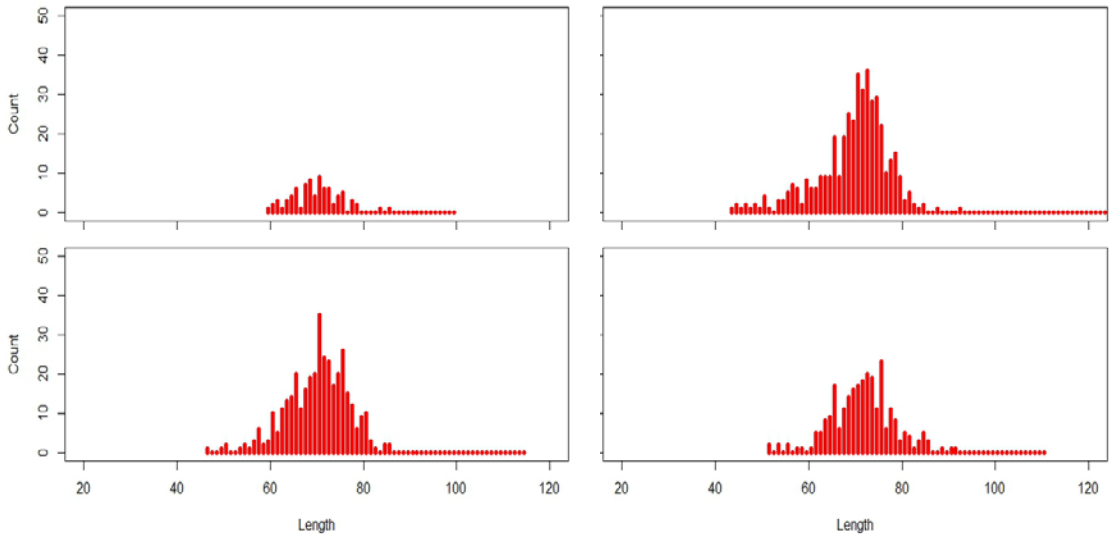


Figure 15.5 Length distributions of pollack sampled by the Norwegian reference fleet in the period 2010 – 2013, Area IV. The data is aggregated for gillnets with a 70mm mesh size.

16 Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak – Kattegat)

16.1 General

Grey gurnard (*Eutrigla gurnardus*) was assessed in the Working Group on Assessment of New MoU Species (ICES, 2014). The information in this section is thus taken from the WGNEW2014 report. For this stock several survey data were available, but available landings data are incomplete or were not reported specifically for grey gurnard. Therefore, only survey trends were used as a stock indicator and the biennial advice is the same as for the last two years.

16.1.1 Biology and ecosystem aspects

Grey gurnard occurs in the Eastern Atlantic from Iceland, Norway, southern Baltic, and North Sea to southern Morocco and Madeira. It is also found in the Mediterranean and Black Seas. In the North Sea and in Skagerrak/Kattegat, grey gurnard is an abundant demersal species. In the North Sea, the species may form dense semi-pelagic aggregations in winter to the northwest of the Dogger Bank, whereas in summer it is more widely distributed. The species is less abundant in the Channel, the Celtic Sea and in the Bay of Biscay.

Spawning takes place in spring and summer. There do not seem to be clear nursery areas. Grey gurnard can reach a maximum length of approximately 50 cm.

Grey gurnard is considered a predator on a number of commercially important demersal stocks (cod, whiting, haddock, sandeel, Norway pout) in the North Sea (de Gee & Kikkert, 1993). The steep increase in abundance of grey gurnard has led to an increase in mortality especially of North Sea cod (age-0) and whiting (age-0 and age-1) in recent years (ICES, 2011). The multi species model SMS estimates that grey gurnard is currently responsible for over 50% of the predation mortality on 0-group cod and whiting. Therefore, the abundance and distribution pattern of grey gurnard and its prey size preferences are highly relevant from an ecological point of view (Floeter and Temming, 2005; Kempf et al. 2013).

16.1.2 Stock ID and possible assessment areas

No studies are known of the stock ID of grey gurnard. In a pragmatic approach for advisory purposes and in order to facilitate addressing ecosystem considerations, the population is currently split among 3 Ecoregions: North Sea including VIId, Celtic Seas and South European Atlantic. This proposal should be discussed considering the low levels of catches reported in recent years in Celtic Seas and South European Atlantic (ICES, 2011; WGNEW).

16.1.3 Management regulations

There is no minimum landing size for this species and there is no TAC.

16.2 Fisheries data

16.2.1 Historical landings

Historically, grey gurnard is taken as a by-catch species in mixed demersal fisheries for flatfish and roundfish. Grey gurnard from the North Sea is mainly landed for human

consumption purposes. However, the market is limited and the largest part of the catch is discarded (see also stock Annex). Owing to the low commercial value of this species, landings data do not reflect the actual catches.

In the past, gurnards were often not sorted by species when landed and were reported as one generic category of "gurnards". Further, catch statistics are incomplete for some years, e.g. the Netherlands did not report gurnards during the years 1984–1999. In recent years, the official statistics seem to improve gradually. However, species misidentification continues to be a major problem in estimating the landings of all gurnards and hence grey gurnard. In addition, some countries continue to report "gurnards" landings and do not provide information on grey gurnard separately. Figure 3.1a displays the official landings for area IV, IIIa and VIId for all species categories in which grey gurnard may be included, e.g. a considerably proportion was reported as "Gurnards, sea robins nei" in recent years.

Since the early 1980s specific landings data for grey gurnard are available from the catch statistics. Before that, these data occurred only sporadically in the statistics (Fig. 16.1b; Table 16.1). Most of gurnard catches are taken in area IV and to a much lesser extent in areas VIId and IIIa (Fig. 16.1b; Table 16.1). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46 598 t in 1987 (Fig. 16.1c; Table 16.2) because of Danish landings for reduction purposes. After this peak, the Danish landings dropped again to a low level. Recent international landings for the last 5 years have been low ranging between 285 to 558 t per year. The average 2000-2013 was at 445 t. Data from 1950 to 2010 were taken from the "ICES catch statistics 1950 to 2010". Data from 2011 to 2012 were taken from the "ICES catch statistics 1985 to 2012". Data for 2013 were taken from the preliminary catch statistics and partly estimated from Inter Catch upload files provided to WGNEW 2014.

16.2.2 Inter Catch data

In 2014 grey gurnard in area IV, IIIa and VIId was included to the Inter Catch data call for the first time. Not all countries were able to provide their data in time for the WGNEW2014. However, data of most countries were provided just before the WGNSSK meeting and were analysed to estimate total landings and discards.

The largest amount of landings was reported by Denmark for the MIS_MIS_0_0_0_all metier (454t), followed by England (265t) for all gears combined (Fig. 16.2.2.1). Compared to the discards, landings were rather low in all reported metiers. The by far largest amount of discards was reported for the Dutch TBB_DEF_70-99_0_0_all (1152t) metier. As a result from the raising procedure, the largest amount of discards was estimated for the combined England fleet (~5000t). The total catch estimated with Inter Catch was 19652t from which 1174t were landings (6%) and 18478t estimated discards (94% of total catch). In total The Netherlands, England and Scotland take the largest proportion of the total catch (Figure 16.2.2.3).

The results of the raising procedure should be interpreted with caution, because there are some issues by using this year Inter Catch data: Germany does not report officially grey gurnard data separately, but reports a combined group of gurnards. Thus, it was not possible to upload German data to Inter Catch. Further, only The Netherlands, Denmark and Sweden uploaded discard information for some metiers. England uploaded landings for all metiers combined. Therefore, it should be noted that not all metiers were sampled in every quarter and that raising procedure may not be adequate in all cases. Table 16.4a shows a detailed overview of discard and landings information by country and quarter uploaded to Inter Catch. However, Inter Catch might enable to

give catch advice for this stock in future years given a sufficient coverage of discard samplings across the most important metiers.

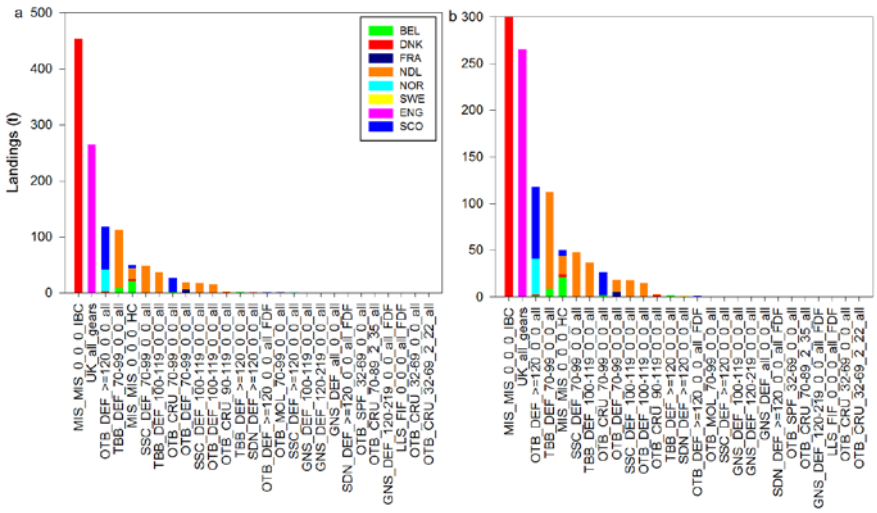


Figure 16.2.2.1 Inter Catch. Grey gurnard landings by metier and country as uploaded to Inter Catch. Panel (a) and (b) showing the same data, but y-axis in panel (b) is downscaled to better visualize details.

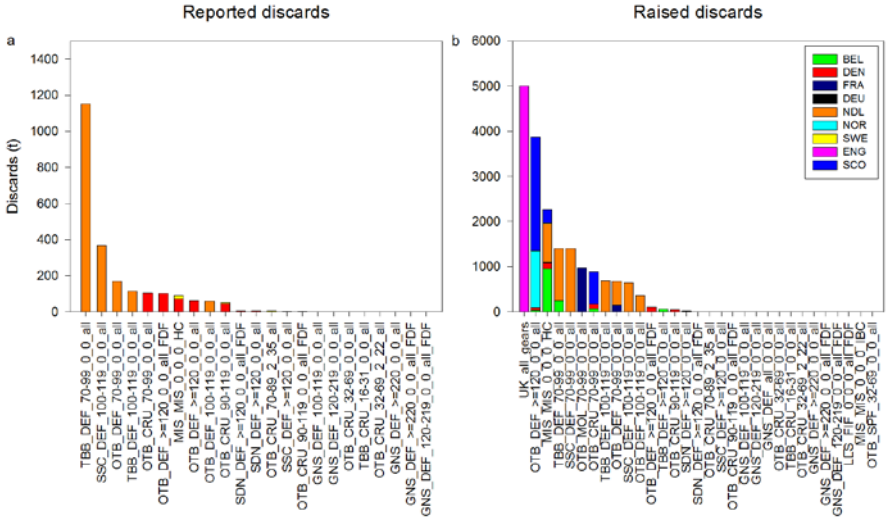


Figure 16.2.2.2 Inter Catch. Grey gurnard discards by metier and country. Reported discards panel (a), raised discards panel (b). Legend valid for both panels.

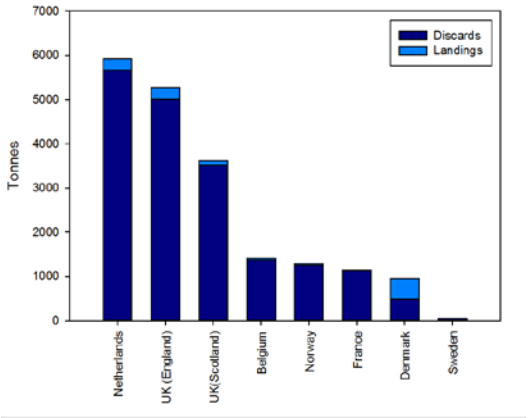


Figure 16.2.2.3 Inter Catch. Grey gurnard total landings and raised discards by country.

16.2.3 Discards

In Table 16.4b the numbers per hour of discarded grey gurnard in Dutch bottom-trawl fisheries in North Sea and Eastern Channel are shown for 2006-2012. The rates are highly variable depending on the specific métiers, with highest values observed for the SSC_DEF métiers. German discard data from an observer programme indicate that the proportion of discarded gurnard in German demersal trawl fisheries ranges between 76.6% and 93.0% (Ulleweit et al., 2010).

16.3 Survey data / recruit series

For the North Sea and Skagerrak/Kattegat, data are available from the International Bottom Trawl survey. The IBTS-Q1 and IBTS-Q3 can provide information on distribution and the length composition of the catches. Grey gurnard occurs throughout the North Sea and Skagerrak/Kattegat. During winter, grey gurnards are concentrated to the northwest of the Dogger Bank at depths of 50–100 m, while densities are low off the Danish coast, in the German Bight and eastern part of the Southern Bight (Figure 16.2 and 16.3). The distribution pattern changes substantially in spring, when the whole area south of 56°N becomes densely populated and the high concentrations in the central North Sea disappear until the next winter (Daan *et al.* 1990). The densities of grey gurnard observed in the Eastern Channel (area VIId) were much lower compared to the North Sea area (Fig. 16.5).

The near absence of grey gurnard in the southern North Sea during winter and the marked shift in the centre of distribution between winter and summer suggests a preference for higher water temperatures (Hertling, 1924; Daan *et al.* 1990).

During winter, grey gurnard occasionally form dense aggregations just above the sea bed (or even in midwater, especially during night time) which may result in extremely large catches. Within one survey, these large hauls may account for 70 % or more of the total catch of the species. Bottom temperatures in high-density areas usually range from 8 to 13°C (Sahrhage, 1964).

16.4 Biological sampling

Individual biological data for this species are still scarce (see also the stock annex). In the North Sea, individual data have been collected sporadically during some years of the IBTS-Q1 and IBTS-Q3 survey.

Length distributions presented in the WGNEW2010 Report have been updated and are presented in Figure 16.10 and in the stock annex. They showed that a bimodal structure occurred in Skagerrak and Kattegat (IIIa) which was not observed in North Sea where smaller fish were only found in relatively small numbers.

An ALK from collected otoliths has shown that the age span of grey gurnard collected in Q1 is large (age 2 to age 14), but not many individuals were aged (Figure 16.8).

Available data on gurnard individual weights and maturity were analysed in order to estimate a mature biomass index (Figures 16.9, 16.10.; Tables 16.5, 16.6).

Not all available maturity data were obtained during the main spawning season which takes place in spring and summer, some were obtained in the first and fourth quarter of the year (Table 3.5). However, a maturity ogive based on all the available grey gurnard maturity data was used to calculate the mature biomass index. The obtained maturity ogive shows that above 24.5 cm more than 90% of all the individuals can be considered mature (Figure 3.9). The corresponding Lmat50% value was 18.5 cm.

The available age and maturity data suggest that grey gurnard is early maturing in North Sea and a certain proportion of fish at age 1 are mature.

16.5 Population biological parameters and other research

The information delivered at the WGNEW 2014 is now in the stock annex.

16.6 Analysis of stock trends / assessment

Information from landings is very poor, due to poor reporting (gurnard species are not always identified in the data, and probably also misreporting has occurred) and also because the low value of the species leads to massive discarding.

The status of the populations in the Ecoregions which cover the Northern European Shelf is not known but some indications of trend are delivered by the survey series available.

To analyse stock trends a mature biomass index was calculated applying a length weight relationship and a maturity ogive which were obtained from all data available to WGNEW2014.

According to van Heesen and Daan (1996), outliers were excluded from the IBTS-Q1 time series since grey gurnards tend to form dense concentrations during winter. Outliers were defined as hauls which accounted for more than 90% of the total gurnard weight caught in the respective year. The time series of mature biomass index of grey gurnard in the IBTS-Q1 and IBTS-Q3 survey has shown a strong increase pattern from the beginning of 90's (Figure 16.4; Table 16.3). Since then it is fluctuating on a high level. The third highest IBTS-Q1 time series record was observed in 2010, followed by a decrease up to 2013. A similar trend since beginning of the 90's was observed for the IBTS-Q3 mature biomass time series. Overall, for the IBTS-Q3 survey lower biomass values were observed. Compared to the North Sea/Skagerrak (area IV/IIIa) the mature biomass values recorded by the CGFS in the Eastern Channel (area VIId) were extremely low (Figure 16.6). No trend could be detected in the CGFS index. Therefore, the advice for grey gurnard in area IV, IIIa and VIId should be based on the IBTS survey, which covers by far the largest part of the stock.

16.7 Data requirements

For management purposes, information should be available on catches and landings. The quality of landings data has been poor for this species because in the past only landings of "gurnards" were reported which is still the case for some countries today. Further, this species is highly discarded and for the past years discard data are not available covering all fleets.

Given the high level of discarding, observation at sea under DCF seems the main source of information to better estimate the catches. A way to obtain specific samples of grey gurnard could be a self-sampling program but it could be difficult to persuade fishermen of an extra work to sample a species they are used to discard.

For a better understanding of this species an increase in our knowledge of biological parameters is required. In the context of ecosystem considerations, it would be useful to obtain more information on age composition of the stock and its diet composition.

From the information presented here, it can be concluded that grey gurnard is currently of very limited commercial interest.

16.8 References

Daan, N., Bromley, P. J., Hislop, J. R. G., and Nielsen, N. A., 1990. Ecology of North Sea Fish. Netherlands Journal of Sea Research 26(2–4): 343–386.

De Gee, A., and Kikkert, A.H., 1993. Analysis of grey gurnard (*Eutrigla gurnardus*) samples collected during the 1991 International Stomach Sampling Project. ICES CM/G:14. 25 pp.

Floeter, J., Temming, A., 2005. Analysis of prey size preference of North Sea whiting, saithe, and grey gurnard. ICES Journal of Marine Science 62: 897-907.

Heessen and Daan (1996) Long-term trends in ten non-target North Sea fish species. ICES Journal of Marine Science, 53: 1063–1078.

Hertling, H. 1924. Über den grauen und den roten Knurrhahn (*Trigla gurnardus* L. und *Trigla hirundo* Bloch). Wissenschaftliche Meeresuntersuchungen Helgoland 15(2), Abhandlung 13: 1–53.

ICES. 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM)

ICES. 2012. Report of the Working Group on Assessment of New MoU Species (WGNEW), 5-9 March 2012, ICES Headquarters, Denmark. ICES CM 2012/ACOMYY.

ICES Catch Statistics 1950-2010. Version dd-mm-yyyy. Accessed 25-03-2014 via http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx. ICES, Copenhagen.

ICES Catch Statistics 1985-2012. Version dd-mm-yyyy. Accessed 25-03-2014 via http://ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx. ICES, Copenhagen.

Kempf, A., Stelzenmüller, V., Akimova, A., Floeter, J., 2013. Spatial assessment of predator-prey relationoship in the North Sea: the influence of abiotic habitat properties on the spatial overlap between 0-group cod and grey gurnard. Fisheries Oceanography 22(3):174-192.

Sahrhage, D. 1964. Über die Verbreitung der Fischarten in der Nordsee. I. Juni-Juli 1959 und Juli 1960. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung 17(3): 165-278.

Table 16.1. Grey gurnard. Official landings (tonnes) of grey gurnard by areas.

Year	IV	IIIa	VIId
1950	0	0	0
1951	0	0	0
1952	0	0	0
1953	0	0	0
1954	0	0	0
1955	0	0	0
1956	0	0	0
1957	0	54	0
1958	0	76	0
1959	0	0	0
1960	0	0	0
1961	0	0	0
1962	0	0	0
1963	202	0	0
1964	0	0	0
1965	0	0	0
1966	0	0	0
1967	0	0	0
1968	0	0	0
1969	0	0	0
1970	0	0	0
1971	0	0	0
1972	0	0	0
1973	0	0	0
1974	0	0	0
1975	0	0	0
1976	0	62	0
1977	0	37	0
1978	13	54	2
1979	105	49	839
1980	43	36	950
1981	0	46	0
1982	100	129	380
1983	64	36	489
1984	71	68	126
1985	173	12	116
1986	93	16	217
1987	44324	20	78
1988	37024	61	360
1989	26348	23	99
1990	22168	37	98
1991	14612	30	99
1992	8242	32	91
1993	979	27	54
1994	193	24	37
1995	153	15	43
1996	232	21	48
1997	151	18	84
1998	75	35	35
1999	225	28	1
2000	548	37	76
2001	611	33	46
2002	393	19	87
2003	420	33	72
2004	376	28	48
2005	316	26	36
2006	200	21	46
2007	205	25	49
2008	158	29	86
2009	201	18	66
2010	264	13	111
2011	334	6	102
2012	525	6	27
2013	467	6	53

Table 16.2. Grey gurnard. Official landings (tonnes) of grey gurnard in areas IIIa, IV, and VIId by country as reported to ICES.

Year	BEL	DNK	FRA	NDL	NOR	SWE	UK
1950	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0
1953	0	0	0	0	0	0	0
1954	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0
1957	0	0	0	0	0	254	0
1958	0	0	0	0	0	311	0
1959	0	0	0	0	0	0	0
1960	0	0	0	0	0	0	0
1961	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0
1963	0	0	0	202	0	0	0
1964	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0
1968	0	0	0	0	0	0	0
1969	0	0	0	0	0	0	0
1970	0	0	0	0	0	0	0
1971	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0
1975	0	0	0	0	0	14	0
1976	0	0	0	0	0	69	0
1977	0	0	0	0	0	37	0
1978	0	0	15	0	0	54	0
1979	0	0	944	0	0	49	0
1980	0	0	993	0	0	38	0
1981	0	0	0	0	0	46	0
1982	0	360	480	0	0	43	0
1983	0	1067	553	0	0	8	0
1984	0	4041	197	0	0	7	0
1985	102	2358	187	0	0	9	0
1986	0	314	283	0	0	10	0
1987	76	46598	122	0	0	6	0
1988	86	38237	389	0	0	3	22
1989	82	26739	135	0	0	5	0
1990	91	22075	134	0	0	3	0
1991	75	14539	122	0	0	5	0
1992	104	8135	106	0	0	10	10
1993	113	840	74	0	0	9	24
1994	67	99	54	0	0	12	22
1995	50	73	62	0	0	5	21
1996	112	70	62	0	0	3	54
1997	52	36	103	0	0	5	57
1998	34	56	47	0	0	8	0
1999	36	86	0	0	0	132	0
2000	37	95	72	452	0	5	0
2001	28	288	60	277	0	4	33
2002	55	63	64	286	0	2	29
2003	34	92	47	319	0	7	26
2004	35	83	9	297	0	5	23
2005	29	73	7	238	0	9	22
2006	18	65	4	155	2	2	21
2007	14	37	5	165	5	3	50
2008	9	48	5	120	5	8	78
2009	16	21	3	157	1	4	83
2010	20	18	12	258	1	2	77
2011	37	11	9	316	16	1	64
2012	60	8	9	478	2	1	0
2013[1)]	54	10	6	278	33	2	144

[1)] **Preliminary data; FRA data from InterCatch**

Table 16.3. Grey gurnard mature biomass indices (kg/hour) from IBTS Q1, IBTS Q3 and CGFS Q4 survey.

Year	IBTS Q1	IBTSQ3	CGFS Q4
1966	0.00		
1967	2.49		
1968	9.35		
1969	17.56		
1970	2.08		
1971	0.64		
1972	0.12		
1973	0.72		
1974	4.74		
1975	3.30		
1976	7.89		
1977	0.92		
1978	2.50		
1979	0.21		
1980	0.91		
1981	0.84		
1982	6.39		
1983	4.34		
1984	12.50		
1985	3.35		
1986	8.38		
1987	4.05		
1988	2.35		0.20
1989	5.96		0.31
1990	7.71		0.08
1991	7.40	5.48	0.28
1992	8.08	9.21	0.06
1993	9.59	6.59	0.07
1994	9.20	9.19	0.06
1995	11.06	8.07	0.02
1996	16.06	13.45	0.04
1997	22.59	10.84	0.12
1998	18.99	18.09	0.05
1999	40.49	19.56	0.57
2000	22.32	14.17	0.05
2001	17.86	19.40	0.03
2002	21.73	13.95	0.16
2003	17.50	13.95	0.06
2004	19.12	10.68	0.20
2005	17.08	11.85	0.02
2006	16.62	11.61	0.00
2007	18.02	14.44	0.05

2008	19.60	16.57	0.03
2009	17.15	17.54	0.03
2010	32.04	14.15	0.02
2011	25.70	18.13	0.05
2012	27.51	16.90	0.08
2013	21.33	19.95	0.07

Table 16.4a Grey gurnard. Discards and landings (t) information grouped by metier and country uploaded to Inter Catch. Displayed are also resulting discard rates in cases were available.

		Q1		Q2		Q3		Q4		Q1-4	Q1	Q2	Q3	Q4
Country	Metier	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Discard rate			
Belgium	MIS_MIS_0_0_0_HC		2.22		12.888		5.225		0.933					
Belgium	OTB_CRU_70-99_0_0_all		0.141		2.095		0.052		0.004					
Belgium	OTB_DEF_>=120_0_0_all		0.171		0.095		0.385		0.283					
Belgium	TBB_DEF_>=120_0_0_all				0.143		0.789		1.244					
Belgium	TBB_DEF_70-99_0_0_all		2.273		2.8		2.054		1.671					
Denmark	GNS_DEF_>=220_0_0_all	0		0		0					0.00	0.00	0.00	
Denmark	GNS_DEF_>=220_0_0_all_FDF					0							0.00	
Denmark	GNS_DEF_100-119_0_0_all			0.196	0.091		0.39		0.005			2.15		
Denmark	GNS_DEF_120-219_0_0_all	0.072		0.027	0.086	0.064	0.136	0.032	0.154			0.31	0.47	0.21
Denmark	GNS_DEF_120-219_0_0_all_FDF	0		0		0	0.003	0			0.00	0.00	0.00	0.00
Denmark	LLS_FIF_0_0_0_all_FDF						0.001							
Denmark	MIS_MIS_0_0_0_HC	5.573	0.663	19.85	0.514	27.091	0.809	18.206	1.056		8.41	38.62	33.49	17.24
Denmark	MIS_MIS_0_0_0_IBC		6.693		394.292		44.745		8.189					
Denmark	OTB_CRU_32-69_0_0_all	0		0		0		0			0.00	0.00	0.00	0.00
Denmark	OTB_CRU_70-99_0_0_all	0.53		6.621		51.662		46.228	0.033					1400.85
Denmark	OTB_CRU_90-119_0_0_all	3.21	0.279	8.503	0.874	29.644	1.049	3.998	0.276		11.51	9.73	28.26	14.49
Denmark	OTB_CRU_90-119_0_0_all_FDF	0.155		0.777		2.285		0.017						
Denmark	OTB_DEF_>=120_0_0_all	6.62	0.006	17.326	0.373	32.931	1.374	6.637	0.187		1103.33	46.45	23.97	35.49
Denmark	OTB_DEF_>=120_0_0_all_FDF	16.497		32.545	0.315	31.454		22.865				103.32		
Denmark	OTB_SPF_32-69_0_0_all								0.103					
Denmark	SDN_DEF_>=120_0_0_all		0.02	5.241	0.137	0.061	0.514	0	0.026			38.26	0.12	0.00
Denmark	SDN_DEF_>=120_0_0_all_FDF			4.301		1.762	0.191	0.427					9.23	
Denmark	SSC_DEF_>=120_0_0_all	0.049		0.733		2.244		1.938						
Denmark	TBB_CRU_16-31_0_0_all	0.003		0.008		0.011		0.011						
France	MIS_MIS_0_0_0_HC		0.03348		0.13732		0.00836		0.00354					
France	OTB_DEF_70-99_0_0_all		2.4466		2.4257		0.28411		0.34					
France	OTB_MOL_70-99_0_0_all		0.61269				0.061		0.025					
Netherlands	MIS_MIS_0_0_0_HC		1.28		8.1		9.59		0.12					
Netherlands	OTB_DEF_100-119_0_0_all				5.16		9.59		0.47	61.02126		4.01*	4.01*	4.01*
Netherlands	OTB_DEF_70-99_0_0_all		1.79		10.13		1.26		0.05	170.84132	12.91*	12.91*	12.91*	12.91*
Netherlands	SSC_DEF_100-119_0_0_all				13.14		4.4		0.48	368.43183		20.45*	20.45*	20.45*
Netherlands	SSC_DEF_70-99_0_0_all		5.44		15.94		23.99		2.77					
Netherlands	TBB_DEF_100-119_0_0_all		0.04		27.94		8.98			113.46466	3.07*	3.07*	3.07*	
Netherlands	TBB_DEF_70-99_0_0_all		22.31		44.75		15.52		21.3	1151.84897	11.09*	11.09*	11.09*	11.09*
Norway	GNS_DEF_all_0_0_all		0.0957		0.1008		0.0028		0.0146					
Norway	OTB_DEF_>=120_0_0_all		0.937		26.688		10.079		0.678					
Norway	SSC_DEF_>=120_0_0_all		0		0.286		0.0055		0.276					
Sweden	MIS_MIS_0_0_0_HC	2.676	0.073	5.339	0.14	6.882	0.035	4.15	0.088		36.66	38.14	196.63	47.16
Sweden	OTB_CRU_32-69_0_0_all	0.007	0	0.012	0	0.016	0	0.017	0		Total catch discarded	Total catch discarded	Total catch discarded	Total catch discarded
Sweden	OTB_CRU_32-69_2_22_all	0.006	0	0.005	0	0.007	0	0.007	0		Total catch discarded	Total catch discarded	Total catch discarded	Total catch discarded
Sweden	OTB_CRU_70-89_2_35_all	0.802	0.003	1.01	0.004	2.441	0.01	0.861	0		267.33	252.50	244.10	Total catch discarded
Sweden	OTB_CRU_90-119_0_0_all	2.408	0.187	2.22	0.35	1.589	0.122	1.108	0.215		12.88	6.34	13.02	5.15
Sweden	OTB_DEF_>=120_0_0_all		0.064		0.081		0.026		0.032					
Sweden	SDN_DEF_>=120_0_0_all						0.097		0.179					
England	C-Allgears		57.952		89.373		69.28		48.856					
Scotland	MIS_MIS_0_0_0_HC		0.385		0.09				6					
Scotland	OTB_CRU_70-99_0_0_all		13.23		4.861		2.108		4.067					
Scotland	OTB_DEF_>=120_0_0_all		30.062		22.862		10.013		13.865					
Scotland	OTB_DEF_>=120_0_0_all_FDF				0.187		0.065		0.207					

* estimated from quarterly combined discards by proportion of landings

Table 16.4b Grey gurnard. Discards per hour of grey gurnard by different metiers in the Netherlands 2006 - 2012.

Métier	TBB_DEF	TBB_DEF*	TBB_DEF	SSC_DEF	SSC_DEF	OTB_MCD	OTB_DEF	OTB_DEF
Mesh	70-99	70-99	100-119	100-119	>120	70-99	70-99	100-119
2006	68.3							
2007	60.2							
2008	34.3							
2009	55	17	37			111	77	15
2010	81	10	109			47	52	110
2011	61	27	10	NA	119	27	55	70
2012	41	24	30	317	307	110	75	12

***≤300 hp segment**

Table 16.5: Grey gurnard maturity ogives available to WGNEW 2014. Sigmoid model fitted to the data: prop_mat = a / (1+exp(-1*(Length-Lmat50%)/b)).

Source	Institute	Year	Quarter	a	b	Lmat (50%)	r^2	p	n
IBTS Q1	IMARES	2010	1	0.996	0.047	18.447	0.995	< 0.001	240
IBTS Q1	TI-SF	2014	1	0.989	1.989	18.072	0.905	< 0.001	347
IBTS Q3	CEFAS	1991	3	0.990	1.762	18.991	0.938	< 0.001	594
IBTS Q3	CEFAS	1992	3	0.983	0.395	17.055	0.981	<0.001	356
WGNEW 2012	CEFAS	1991	4	0.995	2.983	21.617	0.975	< 0.001	254
	all combined			0.992	2.063	18.478	0.997	< 0.001	1791

Table 16.6: Grey gurnard length weight relationship available to WGNEW 2014.

Source	Institute	Year	Quarter	a	b	r^2	p	n
IBTS Q1	IMARES	2010	1	0.005	3.141	0.959	< 0.001	240
IBTS Q1	TI-SF	2014	1	0.009	2.947	0.975	< 0.001	347
	combined			0.006	3.094	0.968	< 0.001	587

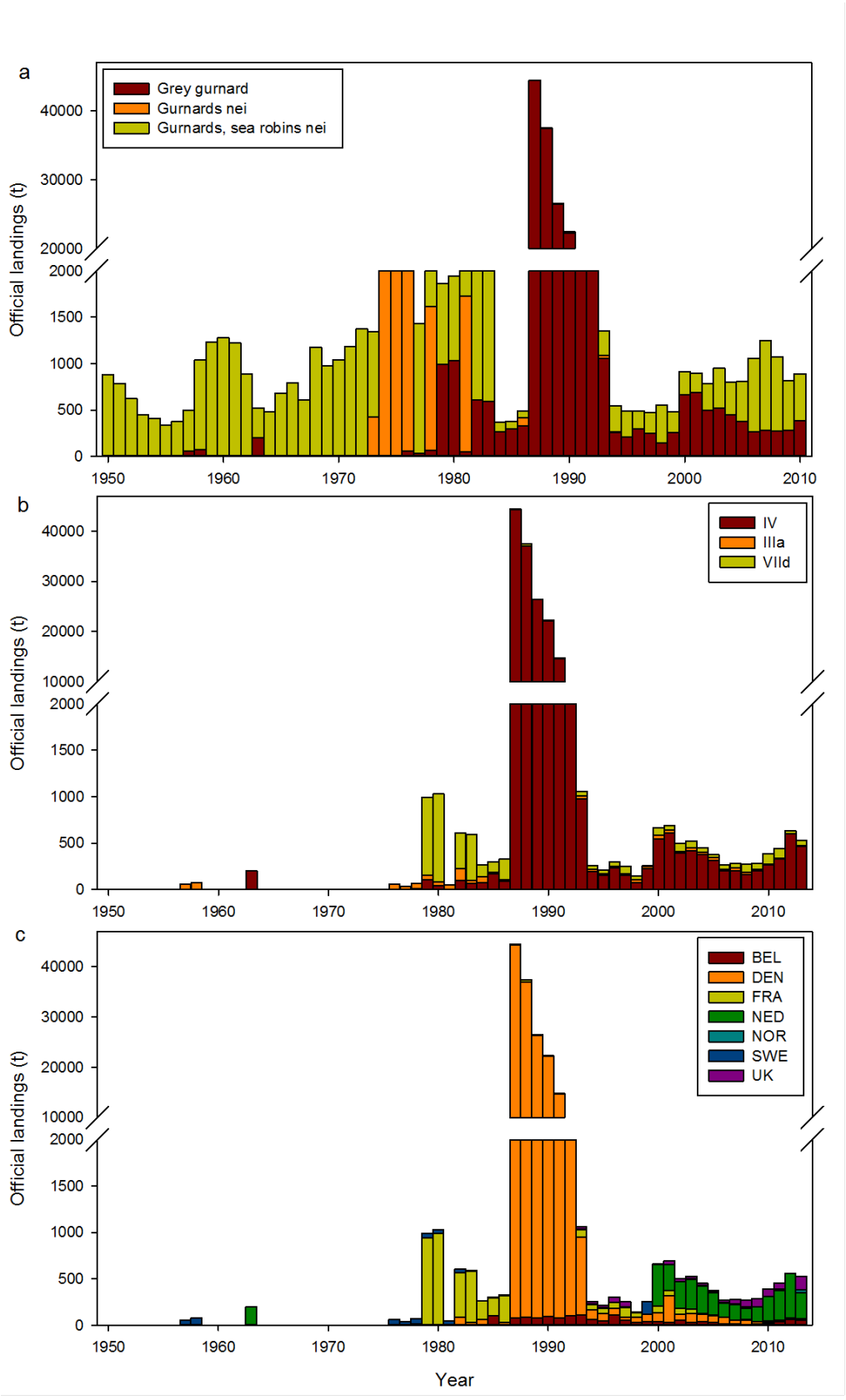


Figure 16.1: Gurnards. Official landings of gurnard categories for all areas (a) , grey gurnards by area (b), and grey gurnards by country (c) reported to ICES.

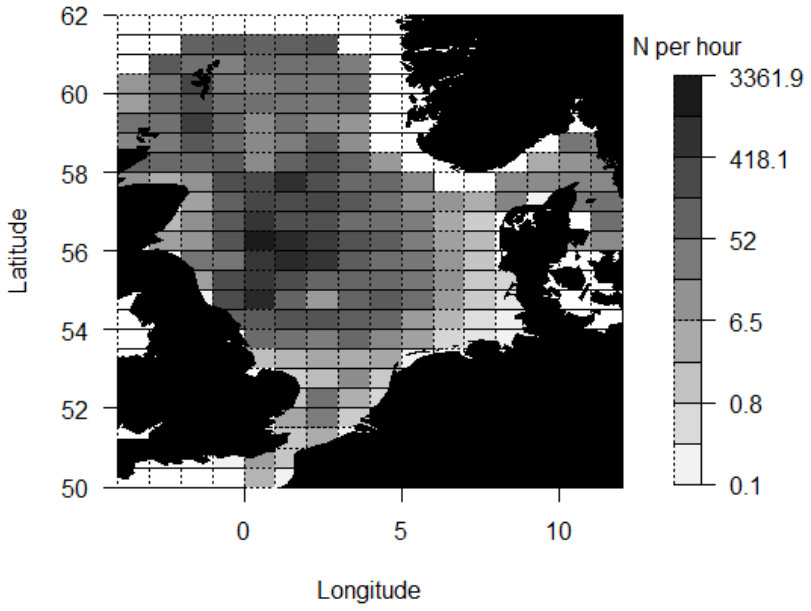


Figure 16.2. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q1 survey in area IV and IIIa.

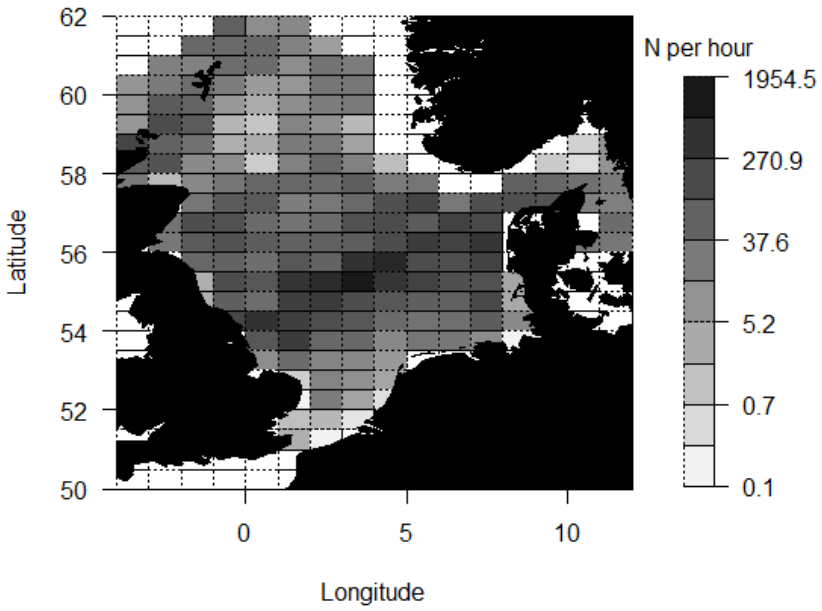


Figure 16.3. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q3 survey in area IV and IIIa.

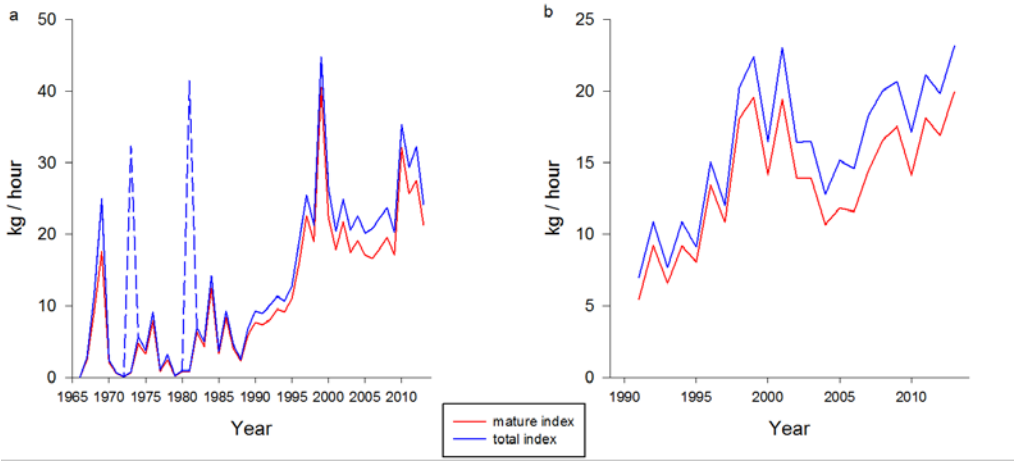


Figure 16.4. Grey gurnard. Total biomass index (blue line) and mature biomass index (red line) of grey gurnard from IBTS-Q1 (panel a) and IBTS-Q3 (panel b) survey time series. Exceptionally high abundances observed occasionally by shoal behaviour in quarter 1 (blue dashed line) were excluded from analyses as proposed in Heessen and Daan (1996).

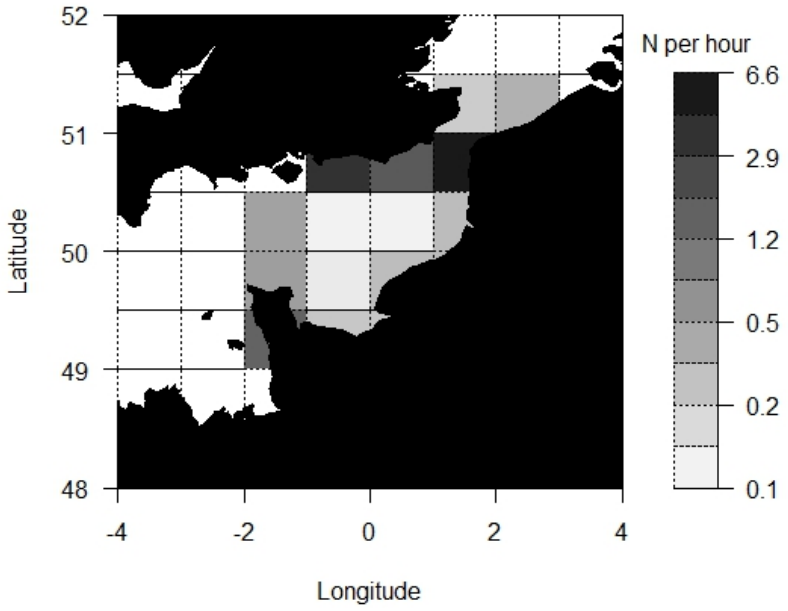


Figure 16.5. Grey gurnard. Spatial distribution of grey gurnard from CGFS-Q4 survey in area VIId.

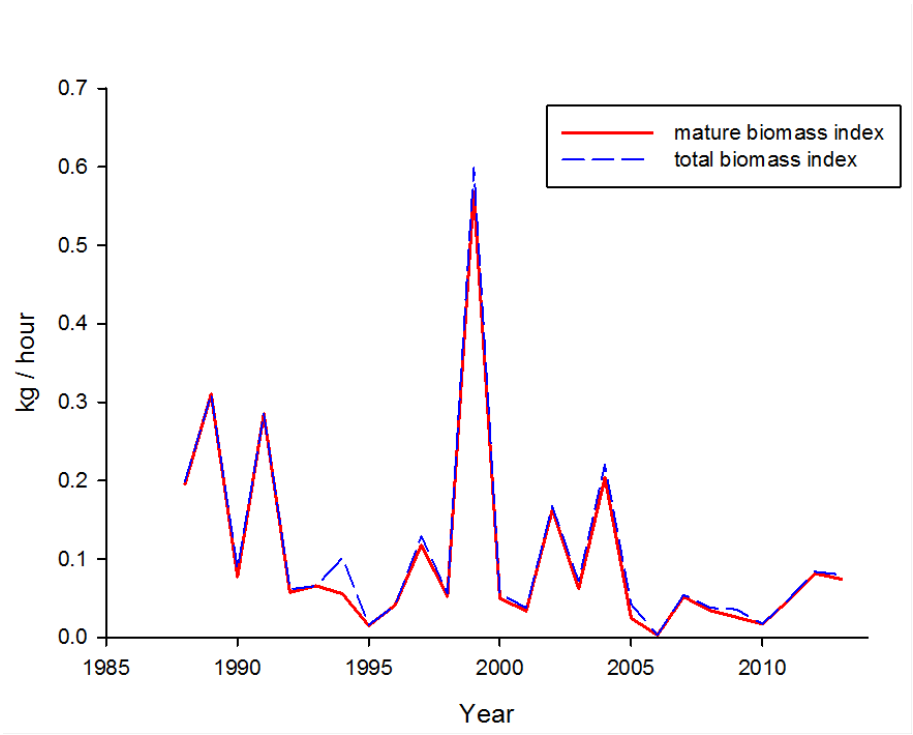


Figure 16.6. Grey gurnard. Abundance index of grey gurnard from CGFS-Q4 survey time series.

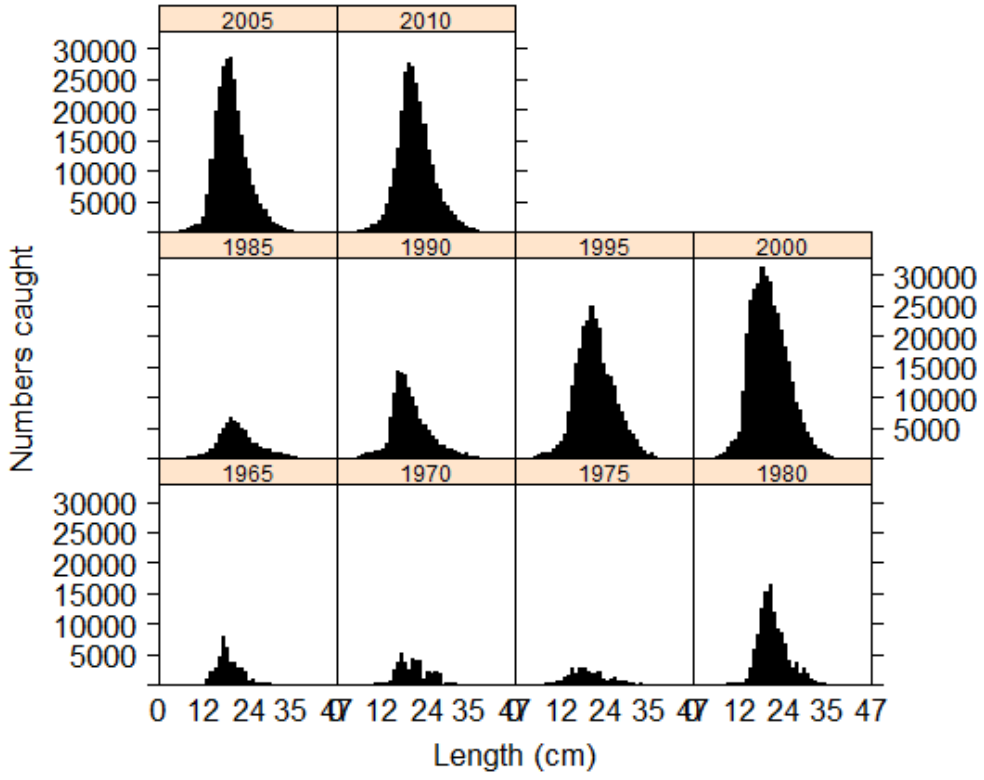


Figure 16.7. Grey gurnard. Length frequency distributions for five year intervals form the IBTS-Q1 data base.

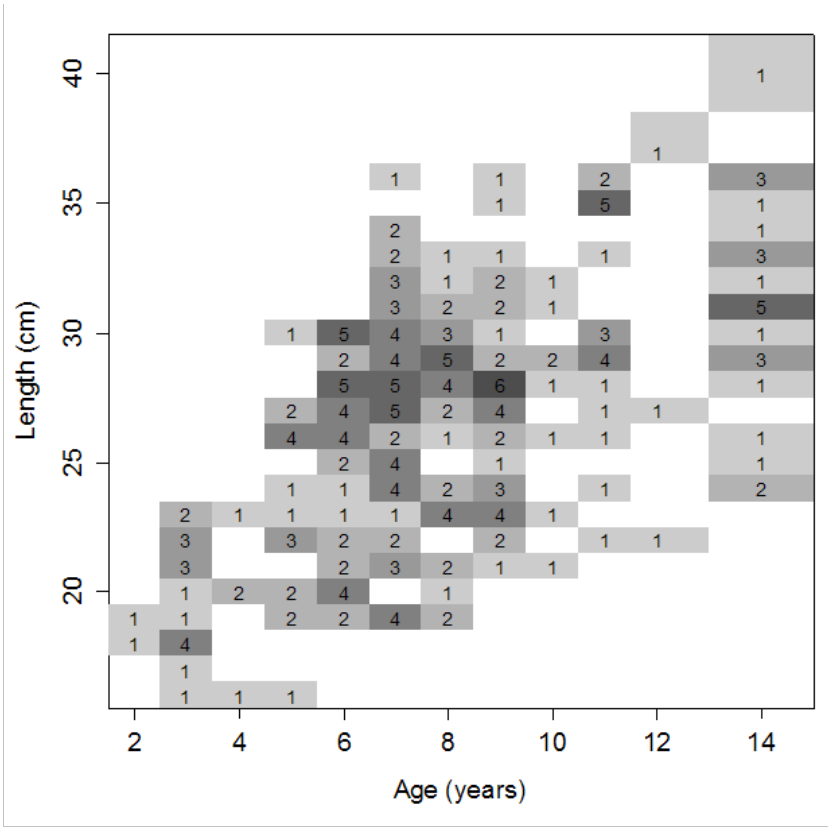


Figure 16.8. Grey gurnard. ALK from otoliths of Grey gurnard collected during 2010 IBTS-Q1 survey.

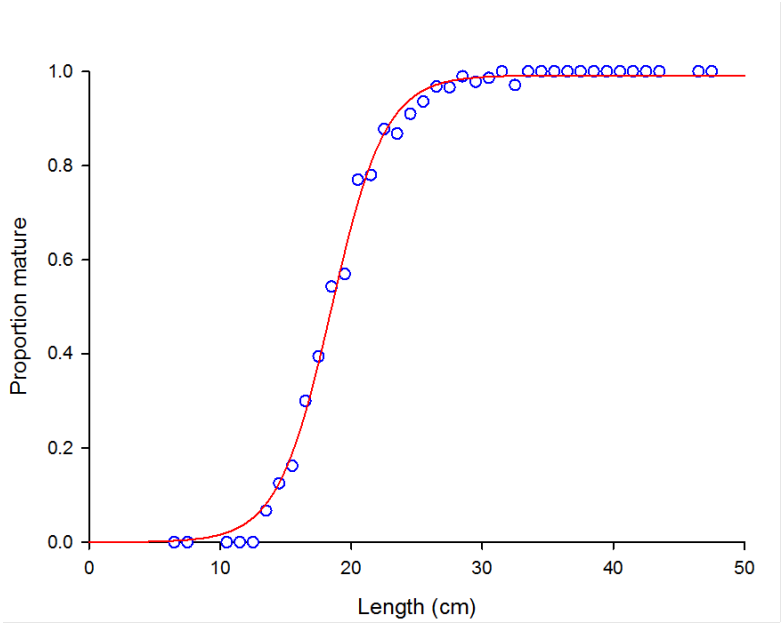


Figure 16.9. Maturity ogive of Grey gurnard sampled during IBTS surveys.

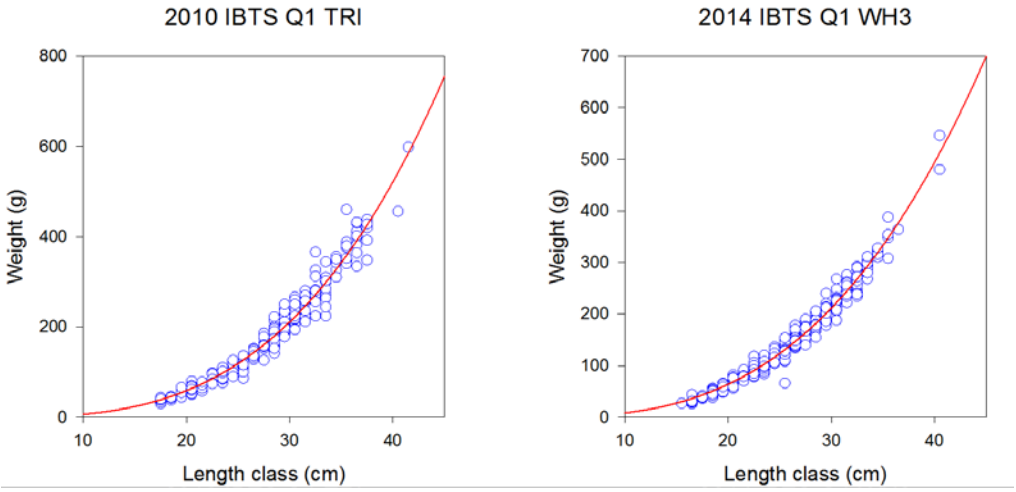


Figure 16.10. Length weight relationship of Grey gurnard sampled during IBTS surveys.

17 Striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern English Channel) and IIIa (Skagerrak–Kattegat)

17.1 General

17.1.1 Ecosystem aspects

Striped red mullet (*Mullus surmuletus*) is a benthic species. Young fish are distributed in coastal areas, while adults have a more offshore distribution. Recent stock identification studies by otolith and fish shape in European waters show that striped red mullet can be geographically divided into two units: Western Unit (Subareas VI and VIII, and Divisions VIIa–c, VIIe–k, and IXa) and Northern Unit (Subarea IV (North Sea) and Divisions VIId (Eastern English Channel) and IIIa (Skagerrak–Kattegat)) Benzinou et al, 2013.

In the English Channel, this species matures at approximately 16 cm.

Juveniles are found in waters of low salinity, while adults are found at high salinity. Striped red mullet prefers sandy sediments.

A study on otolith shape, used to differentiate stocks, was conducted in six geographic sectors: the North Sea, the eastern English Channel, the western English Channel, the Celtic Sea, the northern Bay of Biscay, and the southern Bay of Biscay. The results made it possible to separate the populations of striped red mullet in the Western English Channel and in the Eastern English Channel.

Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud.

17.1.2 Fisheries

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (>90% of landings). This fishery is conducted by bottom trawlers using a mesh size of 70–99 mm in the eastern English Channel and in the southern North Sea. The eastern English Channel and southern North Sea areas are fished by trawlers of various types. Striped red mullet is a bycatch in all of these fisheries. From 2000 a Dutch targeted fishery, using flyshooters, and a UK fisheries have also developed.

17.1.3 ICES advice

2013 advice: Advice for 2014 and 2015

Based on ICES approach to data-limited stocks, including precautionary buffer, ICES advises that catches should be no more than 460 tonnes. All catches are assumed to be landed.

17.1.4 Management

No specific management objectives are known to ICES. There is no TAC for this species.

There is no minimum landing size for this species.

In 2009, the cod plan covered by Council Regulation (EC) N°43/2009 allocated different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. The areas were Kattegat, part of IIIa not covered by

Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned were: Bottom trawls, Danish seines and similar gear, excluding beam trawls of mesh size: TR1 (≤ 100 mm) – TR2 (≤ 70 and < 100 mm) – TR3 (≤ 16 and < 32 mm); Beam trawl of mesh size: BT1 (≤ 120 mm) – BT2 (≤ 80 and < 120 mm); Gill nets excluding trammel nets: GN1; Trammel nets: GT1 and Longlines: LL1.

For 2010-14, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011, Council Regulation (EC) N°43/2012, Council Regulation (EC) N°39 and 40/2013 and Council Regulation (EC) N°43/2014 were updates of the Council Regulation (EC) N°43/2009 with new allocations, based on the same effort groups of vessels and areas as stipulated in Council Regulation (EC) N°43/2009. (see section 1.2.1 for complete list). However fishing effort regulations have not been restrictive so far for the fishery on that stock.

Demersal fisheries in the area are mixed fisheries, with many stocks exploited together in various combinations in the various fisheries. In these cases, management advice must consider both the state of individual stocks and their simultaneous exploitation in demersal fisheries. Stocks in the poorest condition, particularly those which suffer from reduced reproductive capacity, become the overriding concern for the management of mixed fisheries, where these stocks are exploited either as a targeted species or as a bycatch.

17.2 Data available

17.2.1 Catch

Landings data as reported to ICES together with the total landings estimated by the Working Group are shown by country in Table 17.2.1.1 and by area in Table 17.2.1.2 and Figure 17.2.1.1 and Figure 17.2.1.2. There is no indication of discard of stripped red mullet. All catches are assumed to be landed.

Historically, France has taken most of the landings with a targeted fishery for striped red mullet (>90% of landings). This fishery is conducted by bottom trawlers using a mesh size of 70–99 mm in the eastern English Channel and in the southern North Sea. The eastern English Channel and southern North Sea areas are fished by trawlers of various types. Striped red mullet is a bycatch in all of these fisheries. From 2000 a Dutch targeted fishery, using flyshooters, and a UK fisheries have also developed.

Since 2009 landings have been shared by two main fisheries, bottom trawlers and flyshooters. Discards are considered negligible.

Landings have gradually decreased since the last good observed recruitment in 2007.

Total landings were provided under the ICES InterCatch format for 2013. However only France provided age composition. Some work needs to be done to compute a time series of age composition.

17.2.2 Age compositions

Only partial age composition was available to the working group. Age composition of French landings was available for years 2004 to 2008 for areas VIId and IVc (Figure 17.3.2.1 and Figure 17.3.2.3) and for area VIId only from 2009 to 2013. Figure 17.3.2.3 and 17.3.2.4show that most of the catches made during this period were made on ages 1 and 2 in both areas. A consistent time series of catches age composition will be made available for next Benchmark planned in 2015. However, from now, only French length

and length sampling of the catches were made available, the catch at age composition will have to take into account the potential differences in the exploitation pattern of the different fleets operating in the area.

17.2.3 Survey data

The Channel Ground Fish Survey (CGFS) and the IBTS-Q3 surveys were estimated to be good indicators of the population trends as they cover the spatial distribution of this stock. However none of them have an exhaustive coverage of the spatial distribution and in-depth analysis of the observed length distribution of the catches in both surveys is planned for the next benchmark to test for potential difference in spatial distribution based on length/age.

Relative biomass and abundance indices as well as indicators on the mean length of the population are derived from CGFS and are presented in Figure 17.4.1.1 to 17.4.1.3. Age composition of the catches is available since 2004 during CGFS. Figure 17.4.1.4 presents the age composition observed during CGFS for those years.

17.3 CPUE (in number of individuals per hour) is derived from IBTS Q3 and presented in Figure 17.4.1.5.Data analyses

17.3.1 Exploratory survey-based analyses

Biomass estimates from Divison VIId (Fig. 17.4.1.1) show high variability and indicate a considerable decrease in the last four years. CPUE in the North Sea (Fig. 17.4.1.4) has also been low in recent years. The average of the stock size indicator (relative biomass) in the last two years (2012–2013) is 75% lower than the average of the three previous years (2009–2011).Figure 17.4.1.4 shows that age class in the catches during the CGFS survey are clearly dominated by young age classes.

17.3.2 Conclusions drawn from exploratory analyses

No analytic assessment can be presented. Therefore, no catch projections are available. The advice last year was biennial and meant for 2014 and 2015.

17.4 Sources:

Benzinoua, A., Carbinia, S., Nasreddinea, K., Elleboode, R., Mahé K., Discriminating stocks of striped red mullet (Mullus surmuletus) in the Northwest European seas using three automatic shape classification methods

Table 17.2.1.1 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Official and ICES landings by country (tonnes).

.Year	Belgium	Denmark	France	Netherlands	UK	total
1975	0	0	140	0	0	140
1976	0	0	156	3	1	160
1977	0	0	279	12	1	292
1978	0	0	207	25	3	235
1979	0	0	212	32	11	255
1980	0	0	86	25	4	115
1981	0	0	44	19	1	64
1982	0	0	32	18	2	54
1983	0	0	232	15	1	248
1984	0	0	204	0	3	207
1985	0	0	135	0	4	140
1986	0	0	84	0	3	88
1987	0	1	40	0	3	46
1988	0	1	35	0	4	41
1989	0	0	37	0	5	42
1990	0	0	524	0	13	537
1991	0	0	208	0	11	219
1992	0	0	458	0	17	475
1993	0	0	576	0	21	597
1994	0	0	362	0	18	380
1995	0	0	2537	0	69	2606
1996	0	2	2039	2	44	2087
1997	0	2	856	0	61	919
1998	0	2	2966	0	117	3085
19991)	0	4	NA	0	103	107
2000	0	4	3201	464	133	3802
2001	0	10	1789	915	183	2897
2002	0	24	1658	560	141	2383
2003	28	0	3256	626	177	4087
2004	31	0	4137	1148	129	5445
2005	29	0	1918	914	136	2997
2006	16	0	1145	466	97	1724
2007	16	0	3982	1147	183	5328
2008	19	0	3723	1270	353	5365
2009	17	0	827	889	293	2026
2010	80	0	947	802	337	2166
2011	97	0	628	771	244	1740
2012	52	0	155	525	87	747
20132)	33	0	1122)	1792)	382)	364

1) No data reported by France in 1999.

2) ICES estimates.

Table 17.2.1.2 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Official landings by area (tonnes). Note: Most of the Subarea IV catches are made in Division IVc.

Year	IV	IIIa	VIId	total
1975	0	0	140	140
1976	4	0	156	160
1977	19	0	273	292
1978	30	0	205	235
1979	49	0	206	255
1980	29	0	86	115
1981	20	0	44	64
1982	21	0	33	54
1983	41	0	207	248
1984	22	0	185	207
1985	10	0	130	140
1986	6	0	82	88
1987	7	0	38	46
1988	7	0	33	41
1989	5	0	37	42
1990	33	0	504	537
1991	26	0	193	219
1992	60	0	415	475
1993	126	0	471	597
1994	116	0	264	380
1995	1054	0	1552	2606
1996	528	0	1559	2087
1997	278	0	641	919
1998	778	0	2307	3085
19991)	70	0	37	107
2000	1764	0	2038	3802
2001	1600	0	1297	2897
2002	1234	0	1149	2383
2003	1618	0	2469	4087
2004	1820	0	3625	5445
2005	1404	0	1593	2997
2006	641	0	1083	1724
2007	1546	0	3782	5328
2008	1829	0	3536	5365
2009	910	0	1117	2026
2010	698	0	1469	2166
2011	605	0	1135	1740
2012	372	-	375	747
20132)	1352)	-	2282)	3642)

1) No data reported by France in 1999.

2) ICES estimates.

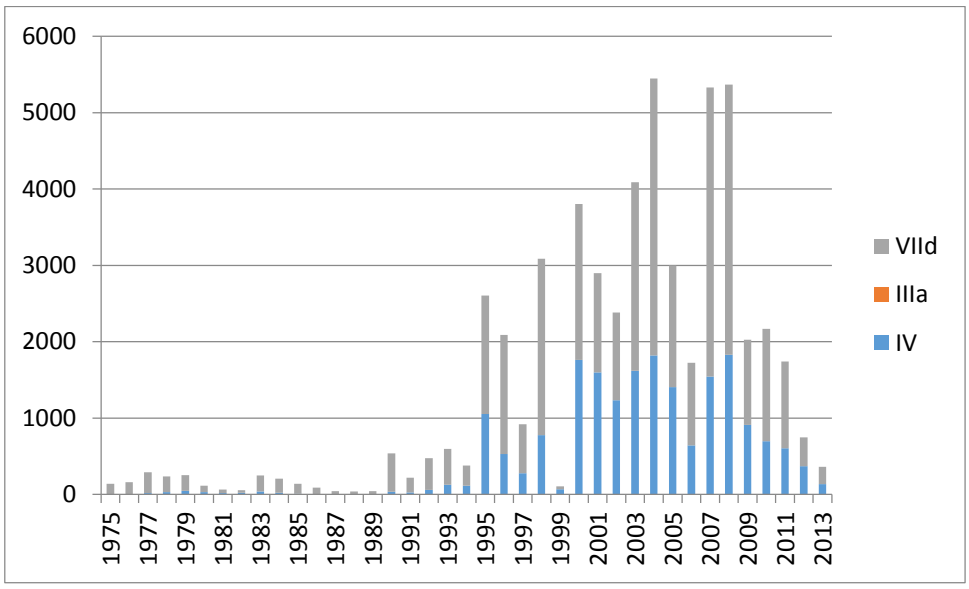


Figure 17.2.1.1 Striped red mullet landings in Subarea IIIa, VIId and IV. Official and ICES landings by country (tonnes).

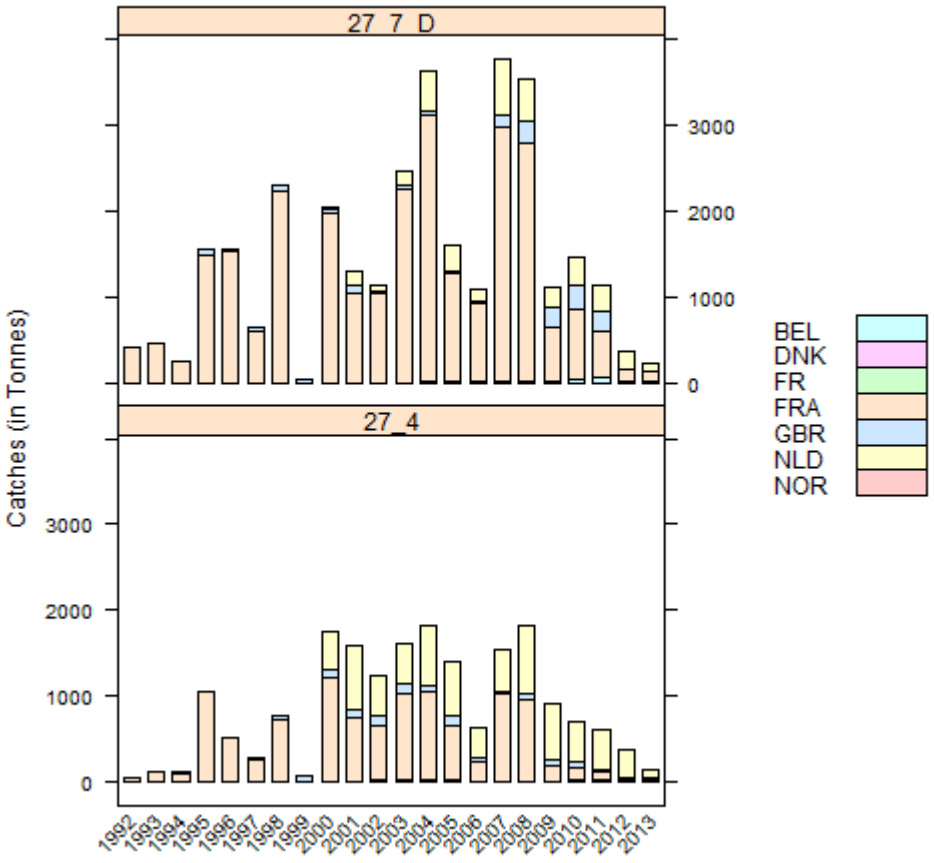


Figure 17.2.1.2 Striped red mullet landings in Subarea VIId (top panel) and IV (bottom panel). Official and ICES landings by country (tonnes).

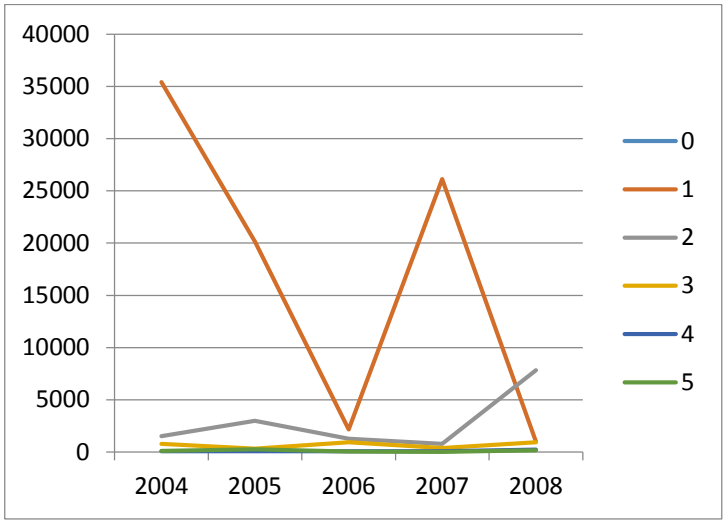


Figure 17.3.2.1 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Age composition (in thousands) of French landings in Divisions VIId and IVc (Eastern English Channel and Southern North Sea).

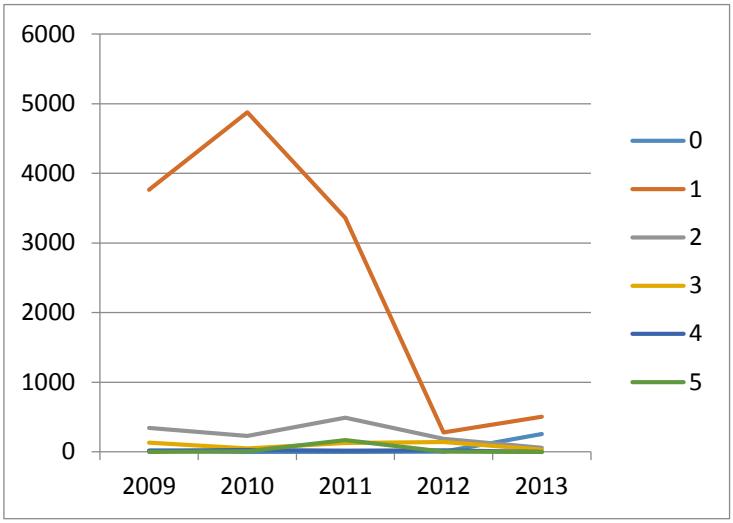


Figure 17.3.2.2 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Age composition (in thousands) of French landings in Divisions VIId (Eastern English Channel).

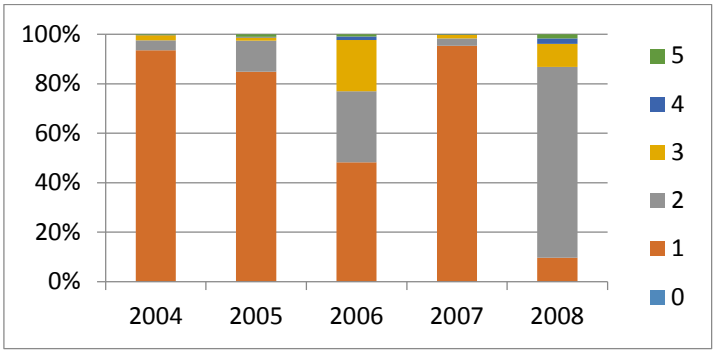


Figure 17.3.2.3 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Age composition (in percentage) of French landings in Divisions VIId (Eastern English Channel).

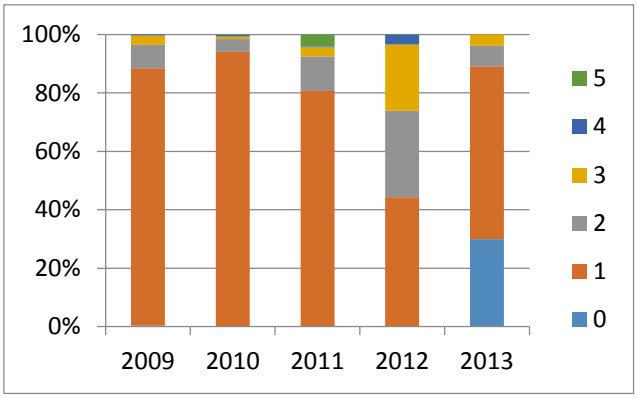


Figure 17.3.2.4 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Age composition (in percentage) of French landings in Divisions VIId and IVc (Eastern English Channel, Southern North Sea).

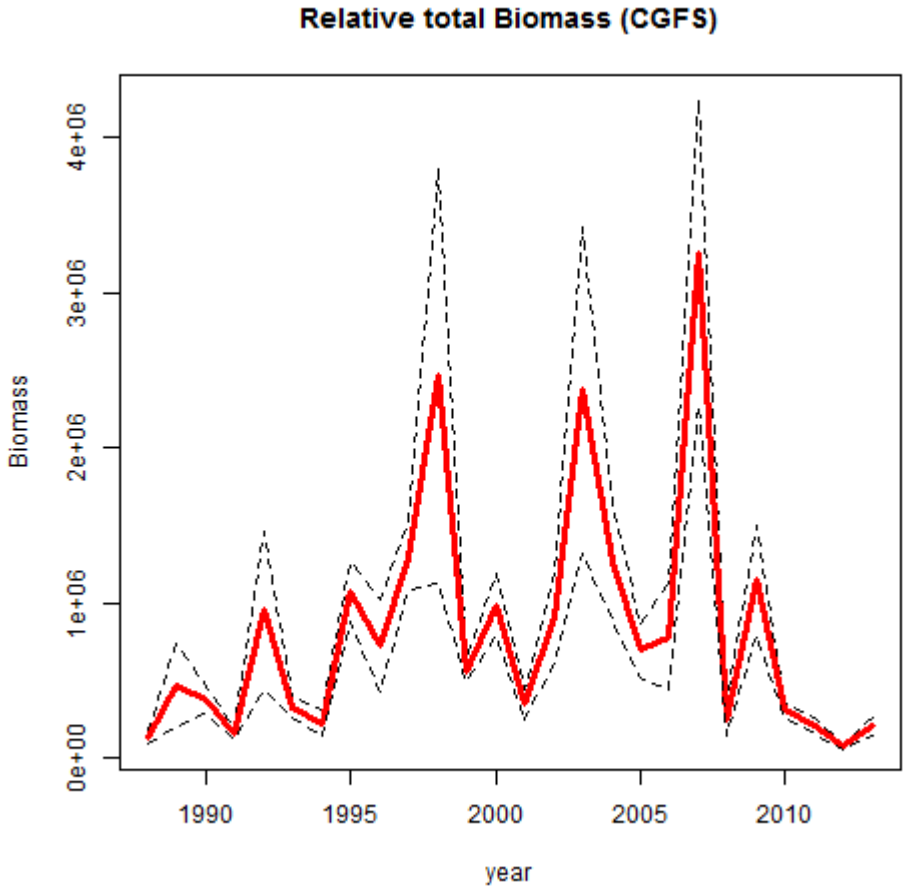


Figure 17.4.1.1 Relative biomass from CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

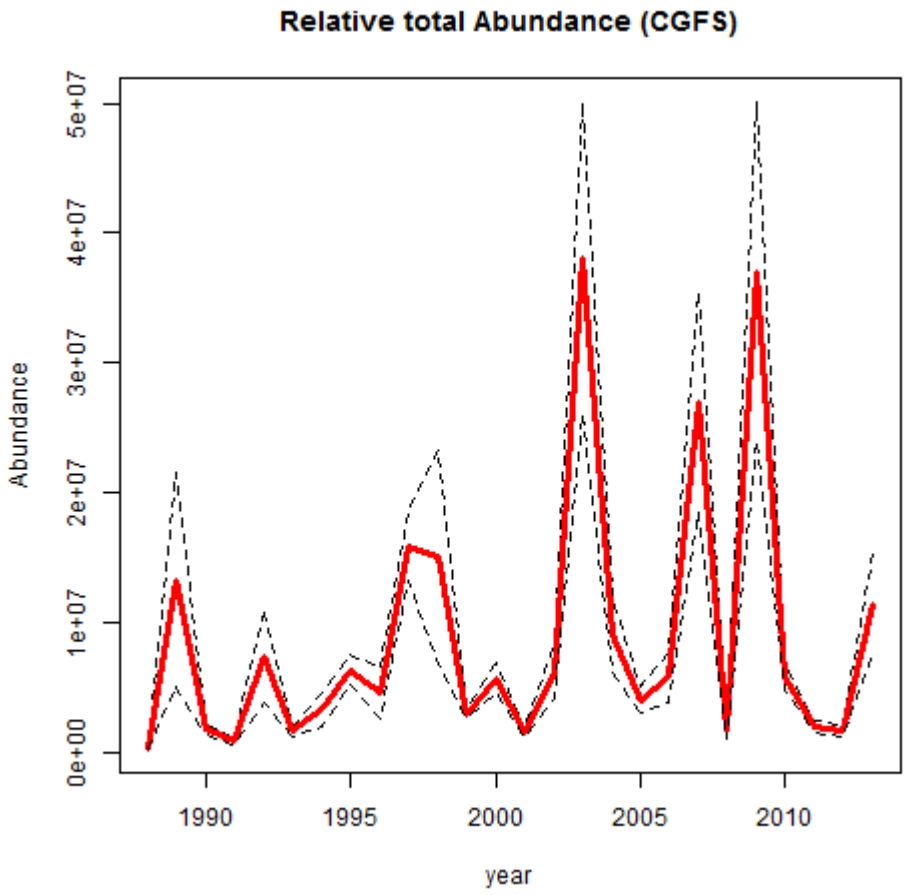


Figure 17.4.1.2 Relative abundance from CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

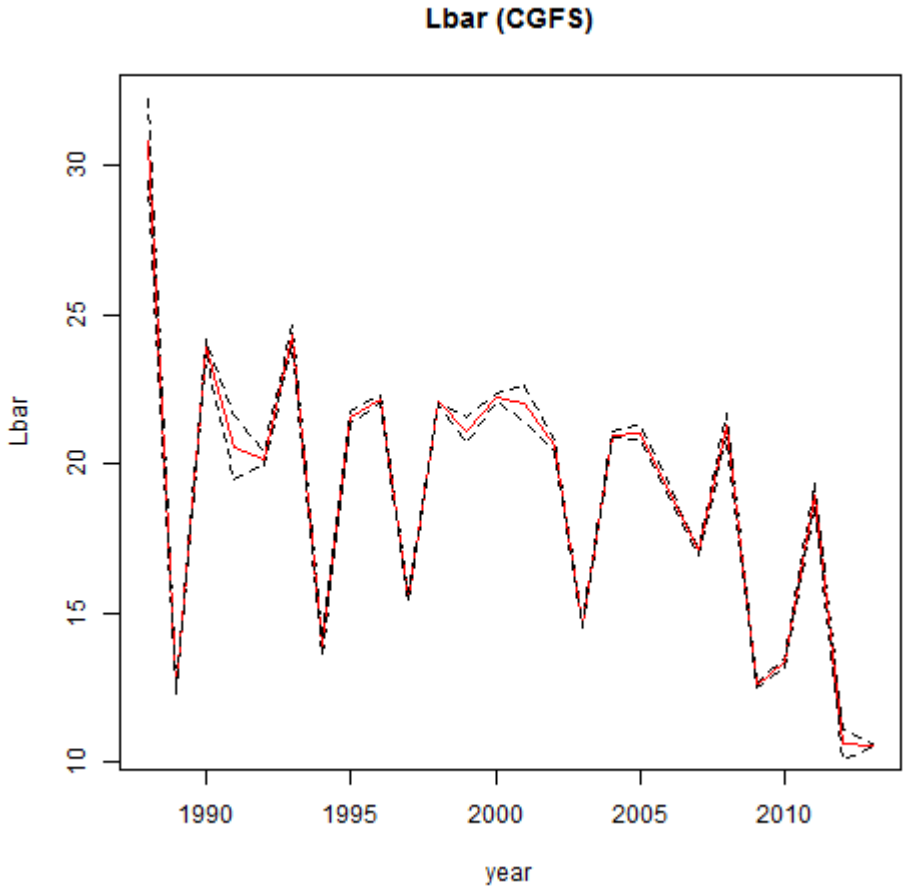


Figure 17.4.1.3 Mean length of the population from CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

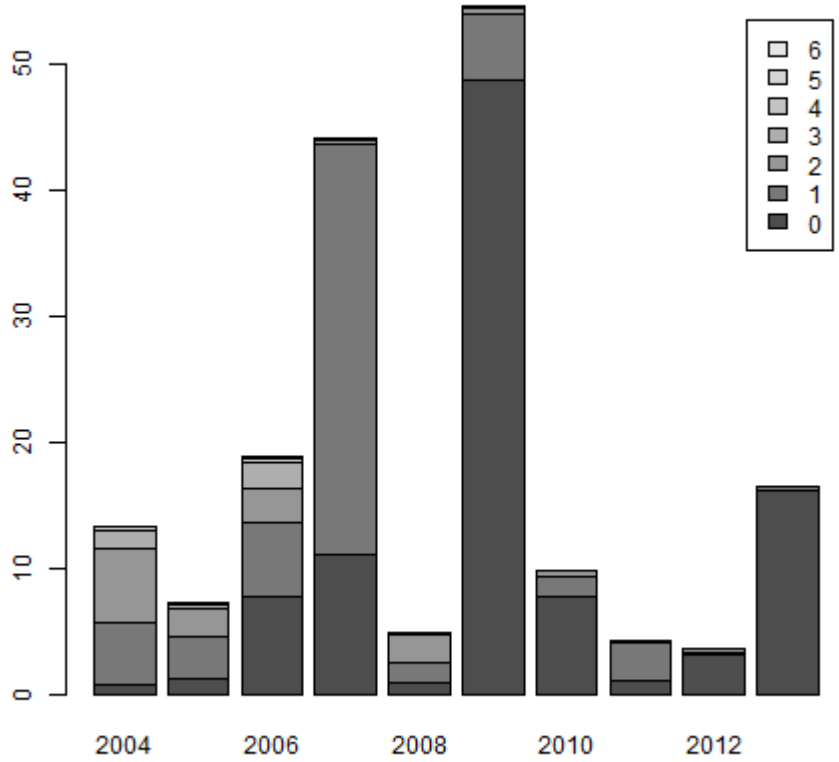


Figure 17.4.1.4 Number of individuals per age group per hour trawled during CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

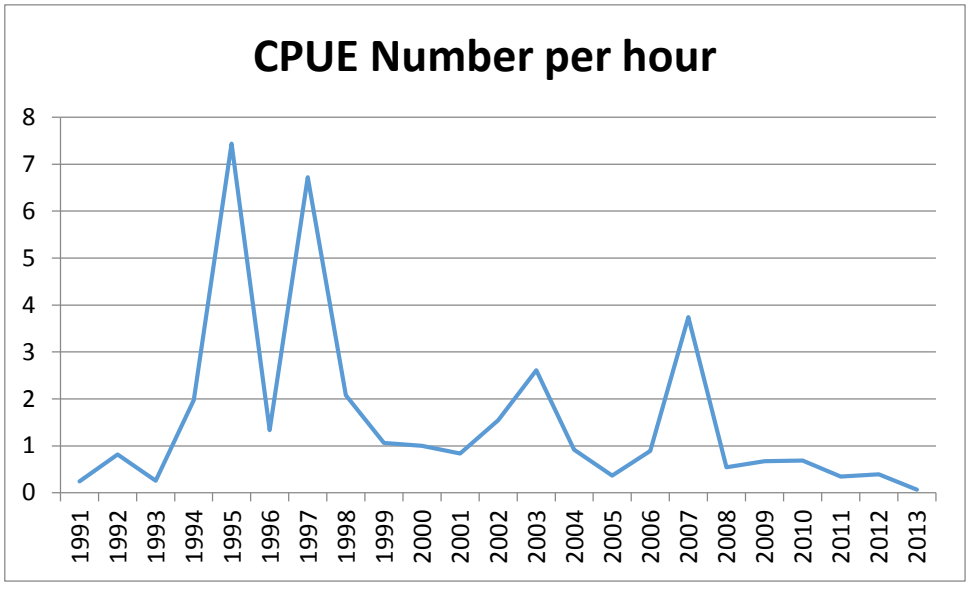


Figure 17.4.1.5 Abundance in Subarea IV (Q3) from IBTS-Q3

18 Turbot in Subarea IV

This report presents the stock assessment carried out for turbot in Subarea IV in 2014. An update assessment (SPALY – 'same procedure as last year') was conducted. Limited time at the WGNSSK meeting meant that time available for additional presentations of exploratory analyses was limited. More details on the data used, assumptions made and the assessment model can be found in the stock annex.

18.1 General

Turbot (*Scophthalmus maxima*) was assessed at WGNSSK for the first time in 2013. At IBPNEW 2012 (ICES, 2012a) an assessment model was developed for turbot in Subarea IV. While the assessment model developed for turbot represents a big step forward, there is still much work to be done to fine tune the model settings to improve the reliability and consistency of outputs. Further work on the turbot assessment is on-going.

At WGNSSK 2013 it was decided to categorise turbot as a 'Category 2' stock under the ICES data-limited stocks (DLS) framework (ICES, 2013a). Category 2 stocks have quantitative assessments that are treated as indicative of trends rather than absolute values. The framework provides a methodology for short term forecast and advice generation from such assessments and this was used in producing the advice for turbot in Subarea IV for 2014.

18.1.1 Biology and ecosystem aspects

Turbot is broadly distributed from Iceland in the North, along the European coastline, to the Mediterranean and Adriatic Sea in the south. In general, turbot is a rather sedentary species, but there are some indications of migratory patterns. For example in the North Sea, migrations from the nursery grounds in the south-eastern part to more northerly areas have been recorded. IBPNEW (ICES, 2012a) concluded that Turbot in the North Sea (Subarea IV) can be considered as a distinct stock for management purposes.

Turbot is typically found at a depth range of 10 to 70 m, on sandy, rocky or mixed bottoms and is one of the few marine fish species that inhabits brackish waters. It is a typical visual feeder and could be regarded as a top predator. Turbot feeds mainly on bottom living fishes (e.g. common gadoids, sandeels, gobies, sole, dab, dragonets, sea breams etc.) and small pelagic fish (e.g. herring, sprat, boarfish, sardine) but also, to a lesser extent, on larger crustaceans and bivalves. Despite its role as a top predator in the North Sea ecosystem, at present turbot is not included as a species in the WGSAM multispecies assessment (ICES, 2012b).

18.1.2 Fisheries

In the 1950s the UK was the biggest contributor to the landings (~50% of the landings). In recent years most of the landings stem from the Netherlands (~50-60%). In most countries turbot is caught in mixed fisheries trawls, with most of the landings in the Netherlands coming from the 80 mm beam trawl fleet (BT2) fishing for sole and plaice. In Denmark, the second largest contributor to the landings in recent times, there is a directed fishery for turbot using gillnets.

See the stock annex (section A.2) for more details.

18.1.3 ICES advice for 2014

The information in this section is taken from the ICES advice sheet 2013, section 6.4.32. This stock is managed under a biennial TAC (together with brill), but ICES has provided advice individually for each of these stocks.

Advice for 2014:

Based on ICES approach to data limited stocks, ICES advises that catches of turbot in Subarea IV should be no more than 2978 t. All catches are assumed to be landed.

Mixed fishery advice:

Turbot is not currently included in the WGMIXFISH Fcube model (ICES, 2012c), and hence no mixed fishery advice is given for this stock. As an important bycatch species in the North Sea demersal fisheries, it is recommended that this stock be include in future models.

18.1.4 Management

A combined EU TAC for turbot and brill is set for EU waters in areas IIa and IV. This TAC only applies to the EU fisheries.

No specific management objectives or plans are known to ICES, and no precautionary reference points have been proposed for the stock.

As a bycatch species, regulations relating to effort restrictions for the primary metiers catching turbot (e.g. beam trawlers) are likely to impact on the stock. Fishing effort has been restricted for demersal fleets in a number of EC regulations (e.g. EC Council Regulation Nos. 2056/2001, 51/2006, 41/2007, and 40/2008).

See the stock annex (section A.2) for more details.

18.2 Data used

To estimate the trends in abundance and exploitation over time, the assessment of the turbot stock requires three main types of data:

1) Catch data: estimates of removals of turbot by the fishery.

2) Survey data and commercial LPUE (landings per unit effort): indices of trends in population abundance over time from fisheries independent and fisheries dependent sources, respectively.

3) Biological data: estimates and/or assumptions on growth, maturation and natural mortality.

Since the assessment is age-based, data for the above is required for each age. The model is developed such that past gaps in the data time series can be handled. This is necessary given the episodic nature of the historic data for this stock.

See the stock annex (section B) for more details on the data used in the assessment, sources and historical values.

18.2.1 Catch data

The assessment model currently only uses catch numbers at age and does not utilise total landings (tonnage per year). Incorporating total landings from the Eurostat database, or from a directed data call, will be examined further in advance of WGNSSK 2015.

For WGNSSK 2014, InterCatch was used for the first time for the North Sea turbot stock. It was the only tool used to raise the catch at age. Given that there is only one metier with age structure information, the results of using Intercatch would be identical to the procedure used last year.

Age structure of the landings for 2004-2012 has been estimated from Dutch samples accounting for auctions, quarters and market categories. In 2012, 11 samples were taken and a total of 596 fish were aged. In 2013, 8 samples were taken and a total of 426 fish were aged. Figure 18.2.1 shows the metiers with numbers at age samples for the landings. The only usable samples remain those from the Dutch TBB_DEF_70-99 metier (beamtrawl fleet), and again this fleet was used to raise all the unsampled métiers in 2013. Very few fish were sampled in some of the Danish métiers (<10 per métier, fewer than the number of ages in the assessment model), not enough to be used in the raising of international landings. The majority of the TBB_DEF_70-99 samples were taken in the first and fourth quarter, with no samples in the second quarter. Raising was done by quarter. To raise the international landings for Q2, samples from both Q1 and Q3 were used. There are a wide variety of métiers that land turbot, including a significant amount from the Danish >220mm gillnet fleet. **More samples of landings at age are required from other métiers to more accurately raise the total landings at age**.

Figure 18.2.2 shows the trend in total landings over time and Figure 18.2.3 shows the breakdown of landings by country for 2013 (from the EuroStat database). Landing of turbot decreased during the 1990s and for the last ten years have been stable in the region of 3000t. Over this time effort by the Dutch beam trawl fleet, which contributes the most of the landings, has decreased notably. Since turbot is primarily a bycatch species, this indicates that abundance of turbot has likely increased over this period.

Landings at age are presented in Table 18.2.1 and Figure 18.2.4 and the proportion of landings by biomass for each age is shown in Figure 18.2.5. The 2005 yearclass shows up clearly in the landings data, but since then there have been no notably large year classes observed. Following a decrease in minimum market size for turbot in the Netherlands in 2002, there has been a notable increase in the amount of age 1 and 2 turbot landed, accounting for half of the catch in some years and about a third of the catch in 2013. Since turbot are only fully mature at age 4, indicates a high proportion of immature fish in the landings. However, the last 5 years have also seen an increase in the propotion of age 5+ fish in the landings compared to the five years prior to that, though still lower than observed in the 1970s and 1980s. This could reflect a reduction in F recently leading to an increasing proportion of older fish in the landings.

Log landings curves and associated Z estimates are presented in Figure 18.2.6. The slopes of the curves were calculated from age 3 to age 9, since it appears that age 1 and 2 fish are not yet fully selected by the fishery. Only the cohorts which have estimates of landings at age for ages 3 to 9 are shown. The cohorts from the late 1990s and early 2000s indicate higher Z than those from the 1980s. The most recent period, following the reduction in effort by the Dutch beam trawl fleet, is not fully represented in these cohorts.

The assessment model assumes that discarding of catches for this stock is negligible. However, there was a sudden increase in the landing of age two turbot following the decrease in minimum market size in the Netherlands in 2002. Given that there was no known change in the fishing behaviour of the main fleets at this time, this indicates that previously more age 2 fish must have been caught than were actually landed. These were either discarded or, as a much sought after fish, kept by the fishermen for personal use. This would mean that the discards could be underestimated in the period up to 2002 relative to the period following this, potentially causing a bias in the assessment outputs. However, the impact on the final year estimates is likely to be small because with the reduction in minimum market size in 2002, the assumption of negligible discards probably holds for the last 10 years.

18.2.2 Survey data and commercial LPUE

Two survey abundance indices, the Beam Trawl Survey (BTS ISIS) and the Sole Net Survey (SNS), and one commercial LPUE abundance index, the Dutch 80 mm beam trawl fleet (BT2), are used to tune the assessment (Table 18.2.2 and Figure 18.2.7).

All abundance indices indicate an increase in the number of fish aged 4 and older in the late 2000s compared to the past. An increase in the amount of older fish would indicate either strong recruitment or a decrease in mortality (e.g. fishing pressure) exerted on the stock. The NL_BT2 LPUE index indicates an increase in the abundance of ages 1 and 2 in recent years, though this is not seen as clearly in the other two indices. All indices indicate an increase in age 3 fish in 2013.

There is fairly close agreement between the three indices on the general trends in abundance at age, but the data are noisy from year to year. This can be seen in the low R^2 values in the internal consistency correlations in the BTS_ISIS and SNS surveys (Figure 18.2.8). The SNS survey is particularly poor at picking up cohort signals, with low R^2 values on the correlations between numbers at consecutive ages. Though all correlations between successive ages are positive, estimated numbers at age, particularly for the younger ages, fluctuate a lot from year to year. The BTS-ISIS is more internally consistent for ages 3 and up. The almost non-existent relationship between the numbers estimated at age 1 and the numbers estimated at age 2 in the following year suggest that in future removing age 1, and potentially age 2, from this index may be appropriate. The internal consistency of the NL_BT2 LPUE index is significantly better, though the removal of age 1 from this index could also be considered.

Noisy indices that are more indicative of general trends are best used in an assessment model that is able to smooth over the noise in the data. The spline based model used for this stock does do this, but nevertheless inputting noisy data into the assessment will increase uncertainty in the outputs.

18.2.3 Biological data

All biological data used in the assessment are presented in Table 18.2.3.

Weight at age

Constant annual catch and stock weights at age (long term means of all available data) are used in the assessment because of large gaps in the time series of weight at age data for turbot in the North Sea (Figure 18.2.9). The data that are available suggest that there have been potentially significant changes in weight at age over time. Assuming constant weight at age in this case could result in inaccurate estimates of total stock biomass or total catch during periods when weights at age may have differed significantly

from the long term mean. IBPNEW (ICES, 2012a) recommended that more work be conducted to obtain better estimates of weights at age over time.

Maturity

At IBPNEW (ICES, 2012a) turbot maturity data from the Netherlands was used to study some reproductive characteristics of turbot from the North Sea. A female maturity ogive constructed from derived from a General Linear Model fit using the maturity data from the recent time period was chosen for the stock.

Natural mortality

There are currently no accepted estimates of turbot natural mortality over time. A number of alternative methods, using different estimates of growth parameters, were used to estimate the level of natural mortality by age for turbot in the North Sea at IBPNEW (ICES, 2012a). Since turbot grows relatively fast compared to other flatfish species in the same areas, results indicate that natural mortality is higher. However, due to high variability for recorded values of K (an estimated growth parameter) for turbot, it proved difficult to find agreement on natural mortality values. Hence, after performing assessment test runs, a constant value of M=0.2 for all ages and years was chosen for this stock. This is twice the level used in the sole and plaice assessments in the North Sea.

18.3 Stock assessment model

Turbot in Subarea IV is assessed using a custom designed age-structured assessment model. The model uses basis splines (or "B-splines") to describe smooth trends, which allow the evaluation of trends in mortality despite gaps in the catch-at-age matrix. The model is fit using AD Model Builder (ADMB; Fournier et al. 2012). The full code for the assessment model (.tpl file) is included in the stock annex (Section C). See also the IBPNEW 2012 report (ICES, 2012a) for further details on the model.

Estimates of parameters were made using a negative log-likelihood objective function consisting of four components: the landings-at-age and the three tuning indices. The current assessment does not weight these four components.

18.3.1 Model settings

The assessment model was conducted using the settings given below. This is the second year that this assessment has been conducted at WGNSSK. Since this is an update year, this year's assessment is a SPALY (same procedure as last year) assessment. **There has been ongoing work to improve on the model, and such changes could be implemented in advance of WGNSSK 2015 or 2016 in an inter-benchmark procedure.**

Assessment settings used in the final assessment

Year:	2014
First tuning year	1975
Last data year	2013
Ages	1-9
Plus group	No
Total Landings	Not used
Landings at age	1975-1978, 1981-1990, 1998, 2000-2013
Discards	Not used (assumed 0)

Abundance indices	BTS-Isis 1985–2013 SNS 1975–2002, 2004-2013 NL-BT2 LPUE 2002–2013
Selectivity at age splines	4 knots, 1975-2001 and 2002-2013
Annual F spline	5 knots, 1975-2013
Catchability independent of age for ages >=	7

18.3.2 Model diagnostics

Diagnostic tests are carried out on the assessment model fit and outputs to identify any irregularities or potential biases that should be taken into account when interpreting the assessment results.

During IBPNEW (ICES 2012a) Monte Carlo-Markov Chain (MCMC) analyses were conducted to examine how the assessment model was fitting to the data (results not shown here). Correlations between estimated parameters, distributions of key outputs and autocorrelation between MCMC estimates were examined. No significant issues were identified to nullify the model results. Uncertainty around resulting metrics (e.g. SSB) was found to be similar to that estimated in the assessment. No MCMC analyses were conducted in 2014.

The estimated selectivity at age curves for the fishery and the three tuning indices are presented in Figure 18.3.1. Fishery selectivity curves are estimated for two periods for the landings: 1975-2001 and 2002-present. These curves differ only in the selectivity of age 1 and 2 fish, with the pre-2001 selectivities for these ages being lower (before the change in minimum market size in the Netherlands). Because of low numbers in the catch for older ages, selectivity at these ages is less well estimated. The decrease in selectivity for age 6 fish in the catch is likely a model artifact due to how it fits to the data, not due to ecological or fishery reasons. Selectivity splines are only fit to ages 1-7 (constant above this). This means that while the estimate of selectivity for age 6 is influenced only by the spline, the estimate for age 7 is also influenced by the assumption of constant catchability for the older ages (since ages 8 and 9 are included in the objective function as well). This dip in selectivity at age 6 is also seen in the NL BT2 LPUE selectivity given that same age information is used in both. The NL BT2 LPUE index selects more older fish, while the BTS-ISIS and SNS indices select more young fish.

The model residuals for landings and the three tuning indices, which result partly from the estimated selectivities, are presented in Figure 18.3.2 and Figure 18.3.3. For the fishery the largest residuals are observed for age 1 and ages greater than 6. Ages 2-4, which contribute to the vast majority of the landings, are estimated by the model to be similar to the observed values. This is similar for the tuning indices as well, where the largest residuals are seen for age 1 and the older ages (>4). The assessment model predicts fewer age 4+ fish in recent years than indicated by the BTS-ISIS and NL BT2 LPUE indices, but more than indicated by the SNS. There are some partial year effects in the SNS residuals, as would be expected from the poor internal consistency correlations for this index (see Section 18.2). The NL BT2 LPUE index has the smallest residuals, though since this index contain information from the landings (age structure and totals from the most important fleet) this is not surprising. The dip in selectivity for age 6 for this index estimated by the model seems inappropriate since for all years the model estimates for age 6 are lower than the index suggests. This suggests that the

functional form of the selectivity curve should be examined further. Though some of the residuals are quite large, there are no clear patterns in the residuals to indicate that the model should be rejected.

In 2013 the official landings (not inputted directly into the assessment model) were compared to the sum of products (SOP) from landings at age inputted into the model and the model estimated values of total landings. The model estimated values are for most years were within 20% of the official landings values. However, the gap in landings data used in the model from 1991-2000 (except 1998) does seem to have a delayed impact on the models estimation of total landings. These differences are still found in this year's assessment. The size of the gap in the time series may also be too long for the splines to accurately estimate exploitation level over this whole period. Another possible reason for this is the assumption of constant weight at age for the landings. If this assumption does not hold for the 1990s, the model estimated total landings may be inaccurate. Similarly, for the last 10 years the model estimates higher total landings than those reported, potentially because weights at age in the recent period are overestimated.

18.4 Assessment model results

Abundance at age and fishing mortality at age estimated by the assessment model are presented in Tables 18.4.1 and 18.4.2, respectively. Key stock and fishery metrics are given in Table 18.4.3 and plotted in Figure 18.4.1.

18.4.1 Status of the stock

Fishing mortality was estimated at 0.46 in 2013, lower than the long term geometric mean (0.54). The SSB in 2013 was estimated to be 4 743t, increasing to 5 239t in 2014. Both years are lower than the long term geometric mean (5 487t). The estimated recruitment (age 1) for 2013 is slightly lower than the geometric mean of the time series. However, this estimate is based on very little data and is unlikely to be a reliable estimate.

18.4.2 Historic stock trends

SSB peaked in the early 1980s, at a time when F was estimated to be at the lowest level of the time series. From the mid-1980s up until the early 2000s SSB declined gradually and F increased gradually. Since then F is estimated to have declined sharply, allowing SSB to gradually increase. This corresponds to a period of reduction in effort by the NL BT2 fleet. The anomalous increase in F in the early 2000s is the result of an increase in the amount of age 2 turbot landed following the change in MLS in the Netherlands. Since the mean F range covers ages 2-6, this increase in F on age 2 fish lead to a sharp increase in mean F over this period. If mean F was calculated over the age range 3-6, this sudden increase would not be observed. There are no clear patterns in recruitment, though values are estimated at a slightly higher level, but with more uncertainty, during the years of missing landings at age data (1990s).

18.4.3 Retrospective assessments

The results of six retrospective assessments, run using the same model settings but removing one year of data from the end of the time series, are plotted in Figure 18.4.2. In recent years there has been a tendency to underestimate F, though the effect on SSB is minimal. While for SSB most of the retrospective assessments are completely contained within the confidence bounds of the current assessment, this is not the case for

F. Since annual exploitation is estimated by using a spline with only 5 knots, removing data from the end of the time series can change the shape of the curve over all years. This explains the underestimation of F around 1990 in the retrospective assessments. This may indicate that more knots are required in the annual F spline so that its shape is not too sensitive to incoming data. The retrospective pattern for F in recent years could also be the result of changes in the estimates of age 2 selectivity since this is only estimated from a short time series of data since 2002 so removing one year of data has a bigger impact on the shape of the spline. There is no clear retrospective pattern for recruitment.

18.5 Biological reference points

Precautionary reference points are undefined for this Category 2 stock.

Since there is no clear stock-recruit relationship for this stock (see WGNSSK 2013 report, ICES 2013b), F_{max}, estimated for the yield per recruit curve was proposed as a proxy for F_{MSY} in 2013. Subsequently it was decided by ACOM that for Category 2 stocks in the ICES DLS $F_{0.1}$ is a more precautionary proxy for F_{MSY}. At WGNSSK 2014, $F_{0.1}$ was estimated in yield per recruit analyses using the latest assessment results (Figure 18.5.1). The value for F_{max} was found to be the same as that estimated in 2013 (0.34) and $F_{0.1}$ (not previously estimated) was found to be 0.22.

The above values were determined such that the assumptions made (recent selectivity and no plusgroup) are in agreement with the assumptions made in the assessment (following the DLS recommendations). Yield per recruit curves using the past selectivity pattern (before the change in minimum landings size in the Netherlands) show limited change in the values of $F_{0.1}$ and F_{max}, but indicate that for most values of F the yield per recruit could be increased in fewer age 2 fish were caught. This suggests that maximum sustainable yield could be increased by reducing the exploitation of younger turbot. However, since turbot is mainly landed as bycatch from a fishery targeting much smaller sole and plaice, bringing about changes in selectivity on turbot would be problematic for this fishery.

The values for $F_{0.1}$ and F_{max} are noticeably lower when age 9 is treated as a plusgroup. However, for F>0.5 there is little difference in the yield per recruit since at such high Fs few fish survive into the plusgroup. The current assessment model assumes no plusgroup, but also indicates that F has been high over the time period examined. As F appears to be decreasing to lower levels at present, it is proposed to include a plusgroup in the assessment in future. Reference points would then need to be revisited.

Biological reference point for turbot in Subarea IV

	Type	Value	Technical basis
MSY Approach	MSY Btrigger	Undefined	
	FMSY	0.22	F0.1 as proxy for FMSY
Precautionary Approach	Undefined		

18.6 Short-term forecast

The short term forecast was carried following the procedure for Category 2 stocks in the ICES approach for data-limited stocks (DLS; ICES 2013a). The forecast was conducted in ADMB.

Weights-at-age, maturity, natural mortality and selectivity are all constant since 2002 and these values are used in the forecast. The numbers at age 2 and older at the start of the projection period (2014) are taken for the assessment model outputs. Recruitment in 2014 and 2015 is assumed to be the long term geometric mean (4.464 million). It is estimated that between 35 and 45% of the predicted catch for the TAC year (2015) would come from fish aged 1-3 i.e. from the assumed recruitment. This adds some uncertainty to the forecast results and TAC advice

Following the DLS Category 2 protocol, F for the intermediate year is set such as landings equal the TAC for that year. Since turbot is landed under a combined TAC (together with brill), this assumption cannot be made for turbot. Hence three different assumptions were examined (scenarios A-C). Table 18.6.1 shows five management options for each scenario: $F_{MSY}=F_{0.1}$, $F_{MSY}=F_{max}$, and constant landings or a 20% decrease or increase in landings (relative to landings in 2013).

Scenario A assumes that F in the intermediate year is the same as F in the final year of the assessment (2013). This implies an F of 0.46 in 2014, corresponding to landings of 3414t, leading to an SSB of 5341t at the start of the TAC year (2015). This represents an increase in landings of 13% between 2013 and 2014. This scenario was chosen by the WGNSSK 2014 as the most appropriate for use in provision of advice.

Scenario B assumes that F in the intermediate year is lower than F in the final year of the assessment (2013), following the trend in recent F (Figure 18.4.1). This implies an F of 0.43 in 2014, corresponding to landings of 3227t, leading to an SSB of 5521t at the start of the TAC year (2015). This represents an increase in landings of 7% between 2013 and 2014.

Scenario C assumes that landings in the intermediate year are the same as landings in the final year of the assessment (2013). This implies an F of 0.39 in 2014, corresponding to landings of 3008t, leading to an SSB of 5733t at the start of the TAC year (2015).

Figure 18.6.1 shows the TACs and resulting SSBs for different values of F in 2015 for Scenario A ($F=F_{sq}$ in the intermediate year). Following the ICES DLS protocol ($F_{MSY}=F_{0.1}$ for Category 2 stocks) would lead to a TAC in 2015 of 1861t, a substantial reduction from the 2013 landings. This substantial reduction in advice compared to last year is a result of the much lower F_{MSY} proxy (in 2013 $F_{MSY}=F_{max}=0.34$, in 2014 $F_{MSY}=F_{0.1}=0.22$), rather than a declining stock, since in all scenarios examined the stock is projected to increase. It is consider more appropriate that the advice should be limited to a 20% change in landings given the uncertainty in the assessment and choice of F_{MSY} proxy.

18.7 Management considerations

There are a number of EC regulations that affect the flatfish fisheries in the North Sea, e.g. as a basis for setting the TAC, limiting effort, and minimum mesh size.

18.7.1 Effort regulations

Regulated effort restrictions in the EU were introduced in 2003 (annexes to the annual TAC regulations) for the protection of the North Sea cod stock. In addition, a long-term plan for the recovery of cod stocks was adopted in 2008 (EC regulation 1342/2008). In

2009, the effort management programme switched from a days-at-sea to a kW-day system (EC regulation 43/2009), in which different amounts of kW-days are allocated within each area by member state to different groups of vessels depending on gear and mesh size. Effort ceilings are updated annually. The most important fleet catching turbot in the North Sea, the Dutch 80mm beam trawl fleet (BT2), was affected by this regulation only once in 2009 but not since.

The overall fleet capacity and deployed effort of the North Sea beam trawl fleet has been substantially reduced since 1995, due to a number of reasons, including the above mentioned effort limitations for the recovery of the cod stock. In 2008, 25 vessels were decommissioned.

18.7.2 Technical measures

Turbot is mainly taken by beam trawlers in a mixed fishery directed at sole and plaice in the southern and central part of the North Sea. Technical measures (EC Council Regulation 1543/2000) applicable to the mixed flatfish fishery affect the catching of turbot. The minimum mesh size of 80 mm in the beam trawl fishery selects sole at the minimum landing size (24 cm). However, this mesh size is likely to catch immature turbot (age 1 and 2 fish). Mesh enlargement would reduce the catch of smaller turbot at the same time potential increasing the yield per recruit, but would also result in loss of marketable sole catches.

A closed area has been in operation since 1989 (the plaice box) and since 1995 this area has been closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation. An additional technical measure concerning the fishing gear is the restriction of the aggregated beam length of beam trawlers to 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9 m.

18.7.3 Combined TAC

At present the EU provides a combined TAC for turbot and brill in the North Sea. It is unclear how the quantitative single species advice for turbot and the qualitative single species advice for brill can/will be used to formulate a combined TAC for these two stocks. In this situation, improving the brill assessment may be necessary in order to ensure efficient management of both of these stocks. Ideally, a combined TAC would not be used.

18.8 Future work

Since this is a new assessment, there is still work to be done to address potential sources of bias and uncertainty in the assessment model. In 2013 turbot was raised to a Category 2 stock in the ICES DLS categorisation, but it is expected with some further work this stock could be elevated to a Category 1 stock in 2015 or 2016. Along with certain issues identified by IBPNEW, some points highlighted in this report will be examined in advance of WGNSSK 2014. These include, but are not limited to, the following:

1) Incorporation of total landings in the assessment model.

2) Examination of potential discarding prior to 2002.

3) Examination of the indices used and the age ranges included. Potentially weight each index in the objective function of the basis of uncertainty estimates for each index.

4) Examination of alternate methods for estimating weights at age during the gaps in the time series of data

5) Examination of the functional form of the selectivity curve(s)

6) Test different numbers (or locations) of knots in the annual exploitation spline

Some work has already been conducted on these points, but there was insufficient time at WGNSSK 2014 to present these in plenary or subgroup. A future inter-benchmark procedure may be an appropriate forum to present this work and update the model procedure.

18.9 References

Fournier, D.A., Skaug, H.J., Ancheta, J., Ianelli, J., Magnusson, A., Maunder, M.N., Nielsen, A., Sibert, J. 2012. AD Model Builder: Using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. *Optimization Methods and Software* **27**: 233–249.

ICES, 2012a. Report of the Inter-Benchmark Protocol on New Species (Turbot and Sea bass; IBPNew 2012), 1–5 October 2012, Copenhagen, Denmark. ICES CM 2012/ACOM: 45. 239pp.

ICES, 2012b. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 22-26 October 2012, Venice, Italy. ICES CM 2012/SSGSUE: 10. 153 pp.

ICES, 2012c. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH), 21-25 May 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:22. 94pp.

ICES, 2013a. (DRAFT) ICES Implementation of Advice for Data-limited Stocks in 2013. ICES CM 2012/ACOM: 68. 42pp.

ICES. 2013b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:13. 1435 pp.

Table 18.2.1 Turbot in Subarea IV: Landings at age estimates (abundance, thousands) used in the assessment.

	AGE								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1975	1.15	427.35	1012.35	239.35	108.35	124.55	90.35	47.25	42.05
1976	0.35	350.35	1346.35	392.35	114.35	76.25	57.75	50.55	38.55
1977	18.55	895.35	644.35	531.35	166.35	44.15	30.85	42.35	36.95
1978	0.35	1324.35	1273.35	309.35	268.35	76.35	37.95	29.35	20.75
1979-1980	**NO DATA**								
1981	0.35	299.35	755.35	532.35	458.35	175.35	67.35	35.35	40.35
1982	0.35	169.35	1046.35	267.35	167.35	292.35	98.35	49.35	41.35
1983	0.35	402.35	673.35	479.35	110.35	113.35	180.35	91.35	31.35
1984	0.35	1296.35	1223.35	311.35	157.35	60.35	57.35	74.35	51.35
1985	0.35	795.35	2415.35	654.35	179.35	109.35	26.35	38.35	48.35
1986	0.35	371.35	1470.35	697.35	183.35	67.35	29.35	16.35	18.35
1987	13.35	648.35	546.35	676.35	158.35	52.35	19.35	5.35	5.35
1988	36.35	1084.35	897.35	178.35	176.35	90.35	28.35	42.35	10.35
1989	0.35	594.35	1037.35	315.35	139.35	73.35	28.35	22.35	10.35
1990	43.35	957.35	1032.35	305.35	160.35	73.35	98.35	58.35	13.35

1991-1997	**NO DATA**								
1998	0.35	540.35	1158.35	476.35	97.35	39.65	11.65	10.45	1.26
1999	**NO DATA**								
2000	4.85	255.35	938.35	270.35	315.35	145.05	116.45	51.65	59.14
2001	0.35	478.35	1642.35	357.35	64.35	75.85	55.45	65.05	21.93
2002	468.35	1283.35	1237.35	265.35	123.35	32.45	16.75	17.65	3.62
2003	267.35	2429.35	586.35	378.35	90.35	42.25	26.65	9.35	8.02
2004	491.15	2234.35	894.35	156.35	93.35	11.25	8.85	4.45	1.37
2005	291.45	1678.35	611.35	195.35	21.35	18.85	2.55	12.15	1.38
2006	706.05	1312.35	644.35	95.35	28.35	6.65	13.25	3.45	1.05
2007	80.25	2829.35	627.35	290.35	41.35	29.95	8.75	9.85	0.35
2008	184.85	1404.35	854.35	229.35	203.35	49.35	13.75	1.55	7.16
2009	117.25	1076.35	1005.35	434.35	92.35	26.25	11.75	8.15	2
2010	237.15	1193.35	328.35	263.35	146.35	75.25	26.35	6.35	4.83
2011	219.45	2017.35	626.35	115.35	143.35	80.35	33.85	16.65	3.72
2012	0.35	1949.35	793.35	272.35	43.35	65.25	74.55	13.65	6.88
2013	138.7	1568.1	1017	292.8	82. 5	25.3	38.1	16.7	2.7

Table 18.2.2 Turbot in Subarea IV: Relative abundance indices used in the assessment.

INDEX 1: BTS-ISIS (sex combined); September

AGE

	1	2	3	4	5	6	7
1985	0.39545	1.28365	0.26525	0.11355	0.05375	0.02135	0.00955
1986	0.22755	0.90425	0.27645	0.10075	0.04255	0.01925	0.00745
1987	0.26385	1.08715	0.27415	0.11135	0.05005	0.03425	0.00765
1988	0.58935	1.19375	0.30315	0.08525	0.03035	0.02755	0.00745
1989	0.37815	1.35885	0.39915	0.12165	0.03985	0.02615	0.01545
1990	2.08255	1.24465	0.25975	0.12565	0.06665	0.02745	0.00965
1991	1.22675	1.66485	0.21705	0.02365	0.01415	0.00025	0.01215
1992	1.36115	1.17845	0.31985	0.03375	0.01545	0.01055	0.00335
1993	1.67955	1.40555	0.18545	0.05225	0.04505	0.00175	0.00075
1994	1.83025	1.58005	0.10225	0.03125	0.00625	0.00325	0.00325
1995	1.83265	0.60705	0.10125	0.01185	0.00895	0.00345	0.00025
1996	0.61465	1.90125	0.11255	0.07465	0.04045	0.00025	0.00915
1997	0.66885	1.30755	0.37765	0.02625	0.03805	0.01335	0.01155
1998	1.91495	0.91595	0.23285	0.15245	0.00475	0.00025	0.00135
1999	1.24255	1.18095	0.19545	0.09545	0.01665	0.00265	0.00115
2000	4.21375	0.84715	0.38565	0.16375	0.05395	0.05465	0.00025
2001	1.04385	1.40955	0.12875	0.15225	0.00025	0.00025	0.04025
2002	2.81445	0.49315	0.14595	0.04625	0.03195	0.02175	0.00095
2003	1.54345	0.87475	0.10115	0.05435	0.00025	0.01215	0.01145
2004	2.16585	0.63995	0.35895	0.00025	0.06855	0.01715	0.00025
2005	1.14255	1.53825	0.52595	0.11575	0.03595	0.00625	0.01215
2006	1.70525	0.79935	0.27315	0.11375	0.00475	0.00025	0.00025
2007	1.34235	0.90235	0.56285	0.27955	0.09035	0.06005	0.00025

2008	1.19555	1.12475	0.43125	0.14325	0.07615	0.01735	0.07975
2009	0.97165	0.41985	0.34585	0.28145	0.15225	0.04955	0.00505
2010	1.69095	0.34825	0.09925	0.07015	0.08895	0.01465	0.01465
2011	1.84005	0.89155	0.16335	0.06325	0.06535	0.01665	0.00025
2012	0.97725	0.93035	0.24015	0.23555	0.02135	0.04495	0.08375
2013	0.6677	0.5848	0.4554	0.1581	0.0175	0.0371	0.0403

Table 18.2.2 cont. Turbot in Subarea IV: Relative abundance indices used in the assessment.

INDEX 2: SNS (sex combined) ; September

AGE

	1	2	3	4	5	6	7
1975	92.7765	80.0575	19.9635	6.8025	2.5955	2.9235	0.6775
1976	43.9395	53.5585	12.8505	4.5435	2.2625	1.5405	0.4575
1977	406.4435	212.4895	43.5875	12.0325	8.4625	3.3085	1.7745
1978	27.5655	121.5145	49.0915	17.3695	7.5775	4.5425	2.3125
1979	14.5295	107.7745	45.9225	13.9525	8.0695	4.8685	2.4875
1980	109.9805	66.3845	24.5475	8.4455	3.7515	2.5315	1.6905
1981	23.6485	65.2125	23.7685	7.4655	8.0285	5.1455	4.2085
1982	87.7025	40.0155	7.5965	1.7605	1.2525	0.3035	0.7955
1983	151.5805	146.6065	27.7185	8.7335	2.7935	2.9135	1.1675
1984	88.7745	76.0395	24.9595	9.5415	5.1865	3.1565	1.3265
1985	42.6505	93.7175	21.9185	6.8335	3.9385	3.0565	0.7115
1986	24.1895	15.9245	4.9955	1.8845	2.7715	3.3135	1.2595
1987	62.2215	16.8645	3.2955	1.0885	0.2885	0.6675	0.4785
1988	166.6585	101.5035	17.9345	4.2315	1.1895	0.6835	0.6684

1989	62.5885	44.8695	13.2645	5.7775	3.4475	1.1415	0.7695
1990	231.0075	102.8355	22.3815	4.7845	2.2265	0.2685	2.7135
1991	37.5065	75.4595	21.0285	6.2545	2.6065	2.5775	0.6465
1992	249.0995	106.4985	33.3155	14.6285	7.5245	4.7545	0.7845
1993	146.6255	154.4875	33.8125	9.1675	3.8695	2.8315	0.8465
1994	94.9145	47.8945	16.5355	9.2765	4.5725	0.9505	1.3515
1995	189.3095	58.2185	5.2265	2.5675	0.8135	0.8495	0.6245
1996	80.0705	79.0695	17.8295	4.7915	1.1525	2.1045	0.8065
1997	31.3715	27.4255	9.3865	5.3905	4.1575	0.5675	1.6635
1998	53.3635	41.9375	9.8765	2.5165	1.6535	0.9105	0.5725
1999	156.4185	97.0725	28.3925	9.1855	3.7725	2.0645	1.3765
2000	147.8075	41.0165	5.4855	2.2645	1.0855	0.9295	0.7035
2001	45.5375	31.4445	19.1445	4.7515	3.5365	1.2165	1.6635
2002	127.0935	53.1605	14.2155	3.2315	0.4025	1.0425	0.0895
2003	NO DATA						
2004	186.5145	27.0285	18.7565	4.0895	2.9985	3.4225	0.0895
2005	75.3905	155.5475	23.6635	0.0895	0.0895	0.0895	0.0895
2006	196.1535	97.4725	14.8685	3.6135	1.0895	0.0895	0.0895

2007	89.7415	55.6055	33.7815	11.8455	1.3245	0.0895	0.0895
2008	52.0905	99.7425	40.8285	11.8675	10.9225	1.2005	7.4825
2009	26.2675	20.3115	5.6455	14.4675	5.0895	0.0895	0.0895
2010	96.0185	35.8115	9.2565	5.3675	3.7005	6.7565	1.2005
2011	116.6895	36.8895	0.0895	0.0895	0.0895	1.6895	0.0895
2012	39.8585	33.5115	9.4645	1.2325	0.0895	0.0895	0.0895
2013	110.07	16.026	15.55	0.351	0.0	0.0	0.0

Table 18.2.2 cont. Turbot in Subarea IV: Relative abundance indices used in the assessment.

INDEX 3: NL_BT2 LPUE; All Year

AGE

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2002	1.8325	13.9925	30.1525	8.7025	6.0525	2.0825	0.7525	0.9625	0.1725
2003	2.3825	25.5325	14.6125	15.0425	4.1725	2.6425	1.5725	0.5325	0.7225
2004	3.1025	27.5825	23.8725	5.2725	5.9025	1.2225	0.9525	0.3325	0.1525
2005	1.4125	23.2125	25.3125	10.8625	1.7925	2.7925	0.1725	0.4825	0.1925
2006	4.1925	20.4525	27.4425	8.3325	4.0725	1.2625	1.5825	0.4025	0.0525
2007	0.9925	42.9225	20.4925	13.7425	3.7925	2.7525	0.4825	0.7025	0.0225
2008	2.7325	30.3125	34.1225	11.1625	11.9825	3.5625	2.5225	0.2825	0.7425
2009	0.9025	17.1325	37.7525	28.7825	8.5025	4.1125	1.9525	1.3125	0.1525
2010	2.7925	22.8825	14.9325	15.7325	11.8925	5.6125	2.6225	1.1325	0.9025
2011	4.5225	29.8325	25.0525	8.8225	10.6325	8.7125	3.4725	1.3925	0.5625
2012	4.3425	35.9725	22.7125	11.7225	3.8225	5.5725	5.0725	0.8925	0.9125
2013	3.685	24.545	39.015	17.575	7.605	4.615	6.365	3.805	0.625

Table 18.2.3 Turbot in Subarea IV: Biological data used in the assessment. All values are constant over years.

AGE

	1	2	3	4	5	6	7	8	9
Stock weight at age (kg)	0.77	0.67	1.15	1.91	2.7	3.69	4.45	5.03	5.82
Catch weight at age (kg)	0.51	0.78	1.23	1.99	2.89	3.87	4.6	5.32	6.11
Maturity	0	0.04	0.47	0.95	1	1	1	1	1
Natural Mortality (*M*)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Table 18.4.1 Turbot in Subarea IV: Estimates of stock numbers at age (thousands) from the assessment model.

N@A	1	2	3	4	5	6	7	8	9
1975	4051	4257	2621	770	432	381	279	167	134
1976	8624	3316	3069	1372	400	248	238	150	90
1977	11831	7059	2386	1596	708	229	154	127	80
1978	4727	9684	5064	1228	815	401	141	81	67
1979	2953	3870	6921	2573	619	457	246	74	42
1980	3313	2417	2752	3459	1274	343	277	126	38
1981	2559	2712	1710	1349	1679	695	205	140	64
1982	4352	2094	1906	819	640	899	411	101	69
1983	7081	3562	1462	891	379	336	524	198	49
1984	5466	5796	2466	664	401	195	192	246	93
1985	2665	4474	3979	1088	290	201	109	88	112
1986	3735	2181	3044	1700	459	142	111	48	39
1987	5883	3057	1470	1258	694	219	77	48	21
1988	4473	4815	2040	587	495	322	116	32	20
1989	5630	3661	3181	786	223	223	167	47	13
1990	7013	4608	2395	1184	289	98	113	65	18
1991	5494	5739	2985	862	420	123	49	43	24
1992	5846	4497	3686	1042	296	175	60	18	16
1993	5926	4785	2865	1251	348	121	84	21	6
1994	5252	4850	3028	950	408	139	57	29	7
1995	8664	4298	3053	986	304	161	65	20	10
1996	4066	7091	2697	982	312	119	75	22	7
1997	3320	3328	4442	863	309	121	55	25	7
1998	3596	2717	2085	1423	272	120	56	19	8
1999	1947	2943	1706	673	451	106	56	19	6
2000	3485	1593	1854	557	216	178	50	19	7
2001	2613	2852	1009	616	182	87	84	17	7
2002	5446	2139	1817	342	206	74	41	30	6
2003	5006	4284	724	632	117	85	36	15	11
2004	5787	3942	1492	259	222	50	42	14	6
2005	4598	4564	1416	549	94	97	25	16	5
2006	8079	3631	1693	538	206	42	50	10	6
2007	5474	6391	1393	664	208	94	22	20	4
2008	2733	4336	2535	565	266	98	50	9	9
2009	3469	2168	1779	1062	234	128	53	22	4
2010	4804	2757	920	770	454	115	71	24	10
2011	6041	3823	1209	411	340	230	65	33	11
2012	4026	4814	1731	557	187	177	133	31	16
2013	4387	3213	2247	821	262	100	104	65	15

Table 18.4.2. Turbot in Subarea IV: Estimates of fishing mortality at age from the assessment model.

F@A	1	2	3	4	5	6	7	8	9
1975	0.00	0.13	0.45	0.46	0.35	0.27	0.42	0.42	0.42
1976	0.00	0.13	0.45	0.46	0.36	0.28	0.43	0.43	0.43
1977	0.00	0.13	0.46	0.47	0.37	0.28	0.44	0.44	0.44
1978	0.00	0.14	0.48	0.49	0.38	0.29	0.45	0.45	0.45
1979	0.00	0.14	0.49	0.50	0.39	0.30	0.47	0.47	0.47
1980	0.00	0.15	0.51	0.52	0.41	0.31	0.48	0.48	0.48
1981	0.00	0.15	0.54	0.55	0.42	0.33	0.51	0.51	0.51
1982	0.00	0.16	0.56	0.57	0.44	0.34	0.53	0.53	0.53
1983	0.00	0.17	0.59	0.60	0.47	0.36	0.56	0.56	0.56
1984	0.00	0.18	0.62	0.63	0.49	0.38	0.58	0.58	0.58
1985	0.00	0.19	0.65	0.66	0.52	0.39	0.61	0.61	0.61
1986	0.00	0.19	0.68	0.70	0.54	0.42	0.65	0.65	0.65
1987	0.00	0.20	0.72	0.73	0.57	0.44	0.68	0.68	0.68
1988	0.00	0.21	0.75	0.77	0.60	0.46	0.71	0.71	0.71
1989	0.00	0.22	0.79	0.80	0.62	0.48	0.74	0.74	0.74
1990	0.00	0.23	0.82	0.84	0.65	0.50	0.78	0.78	0.78
1991	0.00	0.24	0.85	0.87	0.68	0.52	0.81	0.81	0.81
1992	0.00	0.25	0.88	0.90	0.70	0.53	0.83	0.83	0.83
1993	0.00	0.26	0.90	0.92	0.72	0.55	0.85	0.85	0.85
1994	0.00	0.26	0.92	0.94	0.73	0.56	0.87	0.87	0.87
1995	0.00	0.27	0.93	0.95	0.74	0.57	0.88	0.88	0.88
1996	0.00	0.27	0.94	0.96	0.74	0.57	0.89	0.89	0.89
1997	0.00	0.27	0.94	0.96	0.74	0.57	0.89	0.89	0.89
1998	0.00	0.27	0.93	0.95	0.74	0.57	0.88	0.88	0.88
1999	0.00	0.26	0.92	0.94	0.73	0.56	0.87	0.87	0.87
2000	0.00	0.26	0.90	0.92	0.71	0.55	0.85	0.85	0.85
2001	0.00	0.25	0.88	0.90	0.70	0.54	0.83	0.83	0.83
2002	0.04	0.88	0.86	0.87	0.68	0.52	0.81	0.81	0.81
2003	0.04	0.85	0.83	0.84	0.66	0.50	0.78	0.78	0.78
2004	0.04	0.82	0.80	0.81	0.63	0.49	0.75	0.75	0.75
2005	0.04	0.79	0.77	0.78	0.61	0.47	0.73	0.73	0.73
2006	0.03	0.76	0.74	0.75	0.58	0.45	0.69	0.69	0.69
2007	0.03	0.72	0.70	0.72	0.56	0.43	0.66	0.66	0.66
2008	0.03	0.69	0.67	0.68	0.53	0.41	0.63	0.63	0.63
2009	0.03	0.66	0.64	0.65	0.50	0.39	0.60	0.60	0.60
2010	0.03	0.62	0.61	0.62	0.48	0.37	0.57	0.57	0.57
2011	0.03	0.59	0.57	0.59	0.46	0.35	0.54	0.54	0.54
2012	0.03	0.56	0.55	0.56	0.43	0.33	0.52	0.52	0.52
2013	0.02	0.53	0.52	0.53	0.41	0.31	0.49	0.49	0.49

Table 18.4.3. Turbot in Subarea IV: Summary of assessment results. Values by year with the geometric mean over all years.

	Recruitment (age 1, thousands)	Total Biomass (t)	Spawner Stock Biomass (t)	Official landings (t)	Model estimated landings (t)	Mean F (ages 2–6)	Official Landings /Total Biomass
1975	4051	15889	8360	4588	3533	0.33	0.29
1976	8624	19341	8566	4814	3771	0.34	0.25
1977	11831	24175	8918	4484	4085	0.34	0.19
1978	4727	23406	10334	5034	5418	0.35	0.22
1979	2953	22808	13581	6364	6792	0.37	0.28
1980	3313	20734	14620	5485	6247	0.38	0.26
1981	2559	17413	12527	4755	5067	0.4	0.27
1982	4352	16297	10359	4453	4382	0.42	0.27
1983	7081	17096	8376	4575	4050	0.44	0.27
1984	5466	16632	7129	5297	4254	0.46	0.32
1985	2665	14810	7351	6188	4877	0.48	0.42
1986	3735	13812	7516	5263	4646	0.51	0.38
1987	5883	14052	6541	4271	3843	0.53	0.3
1988	4473	13451	5611	4041	3843	0.56	0.3
1989	5630	14424	5721	4927	4375	0.58	0.34
1990	7013	15579	5643	5750	4412	0.61	0.37
1991	5494	15319	5495	6340	4759	0.63	0.41
1992	5846	15638	5898	5933	5172	0.65	0.38
1993	5926	15356	5850	5546	5017	0.67	0.36
1994	5252	14648	5549	5244	4940	0.68	0.36
1995	8664	16805	5414	4671	4839	0.69	0.28
1996	4066	14620	5191	3644	5038	0.7	0.25
1997	3320	13239	5752	3382	5438	0.69	0.26

1998	3596	11276	5353	3086	4258	0.69	0.27
1999	1947	8710	4214	3187	3383	0.68	0.37
2000	3485	8546	3654	4025	2872	0.67	0.47
2001	2613	7573	3052	4100	2426	0.65	0.54
2002	5446	9570	2861	3749	3117	0.76	0.39
2003	5006	9696	2584	3374	3397	0.74	0.35
2004	5787	10381	2455	3317	3365	0.71	0.32
2005	4598	10110	2718	3195	3615	0.68	0.32
2006	8079	12647	3007	2976	3462	0.65	0.24
2007	5474	12499	3262	3509	4306	0.63	0.28
2008	2733	10401	3909	3005	4038	0.6	0.29
2009	3469	9672	4421	3089	3213	0.57	0.32
2010	4804	10222	4115	2692	2881	0.54	0.26
2011	6041	11677	3791	2771	2997	0.51	0.24
2012	4026	11377	4072	2914	3444	0.49	0.26
2013	4387	11636	4743	3008	3277	0.46	0.26
2014	4632	-	5239	-	-	-	-
Geo. Mean	4640	13591	5487	4147	4073	0.54	0.31

Table 18.6.1. Turbot in Subarea IV. Management options for 2015 and their effects on the stock under different intermediate year assumptions on F and landings (scenarios A-C).

A. F status quo (i.e. no change in F): F (2014) = F (2013) = 0.46; Landings (2014) = 3414t; SSB (2015) =5341t; R (2014/5) = 4640k = GM(1957–2013)

Rationale	TAC 2015 (t)	F 2015	SSB 2016 (t)	%SSB change (2015*–2016)	%Landings change (2013–2015)
FMSY = F0.1	1817	0.22	7148	+34	-40
FMSY = Fmax	2676	0.34	6309	+18	-11
Landings -20%	2406	0.30	6572	+23	-20
Landings status quo (=L2013)	3008	0.39	5986	+12	0
Landings +20%	3610	0.49	5402	+1	+20

***Landings in 2014 and SSB in 2015 depend on the intermediate year assumptions**

B. Decreasing trend in F: F (2014) = 0.93 * F (2013) = 0.43; Landings (2014) = 3227t; SSB (2015) =5521t; R (2014/5) = 4640k = GM(1957–2013)

Rationale	TAC 2015 (t)	F 2015	SSB 2016 (t)	%SSB change (2015*–2016)	%Landings change (2013–2015)
FMSY = F0.1	1861	0.22	7354	+33	-38
FMSY = Fmax	2740	0.34	6490	+18	-9
Landings -20%	2406	0.29	6817	+23	-20
Landings status quo (=L2013)	3008	0.38	6228	+13	0
Landings +20%	3610	0.47	5642	+2	+20

***Landings in 2014 and SSB in 2015 depend on the intermediate year assumptions**

C. Landings status quo (i.e. no change in landings): F (2014) = 0.85 * F (2013) = 0.39; Landings (2014) = Landings (2013) = 3008t; SSB (2015) =5733t; R (2014/5) = 4640k = GM(1957–2013)

Rationale	TAC 2015 (t)	F 2015	SSB 2016 (t)	%SSB change (2015*–2016)	%Landings change (2013–2015)
FMSY = F0.1	1912	0.22	7595	+32	-36
FMSY = Fmax	2815	0.34	6703	+17	-6
Landings -20%	2406	0.28	7107	+24	-20
Landings status quo (=L2013)	3008	0.37	6514	+14	0
Landings +20%	3610	0.46	5924	+3	+20

***SSB in 2015 depends on the intermediate year assumptions**

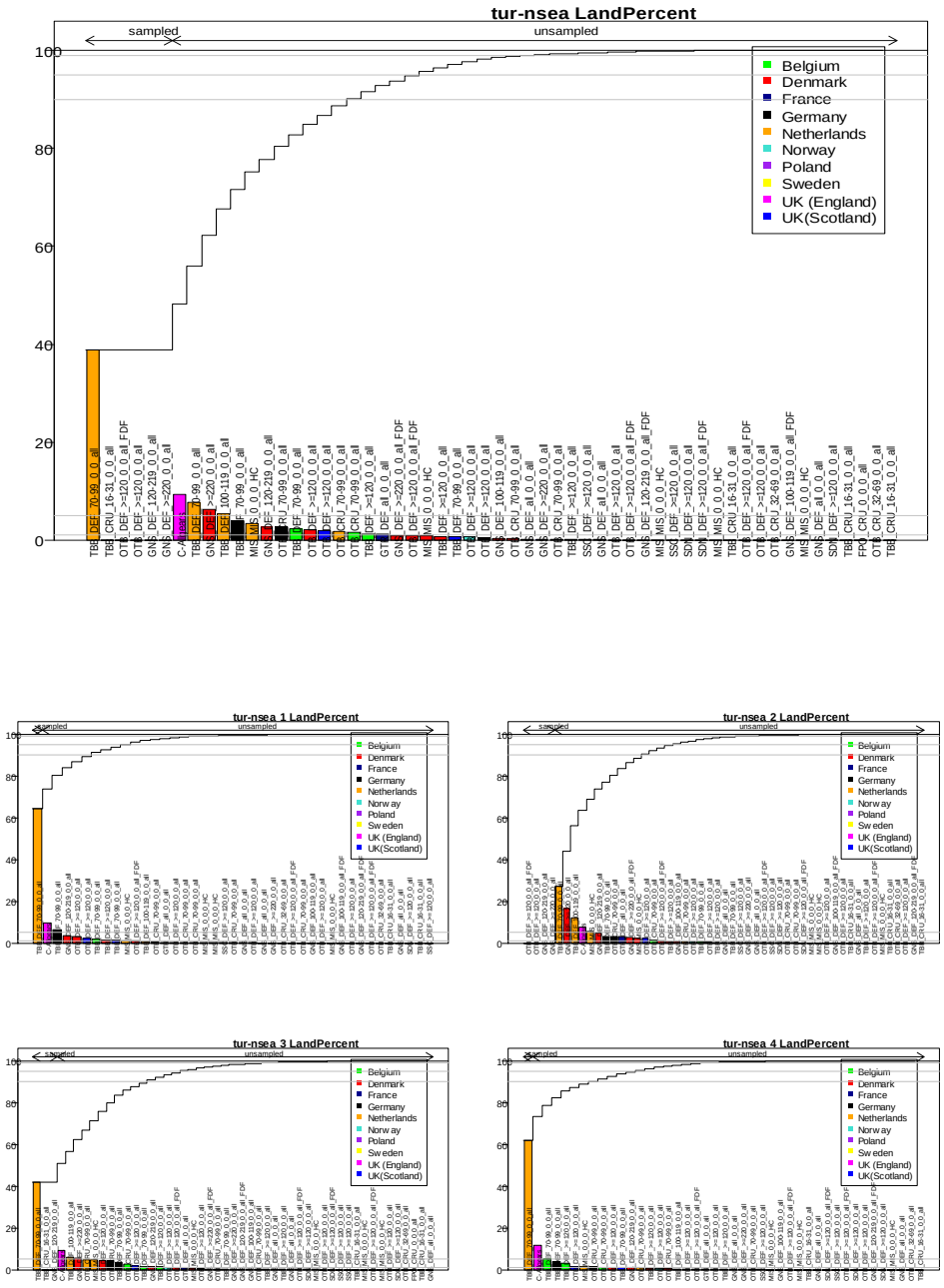


Figure 18.2.1. Turbot in Subarea IV. Total landings by metier in 2013 sorted by sampled/unsampled for numbers at age in InterCatch: whole year (top) and by season (bottom four).

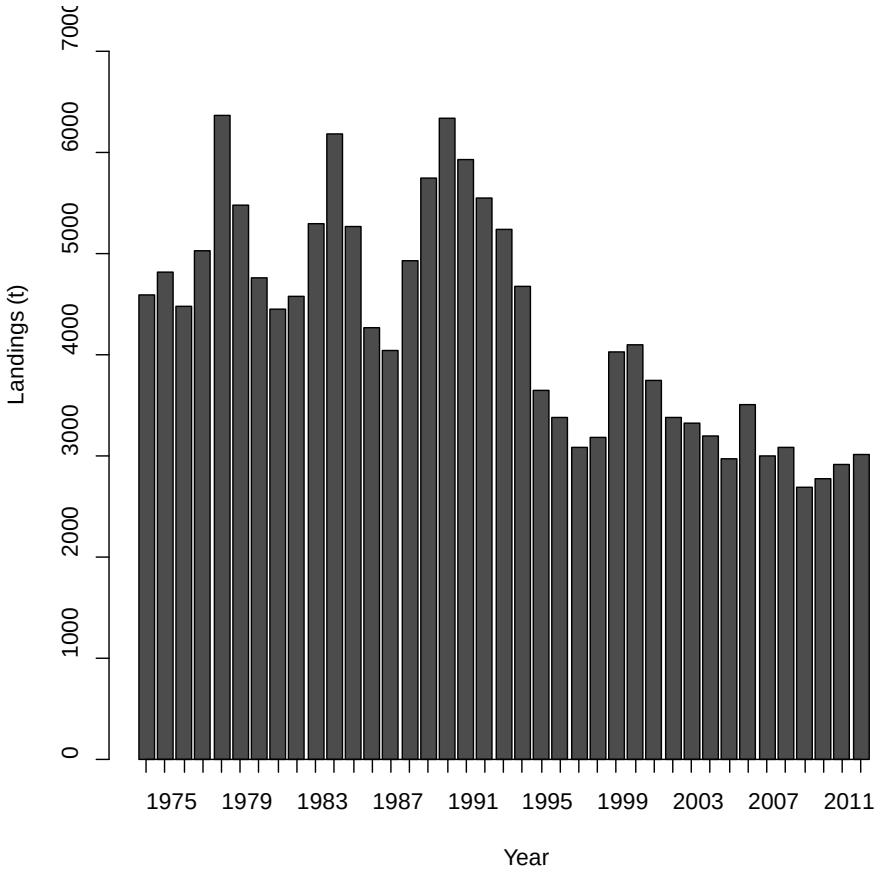


Figure 18.2.2. Turbot in Subarea IV. Total landings 1957-2013 (from the ICES database of official landings).

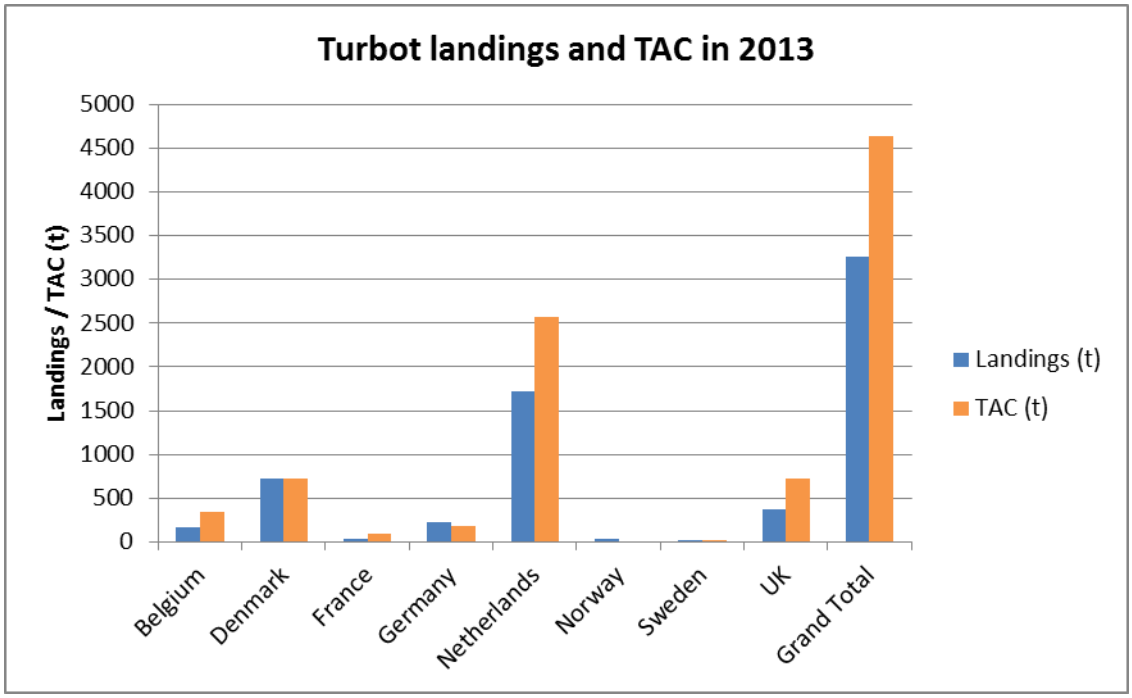


Figure 18.2.3. Turbot in Subarea IV. Landings by country in 2013 (from the ICES database of official landings) compared to the combined TAC for turbot and brill.

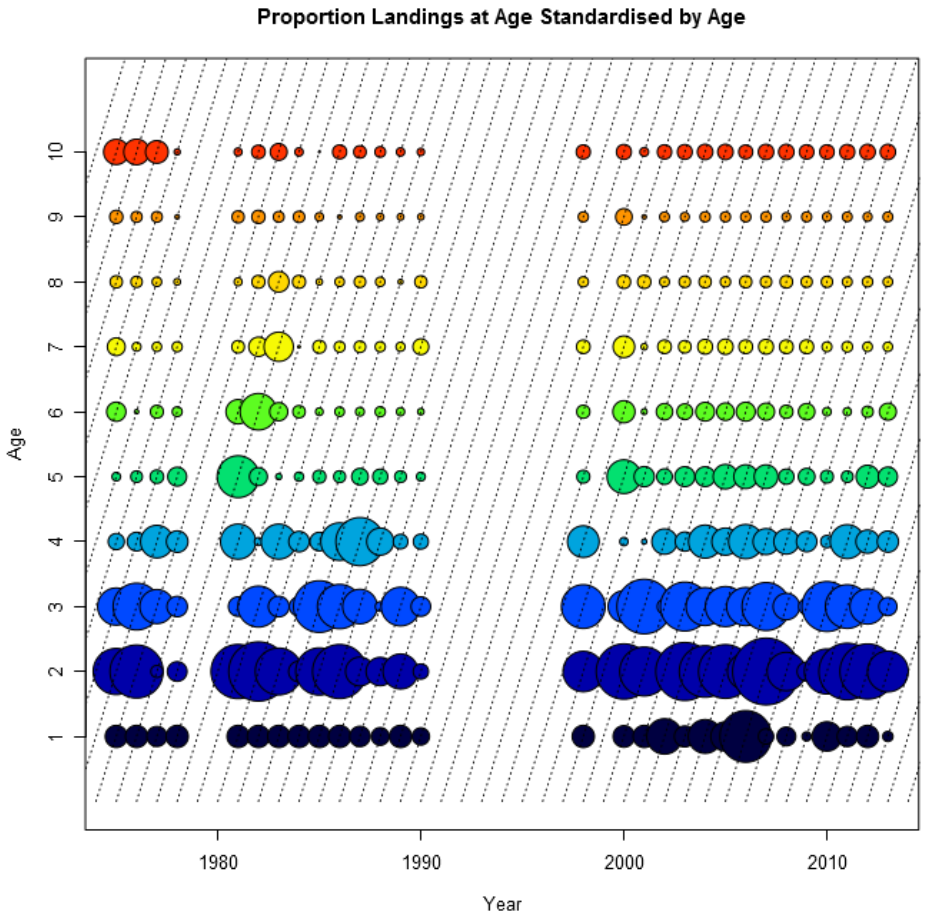


Figure 18.2.4. Turbot in Subarea IV. Landings at age standardised relative to the mean for each age for the years with available data between 1957-2013.

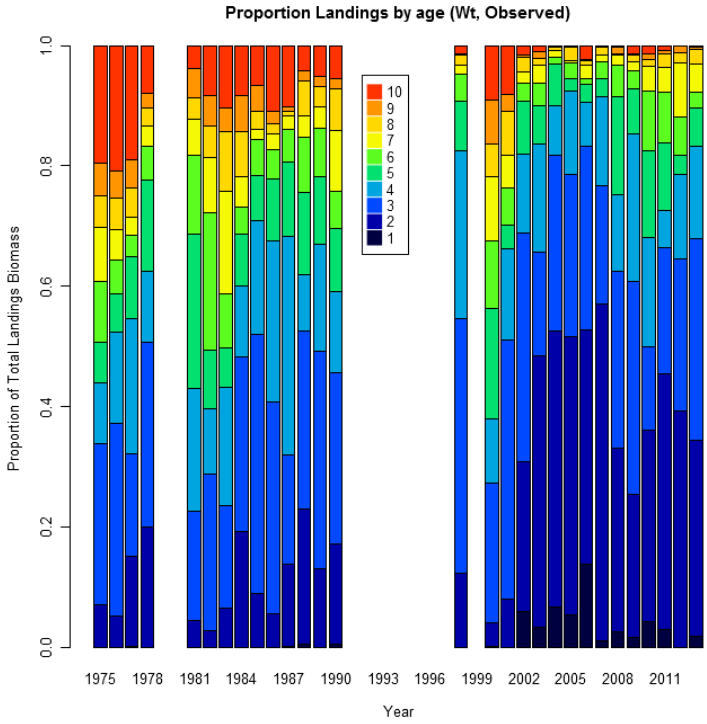


Figure 18.2.5. Proportion of total landings biomass by age for years with observed landings at age values.

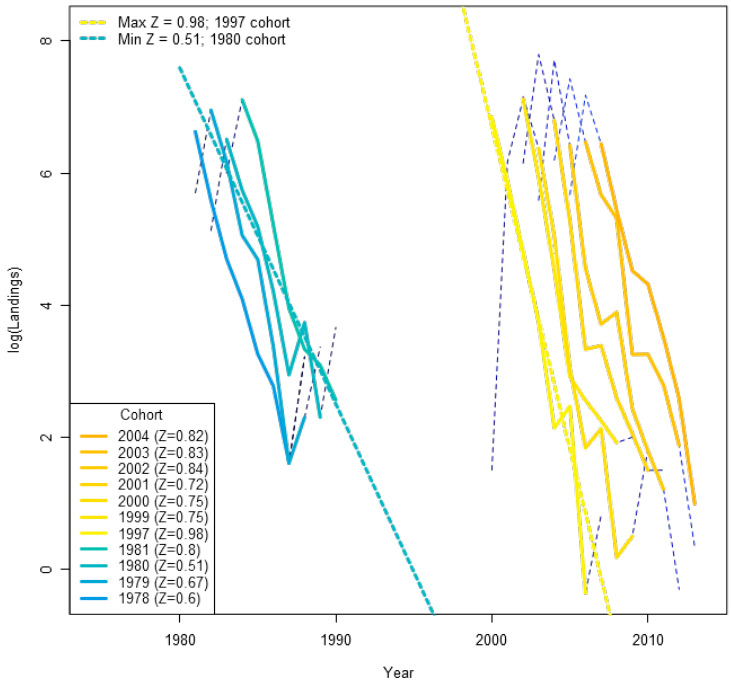


Figure 18.2.6. Log landings curves and associated Z values for all cohorts with estimates of landings at age for ages 3-9. The dotted blue lines show the log(landings) values for ages not used in the calculation of Z (i.e. ages 1 and 2).

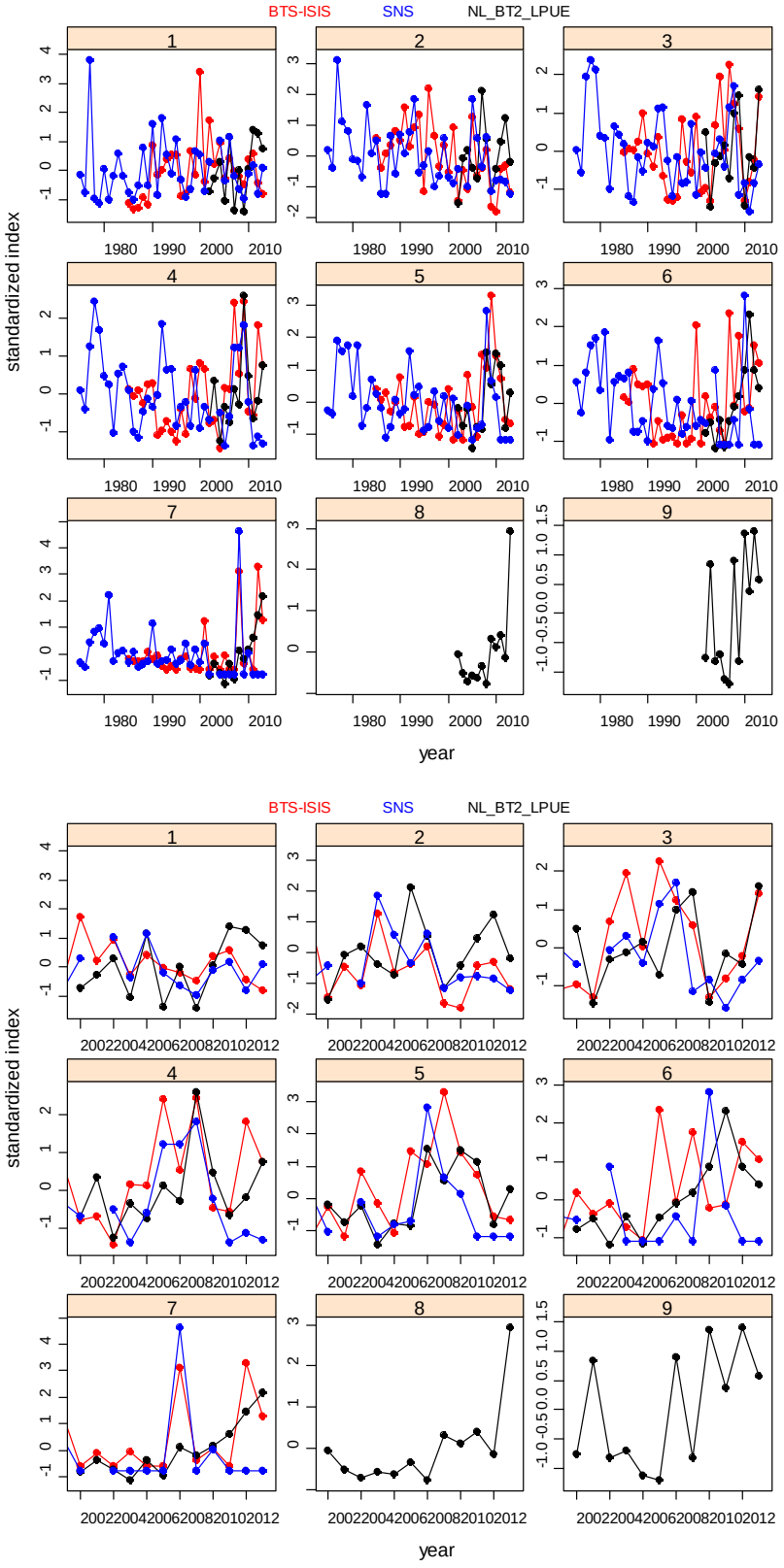


Figure 18.2.7 Turbot in Subarea IV. Time series of the standardized indices for ages 1 to 9 from the three tuning fleets used in the assessment: BTS-ISIS (red), SNS (blue) and NL beam trawl LPUE (black). All years (top) and recent period (2002 onwards, bottom).

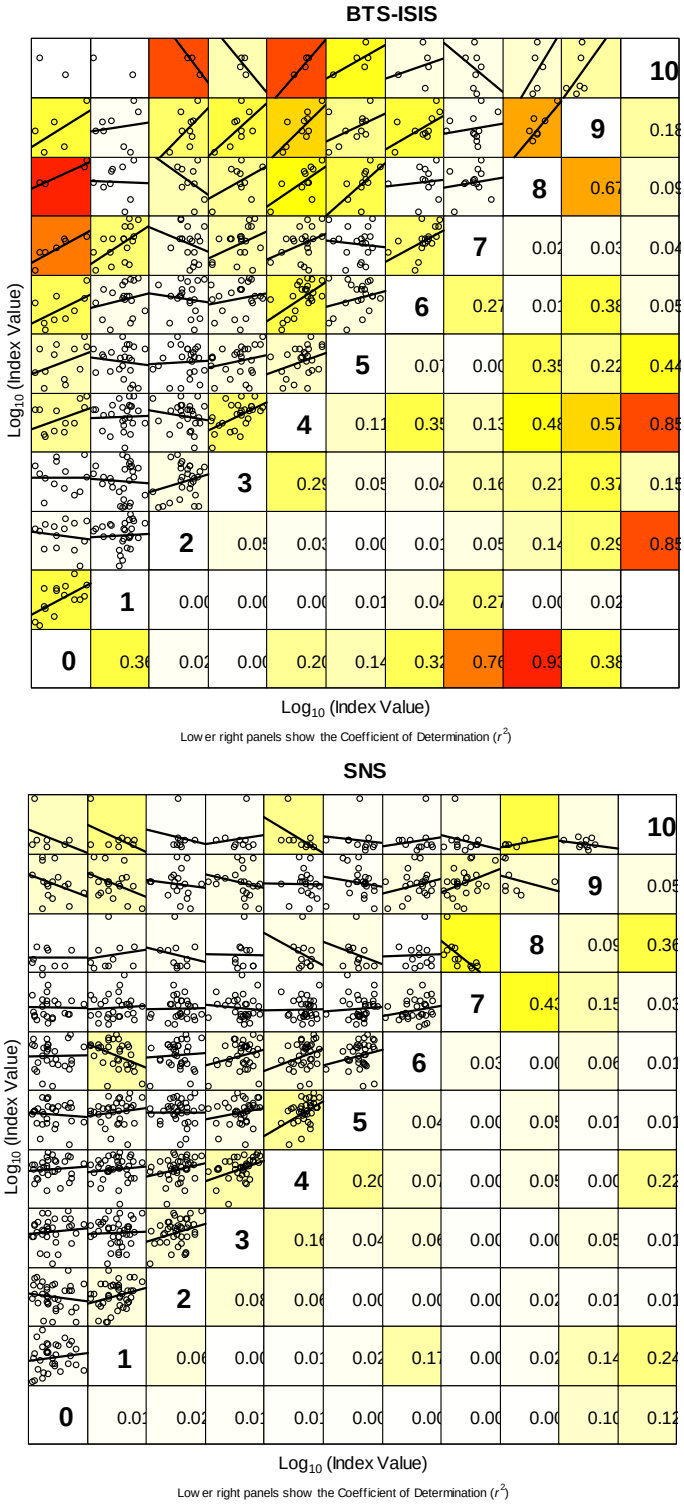


Figure 18.2.8 Turbot in Subarea IV. Internal consistency of the three tuning indices used in the assessment. : BTS-ISIS (top), SNS (bottom) and NL beam trawl LPUE (next page). Note: Only ages 1-7 are used in the assessment for the BTS-ISIS and SNS indices.

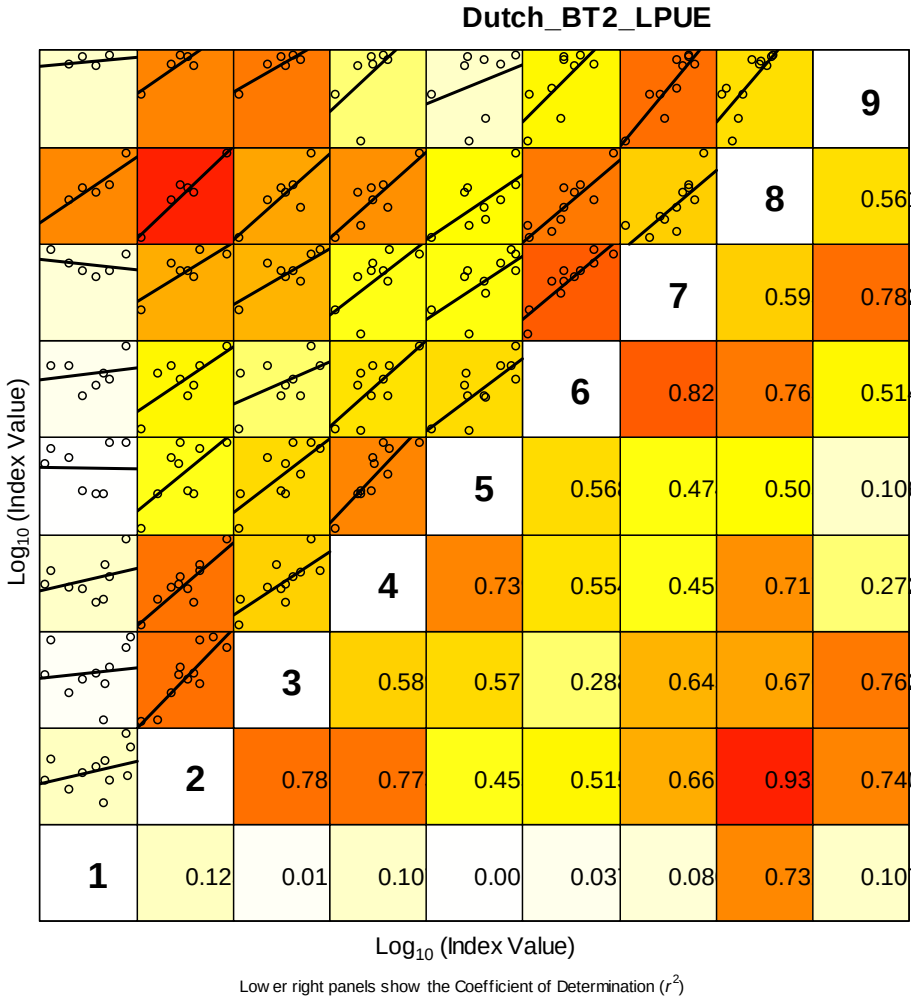


Figure 18.2.8 cont. Turbot in Subarea IV. Internal consistency of the three tuning indices used in the assessment. : BTS-ISIS, SNS (previous page) and NL beam trawl LPUE.

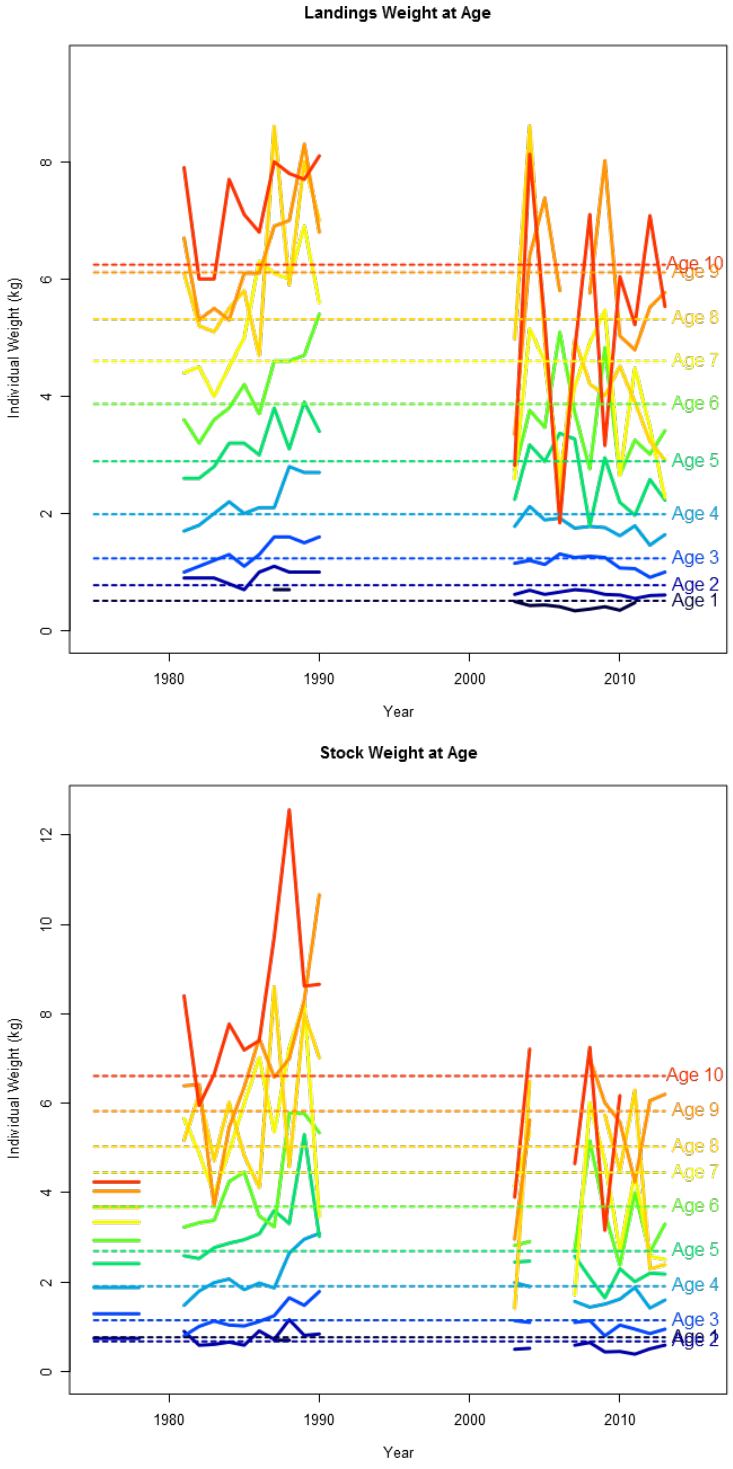


Figure 18.2.9. Landings (top) and stock (bottom) weight and at from observations (solid lines) and mean values (dotted lines).

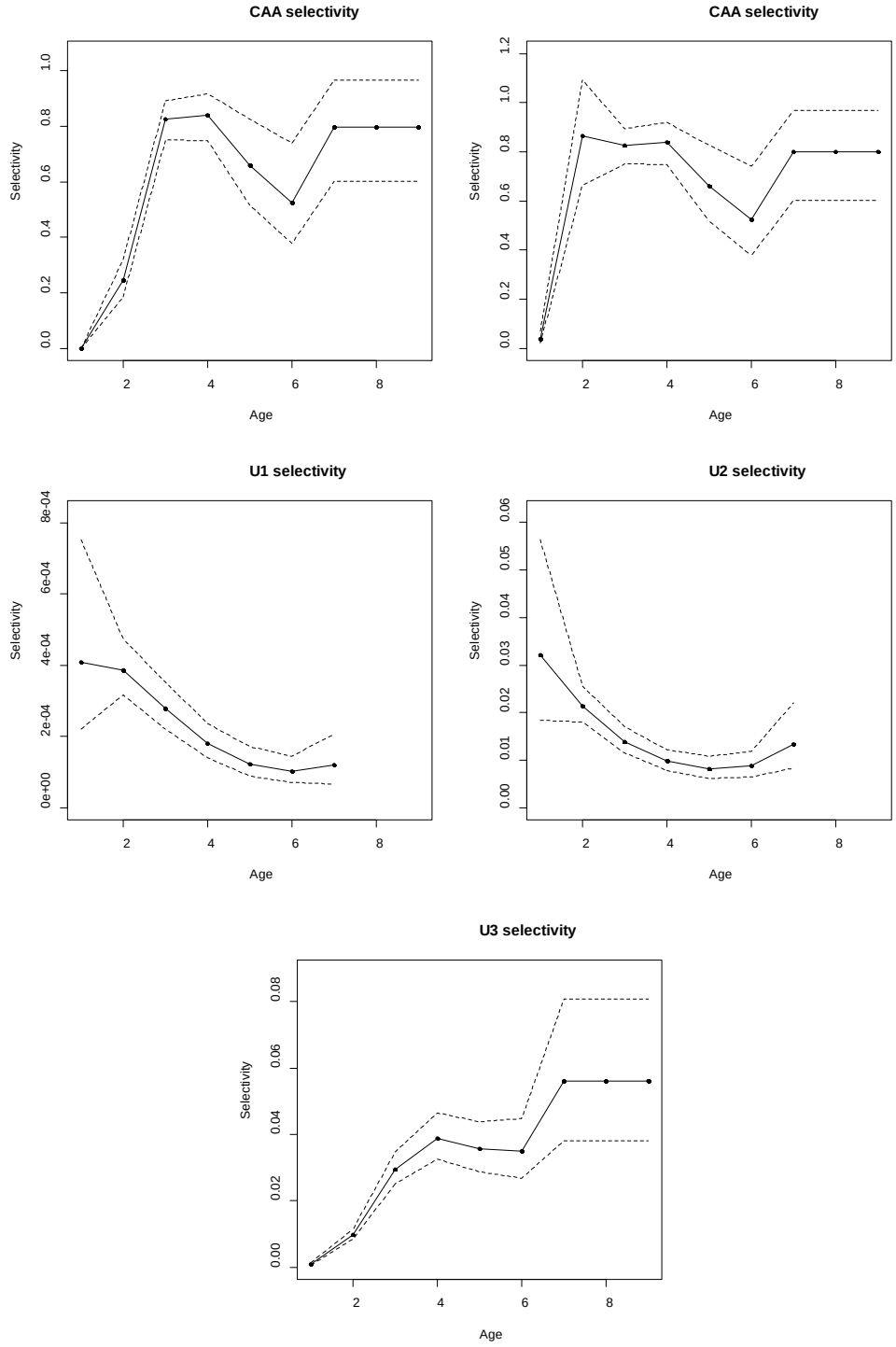


Figure 18.3.1. Turbot in Subarea IV. Model estimated selectivity at age curves (and 95% uncertainty ranges) for the catch at age (CAA, top: left = early period, right = recent period) and the three tuning indices used in the assessment (U1= BTS-ISIS, U2 = SNS and U3 = NL beam trawl LPUE).

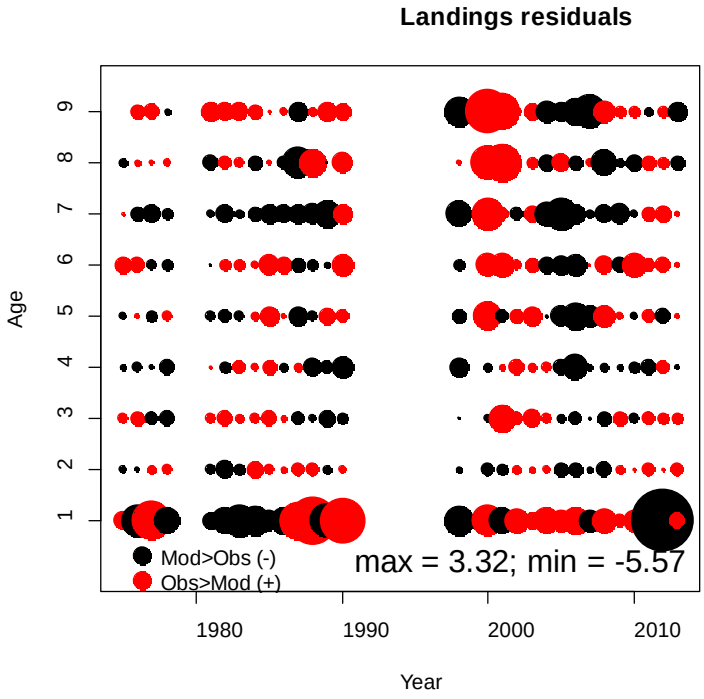


Figure 18.3.2. Turbot in Subarea IV. Log catchability residuals for the landings (top). Black bubbles indicate that the model estimates higher values than observed, red bubbles indicate that the model estimates lower values than observed. Scales are comparable across plots and minimum and maximum values for each series are provided.

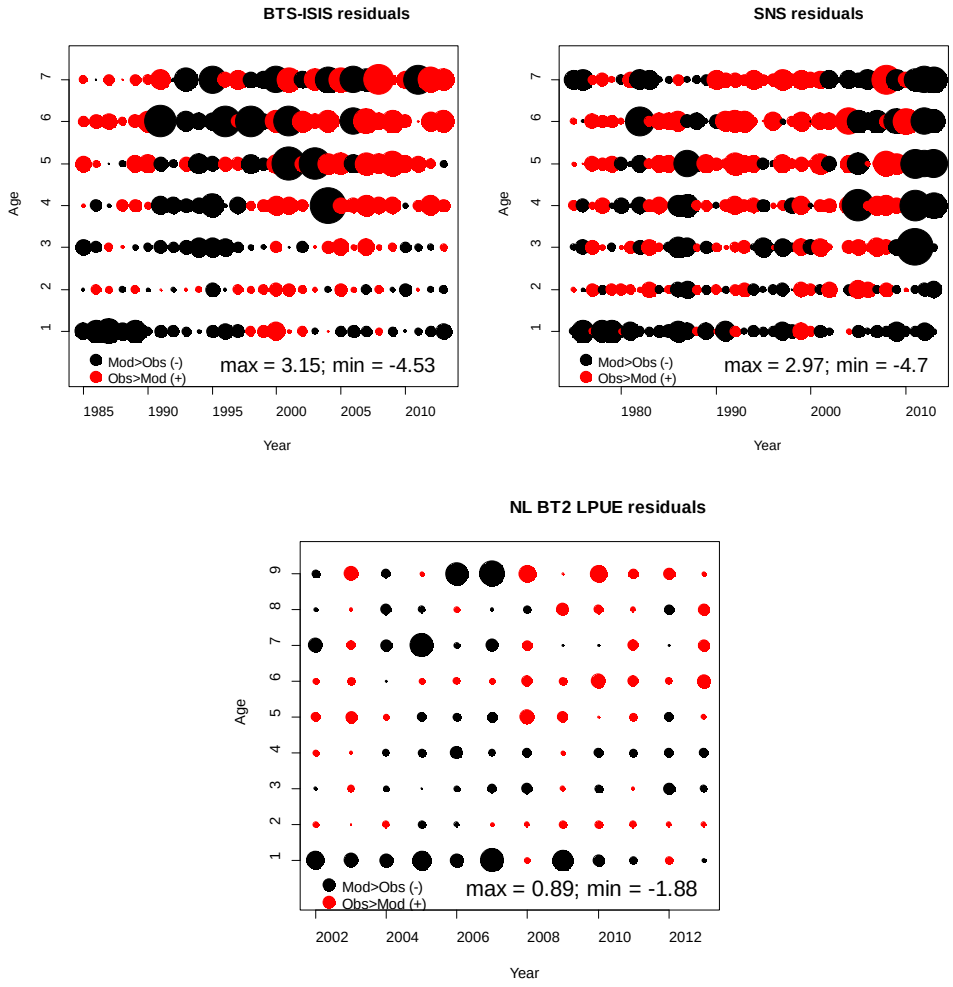


Figure 18.3.3. Turbot in Subarea IV. Log catchability residuals for the three tuning fleets: BTS-ISIS (top left), SNS (top right) and NL beam trawl LPUE (bottom). Black bubbles indicate that the model estimates higher values than observed, red bubbles indicate that the model estimates lower values than observed. Scales are comparable across plots and minimum and maximum values for each series are provided.

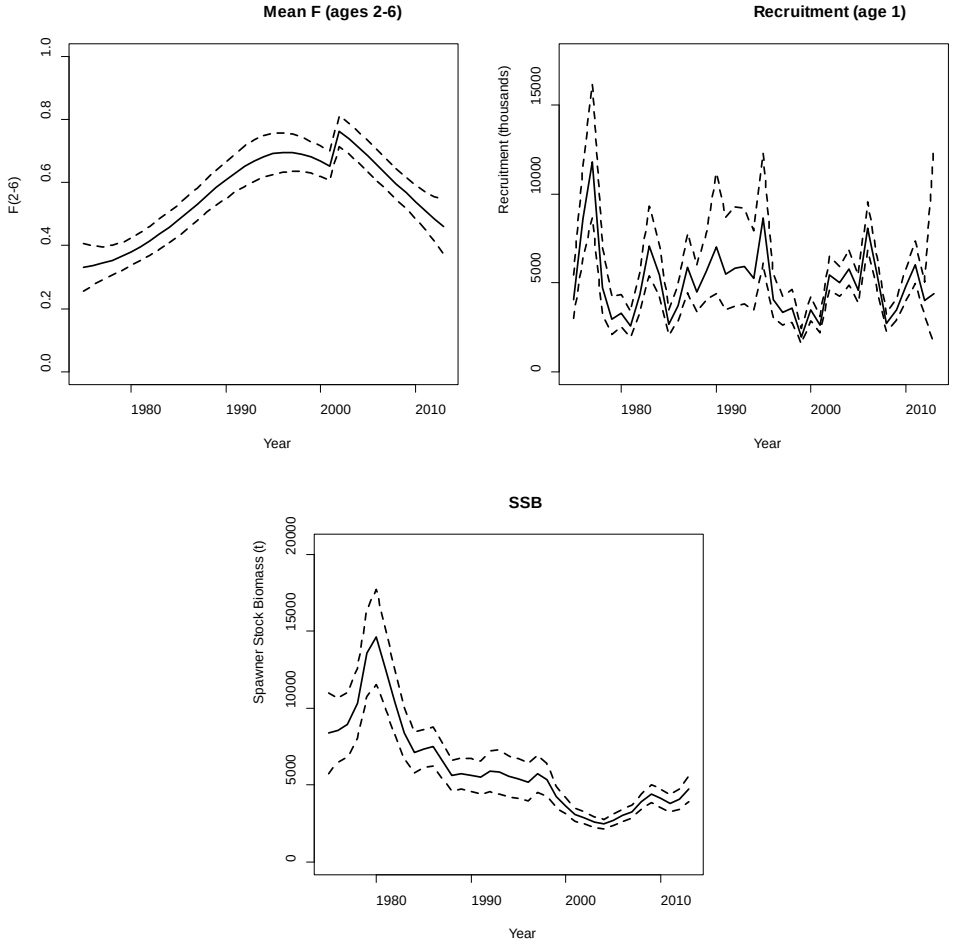


Figure 18.4.1 Turbot in Subarea IV. Key metrics from the assessment model results: fishing mortality (top left), recruitment (top right) and spawner stock biomass (bottom),. The best estimate (solid line) and 95% confidence limits (dashed lines) are plotted.

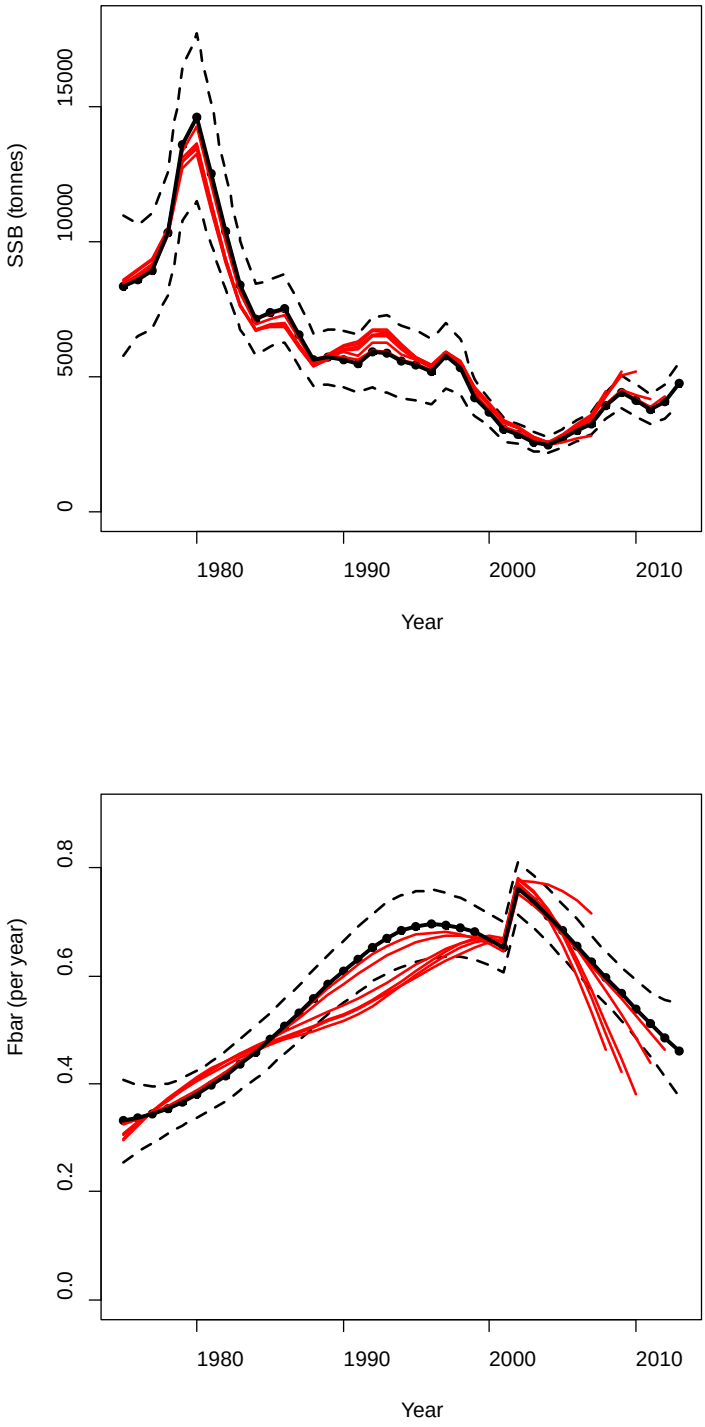


Figure 18.4.2 Turbot in Subarea IV. Retrospective analysis of the key metrics from the assessment model results: spawner stock biomass (top), fishing mortality (bottom) and recruitment (next page). The current assessment (line with points and dashed lines for 95% uncertainty bounds) from the current assessment (dashed lines) and five retrospective 'peels' (plain lines) are shown.

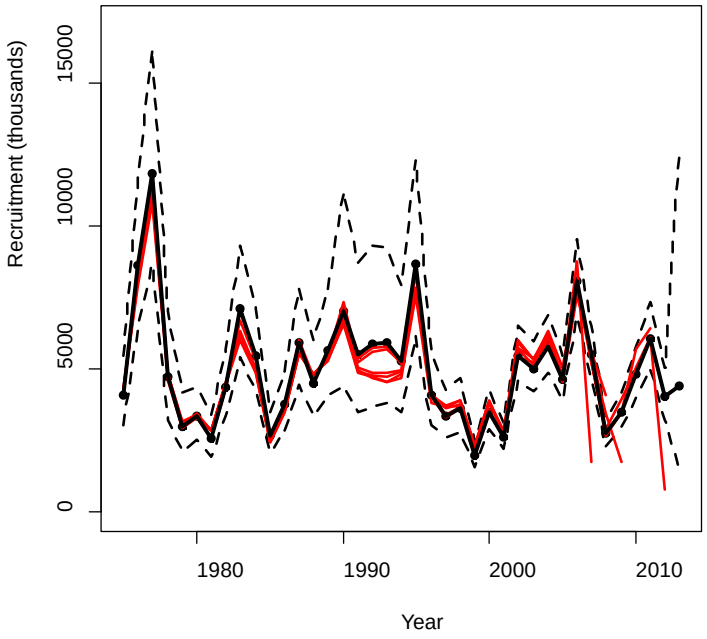


Figure 18.4.2. cont. Turbot in Subarea IV. Retrospective analysis of the key metrics from the assessment model results: spawner stock biomass, fishing mortality (previous page) and recruitment. The current assessment (line with points), uncertain bounds from the current assessment (dashed lines) and five retrospective 'peels' (plain lines) are shown.

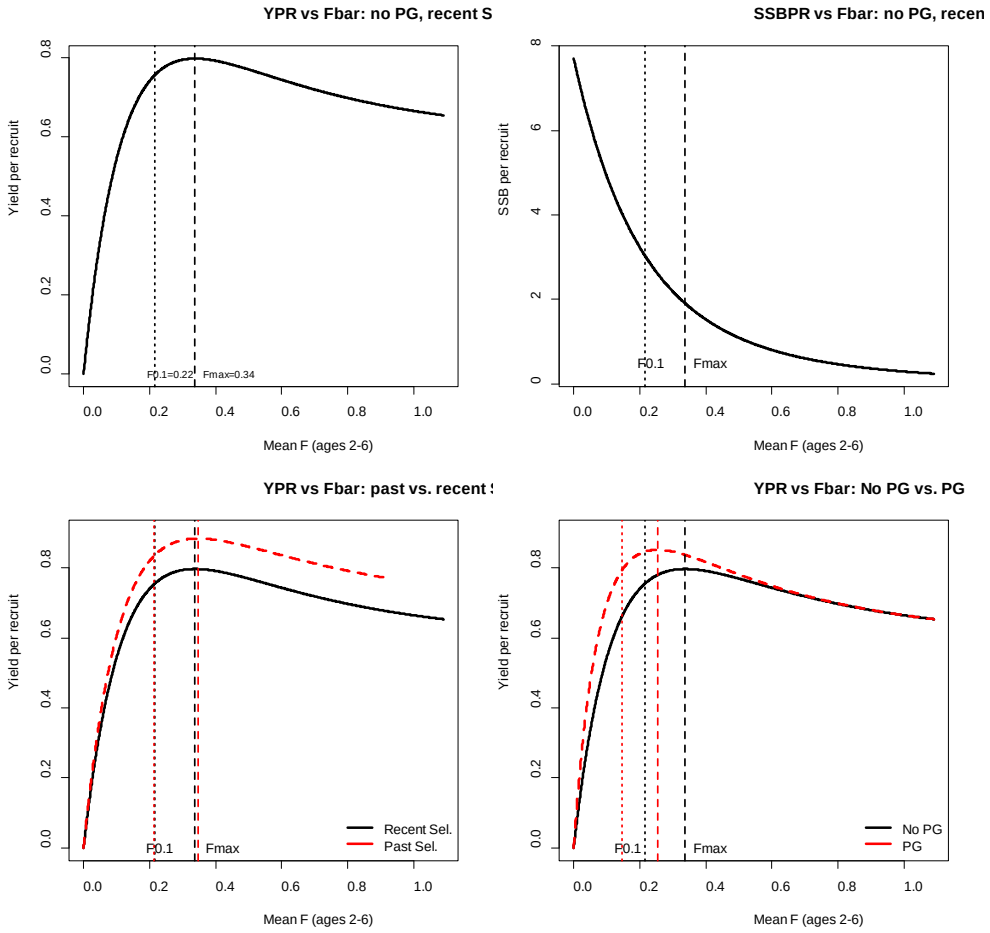


Figure 18.5.1. Turbot in Subarea IV. Top: Yield per recruit (YPR) curve assuming the recent selectivity pattern (top left) and the associated spawner per recruit (SPR, top right). Bottom: Comparisons of YPR curves using the recent selectivity and selectivity prior to 2002 (dashed line, bottom left) and including a plusgroup or not (bottom right). Estimates of $F_{0.1}$ (dotted lines) and F_{max} (dashed lines) are indicated on the graphs.

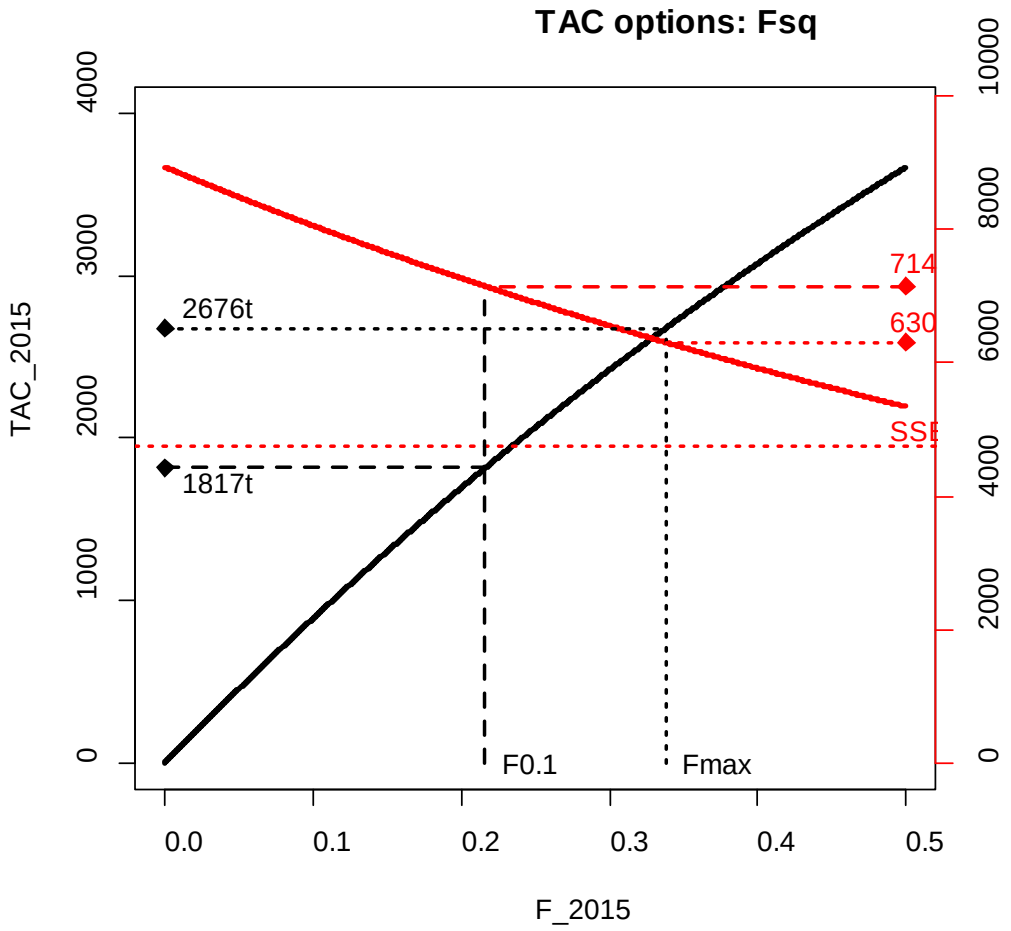


Figure 18.6.1 Turbot in Subarea IV. The impact of the chosen F in 2015 on the expected TAC in 2015 (black, left axis) and resultant SSB in 2016 (red, right axis), assuming $F=F_{sq}$ in the intermediate year (Scenario A from table 18.6.1). TACs and resulting SSBs associated with $F_{0.1}$ and F_{max} are indicated. The red horizontal dotted line shows the SSB estimated in 2014 (start of the intermediate year).

19 Turbot in IIIa (Kattegat–Skagerrak)

Turbot in IIIa has been evaluated for the first time in 2013, in WGNEW working group. Existing information has been collected, including landings and surveys data and a comprehensive literature review on current knowledge on biology and stock identity. WGNEW did also discuss currents issues and limitations in biological sampling for this stock.

Much of this work is available in last year's WGNEW report as well as in the stock annex for this stock, and only this year's updates are presented here.

19.1 General biology and historical trends

See information in stock annex and ICES WGNEW 2013.

19.2 Stock identity and possible assessment areas

Following IPBNEW in 2012 (ICES 2013), and considering the life-history characteristics of turbot (low larval dispersal, strong spawning site fidelity, limited migration of the species) and the observed genetic patterns, ICES WGNEW 2013 argued that Skagerrak and Kattegat turbot populations are inherently different from the turbot in the North Sea, and recommended that turbot from the Skagerrak/Kattegat is not included in the North Sea stock. WGNEW recommended that future analysis should elucidate the fine spatial structure of the species in the transition area of the Skagerrak-Kattegat and Belt Sea (i.e. SD 20-24) and the level of spatial disaggregation necessary in the assessment and sustainable management of the species in this area.

Later in 2013, the Stock Identification Methods Working Group (SIMWG) reviewed the issue and concluded that there is actually reason to assume stock structure in Division IIIa, with a pragmatic separation line following the border between SD21 (Kattegat) and SD 20 (Skagerrak), and another separation line between SD 25/26 to the south and SD 27/28 to the north. In order to formulate more robust and de-finitive advice, SIMWG underlined the need for new, coordinated multidisciplinary studies (e.g. genetic markers + tagging), as well as rigorous comparative studies on fecundity.

WGNSSK reviewed this information in 2014, and concluded along the same lines. WGNSSK noted that the issue of turbot stock structure in the IIIa transition area ressembled the issue of plaice stock structure (Ulrich *et al*., 2013, see section 7).

WGNSSK recommends therefore that IIIa is split. Catches of Kattegat turbot shall be evaluated together with Western Baltic. The linkages between turbot in the Skagerrak and turbot in the North Sea are more putative.

19.3 Management regulations

There are no TACs in place for turbot in area IIIa. So far, no analytical assessments leading to fisheries advice have been carried out for turbot in IIIa by ICES. No precautionary reference points have been proposed, and no management plans are in place for this stock.

There is no official EC minimum landing size, although in several geographical areas, Minimum Landing Sizes (MLS) have been installed by different authorities.

19.4 Fisheries data

In IIIa, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale et al., 2009), while today turbot is only caught as by-catch in the trawl and gillnet fisheries. Table 19.1 and Figure 19.1 summarize turbot landings in ICES area IIIa. Over the period 1950 – 2013, total landings (IIIa) ranged from 64 t to 736 t per year, with the lowest landings during the end of 1960´s and the beginning of the 1970s, and the highest peaks in 1977 and in the early nineties (Figure 19.1). In the last decade, the total landings of turbot in IIIa have declined from around 350 t pr year to around or less than 100 t per year, with the exception of 2012, which resulted in almost 200 t of turbot landed in IIIa. 111 tonnes were landed in 2013.

In 2014, catch data for turbot-kask were uploaded into InterCatch, according to the specification of the common WGNSSK-WGMIXFISH-WGNEW data call. This allowed compiling information by area and metier. Length-based information was provided (mainly for Kattegat), but no ages.

Discard ratios were provided for strata summing up to 82% of the reported landings.For those strata, discards ratios were estimated at 14% of catches in the Kattegat, but only 2% in the Skagerrak (with an average of 6% for the entire area).

19.5 Survey data, recruit series and analysis of stock trends

Two survey series catching turbot are available: the Internationl Bottom Trawl Survey (IBTS); with two research vessels: Argos and Dana), and the Baltic Internationl Trawl Survey (BITS) with the Danish vessel Havfisken (KASU survey). WGNEW noted that the IBTS catches very little turbot and did not investigated this index further (Figure 19.2-3). On the other hand, data from Havfisken trawl survey (BITS), which covers the Kattegat and the southern part of the Skagerrak, showed much larger catches during the same time period and area (Figure19.4-5). Thus it was considered that Havfisken trawl survey (BITS) could be used to derive an index of abundance of turbot in IIIa. The estimated CPUE were computed in n/h, and a tentative biomass proxy was calculated using a fixed length-weight relationship from www.fishbase.org (a=0.00802, b=3.260).

All indices are noisy and trends are unclear. (Figure 19.6). The proportion of change in CPUE estimated for the last two years (2012-2013) compared to the previous three years (2009-2011) was a decrease around for BITS Q4 (both in number and in weight), but no trends were detected for Q1 (CPUE ratios around 1). (Table 19.2). Results are similar using the 3:5 rule.

A reopening of the advice in not needed.

The length frequency distribution estimated from BITS surveys and aggregated every 5 years showed large individuals are very rare in the catches as most of the fish caught are under 30 cm (Figure 19.7-8).

19.6 Biological sampling

WGNEW (2013) noted that turbot is classified as a Group 2 species under the DCF, and detailed some issues limiting the ability of member states to collect biological information for that stock.

19.7 Population biological parameters and other research

No relevant biological information derived from the catches of turbot in IIIa were presented at the WG. No other relevant research is ongoing for turbot in IIIa.

19.8 Data recommendations

WGNEW (2013) formulated a number of recommendations for improving the biological knowledge on this stock:

In order to meet the DCF-requirements for sampling of biological parameters for turbot in the Kattegat- Skagerrak, the following countries could be valid candidates to fill current data gaps, according to their importance in turbot fisheries;

- Denmark in the Kattegat-Skagerrak
- Sweden in Kattegat-Skagerrak

General recommendations

- EU to upgrade turbot from Group 2 to Group 1, forcing relevant Member States to collect biological information on a yearly basis
- Relevant Member States to include market sampling for turbot in their National Proposals, thus generating the required funds through the DCF.

19.9 References

ICES. 2013. Report of the Working Group on Assessment of New MoU Species (WGNEW), 18 - 22 March 2013, ICES HQ, Copenhagen, Denmark. ACOM .

ICES. 2012. Report of the Inter-Benchmark Protocol on New Species (Turbot and Sea bass; IBPNew 2012), 1–5 October 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:45. 239 pp.

Table 19.1. Turbot in IIIa: total landings by country from 1950 to 2013.

Year	BEL	DEU	DNK	GBR	NLD	NOR	SWE	Total
1950	0	13	212	0	0	1	73	299
1951	0	6	191	0	0	6	62	265
1952	0	6	114	0	0	3	58	181
1953	0	4	80	0	0	4	51	139
1954	0	0	78	0	0	1	61	140
1955	0	4	77	0	0	0	49	130
1956	0	7	75	0	0	0	41	123
1957	0	3	108	0	0	0	30	141
1958	0	7	112	0	0	0	41	160
1959	0	6	132	0	0	3	43	184
1960	0	11	115	0	0	2	46	174
1961	0	4	130	0	0	0	45	179
1962	0	5	157	0	0	0	0	162
1963	0	4	124	0	0	0	0	128
1964	0	5	89	0	0	0	0	94
1965	0	6	79	1	0	0	0	86
1966	0	2	104	0	0	0	0	106
1967	0	4	68	1	0	0	0	73
1968	0	0	64	0	0	0	0	64
1969	0	1	75	0	0	0	0	76
1970	0	1	76	0	0	0	0	77
1971	0	1	100	0	0	0	0	101
1972	0	2	130	0	0	0	0	132
1973	0	2	98	0	0	0	0	100
1974	0	1	116	0	0	0	0	117
1975	0	2	167	0	7	0	7	183
1976	7	2	178	0	190	0	6	383
1977	7	4	331	0	389	0	5	736
1978	2	4	327	0	186	0	6	525
1979	8	0	307	0	87	0	4	406
1980	7	0	205	1	14	0	6	233
1981	2	0	183	2	12	0	8	207
1982	1	0	164	1	9	0	7	182
1983	4	0	171	0	24	0	10	209
1984	0	0	176	0	0	0	12	188
1985	1	0	224	0	0	0	16	241
1986	2	0	180	0	0	0	11	193
1987	5	0	147	0	0	0	9	161
1988	2	0	115	0	11	0	10	138
1989	2	0	173	0	0	0	9	184
1990	5	0	363	0	0	0	18	386
1991	4	0	244	0	0	7	21	276
1992	4	0	278	0	0	8	19	309

1993	3	0	336	0	0	10	0	349
1994	2	0	313	0	0	15	22	352
1995	4	0	268	0	0	17	11	300
1996	0	0	185	0	0	13	11	209
1997	0	0	200	0	0	9	11	220
1998	0	0	148	0	0	7	8	163
1999	0	0	139	0	0	10	6	155
2000	0	0	180	0	0	6	6	192
2001	0	0	227	0	0	8	3	238
2002	0	0	205	0	0	11	5	221
2003	0	0	128	0	13	14	4	159
2004	0	0	119	0	14	7	7	147
2005	0	0	108	0	7	6	6	127
2006	0	1	95	0	8	8	9	121
2007	0	1	138	0	15	7	12	173
2008	0	1	121	0	4	6	11	143
2009	0	1	94	0	2	6	17	120
2010	0	0	72	0	6	4	13	95
2011	0	1	78	0	0	7	13	99
2012	0	0	168	0	0	8	14	189
2013	0	0	91			5	15	111

Table 19.2. Turbot in IIIa: Average CPUE (n/h) estimated from BITS (KASU) surveys for quarter 1 and quarter 4 between 1996 and 2014, and DLS calculations using 2:3 and 3:5 rules

	Q1	Q1	Q4	Q4
Year	wt	number	wt	number
1992				
1993			1.294	2.000
1994			0.744	2.000
1996	0.860	1.955	0	0.000
1997	0.557	0.422	0.962	1.727
1998	1.033	2.500	0.207	0.667
2001	0.689	1.818	0.597	1.185
2002	0.254	0.621	0.683	1.515
2003	0.732	1.848	0.236	0.515
2004	0.445	1.030	4.088	2.258
2005	0.393	0.894	0.636	1.197
2006	0.884	1.227	0.362	0.470
2007	0.361	0.894	0.427	1.000
2008	0.809	1.788	0.517	0.867
2009	0.336	0.633	0.303	0.606
2010	0.717	1.533	0.783	2.233
2011	0.400	0.803	0.437	0.712
2012	0.416	0.591	0.304	0.742
2013	0.944	1.455	0.216	0.545
2014	0.190	0.482		
2 yrs average	0.567	0.968	0.260	0.644
3 yrs average	0.516	0.842	0.319	0.667
3 previous	0.511	0.976	0.508	1.184
5 previous	0.525	1.130	0.479	1.035
2:3	1.11	0.99	0.51	0.54
3:5	0.98	0.75	0.67	0.64

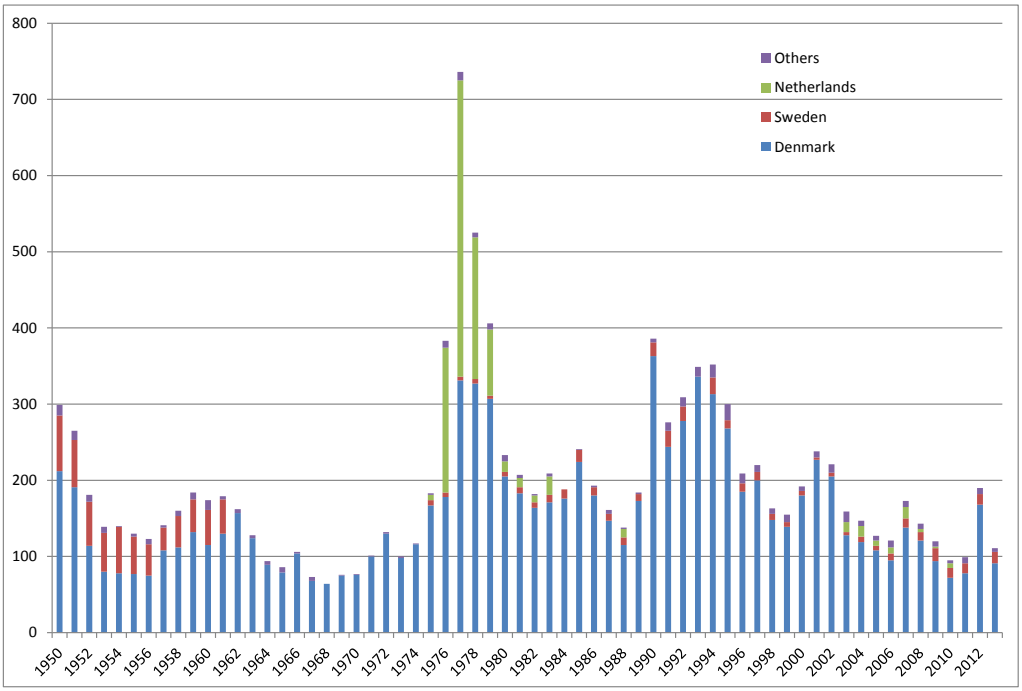


Figure 19.1. Turbot in IIIa: total landings by country from 1950 to 2013.

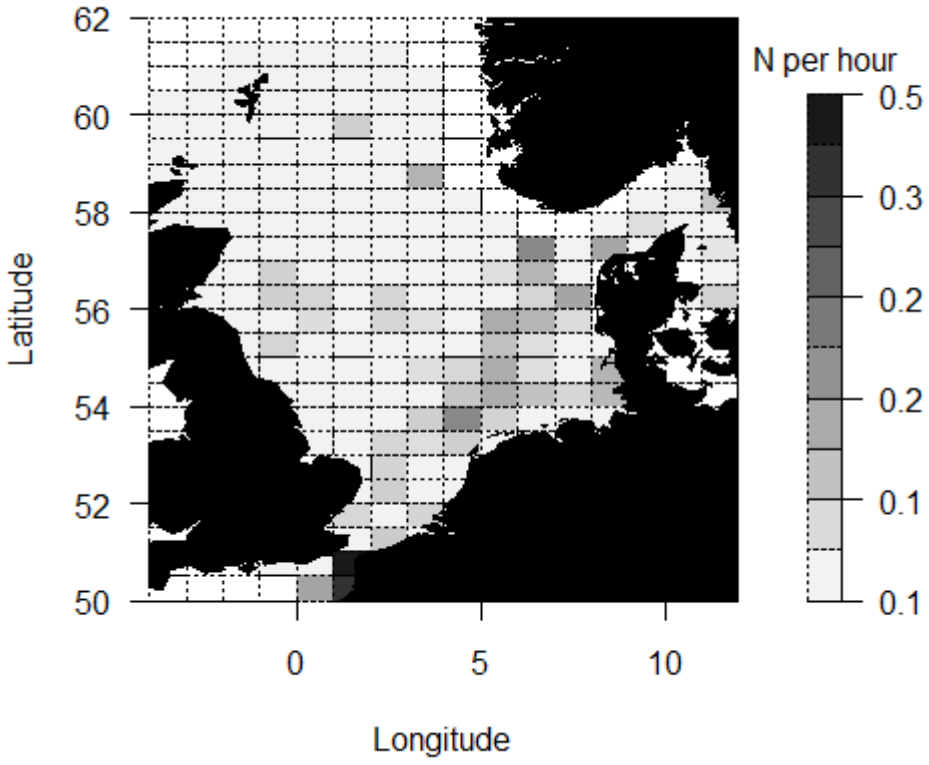


Figure 19.2. Turbot in IIIa. Spatial distribution of the CPUE (n/h) estimated from IBTS trawl surveys during quarter 1 using the entire time series (1966-2012). North Sea is also shown for comparison (from WGNEW, 2013).

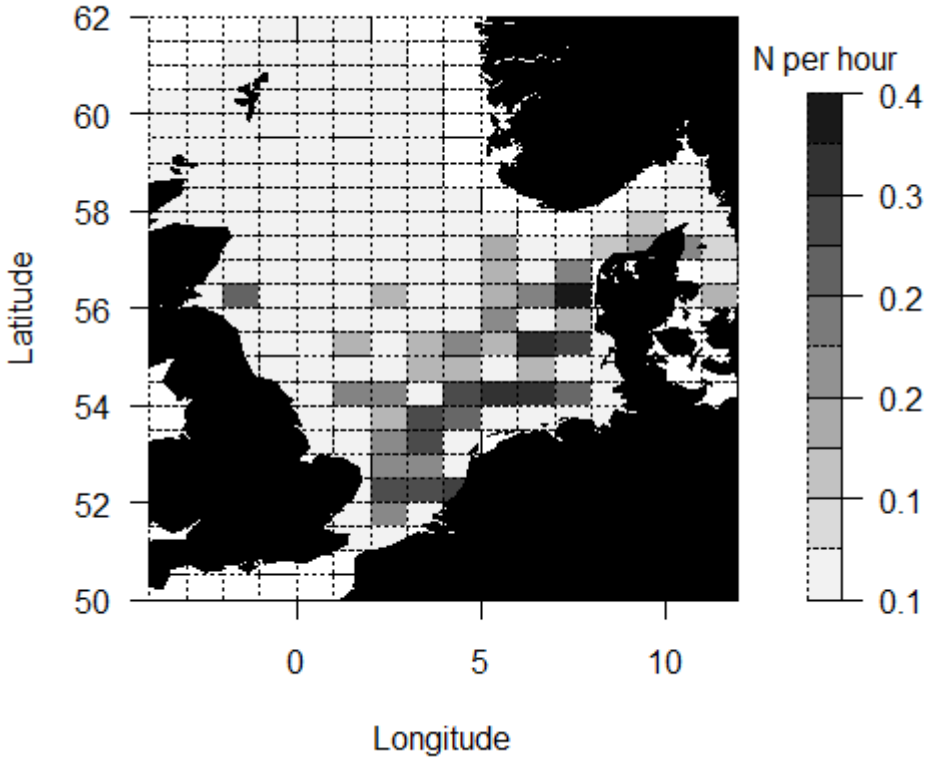


Figure 19.3. Turbot in IIIa. Spatial distribution of the CPUE (n/h) estimated from IBTS trawl surveys during quarter 3 using the entire time series (1991-2012). North Sea is also shown for comparison. (From WGNEW, 2013)

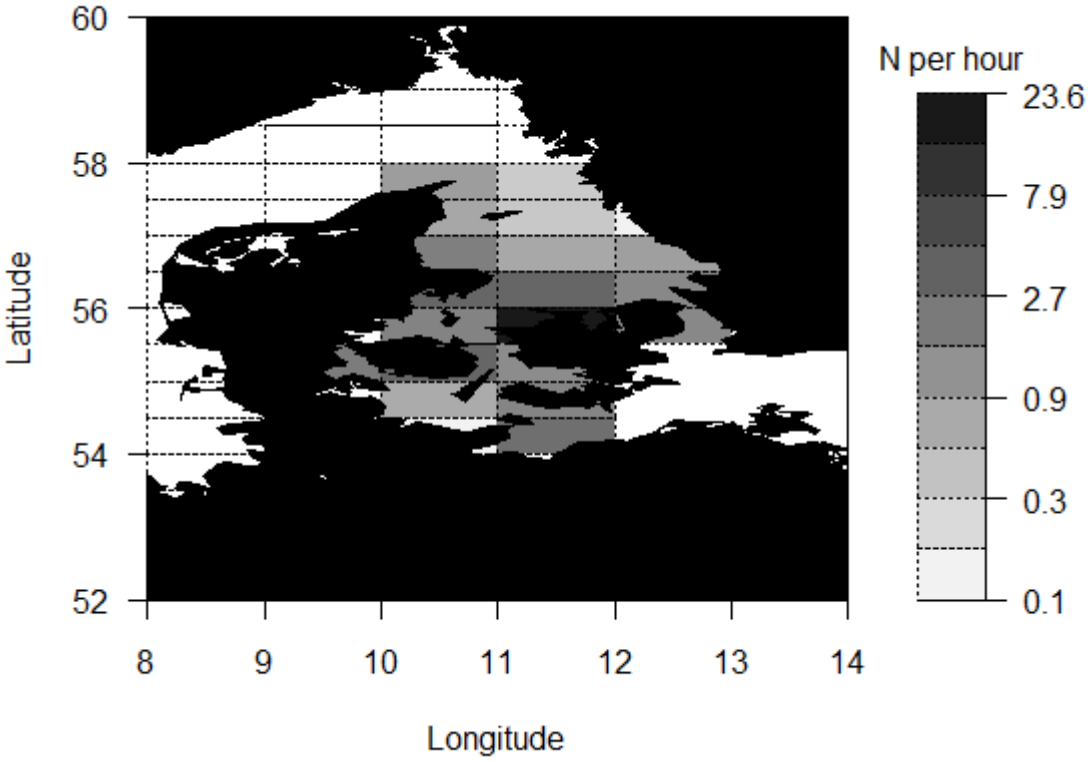


Figure 19.4. Turbot in IIIa. Spatial distribution of the CPUE (n/h) estimated from BITS trawl survey during quarter 1 using the entire time series (2004-2012). Western Baltic Sea is also shown for comparison. (From WGNEW, 2013)

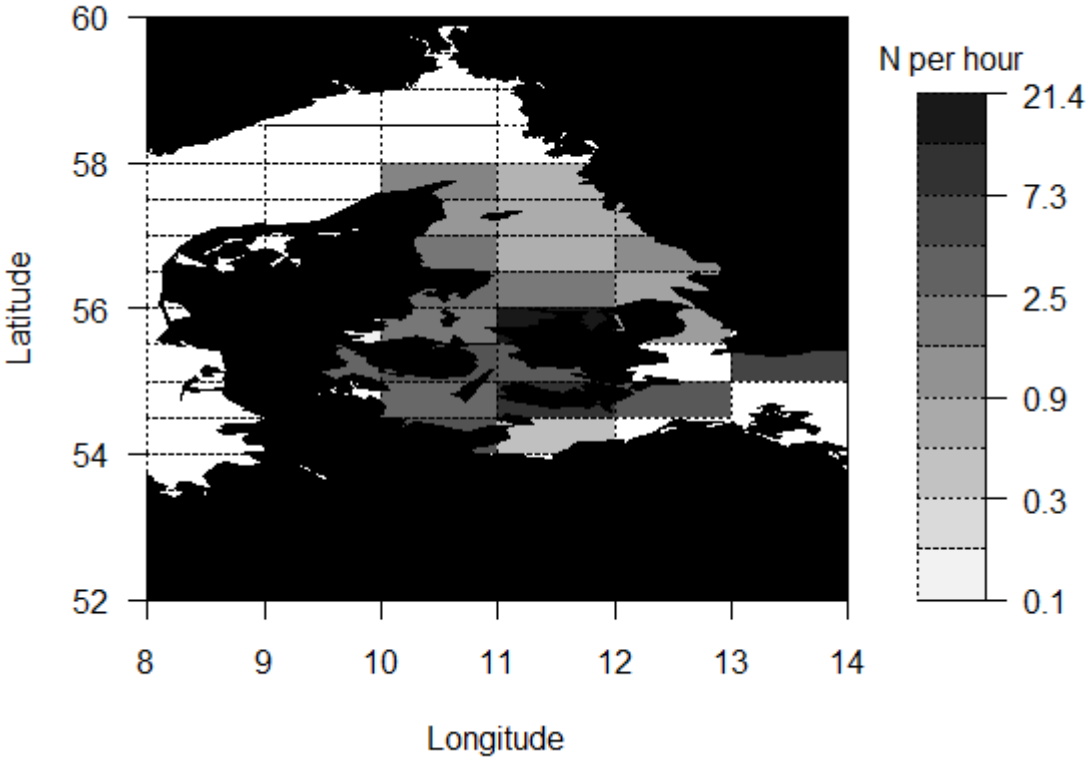


Figure 19.5. Turbot in IIIa. Spatial distribution of the CPUE (n/h) estimated from BITS trawl survey during quarter 4 using the entire time series (2004-2012). Western Baltic Sea is also shown for comparison. (From WGNEW, 2013)

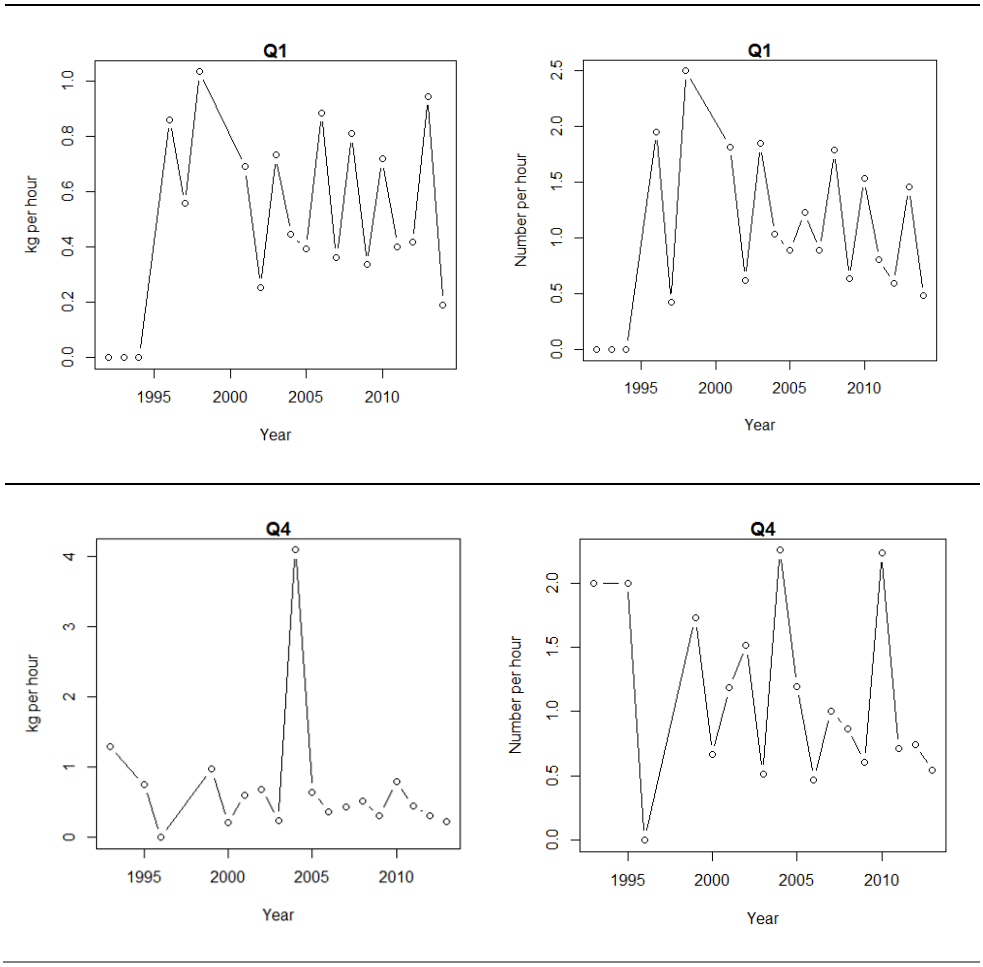


Figure 19.6. Turbot in IIIa. Trend in cpue (in kg/h, left or in n/h, right) estimated from BITS surveys between 2004 and 2012 in quarter 1 (top) and quarter 4 (bottom).

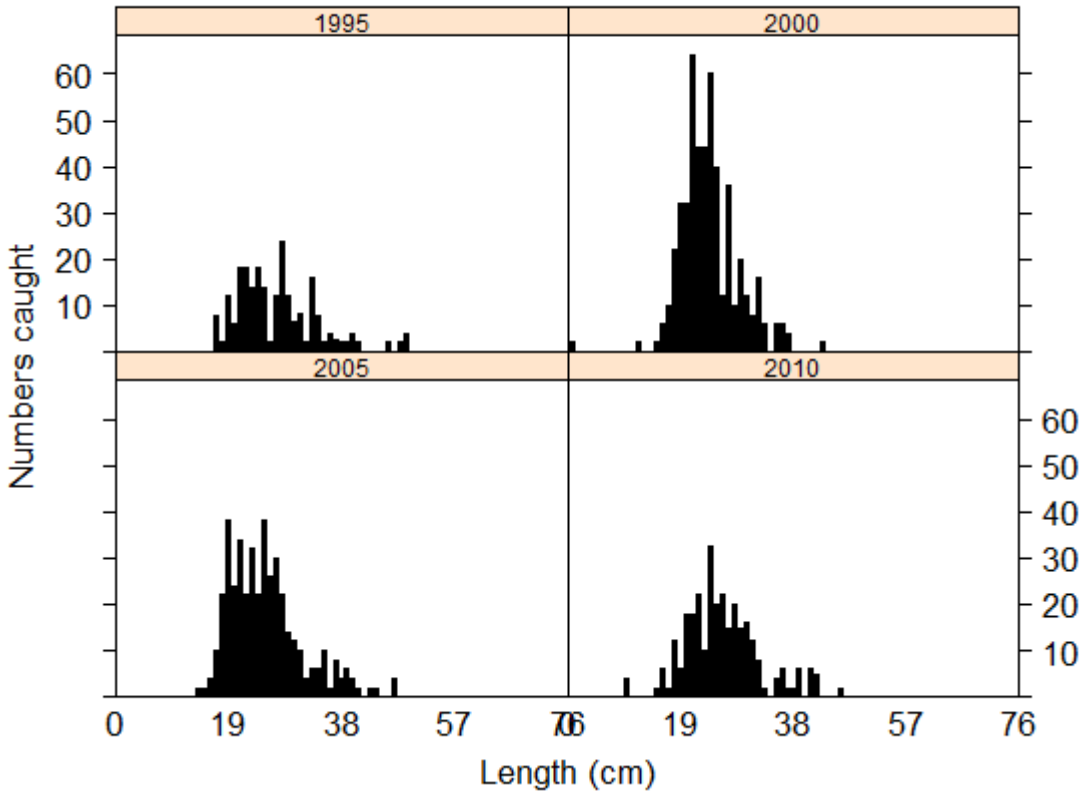


Figure 19.7. Turbot in IIIa. Length frequency distribution derived from BITS surveys in quarter 1 and aggregated every 5 years. (From WGNEW, 2013)

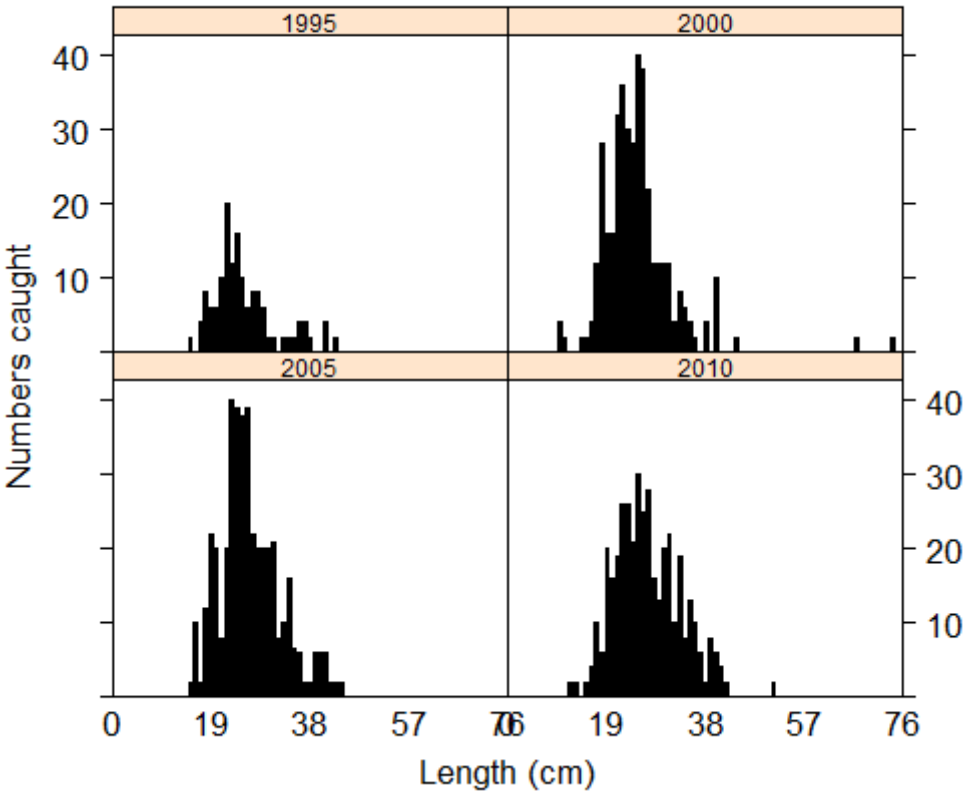


Figure 19.8. Turbot in IIIa. Length frequency distribution derived from BITS surveys in quarter 4 and aggregated every 5 years. (From WGNEW, 2013)

20 Brill in Subarea IV, Subdivision IIIa and VIId e

20.1 General

Brill (*Scophthalmus rhombus*) was assessed in the Working Group on Assessment of New MoU Species until 2013 (ICES, 2013a). Because only official landings and survey data were available, brill in the Greater North Sea was defined as a category 3 stock according to the ICES guidelines for data limited stocks (ICES, 2012a). WGNSSK refined the WGNEW-advice in this final year (ICES, 2013b), and biennial advice was given in 2013 (ICES, 2013c) on the basis of LPUE-trends of the Dutch beam trawl fleet (vessels > 221kW). In 2014, the stock was included in the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group.

20.1.1 Biology and ecosystem aspects

Brill is a shallow-water flatfish mainly found in areas close inshore. It prefers sandy bottoms, but can sometimes also be found on gravel and muddy grounds. Its vertical distribution ranges from 4 meters to 73 meters, although small juvenile fish are often common in sand shore pools. Mature brill are rarely observed inshore, whereas immature specimens are often caught near the coast and even in estuaries.

The distribution of brill in the North Eastern Atlantic ranges along the European coastline from 64° N (the Lofotes) down to 30° N, extending into the Mediterranean and even into the Black Sea (Nielsen, 1986). Brill is also found in the Skagerrak, the Kattegat, and small quantities in the Baltic Sea. The western limit of its distribution area is reached in southern Iceland. The distribution in the North Sea, Skagerrak and Kattegat, based on presence/absence in a number of surveys, is shown in Figure 9-1.

The feeding habits of this species closely resemble those of turbot and were extensively reviewed by de Groot (1971) and Wetsteijn (1981). The pelagic larvae feed primarily on copepod nauplii, decapod and mollusc larvae. With increasing size, this diet gradually changes from larger invertebrate prey and larvae of several fish species to small fish. Larger brill (> 40 cm) are primarily piscivorous.

More information on the biology of brill can be found in Annex 5 of WGNEW(2010).

20.1.2 tock identity and possible assessment areas

The oldest study that could be found containing information on the genetic structure of brill was carried out by Blanquer *et al.* (1992), using allozyme electrophoresis. No genetic differentiation could be found between Atlantic and Mediterranean populations, suggesting that there are also very low levels of differentiation in brill from different areas.

In the EU funded study on 'Stock discrimination in relation to the assessment of the brill fishery' the following was concluded (Delbare and De Clerck, 1999): "As a final conclusion, biological parameters (composition of Belgian brill landings, growth rate and reproduction characteristics) and the sequencing of the D-loop resulted in insignificant differences between brill from the different areas. Therefore, arguments favour the hypothesis that brill from the NE Atlantic might be considered to be only one population: the North-eastern Atlantic brill population. Further research on spawning areas and migration through respectively egg surveys and tagging experiments, could generate valuable information about (sub-)population structures of brill throughout its

entire distribution area. Therefore it is advisable to extend the sampling area to the Mediterranean Sea and the Black Sea."

Currently, the genetic structure of brill over its entire distribution area is being characterized by ILVO and the University of Leuven, Belgium. Genetic variation was found to be of mean to high levels, but the results show almost no differentiation between potential biological populations and/or management units. Therefore, we still feel confident in treating brill in IIIa, IV and VIIde as a single stock, that could potentially have an even wider geographical spread.

Further research on brill spawning areas (egg surveys), and of migration of adult (tagging experiments) and especially immature brill (tagging experiments and genetic analysis of the immature population components) could still generate valuable information about (sub-)population structure of brill throughout its entire distribution area.

More information on the delineation of potential brill stocks can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.1.3 Management regulations

Although several EC regulations affect the flatfish fisheries in the North Sea (e.g. effort restrictions, minimum mesh sizes), no explicit management objectives have been defined for the stock of brill in the Greater North Sea, and no management plans are in place. However, for the EU-waters in Division IIa and Subarea IV, precautionary TACs have been defined for brill and turbot (combined) in the past. It is unclear how the quantitative single species advices for turbot and brill are used to formulate a combined TAC, that belongs entirely to the EU-fisheries. A historical overview is presented in the table below.

Historical overview of combined TACs for brill *Scophthalmus rhombus* and turbot *Scophthalmus rhombus* in Division IIa and Subarea IV

Year	2000	2001	2002	2003	2004	2005	2006	2007
TAC	9000	9000	6750	5738	4877	4550	4323	4323
Year	2008	2009	2010	2011	2012	2013	2014	
TAC	5263	5263	5263	4642	4642	4642	4642	

No restriction on the minimum length for landing brill is imposed by the EC. Some authorities have however installed Minimum Landing Sizes (MLS) for brill. The most frequently applied MLS is 30 cm (e.g., in Belgium, the Baltic, the English Sea Fisheries District Cornwall, …).

20.2 Fisheries data

20.2.1 Landings

Table 20.1 and Figure 20.1.a summarise the official brill landings from the Greater North Sea, subdivided into Subarea IV, Division IIIa and Divisions VIIde (Source: ICES Fishstat). Over the period 1950 – 1970, total landings ranged from 582 t to 947 t per year, followed by a gradual increase to 2121 t in 1977. During 1978 – 2013, total landings varied between 1517 t (in 1980) and 3141 t (in 1993). Since 2000, annual total landings fluctuated around an average of 2371 t (range: 2142 t – 3141 t). The North Sea (IV) accounts for the major part of these landings (Figure 20.1.b), on average generating 68% of the totals over the time series (range: 50-86%). The English Channel and the Skagerrak are responsible for average contributions to the international brill landings of 19%

and 13% respectively. The Skagerrak was responsible for a higher relative importance in the total landings during the first two decades of the time series, and the English Channel has gained importance since the late seventies. No trend towards a higher or lower mean relative contribution of a certain Subarea or Division is apparent in the data for the more recent years. It is however possible that these trends (or lack thereof) are influenced by incomplete statistics for the early part of the time series.

The landings by country for the Skagerrak, the North Sea and the English Channel are not presented in this update year, but historical patterns can be consulted in the report of WGNEW 2013 (ICES, 2013a). More details on the Belgian, Dutch, French and UK fisheries catching brill, and information on length- and age-distributions of Belgian brill landings can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.2.2 Discards

Due to its high value and the absence of a European Minimum Landing Size, brill is not expected to be discarded easily by fishermen catching the species as long as the quota have not been fully taken. The fact that the species is characterised by a fast growth, quickly reaching commercially interesting lengths (unfortunately at relatively young ages and while still immature), smaller individuals are rather rare in commercial catches, which contributes to the low numbers of discards.

Although discard rates and/or discard data that were raised to fleet levels were available to WGNSSK 2014 for some countries participating in the brill fishery, these were not analysed or incorporated in the assessment as 2014 was an update year. Furthermore, earlier evaluations resulted in the labelling of this stock as a one with negligible discards. Discard rates from the Belgian (ILVO) discard observer programme in the beam trawl fishery (mesh size range 70-99) for the years 2008 – 2012 in IV, VIId and VIIe, and length distributions of these discards, were presented by WGNEW 2013 (ICES, 2013a). The highest rate that was ever documented in this programme was only 0.7% (in IV). Keeping in mind these low rates for beam trawls that are traditionally known for their aselective properties and large proportions of discards, the amount of discarding of brill does not seem to be a substantial problem for the assessment of the state of the species's stocks in terms of data quality : landings can be considered to be a reliable proxy for total catch.

From a biological perspective it's a very different story, as most of the discarded fish have not reached sexual maturity yet, and as such have not had the chance to reproduce and contribute to the future generations.

More details on the numbers at length discarded per hour in the Dutch beam trawl fleet (North Sea) can be found in Annex 5 of WGNEW 2010 (ICES, 2010).

20.3 Survey data, recruit series

20.3.1 Survey Data

General

Catches of brill are generally very low on surveys. These low catch numbers very often result in an underrepresentation of some year-classes (mainly the older ones), leading to a poor quality of the resulting survey abundance series and indices, and poor agreement among different surveys.

WGNEW 2012 (ICES, 2012b) tested four surveys for their potential use in describing stock trends of brill in the greater North Sea. Three of these surveys take place in the

North Sea (IBTS_TRI_Q1, BTS_TRI_Q3 and BTS_ISI_Q3) and one in the English Channel (CGFS_Q4). Time series of total numbers of brill caught by the three North Sea surveys and the Channel are depicted in WGNEW 2012 (ICES, 2012b), but only the BTS_ISI_Q3 was found to catch a sufficient number of individuals to be useful in the context of evaluating stock trends of North Sea brill. WGNEW 2013 and WGNSSK 2014 did not go into these surveys again, with exception for the BTS_ISI_Q3 that was updated because of its use as an indicator in the advice that was issued in 2013 (ICES, 2013c). For the Skagerrak/Kattegat, the Danish IBTS_HAF_Q1&4 was identified to be a usefull indicator for the evaluation of the substock of brill in Division IIIa, and the plots and tables were also updated for this survey.

North Sea (Subarea IV)

The abundance indices (numbers per hour) for brill in the BTS_ISI_Q3 in IV are spatially plotted per rectangle in Figure 20.2 and over time in Figure 20.3 and Table 20.2. These seem to illustrate a recovery of the species in IV since 2009 after a period of consistent lower catches during 2001-2008, followed by a drop in abundance in 2012-2013. The inter-annual variation between all other years is so big that no real trend is apparent over the entire time series. Therefore, the lower catches per hour in 2012 (1.04/hr) in comparison with the higher values in the three preceding years (1.42-2.41/hr), were not yet considered to represent an alarming signal by WGNEW 2013. The confirmation of the low abundance by the survey in 2013 (0.76/hr, even lower than in 2012 and the 6th lowest value in the time series) raises some concerns.

The corresponding ALK, length distributions (per 5 years) and length-at-maturity are illustrated in ICES (2012b) (without the final year 2013). These showed that mainly brill of ages 1-2 and lengths of 20-45cm are caught in this survey and that no obvious shifts in length distributions are apparent over the time series (1987-2012). All brill under 30 cm were immature, and all above 40 cm were mature, with a mix of mature and immature individuals between 30 and 40 cm.

Skagerrak/Kattegat (Division IIIa)

Data on brill from the Danish BITS-survey in the Kattegat (BITS_HAF_Q1&4) were analysed separately for the two quarters in which this survey runs by WGNEW 2013 (ICES, 2013a), revealing almost identical patterns for Q1 and Q4. Therefore, it was decided to combine the data from both quarters for the evaluation of the brill substock in IIIa, and only the results of this combined analysis are updated and presented in this report. The fact that this survey only covers the Kattegat (IIIaS) and not the Skagerrak (IIIaN) was not considered to be a problem by WGNEW 2013 as the deeper northern waters don't harbour important numbers or densities of brill, that generally prefers more shallow waters.

The abundance indices (numbers per hour) for brill in the BITS_HAF_Q1&4 are spatially plotted per rectangle in Figure 20.4 and over time in Figure 20.5 and Table 20.3. These illustrate a period with higher catches (2006-2011) after a period of consistent lower catches (1996-2005). In 2012, the numbers caught per hour dropped to the level of 2004-2005 again but given the noise in the data (large inter-annual variations) it may be preliminary to interprete this as a sign of a decreasing stock. However, as in the survey used as an indicator for brill in the North Sea, the lower abundance of 2012 (2.27/hr) in IIIa was also followed by an even lower abundance in 2013 (2.13/hr). Although the 2013 survey index value is around three times higher in IIIa compared to IV, the confirmation of decreasing survey catches in IIIa adds to the concern expressed above.

The corresponding ALK, length distributions (per 5 years) and length-at-maturity for the BITS_HAF_Q1&4 in IIIa were illustrated in ICES (2013a) and the updates are not presented in this report. These showes that mainly brill of ages 1-3 and lengths of 10-40cm are caught in this survey and that no alarming shifts in length distributions (no obvious loss of larger/older individuals from the population) are apparent over the time series (1996-2012). All brill under 30 cm were immature, but there is a much bigger overlap in length between the immature and mature stages compared to the North Sea, with mature individuals of lengths lower than 20 cm. This illustrates the general phenomenon of slower growth at higher lattitudes that was also published for brill by Delbare & Declerck (1999), that didn't include the Skagerrak/Kattegat in their overview.

English Channel (Divisions VIIde)

Unfortunately, no usefull survey index could be identified for the evaluation of the brill substock in the English Channel during previous WGNEW meetings (ICES, 2010, 2012b, 2013a).

20.3.2 Commercial LPUE series

Although the survey indices presented above are useful indicators when evaluating the state of the brill stock in (parts of) the Greater North Sea area, WGNSSK 2013 argued that the spatial coverage of both surveys was insufficiently spanning the stock area, and the catches too low, to use these surveys as a basis for catch advice.

Landings of brill from the North Sea, the accompanying effort and a corrected LPUE series from the Dutch beam trawl fleet > 221 kW were presented to and discussed during WGNEW 2013 (see ICES, 2013a for interpretation). The landings fluctuated with little variation while the effort showed a consistent decline from 2002 to 2008 and a stabilization from 2008 to 2012, resulting in an increasing LPUE series (kg/day). Given the facts that the majority of the brill landings from the greater North Sea originate from Subarea IV, and that around 70% (on average) of these are landed by the Netherlands, this LPUE series may be considered a more reliable time series when evaluating the stock trend of brill in the Greater North Sea. The updated LPUE series is presented in Table 20.4 and Figure 20.6 (including comparison with the LPUE trend used last year).

The Landings Per Unit of Effort (LPUE) were standardised for engine power and corrected for targeting behavior in a way similar to those used to analyse commercial LPUE data for North Sea plaice. The standardization for engine power is relevant as trawlers are likely to have higher catches with higher engine powers, as they can trawl heavier gear or fish at higher speeds. The correction for targeting behaviour relies on reducing the effects of spatial shifts in fishing effort by calculating the fishing effort by ICES rectangle and subsequently averaging these over the entire fishing area. More information on the data that were used (EU logbook auction data and, market sampling data), the calculation of the LPUEs, the standardization of engine power, the correction for targeting behavior and the results can be found in van der Hammen *et al.* (2011).

20.4 Biological sampling and population biology parameters

No new information was obtained compared to previous WGNEW reports.

20.5 Analyses of stock trends and potential status indicators

So far, no analytical assessments leading to fisheries advice have been carried out for brill in the Greater North Sea by ICES. In the absence of collated and analysed biological data, Category 3 of the ICES Data Limited Stocks Methodology (ICES, 2012a) is currently the highest attainable category for this stock. Method 3.2.0 specifies that catch advice can be derived from the survey-adjusted status-quo catch in situations where there are survey data on abundance (e.g. CPUE over time), but survey-based proxies for MSY $B_{trigger}$ and F values are not known. Also other indicators of stock size can be used.

WGNEW and WGNSSK tested several surveys for their information content regarding brill in the Greater North Sea over the last few years, and decided to retain only the BTS_ISI_Q3 in IV and the BITS_HAF_Q1&4 in IIIa as indicators for this stock. WGNSSK 2013 opted to use the commercial LPUE series from the Dutch beam trawl fleet > 221kW as a more reliable time series and basis for the advice, and this information was recalculated and updated with the information from 2013 during WGNSSK 2014. The exact values of the commercial LPUE series have changed compared to last year (see Fig. 20.6 and Table below), but the new series shows the same trend as the old one (less steep increase in the new series) and ends at comparable values in the final year. Therefore it was concluded that the perception of the stock did not change compared to last year, and that the advice issued in 2013 is still valid in 2014.

Calculation of the catch advice

Although no new catch advice is calculated for this stock in 2014, it is worth reflecting on the calculation methodology as two different systems are currently applied within ICES.

To calculate the catch advice, WGNEW 2013 suggested for a number of stocks to deviate from the agreed methodology (the 2:3-rule) in which the change of the stock size indicator (lpue in this case) is calculated as the mean of the last two years divided by the mean of the preceding three years. Instead it was suggested to use a 3:5-rule, with the main reason for this suggestion being the noise in the survey data. Calculating means over longer time periods would lower the influence of these big inter-annual differences, that may well be caused by the low numbers of individuals caught and by different climatic circumstances during the survey in different years, and don't necessarily reflect real changes in stock size. This way the catch advice would not jump up and down with the noise in the survey data. WGNSSK 2013 adopted the suggested approach, but applied it to the lpue-data whereas WGNEW intended its recommendation to be carried out in case the survey series would have been used as basis for the advice. In this discussion there will be no further focus on the type of data that are used to calculate the catch advice, as 2014 is the second year in the advice cycle of this biennial stock. But given the fact that the 3:5-system was not evaluated by ICES (the 2:3-rule was evaluated and found to be precautionary), it should be thoroughly rediscussed during WGNSSK 2015 that will issue a new advice for brill in the Greater North Sea.

As can be seen from the table below, applying a certain calculation method to the 'old' or the 'new' lpue series doesn't make a lot of difference in both the 2:3 and the 3:5 scenario's. The difference between the two calculation methods when applied on the same data series however does create a very different perception of the stock. The stock increases in both cases, but with very different rates (25% increase when applying 2:3,

44% when applying 3:5). As the allowed increase of the catch advice is capped at 20%, this does not make a difference in this case. Applying a 20% increase to the three-recent-years average catch (2194 tonnes) would results in a new catch advice of maximum 2632,5 tonnes, being in the same range as the maximum catch of 2727 tonnes that was adviced in 2013 (and repeated in 2014).

	LPUE (kg/day)					
	New (2014)	Old (2013)				
2002	21,46	22,3				
2003	25,17	27,8				
2004	25,67	26,8				
2005	24,71	25,8				
2006	25,57	26,5				
2007	31,32	32,2				
2008	38,22	39,1				
2009	37,86	39,2				
2010	42,40	46,4				
2011	45,98	51,1	"2:3 New"	"2:3 Old"	"3:5 New"	"3:5 Old"
2012	51,40	55,3	23%	28%	48%	56%
2013	53,73		25%		44%	

20.6 References

Blanquer, O.A., Alayse, J.P., Berrada-Rkhami, O. and Berrebi S. 1992. Allozyme variation in turbot (Psetta maxima) and brill (Scophthalmus rhombus) (Osteichthyes, Pleuronectiformes, Scophthalmidea) throughout their range in Europe. J. of Fish Biol., 41: 725-736.

de Groot, S.J. 1971. On the inter-relationships between the morphology of the alimentary tract, food and feeding behaviour in flatfishes. Netherlands Journal of Sea Research, 5: 121–196

Delbare, D. and De Clerck, R. 1999. Stock discrimination in relation to the assessment of the brill fishery - Study in support of the Common Fisheries Policy. Final Report EC-Study Contract DG XIV 96/001.

ICES 2010. Report of the Working Group on Assessment of New MoU Species (WGNEW), 11-15 October 2010, ICES Headquarters, Denmark. ICES CM 2010/ACOM: 21.

ICES 2012a. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

ICES 2012b. Report of the Working Group on Assessment of New MoU Species (WGNEW), 5-9 March 2012, ICES Headquarters, Denmark. ICES CM 2012/ACOM:20.

ICES 2013a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM:21.

ICES 2013b. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24-30 April 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM:13.

ICES 2013c. Dab in Subarea IV and Division IIIa, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.28.

Nielsen, J.G. 1986. Scophthalmidae. In: Fishes of the North-eastern Atlantic and the Mediterranean. Volume III. P.J.P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (Eds.). Published by the United Nations Educational, Scientific and Cultural Organizations.

van der Hammen, T., J.J. Poos & F. Quirijns (2011). Data availability for the evaluation of stock status of species without catch advice. Case study: Turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*). IMARES-report C109/11.

Wetsteijn, B. 1981. Feeding of North Sea turbot and brill. ICES CM 1981/G:74.

Table 20.1. Total international landings (t) of brill *Scophthalmus rhombus* in the Greater North Sea over the period 1950-2013, subdivided into Subarea IV, Division IIIa and Divisions VIIde (Source: ICES Fishstat).

Year	IIIa	IV	VIIde	TOTAL
1950	319	384	59	762
1951	337	511	78	926
1952	236	565	72	873
1953	246	589	62	897
1954	234	529	60	823
1955	212	571	61	844
1956	213	516	60	789
1957	148	468	70	686
1958	203	480	67	750
1959	233	424	59	716
1960	318	486	52	856
1961	305	581	47	933
1962	207	591	55	853
1963	120	620	51	791
1964	106	565	60	731
1965	155	535	48	738
1966	187	546	53	786
1967	106	409	67	582
1968	100	579	57	736
1969	99	658	190	947
1970	97	618	59	774
1971	104	1073	66	1243
1972	120	994	75	1189
1973	131	989	90	1210
1974	200	1152	81	1433
1975	187	1222	137	1546
1976	224	1208	285	1717
1977	388	1410	323	2121
1978	216	1375	411	2002
1979	184	1363	459	2006
1980	82	1033	402	1517
1981	59	1218	490	1767
1982	74	1294	487	1855
1983	83	1448	526	2057
1984	97	1522	531	2150
1985	110	1709	494	2313
1986	107	1207	456	1770
1987	105	970	493	1568
1988	101	1085	452	1638
1989	97	1302	425	1824
1990	128	893	543	1564

Year	IIIa	IV	VIIde	TOTAL
1991	99	1682	470	2251
1992	146	1810	463	2419
1993	212	2439	490	3141
1994	222	1916	490	2628
1995	151	1434	558	2143
1996	112	1247	608	1967
1997	106	957	501	1564
1998	132	1283	451	1866
1999	157	1280	240	1677
2000	141	1508	678	2327
2001	98	1573	738	2409
2002	90	1302	716	2108
2003	128	1346	759	2233
2004	156	1249	666	2071
2005	133	1160	611	1904
2006	140	1175	649	1964
2007	158	1240	741	2139
2008	184	1004	593	1781
2009	147	1162	591	1900
2010	122	1500	695	2317
2011	131	1497	622	2250
2012	120	1512	617	2249
2013	92	1390	601	2082

Table 20.2. Survey index (N°/hr) for brill *Scophthalmus rhombus* in the BTS_ISI_Q3, Subarea IV.

Year	N/hr	Year	N/hr
1987	1,9957265	2001	0,6913580
1988	0,6666667	2002	0,7947304
1989	0,9362745	2003	1,0000000
1990	2,2962963	2004	0,8214286
1991	1,8710526	2005	0,0000000
1992	3,6793860	2006	0,8716931
1993	3,3062753	2007	1,0952381
1994	2,3622590	2008	0,5138889
1995	1,8011775	2009	1,4246488
1996	0,7647059	2010	2,1853733
1997	2,0000000	2011	2,4057061
1998	1,4301503	2012	1,0411007
1999	0,7523810	2013	0,7586207
2000	2,1945342		

Table 20.3. Survey index (N°/hr) for brill *Scophthalmus rhombus* in the BITS_HAF_Q1&4, Division IIIa.

Year	N/hr
1996	1.9090909
1997	0.3888889
1998	0.5000000
1999	1.8333333
2000	0.5555556
2001	1.0416667
2002	1.8030303
2003	1.3636364
2004	2.2045455
2005	2.0833333
2006	3.8181818
2007	3.6196970
2008	4.0500000
2009	3.0912698
2010	3.8893939
2011	3.6136364
2012	2.2651515
2013	2.1390227

Table 20.4. Commercial LPUE (kg/day) for brill *Scophthalmus rhombus* in the Dutch beam trawl fleet > 221kW, Subarea IV.

Year	LPUE (kg/day)
2002	21.46
2003	25.17
2004	25.67
2005	24.71
2006	25.57
2007	31.32
2008	38.22
2009	37.86
2010	42.40
2011	45.98
2012	51.40
2013	53.73

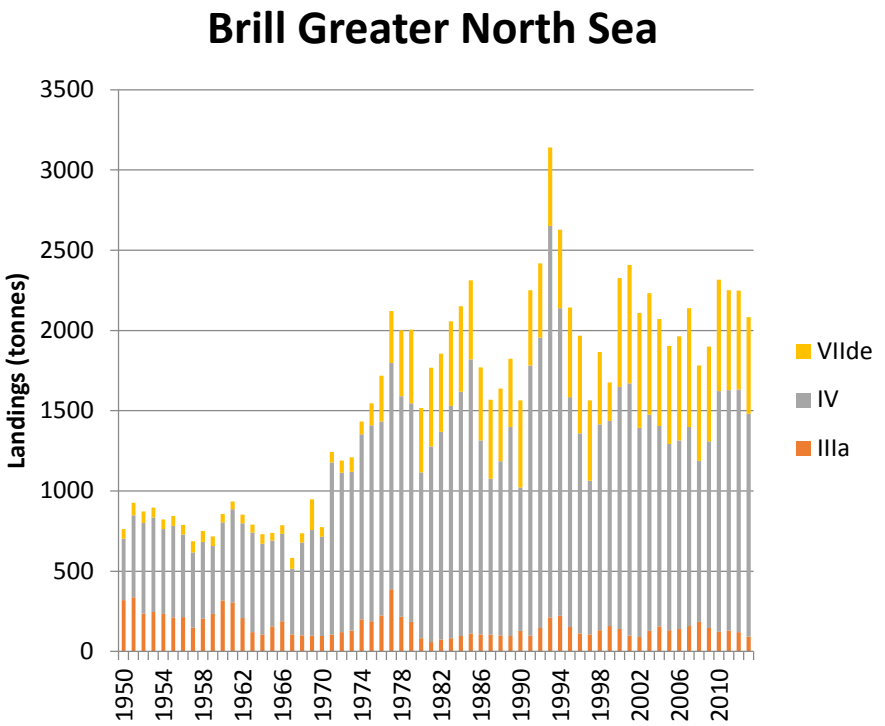


Figure 20.1.a. Total international landings (t) of brill *Scophthalmus rhombus* in the Greater North Sea over the period 1950-2013, subdivided into Subarea IV, Division IIIa and Divisions VIIde (Source: ICES Fishstat).

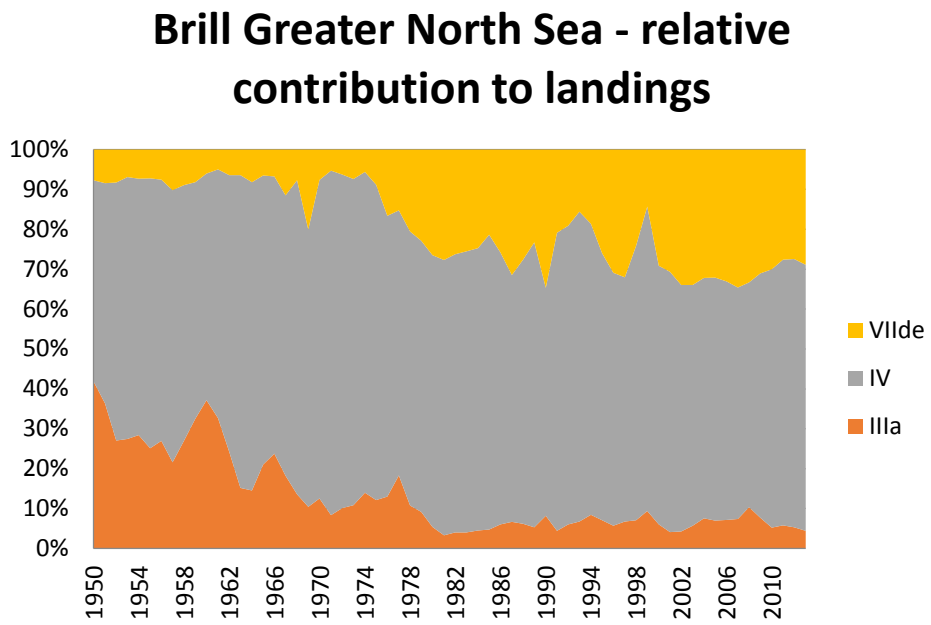


Figure 20.1.b. Relative contribution of landings of brill *Scophthalmus rhombus* from Subarea IV, Division IIIa and Divisions VIIde to the total international landings (t) in the Greater North Sea over the period 1950-2013 (Source: ICES Fishstat).

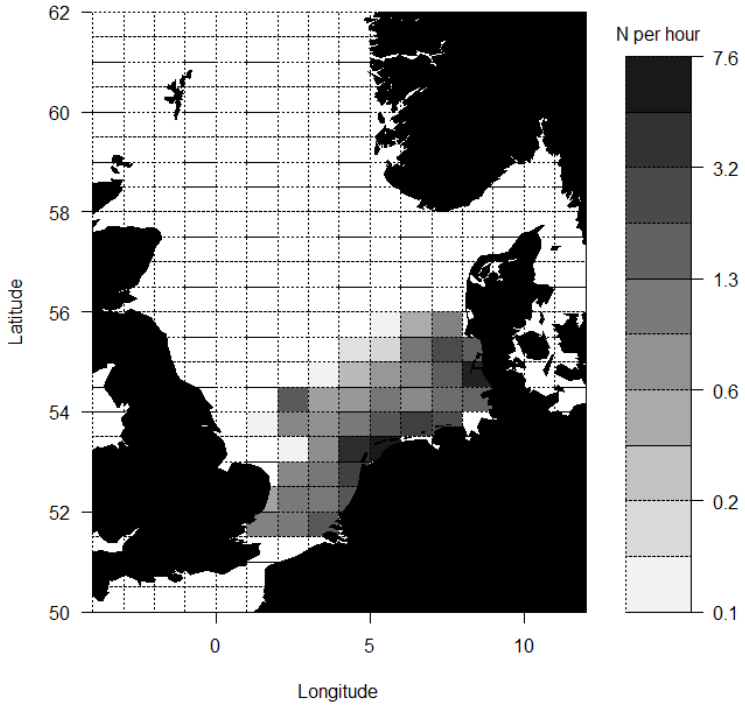


Fig. 20.2. Numbers of brill *Scophthalmus rhombus* caught per hour and rectangle by BTS_ISI_Q3 in the North Sea (IV).

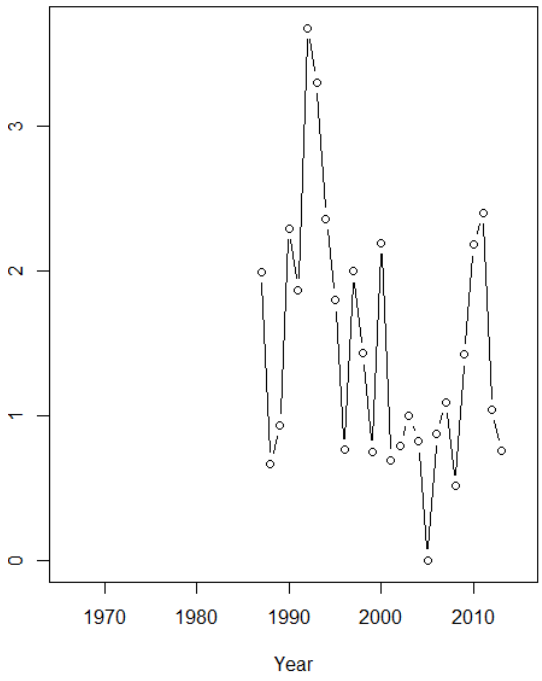


Fig. 20.3. Abundance index (numbers caught per hour) of brill *Scophthalmus rhombus* for the BTS_ISI_Q3 in the North Sea (IV).

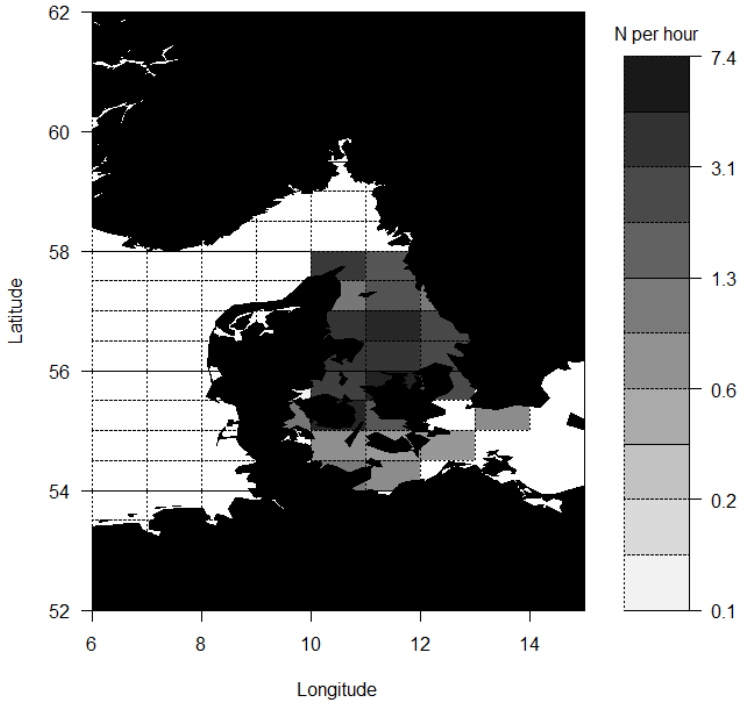


Fig. 20.4. Numbers of brill *Scophthalmus rhombus* caught per hour and rectangle by BITS_HAF_Q1&4 in the Kattegat (IIIaS).

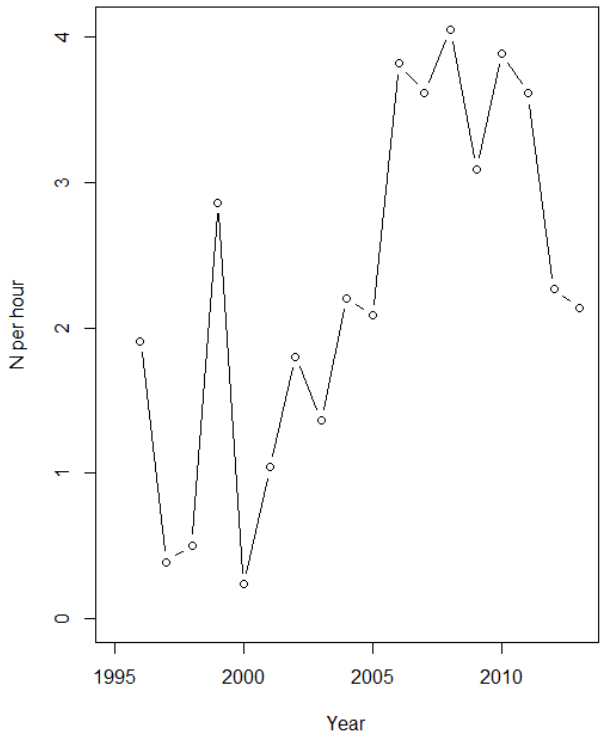


Fig. 20.5. Abundance index (numbers caught per hour) of brill *Scophthalmus rhombus* for the BITS_HAF_Q1&4 in the Kattegat (IIIaS).

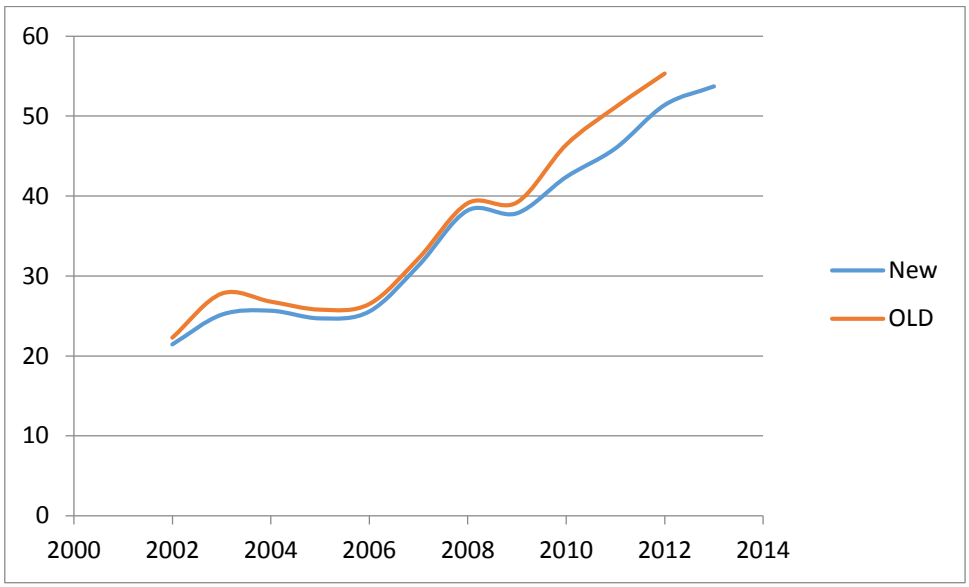


Fig. 20.6. Commercial LPUE (kg/day) of brill in the Dutch beam trawl fleet > 221kW (standardized for engine power and corrected for targeting behaviour). The blue line represents the updated LPUE series, the red line is last year's perception.

21 Dab in Subarea IV (North Sea) and Division and IIIa (Skagerrak – Kattegat)

21.1 General

Dab (*Limanda limanda*) was assessed so far in the Working Group on Assessment of New MoU Species (ICES, 2013a). Because only official landings and survey data were available, dab was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for dab was given in 2013 (ICES, 2013b), based on survey trends. In 2014, dab was included to the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group.

21.1.1 Biology and ecosystem aspects

Dab is a widespread demersal species on the Northeast Atlantic shelf and distributed from the Bay of Biscay to Iceland and Norway, including the Barents Sea and the Baltic. In the North Sea it is one of the most abundant species distributed over the whole area in depths down to 100m, but it was also found occasionally down to depths of 150m. The main concentration of dab can be found in the south eastern North Sea. Dab feeds on a variety of small invertebrates, mainly polychaete worms, shellfish and crustaceans. Early sexual maturation was reported for dab, maturing at ages of 2 to 3 years corresponding to approximately 11 to 14cm. Peak spawning in the south eastern North Sea occurs from February to April.

More details on available data and knowledge can be found in the dab stock annex.

21.1.1.1 Stock ID and possible assessment areas

The several spawning grounds and the wide distribution of dab indicate the presence of more than one stock. Meristic data (Lozán 1988) corroborate the hypothesis of several stocks for dab, distinguishing significantly between populations from western British waters and the North Sea and the Baltic.

21.1.2 Management regulations

According to EU-Regulations a precautionary TAC is given in EU waters of IIa and IV together with flounder (*Plathichthys flesus*). The TAC decreased from 2002 to 2013 from about 27 000 to 18 343 t. No minimum landing size is defined. Dab is mainly a bycatch species in fisheries for plaice and sole. The discard rates for dab are extremely high. TACs may not be appropriate as a management tool for bycatch species.

21.2 Fisheries data

21.2.1 Historical landings

Dab is a by-catch species in fisheries for plaice, sole and demersal roundfish. According to ICES catch statistics, annual landings of dab in ICES Divisions IV and IIIa has been well above 10 000 t since 1973 (Figure 21.2.1.1). The apparent decreases in official landings in the 1980's and 1990's are due to unreported catches by the Netherlands and Norway. However, in recent years landings in area IV and area IIIa decreased. The main fishing gear in the North Sea is the beam trawl with mesh sizes between 80 and

100mm. The largest part of the landings in area IV is taken by the Netherlands, followed by UK and Denmark (Figure 21.2.1.2). In division IIIa Denmark is landing the largest amount of dab (Figure 21.2.1.3). Dab is among the most discarded fish species in ICES Division IV. In the beam trawl fishery on sole and the otter trawl fishery on plaice about 95% of the catches on dab are discarded (e.g. van Helmond et al. 2012).

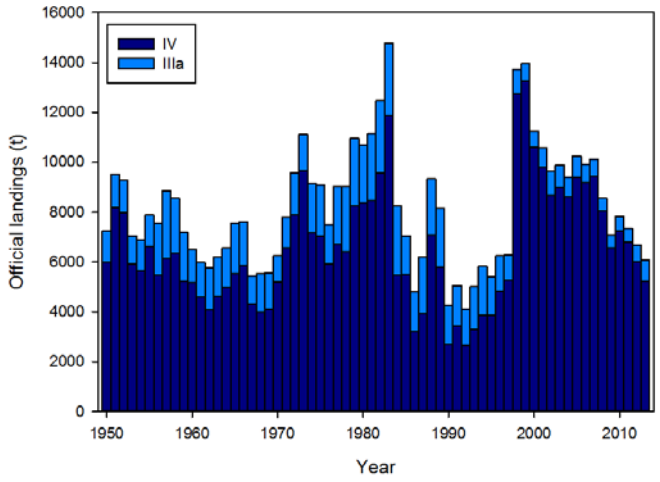


Figure 21.2.1.1 Total official landings of dab in area IV and division IIIa.

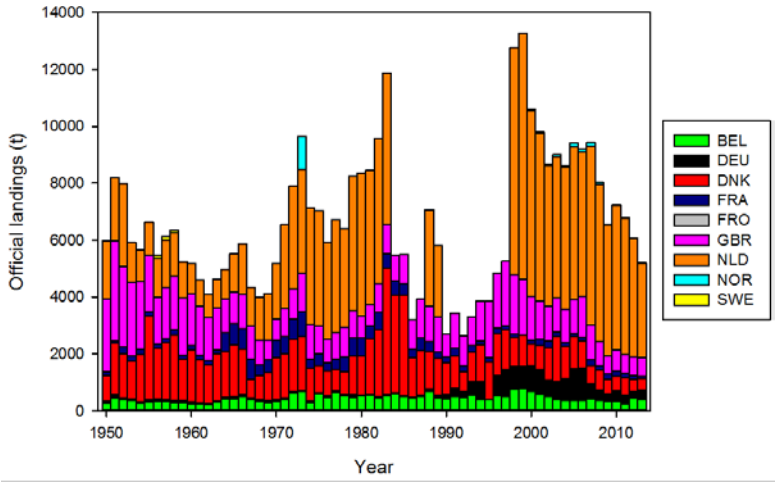


Figure 21.2.1.2 Official landings of dab in area IV by country.

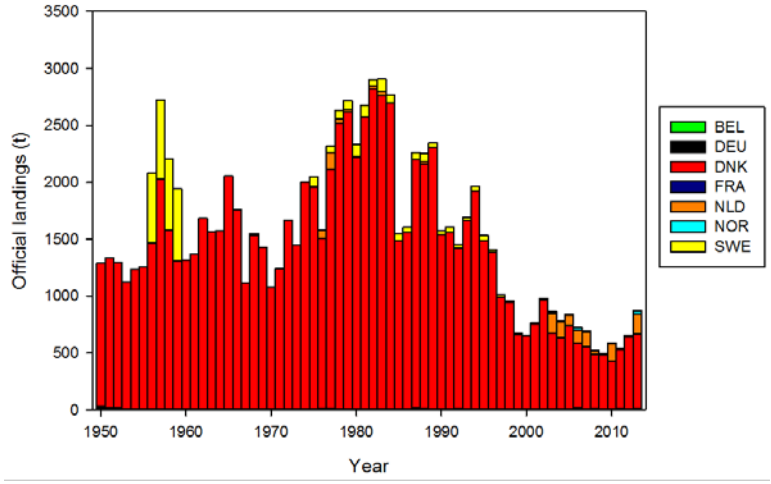


Figure 21.2.1.3 Official landings of dab in division IIIa by country.

21.2.2 InterCatch

In 2014 dab was included for the first time into the data call for WGNSSK 2014. From all countries data were uploaded to the InterCatch data portal. However, UK (England) only provided total landings for all metiers combined, but provided more detailed data for the main metiers separately. France and Scotland only reported landings but no discard information. The largest amount of landings and discards was reported by the Netherlands for the TBB_DEF_70-99_0_0_all metier (Fig. 21.2.2.1 and Fig. 21.2.2.2). Consequently, by far the largest catch is taken by the Netherlands (44544t). All other countries catch less than 10000t (Figure 21.2.2.3). The total catch estimated with Inter-Catch was 68395t from which 6236t were landings and 62159t discards (91% of total catch). It should be noted that not all metiers were sampled in every quarter and that raising procedure may not be adequate in all cases. However, the Dutch TBB_DEF_70-99_0_0_all metier is by far the most important one in terms of landings and discards weight and was sampled in every quarter.

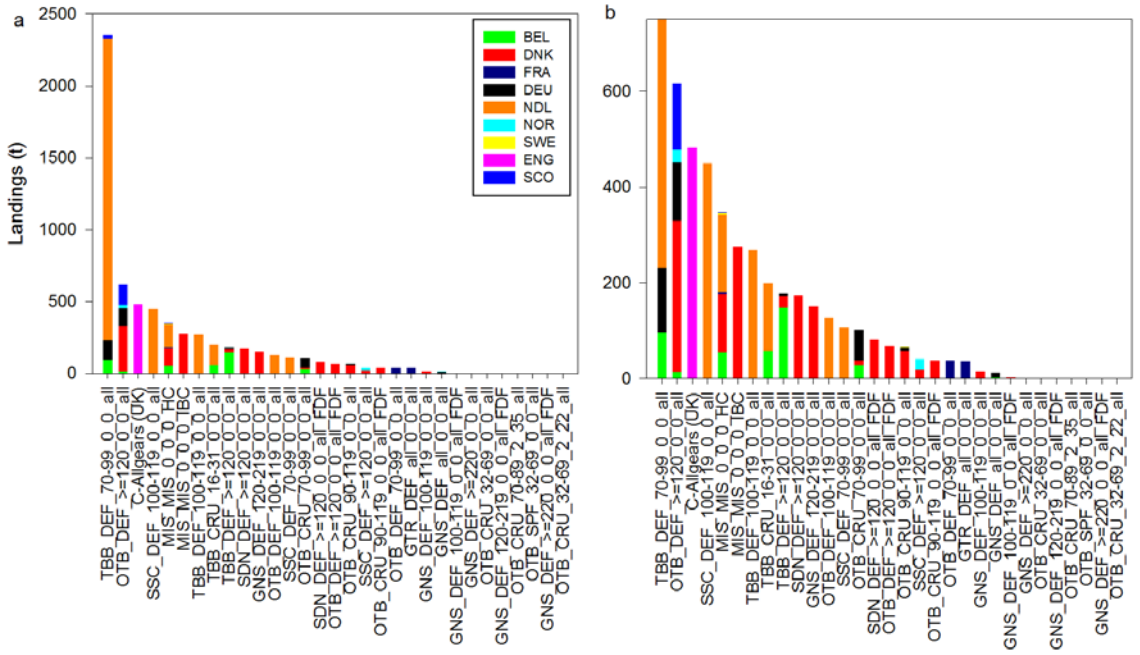


Figure 21.2.2.1 InterCatch. Dab landings for sub-area IV and division IIIa by metier and country as uploaded to InterCatch. Panel (a) and (b) showing the same data, but y-axis in panel (b) is downscaled to visualize details.

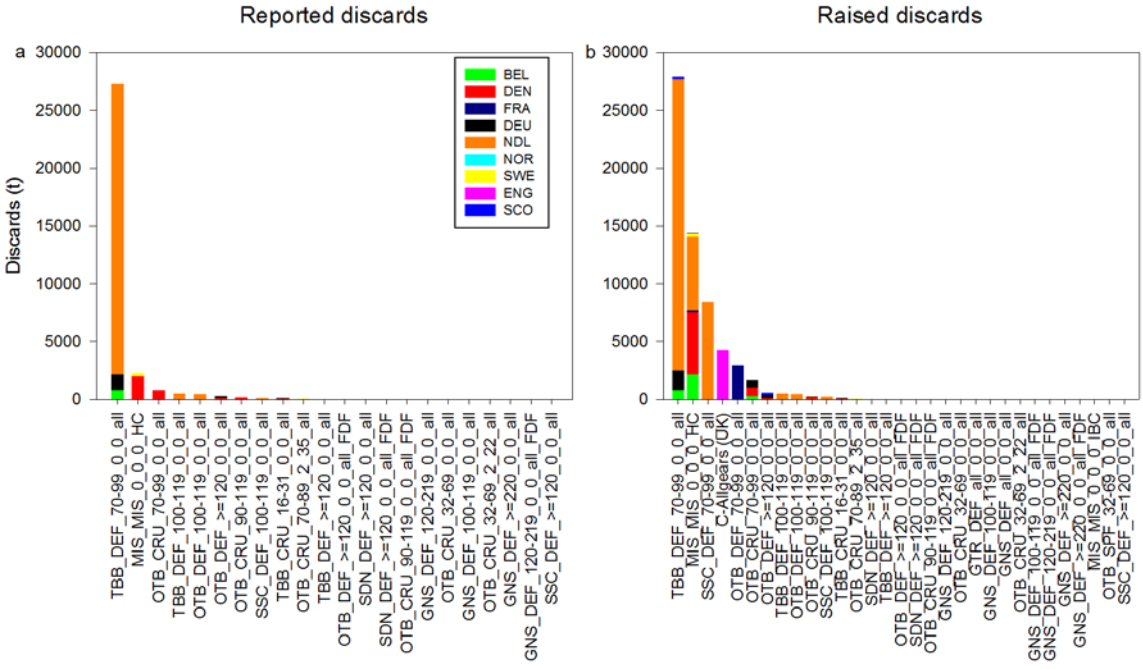


Figure 21.2.2.2 InterCatch. Dab discards for sub-area IV and division IIIa by metier and country. Reported discards panel (a), raised discards panel (b).

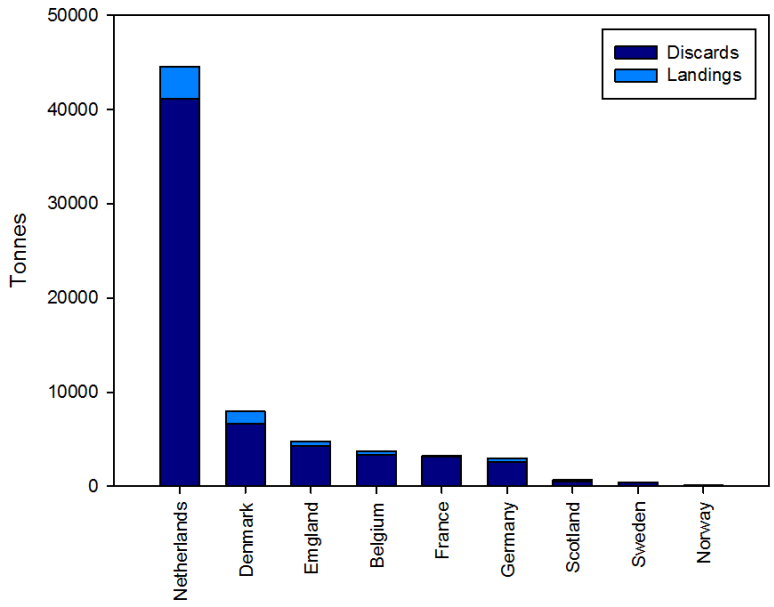


Figure 21.2.2.3 InterCatch. Estimated dab landings and discards for sub-area IV and division IIIa by countries.

21.3 Survey data / recruit series

Surveys providing information on distribution, abundance and length frequency for dab in area IV and division IIIa are the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3 (Figure 21.3.1.), the Beam Trawl Surveys (BTS; only area IV) in quarter 3 and the BITS (only in division IIIa). The IBTS Q1 was used in the case of dab to analyse stock trends. The IBTS Q1 uses a bottom trawl which is not the optimal gear to catch flatfishes. However, the beam trawl surveys do not cover the whole distribution area of dab and catches of dab are also quite high for the IBTS. It should be noted here that for the IBTS the gear in use was fully standardized since 1983. Therefore, index data before this year should be interpreted with caution.

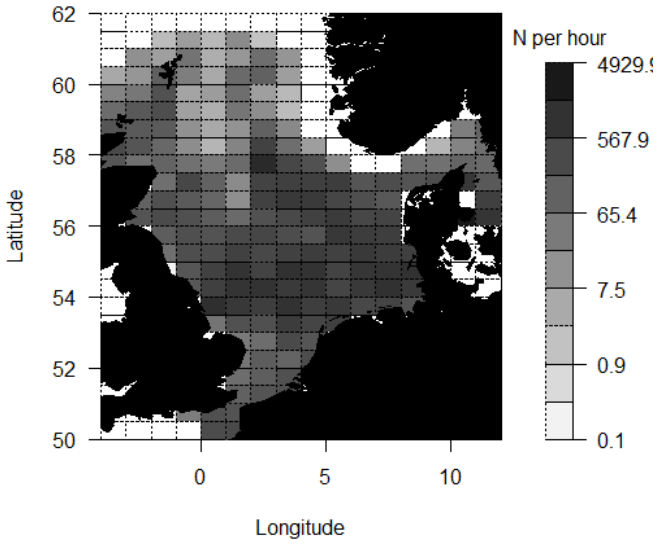


Figure 21.3.1. Distribution of dab in the North Sea derived from IBTS Q1 data.

21.4 Analysis of stock trends / assessment

In 2013, dab was dealt with in the Working Group on the assessment of MoU New Species (ICES, 2013). So far, only landings data and survey trends were available for this species. Therefore, dab was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2013). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. The guidelines further explicitly suggest that in case of missing catch information landings should be taken as the basis for the method. This was the case for dab, for which it was not possible in 2013 to estimate total catches. WGNEW2013 decided to set x=3 and z=8, in order to account for the relative long lived species dab and the noisy nature of the survey indices. An abundance index in number per hour was estimated from the IBTS Q1 survey, because this survey covers most of the distribution area of dab in area IV and IIIa. The 3:5 ratio of the abundance index was estimated to be 7%, resulting in an advised increase in landings (<7795t). Based on these results the advice was drafted for WGNSSK2013, which accepted the advice draft.

However, ACOM criticised the use of a pure abundance index, which reflects more the recruitment. Hence, it was suggested to use of a mature biomass index instead. Further, the approach to change the settings of x and z where not accepted. Based on these criticisms WGNSSK2014 re-examined the available survey data for dab to estimate a mature biomass index and to evaluate the effect of using the 2:3 ratio instead of the applied 3:5 ratio.

Estimated indices

The index estimated by WGNEW2013 used the IBTS Q1 survey which covers most of the distribution area of dab in area IV and IIIa. To estimate the mature biomass index a length weight relationship derived from IBTS Q1 data was estimated (Fig. 21.4.1a). The same data set was used to create a length based maturity ogive (Fig. 21.4.1b). The obtained length weight relationship and the maturity ogive were then applied to estimate the mature biomass index in kg per hour.

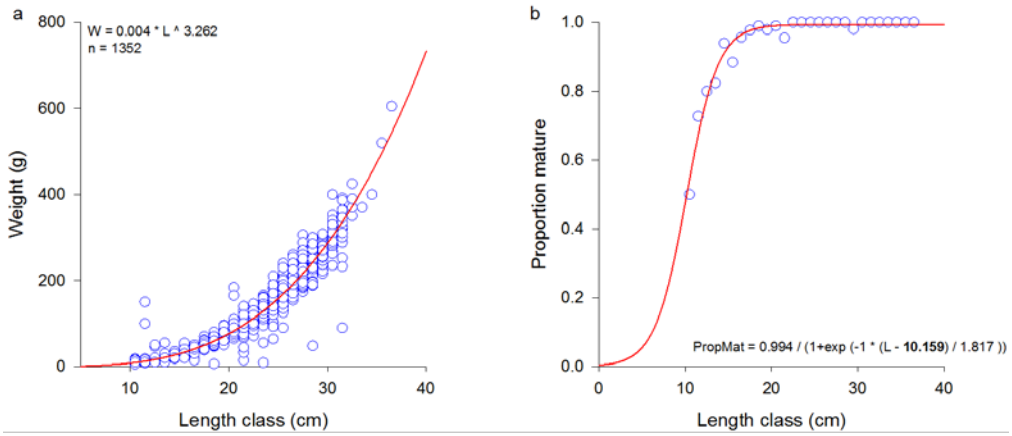


Figure 21.4.1. Length weight relationship of dab (a) and length based maturity ogive (b) obtained from IBTS Q1 data.

From 1983 onwards the abundance index showed an increasing trend (Figure 21.4.2). Since the beginning of the 1990s the stock abundance index is fluctuating on a rather stable level. Compared to 2012 the 2013 value is lower (-26%), but the 2014 value is increasing again (+39% compared to 2012 and +88% compared to 2013). Due to the fact that dab seems to mature quite early ($L_{mat50\%}$=10.2cm) the trend of the mature biomass index in general follows the trend of the abundance index. Compared to 2012 the 2013 value is also lower (-37%). The 2014 data point for the mature biomass index does not show that sharp increase as the abundance index does (-7% compared to 2012 and +49% compared to 2013).

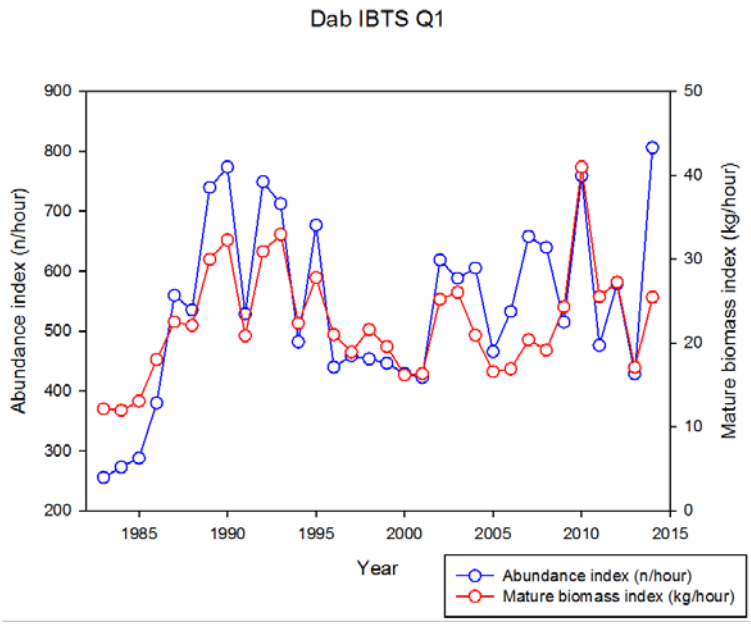


Figure 21.4.2. Abundance index in numbers and mature biomass in kg/hour estimated for dab from IBTS Q1 data.

Different options applying the DLS 3.2 method are displayed in table 21.4.1. Given the high variability in the survey index the change in the advised landings is also very variable ranging from -32% (applying an updated mature biomass index and the 2:3 rule) to +61% (applying 2013 mature biomass index and 3:5 rule). However, the large differences in the change of the advised landings are due to the high variability in the used survey indices and might be driven by one single exceptional value alone, e.g. 2010 in the examples displayed in table 21.4.1.

Table 21.4.1. Results of applying the 3:5 or the 2:3 ratio to the 3.2 DLS method for different stock indices. The basis for the biennial advice given in 2013 is highlighted in green.

	stock indicator	method	ratio	landings avg last 3 yrs	adviced landings	Change
WGNEW 2013	IBTS Q1 abundance	3:5	1.076	7285	7795	7%
	IBTS Q1 abundance	2:3	0.827	7285	6023	-17%
	IBTS Q1 mature biomass	3:5	1.606	7285	11698	61%
	IBTS Q1 mature biomass	2:3	0.938	7285	6833	-6%
WGNSSK 2014	IBTS Q1 abundance	3:5	0.991	6703	6646	-1%
	IBTS Q1 abundance	2:3	1.021	6703	6841	2%
	IBTS Q1 mature biomass	3:5	0.893	6703	5982	-11%
	IBTS Q1 mature biomass	2:3	0.681	6703	4561	-32%

Conclusions

The advice for dab given by ICES in 2013 was biennial and hence valid for 2014 and 2015. WGNSSK concluded not to re-open the advice for dab in 2014. Given the high variability in the survey indices, the new survey information did not change the overall perception of the stock.

Doubts were raised concerning the applicability of the DLS 3.2 method for this stock. First, the survey indices show large variability and estimates of uncertainty are lacking. Further, the applied method is based on landings which is meaningless for a species with very high discards (~90% of total catch in the case of dab estimated for 2013). By applying the DLS 3.2 method not only an average index ratio below one will affect the advised landings but also the average of the last year's landings. This is not suitable for stocks with very high discard rates such as dab where landings do not reflect stock

size at all. However, this year dab was included in the official data call and discards could be raised for the first time using InterCatch. This might enable to give catch advice for this stock in future years given a sufficient coverage of discard samplings across the most important metiers.

21.5 References

ICES 2013a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM.

ICES 2013b. Dab in Subarea IV and Division IIIa, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.28.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Lozán J.L., 1988. Verbreitung, Dichte, und Struktur der Population der Klieschen (*Limanda limanda* L.) in der Nordsee mit Vergleichen zu Popualtionen um Island und in der Ostsee anhand meristischer Merkmale. Arch. Fischereiwiss. 38: 165-189.

Tables

Table 21.6.1 Official dab landings by ICES area IV an division IIIa.

Year	IV	IIIa	Total
1950	5971	1287	7258
1951	8190	1332	9522
1952	7976	1294	9270
1953	5915	1123	7038
1954	5652	1237	6889
1955	6623	1257	7880
1956	5468	2081	7549
1957	6127	2724	8851
1958	6342	2210	8552
1959	5239	1943	7182
1960	5168	1314	6482
1961	4602	1367	5969
1962	4082	1683	5765
1963	4615	1565	6180
1964	4982	1575	6557
1965	5519	2052	7571
1966	5862	1755	7617
1967	4324	1115	5439
1968	3995	1548	5543
1969	4122	1430	5552
1970	5183	1079	6262
1971	6546	1242	7788
1972	7901	1669	9570
1973	9657	1449	11106
1974	7146	2003	9149
1975	7033	2049	9082
1976	5917	1583	7500
1977	6702	2318	9020
1978	6407	2630	9037
1979	8243	2716	10959
1980	8357	2333	10690
1981	8454	2679	11133
1982	9565	2902	12467
1983	11865	2906	14771
1984	5482	2769	8251
1985	5502	1545	7047
1986	3205	1608	4813
1987	3931	2258	6189
1988	7067	2254	9321
1989	5816	2346	8162
1990	2701	1574	4275
1991	3448	1609	5057
1992	2647	1454	4101
1993	3309	1695	5004
1994	3861	1961	5822
1995	3865	1530	5395
1996	4834	1405	6239
1997	5259	1012	6271
1998	12759	961	13720
1999	13276	673	13949
2000	10595	654	11249
2001	9799	765	10564
2002	8678	977	9655
2003	9008	865	9873
2004	8608	779	9387
2005	9402	836	10238
2006	9190	725	9915
2007	9434	694	10128
2008	8029	522	8551
2009	6561	498	7059
2010	7240	589	7829
2011	6808	545	7353
2012	6019	654	6673
2013	5212	870	6082

Table 21.6.2 Official dab landings by country in area IV.

Year	BEL	DEU	DNK	FRA	FRO	GBR	NLD	NOR	SWE	Total
1950	254	92	900	139	0	2555	2031	0	0	5971
1951	462	114	1800	90	0	3503	2221	0	0	8190
1952	386	74	1562	227	0	2823	2904	0	0	7976
1953	357	58	1337	189	0	2591	1383	0	0	5915
1954	255	62	1666	177	0	2393	1099	0	0	5652
1955	305	92	2923	161	0	1993	1149	0	0	6623
1956	338	99	1766	138	0	1660	1368	0	99	5468
1957	336	73	1983	154	0	1785	1669	0	127	6127
1958	290	71	2320	175	0	1885	1517	0	84	6342
1959	285	93	1433	146	0	2011	1265	0	6	5239
1960	246	70	1833	154	0	1813	1052	0	0	5168
1961	227	67	1497	161	0	1734	916	0	0	4602
1962	205	54	1357	147	0	1524	795	0	0	4082
1963	306	40	1660	128	0	1481	1000	0	0	4615
1964	424	48	1612	672	0	1177	1049	0	0	4982
1965	432	64	1841	734	0	1099	1349	0	0	5519
1966	507	65	1589	719	0	1215	1767	0	0	5862
1967	384	77	659	716	0	1147	1341	0	0	4324
1968	334	57	861	350	0	877	1516	0	0	3995
1969	302	69	984	448	0	689	1630	0	0	4122
1970	338	71	1476	588	0	752	1958	0	0	5183
1971	409	46	1546	618	0	986	2941	0	0	6546
1972	638	46	1816	727	0	1057	3617	0	0	7901
1973	678	41	1899	873	0	1349	3638	1179	0	9657
1974	281	59	1168	310	0	1227	4101	0	0	7146
1975	600	45	944	418	0	992	4031	0	3	7033
1976	489	52	852	306	0	816	3402	0	0	5917
1977	652	70	743	371	0	907	3959	0	0	6702
1978	520	64	799	513	0	1038	3473	0	0	6407
1979	484	87	1366	630	0	951	4724	0	1	8243
1980	518	24	1376	639	0	777	5023	0	0	8357
1981	542	31	1968	447	0	737	4729	0	0	8454
1982	460	42	2356	594	0	1002	5111	0	0	9565
1983	541	49	4428	495	0	1034	5318	0	0	11865
1984	603	35	3438	486	0	920	0	0	0	5482
1985	509	24	3535	404	0	1030	0	0	0	5502
1986	445	34	1400	289	0	1036	0	0	1	3205
1987	514	36	1574	434	0	1373	0	0	0	3931
1988	697	72	1324	349	0	1221	3404	0	0	7067
1989	443	117	1280	223	0	1232	2521	0	0	5816
1990	416	162	1103	214	0	802	0	0	4	2701
1991	491	290	1160	258	0	1249	0	0	0	3448
1992	464	218	699	217	0	1049	0	0	0	2647
1993	548	493	1016	235	0	1017	0	0	0	3309
1994	397	626	1307	133	0	1398	0	0	0	3861
1995	410	0	1306	155	1	1993	0	0	0	3865
1996	527	718	1484	177	0	1928	0	0	0	4834
1997	507	945	1399	124	0	2284	0	0	0	5259
1998	757	796	1024	126	0	2085	7971	0	0	12759
1999	802	758	1101	0	0	1964	8651	0	0	13276
2000	684	892	785	124	0	1534	6527	49	0	10595
2001	575	878	839	206	0	1368	5886	47	0	9799
2002	516	582	1126	228	0	1224	4951	51	0	8678
2003	396	642	1580	154	0	1204	4955	77	0	9008
2004	382	767	1136	121	0	1158	4989	55	0	8608
2005	372	1105	1128	121	0	1193	5352	131	0	9402
2006	369	1149	949	130	0	1415	5071	107	0	9190
2007	436	526	634	195	0	1212	6313	118	0	9434
2008	371	375	670	161	0	847	5544	61	0	8029
2009	349	262	489	196	0	648	4588	29	0	6561
2010	337	365	523	178	0	724	5097	16	0	7240
2011	243	312	622	149	0	645	4808	29	0	6808
2012	446	252	421	126	0	665	4130	41	0	6019
2013	404	333	404	82	0	647	3316	26	0	5212

Table 21.6.3 Official dab landings in ICES division IIIa.

Year	BEL	DEU	DNK	FRA	NLD	NOR	SWE	Total
1950	0	34	1253	0	0	0	0	1287
1951	0	17	1315	0	0	0	0	1332
1952	0	21	1273	0	0	0	0	1294
1953	0	9	1114	0	0	0	0	1123
1954	0	4	1233	0	0	0	0	1237
1955	0	3	1254	0	0	0	0	1257
1956	0	5	1462	0	0	0	614	2081
1957	0	5	2025	0	0	0	694	2724
1958	0	4	1578	0	0	0	628	2210
1959	0	2	1307	0	0	0	634	1943
1960	0	1	1313	0	0	0	0	1314
1961	0	0	1367	0	0	0	0	1367
1962	0	2	1681	0	0	0	0	1683
1963	0	0	1565	0	0	0	0	1565
1964	0	1	1574	0	0	0	0	1575
1965	0	1	2051	0	0	0	0	2052
1966	0	0	1755	0	0	0	0	1755
1967	0	0	1115	0	0	0	0	1115
1968	0	0	1535	13	0	0	0	1548
1969	0	0	1430	0	0	0	0	1430
1970	0	0	1079	0	0	0	0	1079
1971	0	0	1242	0	0	0	0	1242
1972	0	0	1669	0	0	0	0	1669
1973	0	0	1449	0	0	0	0	1449
1974	0	0	2003	0	0	0	0	2003
1975	0	0	1959	0	2	0	88	2049
1976	10	0	1493	0	80	0	0	1583
1977	11	0	2105	0	142	0	60	2318
1978	2	0	2515	0	39	0	74	2630
1979	3	0	2616	0	15	0	82	2716
1980	3	0	2218	0	3	0	109	2333
1981	0	0	2574	0	5	0	100	2679
1982	1	0	2823	0	22	0	56	2902
1983	1	0	2759	0	34	0	112	2906
1984	0	0	2695	0	0	0	74	2769
1985	1	0	1486	0	0	0	58	1545
1986	5	0	1551	0	0	0	52	1608
1987	19	0	2182	0	0	0	57	2258
1988	13	0	2150	0	15	0	76	2254
1989	4	0	2302	0	0	0	40	2346
1990	3	0	1535	0	0	0	36	1574
1991	5	1	1556	0	0	0	47	1609
1992	10	0	1412	0	0	0	32	1454
1993	7	0	1656	0	0	0	32	1695
1994	9	0	1917	0	0	0	35	1961
1995	3	0	1482	0	0	0	45	1530
1996	0	0	1387	0	0	0	18	1405
1997	0	0	990	0	0	0	22	1012
1998	0	0	942	0	0	0	19	961
1999	0	0	661	0	0	0	12	673
2000	0	0	647	0	0	1	6	654
2001	0	0	751	0	0	7	7	765
2002	0	0	968	0	0	3	6	977
2003	0	0	674	0	173	14	4	865
2004	0	0	637	0	138	1	3	779
2005	0	0	738	0	95	0	3	836
2006	0	20	566	0	117	18	4	725
2007	0	9	547	0	126	3	9	694
2008	0	12	475	0	26	2	7	522
2009	0	4	478	0	3	1	12	498
2010	0	4	426	0	151	0	8	589
2011	0	10	517	0	0	11	7	545
2012	0	5	633	0	0	10	6	654
2013	0	11	654	0	174	26	6	870

Table 21.6.4 InterCatch. Reported landings and discards (t) by country, quarter and metier. Metiers for which landings and discards are reported are highlighted in green. Displayed are also the resulting discard rates for cases were available.

		Q1		Q2		Q3		Q4		Q1-4	Q1	Q2	Q3	Q4
Country	Metier	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Discard rate			
Belgium	GNS_DEF_all_0_0_all		0.282		1.47		0.035		0.15					
Belgium	MIS_MIS_0_0_0_HC		3.099		13.715		37.157		0.603					
Belgium	OTB_CRU_70-99_0_0_all		4.768		9.263		10.986		3.503					
Belgium	OTB_DEF_>=120_0_0_all		0.023		0.89		0.161		12.839					
Belgium	TBB_CRU_16-31_0_0_all		10.212		19.056		2.112		26.788					
Belgium	TBB_DEF_>=120_0_0_all			1.321	6.879	8.845	46.08	18.294	95.31			0.19	0.19	0.19
Belgium	TBB_DEF_70-99_0_0_all	89.97	10.489	509.486	59.398	90.493	10.55	139.11	16.218		8.58	8.58	8.58	8.58
Denmark	GNS_DEF_>=220_0_0_all	0	0.004	0	0.488	0	0.382		0.004		0.00	0.00	0.00	0.00
Denmark	GNS_DEF_>=220_0_0_all_FDF						0.003							
Denmark	GNS_DEF_100-119_0_0_all		1.242	0.371	10.418	0.083	3.711		0.579			0.04	0.02	
Denmark	GNS_DEF_100-119_0_0_all_FDF		1.702		0.488									
Denmark	GNS_DEF_120-219_0_0_all	2.492	66.91	4.28	55.397	2.085	10.265	1.18	18.708		0.04	0.08	0.20	0.06
Denmark	GNS_DEF_120-219_0_0_all_FDF	0	0.018	0	0.033	0	0.03	0	0.365		0.00	0.00	0.00	0.00
Denmark	MIS_MIS_0_0_0_HC	403.832	21.004	502.232	63.818	484.438	22.544	586.653	14.229		19.23	7.87	21.49	41.23
Denmark	MIS_MIS_0_0_0_IBC		143.663		1.97		6.97		123.194					
Denmark	OTB_CRU_32-69_0_0_all	0.155		0.198		0.227		0.165						
Denmark	OTB_CRU_70-99_0_0_all	3.894	0.343	48.65	0.678	379.631	7.163	339.698	1.613		11.35	71.76	53.00	210.60
Denmark	OTB_CRU_90-119_0_0_all	24.969	13.882	59.153	0.018	43.074	15.847	31.926	28.778		1.80	3286.28	2.72	1.11
Denmark	OTB_CRU_90-119_0_0_all_FDF	1.204	2.407	5.406	14.168	3.32	22.121	0.176			0.50	0.38	0.15	
Denmark	OTB_DEF_>=120_0_0_all	12.686	42.262	43.777	17.956	48.783	153.209	21.114	101.973		0.30	2.44	0.32	0.21
Denmark	OTB_DEF_>=120_0_0_all_FDF	3.019	4.493	9.501	7.129	6.738	24.045	8.113	31.918		0.67	1.33	0.28	0.25
Denmark	SDN_DEF_>=120_0_0_all	0.725	3.852	0.86	33.314	19.987	87.169	4.229	48.909		0.19	0.03	0.23	0.09
Denmark	SDN_DEF_>=120_0_0_all_FDF	0.433	0.964	1.459	13.034	12.096	40.207	2.319	27.938		0.45	0.11	0.30	0.08
Denmark	SSC_DEF_>=120_0_0_all	0	0.019	0	0.593	0	13.007	0	4.395		0.00	0.00	0.00	0.00
Denmark	TBB_CRU_16-31_0_0_all	8.219		22.566		31.194		30.506						
Denmark	TBB_DEF_>=120_0_0_all		1.783		3.249		7.577		11.875					
France	GTR_DEF_all_0_0_all		24.19733		7.40202		1.23571		3.71378					
France	MIS_MIS_0_0_0_HC		0.30741		2.71339		0.5642		1.15061					
France	OTB_DEF_70-99_0_0_all		8.38016		4.5384		7.50948		17.21939					
Germany	GNS_DEF_all_0_0_all		3.795		2.493		1.992		1.818					
Germany	MIS_MIS_0_0_0_HC				0.027				0.001					
Germany	OTB_CRU_70-99_0_0_all		21.005		28.203		10.91		3.78					
Germany	OTB_CRU_90-119_0_0_all				0.488		3.07		2.206					
Germany	OTB_DEF_>=120_0_0_all	0.023	9.938	120.406	20.989	53.46	35.833		55.095		0.00	5.74	1.49	
Germany	OTB_DEF_>=120_0_0_all_FDF	0.005	0.016	0.058	0.01	0.033	0.021		0.095		0.31	5.80	1.57	
Germany	TBB_CRU_16-31_0_0_all			5.233	0.17		0.026	10.398	0.047			30.78		221.23
Germany	TBB_DEF_>=120_0_0_all			3.211	0.821	0.096	2.516		2.021			3.91	0.04	
Germany	TBB_DEF_70-99_0_0_all	980.139	70.076		29.544	176.114	27.434	182.88	8.889		13.99		6.42	20.57
Netherlands	MIS_MIS_0_0_0_HC		56.7		25.27		52.46		26.46					
Netherlands	OTB_DEF_100-119_0_0_all		10.58		33.36		40.1		42.42	467.86847	3.70*	3.70*	3.70*	3.70*
Netherlands	SSC_DEF_100-119_0_0_all		0.11		37.61		232.63		179.56	142.48972	0.32*	0.32*	0.32*	0.32*
Netherlands	SSC_DEF_70-99_0_0_all		1.84		47.36		52.91		5.15					
Netherlands	TBB_CRU_16-31_0_0_all		27.45		64.22		2.2		47.47					
Netherlands	TBB_DEF_100-119_0_0_all		11.66		165.18		91.12		0.41	529.80781	1.97*	1.97*	1.97*	1.97*
Netherlands	TBB_DEF_70-99_0_0_all	10019.66718	950.77	6321.76628	530.34	4862.98434	406.36	3959.73045	210.35		10.54	11.92	11.97	18.82
Norway	GNS_DEF_all_0_0_all		0.6067		0.3537		0.0912		0.081					
Norway	OTB_CRU_32-69_0_0_all		0.4072		0.1027		0.1259		0					
Norway	OTB_DEF_>=120_0_0_all		4.8574		7.8448		4.5409		9.52					
Norway	SSC_DEF_>=120_0_0_all		0.0303		4.6649		8.4216		9.5231					
Sweden	GNS_DEF_all_0_0_all				0.074		0.001							
Sweden	GTR_DEF_all_0_0_all				0.019		0.002							
Sweden	MIS_MIS_0_0_0_HC	33.941	1.411	81.374	2.885	130.244	0.216	52.6	0.047		24.05	28.21	602.98	1119.15
Sweden	OTB_CRU_32-69_0_0_all	0.009	0	0.015	0	0.02	0	0.021	0		total catch discarded	total catch discarded	total catch discarded	total catch discarded
Sweden	OTB_CRU_32-69_2_22_all	0.025	0	0.024	0	0.031	0	0.033	0		total catch discarded	total catch discarded	total catch discarded	total catch discarded
Sweden	OTB_CRU_70-89_2_35_all	13.5	0	16.995	0.005	41.082	0.004	14.483	0		total catch discarded	3399.00	10270.50	total catch discarded
Sweden	OTB_CRU_90-119_0_0_all	14.365	0.164	13.245	0.232	9.478	0.985	10.974	0.295		87.59	57.09	9.62	37.20
Sweden	OTB_DEF_>=120_0_0_all		0.027		0.027		0.046		0.018					
Sweden	OTB_SPF_32-69_0_0_all								0.005					
UK (England)	C-Allgears		116.848		129.524		117.366		118.279					
UK (Scotland)	MIS_MIS_0_0_0_HC				1.425		0.057							
UK (Scotland)	OTB_CRU_70-99_0_0_all		0.009				0.141							
UK (Scotland)	OTB_DEF_>=120_0_0_all		20.543		33.744		23.014		61.438					
UK (Scotland)	OTB_DEF_>=120_0_0_all_FDF						0.422							
UK (Scotland)	TBB_DEF_70-99_0_0_all		18.08		3.09		1.158		0.871					

* estimated from quarterly combined discards by proportion of landings

22 Flounder in Subarea IV (North Sea) and Division and IIIa (Skagerrak – Kattegat)

22.1 General

Flounder (*Platichthys flesus*) was assessed so far in the Working Group on Assessment of New MoU Species (ICES, 2013a). Because only official landings and survey data were available, flounder was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for flounder was given in 2013 by ICES (ICES, 2013b) based on survey trends. In 2014, flounder was included to the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group.

22.1.1 Biology and ecosystem aspects

Flounder is an euryhaline flatfish: the life cycle of each individual usually includes marine, brackish, and freshwater habitats. It has a coastal distribution in the Northeast Atlantic, ranging from the White Sea and the Baltic in the north, to the Mediterranean and Black Sea in the south. Flounder can live in low salinity water but they reproduce in water of higher salinity. In the North Sea, Skagerrak and Kattegat flounder spawn between February and April.

Flounder feeds on a wide variety of small invertebrates (mainly polychaete worms, shellfish, and crustaceans), but locally the diet may include small fish species like smelt and gobies. The most intensive feeding occurs in the summer, while food is sparse in the winter.

During autumn, both mature and immature flounder withdraw from the inshore and estuarine feeding areas. Immature flounder migrate into coastal areas, where they spend the winter. The adults move further offshore to the 25 – 40 m deep spawning grounds, the most important of which are situated along the coasts of Belgium, the Netherlands, Germany, and Denmark.

More details on available data and knowledge can be found in the flounder stock annex.

22.1.2 Stock ID and possible assessment areas

There is no information about stock identity and possible stock assessment areas in the North Sea, Skagerrak and Kattegat. Within the North Sea there may exist a number of sub-populations (WGNEW, 2013).

22.1.3 Management regulations

There is no minimum landing size for this species in EC waters.

In the EC waters of area IIa and IV there is a combined TAC for flounder and dab. The TAC for both species of 18.343t was not changed in the last three years.

22.2 Fisheries data

22.2.1 Historical landings

In the North Sea and in Skagerrak-Kattegat flounder is mainly a by-catch in the fishery for commercially more important flatfish such as sole and plaice and in the mixed demersal fisheries. The largest part of official landings is reported for sub-area IV, especially for the last decade (Fig. 22.4.1.1; Table 21.9.3). Landings in ICES sub-area IV and Division IIIa by country are shown in Figures 22.4.1.2 and 22.4.1.3 and in Tables 21.9.1 and 21.9.2. From Figure 22.4.1.2 it can be seen that the landings data are not complete: there is a gap in Dutch landings data from 1984 to 1997.

Since 1950, annual landings from the North Sea have fluctuated, without a clear pattern (Figure 21.1.4.2). In the last decade, landings declined considerably. This decline goes hand in hand with a considerable reduction in fishing effort of bottom trawl fleets in the North Sea. For 2013, total official landings were reported with 1875t, compared to 2305t in 2012. However, reported official landings for 2013 are based on preliminary catch statistics. In area IIIa, annual landings have been fluctuating from 2700 t in 1984 to 118 t in 2012 (Figure 22.4.1.3). Landings increased in 2013 to 173 t. In the beginning of the time series the landings seem to be fluctuating without a clear trend, however in last two decades the trend is declining. Flounder is of relatively little commercial importance in the North Sea and the Skagerrak-Kattegat. In the North Sea and the Skagerrak-Kattegat the landings data may be misreported in years that quota for commercially more important species are limited. The amount of misreporting however is not known. In addition, the North Sea landings may not reflect the catches very well. Flounder is often discarded and discarding is influenced by the prices and the availability of other, commercially more important species.

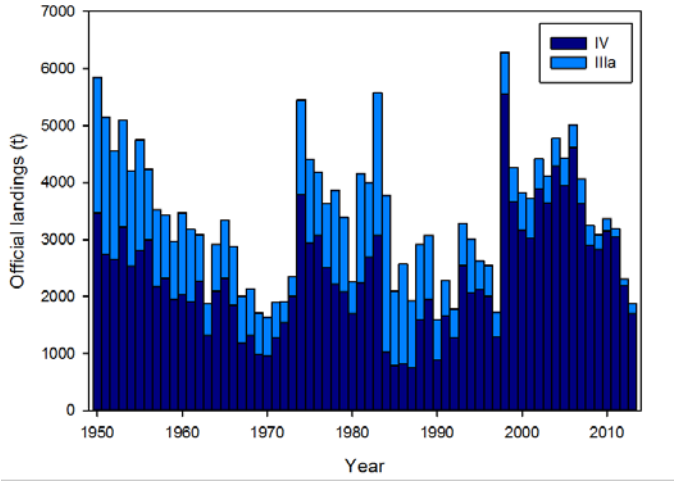


Fig. 22.4.1.1 Official landings of flounder by area.

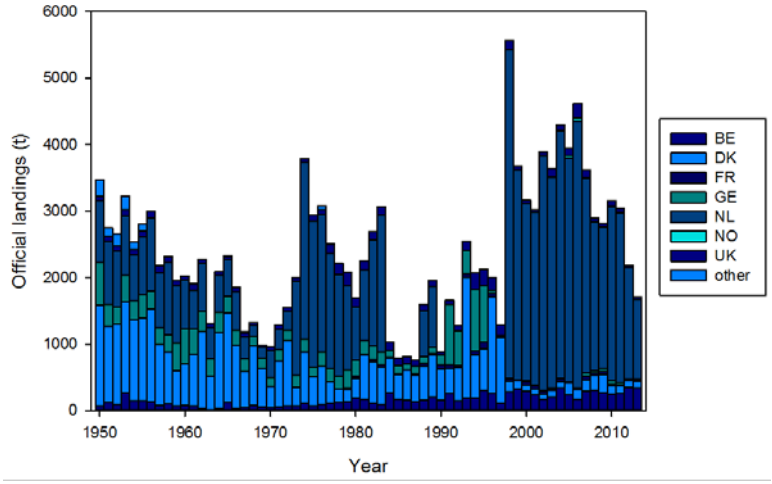


Fig. 22.4.1.2 Official landings of flounder in ICES area IV by country.

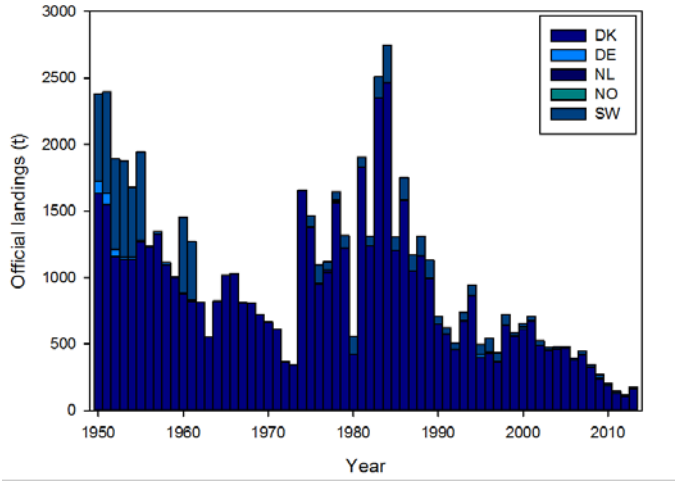


Fig. 22.4.1.3 Official landings of flounder in ICES division IIIa by country.

22.2.2 Inter Catch

In 2014 flounder was included for the first time into the data call for WGNSSK 2014. From all countries data were uploaded to the Inter Catch data portal. However, UK (England) only provided total landings for all metiers combined, but provided more detailed data on landings and discards for the main metiers separately. France and Scotland only reported landings but no discard information. The largest proportion of landings was reported by the Netherlands and Belgium beam trawlers (TBB_DEF_70_99_0_0_all) followed by the Danish MIS_MIS_0_0_0_HC metier (Fig. 22.4.2.1a). Landings for all other metiers were below 50t (Fig. 22.4.2.1b). Correspondingly, the amount of discarded flounders is highest in these metiers with Belgian beam trawlers discarding the largest amount of flounder catches (Fig. 22.4.2.2a). Apart from the metier MIS_MIS_0_0_0_all for which the raising procedure in Inter Catch added a considerable amount of flounder discards for the Dutch fleet, the raised discards did not differ that much from the reported discards (Fig. 24.4.2.2b). The highest total catch is taken by the Netherlands, followed by Belgium and Denmark (Fig. 22.4.2.3). The

total catch estimated with Inter Catch was 3212t from which 1772t were landings (compared to 1875t reported official landings) and 1441t discards (45% of total catches). However, it should be noted that not all metiers were sampled in every quarter and that the raising procedure may not be adequate in all cases. Discard rates were highly variable also between comparable fleets, e.g. the discard rate for the Belgian TBB_DEF_70-99_0_0_all was 2.39 while the discard rate for the same metier of other countries was in the range of 0.11 – 0.48. Even worse, the case of two shrimp fleets (TBB_CRU_16-32_0_0_all) where an obvious different behaviour in discard practices between the German fleet (discarding nearly 100% of the flounder catch) and the Belgian fleet (probably landing nearly all of the flounder catch) made the use of the German fleet as raising fleet impossible, because it would lead to unrealistic high discards for the Belgian fleet. Unfortunately, no other discard information for this metier was available. Details of reported landings and discards are listed in table 21.9.4.

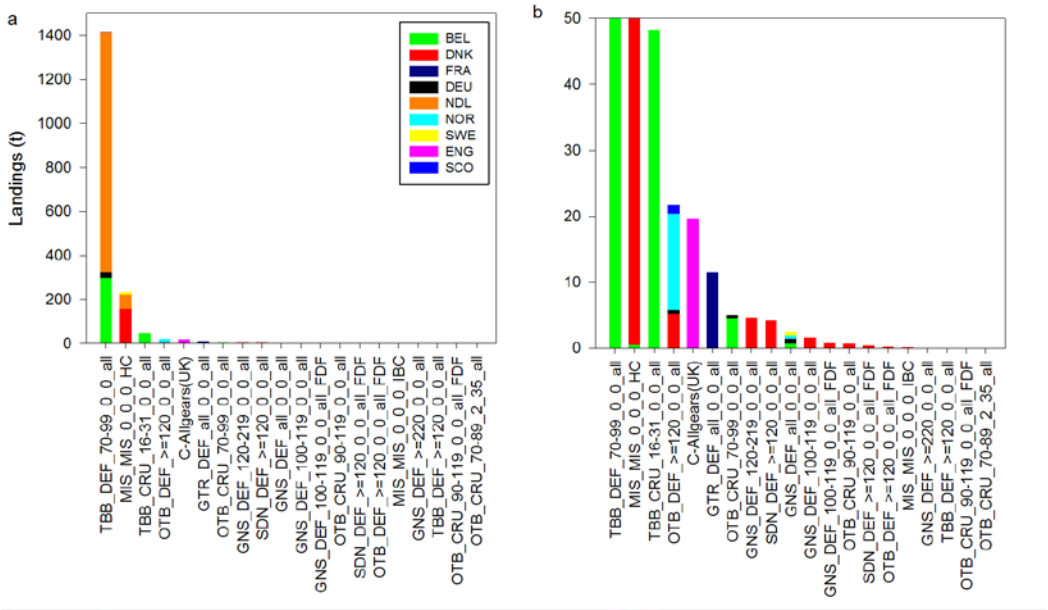


Fig. 22.4.2.1 Inter Catch. Flounder landings by metier and country as uploaded to Inter Catch. Panel (a) and (b) showing the same data, but y-axis in panel (b) is downscaled to visualize details.

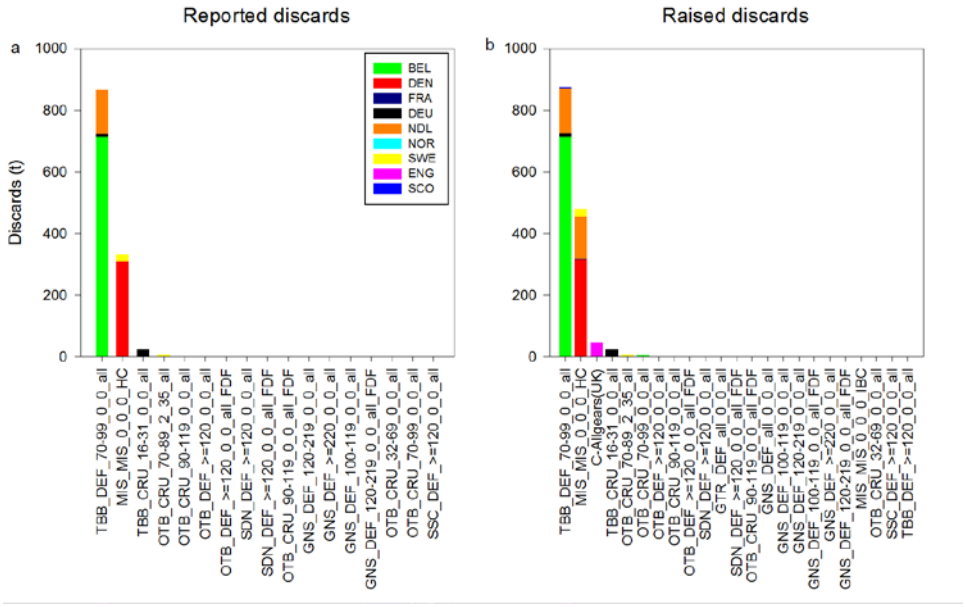


Fig. 22.4.2.2 Inter Catch. Flounder discards by metier and country. Reported discards panel (a), raised discards panel (b).

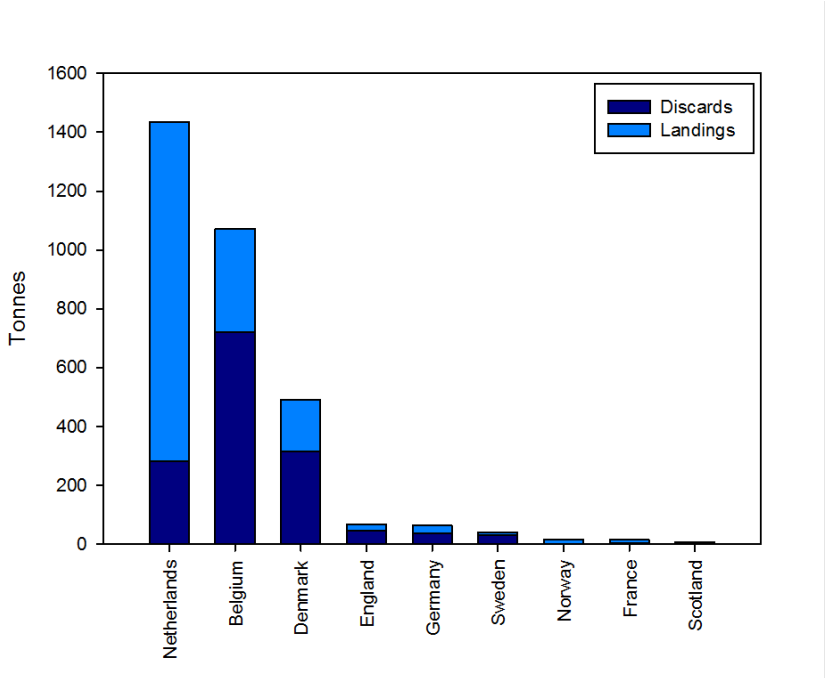


Fig. 22.4.2.3 Inter Catch. Flounder landings and discards by country.

22.3 Survey data / recruit series

Several surveys in the North Sea, Skagerrak and Kattegat provide information on distribution, abundance and length composition of flounder. Most relevant for flounder is probably the International Bottom Trawl Survey IBTS in quarter 1 (Figure 22.5.1). However, the IBTS Q1 uses a bottom trawl which is not very well suited to catch demersal flatfishes. The BTS surveys use a beam trawl, but they are carried out in quarter 3, in a time of year in which flounder is usually distributed in more coastal, shallow and brackish waters. Therefore, it was decided by WGNEW2013 to use the IBTS Q1 to analyse survey trends for this species. It should be noted here that for the IBTS the gear

in use was fully standardized since 1983. Therefore, index data before this year should be interpreted with caution.

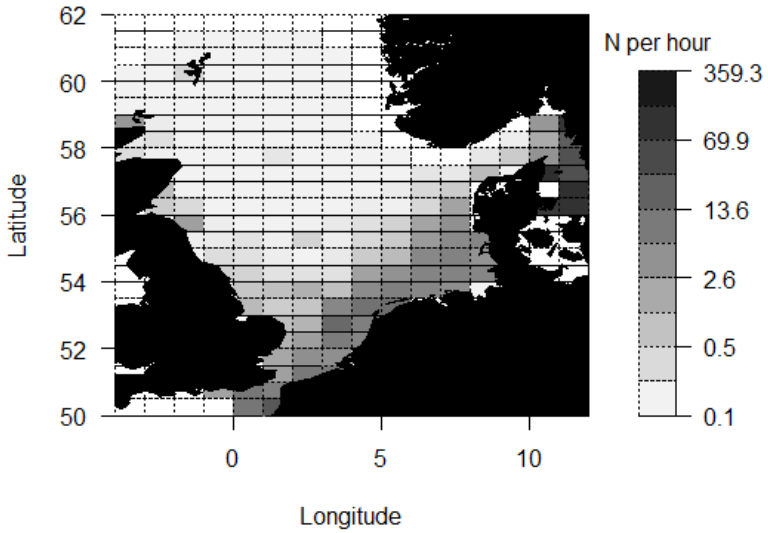


Fig. 22.5.1 Distribution of flounder derived from the IBTS Q1 survey in area IV and division IIIa.

22.4 Analysis of stock trends / assessment

In 2013 flounder was dealt with in the Working Group on Assessment of New MoU Species (ICES, 2013). So far, only landings data and survey trends were available for this species. Therefore, flounder was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2012). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. The guidelines further explicitly suggest that in case of missing catch information landings should be taken as the basis for the method. This was the case for flounder, for which it was not possible in 2013 to estimate total catches. WGNEW2013 decided to set x=3 and z=8, in order to account for the relative long lived species flounder and the noisy nature of survey indices. An abundance index in number per hour was estimated from the IBTS Q1 survey, because this survey covers most of the distribution area of flounder in area IV and IIIa. The 3:5 ratio of the abundance index was estimated to be 7%, resulting in an advised increase in landings (<3160t). Based on these results the advice was drafted for WGNSSK2013, which accepted the advice draft.

However, ACOM criticised the use of a pure abundance index, which reflects more the recruitment. Hence, it was suggested to use a mature biomass index instead. Further, the approach to change the settings of x and z where not accepted. Based on these criticisms WGNSSK2014 re-examined the available survey data for flounder to estimate a mature biomass index and to evaluate the effect of using the 2:3 ratio instead of the applied 3:5 ratio.

Estimated indices

The abundance index (n/hour) estimated by WGNEW2013 was based on the IBTS Q1 survey which covers most of the distribution area of flounder in area IV and IIIa. Roundfish areas 1 and 2 were excluded from analyses because flounder does only occur very occasionally in these areas (Fig. 22.5.1). To estimate a mature biomass index (kg/hour) a length weight relationship derived from IBTS Q1 data was applied. The same data set shows that above 20cm probably most flounder are mature (Fig. 22.6.1).

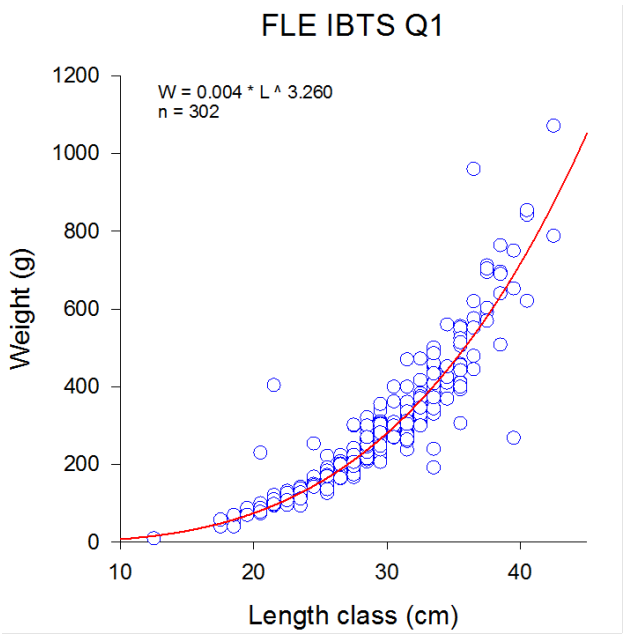


Fig. 22.6.1 Length weight relationship of flounder derived from IBTS Q1 data.

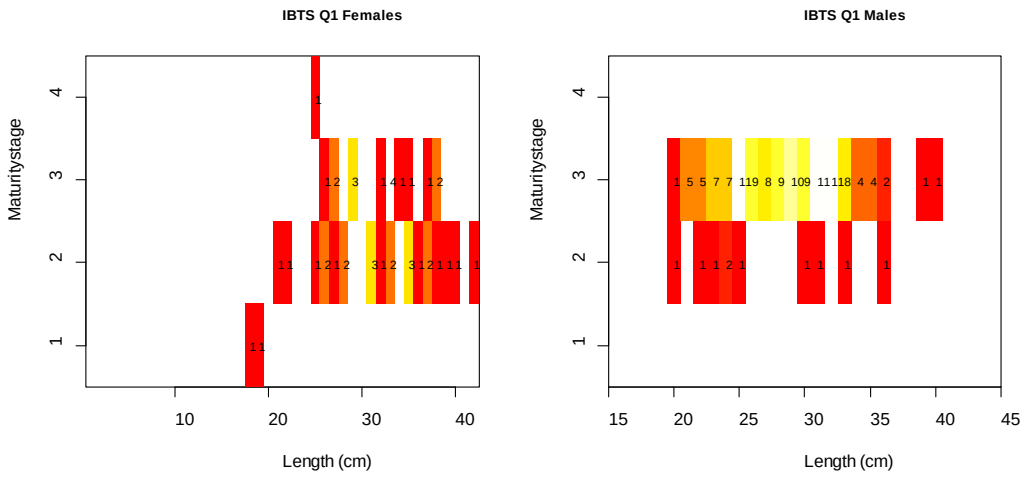


Fig. 22.6.2 Maturity at length of female and male flounder derived from IBTS Q1 data.

The abundance index shows an increasing trend from 1983 onwards with two major peaks between 1985 and 1995 (Fig. 22.6.3). From 1996 to 2001 the abundance index declined, followed by an increase up to 2005. Since then it fluctuated without a clear trend up to 2010. The 2013 data point was nearly the same as for 2012, while the 2014 data

point was slightly lower compared to 2013. Overall, a declining trend can be observed from 2010 to 2014. The trend of the mature biomass index follows quite closely the trend of the abundance index, due to the fact that most of flounder caught by the IBTS are >20cm. Therefore, the mature biomass index does not change the perception of the stock trend in case of flounder.

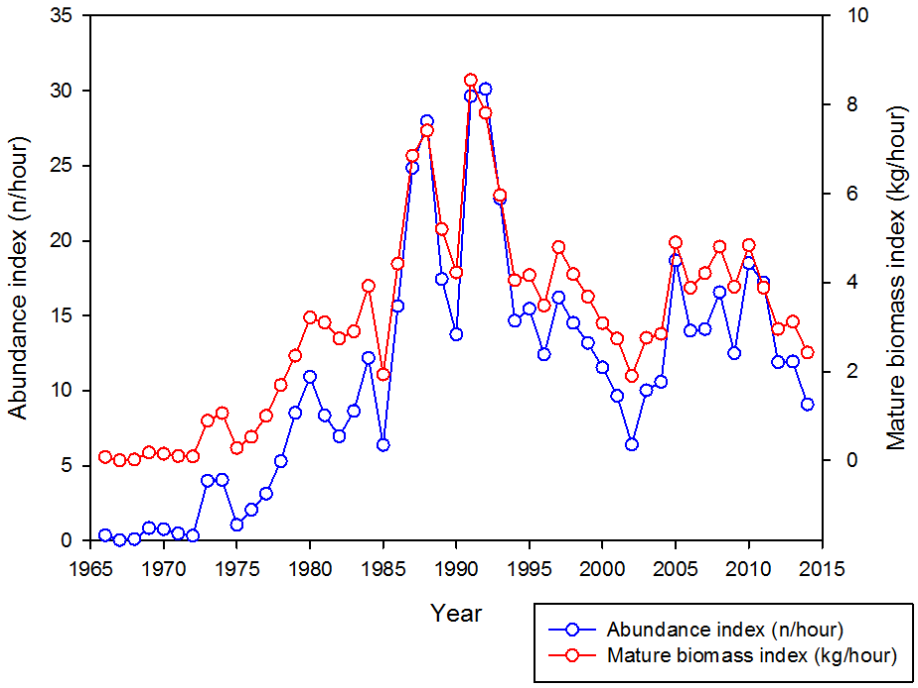


Fig. 22.6.3 Abundance index and mature biomass index of flounder in area IV and division IIIa derived from IBTS Q1 data.

Different options applying the DLS 3.2 method are displayed in table 22.6.1. Only the suggested 3:5 rule (WGNEW, 2013) resulted in an increase of the advised landings. All other options would result in a decrease of advised landings in a range of 3% - 35%, or 3% - 20% applying the uncertainty cap (ICES, 2012).

Tab. 22.6.1 Results of applying the 3:5 and 2:3 ratio to the 3.2 DLS method for different stock indices. First row highlighted in green colour shows the basis for advice in 2013.

	stock indicator	method	ratio	landings avg last 3 yrs	adviced landings	Change in %
WGNEW 2013	IBTS Q1 abundance	3:5	1.065	2953	3145	7%
	IBTS Q1 abundance	2:3	0.970	2953	2866	-3%
	IBTS Q1 mature biomass	3:5	0.897	2953	2649	-10%
	IBTS Q1 mature biomass	2:3	0.757	2953	2236	-24%
WGNSSK 2014	IBTS Q1 abundance	3:5	0.748	2457	1837	-25%
	IBTS Q1 abundance	2:3	0.693	2457	1702	-31%
	IBTS Q1 mature biomass	3:5	0.654	2457	1607	-35%
	IBTS Q1 mature biomass	2:3	0.712	2457	1749	-29%

Conclusion

The advice for flounder given by ICES in 2013 was biennial and hence valid for 2014 and 2015. WGNSSK concluded not to re-open the advice for flounder in 2014. Given the high variability in the survey indices, the new survey information did not change the overall perception of the stock.

Doubts were raised concerning the applicability of the DLS 3.2 method for this stock. First, the survey indices show large variability and estimates of uncertainty should be provided. Further, the applied method is based on landings which is not meaningful for a species with very high discards (~45% of total catch estimated for 2013). However, this year flounder was included in the official data call and discards could be raised for the first time using Inter Catch. This might enable to give catch advice for this stock in future years given a good coverage of sampled metiers.

A further problem is the combined TAC for flounder and dab. The combined TAC for 2013 was set to 18434t. The advised landings for flounder and dab combined were 10955t for 2014 and 2015 which is a reduction of the combined TAC of 40%, although a 7% increase in landings was advised for both species (based on WKLIFE rules not the TAC but the average landings from the last three years were used as basis). However, the official reported total landings of both species in 2013 were 7957t and the TAC was not fully utilized. All options tested would result in a reduction of landings by 20% applying the uncertainty cap. This would translate into advised landings to be not more than 1965t for flounder, which is still more than the reported landings for 2013. Assuming that the advice for dab is the same as for last year, the combined advised landings would be 9760t which would translate in a TAC reduction of 47% for both species, but is still higher than the total landings for 2013. Therefore, reopening the advice on this basis does not make sense.

22.5 References

ICES 2013a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM 21.

ICES 2013b. Flounder in Subarea IV and Division IIIa, Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.29.

ICES. 2013c. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24–30 April 2013. ICES CM 2013/ACOM:13.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Tables

Table 22.8.1 Flounder official landings by country in ICES area IV.

Year	Belgium	Denmark	France	Germany	Netherlands	Norway	UK	Other	Total
1950	67	1514	0	641	937	0	67	241	3467
1951	119	1143	0	329	949	0	81	127	2748
1952	91	1210	0	257	841	0	71	186	2656
1953	270	1372	0	397	886	0	92	203	3220
1954	142	1225	0	281	696	0	71	121	2536
1955	145	1244	0	353	871	0	88	109	2810
1956	132	1389	0	277	1097	0	102	2	2999
1957	81	910	0	250	825	0	112	0	2178
1958	99	784	0	257	1088	0	94	0	2322
1959	62	533	0	424	857	0	79	1	1956
1960	82	614	0	540	733	0	49	8	2026
1961	68	776	0	390	579	0	81	13	1907
1962	37	1146	0	313	717	0	53	2	2268
1963	16	501	0	263	467	0	65	0	1312
1964	30	1141	0	305	563	0	48	6	2093
1965	121	1349	0	248	549	0	54	3	2324
1966	32	946	0	229	573	0	71	2	1853
1967	43	540	0	193	331	0	57	25	1189
1968	75	894	0	152	160	0	43	1	1325
1969	54	582	0	158	161	0	33	0	988
1970	50	316	0	135	405	0	57	0	963
1971	60	685	0	173	297	0	70	0	1285
1972	63	991	0	159	275	0	60	0	1548
1973	63	290	0	172	1424	0	53	0	2002
1974	115	766	0	190	2661	0	58	0	3790
1975	68	437	0	155	2191	0	87	1	2939
1976	94	575	0	209	2077	0	70	54	3079
1977	107	320	0	208	1732	0	127	11	2505
1978	122	203	0	198	1519	0	169	0	2211
1979	129	181	31	275	1260	0	201	0	2077
1980	190	300	33	229	806	0	140	0	1698
1981	164	669	14	200	1068	0	133	0	2248
1982	110	630	31	200	1597	0	121	0	2689
1983	88	564	36	197	2059	0	125	0	3069
1984	272	518	15	103	0	0	122	0	1030
1985	163	379	14	128	0	0	109	0	793
1986	155	456	1	91	0	0	111	0	814
1987	132	394	32	106	0	0	90	0	754
1988	160	509	44	105	682	0	98	0	1598
1989	200	632	28	95	916	0	80	0	1951
1990	153	467	69	147	0	0	45	0	881
1991	260	377	51	902	0	0	69	0	1659
1992	152	492	35	521	0	0	76	0	1276
1993	194	1812	47	356	0	0	136	0	2545
1994	196	642	57	921	0	0	247	0	2063
1995	301	628	103	843	0	0	250	0	2125
1996	262	1439	68	43	0	0	193	0	2005
1997	110	988	10	25	0	0	157	0	1290
1998	283	154	40	13	4938	0	132	0	5560
1999	326	123	0	11	3158	0	54	0	3672
2000	289	100	46	17	2656	5	52	0	3165
2001	241	92	42	4	2608	3	32	0	3022
2002	165	83	51	2	3531	3	55	0	3890
2003	206	94	33	3	3172	9	120	0	3637
2004	335	96	46	5	3720	18	74	0	4294
2005	241	171	17	5	3363	38	111	0	3946
2006	167	152	19	1	4020	39	216	0	4614
2007	298	166	56	46	2925	11	120	0	3622
2008	306	228	30	40	2231	3	57	0	2895
2009	272	274	38	46	2124	3	59	0	2816
2010	250	126	20	58	2612	6	87	0	3159
2011	262	112	15	25	2566	1	65	0	3046
2012	346	100	11	19	1673	0	38	0	2187
2013	343	93	13	30	1199	0	24	0	1702

Table 22.8.2 Flounder official landings by country in ICES division IIIa.

Year	Denmark	Germany	Netherlands	Norway	Sweden	Total
1950	1632	92	0	0	657	2381
1951	1548	88	0	0	759	2395
1952	1161	48	0	0	683	1892
1953	1135	17	0	0	724	1876
1954	1138	13	0	0	528	1679
1955	1265	11	0	0	667	1943
1956	1229	6	0	0	0	1235
1957	1331	12	0	0	0	1343
1958	1099	12	0	0	0	1111
1959	1003	3	0	0	0	1006
1960	875	10	0	0	566	1451
1961	821	9	0	0	442	1272
1962	812	3	0	0	0	815
1963	554	0	0	0	0	554
1964	822	1	0	0	0	823
1965	1016	0	0	0	0	1016
1966	1027	0	0	0	0	1027
1967	811	3	0	0	0	814
1968	808	2	0	0	0	810
1969	721	0	0	0	0	721
1970	667	0	0	0	0	667
1971	611	1	0	0	0	612
1972	365	0	0	0	0	365
1973	346	0	0	0	0	346
1974	1656	2	0	0	0	1658
1975	1377	1	0	0	89	1467
1976	949	2	4	0	144	1099
1977	1036	0	19	0	64	1119
1978	1560	10	14	0	64	1648
1979	1219	0	0	0	100	1319
1980	426	0	0	0	135	561
1981	1831	0	0	0	74	1905
1982	1236	0	0	0	75	1311
1983	2352	0	0	0	160	2512
1984	2463	0	0	0	283	2746
1985	1203	0	0	0	102	1305
1986	1585	0	0	0	166	1751
1987	1050	0	0	0	119	1169
1988	1164	0	0	0	149	1313
1989	996	0	0	0	133	1129
1990	650	1	0	0	57	708
1991	574	0	0	0	50	624
1992	455	0	0	0	52	507
1993	673	3	0	0	67	743
1994	865	1	0	0	77	943
1995	403	19	0	0	76	498
1996	429	9	0	0	104	542
1997	367	2	0	0	68	437
1998	637	5	0	0	83	725
1999	558	6	0	0	24	588
2000	609	17	0	0	30	656
2001	672	2	0	1	30	705
2002	493	0	0	1	30	524
2003	452	3	0	0	18	473
2004	462	2	0	0	14	478
2005	467	0	0	0	15	482
2006	380	0	0	0	13	393
2007	419	3	1	0	22	445
2008	326	4	0	0	16	346
2009	238	2	0	0	33	273
2010	188	0	0	0	17	205
2011	129	0	0	0	16	145
2012	110	0	0	0	8	118
2013	162	0	0	0	11	173

Table 22.8.3 Flounder total official landings by ICES areas.

Year	IIIa	IV	Total
1950	2381	3467	5848
1951	2395	2748	5143
1952	1892	2656	4548
1953	1876	3220	5096
1954	1679	2536	4215
1955	1943	2810	4753
1956	1235	2999	4234
1957	1343	2178	3521
1958	1111	2322	3433
1959	1006	1956	2962
1960	1451	2026	3477
1961	1272	1907	3179
1962	815	2268	3083
1963	554	1312	1866
1964	823	2093	2916
1965	1016	2324	3340
1966	1027	1853	2880
1967	814	1189	2003
1968	810	1325	2135
1969	721	988	1709
1970	667	963	1630
1971	612	1285	1897
1972	365	1548	1913
1973	346	2002	2348
1974	1658	3790	5448
1975	1467	2939	4406
1976	1099	3079	4178
1977	1119	2505	3624
1978	1648	2211	3859
1979	1319	2077	3396
1980	561	1698	2259
1981	1905	2248	4153
1982	1311	2689	4000
1983	2512	3069	5581
1984	2746	1030	3776
1985	1305	793	2098
1986	1751	814	2565
1987	1169	754	1923
1988	1313	1598	2911
1989	1129	1951	3080
1990	708	881	1589
1991	624	1659	2283
1992	507	1276	1783
1993	743	2545	3288
1994	943	2063	3006
1995	498	2125	2623
1996	542	2005	2547
1997	437	1290	1727
1998	725	5560	6285
1999	588	3672	4260
2000	656	3165	3821
2001	705	3022	3727
2002	524	3890	4414
2003	473	3637	4110
2004	478	4294	4772
2005	482	3946	4428
2006	393	4614	5007
2007	445	3622	4067
2008	346	2895	3241
2009	273	2816	3089
2010	205	3159	3364
2011	145	3046	3191
2012	118	2187	2305
2013	173	1702	1875

Table 22.8.4 Inter catch. Reported landings and discards by country, metier and quarter. Also displayed are the resulting discard rates which were used to raise discrads for all seasons and metiers.

		Q1		Q2		Q3		Q4		Q1-4				
Country	Metier	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Discard rate			
Belgium	GNS_DEF_all_0_0_all				148		521		13					
Belgium	MIS_MIS_0_0_0_HC				132		396							
Belgium	OTB_CRU_70-99_0_0_all		2901		1206		329		174					
Belgium	OTB_DEF_>=120_0_0_all		14		29									
Belgium	TBB_CRU_16-31_0_0_all		2800		11776		23367		10328					
Belgium	TBB_DEF_>=120_0_0_all								8					
Belgium	TBB_DEF_70-99_0_0_all	17584	7344	537128	224342	106211	44361	53986	22548		2.39	2.39	2.39	2.39
Denmark	GNS_DEF_>=220_0_0_all	0	5	0	6	0					0.00	0.00		
Denmark	GNS_DEF_100-119_0_0_all		388	0	366	0	848					0.00	0.00	
Denmark	GNS_DEF_100-119_0_0_all_FDF		452		318									
Denmark	GNS_DEF_120-219_0_0_all	0	1466	8	2360	0	243	0	588		0.00	0.00	0.00	0.00
Denmark	GNS_DEF_120-219_0_0_all_FDF	0		0		0		0						
Denmark	MIS_MIS_0_0_0_HC	296096	106475	1657	15226	3745	16564	8286	18254		2.78	0.11	0.23	0.45
Denmark	MIS_MIS_0_0_0_IBC		160		1									
Denmark	OTB_CRU_32-69_0_0_all	0		0		0		0						
Denmark	OTB_CRU_70-99_0_0_all	0		0		0		0						
Denmark	OTB_CRU_90-119_0_0_all	0	137	425	115	0	69	242	370		0.00	3.70	0.00	0.65
Denmark	OTB_CRU_90-119_0_0_all_FDF	0		39		0	1	1					0.00	
Denmark	OTB_DEF_>=120_0_0_all	0	225	160	782	0	2714	103	1418		0.00	0.20	0.00	0.07
Denmark	OTB_DEF_>=120_0_0_all_FDF	0	1	64	34	0		59	225		0.00	1.88		0.26
Denmark	SDN_DEF_>=120_0_0_all	3	465	85	1211	0	1534	18	1080		0.01	0.07	0.00	0.02
Denmark	SDN_DEF_>=120_0_0_all_FDF	2	59	52	295	0	10	8	62		0.03	0.18	0.00	0.13
Denmark	SSC_DEF_>=120_0_0_all	0		0		0		0						
Denmark	TBB_CRU_16-31_0_0_all	0		0		0		0						
France	GTR_DEF_all_0_0_all		7979.97		170.99		2840.91		557.93					
France	MIS_MIS_0_0_0_HC		407.91		360.2		204.2		323.7					
Germany	GNS_DEF_all_0_0_all		656		75		14							
Germany	MIS_MIS_0_0_0_HC								79					
Germany	OTB_CRU_70-99_0_0_all		236		217		1		5					
Germany	OTB_DEF_>=120_0_0_all		206		231		180							
Germany	TBB_CRU_16-31_0_0_all			24569	6							4094.83		
Germany	TBB_DEF_70-99_0_0_all	8132	16972		4734	0	3131		1639		0.48		0.00	
Netherlands	MIS_MIS_0_0_0_HC		7640		21660		27850		7360					
Netherlands	TBB_DEF_70-99_0_0_all		441930		250330		274350		122790	144944.39	0.41*	0.23*	0.25*	0.11*
Norway	GNS_DEF_all_0_0_all		262.7		106.8		90.5		84					
Norway	OTB_DEF_>=120_0_0_all		44.7		2250.1		5638		6716.5					
Sweden	GNS_DEF_all_0_0_all				206		275		13					
Sweden	MIS_MIS_0_0_0_HC	3218	6152	5904	3318	9218	323	6164	287		0.52	1.78	28.54	21.48
Sweden	OTB_CRU_70-89_2_35_all	976	0	1229	0	2971	0	1047	0		total catch discarded	total catch discarded	total catch discarded	total catch discarded
Sweden	OTB_CRU_90-119_0_0_all	73	45	68	0	48	5	56	0		1.62	total catch discarded	9.60	total catch discarded
UK	C-Allgears		9802		3346		3766		2714					
UK_SCO	MIS_MIS_0_0_0_HC				41									
UK_SCO	OTB_DEF_>=120_0_0_all		680		158		423		1					
UK_SCO	TBB_DEF_70-99_0_0_all		2284						400					

* estimated from combined quarterly discards by proportion of landings

23 Lemon sole in Subarea IV (North Sea) and Divisions IIIa (Skagerrak – Kattegat) and Division VIId (Eastern Channel)

23.1 General

Lemon sole (*Microstomus kitt*) was assessed so far in the Working Group on Assessment of New MoU Species (ICES, 2013a). Lemon sole was defined as a category 3 species according to the ICES guidelines for data limited stocks (ICES, 2012). Biennial advice for lemon sole was given in 2013 (ICES, 2013b), based on survey trends. In 2014, lemon sole was included to the data call for the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the biennial advice was evaluated in this group in 2014.

23.1.1 Biology and ecosystem aspects

Lemon sole is a commercially important flatfish that is found in the shelf waters of the North Atlantic from the White Sea and Iceland southwards to the Bay of Biscay. In Scottish waters, lemon sole spawn in the northwest of the North Sea in April and spawning spreads north and east as the season progresses (Rae, 1965). In the western English Channel, lemon sole spawn in April and May (Jennings *et al.* 1993). In the English Channel, investigations of habitat association for plaice, sole and lemon sole indicated that distribution was restricted to a few sites and that lemon soles appeared to prefer sandy and gravely strata, living deeper and at a higher salinity and lower temperature than plaice or sole (Hinz *et al*., 2006). Lemon sole feeds on small invertebrates, mainly polychaete worms, bivalves and crustaceans.

23.1.2 Stock ID and possible assessment areas

There is little information available on lemon sole stock identity for the greater North Sea.

23.1.3 Management regulations

No specific management objectives are known to ICES. An EU TAC is set for EU waters of ICES Division IIa and Subarea IV together with witch flounder (ICES, 2013a).

23.2 Fisheries data

23.2.1 Historical landings

In the North Sea and in Skagerrak-Kattegat lemon sole is mainly a by-catch species in the fishery for plaice and in the mixed demersal fisheries. Landings in ICES Division VIId, and sub-area IV and division IIIa are shown in Figures 23.4.1.1 to 23.4.1.4 and in Tables 23.6.1 to 23.6.4. From Figure 23.4.1.2 it can be seen that the landings data are not complete because there is a gap in Dutch landings data from 1984 to 1997. Further, official landings data may be incomplete for the earlier years in the time series.

Landings in sub-area IV (Figure 23.4.1.3) between 1950 and 2000 averaged between 3000-5000t pa, with successive peaks, followed by declines in landings, but between 2000 and 2011 averaged at around 3500t pa. Landings in 2010 were at a series low of 2625t, but increased in 2011 to 3365t. Preliminary landings of the recent two years are within this range with 3084t (in 2012) and 2980t (in 2013). The majority of landings from

sub-area IV are made by UK vessels, although landings by Danish and Netherlands vessels contributed a high proportion of total landings in the most recent years.

Total landings from Division VIId (Figure 23.4.1.2) have fluctuated throughout the time series between a series low of 33t in 1975 and a series high of 1151t in 1996. During the early part of the time series, the majority of landings were made by the UK fleet. Between 1978 and 2000, France took the largest proportion of the landings, followed by Belgium and the UK. These three countries have landed the majority of the catch in Division VIId since that time. In 2013 (491t) landings increased slightly compared to the previous two years.

Reported landings in Division IIIa (Figure 21.2.1.4) were below 200t per annum (pa) between 1950 and 1974, after which a sharp increase to over 600 t was seen in 1976. Landings averaged between 500 and 600t pa until 2000, since when they have declined. The catch of 254t in 2011 was the lowest since 1974 (183 t). In 2012, landings nearly doubled (482t) compared to 2011 landings, but were observed to be at a relatively low level again in 2013 (289t). The majority of lemon sole from IIIa are caught by Denmark.

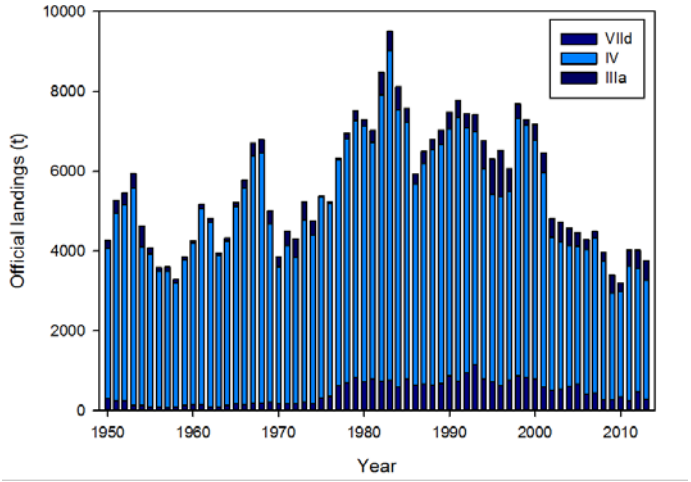


Figure 23.4.1.1 Official landings of lemon sole by area in the greater North Sea.

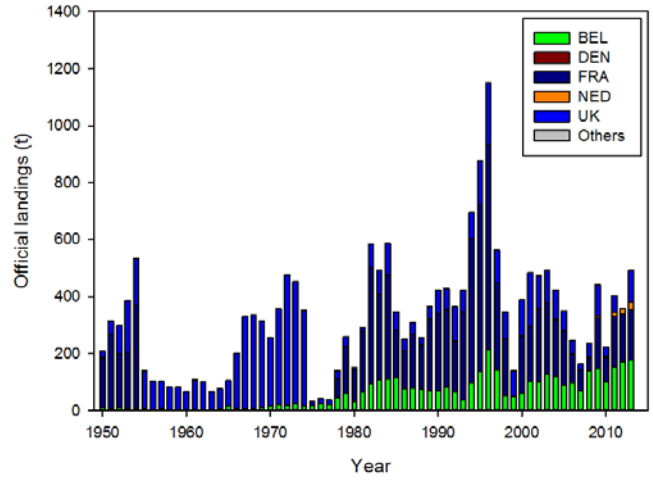


Figure 23.4.1.2 Official landings of lemon sole in area VIId by country. For 2012 official landings data for UK are missing.

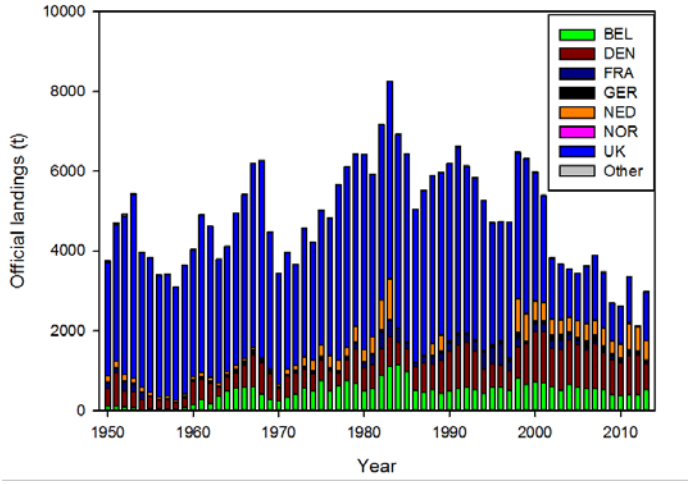


Figure 23.4.1.3 Official landings of lemon sole in area IV by country. For 2012 official landings data for UK are missing.

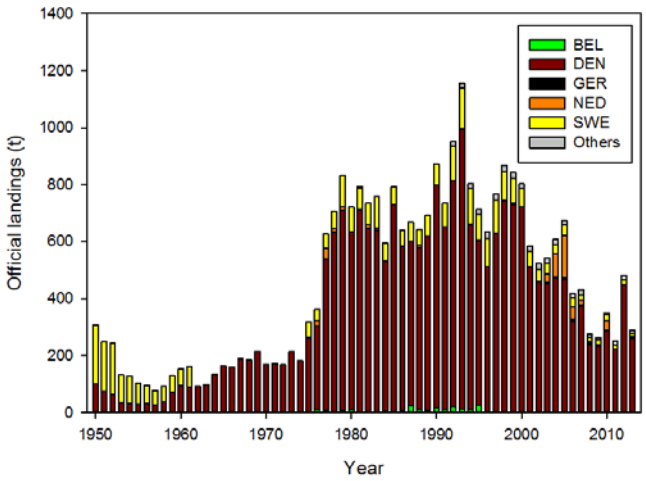


Figure 23.4.1.4 Official landings of lemon sole in area IIIa by country.

23.2.2 Discards

Discards are known to take place, but were not estimated by WGNSSK2014 to give catch advice. Although, lemon sole was included in the official data call there was no stock coordinator assigned to analyze Inter Catch data and possibly to estimate discards. Therefore, total catches could not be calculated.

23.3 Survey data / recruit series

Surveys providing information on distribution, abundance and length frequency for lemon sole in area IV, division VIId and division IIIa are the International Bottom Trawl Survey (IBTS) in quarter 1 and quarter 3, the Beam Trawl Surveys (BTS; only area IV) in quarter 3. The IBTS Q1 was used in the case of lemon sole to analyse stock trends. The IBTS Q1 uses a bottom trawl which is not the optimal gear to catch flatfishes. However, the beam trawl surveys do not cover the whole distribution area of lemon sole and catches of lemon sole are sufficient from the IBTS. It should be noted here that for the IBTS the gear in use was fully standardized since 1983. Therefore,

index data before this year should be interpreted with caution. Figure 23.5.1 displays the distribution of the mature biomass of lemon sole in the greater North Sea obtained from IBTS Q1 data. The highest concentrations occur in the north western part of the North Sea.

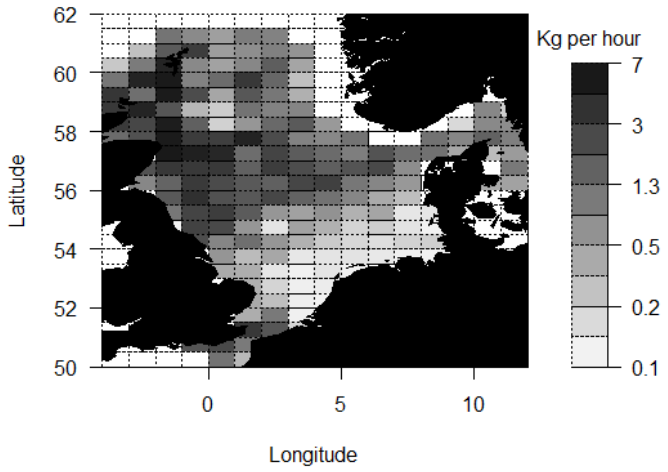


Figure 23.5.1. Distribution of lemon sole in the greater North Sea derived from IBTS Q1 data.

23.4 Analysis of stock trends / assessment

In 2013, lemon sole was assessed within the Working Group on the Assessment of MoU New Species (ICES, 2013). Only landings data and survey trends were available for this species. Therefore, lemon sole was defined as a category 3 species following the ICES guidelines for data limited stocks (ICES, 2013). Consequently, the basis of the advice was a trend based assessment applying method 3.2 of the guidelines for data limited stocks:

$$C_{y+1} = C_{y-1}\left(\frac{\sum_{i=y-x}^{y=y-1} I_i/x}{\sum_{i=y-z}^{y-x-1} I_i/(z-x)}\right)$$

Where C_{y+1} is the advised catch for the next year, C_{y-1} should be the average catch of the last three years, and I is the stock index. By default x=2 and z=5. The guidelines further explicitly suggest that in case of missing catch information landings should be taken as the basis for the method. This was the case for lemon sole, for which it was not possible in 2013 to estimate total catches. WGNEW2013 decided to set x=3 and z=8, in order to account for the relative longevity of lemon sole and to account for the noisy nature of the survey indices. An abundance index in mature biomass (g/hour) was estimated from the IBTS Q1 survey, because this survey covers most of the distribution area of lemon sole in area IV and divisions VIId and IIIa. The 3:5 ratio of the abundance index was estimated to be 16%, resulting in an advised increase in landings (<4356t). Based on these results the advice was drafted for WGNSSK2013, which accepted the advice draft.

However, ACOM criticised the approach to change the settings of x and z. Based on these criticisms WGNSSK2014 re-examined the available survey data for lemon sole to estimate a mature biomass index and to evaluate the effect of using the 2:3 ratio instead of the applied 3:5 ratio.

Estimated indices

An index of mature biomass (Figure 23.4.1.) was calculated annually from the IBTS Q1 data. For mature biomass index, the total weight per hour by centimetre length group was calculated using the length-weight relationship from Bedford *et al*. (1986):

Wt(g) = 0.00756*L(cm) 3.142

The length-maturity ogive (Figure 23.4.2.) was then applied to calculate the mature biomass index. Lemon sole are reported to spawn in the west central North Sea during the period May to November with peak spawning during July-August (Rae, 1965). Therefore most spawning occurs between the Q1 and Q3 IBTS surveys. For this reason, the maturity ogive shown in Figure 23.4.2 was derived from the age at maturity data (2006 – 2012) from both of these surveys (see stock annex for maturity-length key). Information from around spawning time would improve the accuracy of these estimates.

The indices calculated by WGBEAM2013 and WGNSSK2014 (Figure 23.4.1) were not exactly the same, probably due to slight methodological differences. Because of the limited time during the WGNSSK meeting it was not possible to investigate the reason for this discrepancy. However, the overall trend is the same and especially for the last two decades the differences between both mature biomass indices is negligible.

The mature biomass index was updated for the years 2013 and 2014. For both years it is nearly the same with 1721 and 1705 g/hour, respectively. Compared to the 2012 value this was a decrease. However, overall the index increased since the beginning of the 1980's and fluctuated with large variability on a rather stable level since then. Therefore, the updated biomass index did not change the perception of this stock.

Table 23.4.1 shows different results for using the DLS 3.2 method applying the 2:3 or 3:5 ratios to the old and updated indices. Applying the 2:3 ratio resulted in an increase in landings of 20% (with uncertainty cap) compared to the advised 16%. In case of the updated index the 3:5 ratio resulted in an increase in advised landings of 17%, while the 2:3 ratio resulted in a decrease of 7%.

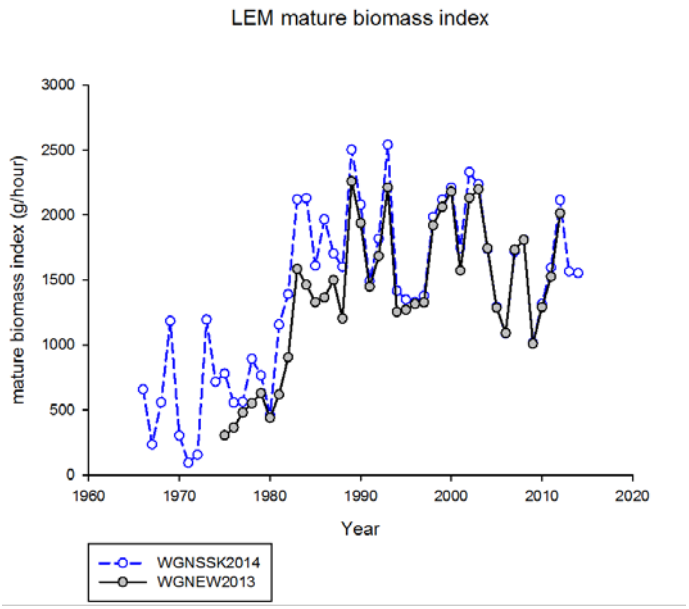


Figure 23.4.1. Comparison of WGNEW 2013 and WGNSSK 2014 survey indices of lemon sole (IBTS Q1 data).Conclusions

The advice for lemon sole given by ICES in 2013 was biennial and hence valid for 2014 and 2015. WGNSSK concluded not to re-open the advice for lemon sole in 2014. Given the high variability in the survey indices, the new survey information did not change the perception of the stock this year.

Doubts were raised concerning the applicability of the DLS 3.2 method for this stock. First, the survey indices show large variability and estimates of uncertainty are lacking. Further, the applied method is based on landings which is meaningless for a bycatch species with potentially high discards. This year, lemon sole was included in the official data call for WGNSSK and as well landings and discards would have been available using the Inter Catch data portal. However, this year no stock coordinator was assigned for the analyses of the Inter Catch data and discards could not be quantified. However, Inter Catch might enable to give catch advice for this stock in future years given a sufficient coverage of discard samplings across the most important metiers catching lemon sole.

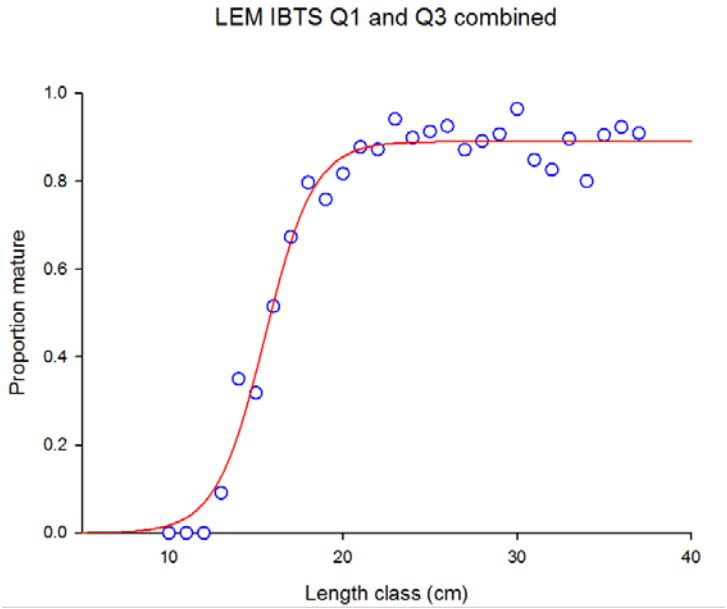


Figure 23.4.2. Length based maturity ogive for Lemon sole derived from IBTS Q1 data.

Table 23.4.1. Results of applying the 3:5 or the 2:3 ratio to the 3.2 DLS method for different stock indices. The basis for the biennial advice given in 2013 is highlighted in green.

	stock indicator	method	ratio	landings avg last 3 yrs	adviced landings	Change in %
WGNEW 2013	IBTS Q1 mature biomass	3:5	1.162	3750	4356	16%
	IBTS Q1 mature biomass	2:3	1.292	3750	4846	29%
WGNSSK 2014	IBTS Q1 mature biomass	3:5	1.170	3936	4607	17%
	IBTS Q1 mature biomass	2:3	0.931	3936	3665	-7%

23.5 References

Bedford, B.C., L.E Woolner and B.W. Jones (1986) Length-Weight relationships for commercial fish species and conversion factors for various presentations. MAFF Directorate of fisheries Research data report No 10.

Hinz, H., Bergmann, M., Shucksmith, R., Kaiser, M. J., Rogers, S. I. (2006) Habitat association of plaice, sole, and lemon sole in the English Channel. ICES Journal of Marine Science 63: 912-927.

ICES 2013a. Report of the Working Group on Assessment of New MoU Species (WGNEW), 24-28 March 2013, ICES Headquarters, Denmark. ICES CM 2013/ACOM.

ICES. 2013b. Witch in Subarea IV and Divisions IIIa and VIId. In Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.4.31.

ICES 2012. ICES implementation of advice for data limited stocks in 2012. Report in support of ICES advice. ICES CM2012/ACOM:68.

Jennings, S., Howlett, G. J., Flatman, S. (1993). The distribution, migration and stock integrity of lemon sole *Microstomus kitt* in the western English Channel. Fisheries Research 18: 377–388.

Rae, B.B. (1965). The lemon sole. Fishing News (Books) Ltd. London, 1965. 106pp.

Tables

Table 23.6.1 Official lemon sole landings by area. Data for 2012 and 2013 are preliminary data.

Year	IIIa	IV	VIId	Total
1950	307	3754	208	4269
1951	248	4710	314	5272
1952	243	4922	298	5463
1953	132	5440	386	5958
1954	128	3972	534	4634
1955	102	3836	141	4079
1956	96	3395	103	3594
1957	78	3419	102	3599
1958	94	3104	82	3280
1959	130	3647	82	3859
1960	153	4035	66	4254
1961	161	4900	108	5169
1962	93	4630	101	4824
1963	99	3791	66	3956
1964	134	4121	77	4332
1965	164	4949	105	5218
1966	159	5415	201	5775
1967	191	6188	331	6710
1968	185	6270	337	6792
1969	215	4470	315	5000
1970	169	3434	256	3859
1971	173	3967	357	4497
1972	168	3672	475	4315
1973	214	4568	451	5233
1974	183	4227	351	4761
1975	317	5029	33	5379
1976	361	4830	42	5233
1977	627	5661	36	6324
1978	705	6108	139	6952
1979	833	6428	260	7521
1980	722	6424	152	7298
1981	793	5933	290	7016
1982	735	7168	584	8487
1983	759	8257	491	9507
1984	595	6930	586	8111
1985	793	6435	347	7575
1986	639	5047	251	5937
1987	669	5516	310	6495
1988	642	5898	258	6798
1989	693	5967	364	7024
1990	872	6190	423	7485

1991	734	6618	428	7780
1992	952	6126	364	7442
1993	1152	5839	422	7413
1994	801	5262	695	6758
1995	712	4712	877	6301
1996	634	4737	1151	6522
1997	766	4727	563	6056
1998	865	6466	346	7677
1999	841	6316	140	7297
2000	802	5980	388	7170
2001	583	5389	483	6455
2002	518	3827	474	4819
2003	537	3688	491	4716
2004	602	3543	424	4569
2005	669	3444	350	4463
2006	417	3627	246	4290
2007	432	3892	164	4488
2008	276	3465	234	3975
2009	262	2691	441	3394
2010	351	2627	223	3201
2011	254	3365	403	4022
2012 *	483	3084	459	4026
2013 *	290	2980	491	3761

* preliminary data

Table 23.6.2 Official lemon sole landings in area VIId by country.

Year	BEL	DNK	FRA	NED	UK	Other	Total
1950	10	0	174	0	24	0	208
1951	5	0	262	0	47	0	314
1952	10	0	188	0	100	0	298
1953	7	0	196	0	183	0	386
1954	9	0	361	0	164	0	534
1955	9	0	0	0	132	0	141
1956	4	0	0	0	99	0	103
1957	7	0	0	0	95	0	102
1958	1	0	0	0	81	0	82
1959	2	0	0	0	80	0	82
1960	4	0	0	0	62	0	66
1961	1	0	0	0	106	1	108
1962	2	0	0	0	99	0	101
1963	3	0	0	0	63	0	66
1964	5	0	0	0	72	0	77
1965	16	0	0	0	89	0	105
1966	7	0	0	0	194	0	201
1967	6	0	0	0	325	0	331
1968	8	0	0	0	329	0	337
1969	12	0	0	0	303	0	315
1970	16	0	0	0	240	0	256
1971	22	0	0	0	335	0	357
1972	18	0	0	0	457	0	475
1973	25	0	0	0	426	0	451
1974	16	0	0	1	334	0	351
1975	19	0	0	0	14	0	33
1976	24	0	0	0	18	0	42
1977	21	1	0	0	15	0	37
1978	45	2	63	0	31	0	141
1979	60	0	165	0	35	0	260
1980	33	0	109	0	10	0	152
1981	66	0	212	0	12	0	290
1982	96	0	406	1	81	0	584
1983	108	0	298	0	85	0	491
1984	110	0	367	0	109	0	586
1985	117	0	164	0	66	0	347
1986	77	0	133	0	41	0	251
1987	81	0	185	0	44	0	310
1988	74	0	155	0	29	0	258
1989	68	0	252	0	44	0	364
1990	68	0	272	0	83	0	423
1991	83	0	272	0	73	0	428
1992	66	0	176	0	122	0	364

1993	36	0	311	0	75	0	422
1994	97	0	505	0	93	0	695
1995	138	0	584	0	155	0	877
1996	213	0	720	0	218	0	1151
1997	143	0	305	0	115	0	563
1998	53	0	198	0	95	0	346
1999	50	0	0	0	90	0	140
2000	62	0	200	0	126	0	388
2001	104	0	191	0	188	0	483
2002	101	0	256	0	117	0	474
2003	128	0	251	0	112	0	491
2004	120	0	198	1	105	0	424
2005	90	0	187	2	71	0	350
2006	98	0	100	0	48	0	246
2007	70	0	72	1	21	0	164
2008	140	0	46	3	45	0	234
2009	149	0	176	9	108	0	442
2010	101	0	85	5	32	0	223
2011	153	0	178	15	57	0	403
2012*	171	0	167	20	0	0	358
2013*	176	0	179	26	110	0	491

* preliminary data

Table. 23.6.3 Official lemon sole landings in ICES sub-area IV by country. Data for 2012 and 2013 are preliminary.

Year	BEL	DNK	FRA	GER	NED	NOR	UK	Other	Total
1950	112	435	139	31	156	0	2855	26	3754
1951	115	845	90	21	167	0	3430	42	4710
1952	98	391	227	26	168	0	3953	59	4922
1953	73	409	189	18	132	0	4590	29	5440
1954	2	272	177	24	112	0	3368	17	3972
1955	49	311	0	15	78	0	3374	9	3836
1956	48	222	0	19	58	0	3034	14	3395
1957	39	249	0	24	64	0	3032	11	3419
1958	30	171	0	13	43	0	2835	12	3104
1959	85	242	0	40	43	0	3226	11	3647
1960	155	577	0	46	67	0	3178	12	4035
1961	286	488	0	79	102	0	3934	11	4900
1962	175	501	0	54	106	0	3794	0	4630
1963	365	222	0	36	71	0	3097	0	3791
1964	484	358	0	62	75	0	3142	0	4121
1965	562	385	0	91	93	0	3818	0	4949
1966	594	548	0	98	65	0	4110	0	5415
1967	601	791	0	136	61	0	4599	0	6188
1968	422	775	0	96	34	0	4943	0	6270
1969	292	639	0	80	36	0	3423	0	4470
1970	241	307	0	52	58	0	2776	0	3434
1971	348	514	0	54	122	0	2929	0	3967
1972	423	530	0	59	130	0	2530	0	3672
1973	566	478	0	73	217	16	3218	0	4568
1974	486	447	0	59	269	0	2966	0	4227
1975	748	521	0	83	299	0	3367	11	5029
1976	493	506	0	68	308	0	3443	12	4830
1977	618	321	0	71	262	0	4387	2	5661
1978	760	517	28	54	231	0	4518	0	6108
1979	674	876	136	41	390	0	4308	3	6428
1980	484	599	102	49	303	0	4885	2	6424
1981	555	605	237	39	412	0	4084	1	5933
1982	879	670	419	52	759	0	4386	3	7168
1983	1122	735	402	28	1009	0	4957	4	8257
1984	1144	567	344	22	0	0	4850	3	6930
1985	989	555	157	26	0	0	4703	5	6435
1986	511	577	103	16	0	0	3839	1	5047
1987	448	742	174	14	0	0	4137	1	5516
1988	539	639	184	14	301	0	4220	1	5898
1989	441	828	176	40	397	0	4083	2	5967
1990	491	1007	208	49	0	0	4431	4	6190
1991	544	1099	250	41	0	12	4666	6	6618

1992	577	1149	177	30	0	13	4175	5	6126
1993	525	966	240	37	0	9	4059	3	5839
1994	436	597	436	27	0	11	3754	1	5262
1995	588	585	412	70	0	9	3046	2	4712
1996	592	547	534	67	0	18	2976	3	4737
1997	504	499	224	76	0	29	3391	4	4727
1998	815	796	197	149	838	23	3643	5	6466
1999	662	1015	0	62	681	24	3866	6	6316
2000	711	1277	184	72	492	17	3222	5	5980
2001	694	1281	191	77	451	22	2666	7	5389
2002	604	971	190	116	402	17	1521	6	3827
2003	517	1008	239	136	369	16	1399	4	3688
2004	667	1113	120	81	355	12	1192	3	3543
2005	595	1057	102	85	402	13	1188	2	3444
2006	552	968	57	183	412	13	1440	2	3627
2007	542	1136	65	143	367	23	1610	6	3892
2008	527	925	47	120	434	26	1383	4	3466
2009	389	898	88	64	294	31	927	2	2693
2010	375	821	32	102	323	35	935	2	2625
2011	387	999	56	96	641	27	1157	2	3365
2012*	406	999	34	61	587	30	0	2	2119
2013*	527	649	27	67	479	16	1214	2	2981

* preliminary data

Table 23.6.4 Official landings in area IIIa by country. Data for 2013 are preliminary.

Year	BEL	DNK	GER	NED	SWE	Other	Total
1950	0	100	1	0	206	0	307
1951	0	74	1	0	173	0	248
1952	0	64	0	0	179	0	243
1953	0	35	0	0	97	0	132
1954	0	33	0	0	95	0	128
1955	0	29	0	0	73	0	102
1956	0	33	0	0	63	0	96
1957	0	27	0	0	51	0	78
1958	0	38	0	0	56	0	94
1959	0	71	0	0	59	0	130
1960	0	95	1	0	57	0	153
1961	0	90	0	0	71	0	161
1962	0	92	1	0	0	0	93
1963	0	99	0	0	0	0	99
1964	0	133	1	0	0	0	134
1965	0	163	1	0	0	0	164
1966	0	159	0	0	0	0	159
1967	0	189	1	0	0	1	191
1968	0	184	0	0	0	1	185
1969	0	215	0	0	0	0	215
1970	0	169	0	0	0	0	169
1971	0	173	0	0	0	0	173
1972	0	168	0	0	0	0	168
1973	0	214	0	0	0	0	214
1974	0	183	0	0	0	0	183
1975	0	263	1	1	52	0	317
1976	10	294	1	19	37	0	361
1977	9	528	2	37	51	0	627
1978	4	628	2	12	59	0	705
1979	7	704	1	10	111	0	833
1980	12	622	0	0	87	1	722
1981	1	710	0	3	75	4	793
1982	2	647	0	9	77	0	735
1983	3	636	0	10	110	0	759
1984	6	525	0	0	64	0	595
1985	0	729	0	0	64	0	793
1986	7	576	0	0	56	0	639
1987	24	577	0	0	68	0	669
1988	11	569	0	6	56	0	642
1989	8	610	0	0	75	0	693
1990	16	782	0	0	74	0	872
1991	11	640	0	0	83	0	734
1992	22	793	0	0	120	17	952

1993	14	980	4	0	141	17	1156
1994	10	648	2	0	127	16	803
1995	27	576	2	0	91	18	714
1996	0	513	1	0	97	24	635
1997	0	628	2	0	115	23	768
1998	0	743	3	0	100	22	868
1999	0	731	3	0	88	22	844
2000	0	722	1	0	65	15	803
2001	0	511	1	0	53	19	584
2002	0	457	4	0	41	20	522
2003	0	451	6	30	35	21	543
2004	0	472	5	82	29	19	607
2005	0	468	5	147	38	16	674
2006	0	321	8	40	32	16	417
2007	0	374	5	16	18	19	432
2008	0	239	7	3	15	12	276
2009	0	233	4	1	15	9	262
2010	0	286	3	35	19	7	350
2011	0	223	0	0	12	16	254
2012	0	446	3	0	15	18	482
2013*	0	259	3	5	10	12	289

* preliminary data

Table 23.6.5 Mature biomass index (g/hour) calculated from IBTS Q1 data by WGNEW2013 and WGNSSK2014.

Year	WGNEW2013	WGNSSK2014
1983	1585	2330
1984	1464	2340
1985	1328	1771
1986	1365	2163
1987	1500	1875
1988	1202	1760
1989	2260	2752
1990	1938	2284
1991	1449	1642
1992	1685	1998
1993	2213	2793
1994	1253	1558
1995	1271	1484
1996	1315	1462
1997	1326	1516
1998	1920	2183
1999	2062	2325
2000	2181	2429
2001	1573	1920
2002	2132	2560
2003	2199	2457
2004	1745	1910
2005	1285	1420
2006	1092	1195
2007	1733	1888
2008	1809	1988
2009	1010	1116
2010	1290	1444
2011	1526	1751
2012	2014	2323
2013		1721
2014		1705

24 Witch flounder in Subarea IV, Division IIIa and VIId

The existing knowledge of witch biology is summarized in the Stock Annex.

Witch flounder has been classified as category 3 stocks following the guidelines of the ICES Data Limited Stocks (DLS) methodological document (ICES 2012). This category includes stocks for which survey indices (or other indicators of stock size) are available and provide reliable indications of trends in stock metrics.

The last advice for this species drafted in June 2013 is biennial and thus valid for 2014 and 2015. The advice was based on stock size indicators (standardized CPUE in number/hour) derived from IBTS (both Q1 and Q3) and exploratory estimates (merely indicative of trends and not used for catch forecast) suggesting that fishing mortality is above potential FMSY proxies.

Based on the ICES approach for data limited stocks, the advice in 2013 considered the comparison of the last three years index values (2011–2013 for IBTSQ1 and 2010-2012 for IBTSQ3) with the five preceding years values (2006–2010 for IBTSQ1 and 2005-2009 for IBTSQ3) combined with recent catch or landings data. The survey indices, showed a declining trend since the peak observed in 2000 and an increase in recent years, mirroring the trend observed in landings. As for both surveys the three most recent year index were more than 20% higher than five previous year index, an uncertainty Cap of +20% and a precautionary approach (PA) buffer of -20% were applied to catch advice in accordance with the DLS guidelines. Based on these, ICES advised that landings should not be more than 1574 tonnes for the period 2014 and 2015. During WGNSSK 2014 data and methods were reviewed to appraise the need for an advice update. The stock size indicators obtainded using IBTS Q1 and Q3 were updated, but in addition to the CPUE (N/h) the total biomass in terms of Kg/h was also estimated (Table 24.1 and Figure 24.1-24.4).Furthermore a logistic regression applied on the Datras CA records showed that L50, i.e. the length at which 50% of the stock is mature, corresponds to 34 cm. Thus the indices were also estimated taking into account only the biomass of reproducing fish, i.e. all specimens larger than 34 cm.

The choice to compare three versus five rather than two versus three years index values applied for the advice 2013 was made for accounting the inter-annual variability of surveys. The inclusion of an extra year does in fact reduce the possibility that the observed pattern may be just due to the variability between surveys from two consecutive years. Furthermore this species becomes reproductively mature at age 3, thus considering a three years average will include at least one generation.

During WGNSSK 2014 both the three versus five and two versus three years index values were explored for all indices estimated. In all cases the latest years' indices are more than 20% higher than the average of the preceding years (table 24.2).

As the exploration of new data (both landings and survey data) available for this stock do not change the perception of the stock, the advice for this fishery in 2014 is the same as the advice for 2013 (see ICES, 2013)

In addition, following the data call, discard data were available on Intercatch. However a first exploration of data evidenced some inconsistencies that need to be further investigated. For some métiers discards were available but the landings were null being unclear if this depends on the fact that the entire catch is discarded by some métiers or if the landings information was unreported. Similarly for some métiers the discard

were null being unclear if this depends on the fact that the entire catch is landed by some countries or if the discard information was unreported.

Additional information for solving this issue will be gathered before the witch flounder benchmark planned for February 2015.

Table 24.1. Witch flounder in IV and IIIa. Abundance indices estimated from IBTS surveys in quarter 1 and quarter 3 both as N/h and Kg/h .

	Total stock					Spawning stock			
	N/h		Kg/h			N/h		Kg/h	
Year	Quarter 1	Quarter 3	Quarter 1	Quarter 3	Year	Quarter 1	Quarter 3	Quarter 1	Quarter 3
1965					1965				
1966					1966				
1967					1967				
1968	0.175		0.082		1968	0.142		0.077441706	
1969	0.095		0.040		1969	0.087		0.03812073	
1970	0.474		0.157		1970	0.410		0.150486815	
1971	0.030		0.008		1971	0.012		0.005729767	
1972	0.407		0.029		1972	0.031		0.011778644	
1973	0.704		0.088		1973	0.151		0.060496008	
1974	0.375		0.060		1974	0.091		0.041941369	
1975	1.096		0.105		1975	0.112		0.025879342	
1976	0.841		0.162		1976	0.366		0.127155545	
1977	0.920		0.083		1977	0.132		0.04322167	
1978	0.656		0.087		1978	0.156		0.051881307	
1979	0.430		0.090		1979	0.211		0.068136071	
1980	0.141		0.036		1980	0.086		0.028303003	
1981	1.469		0.408		1981	0.917		0.379873505	
1982	0.237		0.068		1982	0.163		0.060519016	
1983	0.684		0.169		1983	0.391		0.146429581	
1984	0.594		0.135		1984	0.326		0.113497198	
1985	0.851		0.184		1985	0.426		0.161323405	
1986	0.854		0.210		1986	0.412		0.173920294	
1987	0.919		0.247		1987	0.538		0.207775311	
1988	0.218		0.071		1988	0.168		0.065633123	
1989	1.788		0.386		1989	0.885		0.297900647	
1990	0.800		0.160		1990	0.337		0.120279948	
1991	0.725	1.140	0.134	0.194	1991	0.292	0.385	0.099757054	0.114983739
1992	1.854	0.716	0.453	0.152	1992	1.254	0.363	0.388576437	0.119162132
1993	2.050	1.008	0.382	0.115	1993	0.874	0.197	0.277877966	0.061881168
1994	1.218	0.731	0.111	0.110	1994	0.282	0.237	0.085648886	0.081098336
1995	3.357	0.852	0.354	0.166	1995	0.741	0.383	0.245296719	0.125968615
1996	1.221	1.824	0.140	0.190	1996	0.260	0.298	0.088564541	0.100076267
1997	2.864	4.320	0.388	0.392	1997	0.786	0.611	0.254843012	0.16962265
1998	3.789	1.535	0.452	0.166	1998	0.793	0.263	0.247732673	0.084857194
1999	2.860	1.019	0.374	0.181	1999	0.613	0.403	0.193646099	0.116193076
2000	2.515	0.427	0.353	0.064	2000	0.795	0.142	0.241599636	0.041132448
2001	1.253	1.699	0.195	0.191	2001	0.400	0.385	0.127870814	0.111581006
2002	1.848	0.806	0.259	0.123	2002	0.560	0.303	0.157398687	0.087597732
2003	1.703	0.619	0.231	0.093	2003	0.412	0.180	0.121149173	0.050792154
2004	0.835	0.840	0.156	0.127	2004	0.378	0.240	0.113935201	0.07061526

2005	0.755	0.591	0.167	0.092	2005	0.452	0.182	0.135597831	0.055192181
2006	0.321	1.176	0.067	0.155	2006	0.189	0.297	0.055229718	0.084757761
2007	0.699	1.082	0.110	0.185	2007	0.277	0.422	0.076994888	0.12269367
2008	1.006	0.619	0.170	0.099	2008	0.381	0.196	0.115670764	0.058735358
2009	0.538	0.767	0.094	0.086	2009	0.213	0.196	0.062070124	0.053262191
2010	0.721	0.640	0.074	0.104	2010	0.140	0.203	0.044013622	0.065684914
2011	1.371	1.022	0.127	0.153	2011	0.173	0.319	0.04799012	0.093707311
2012	1.320	1.492	0.178	0.234	2012	0.282	0.429	0.086418535	0.130059132
2013	1.398	0.691	0.201	0.146	2013	0.318	0.369	0.084470422	0.108753528
2014	2.222		0.420		2014	1.044		0.296297735	

Table 24.2. Witch flounder in IV and IIIa. Comparison of the last two years index values (2013–2014 for IBTSQ1 and 2012-2013 for IBTSQ3) with and of the last three years index values (2012–2014 for IBTSQ1 and 2011-2013 for IBTSQ3) with the five preceding years values (2007–2011 for IBTSQ1 and 2006-2010 for IBTSQ3). The indices were estimated both for the total and the spawning biomass.

	2 versus 3		3 versus 5	
	Quarter 1	Quarter 3	Quarter 1	Quarter 3
Total stock (N/h)	59%	34%	90%	24%
Spawning Stock (N/h)	243%	67%	132%	42%
Total stock (Kg/h)	145%	66%	131%	41%
Spawning Stock (Kg/h)	220%	68%	125%	44%

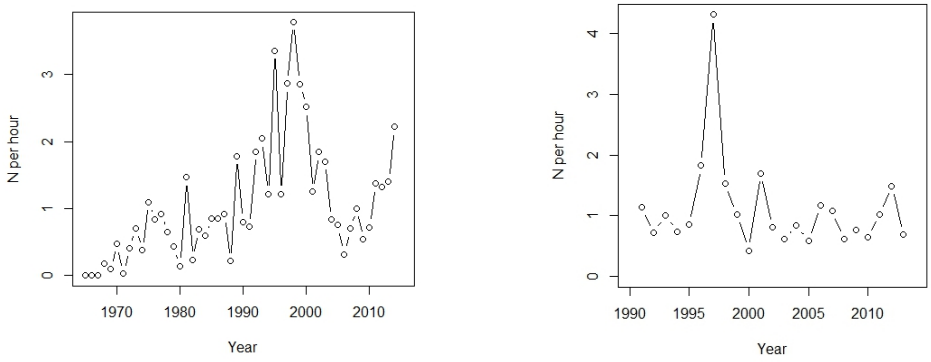


Figure 24.1: Abundance indices, trend in cpue (n/h) from the IBTS survey in quarter 1 (on the left) and quarter 3 (on the right) estimated for the total stock.

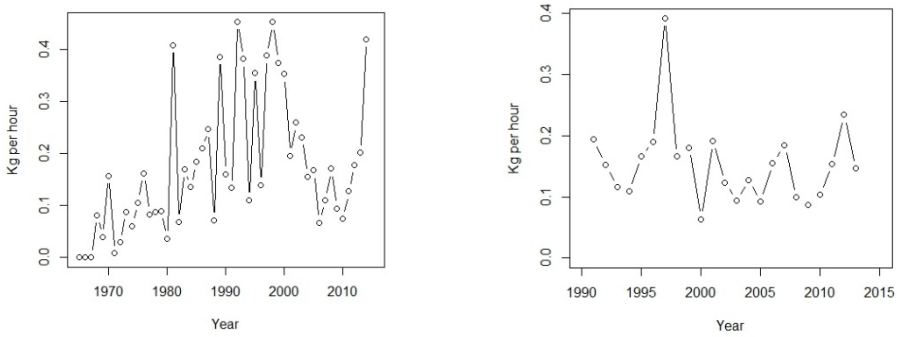


Figure 24.2: Abundance indices, trend in biomass (Kg/h) from the IBTS survey in quarter 1 (on the left) and quarter 3 (on the right) estimated for the total stock.

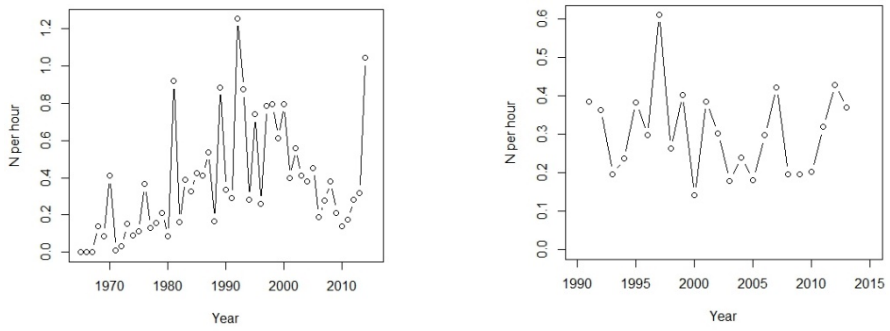


Figure 24.3: Abundance indices, trend in cpue (n/h) from the IBTS survey in quarter 1 (upper plot) and quarter 3 (lower plot) estimated for the mature stock, i.e. all individuals larger than 34 cm.

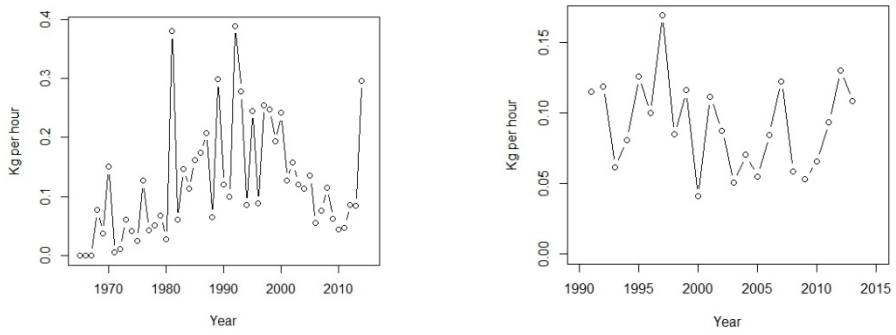


Figure 24.4: Abundance indices, trend in biomass (Kg/h) from the IBTS survey in quarter 1 (on the left) and quarter 3 (on the right) estimated for the mature stock, i.e. all individuals larger than 34 cm.

Annex 1 List of Participants

First name	Surname	Institute		E-mail
Alexander	Kempf	Thünen Institute	Institute for Sea Fisheries	alexander.kempf@ti.bund.de
Arved	Staby	Institute of Marine Research		arved.staby@imr.no;
Aukje	Coers	Wageningen IMARES		aukje.coers@wur.nl
Carlos	Mesquita	Marine Scotland Science	Marine Laboratory	c.mesquita@marlab.ac.uk
Clara	Ulrich	DTU Aqua - National Institute of Aquatic Resources		clu@aqua.dtu.dk
Coby	Needle	Marine Scotland Science	Marine Laboratory	needlec@marlab.ac.uk
David	Miller	Wageningen IMARES		david.miller@wur.nl
Elisa	Barreto	Marine Scotland Science	Marine Laboratory	e.barreto@marlab.ac.uk
Ewen D.	Bell	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Lowestoft Laboratory	ewen.bell@cefas.co.uk
Frans	van Beek	Centre for Fisheries Research		frans.vanbeek@wur.nl
Guldborg	Søvik*	Institute of Marine Research		guldborg.soevik@imr.no
Henrik	Svedäng	Swedish University of Agricultural Sciences	Institute of Marine Research	henrik.svedang@slu.se
Holger	Haslob	Thünen Institute	Institute for Sea Fisheries	
Jennifer	Devine	Institute of Marine Research		jennifer.devine@imr.no
Jordan P.	Feekings	DTU Aqua - National Institute of Aquatic Resources		jpfe@aqua.dtu.dk
José	De Oliveira	Centre for Environment, Fisheries and Aquaculture Science (Cefas)	Lowestoft Laboratory	jose.deoliveira@cefas.co.uk
Kelle	Moreau*	Institute for Agricultural and Fisheries Research (ILVO)		kelle.moreau@ilvo.vlaanderen.be
Knut	Korsbrekke	Institute of Marine Research		knut.korsbrekke@imr.no
Lynda	Blackadder	Marine Scotland Science		lynda.blackadder@scotland.gsi.gov.uk
Marie	Savina-Rolland	Ifremer	Boulogne-sur-Mer Centre	Marie.Savina.Rolland@ifremer.fr
Mats	Ulmestrand	Swedish University of Agricultural Sciences	Institute of Marine Research	mats.ulmestrand@slu.se
Rasmus	Nielsen	DTU Aqua - National Institute of Aquatic Resources	Section for Fisheries Advice	rn@aqua.dtu.dk

Willy	Vanhee	Institute for Agricultural and Fisheries Research (ILVO)		willy.vanhee@ilvo.vlaanderen.be
Youen	Vermard	Ifremer	Boulogne-sur-Mer Centre	youen.vermard@ifremer.fr
William	Lart*			
Francesca	Vitale			
Lisa	Readdy*			

*By correspondence

Annex 02 Update Forecasts and Assessments

2.1 Summary

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chair: Alexander Kempf, DE) met by correspondence at the beginning of October 2013 to evaluate new information from the fisheries independent surveys carried out during 2013 subsequent to the meeting of the group in April.

The WGNSSK followed the protocol defined by the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES CM 2008/ACOM:60) in its evaluation of the survey information - fitting the RCT3 regression model to data that included the 2014 survey information to estimate the recent recruitment abundance and then comparing the prediction and its associated uncertainty with the estimate from previous surveys used as the basis for the ACOM spring advice.

As every year, the indices used in the current update must be considered as provisional and will likely be revised for the assessment in May next year.

An update is also presented for the *Nephrops* stocks, given that UTV surveys usually take place over summer. This allows for a considerably smaller time lag between the last abundance observations and their use for next year's advice.

The comparisons indicated that there is potential for re-opening of advice for Northern Shelf haddock, whiting in IV, IIIaN and VIId, North Sea plaice and sole and *Nephrops* FU6 (Farn Deeps). For Northern Shelf haddock, updated advice would imply a 12% increase in the TAC for Subarea IV, IIIa and VIa, compared with a 8% increase in the ICES advice presented in June. For sole in IV the advice would change from -8% to -5%. For *Nephrops* FU6, the new advice would be 14% higher than the advice presented in June. For whiting in IV, IIIaN and VIId and plaice in IV the new survey information indicates significant deviations from forecast assumptions. However, the adviced TAC would not change for both stocks (+/-15% TAC constraint). Catches are forecasted to change to some extent in all five forecasts. Especially the discards for haddock are forecasted to increase because the 2014 year class is estimated by RCT3 to be considerably higher than the assumed recruitment in the June forecast.

2.2 Cod in Subarea IV, VIID and IIIa

No update has been presented for cod since 2011, due to the removal of the IBTS 3rd quarter from the assessment following the Inter-Benchmark WKCOD 2011. Therefore the advice is unchanged.

2.3 Haddock in Sub-Area IV and Divisions IIIa and VIa

2.3.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 2.3.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2014), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

2.3.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2014) year-class at age 0. The RCT3 input and output files are given in Tables 2.3.2 and 2.3.3.

Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2014 year-class at age 0	
Log WAP from RCT3 (R)	9.561
Log of recruitment assumed in spring (A)	7.920
Int SE of log WAP (S)	0.314
Distance D $\left(D = \frac{R-A}{S}\right)$	5.229

2.3.3 Conclusions from protocol

As the distance D >> 1.0, the protocol concludes that **the advisory process for Northern Shelf haddock should be reopened.** The autumn indices suggest that the size of the incoming year-class is significantly larger than had been assumed in the forecast produced by WGNSSK in May 2014.

2.3.4 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for Northern Shelf haddock using the new estimate of recruitment in 2014 (14195 millions at age 0; see Table 2.3.3). The settings and assumptions for the forecast were otherwise unchanged from those presented in ICES-WGNSSK (2014): in particular, the increased recruitment was assumed to apply for the 2014 year-class only, and subsequent year-classes reverted to the lower mean estimate used by ICES-WGNSSK (2014).

Table 2.3.4 compares the MFDP output tables from the new October 2014 run, and the original June 2014 run, while Table 2.3.5 gives a draft advice table for the October 2014 run. Note that this includes columns showing the catch options split into the North Sea (IV), Skagerrak (IIIa) and West of Scotland (VIa) using the same method as proposed by WGNSSK in May 2014 – a catch split method has not yet been agreed by ICES so these columns should only be considered as indicative. The "full NoSh" columns cover the entire stock area, however, and these can be considered further here.

The baseline advice uses F(msy). On this basis, predicted landings in 2015 increase from 48176 (June results) to 50163 (October results), while the corresponding full-area TAC change increases from +8% to +12%. The effect of the new recruitment estimate on the forecast 2015 discards is considerable, increasing them from 6404 tonnes to 18528 tonnes assuming an unchanged discard rate (the discard rate for young haddock has been high in recent years). The forecasts for SSB are unchanged as the assessment assumes knife-edged maturity at age 3, and the recruiting fish are therefore all assumed still to be immature by the start of 2016.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2014). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2014/ACOM:13.

Table 2.3.1. Haddock in Sub-Area IV and Divisions IIIa and VIa. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2014 are highlighted.

	Age					
	0	1	2	3	4	5
1991	718.479	233.55	22.921	2.842	0.507	1.561
1992	2741.14	595.235	189.015	10.529	1.583	0.396
1993	577.382	605.99	140.146	37.604	2.36	0.372
1994	1781.191	195.331	262.643	32.423	8.383	0.381
1995	520.855	1019.607	106.642	97.383	8.06	3.131
1996	627.502	247.469	428.471	30.426	20.215	2.649
1997	195.255	347.567	123.793	149.048	6.672	5.282
1998	276.401	257.14	164.853	53.69	42.66	3.093
1999	6904.561	176.461	94.108	47.947	13.268	9.904
2000	1092.83	2511.127	44.361	19.494	10.29	4.276
2001	34.751	360.531	1100.248	30.305	6.377	3.653
2002	138.204	49.504	223.792	583.061	10.079	2.601
2003	163.924	69.356	31.171	199.252	368.656	2.942
2004	184.19	69.69	40.666	23.165	82.886	155.351
2005	1410.156	68.238	47.864	16.214	9.279	33.22
2006	193.023	552.595	27.683	11.781	3.661	3.408
2007	112.459	149.63	385.801	10.408	5.378	1.132
2008	126.531	86.978	90.222	175.485	5.253	2.266
2009	909.349	77.692	79.989	38.131	73.976	1.643
2010	30.244	562.819	59.551	35.229	22.417	44.883
2011	30.64	77.093	344.933	26.994	12.167	8.921
2012	68.708	31.998	40.522	132.69	7.152	4.409
2013	86.076	59.168	25.052	18.256	83.05	2.564
2014	749.312	46.110	57.568	4.533	7.349	50.434

Table 2.3.2. Haddock in Sub-Area IV and Divisions IIIa and VIa. RCT3 input file. Data from surveys in autumn 2014 are highlighted.

yearclass	recruitment	ibtsq11	ibtsq12	ibtsq30	ibtsq31	ibtsq32
1981	28241.05	NA	403.079	NA	NA	NA
1982	16209.68	302.278	221.275	NA	NA	NA
1983	49725.06	1072.285	833.257	NA	NA	NA
1984	11889.57	230.968	266.912	NA	NA	NA
1985	17319.71	573.023	328.062	NA	NA	NA
1986	31801.64	912.559	677.641	NA	NA	NA
1987	3134.45	101.691	98.091	NA	NA	NA
1988	3313.21	219.705	139.114	NA	NA	NA
1989	5003.85	217.448	134.076	NA	NA	22.921
1990	17195.99	680.231	331.044	NA	233.55	189.015
1991	19251.48	1141.396	519.521	718.479	595.235	140.146
1992	28886.97	1242.121	491.051	2741.14	605.99	262.643
1993	8919.39	227.919	201.069	577.382	195.331	106.642
1994	35073.27	1355.485	813.268	1781.191	1019.607	428.471
1995	9811.16	267.411	353.882	520.855	247.469	123.793
1996	13212.21	849.943	420.926	627.502	347.567	164.853
1997	7094.64	357.597	222.907	195.255	257.14	94.108
1998	5198.25	211.139	96.075	276.401	176.461	44.361
1999	89946.2	3482.017	2255.213	6904.561	2511.127	1100.248
2000	17351.34	894.651	473.628	1092.83	360.531	223.792
2001	1704.39	57.312	39.267	34.751	49.504	31.171
2002	2606.05	89.991	79.595	138.204	69.356	40.666
2003	2639.58	71.847	60.984	163.924	69.69	47.864
2004	2551.26	69.697	48.553	184.19	68.238	27.683
2005	26541.35	1156.65	963.377	1410.156	552.595	385.801
2006	5131.98	109.11	106.46	193.023	149.63	90.222
2007	3577.43	60.037	140.033	112.459	86.978	79.989
2008	2674.99	74.749	72.371	126.531	77.692	59.551
2009	17020.33	686.078	777.833	909.349	562.819	344.933
2010	1497.17	45.647	65.061	30.244	77.093	40.522
2011	777.16	14.099	23.68	30.64	31.998	25.052
2012	NA	58.261	104.211	68.708	59.168	57.568
2013	NA	24.077	NA	86.076	46.11	NA
2014	NA	NA	NA	749.312	NA	NA

Table 2.3.3. Haddock in Sub-Area IV and Divisions IIIa and VIa. RCT3 output file.

Analysis by RCT3 ver4.0

Haddock

Data for 5 surveys over 34 years : 1981 - 2014

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction		
	se.pred	WAP.weights							
ibtsq11	0.9273	3.816	0.343	0.922	30	NA	NA	NA	NA
ibtsq12	1.11	3.082	0.3373	0.9245	31	NA	NA	NA	NA
ibtsq30	0.8529	3.915	0.3014	0.9453	21	6.619	9.561	0.3265	1
ibtsq31	1.1179	2.969	0.2743	0.953	22	NA	NA	NA	NA
ibtsq32	1.2194	3.267	0.4785	0.8646	23	NA	NA	NA	NA
VPA mean		NA	NA	NA	NA	31	NA	9.071	1.1601	0

	WAP	logWAP	int.se
yearclass:2014	14195	9.561	0.3143

Table 2.3.4. Haddock in Sub-Area IV and Divisions IIIa and VIa. MFDP output for October 2014 revision (top) and original June 2014 run (bottom).

MFDP version 1a											
Run: Oct01											
Time and date: 10:15 02/10/2014											
Fbar age range (Total) : 2-4											
Fbar age range Fleet 1 : 2-4											
Fbar age range Fleet 2 : 2-4											
2014											
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield		
723613	185889	1.0	0.155	32236	0.034	3503	1	0.000	0		
2015										2016	
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB
849264	164257	0.0	0.000	0	0.000	0	1	0.000	0	694337	167986
.	164257	0.1	0.016	3120	0.003	1037	1	0.000	0	690061	164812
.	164257	0.2	0.031	6182	0.007	2069	1	0.000	0	685851	161700
.	164257	0.3	0.047	9187	0.010	3097	1	0.000	0	681706	158650
.	164257	0.4	0.062	12138	0.014	4120	1	0.000	0	677624	155660
.	164257	0.5	0.078	15034	0.017	5139	1	0.000	0	673605	152729
.	164257	0.6	0.093	17878	0.020	6153	1	0.000	0	669647	149855
.	164257	0.7	0.109	20669	0.024	7162	1	0.000	0	665749	147038
.	164257	0.8	0.124	23409	0.027	8168	1	0.000	0	661910	144277
.	164257	0.9	0.140	26100	0.031	9168	1	0.000	0	658129	141570
.	164257	1.0	0.155	28742	0.034	10165	1	0.000	0	654404	138916
.	164257	1.1	0.171	31335	0.037	11157	1	0.000	0	650734	136314
.	164257	1.2	0.186	33882	0.041	12145	1	0.000	0	647119	133763
.	164257	1.3	0.202	36383	0.044	13129	1	0.000	0	643557	131262
.	164257	1.4	0.218	38838	0.048	14108	1	0.000	0	640048	128811
.	164257	1.5	0.233	41250	0.051	15084	1	0.000	0	636590	126407
.	164257	1.6	0.249	43618	0.054	16055	1	0.000	0	633182	124050
.	164257	1.7	0.264	45943	0.058	17022	1	0.000	0	629824	121740
.	164257	1.8	0.280	48227	0.061	17986	1	0.000	0	626514	119474
.	164257	1.9	0.295	50471	0.065	18945	1	0.000	0	623251	117253
.	164257	2.0	0.311	52674	0.068	19900	1	0.000	0	620036	115075
Input units are thousands and kg - output in tonnes											

MFDP version 1a											
Run: June02											
Time and date: 11:10 12/06/2014											
Fbar age range (Total) : 2-4											
Fbar age range Fleet 1 : 2-4											
Fbar age range Fleet 2 : 2-4											
2014											
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield		
391565	185889	1.0	0.155	32236	0.034	3145	1	0.000	0		
2015										2016	
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB
396719	164257	0.0	0.000	0	0.000	0	1	0.000	0	421676	167986
.	164257	0.1	0.016	3010	0.003	368	1	0.000	0	418271	164812
.	164257	0.2	0.031	5963	0.007	734	1	0.000	0	414930	161700
.	164257	0.3	0.047	8859	0.010	1096	1	0.000	0	411650	158650
.	164257	0.4	0.062	11701	0.014	1456	1	0.000	0	408432	155660
.	164257	0.5	0.078	14489	0.017	1812	1	0.000	0	405272	152729
.	164257	0.6	0.093	17224	0.020	2166	1	0.000	0	402172	149855
.	164257	0.7	0.109	19908	0.024	2517	1	0.000	0	399128	147038
.	164257	0.8	0.124	22540	0.027	2865	1	0.000	0	396141	144277
.	164257	0.9	0.140	25123	0.031	3210	1	0.000	0	393209	141570
.	164257	1.0	0.155	27658	0.034	3553	1	0.000	0	390330	138916
.	164257	1.1	0.171	30145	0.037	3893	1	0.000	0	387504	136314
.	164257	1.2	0.186	32585	0.041	4231	1	0.000	0	384730	133763
.	164257	1.3	0.202	34979	0.044	4565	1	0.000	0	382007	131262
.	164257	1.4	0.218	37329	0.048	4898	1	0.000	0	379333	128811
.	164257	1.5	0.233	39634	0.051	5227	1	0.000	0	376708	126407
.	164257	1.6	0.249	41897	0.054	5555	1	0.000	0	374130	124050
.	164257	1.7	0.264	44117	0.058	5879	1	0.000	0	371600	121740
.	164257	1.8	0.280	46296	0.061	6202	1	0.000	0	369115	119474
.	164257	1.9	0.295	48435	0.065	6521	1	0.000	0	366675	117253
.	164257	2.0	0.311	50533	0.068	6839	1	0.000	0	364279	115075
Input units are thousands and kg - output in tonnes											

Table 2.3.5. Haddock in Sub-Area IV and Divisions IIIa and VIa. Draft advice table following October 2014 revision.

Rationale	Total catch 2015	Total Landings NoSh 2015	Total Discards 2015	Total IBC 2015	Landings IV 2015	Landings IIIa 2015	Landings VIa 2015	Basis	Total F 2015	F(land) 2015	F(disc) 2015	F(IBC) 2015	SSB 2016	% SSB change	% TAC change (IV)	% TAC change (IIIa)	% TAC change (VIa)	% TAC cha (No
MSY	68.690	50.163	18.528	0.000	39.469	0.925	9.768	New F(msy) estimate	0.350	0.287	0.063	0.000	117.476	-28%	3%	-61%	145%	12%
Management plan	59.123	43.222	15.901	0.000	34.008	0.797	8.417	MP target F	0.300	0.246	0.054	0.000	124.446	-24%	-11%	-66%	111%	-3%
IBC only	0.000	0.000	0.000	0.000	0.000	0.000	0.000	No HC fishery	0.000	0.000	0.000	0.000	167.986	2%	-100%	-100%	-100%	-100
Other options	28.890	21.291	7.599	0.000	16.752	0.393	4.146	0.75 * F(sq)	0.142	0.116	0.026	0.000	146.472	-11%	-56%	-83%	4%	-52%
	38.907	28.742	10.165	0.000	22.615	0.530	5.597	Fsq	0.189	0.155	0.034	0.000	138.916	-15%	-41%	-77%	40%	-36%
	47.004	34.431	12.573	0.000	27.091	0.635	6.705	1.25 * F(sq)	0.237	0.194	0.043	0.000	133.275	-19%	-29%	-73%	68%	-23%
	51.824	37.933	13.891	0.000	29.847	0.700	7.387	15% TAC decrease (full)	0.262	0.215	0.047	0.000	129.756	-21%	-22%	-70%	85%	-15%
	61.047	44.627	16.420	0.000	35.114	0.823	8.690	Rollover TAC (full)	0.310	0.254	0.056	0.000	123.032	-25%	-8%	-65%	118%	0%
	70.271	51.321	18.950	0.000	40.381	0.947	9.994	15% TAC increase (full)	0.358	0.294	0.064	0.000	116.308	-29%	5%	-60%	151%	15%

Units: 000 tonnes.
Under the assumption that effort is linearly related to fishing mortality
Total human consumption landings are assumed to be split 78.68% (Subarea IV), 1.84% (Division IIIa), 19.47% (Division VIa) (survey-based split).
1) SSB 2016 relative to SSB 2015. 2)Landings IV 2015 relative to TAC IV 2014

2.4 Saithe in Subarea IV, VI and Division IIIa

2.4.1 New survey information

New survey data available for a potential autumn forecast include the international third quarter IBTS survey (IBTS Q3). Data from the summer Norwegian acoustic saithe survey (NORACU) were not available at the time of this update, therefore, only data up to 2013 were included. In 2014, the survey design of NORACU was modified to cover most of the expected saithe distributional area with transects. In addition, for the first time, target identification and random tows were performed. The information from these tows indicated that saithe had been miscategorised to some extent in the past, necessitating a more thorough acoustic analysis; there was no time to complete this before the update. The series for both surveys are given in Table 2.4.1.

Table 2.4.1. Saithe in Subareas IV and VI and Division IIIa. Indices from the IBTS Q3 and NORACU surveys with the new IBTS Q3 2014 data.

IBTS-Q3		NORACU	
1991	2014	1995	2013
1	1.946	1	56244
1	1.077	1	21480
1	7.965	1	22585
1	1.117	1	15180
1	13.959	1	16933
1	3.825	1	34551
1	3.756	1	72108
1	1.181	1	82501
1	2.086	1	67774
1	3.479	1	34153
1	21.614	1	48446
1	10.748	1	18909
1	19.272	1	77958
1	4.979	1	7122
1	8.89	1	NA
1	10.636	1	34953
1	34.017	1	18118
1	3.438	1	3232
1	1.346	1	10023
1	1.367	1	NA
1	4.488		
1	11.106		
1	14.903		
1	2.033		

2.4.2 RCT3 analysis

An RCT3 analysis, following the protocol outlined by AGCREFA (ICES-AGCREFA 2008), was run to provide an estimate of the abundance of the incoming age 3 year-

class. The analysis compares the effect of including the new survey data with the forecast provided by WGNSSK (ICES-WGNSSK 2014). The RCT3 input and output files are given in Tables 2.4.2 and 2.4.3.

Table 2.4.2. Saithe in Subareas IV and VI and Division IIIa. RCT3 data input file for the age 3 year-class.

North Sea saithe age 3			
2	21	2	
1991	103741	-11	1.117
1992	226372	56244	13.959
1993	112546	21480	3.825
1994	162979	22585	3.756
1995	71024	15180	1.181
1996	142258	16933	2.086
1997	95717	34551	3.479
1998	225436	72108	21.614
1999	192200	82501	10.748
2000	127706	67774	19.272
2001	99833	34153	4.979
2002	189407	48446	8.89
2003	63528	18909	10.636
2004	111137	77958	34.017
2005	67137	7122	3.438
2006	54695	-11	1.346
2007	123933	34953	1.367
2008	52334	18118	4.488
2009	102456	3232	11.106
2010	61407	10023	14.903
2011	-11	-11	2.033
NORACU			
IBTSq3			

Table 2.4.3. Saithe in Subareas IV and VI and Division IIIa. RCT3 data output file for the age 3 year-class.

Analysis by RCT3_R ver3.1 of data from file :

RCT3 Saithe AGE 3 2014.txt

RCT3 input for D calculations for Saithe in Subareas IV, VI and Division IIIa

Data for 2 surveys over 21 years : 1991 - 2011

Regression type = c

Tapered time weighting applied

Power = 3 over 20 years

Survey weighting not applied

Final estimates shrunk towards mean

Minimum S.E. for any survey taken as 0.000

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass = 2011

	I----------Regression----------I				I----------Prediction---------I			
Survey/ Series	Slope	Inter-cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
NORACU	NA	NA	NA	NA	NA	NA	NA	NA	NA
IBTSq3	1.73	7.87	1.49	0.097	20	1.11	9.79	1.782	0.064

VPA Mean = 11.46 0.466 0.936

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2011	85401	11.36	0.45	0.41	0.82		

2.4.3 Update protocol calculation

The outcome of following the protocol was:

Calculation of 2013 year-class at:	Age 3
Log WAP from RCT3 (R)	11.36
Log of recruitment assumed in spring (A)	11.33
Int SE of log WAP (S)	0.41
Distance D $= (R - A)/S$	0.06

2.4. Conclusions from protocol

As the distance -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea saithe should not be reopened.** The autumn indices suggest that the size of the incoming year-class is similar to what had been assumed in the forecast produced by WGNSSK in May 2014.

An RCT3 analysis for age 4 was also explored and indicated contradictory results; the *D* estimate indicated the age 4 2010 year-class was much stronger than expected (*D* >> 2). New information from the IBTS Q3 survey caused the much higher age 4 abundance estimate, but this survey has a low weight in the survivor estimates and can be regarded as uncertain. In addition, there could be no comparison of signal from the IBTS Q3 survey with NORACU, which makes the results of the RCT3 analysis for the age 4

year-class too uncertain to include. In general, the saithe assessment relies to a large extent on commercial CPUE indices and no new information is available for these indices in autumn. Therefore, it is unclear whether new indices from the scientific surveys NORACU and IBTS Q3 are a sufficient basis to reopen the advice. These issues will be investigated during the next benchmark.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2014). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2014/ACOM:14.

2.5 Whiting in Sub-Area IV and Division VIId

2.5.1 New survey information

The new data available for a potential autumn forecast are the international third-quarter North Sea IBTS survey (IBTS Q3). The full available dataset for the IBTS Q3 series is given in Table 2.5.1. Note that the following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2014), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008).

2.5.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the 2013 year-class at age 1 in 2014, and the incoming (2014) year-class at age 1 in 2015. The RCT3 input and output files are given in Tables 2.5.2 and 2.5.3.

2.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2013 year-class at age 1 (in 2014)	
Log WAP from RCT3 (R)	14.73
Log of recruitment assumed in spring (A)	14.78
Int SE of log WAP (S)	0.168
Distance D $\left(D=\frac{R-A}{S}\right)$	-0.298

Calculations for 2014 year-class at age 1 (in 2015)	
Log WAP from RCT3 (R)	15.61
Log of recruitment assumed in spring (A)	15.12
Int SE of log WAP (S)	0.287
Distance D $\left(D=\frac{R-A}{S}\right)$	1.707

2.5.4 Conclusions from protocol

- 2013 yearclass at age 1 in 2014: as the distance -1.0 < D < 1.0, the protocol concludes that the RCT3 estimate used for 2014 recruitment was appropriate and need not be changed.
- 2014 yearclass at age 1 in 2015: in the June advice, a geometric mean value was used for this yearclass. As D > 1.0 for this year-class, the protocol concludes that the original geometric mean underestimates the true size of the 2014 yearclass by a significant amount.

The overall conclusion is that **the advisory process for North Sea whiting should be reopened based on the RCT3 analysis.** The autumn indices suggest that the size of the

incoming (2014) year-class is significantly larger than had been assumed in the forecast produced by WGNSSK in May 2014.

2.5.5 Updated forecast

Given the conclusion of the application of the protocol, the forecast was revised for North Sea whiting using the new estimate of recruitment in 2015 (6039 millions for the 2014 year-class at age 1; see Table 2.5.3). The settings and assumptions for the forecast were otherwise unchanged from those presented in ICES-WGNSSK (2014): in particular, the increased recruitment was assumed to apply for the 2014 year-class only, and subsequent year-classes reverted to the lower mean estimate used by ICES-WGNSSK (2014).

Table 2.5.4 compares the MFDP output tables from the new October 2014 run, and the original April 2014 run, while Table 2.5.5 gives a draft advice table for the October 2014 run.

The baseline advice uses the EU-Norway management plan with a target F of 0.15. On this basis, predicted North Sea (Subarea IV) landings in 2015 increase from 13878 t (April results) to 14971 t (October results), while the corresponding TAC change (subarea IV only) increases from -31% to -26%. **The implied TAC change under the application of the management plan is limited to -15% as before, so the proposed landings are unchanged under this new forecast but catches increased due to the higher recruitment.** The effect of the new recruitment estimate on the forecast 2015 discards (assuming F = 0.15) can also be seen, increasing them from 8296 t to 10919 t assuming an unchanged discard rate. The forecast for SSB in 2016 increases from 270446 t to 351804 t as the strong 2014 year-class grows and matures, and the future contribution of this year-class to the spawning stock and fishery (assuming continued low fishing mortality) is likely to be considerable.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2014). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2014/ACOM:13.

Table 2.5.1. Whiting in Sub-Area IV and Division VIId. Indices from the third-quarter IBTS (IBTS Q3) groundfish survey series. New data from autumn 2014 are highlighted.

	Age						
Year	0	1	2	3	4	5	6
1991	536.99	703.37	158.59	79.02	14.57	5.18	1.02
1992	1379.46	600.87	296.10	72.45	57.50	10.27	6.21
1993	919.19	638.72	177.38	66.12	14.71	15.90	3.04
1994	610.74	677.65	219.54	74.71	19.51	4.72	3.16
1995	729.25	619.79	291.18	107.20	21.51	6.01	3.46
1996	316.50	545.71	278.22	129.36	34.00	6.89	4.10
1997	2062.67	332.97	180.68	108.99	28.01	10.71	4.25
1998	2631.69	330.60	150.21	52.77	31.01	11.18	4.70
1999	2498.55	1203.50	190.65	53.93	24.45	9.53	4.18
2000	1968.07	941.66	326.94	64.11	13.63	6.53	4.87
2001	3031.44	645.00	282.32	94.85	19.28	4.32	7.51
2002	264.06	732.14	237.37	125.15	33.96	5.28	2.76
2003	363.41	246.16	302.05	134.82	66.06	16.45	4.66
2004	714.34	150.69	59.09	66.39	45.81	27.19	9.75
2005	166.87	163.11	80.54	34.89	47.07	29.41	26.89
2006	200.46	173.65	85.91	32.12	13.33	22.98	25.32
2007	821.77	95.66	64.04	37.92	11.60	8.46	20.85
2008	764.68	362.33	68.91	30.97	13.81	4.10	14.81
2009	593.81	585.55	384.81	40.99	12.30	8.04	6.81
2010	509.94	223.60	146.61	56.48	13.12	6.34	7.96
2011	247.09	446.81	144.42	47.21	16.18	6.97	4.71
2012	307.24	258.57	194.62	57.38	20.00	10.57	5.35
2013	335.13	67.49	60.20	66.08	17.73	7.08	3.75
2014	1417.99	222.51	106.42	59.06	36.13	11.32	7.83

Table 2.5.2. Whiting in Sub-Area IV and Division VIId. RCT3 input file. Data from surveys in autumn 2014 are highlighted.

Year	VPA Recruits at age 1	IBTS Q1 Age 1	IBTS Q1 Age 2	IBTS Q3 Age 0	IBTS Q3 Age 1	IBTS Q3 Age 2
1989	5584149	518.936	686.445	-11	-11	158.594
1990	5704990	1007.621	665.714	-11	703.368	296.1
1991	5427698	907.297	522.811	536.99	600.867	177.377
1992	6345393	1075.624	627.406	1379.459	638.722	219.541
1993	6016410	721.709	448.484	919.193	677.645	291.18
1994	5465481	678.59	485.968	610.743	619.786	278.218
1995	3865863	502.361	342.212	729.246	545.708	180.681
1996	2941914	287.733	160.695	316.501	332.968	150.205
1997	4143379	543.117	305.445	2062.67	330.6	190.645
1998	6777335	676.27	460.697	2631.69	1203.503	326.943
1999	8198033	741.49	598.388	2498.55	941.658	282.32
2000	6663282	648.649	343.308	1968.07	645.003	237.372
2001	5744721	557.353	296.405	3031.442	732.137	302.054
2002	1931222	131.033	89.595	264.063	246.155	59.088
2003	1944928	184.468	97.92	363.406	150.686	80.543
2004	2475535	112.688	125.265	714.342	163.112	85.91
2005	2421506	184.574	150.45	166.87	173.652	64.038
2006	2236667	64.593	205.826	200.459	95.655	68.912
2007	4089046	268.451	295.618	821.767	362.329	384.806
2008	3307736	211.006	225.541	764.68	585.552	146.61
2009	3222901	326.994	336.844	593.812	223.595	144.417
2010	4340978	184.287	580.934	509.941	446.809	194.622
2011	1858168	231.037	162.999	247.092	258.568	60.199
2012	-11	53.095	226.241	307.24	67.488	106.417
2013	-11	205.313	-11	335.126	222.514	-11
2014	-11	-11	-11	1417.994	-11	-11

Table 2.5.3. Whiting in Sub-Area IV and Division VIId. RCT3 output file.

Analysis by RCT3 ver4.0

Data for 5 surveys over 26 years : 1989 - 2014
Regression type = C
Tapered time weighting not applied
Survey weighting not applied
Final estimates not shrunk towards mean
Estimates with S.E.'S greater than that of mean included
Minimum S.E. for any survey taken as .00
Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.6972	11.08	0.2893	0.7251	23	5.325	14.79	0.3130	0.3328
IBTSq12	0.8307	10.45	0.2521	0.7765	23	NA	NA	NA	NA
IBTSq30	0.6542	10.87	0.3369	0.6695	21	5.815	14.67	0.3690	0.2395
IBTSq31	0.7890	10.45	0.2530	0.7792	22	5.405	14.71	0.2761	0.4277
IBTSq32	0.8681	10.77	0.2403	0.7926	23	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	23	NA	15.20	0.4591	0.0000

yearclass:2014

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
IBTSq11	0.6972	11.08	0.2893	0.7251	23	NA	NA	NA	NA
IBTSq12	0.8307	10.45	0.2521	0.7765	23	NA	NA	NA	NA
IBTSq30	0.6542	10.87	0.3369	0.6695	21	7.257	15.61	0.3679	1
IBTSq31	0.7890	10.45	0.2530	0.7792	22	NA	NA	NA	NA
IBTSq32	0.8681	10.77	0.2403	0.7926	23	NA	NA	NA	NA
VPA Mean	NA	NA	NA	NA	23	NA	15.20	0.4591	0

	WAP	logWAP	int.se
yearclass:2013	2497236	14.73	0.1680
yearclass:2014	6038870	15.61	0.2871

Table 2.5.4. Whiting in Sub-Area IV and Division VIId. MFDP output for October 2014 revision (bottom) and original June 2014 run (top).

MFDP version 1a											
Run: 01											
Time and date: 14:36 03/05/2014											
Fbar age range (Total) : 2-6											
Fbar age range Fleet 1 : 2-6											
Fbar age range Fleet 2 : 2-6											
2014											
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield		
417861	204360	1	0.1264	19367	0.0527	8447	1	0.0064	917		
2015										2016	
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB
536583	230124	0	0	0	0	0	1	0.0064	861	599111	288960
.	230124	0.1	0.0126	1888	0.0053	1083	1	0.0064	854	596554	286453
.	230124	0.2	0.0253	3746	0.0105	2157	1	0.0064	846	594036	283985
.	230124	0.3	0.0379	5573	0.0158	3222	1	0.0064	838	591556	281554
.	230124	0.4	0.0506	7371	0.0211	4278	1	0.0064	831	589113	279161
.	230124	0.5	0.0632	9141	0.0264	5325	1	0.0064	824	586707	276803
.	230124	0.6	0.0759	10882	0.0316	6364	1	0.0064	816	584335	274481
.	230124	0.7	0.0885	12595	0.0369	7394	1	0.0064	809	581999	272193
.	230124	0.8	0.1011	14282	0.0422	8415	1	0.0064	802	579697	269940
.	230124	0.9	0.1138	15942	0.0475	9429	1	0.0064	795	577429	267720
.	230124	1	0.1264	17576	0.0527	10434	1	0.0064	788	575194	265533
.	230124	1.1	0.1391	19184	0.058	11431	1	0.0064	781	572991	263378
.	230124	1.2	0.1517	20768	0.0633	12420	1	0.0064	775	570820	261254
.	230124	1.3	0.1644	22327	0.0686	13401	1	0.0064	768	568680	259161
.	230124	1.4	0.177	23862	0.0738	14375	1	0.0064	762	566570	257099
.	230124	1.5	0.1896	25373	0.0791	15340	1	0.0064	755	564491	255066
.	230124	1.6	0.2023	26861	0.0844	16299	1	0.0064	749	562441	253063
.	230124	1.7	0.2149	28327	0.0897	17250	1	0.0064	743	560419	251088
.	230124	1.8	0.2276	29771	0.0949	18193	1	0.0064	736	558426	249142
.	230124	1.9	0.2402	31192	0.1002	19130	1	0.0064	730	556461	247223
.	230124	2	0.2529	32593	0.1055	20059	1	0.0064	724	554523	245331
Input units are thousands and kg - output in tonnes											

MFDP version 1a											
Run: Oct01											
Time and date: 14:03 07/10/2014											
Fbar age range (Total) : 2-6											
Fbar age range Fleet 1 : 2-6											
Fbar age range Fleet 2 : 2-6											
2014											
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield		
417861	204360	1	0.1264	19367	0.0527	8447	1	0.0064	917		
2015										2016	
		Catch	Landings		Discards		IBC	Landings			
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB
750542	253659	0	0	0	0	0	1	0.0064	861	690658	373183
.	253659	0.1	0.0126	2027	0.0053	1416	1	0.0064	854	687704	370311
.	253659	0.2	0.0253	4023	0.0105	2822	1	0.0064	846	684789	367478
.	253659	0.3	0.0379	5988	0.0158	4218	1	0.0064	838	681915	364684
.	253659	0.4	0.0506	7924	0.0211	5604	1	0.0064	831	679079	361929
.	253659	0.5	0.0632	9830	0.0264	6980	1	0.0064	824	676281	359211
.	253659	0.6	0.0759	11708	0.0316	8347	1	0.0064	816	673520	356531
.	253659	0.7	0.0885	13557	0.0369	9704	1	0.0064	809	670796	353887
.	253659	0.8	0.1011	15380	0.0422	11051	1	0.0064	802	668108	351278
.	253659	0.9	0.1138	17175	0.0475	12389	1	0.0064	795	665456	348704
.	253659	1	0.1264	18943	0.0527	13718	1	0.0064	788	662838	346165
.	253659	1.1	0.1391	20686	0.058	15037	1	0.0064	781	660254	343659
.	253659	1.2	0.1517	22404	0.0633	16348	1	0.0064	775	657703	341187
.	253659	1.3	0.1644	24096	0.0686	17650	1	0.0064	768	655185	338746
.	253659	1.4	0.177	25764	0.0738	18943	1	0.0064	762	652699	336338
.	253659	1.5	0.1896	27408	0.0791	20227	1	0.0064	755	650245	333961
.	253659	1.6	0.2023	29029	0.0844	21503	1	0.0064	749	647822	331614
.	253659	1.7	0.2149	30626	0.0897	22770	1	0.0064	743	645430	329298
.	253659	1.8	0.2276	32201	0.0949	24029	1	0.0064	736	643067	327011
.	253659	1.9	0.2402	33754	0.1002	25280	1	0.0064	730	640734	324754
.	253659	2	0.2529	35285	0.1055	26522	1	0.0064	724	638429	322525
Input units are thousands and kg - output in tonnes											

Table 2.5.5. Whiting in Sub-Area IV and Division VIId. Draft advice table following October 2014 revision.

Basis: F(2014) = status quo F = 0.186; SSB (2014) = 204; TAC IV (2014) = 16.092; HC landings (2014) = 19.367; Discards (2014) = 8.447; IBC (2014) = 0.917;														
Recruitment (2014) = RCT3 forecast = 2164 millions; Recruitment (2015) = RCT3 forecast = 6039 millions.														
Lookup column:	6	8	12	15	9	10	20	5	7	11	14	17	19	18
Rationale	Total catch 2015	Total Landings IV+VIId 2015	Total Discards 2015	Total IBC 2015	Landings IV 2015	Landings VIId 2015	Basis	Total F 2015	F(landings) 2015	F(disc) 2015	F(IBC) 2015	SSB 2016	% SSB change	% TAC change
Management plan	26.694	14.971	10.919	0.803	11.911	3.059	MP target F	0.150	0.101	0.042	0.006	351.804	38.69%	-25.98%
IBC only	0.861	0.000	0.000	0.861	0.000	0.000	No HC fishery	0.006	0.000	0.000	0.006	373.183	47.12%	-100.00%
Other options	25.107	14.064	10.237	0.807	11.189	2.873	0.75 * F(2013)	0.141	0.095	0.040	0.006	353.107	39.21%	-30.47%
	40.507	22.870	16.864	0.773	18.196	4.672	1.25 * F(2013)	0.230	0.158	0.066	0.006	340.460	34.22%	13.07%
	33.449	18.943	13.718	0.788	15.071	3.870	Fsq	0.186	0.126	0.053	0.006	346.165	36.47%	-6.34%
	35.882	20.226	14.873	0.783	16.092	4.132	Rollover TAC (IV)	0.203	0.139	0.058	0.006	344.258	35.72%	0.00%
	41.186	23.260	17.154	0.771	18.506	4.752	15% TAC increase (IV)	0.234	0.161	0.067	0.006	339.901	34.00%	15.00%
	30.579	17.192	12.592	0.795	13.678	3.512	15% TAC decrease (IV)	0.173	0.117	0.049	0.006	348.614	37.43%	-15.00%

2.6 North Sea plaice

2.6.1 Short term forecast and June advice

At WGNSSK 2014 (ICES 2014), the following short term forecast settings were used:

Year class	At age in 2014	XSA Survivors	RCT3	GM 1957–2011	Accepted estimate
2012	2	1071141	1024633	686995	XSA survivors
2013	1		1160658	936981	GM 1957–2011
2014	0			936981	GM 1957–2011

The final advice followed from the North Sea flatfish management plan, applying the maximum 15% increase in TAC. Given that this advice for plaice from the spring time was constrained by the +15% TAC change limit, updating of advice would only be recommended if either of the D values are significantly negative (i.e. D < -1). i.e. no further increase can be recommended.

Rationale	Catch (2015)	Basis
Management plan	179301	TAC + 15%

2.6.2 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS), that was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea. Since IBPplaice (ICES 2013), the assessment uses the combined BTS-Isis and BTS-Tridens index. This index have a shorter time series due to the BTS-Tridens only starting in 1996.

2.6.3 RCT3 Analysis

The RCT3 analysis on the BTS-combined survey indices for ages 1 and 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 40 years including the assessment estimates for the two ages are presented in Table 2.6.1. In 2013, the new data comprises age 1 of year class 2012 and age 2 of year class 2011. The last 4 years from the assessment estimates were removed from the time series.

Table 2.6.1 North Sea plaice RCT3 input data

PLAICE	NORTHSEA	AGE1	PLAICE	NORTHSEA	AGE2
6	40	2	6	40	2
1974	863655	-11	1974	547454	-11
1975	690881	-11	1975	447473	-11
1976	988522	-11	1976	647272	-11
1977	916917	-11	1977	612805	-11
1978	897617	-11	1978	532078	-11
1979	1133010	-11	1979	808915	-11
1980	864123	-11	1980	654046	-11
1981	2017226	-11	1981	1430826	-11
1982	1300560	-11	1982	926998	-11
1983	1253422	-11	1983	838519	-11
1984	1843651	-11	1984	1282478	-11
1985	4742574	-11	1985	3226834	-11
1986	1940642	-11	1986	1412078	-11
1987	1763214	-11	1987	1263826	-11
1988	1179320	-11	1988	863024	-11
1989	1031648	-11	1989	793796	-11
1990	910359	-11	1990	648193	-11
1991	775023	-11	1991	566093	-11
1992	530061	-11	1992	384728	-11
1993	442351	-11	1993	339872	-11
1994	1164069	-11	1994	932897	99.62
1995	1292393	143.90	1995	1062546	28.68
1996	2148445	386.84	1996	1820775	177.63
1997	771547	131.19	1997	598502	53.60
1998	840137	116.99	1998	638563	38.89
1999	989336	108.39	1999	794341	39.79
2000	540716	80.30	2000	456147	26.71
2001	1728770	217.28	2001	1268394	94.43
2002	528668	53.58	2002	413296	30.31
2003	1265282	101.41	2003	922788	45.65
2004	745754	70.84	2004	583029	42.92
2005	885430	54.86	2005	591081	44.43
2006	1094759	139.39	2006	915899	89.74
2007	1014129	98.91	2007	788525	76.53
2008	1102499	170.84	2008	854714	69.54
2009	1300045	144.79	2009	1016589	125.99
2010	-11	226.46	2010	-11	149.63
2011	-11	118.44	2011	-11	90.45
2012	-11	192.77	2012	-11	123.19
2013	-11	155.22	2013	-11	-11
BTS1			BTS2		

2.6.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 2.6.2.

For age 1, the D value for this age indicates 1.08, a significant positive signal (i.e. >1). For age 2 the D value=0.30 indicating a, positive signal, but not significantly different from spring assumptions.

Table 2.6.2 North Sea plaice RCT3 output for age 1 and 2 and D calculation

D calculation North Sea plaice age 1

Analysis by RCT3 ver4.0

Data for 1 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

	index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
	BTS1	0.8946	9.56	0.2636	0.6966	15	5.045	14.07	0.2952	0.7101
VPA Mean		NA	NA	NA	NA	36	NA	13.89	0.4621	0.2899

	WAP	logWAP	int.se
yearclass:2013	1225519	14.02	0.2488

Spring assumption for age 1: 936981; log(936981) = 13.75

Calculations for 2013 year-class at age 1	
Log WAP from RCT3 (R)	14.02
Log of recruitment assumed in spring (A)	13.75
Int SE of log WAP (S)	0.25
Distance D $\left(D = \frac{R - A}{S}\right)$	1.08

A positive signal, significantly different from spring assumptions.

D calculation North Sea plaice age 2

Analysis by RCT3 ver4.0

Data for 1 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2012

	index	slope	intercept	se	rsquare	n indices	prediction	se.pred	WAP.weights
	BTS2	0.9037	9.917	0.3476	0.5621	16	4.814	14.27	0.404	0.5666
VPA Mean		NA	NA	NA	NA	36	NA	13.58	0.462	0.4334

	WAP	logWAP	int.se
yearclass:2012	1165137	13.97	0.3041

Spring assumption for age 2: 1071141; log(1071141) = 13.88

Calculations for 2012 year-class at age 2	
Log WAP from RCT3 (R)	13.97
Log of recruitment assumed in spring (A)	13.88
Int SE of log WAP (S)	0.30
Distance D $\left(D = \frac{R-A}{S}\right)$	0.30

A positive signal, but not significantly different from spring assumptions.

2.6.5 Revised forecast

Since a change in advice would only be affected in the case of a significant negative value, the spring assessment does not need to be updated. However, in order to gain an understanding of expected changes to the advised catch, a new forecast with updated 2013 year class estimates was conducted.

The short-term forecasts were carried out with FLR (FLCore 2.3, R 2.13.2). Settings used were exactly the same as those used at the WGNSSK meeting in May 2014, with the exception of the assumption of the number of age 1 fish in 2014. The number of fish at age 1 was estimated using an RCT3 analysis including all available indices:

Plaice	NorthSea	Age1					
6	40	2					
1974	863655	568	11628	2403	-11	-11	-11
1975	690881	314	8537	3424	-11	-11	-11
1976	988522	1166	18537	12678	-11	-11	-11
1977	916917	373	14012	9829	-11	-11	-11
1978	897617	268	21495	12882	-11	-11	-11
1979	1133010	29058	59174	18785	-11	-11	-11
1980	864123	210	24756	8642	-11	-11	-11
1981	2017226	35506	69993	13909	-11	-11	-11
1982	1300560	24402	33974	10413	-11	-11	-11
1983	1253422	32942	44965	13848	-11	-11	-11
1984	1843651	7918	28101	7580	-11	-11	-11
1985	4742574	47256	93552	32991	-11	-11	-11
1986	1940642	8820	33402	14421	-11	-11	-11
1987	1763214	21335	36609	17810	-11	-11	-11
1988	1179320	15670	34276	7496	-11	-11	-11
1989	1031648	24585	25037	11247	-11	-11	-11
1990	910359	369	57221	13842	-11	-11	440
1991	775023	7257	46798	9686	-11	-11	332
1992	530061	473	22098	4977	-11	-11	180
1993	442351	234	19188	2796	-11	-11	217
1994	1164069	26781	24767	10268	-11	100	283
1995	1292393	12541	23015	4473	144	29	146
1996	2148445	84042	95901	30242	387	178	620
1997	771547	7344	33666	10272	131	54	229
1998	840137	5522	32951	2493	117	39	-11
1999	989336	9262	22855	2899	108	40	-11
2000	540716	4214	11511	1103	80	27	125
2001	1728770	99628	30809	-11	217	94	313
2002	528668	1202	-11	1350	54	30	123
2003	1265282	-11	18202	1819	101	46	239
2004	745754	3537	10118	1571	71	43	127
2005	885430	7391	12164	2134	55	44	86
2006	1094759	1124	14175	2700	139	90	168
2007	1014129	40581	14706	2019	99	77	98
2008	1102499	50179	14860	1812	171	70	130
2009	1300045	53259	11947	1143	145	126	142
2010	-11	49347	18349	2929	226	150	180
2011	-11	52643	5893	3021	118	90	93
2012	-11	45027	15395	-11	193	123	181
2013	-11	44328	-11	-11	155	-11	164
SNS0							
SNS1							
SNS2							
BTS1							
BTS2							
DFS0							

Full RCT3 North Sea plaice age 1

Analysis by RCT3 ver4.0

Data for 6 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
SNS0	0.3762	10.622	0.5629	0.4159	35	10.699	14.65	0.5972	0.14212
SNS1	1.2227	1.515	0.6210	0.3535	35	NA	NA	NA	NA
SNS2	0.8280	6.701	0.6753	0.3248	35	NA	NA	NA	NA
BTS1	0.8946	9.560	0.2636	0.6966	15	5.045	14.07	0.2952	0.58153
BTS2	0.8952	10.199	0.3483	0.5520	16	NA	NA	NA	NA
DFS0	2.0622	2.899	1.0447	0.1514	18	5.103	13.42	1.1412	0.03893
VPA Mean	NA	NA	NA	NA	36	NA	13.89	0.4621	0.23742

	WAP	logWAP	int.se
yearclass:2013	1309243	14.08	0.2252

Updated assumptions table for the new short term forecast:

Year class	At age in 2014	XSA Survivors	RCT3	GM 1957–2011	Accepted estimate
2012	2	1071141	1024633	686995	XSA survivors
2013	1		1309243 1160658	936981	RCT3 GM 1957–2011
2014	0			936981	GM 1957–2011

The exploitation pattern (F), relative proportions of landings versus discards in the catch, and weight-at-age in the stock and catch were taken to be the mean of the last three years. Population numbers at ages 2 and older are XSA survivor estimates. Numbers at age 1 are taken from the new RCT3 analysis and recruitment of the 2014 and later year-classes are taken from the long-term geometric mean (1957–2011: 940 million). Input to the short term forecast is presented in Table 2.6.1.

For 2014, it was assumed that F2014 = F2013 = 0.209. The expected landings in 2014 of 93 100 t (=136 511t catch) are below the agreed TAC of 111 631t. However, the assumption of Fsq was considered by WGNSSK to be more valid, and is consistent with recent under-utilisation of the TAC. The short term forecast management options are presented in Table 2.6.2.

Fishing at Fmp in 2015 (=0.30) results in a TAC of 134 125 t (less than 1% greater than the landings associated with Fmp in the June advice). This exceeds the 15% TAC change limit specified in the MP, so the same landings of 128 376t, corresponding to a 15% increase in TAC, are advised.

Given the larger estimated 2013 year class following the update analyses, the amount of discards in the catch increases in both the assumed 2014 value and the estimated 2015 value. The TAC in 2015 is expected to be greater giving a larger total catch than previously estimated: 185 798kt vs 179 301kt (a 4% increase). As a result the percentage increase between the assumed 2014 catch and the estimated 2015 catch changes from 33% to 36%.

The expected remaining SSB in 2016 is also 752 727t, 2% greater than previously estimated (735 259t) .

Table 2.6.1. Plaice in sub area IV: STF Input table (F values presented are for Fsq).

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	2014	0.094	0.09	0	1309243	0.05	0.15	0.05	0.04	0	0.1
2	2014	0.225	0.22	0.01	1071226	0.1	0.23	0.09	0.1	0.5	0.1
3	2014	0.217	0.14	0.07	512730	0.19	0.28	0.14	0.16	0.5	0.1
4	2014	0.236	0.08	0.16	698584	0.28	0.33	0.17	0.2	1	0.1
5	2014	0.203	0.03	0.17	387469	0.35	0.38	0.19	0.34	1	0.1
6	2014	0.163	0.01	0.15	235686	0.42	0.45	0.2	0.41	1	0.1
7	2014	0.101	0	0.1	135773	0.53	0.54	0.21	0.45	1	0.1
8	2014	0.071	0.01	0.06	130374	0.53	0.56	0.26	0.46	1	0.1
9	2014	0.052	0	0.05	63907	0.57	0.57	0	0.56	1	0.1
10	2014	0.052	0	0.05	84870	0.72	0.72	0	0.6	1	0.1
1	2015	0.094	0.09	0	936994	0.05	0.15	0.05	0.04	0	0.1
2	2015	0.225	0.22	0.01	NA	0.1	0.23	0.09	0.1	0.5	0.1
3	2015	0.217	0.14	0.07	NA	0.19	0.28	0.14	0.16	0.5	0.1
4	2015	0.236	0.08	0.16	NA	0.28	0.33	0.17	0.2	1	0.1
5	2015	0.203	0.03	0.17	NA	0.35	0.38	0.19	0.34	1	0.1
6	2015	0.163	0.01	0.15	NA	0.42	0.45	0.2	0.41	1	0.1
7	2015	0.101	0	0.1	NA	0.53	0.54	0.21	0.45	1	0.1
8	2015	0.071	0.01	0.06	NA	0.53	0.56	0.26	0.46	1	0.1
9	2015	0.052	0	0.05	NA	0.57	0.57	0	0.56	1	0.1
10	2015	0.052	0	0.05	NA	0.72	0.72	0	0.6	1	0.1
1	2016	0.094	0.09	0	936994	0.05	0.15	0.05	0.04	0	0.1
2	2016	0.225	0.22	0.01	NA	0.1	0.23	0.09	0.1	0.5	0.1
3	2016	0.217	0.14	0.07	NA	0.19	0.28	0.14	0.16	0.5	0.1
4	2016	0.236	0.08	0.16	NA	0.28	0.33	0.17	0.2	1	0.1
5	2016	0.203	0.03	0.17	NA	0.35	0.38	0.19	0.34	1	0.1
6	2016	0.163	0.01	0.15	NA	0.42	0.45	0.2	0.41	1	0.1
7	2016	0.101	0	0.1	NA	0.53	0.54	0.21	0.45	1	0.1
8	2016	0.071	0.01	0.06	NA	0.53	0.56	0.26	0.46	1	0.1
9	2016	0.052	0	0.05	NA	0.57	0.57	0	0.56	1	0.1
10	2016	0.052	0	0.05	NA	0.72	0.72	0	0.6	1	0.1

Table 2.6.2. Plaice in sub area IV: STF option table, assuming F(2014) = F(sq).

2014								
Landings	basis	f2-6	f_dis2-3	f_hc2-6	discards	catch	TAC	f2-6
93100	Fsq	0.209	0.18	0.111	43718	136511	111631	0.209
2015								
landings	basis	f2-6	f_hc2-6	f_dis2-3	discards	catch	ssb2016	ssb_change
128376	15%_TAC_inc	0.285	0.15	0.25	57897	185798	752727	1
114033	Fmsy	0.25	0.13	0.21	51550	165161	773246	3
134125	Fmp	0.3	0.16	0.26	60433	194062	744517	0
238871	Fpa	0.6	0.32	0.52	105578	343576	596618	-20
279761	Flim	0.74	0.39	0.64	122589	401333	539877	-28
515413	SSB>Bpa	2.095	1.12	1.8	210380	724009	230000	-69
111631	TACsq	0.244	0.13	0.21	50483	161701	776688	4
94886	15%_TAC_dec	0.204	0.11	0.18	43025	137559	800719	7
0	Fsq*0	0	NA	NA	0	0	938107	26
25730	Fsq*0.25	0.052	0.03	0.04	11788	37422	900660	21
50356	Fsq*0.5	0.104	0.06	0.09	22988	73156	864950	16
87936	Fsq*0.9	0.188	0.1	0.16	39917	127526	810714	9
96926	Fsq*1	0.209	0.11	0.18	43936	140503	797788	7
105761	Fsq*1.1	0.23	0.12	0.2	47874	153243	785104	5
118525	Fsq*1.25	0.261	0.14	0.22	53541	171627	766814	3
139214	Fsq*1.5	0.313	0.17	0.27	62672	201372	737257	-1
159038	Fsq*1.75	0.365	0.19	0.31	71354	229805	709045	-5
178392	Fsq*2	0.418	0.22	0.36	79763	257499	681607	-9

2.6.6 Conclusions

The D values suggest an increase in the estimate of age 1 fish and no significant change in the estimate of age 2 fish. Since a change would only be affected in the case of a significant negative value, the spring assessment does not need to be updated and **there is no requirement to reopen the advice based on landings advice**.

The increased 2013 year class estimate results in an expected 4% increase in catch for the same amount of landings. This is due to a higher abundance of discard size fish in 2015.

References

ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2013. Report of the Inter-Benchmark Protocol for Plaice in Subarea IV (IBP Plaice), April 2013, By correspondence. ICES CM 2013/ACOM:63. 78 pp.

ICES. 2014. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 30 April–7 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:13. 1493 pp.

2.7 North Sea sole

2.7.1 Short term forecast and June advice

At WGNSSK 2014 (ICES 2014), the following short term forecast settings were used:

Year class	At age in 2014	XSA Survivors	RCT3	GM 1957–2011	Accepted estimate
2012	2	54 268	54 228	82 889	XSA survivors
2013	1		147 276	94 491	RCT3
2014	0			94 491	GM 1957–2011

The final advice followed from the North Sea flatfish management plan, applying Fmsy resulting in a 8% decrease in TAC. Given that this advice for sole from the spring time was not constrained by the +15% TAC change limit, updating of advice would be recommended if either of the D values are significantly negative or significantly positive (i.e. D < -1 or D > 1).

Rationale	Landings (2015)	Basis
Management plan	10 973	Stage two: −FMSY

2.7.2 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS), that was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea.

2.7.3 RCT3 Analysis

The RCT3 analysis on the BTS ISIS survey indices for ages 1 and 2 was conducted as specified in the Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA; ICES 2008). Hence, the specifications for the RCT3 were:

Regression type?	C
Tapered time weighting required?	N
Shrink estimates toward mean?	N
Exclude surveys with SE's greater than that of mean:	N
Enter minimum log S.E. for any survey:	0.0
Min. no. of years for regression (3 is the default)	3
Apply prior weights to the surveys?	N

The input data for the last 40 years including the assessment estimates for the two ages are presented in Table 2.6.1. In 2013, the new data comprises age 1 of year class 2012 and age 2 of year class 2011. The last 4 years from the assessment estimates were removed from the time series.

Table 2.6.1 North Sea sole RCT3 input data

NorthSea	Age1	NorthSea	Age2
40	2	40	2
41330	-11	37143	-11
114365	-11	102469	-11
141787	-11	126601	-11
47986	-11	43394	-11
11833	-11	10698	-11
153479	-11	138255	-11
149567	-11	134921	-11
152545	-11	135463	-11
140838	-11	127064	-11
70397	-11	63515	7.12
81515	7.03	73603	5.18
158274	7.17	142858	12.55
71959	6.97	65023	12.51
452839	83.11	409736	68.08
106698	9.01	96435	24.49
174825	37.84	157376	28.84
69557	4.03	62826	22.28
348980	81.63	314852	42.35
68414	6.35	61853	7.12
56380	7.66	50340	8.46
94955	28.13	81385	7.63
48806	3.98	44000	4.92
267337	169.34	240400	27.42
111994	17.11	101106	18.36
80926	11.96	72954	6.14
121603	14.59	107815	9.96
62638	8.00	55862	4.18
183742	20.99	165261	9.95
81527	10.51	72773	4.35
43913	4.19	39244	3.40
48417	5.53	42734	2.33
199018	17.09	173413	19.50
54267	7.50	48803	9.06
66228	15.25	58062	5.00
92485	15.95	82133	10.71
161746	54.81	146001	17.39
-11	26.17	-11	18.21
-11	5.15	-11	3.56
-11	6.84	-11	15.58
-11	18.93	-11	-11

2.7.4 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 2.6.2.

The D value for age 1 is -0.60, a negative signal but not significantly different from the spring assumption. For age 2 the D value=2.0 indicating a strong positive signal, significantly larger than the spring assumption. Therefore **the short term forecast needs to be re-run with an alternative assumption on the numbers at age 2 in 2014**.

Table 2.6.2 North Sea sole RCT3 output for age 1 and 2 and D calculation

D calculation North Sea sole age 1

Analysis by RCT3 ver4.0

Data for 1 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2013

	index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
	BTS1	0.7332	9.607	0.3897	0.7283	26	2.941	11.76	0.4141	0.7336
VPA Mean		NA	NA	NA	NA	36	NA	11.48	0.6872	0.2664

	WAP	logWAP	int.se
yearclass:2013	119040	11.69	0.3547

Spring assumption for age 1: 147276; log(147276) = 11.90

Calculations for 2013 year-class at age 1	
Log WAP from RCT3 (R)	11.69
Log of recruitment assumed in spring (A)	11.90
Int SE of log WAP (S)	0.35
Distance D $\left(D=\frac{R-A}{S}\right)$	-0.60

A negative signal, but not significantly different from spring assumptions.

D calculation North Sea sole age 2

Analysis by RCT3 ver4.0

Data for 1 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2012

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
BTS2	0.9143	9.262	0.421	0.6924	27	2.746	11.77	0.4474	0.7024
VPA Mean	NA	NA	NA	NA	36	NA	11.37	0.6874	0.2976

	WAP	logWAP	int.se
yearclass:2012	114970	11.65	0.375

Spring assumption for age 2: 54268; log(54268) = 10.90

Calculations for 2012 year-class at age 2	
Log WAP from RCT3 (R)	11.65
Log of recruitment assumed in spring (A)	10.90
Int SE of log WAP (S)	0.375
Distance D $\left(D=\frac{R-A}{S}\right)$	2.00

A positive signal, significantly larger than the spring assumptions.

2.7.5 Revised forecast

The short-term forecasts were carried out with FLR (FLCore 2.3, R 2.13.2). Settings used were exactly the same as those used at the WGNSSK meeting in May 2014, with the exception of the assumption of the number of age 2 fish in 2014. The number of fish at age 2 was estimated using an RCT3 analysis including all available indices:

```
Sole   NorthSea     Age2
5      40     2
1974   37143  -11    525.42        73.56         -11    -11
1975   102469 -11    1399.43       776.10        -11    -11
1976   126601 -11    3742.94       1354.66       -11    -11
1977   43394  -11    1547.71       408.27        -11    -11
1978   10698  -11    93.78         88.89         -11    -11
1979   138255 -11    4312.89       1413.05       -11    -11
1980   134921 -11    3737.20       1146.20       -11    -11
1981   135463 -11    5856.46       1123.33       -11    -11
1982   127064 -11    2621.14       1099.91       -11    -11
1983   63515  -11    2493.11       715.60        -11    7.12
1984   73603  -11    3619.44       457.61        7.03   5.18
1985   142858 -11    3705.06       943.70        7.17   12.55
1986   65023  -11    1947.85       593.83        6.97   12.51
1987   409736 -11    11226.67      5005.00       83.11  68.08
1988   96435  -11    2830.74       1119.50       9.01   24.49
1989   157376 -11    2856.17       2529.10       37.84  28.84
1990   62826  6.38   1253.62       144.40        4.03   22.28
1991   314852 167.56 11114.01      3419.57       81.63  42.35
1992   61853  9.27   1290.78       498.25        6.35   7.12
1993   50340  15.32  651.78        223.67        7.66   8.46
1994   81385  22.06  1362.10       349.09        28.13  7.63
1995   44000  7.06   218.36        153.63        3.98   4.92
1996   240400 40.27  10279.33      3126.37       169.34 27.42
1997   101106 26.94  4094.61       971.78        17.11  18.36
1998   72954  -11    1648.85       125.88        11.96  6.14
1999   107815 -11    1639.17       655.36        14.59  9.96
2000   55862  9.50   970.31        379.04        8.00   4.18
2001   165261 51.42  7547.46       -11           20.99  9.95
2002   72773  58.58  -11           624.38        10.51  4.35
2003   39244  10.61  1369.50       162.92        4.19   3.40
2004   42734  31.25  568.08         117.08       5.53   2.33
2005   173413 40.99  2726.42       910.99        17.09  19.50
2006   48803  12.57  848.64        258.55        7.50   9.06
2007   58062  13.73  1259.12       344.35        15.25  5.00
2008   82133  11.77  1931.60       237.13        15.95  10.71
2009   146001 27.33  2636.93       883.87        54.81  17.39
2010   -11    42.86  1247.97       159.48        26.17  18.21
2011   -11    12.13  226.58        426.62         5.15  3.56
2012   -11    11.23  967.40        -11           6.84   15.58
2013   -11    -11    -11            -11           18.93 -11
DFS0
SNS1
SNS2
BTS1
BTS2
```

Full RCT3 North Sea sole age 2

Analysis by RCT3 ver4.0

Data for 5 surveys over 40 years : 1974 - 2013

Regression type = C

Tapered time weighting not applied

Survey weighting not applied

Final estimates not shrunk towards mean

Estimates with S.E.'S greater than that of mean included

Minimum S.E. for any survey taken as .00

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

yearclass:2012

index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	0.9489	8.445	0.5385	0.5903	18	2.418	10.74	0.5952	0.12045
SNS1	0.7500	5.685	0.3370	0.8150	35	6.875	10.84	0.3544	0.33986
SNS2	0.7353	6.710	0.3723	0.7788	35	NA	NA	NA	NA
BTS1	0.7388	9.481	0.3969	0.7224	26	1.923	10.90	0.4251	0.23614
BTS2	0.9143	9.262	0.4210	0.6924	27	2.746	11.77	0.4474	0.21322
VPA Mean	NA	NA	NA	NA	36	NA	11.37	0.6874	0.09033

	WAP	logWAP	int.se
yearclass:2012	65474	11.09	0.2066

Updated assumptions table for the new short term forecast:

Year class	At age in 2014	XSA Survivors	RCT3	GM 1957–2011	Accepted estimate
2012	2	54 268	54 228	82 889	XSA survivors
			65 474		RCT3
2013	1		147 276	94 491	RCT3
2014	0			94 491	GM 1957–2011

The exploitation pattern (F) was taken to be the mean value of the last three years. Weight-at-age in the stock and weight-at-age in the catch were taken to be the mean of the last three years. Population numbers at ages 3 and older are XSA survivor estimates. Numbers at age 1 and age 2 are taken from the RCT3 analysis and recruitment of the 2014 and later year-classes are taken from the long-term geometric mean (1957–2010: 94 million). Input to the short term forecast is presented in Table 2.7.1.

For 2014, it was assumed that F2014 = F2013 = 0.232. The expected landings in 2014 of 11 700 t are close to the agreed TAC of 11 900 t. The short term forecast management options are presented in Table 2.7.2.

Fishing at Fmsy in 2015 (=Fhcr) results in a TAC of 11 365 t. This implies a reduction of 5% compared to the TAC in 2014. The expected remaining SSB in 2016 is 55 300 t.

Figure 2.7.2 shows the projected contribution of different year classes to the estimates of the landings in 2015 and of the SSB in 2016, when fishing at Fsq. The figure shows that almost three quarters of the estimated landings in 2015 is based on information from the XSA, with the remainder from RCT3 analysis outputs. Only for year classes 2014 and 2015 the assumption of GM recruitment have been made, but these do not affect the projections (i.e. do not contribute to the SSB in 2016 or landings in 2015).

Table 2.7.1. Sole in sub area IV: STF Input table (F values presented are for Fsq).

	2014								
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
RCT3	1	147276	0.1	0.00	0	0	0.043	0.000	0.164
RCT3	2	65474	0.1	0.00	0	0	0.144	0.063	0.167
XSA	3	28952	0.1	1.00	0	0	0.170	0.270	0.191
XSA	4	67521	0.1	1.00	0	0	0.221	0.289	0.235
	5	57823	0.1	1.00	0	0	0.261	0.295	0.258
	6	17474	0.1	1.00	0	0	0.277	0.243	0.276
	7	7465	0.1	1.00	0	0	0.309	0.319	0.294
	8	3185	0.1	1.00	0	0	0.304	0.298	0.297
	9	7216	0.1	1.00	0	0	0.421	0.257	0.337
	10	1652	0.1	1.00	0	0	0.422	0.257	0.400
	2015								
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
GM	1	94490	0.1	0.00	0	0	0.043	0.000	0.164
	2		0.1	0.00	0	0	0.144	0.063	0.167
	3		0.1	1.00	0	0	0.170	0.270	0.191
	4		0.1	1.00	0	0	0.221	0.289	0.235
	5		0.1	1.00	0	0	0.261	0.295	0.258
	6		0.1	1.00	0	0	0.277	0.243	0.276
	7		0.1	1.00	0	0	0.309	0.319	0.294
	8		0.1	1.00	0	0	0.304	0.298	0.297
	9		0.1	1.00	0	0	0.421	0.257	0.337
	10		0.1	1.00	0	0	0.422	0.257	0.400
	2016								
		Stock	Natural	Maturity	Prop. of M	Prop. of F	Weight	Exploit.	Weight
	Age	Size	mortality	ogive	bef. spaw.	bef. spaw.	in stock	pattern	in catch
GM	1	94490	0.1	0.00	0	0	0.043	0.000	0.164
	2		0.1	0.00	0	0	0.144	0.063	0.167
	3		0.1	1.00	0	0	0.170	0.270	0.191
	4		0.1	1.00	0	0	0.221	0.289	0.235
	5		0.1	1.00	0	0	0.261	0.295	0.258
	6		0.1	1.00	0	0	0.277	0.243	0.276
	7		0.1	1.00	0	0	0.309	0.319	0.294
	8		0.1	1.00	0	0	0.304	0.298	0.297
	9		0.1	1.00	0	0	0.421	0.257	0.337
	10		0.1	1.00	0	0	0.422	0.257	0.400

Table 2.7.2. Sole in sub area IV: STF option table, assuming F(2013) = F(sq).

landings	basis	f2-6	f_dis2-3	discards	catch	ssb2015	tac 2014
11.769	Fsq	0.232	0	0	11.7	46.764	11.9

landings	basis	f2-6	f_dis2-3	discards	catch	ssb2016	ssb_change	tac_change
10.4	MP_Ftar	0.2	0	0	10.4	56.2	24	-12
10.8	MP_Fmp stage 1	0.209	0	0	10.8	55.8	23	-9
11.365	Fmsy	0.22	0	0	11.3	55.3	22	-5
11.365	Fhcr	0.22	0	0	11.3	55.3	22	-5
18.8	Fpa	0.4	0	0	18.8	47.5	4	58
0	Flim	NA	NA	0	NA	NA	NA	-100
30.8	SSB>Bpa	0.784	0	0	30.8	35	-23	159
0	F=0	0	NA	0	0	67.2	48	-100
13.7	15%_TAC_inc	0.272	0	0	13.7	52.9	16	15
11.9	TACsq	0.232	0	0	11.9	54.7	20	0
10.1	15%_TAC_dec	0.193	0	0	10.1	56.6	25	-15
3.9	Fsq*0.3	0.07	0	0	3.9	63.1	39	-67
7.5	Fsq*0.6	0.139	0	0	7.5	59.3	31	-37
9.8	Fsq*0.8	0.186	0	0	9.8	56.9	25	-18
11.9	Fsq*1	0.232	0	0	11.9	54.7	20	0
12.9	Fsq*1.1	0.255	0	0	12.9	53.6	18	9
15.9	Fsq*1.4	0.325	0	0	15.9	50.5	11	34
20.4	Fsq*1.9	0.441	0	0	20.4	45.9	1	71

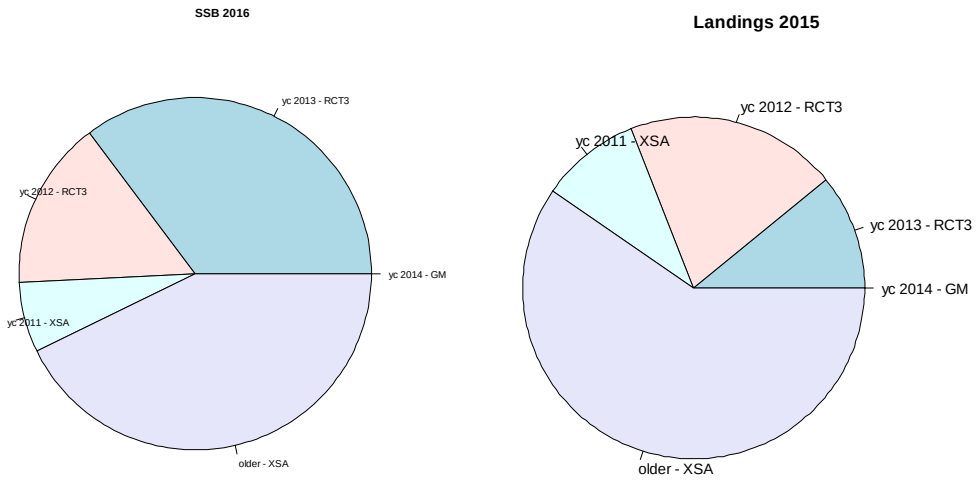


Figure 10.7.2 Sole in Sub-Area IV. Relative year class contribution to 2016 predicted SSB (right) and 2015 landings (left).

2.7.6 Conclusions

The D values suggest an insignificant decrease in the estimate of age 1 fish and a significant increase in the estimate of age 2 fish. Given that the distance D > 1.0 for age 2, the autumn indices suggest that the size of the incoming 2012 year-class is larger than what had been assumed in the forecast produced by WGNSSK in May 2014. Hence, the protocol concludes that **the advisory process for North Sea sole should be reopened.**

Following the same conclusion as the ADG (F2015=Fmsy), the new short term forecasts lead to an **increase in advised TAC from 10 973t to 11 365t** (an increase of 392t). This is still a decrease in comparison with the 2014 TAC, but only a 5% decrease rather than an 8% decrease as advised in June.

References

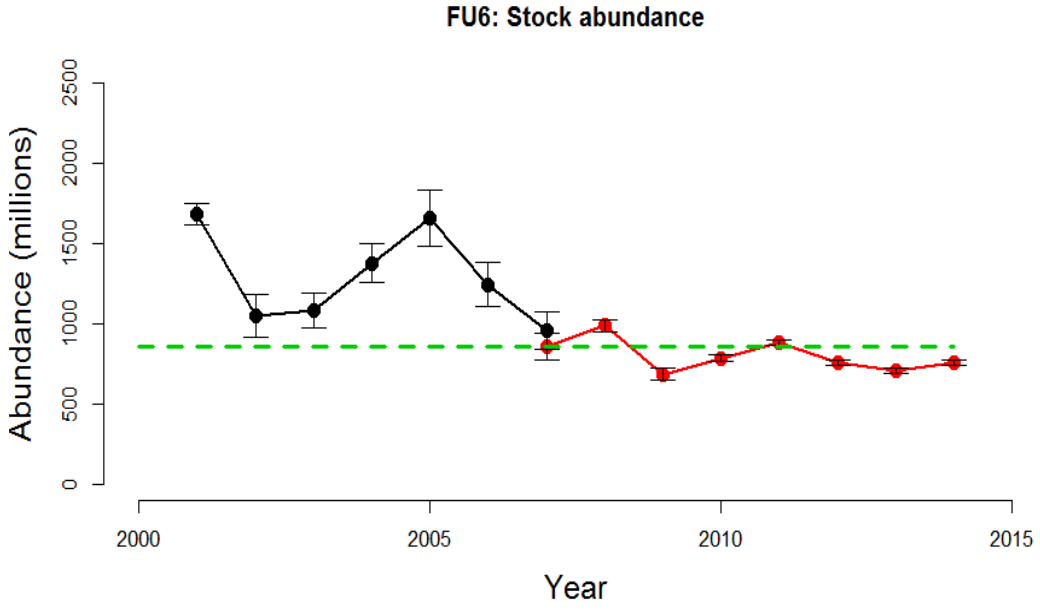
ICES. 2008. Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES. 2014. Report of the Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 30 April–7 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:13. 1493 pp.

2.8 North Sea Nephrops

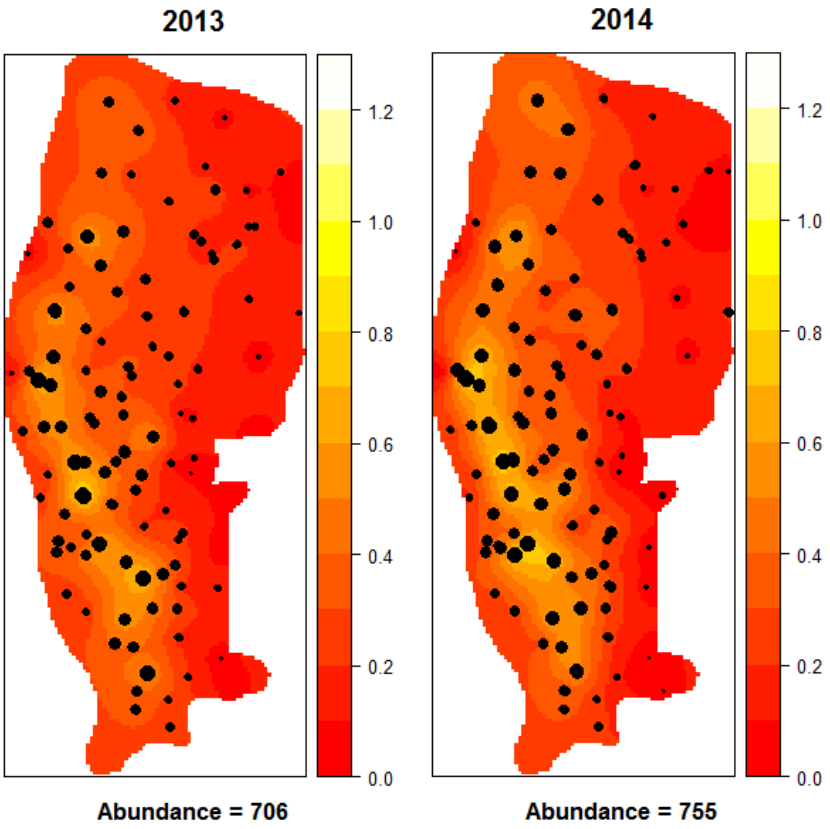
Autumn update Nephrops in IV, FU6 (Farn Deeps).

- The annual TV survey for FU6 Nephrops was conducted 8th- 16th June.
- 108 stations were successfully completed and the quality of the footage was excellent due to calm weather and good visibility.
- The same procedure for estimating Nephrops abundance has been followed since 2007 using a geostatistical approach.
- The 2014 TV abundance estimate is 755 ± 18 (2 SD)
- The value used to generate the June 2014 advice came from the 2013 TV survey which was 706 ±18 (2 sd)
- These two distributions do not overlap at the 2SD level, let alone the 1SD guidelines for advice reopening.
- This translates into LANDINGS advice for 2015 of 1127t (June advice gives 985t)
- The change in landings is +14% whereas the change in survey is +7%. This is because the latest survey index has increased and whilst still below the Btrigger level requires less penalisation of the MSY target Harvest Rate.



Discard proportion =26.6%, mean weight in retained portion =27.32g, Absolute Survey Abundance Index=755

	Harvest ratio	Retained number	**Landings**	Dead Discards	Surviving Discards
	2%	12	**315**	37	6
	4%	23	**631**	73	13
	6%	35	**946**	110	19
MSY Approach	7.1%	41	**1127**	131	23
Fmsy=Male F35%SpR	8%	47	**1280**	149	26
	9%	52	**1419**	165	29
	10%	58	**1577**	184	32
	11%	63	**1734**	202	36
	12%	69	**1892**	220	39
	14%	81	**2207**	257	45
	16%	92	**2523**	294	52
Fcurrent	16.5%	95	**2601**	303	53
	20%	115	**3153**	367	65


2013
2014
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Abundance = 706
Abundance = 755

Fladen (FU7)

The most recent UWTV survey for this stock was carried out in June 2014. The survey followed the usual procedures for Scottish UWTV surveys, and these are described in more detail in the Stock Annex.

The UWTV estimate of abundance used in the June 2014 advice and based on the 2013 survey is 2902 million (Table 2.8.3 and Figure 2.8.3). The estimate from the 2014 summer survey is 2990 million with a 95 % CI of 412 million. The 2013 value is within 1 SD of the new 2014 abundance estimate and therefore the advice for FU7 should not be reopened.

Table 2.8.3. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2014 TV surveys.**

		Abundance	Mean density	95% confidence interval
Year	Stations	millions	burrows/m2	millions
1992	69	3661	0.13	376
1993	74	4450	0.16	569
1994	59	6170	0.22	814
1995	61	4987	0.18	896
1996	No survey			
1997	56	2767	0.10	510
1998	60	3838	0.13	717
1999	62	4146	0.15	649
2000	68	3628	0.13	491
2001	50	4981	0.17	970
2002	54	6087	0.21	757
2003	55	5547	0.20	1076
2004	52	5725	0.20	1030
2005	72	4325	0.16	662
2006	69	4862	0.17	619
2007	82	7017	0.25	730
2008	74	7360	0.26	1019
2009	59	5457	0.19	772
2010	67	5224	0.19	710
2011	73	3382	0.12	435
2012	70	2748	0.10	392
2013	71	2902	0.10	335
2014	70	2990	0.11	412

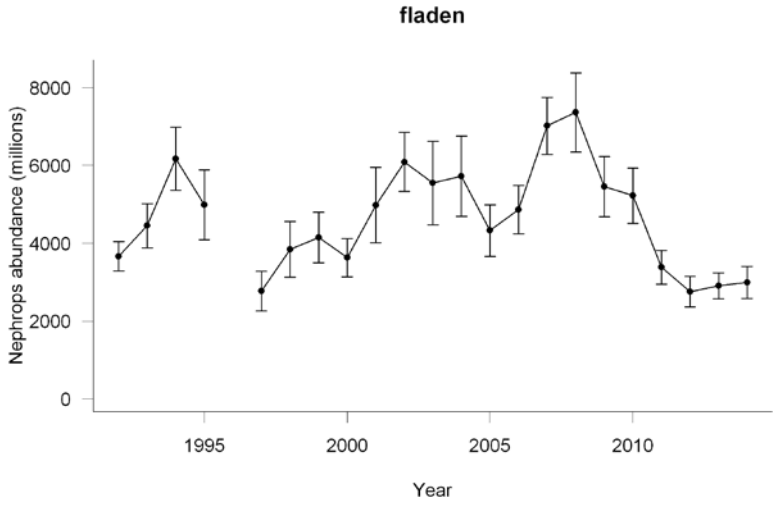


Figure 2.8.3. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2014 TV surveys.**

Firth of Forth (FU8) and Moray Firth (FU9)

The UWTV surveys for these two FUs take place later in the summer (late August/early September) than those of other FUs. Therefore the survey data are as yet not fully worked up and it will not be possible to consider an update to the advice.

Annex 03 Stock Annexes Part 1

Stock Annex – Whiting IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Whiting IIIa
Working Group:	WGNSSK
Date:	May 2014
By:	(WGNSSK/Henrik Svedang)

A. General

A.1. Stock definition

There is a paucity of information on the population structure of whiting in IIIa (the Skagerrak-Kattegat area). A population separation between the North Sea and the IIIa has been observed for gadoids such as Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*; e.g. Knutsen *et al*. 2004; Svedäng *et al*. 2007; 2010; Cardinale *et al*. 2012), as well as for herring (*Clupea harengus*; Ruzzante *et al*. 2006) and plaice (*Pleuronectes platessa* Ulrich *et al*. 2013). No genetic surveys have been conducted, nor otolith based surveys. Tagging of whiting have previously been made, yet these data need to be re-examined. Results from modelled survey data (SURBAR) are inconclusive regarding independent population dynamics in IIIa in comparison with the North Sea. The drop in landings in the beginning of the 1990s gives however an indication of local stock structure, as this reduction was not paralleled by any similar event in the North Sea nor in existing surveys, thus giving a support for a stock separation between the North Sea and IIIa.

A.2. Fishery

Landings

The total landings of whiting from IIIa have declined from over 20 000 tonnes in the 1980s (>40 000 tonnes in single years) to 115 tonnes in 2013, including both human consumption and industrial by-catch. It remains unclear to what extent the drastic reduction in landings was due to a decline in the whiting stock biomass in IIIa or to changed fishing patterns. Whiting from IIIa are taken as bycatch in the demersal trawl fisheries, which mostly are discarded.

Discards

Discard rates were obtained from samples provided by Denmark and Sweden, where a discards sampling programme has been carried out on board bottom otter trawl fleets since 2003. ICES estimates of discards are 1486 tonnes in 2013. The iscards estimates have strong interannual variation. This is probably caused by the low sample sizes, which would potentially lead to incorrect estimates.

A.3. Ecosystem aspects

Understanding the complex mechanisms linked to the temporal and spatial distribution of fish abundances play a central role in ecosystem functioning and dynamics. The

analysis of a time series of juveniles whiting along the Norwegian coast in the Skagerrak (Frometin *et al*. 1997) from 1919 to 1994 provided useful information on the spatial variability of this species related to both biotic and abiotic factors. The recent decline of this population may be also related to a decline of *Calanus finmarchicus* that constitutes an important food resource for the fish larvae (Fromentin & Planque 1996; Planque & Fromentin 1996).

The size structure and abundance of this species along the Swedish Skagerrak coast (Svedäng 2003) showed a distinct shift in the size spectra to smaller sizes in comparison with the historical time series between the 1920's to 1970's. Historical survey data (described in Cardinale *et al*. 2010) showed relatively much higher abundance of large sized whiting between the 1920´s and 1950´s in the IIIa than in the time period thereafter (Hagberg 2005).

A.3. Biology

Whiting are a major prey component of the diet of many piscivorous fish and marine mammals. The spatial distribution of whiting in the neighbouring North Sea is considered to have changed over the last decade. This may represent a contraction to a substock structure coinciding with the main spawning areas in the North Sea. Spawning occurs from January to July at 30–100 m depth. Whiting attain sexual maturity at age 2–3 yrs (50% point of the maturity ogive is about 21.5 cm). Maximal recorded length 70 cm, maximal age 20 yrs.

B. Data

B.1. Commercial catch

The new data available for this stock are too insufficient to undertake an assessment of this stock. Due to the uncertain nature of stock status the advice was revised. The commercial landings for this stock are available from 1975 to present, and estimate of discards from 2003 to present.

B.2. Biological

No biological data from commercial landings are available for this stock.

B.3. Surveys (IBTS)

IBTS survey data for Q1 are available from 1967 to present and data for Q3 are available from 1991 to present, except for year 2000 as the expedition in that year and quarter was cancelled. However, the internal consistencies in age structure for both tuning fleets are very poor and cohorts can therefore not be followed in a meaning way, impeding analytical assessment based on surveys (SURBAR). The fact that CPUE per age and haul were calculated by using ALKs from IV (North Sea) further limits the value of the present analytical assessment. For a better understanding of the population dynamics in IIIa age readings and maturity estimates from the studied stock are needed.

C. References

Cardinale, M., Hagberg, J., Svedäng, H., Bartolino, V., Gedamke, T., Hjelm, J., Börjesson, P. & Norén, F. 2010. Fishing through time: population dynamics of plaice (*Pleuronectes platesa*) in the Kattegat-Skagerrak over a century. Population ecology 52: 251-262.

Cardinale M., Svedäng H., Bartolino V., Maiorano L., Casini M. & Linderholm H.W. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. 2012 J. Appl. Ichthyol. 28: 1–9

Hagberg, J. 2005. Utökad analys av historiska data för att säkerställa referensvärden för fisk. (Extended analysis for establishing reference values for marine fish). Swedish Board of Fisheries, Institute of Marine Research, Lysekil. 22 p.

Frometin J-M., Stenseth N. C., *et al*. 1997 Spatial patterns of temporal dynamics of three gadoid species along the Norwegian Skagerrak coast. Mar. Ecol. Prog. Ser. 55:209-222

Fromentin J-M. and Planque B. 1996 *Calanus* and environment in the eastern North Atlantic II. Influence of the North Atlantic Oscillation on *C. finmarchicus* and *C. helgolandicus*. Mar. Ecol. Prog. Ser. 134:111-118

Planque B. and Fromentin J-M. 1996 *Calanus* and environment in the eastern North Atlantic I. Spatial and temporal patterns of *C. finmarchicus* and *C. helgolandicus*. Mar. Ecol. Prog. Ser. 134:101-109

Knutsen H., André C, Jorde P.E., Skogen M.D., Thuróczy E. & Stenseth N.C. 2004 Transport of North Sea cod larvae into the Skagerrak coastal populations. Proc R Soc Lond B 271:1337–1344.

Svedäng H. 2003 The inshore demersal fish community on the Swedish Skagerrak coast: regulation by recruitment from offshore sources. ICES J. Mar. Sci. 60:23-31

Svedäng H., Righton, D. and Jonsson, P. 2007. Migratory behaviour of Atlantic cod *Gadus morhua*: natal homing is the prime stock-separating mechanism. Mar. Ecol. Prog. Ser. 345: 1-12

Svedäng H., André C., Jonsson P., Elfman M. & Limburg K. 2010. Migartory behaviour and otolith chemistry suggest fine-scale sub-population structure within a genetically homogenous Atlantic cod population. Environ. Biol. Fishes 89: 383–397

Ulrich, C. Boje, J., Cardinale, M., Gatti, P., LeBras, Q., Andersen, M., Hemmer-Hansen, J., Hintzen, N.T., Jacobsen, J.B., Jonsson, P., Miller, D.C., Nielsen, E.E., Rijnsdorp, A.D., Svedäng, H., & Wennhage, H. 2013. Variability and connectivity of plaice populations from the Eastern North Sea to the Western Baltic Sea, and their consequences for assessment and management. Journal of Sea Research (in press).

Stock annex Haddock in Subarea IV and Divisions IIIaW and VIa (North Sea, Skagerrak and West of Scotland)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock in Subarea IV and Divisions IIIaW and VIa (North Sea, Skagerrak and West of Scotland)
Working Group:	GNSSK
Date:	April 2014
Revised by	WKHAD 2014 [Coby Needle]

A. General

A.1. Stock definition

Haddock in Subarea IV and Divisions IIIaW and VIa (North Sea, Skagerrak and West of Scotland) are assessed as one stock, following the WKHAD meeting in February 2014, although quota advice is provided for the three areas separately as they are still managed on this basis. In the following text, the stock is referred to as Northern Shelf haddock for brevity.

A relatively continuous and unbroken spatial distribution of haddock extends from the west coast of Scotland, around the north of Scotland and into the the northern and central North Sea and Skagerrak. Genetic and biological marker studies suggest the possibility that a biologically distinct stock inhabits the Clyde area (in the far south-east of Division VIa), but there is insufficient knowledge to provide a separate assessment of that stock and the area remains incorporated in the full Northern Shelf stock extent. A number of different spawning aggregations for haddock exist in the total stock area, mainly around the east and west coasts of Scotland. The haddock found in the Skagerrak consist mainly of younger fish.

Haddock are pelagic during the first half year of life (as eggs and larvae) and are transported both from the West Of Scotland into the North Sea (as eggs and free-floating larvae, following the prevailing currents), and from the North Sea to the West of Scotland (as juveniles). Adult haddock are thought to be more sedentary.

Haddock are seldom found below 300 m in this area, although Rockall (Division VIb) haddock can be found much deeper, and North Sea haddock prefer depths between 50 m and 200 m. They are found as juvenile fish in coastal areas in particular in the Moray Firth, around Orkney and Shetland, along the continental shelf at around 200 m and continuing round to the Skagerrak. Adult fish are predominantly found around Shetland and in the northern North Sea near the continental shelf edge.

The choice to assess haddock in the whole area (merging the former stocks in Division VIa with the stock in Division IIIaW and Subarea IV) is based on a number of factors, including:

1. the problem in assessing the West of Scotland stock due to misreporting of landings from that area into the North Sea;
2. consistent patterns of recruitment in all former notional substocks, and relatively unbroken survey- and catch-based patterns of spatial distribution across all areas; and

3. high likelihood of area inter-mixing at the egg, larval and juvenile stage, as evidenced by otolith micro-chemistry analyses and particle tracking studies.

A.2. Fishery

The haddock fishery is this area is principally undertaken by the Scottish demersal whitefish fleet, which receives the bulk of the available quota and consequently takes the largest proportion of the haddock stock. This fleet is not just confined to the Northern Shelf, as vessels will sometimes operate in Divisions VIb (Rockall) and Vb (Faeroes) The demersal fisheries in the Northern Shelf are predominantly conducted by demersal trawlers fishing for cod, haddock, anglerfish and whiting, with bycatches of saithe, megrim, lemon sole, ling and several species of skate.

In the North Sea the main fisheries are carried out by demersal trawlers (single, twin, and pair), and (to a lesser extent) by seiners. Haddock are a specific target for some fleets, but are also caught as part of a mixed fishery catching cod, whiting, and *Nephrops*. The minimum permitted mesh size for targeted fisheries was increased to 120 mm in 2002. Estimates of haddock bycatch in the industrial fisheries for sandeel and Norway pout are low. Haddock in Division VIa is caught mainly by Scottish and Irish bottom trawlers, which target mixed demersal fish assemblages. Catches are widely distributed and are concentrated in several areas, e.g. the Butt of Lewis and on the shelf west of the Outer Hebrides.

A.2.1. Management plans

As Northern Shelf haddock are still managed according to the previously-implemented stock definitions, details on extant management plans and technical regulations are given below in separate area-specific sections.

Subarea IV and Division IIIa

In 1999 the EU and Norway "agreed to implement a long-term management plan for the haddock stock, which is consistent with the precautionary approach and is intended to constrain harvesting within safe biological limits and designed to provide for sustainable fisheries and greater potential yield." This plan was implemented in January 2005, updated in December 2006, and implemented in revised form in January 2007. It consists of the following elements:

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass greater than 100,000 tonnes (Blim).
2. For 2007 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of no more than 0.3 for appropriate age-groups, when the SSB in the end of the year in which the TAC is applied is estimated above 140,000 tonnes (Bpa).
3. Where the rule in paragraph 2 would lead to a TAC which deviates by more than 15% from the TAC of the preceding year the Parties shall establish a TAC that is no more than 15% greater or 15% less than the TAC of the preceding year.
4. Where the SSB referred to in paragraph 2 is estimated to be below Bpa but above Blim the TAC shall not exceed a level which will result in a fishing mortality rate equal to 0.3-0.2*(Bpa-SSB)/(Bpa-Blim). This consideration overrides paragraph 3.

5. Where the SSB referred to in paragraph 2 is estimated to be below Blim the TAC shall be set at a level corresponding to a total fishing mortality rate of no more than 0.1. This consideration overrides paragraph 3.

6. In order to reduce discarding and to increase the spawning stock biomass and the yield of haddock, the Parties agreed that the exploitation pattern shall, while recalling that other demersal species are harvested in these fisheries, be improved in the light of new scientific advice from inter alia ICES.

7. In the event that ICES advises that changes are required to the precautionary reference points Bpa (140 000 t) or Blim (100 000 t) the parties shall meet to review paragraphs 1-5.

8. No later than 31 December 2009, the parties shall review the arrangements in paragraphs 1 to 7 in order to ensure that they are consistent with the objective of the plan. This review shall be conducted after obtaining inter alia advice from ICES concerning the performance of the plan in relation to its objective.

In October 2007, ICES evaluated this plan and concluded that it could "provisionally be accepted as precautionary and be used as the basis for advice." The methods used to reach this conclusion (along with illustrative results) are given in Needle (2008). ICES considers that the agreed Precautionary Approach reference points in the management plan are consistent with the precautionary approach, provided they are used as lower boundaries on SSB, and not as targets.

The plan was modified during 2008 to allow for limited interannual quota flexibility, following the meeting in June of the Norway-EC Working Group on Interannual Quota Flexibility and subsequent simulation analysis (Needle 2008).

Division VIa

In 2009, following a request from the EC, ICES evaluated a proposal for a draft management plan for Division VIa haddock, which was along similar lines to the EU-Norway management plan for North Sea haddock but with a different TAC constraint (±25% for biomass levels). Two more evaluations followed early in the following year after requests for modifications (Needle 2010a, 2010b), and ICES concluded on the basis of these that the plan as presented was precautionary. However, the plan has not yet been implemented by fisheries managers in the area, and the Division VIa part of the Northern Shelf stock continues to be managed on the basis of MSY considerations.

The TAC relating to this stock covers EU and international waters in both ICES Divisions Vb and VIa.

A.2.2. Further technical conservation measures

Subarea IV and Division IIIaW

Under the provisions laid down in point 8.5 of Annex IIa to the 2008 year's EU TAC and Quota Regulation, Scotland implemented in 2008 a national KWdays scheme known as the Conservation Credits Scheme. The principle of this two-part scheme involves credits (in terms of additional time at sea) in return for the adoption of and adherence to measures which reduce mortality on cod and lead to a reduction in dis discard numbers. The initial scheme was implemented from the beginning of February 2008 and granted vessels their 2007 allocation of days (operated as hours at sea) in

return for observance of Real Time Closures (RTC) and a one-net rule, adoption of more selective gears (110mm square meshed panels in 80mm gears or 90mm SMP in 95mm gear), agreeing to participate in additional gear trials and participation in an enhanced observer scheme.

For the first part of 2008 the RTC system was designed to protect aggregations of larger, spawning cod (>50cm length). Trigger levels leading to closures were in-formed by commercial catch rates of cod observed by FRS on board vessels. During 2008, there were 15 such closures. Protection agency monitoring suggested good observance. A joint industry/ science partnership (SISP) undertook a number of gear trials in 2008 examining methods to improve selectivity and reduce discards and an enhanced observer scheme was announced by the Scottish Government.

The RTC system was expanded in 2009 (144 closures), 2010 (165 closures), 2011 (185 closures), 2012 (173 closures), 2013 (166 closures) and 2014 (35 closures by mid-April). The area covered by each closure has also been increased, and their shape can be modified to account for local bathymetry. Needle and Catarino (2011) used VMS data to analyse the movements of vessels affected by closures during 2009, and concluded that such vessels did move to areas of lower cod abun-dance during the first and third quarters (the second and fourth quarters were inconclusive).

Scotland has also been instrumental in the development of Catch Quota Management (http://www.scotland.gov.uk/Topics/marine/Sea-Fisheries/17681/catchquota). Participating vessels are fitted with CCTV and other remote electronic monitoring systems and are required not to discard any cod. Additional cod quota (up to 30%) is made available to these vessels, with the intention to "catch less and land more". While the scheme does not yet cover haddock, the consequent changes in fleet dynamics are likely to affect patterns of exploitation on haddock, and the implications will need to be considered carefully in future advice.

Division VIa

The agreed minimum landing size for haddock in Division VIa is 30 cm. Further regulations implemented for the west of Scotland include technical measures associated with the cod recovery plan (EC regulation 1342/2008) and emergency measures introduced with EC regulation 43/2009.

A.3. Ecosystem aspects

The Northern Shelf haddock stock is characterised by sporadically high recruitment leading to dominant year classes in the fishery. These large year classes may grow more slowly than less abundant year classes, possibly due to density dependent effects. Haddock primarily prey on benthic and epibenthic invertebrates, sandeels and demersal herring egg deposits. They are also an important prey species, mainly for other gadoids.

It is desirable to maintain spatial structure in spawning stock biomass; hence, spawning aggregations should be exploited approximately the same (i.e. experience the same exploitation rates) or managed with this objective, where possible. Existing spatial knowledge on spawning aggregations is currently insufficient to indicate exact areas that may need specific protection.

B. Data

B.1. Commercial catch

Subarea IV and Division IIIa

In the North Sea and Skagerrak, three catch components are considered: landings for human consumption, discards and industrial bycatch. The sources of information on these components were as follows (this table dates from the 2010 assessment, but the sources are unchanged):

		Belgium		Denmark		France		Germany		Netherlands		Norway		Sweden		United Kingdon	
		WG	SA	WG	SA	WG	SA	WG	SA	WG	SA	WG	SA	WG	SA	WG	SA
Catches	Landings	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Discards	N	N	Y	Y	NP	N	Y	Y	NP	N	NP	N	Y	Y	Y	Y
Length Composition	Landings	NR	N	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	Discards	NR	N	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Age/Length Key		NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Age Composition	Landings	NP	N	Y	Y	NP	N	NP	NP	NP	N	Y	Y	Y	Y	Y	Y
	Discards	NP	N	Y	Y	NP	N	NP	NP	NP	N	NP	N	Y	Y	Y	Y
Weight at age		NP	N	Y	Y	NP	N	Y	Y	NP	N	Y	Y	Y	Y	Y	Y
Maturity Information		NR	N	NR	N	NR	N	NR	N	NR	NR	NR	NOR	NR	N	NR	NOR
Sex ratio		NR	N	NR	NR	NR	NR	NR	N	NR	NR	NR	N	NR	N	NR	NOR
Tuning fleets	Commercial fleets	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	NP	Y2	NBQ
	Surveys at sea	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	NP	Y3	Y3

In this table, the notes in the **WG** (Working Group) columns indicate the following: Y = provided to the WG, NP = not provided to the WG, and NR = not requested. In the **SA** (stock assessment) columns: Y = used in the assessment, NBQ = not used due to bad quality, NTS = not used due to short or inconsistent data time series, NOR = not used due to other reason, and NR = not relevant.

Division VIa

The following table gives the source of landings data for Division VIa haddock:

Country	Catch yield	Catch-at-age in numbers	Weight-at-age in the catch	Pproportion mature-by-age	Catch length composition
UK(NI)	X				
UK(E&W)	X				
UK(Scotland)	X	X	X	X	X
Ireland	X	X	X		X
France	X				
Norway	X				

Quarterly landings are provided by the UK (Scotland), UK (E/W), UK (NI), France and Ireland. The quarterly estimates of landings-at-age by UK (Scotland) and Ireland are raised to include landings by France, UK (NI) and Norway (distributed proportionately over quarters), then summed over quarters to produce the annual landings-at-age.

EU countries are now required under the EU Data Collection regulation to collect data on discards of haddock and other species. Up to 2003, estimates of discards were available only from UK (Scotland) and Ireland. Observer data are collected using standard at-sea sampling schemes. Results are reported to ICES.

The quantity, length and age of haddock discarded by Scottish *Nephrops* trawlers are collected during observer trips on board commercial vessels. Haddock discarded by boats using other gears (heavy trawl, seine, light trawl and pair trawl) are also collected by Scotland. Haddock discarded by otter board trawl and otter board/twin rig gears are collected by Ireland.

Discards from Scottish and Irish boats using several different gear types are estimated by observers.

Data used in the assessment

Numbers at age and yield in the three available catch components are summed across the two previous stock areas to generate the requisite data for the Northern Shelf assessment. Weights-at-age in the catch components (and in the stock) are calculated as the average of the weights from each area, weighted by catch abundance (see below).

The catch time-series used in the assessment includes data from 1972 onwards, which is the period for which there was age sampling of the industrial by-catch fishery. Earlier data on industrial bycatch were estimated and are not considered reliable. Discard sampling commenced on a statistically-defensible scale in 1978, which means that the assessment period include six years (1972-1977) during which discard estimates were inferred by applying discard rates observed during 1978-1980 to earlier years.

B.2. Biological

Natural mortality

Natural mortality (M) for the Northern Shelf assessment is determined by the smoothed estimates produced by the most recent North Sea SMS key run. When a key

run has not been conducted recently, the estimates of M for the last year of the most recent SMS run are to be used in all subsequent years up to the present.

Maturity

Maturity is set to be a knife-edge at age 3 for the Northern Shelf area (that is, maturity = 0.0 for ages 0-2, and maturity = 1.0 for ages ≥ 3). This is an interim measure until a more appropriate model of reproductive potential can be determined.

Weights:

The weights-at-age for each catch component are determined by national sampling programmes for length and weight, which are then collated through the Intercatch system. This approach generates weights-at-age for the two previous stock areas separately. The combined Northern Shelf weights-at-age are then given by the weighted means of the separate stock area values, weighted by the relevant catch-component abundance *N*. For example, to estimate Northern Shelf catch weight $W_{a,y}^{NSh}$ at age a in year y, calculate the weighted mean of the catch component weights:

$$W_{a,y}^{NSh} = \frac{N_{a,y}^{NS} W_{a,y}^{NS} + N_{a,y}^{WC} W_{a,y}^{WC}}{N_{a,y}^{NS} + N_{a,y}^{WC}}$$

Here *NSh* denotes Northern Shelf, *NS* denotes the North Sea and Skagerrak, and *WC* denotes the West Coast of Scotland.

B.3. Surveys

The Northern Shelf assessment uses two survey indices, as follows:

Area	Country	Quar-	Code	Year range	Age
Subarea IV and Division	Interna-	Q1	IBTS	1983-pre-	1-5
Subarea IV and Division	Interna-	Q3	IBTS	1991-pre-	0-5

In addition, the following Division VIa survey is used as a biomass index for separating the forecast between management areas.

Area	Country	Quar-	Code	Year range	Age range
Subarea VIa	Scotland	Q1	ScoGFS-WIBTS Q1	2011-pre-	1-8

In recent assessments, exploratory data analysis using survey time-series has included:

1. Distribution plots by age and year.

2. Survey log CPUE by age.

3. Log survey catch curves by cohort.

4. Bivariate correlations of survey indices by cohort, with fitted regression lines. That is, indices at age 0 are plotted against indices at age 1 for each cohort, then age 0 against age 2, and so on for all age combinations.

5. Results of SURBAR model fits (Needle 2012). These give estimated mean *Z*, relative SSB and relative recruitment trends, along with confidence intervals. Further details on SURBAR settings are given below (Section C).

Although they have not been included in WGNSSK reports before, WKHAD found the production of SPAY (standardized proportions at age) plots of catch and survey age

compositions to be extremely valuable in understanding data problems, and recommends that they be presented by WGNSSK as a matter of course.

B.4. Commercial CPUE

Commercial CPUE (or LPUE) data are not used for tuning the final assessment. During preparations for the 2000 round of assessment WG meetings it became apparent that the 1999 effort data for the Scottish commercial fleets were not in accordance with the historical series and specific concerns were outlined in the 2000 report of WGNSSK (ICES-WGNSSK 2001). Effort recording is still not mandatory for these fleets, and concerns remain about the validity of the historical and current estimates of commercial CPUE. In addition, the LPUE indices from Scottish commercial fleets presented at previous WGs (ScoLtr and ScoSei) can no longer be generated in that form due to changes in EU definitions of fishery metiers. Data are also available from the Irish trawler fleet fishing in Division VIa, but are not used in the assessment as a consequence of concerns about targeting leading to hyperstability.

B.5. Other relevant data

No other relevant data have been used in the assessment to date.

C. Assessment: data and method

Model used: Time-Series Analysis (TSA)

Software used: Bespoke software provided by Marine Scotland Science at the Marine Laboratory, Aberdeen, Scotland.

Model options chosen:

Landings	Ages	0–8+
	Years	1972-2013
Discards	Ages	0-8+
	Years	1972, 1978-2013
Industrial bycatch	Ages	0-8+
	Years	1972, 1978-2013
Survey: NS IBTS Q1	Ages	1-5
	Years	1983-2013
Survey: NS IBTS Q3	Ages	0-5
	Years	1991-2013
Maturity		Knife-edge at age 3 (interim measure)
Natural mortality		Age- and time-varying from NS SMS key runs
Catch weights		Catch abundance-weighted average of NS and WC catch weights
Stock weights		Set equal to catch weights (interim measure)
Large year-classes ($\lambda = 5$)		1974, 1979, 1999, 2005, 2009
Age-dependent F variability		$H(a) = (2,1,1,1,1,1,1,1,1)$
F plateau		$a_m = 5$
Measurement-error multiplier for landings		$B_{landings}(a) = (*, 2, 1, 1, 1, 1, 1, 2, 2)$

Measurement-error multiplier for discards+bycatch	$B_{discards}(a) = (2, 1, 1, 1, 2, 2, *, *, *)$
Downweighted landings outliers	1996, age 7
Downweighted discards+bycatch outliers	1982, age 5; 2012, age 2
Downweighted survey outliers	NS IBST Q1: 2011, age 5

Note that the correction that is applied to allow for large year-classes is not implemented automatically, but must be stipulated by the stock assessor once enough evidence has accumulated that a large recruitment event has occurred. WKHAD (2014) suggested that this decision should be made following a benchmark (or inter-benchmark) procedure.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1972 – last data year	0 – 8+	Yes
Caton landings	Landings in tonnes	1972 – last data year	1 – 8+	Yes
Caton discards	Discards in tonnes	1972, 1978 – last data year	0 – 8+	Yes
Caton bycatch	Industrial bycatch in tonnes	1972 – last data year	0 – 8+	Yes
Canum	Catch at age in numbers	1972 – last data year	0 – 8+	Yes
Canum landings	Landings at age in numbers	1972 – last data year	1 – 8+	Yes
Canum discards	Discards at age in numbers	1972, 1978 – last data year	0 – 8+	Yes
Canum bycatch	Industrial bycatch at age in numbers	1972 – last data year	0 – 8+	Yes
Weca	Weight at age in the commercial catch	1972 – last data year	0 – 8+	Yes
Weca landings	Weight at age in landings	1972 – last data year	1 – 8+	Yes
Weca discards	Weight at age in discards	1972, 1978 – last data year	0 – 8+	Yes
Weca bycatch	Weight at age in industrial bycatch	1972 – last data year	0 – 8+	Yes
West = Weca	Weight at age of the spawning stock at spawning time.	1972 – last data year	0 – 8+	Yes
Mprop	Proportion of natural mortality before spawning	1972 – last data year	0 – 8+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1972 – last data year	0 – 8+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1972 – last data year	0 – 8+	No – the same ogive for all years

Natmor	Natural mortality	1972 – last data year	0 – 8+	Yes

Tuning data:

Type	Name	Year range	Age range
Research Vessel Survey			
Tuning fleet 1	IBTSQ1	1983 – most recent	1-5
Tuning fleet 2	IBTSQ3	1991 – most recent	0-5

Second model to run alongside in an exploratory fashion:

Model used: SAM

Software used: ADMB. The entire assessment, data, and configuration is available online (www.stockassessment.org) under the assessment name "Haddock-2014-S6".

Model Options chosen:

SAM model configuration file (model.cfg):

Min Age (should not be modified unless data is modified accordingly)

0

Max Age (should not be modified unless data is modified accordingly)

8

Max Age considered a plus group (0=No, 1=Yes)

1

The following matrix describes the coupling

of fishing mortality STATES

Rows represent fleets.

Columns represent ages.

1 2 3 4 5 6 7 7 7

0 0 0 0 0 0 0 0 0

0 0 0 0 0 0 0 0 0

Use correlated random walks for the fishing mortalities

(0 = independent, 1 = correlation estimated)

1

Coupling of catchability PARAMETERS

0 0 0 0 0 0 0 0 0

0 1 2 3 4 4 0 0 0

5 6 7 8 9 9 0 0 0

Coupling of power law model EXPONENTS (if used)

0 0 0 0 0 0 0 0 0

```
0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0
# Coupling of fishing mortality RW VARIANCES
1    1    1    1    1    1    1    1    1
0    0    0    0    0    0    0    0    0
0    0    0    0    0    0    0    0    0
# Coupling of log N RW VARIANCES
1    2    2    2    2    2    2    2    2
# Coupling of OBSERVATION VARIANCES
4    1    1    1    1    1    1    1    1
0    2    2    2    2    2    0    0    0
3    3    3    3    3    3    0    0    0
#
0 0 0 0 0 0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
0
# Years in which catch data are to be scaled by an estimated parameter
0
# first the number of years
# Then the actual years
# Them the model config lines years cols ages
# Define Fbar range
2    4
```

Input data types and characteristics (same as for TSA, only catch input is used in SAM):

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1972 – last data year	0 – 8+	Yes
Canum	Catch at age in numbers	1972 – last data year	0 – 8+	Yes
Weca	Weight at age in the commercial catch	1972 – last data year	0 – 8+	Yes
Weca landings	Weight at age in landings	1972 – last data year	1 – 8+	Yes
Weca discards	Weight at age in discards	1972, 1978 – last data year	0 – 8+	Yes
Weca bycatch	Weight at age in industrial bycatch	1972 – last data year	0 – 8+	Yes

West = Weca	Weight at age of the spawning stock at spawning time.	1972 – last data year	0 – 8+	Yes
Mprop	Proportion of natural mortality before spawning	1972 – last data year	0 – 8+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1972 – last data year	0 – 8+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1972 – last data year	0 – 8+	No – the same ogive for all years
Natmor	Natural mortality	1972 – last data year	0 – 8+	Yes

Tuning data:

Type	Name	Year range	Age range
Research Vessel Survey			
Tuning fleet 1	IBTSQ1	1983 – most recent	1-5
Tuning fleet 2	IBTSQ3	1991 – most recent	0-5

Third model to run alongside in an exploratory fashion:

The third standard model to be run each year is SURBAR (Needle 2012). This is a survey-based separable assessment model which is widely used in ICES and elsewhere, both as an exploratory analysis tool and as the basis for management advice. An earlier version (SURBA 3.0) with a Windows GUI (Needle 2003) has been available for several years, but the more recent R implementation is more robust and produces a broader range of output. SURBAR uses the same input data as TSA and SAM (see above) for stock weights and maturity, and the two NS IBTS surveys (Q1 and Q3). Run settings are as follows:

1. Moderate smoothing ($\lambda = 3.0$) on age and year effects of mortality, following the suggestion by Needle (in prep.) that the degree of smoothing used should be related to the time gap between spawning and the survey (here the Q1 survey is coincident with spawning, while the Q3 survey is separated from spawning by 6 months).
2. Spawning time set to 0.25.
3. Reference age (that is, the age at which the age-effect s_a of mortality is fixed to 1.0) set to 3.
4. Parameter bounds set as follows: $s_a \in (-5,5), f_y \in (-1,5), r_{yc} \in (-\infty, \infty)$.
5. SSQ age-weightings and survey catchabilities set to 1.0 for all ages and years.

SURBAR is used to generate exploratory survey-based estimates of relative SSB and recruitment, and total mortality, which can then be compared with the catch-and-survey based TSA and SAM models.

D. Short-Term Projection

Initial stock size

Deterministic starting populations taken from TSA survivors' estimates.

Maturity

Knife edge at age 3 for the whole area. This is an interim measure until a more appropriate model of reproductive potential can be generated.

Natural mortality

Average of final three years of assessment data.

F and M before spawning

Both taken as zero.

Weight at age in the catch:

Modelled using a linear cohort-based approach (Jaworski 2011). Weights at age *a* for cohort *c* are fit with the linear model

$$W_{a,c} = \alpha_c + \beta_c a$$

where parameters α_c and β_c are cohort-specific. For recent cohorts, for which there are fewer than three data points, weights at age are taken as an average of three previous weights at the same age (as estimates of α_c and β_c cannot reliably be generated for these cohorts). This procedures is applied separately for each catch component (catch/stock, landings, discard, industrial bycatch). If there is insufficient cohort-based weight information, a simple three-year mean is used here instead.

Weight at age in the stock:

These are assumed to be the same as weight-at-age in the catch.

Exploitation pattern:

Same as the last year, considering that exploitation is smoothed within the TSA model.

Intermediate year assumptions:

Fishing mortality estimate for the current year are taken to be the same as the final year, considering that F is smoothed within the model. Where this results in landings that overshoot the TAC, a TAC constraint should be considered.

Stock recruitment model used:

Recruits in the intermediate year (IY) and recruits i

Stock Annex – Cod in 347d

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Cod in Sub-area IV, Divison VIId & Division IIIa West (Skagerrak)
Working Group:	Working Group North Sea, Skagerrak and Kattegat
Date:	April 2013
By:	Several contributors, coordinated by José De Oliveira

A. General

A.1. Stock definition

Cod are widely distributed throughout the North Sea. Scientific survey data indicate that historically, young fish (ages 1 and 2) have been found in large numbers in the southern part of the North Sea. Adult fish have in the past been located in concentrations of distribution in the Southern Bight, the north east coast of England, in the German Bight, the east coast of Scotland and in the north-eastern North Sea. As stock abundance fluctuates, these groupings appear to be relatively discrete but the area occupied has contracted. During recent years, the highest densities of 3+ cod have been observed in the deeper waters of the central to northern North Sea.

Population genetic research has identified sub-structuring of Atlantic cod populations on both large and smaller geographical scales, for instance between the North Sea and Baltic Sea (Nielsen *et al*. 2003). Within the North Sea and neighbouring areas, several studies have suggested sub-structuring on small geographical scales (e.g. Hutchinson *et al*. 2001, Knutsen *et al*. 2003, 2011). This supports the hypothesis that North Sea cod is really a meta-population of sub-populations with differential rates of mixing among them (Horwood *et al*. 2006, Metcalfe 2006, Heath *et al*. 2008). A genetic survey of cod in European continental shelf waters using micro-satellite DNA detected significant fine scale differentiation suggesting the existence of at least 4 genetically divergent cod populations, resident in the northern North Sea off Bergen Bank, within the Moray Firth, off Flamborough Head and within the Southern Bight (Hutchinson *et al*. 2001). The differentiation was weak (typical of marine fishes with large population sizes and high dispersal potentials), but significant, with the degree of genetic isolation weakly correlated with geographical separation distance. This recent genetic evidence is largely consistent with the limited movements suggested by earlier tagging studies (ICES-NSRWG 1971, Metcalfe 2006, Righton *et al*. 2007, 2010). Furthermore, Holmes *et al*. (2008) found significant differences in SSB trends and Wright *et al*. (2011b) identified different maturation schedules between spawning areas in the North Sea, consistent with asynchronous population dynamics across spawning areas, providing support for the concept of meta-population structure.

Hemmer-Hansen and Wright (WD, ICES-WGNSSK 2013) reviewed current evidence for a unique population in the deeper and cooler water in the northern part of the North Sea (see also Wright *et al*. 2011a). They found that results from several studies suggest a genetic isolation of the Viking Bank from the remaining North Sea (Nielsen *et al*. 2009, Wright *et al*. 2011a), and data from the eastern part of the North Sea suggest a similar

isolation of a population in the deeper parts of the region (Poulsen *et al*. 2011). In addition, they found indications that this northern North Sea population is related to Norwegian coastal cod populations further north. These genetic data are also supported by both tagging (Righton *et al*. 2010, Neat *et al*. in prep) and life-history data (Wright *et al*. 2011b), which suggest limited exchange and important life-history differences between the two populations (deep northern vs. shallow southern/central North Sea, see Figure 1). Thus, these data suggest a decoupling of population dynamics in the two different regions within the North Sea. Still, further work is needed to establish the relationship between the northern North Sea population and populations in nearby regions, and to estimate seasonal dynamics and the proportion of different populations targeted in mixed fisheries. Temporal patterns over longer timescales (50-100 years) could be used to examine past changes in genetic composition, thereby facilitating predictions of future population response to fishing and environmental change.

Available information indicates that the majority of spawning takes place from the beginning of January through to April offshore in waters of salinity 34-35% (Brander 1994, Riley and Parnell 1984). Around the British Isles there is a tendency towards later timing with increasing latitude (ICES 2005). Cod spawn throughout much of the North Sea but spawning adult and egg survey data and fishermen's observations indicate a number of spawning aggregations. Results from the first ichthyoplankton survey to cover the whole of the North Sea, conducted in 2004 to map spawning grounds of North Sea cod, are reported in Fox *et al*. (2008). This study compared the results from the plankton survey with estimates of egg production inferred from the distribution of mature cod in contemporaneous trawl surveys. The comparison found general agreement of hot spots of egg production around the southern and eastern edge of the Dogger Bank, in the German Bights, the Moray Firth and to the east of the Shetlands, which mapped broadly into known spawning areas from the period 1940-1970, but was unable to detect any significant spawning activity off Flamborough (a historic spawning ground off the northeast coast of England). The study showed that most of the major cod spawning grounds in the North Sea are still active, but that the depletion of some localised populations may have made the detection of spawning activity in the corresponding areas difficult (Fox *et al*. 2008).

At the North Sea scale, there has been a northerly shift in the mean latitudinal distribution of the stock (Hedger *et al*. 2004, Perry *et al*. 2005). However the evidence for this being a migratory response is slight or non-existent. More likely, cod in the North Sea are composed of a complex of more or less isolated sub-stocks (as indicated above) and the southern units have been subjected to disproportionately high rates of fishing mortality (STECF-SGRST-07-01). Blanchard *et al*. (2005) demonstrated that the contraction in range of juvenile North Sea cod could be linked to reduced abundance as well as increased temperature, and further noted that the combined negative effects of increased temperature on recruitment rates and the reduced availability of optimal habitat may have increased the vulnerability of the cod population to fishing mortality.

Rindorf and Lewy (2006) linked the northward shift in distribution to the effect of a series of warm, windy winters on larvae and the resultant distribution of recently settled cod, followed by a northwards shift in the distribution of older age groups (because of the tendency for northerly distributed juveniles to remain northerly throughout their life). They noted further that this effect is intensified by the low abundance of older age cod due to heavy fishing pressure. In contrast, Neat and Righton (2007) analysed the temperature experienced by 129 individual adult cod throughout the North Sea, and found that the majority experienced a warmer fraction of the sea than was potentially available to them (even though they had the capacity to find

cooler water), with individuals in the south in summer experiencing temperatures considered superoptimal for growth. This suggests that the thermal regime of the North Sea is not yet causing adult cod to move to cooler waters. Despite the drastic decline in stock abundance over the period 1983-2006, and the movement of the centre of gravity of the distribution towards the northeast, Lewy and Kristensen (2009) found that the spatial correlation and dispersion of IBTS Q1 survey catches remained unchanged throughout this 24-year period, with the concentration of the stock remaining constant or declining. They therefore concluded that cod does not follow the theory of density-dependent habitat selection, because stock concentration does not increase with decreasing stock abundance.

Several tagging studies have been conducted on cod in the North Sea since the mid 1950s in order to investigate the migratory movements and geographical range of cod populations (Bedford 1966, ICES-NSRWG 1971, Daan 1978, Righton *et al*. 2007). These studies support the existence of regional populations of cod that separate during the spawning season and, in some cases, intermix during the feeding season (Metcalfe 2006). Righton *et al*. (2007) re-analysed some of the historical datasets of conventional tags and used recent data from electronic tags to investigate movement and distribution of cod in the southern North Sea and English Channel. Their re-analysis of conventional tags showed that, although most cod remained within their release areas, a larger proportion of cod were recaptured outside their release area in the feeding season than the spawning season, and a larger proportion of adults were recaptured outside their release area than juveniles, with the displacement (release to recapture) occurring mostly to the southern North Sea for fish released in the English Channel, and to areas further north for fish released in the southern North Sea (see Table 5 in Righton *et al*. 2007). This suggests a limited net influx of cod from the English Channel to the southern North Sea, but no significant movement in the other direction (Metcalfe 2006).

The lack of obvious physical barriers to mixing between different sub-populations in the North Sea suggests that behavioural and/or environmental factors are responsible for maintaining the relative discreteness of these populations (Metcalfe 2006). For example, Righton *et al*. (2007) conclude that behavioural differences between cod in the southern North Sea and English Channels (such as tidal stream transport being used by fish tagged and released in the southern North Sea to migrate, but rarely being used by those tagged and released in the English Channel) may limit mixing of cod from these two areas during feeding and spawning seasons. Robichaud and Rose (2004) describe four behavioural categories for cod populations: "sedentary residents" exhibiting year-round site fidelity, "accurate homers" that return to spawn in specific locations, "inaccurate homers" that return to spawn in a broader area around the original site, and "dispersers" that move and spawn in a haphazard fashion within a large geographical area. These categories are not necessarily mutually exclusive and behaviours in different regions may be best described by differing degrees of each category (Heath *et al*. 2008).

Evidence from electronic tags suggest that cod populations have a strong tendency for site attachment (even in migratory individuals), rapid and long-distance migrations, the use of deeper channels as migratory "highways" and, in some cases, clearly defined feeding and spawning "hot spots" (Righton *et al*. 2008). Andrews *et al*. (2006) used a spatially and physiologically explicit model describing the demography and distribution of cod on the European shelf in order to explore a variety of hypotheses about the

movements of settled cod. They fitted the model to spatial data derived from International Bottom Trawl Surveys, and found that structural variants of the model that did not recognise an active seasonal migration by adults to a set of spatially stable spawning sites, followed by a dispersal phase, could not explain both the abundance and distribution of the spawning stock. Heath *et al*. (2008) investigated different hypotheses about natal fidelity, and their consequence for regional dynamics and population structuring, by developing a model representing multiple demes, with the spawning locations of fish in each deme governed by a variety of rules concerning oceanographic dispersal, migration behaviour and straying. They used an age-based discrete time methodology, with a spatial representation of physical oceanographic patterns, fish behaviour patterns, recruitment, growth and mortality (both natural and fishing). They found that although active homing is not necessary to explain some of the sub-population structures of cod (with separation possible through distance and oceanographic processes affecting the dispersal of eggs and larvae, such is in the Southern Bight), it may well be necessary to explain the structure of other sub-populations.

A Working Document about North Sea cod movements and population structure was provided to the North Sea cod inter-benchmark meeting by Wright, Neat and Righton (WD7 in ICES-WKCOD, 2011). The main findings are as follows:

1) The hypothesis that fish may be "lost" northwards out of the range of the survey appears inconsistent with recent and historical information on cod movements since age 2+ from the southern North Sea are only likely to migrate as far as the central North Sea.

2) Direct observations on cod in relation to sea temperature do not suggest they actively avoid the warm southern North Sea in summer.

3) As a proportion of cod from the eastern channel may migrate into the North Sea, abundance near the southern edge of the IBTS Q3 survey may have been important to recent trends in IBTS Q3.

4) Two subpopulations of cod have been indicated from genetic studies and there do appear to be long-term differences in recruitment trends. The presence of two subpopulations largely inhabiting different regions of the North Sea will mean that there is the potential for regional differences in mortality, because cod from the deep-water subpopulation would not be expected to re-colonize areas depleted in the southern North Sea.

A.2. Fishery

Cod are caught by virtually all the demersal gears in Sub-area IV and Divisions IIIa (Skagerrak) and VIId, including beam trawls, otter trawls, seine nets, gill nets and lines. Most of these gears take a mixture of species. In some of them cod are considered to be a by-catch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, some of the fixed gear fisheries).

An analysis of landings and estimated discards of cod by gear category (excluding Norwegian data) highlighted the following fleets as the most important in terms of cod for 2003-5 (accounting for close to 88% of the EU landings), listed with the main use of each gear (STECF SGRST-07-01):

- Otter trawl, ≥ 120mm, a directed roundfish fishery by UK, Danish and German vessels.

- Otter trawl, 70-89mm, comprising a 70-79mm French whiting trawl fishery centered in the Eastern Channel, but extending into the North Sea, and an 80-89mm UK *Nephrops* fishery (with smaller landings of roundfish and anglerfish) occurring entirely in the North Sea.
- Otter trawl, 90-99mm, a Danish and Swedish mixed demersal fishery centered in the Skagerrak, but extending into the Eastern North Sea.
- Beam trawl, 80-89mm, a directed Dutch and Belgian flatfish fishery.
- Gillnets, 110-219mm, a targeted cod and plaice fishery.

For Norway in 2007, trawls (mainly bycatch in the saithe fishery) and gillnets account for around 60% (by weight) of cod catches, with the remainder taken by other gears mainly in the fjords and on the coast, whereas in the Skagerrak, trawls and gillnets account for up to 90% of cod catches.

With regard to trends in effort for these major cod fisheries since 2000, the largest changes to have happened in North Sea fisheries have involved an overall reduction in trawl effort and changes in the mesh sizes in use, due to a combination of decommissioning and days-at-sea regulations. In particular 100-119mm meshes have now virtually disappeared, and instead vessels are using either 120mm+ (in the directed whitefish fishery) or 80-99mm (primarily in the *Nephrops* fisheries and in a variety of mixed fisheries). The use of other mesh sizes largely occurs in the adjacent areas, with the 70-79mm gear being used in the Eastern Channel/Southern North Sea Whiting fishery, and the majority of the landings by 90-99mm trawlers coming from the Skagerrak. Higher discards are associated with these smaller mesh trawl fisheries, but even when these are taken into account, the directed roundfish fishery (trawls with ≥ 120mm mesh) still has the largest impact of any single fleet on the cod stock, followed by the mixed demersal fishery (90-99mm trawls) in the Skagerrak.

Technical Conservation Measures

The present technical regulations for EU waters came into force on 1 January 2000 (EC 850/98 and its amendments). The regulations prescribe the minimum target species' composition for different mesh size ranges. Additional measures were introduced in Community waters from 1 January 2002 (EC 2056/2001).

In 2001, the European Commission implemented an emergency closure of a large area of the North Sea from 14 February to 30 April (EC 259/2001). An EU-Norway expert group in 2003 concluded that the emergency closure had an insignificant effect upon the spawning potential for cod in 2001. There were several reasons for the lack of impact. The redistribution of the fishery, especially along the edges of the box, coupled to the increases in proportional landings from January and February appear to have been able to negate the potential benefits of the box. The conclusion from this study was that the box would have to be extended in both space and time to be more effective. This emergency measure has not been adopted after 2001. A cod protection area was implemented in 2004 (EC 2287/2003 and its amendments), which defined conditions under which certain stocks, including haddock, could be caught in Community waters, but this was only in force in 2004. A recent study on the use of MPAs to address regional-scale ecological objectives in the North Sea (Greenstreet *et al*. 2009) concluded that MPAs on their own are unlikely to achieve significant regional-scale ecosystem benefits, because local gains are largely negated by fishing effort displacement into the remainder of the North Sea.

Apart from the technical measures set by the Commission, additional unilateral measures are in force in the UK, Denmark and Belgium. The EU minimum landing size (mls) is 35cm, but Belgium operate a 40cm mls, while Denmark operate a 35cm mls in the North Sea and 30cm in the Skagerrak. Additional measures in the UK relate to the use of square mesh panels and multiple rigs, restrictions on twine size in both whitefish and *Nephrops* gears, limits on extension length for whitefish gear, and a ban on lifting bags. In 2001, vessels fishing in the Norwegian sector of the North Sea had to comply with Norwegian regulations setting the minimum mesh size at 120mm. Since 2003, the basic minimum mesh size for towed gears targeting cod is 120mm.

Effort regulations in days at sea per vessel and gear category are summarised in the following table, which only shows changes in 2008 compared to 2007 (2006 is included for comparison). The changes (2007-2008) were intended to generate a cut in effort of 10% for the main gears catching cod.

Maximum number of days a vessel can be present in the North Sea, Skagerrak and Eastern Channel, by gear category and special condition (see EC 40/2008 for more details). The table only shows changes in 2008 compared to 2007, but 2006 is also included for comparison.

Description of gear and special condition (if applicable)	Area			Max days at sea		
	IV,II	Skag	VIId	2006	2007	2008**
Trawls or Danish seines with mesh size ≥ 120mm	x	x	x	103	96	86
Trawls or Danish seines with mesh size ≥ 100mm and < 120mm	x	x	x	103	95	86
Trawls or Danish seines with mesh size ≥ 90mm and < 100mm	x		x	227	209	188
Trawls or Danish seines with mesh size ≥ 90mm and < 100mm		x		103	95	86
Trawls or Danish seines with mesh size ≥ 70mm and < 90mm	x			227	204	184
Trawls or Danish seines with mesh size ≥ 70mm and < 90mm			x	227	221	199
Beam trawls with mesh size ≥ 120mm	x	x		143	143	129
Beam trawls with mesh size ≥ 100mm and < 120mm	x	x		143	143	129
Beam trawls with mesh size ≥ 80mm and < 90mm	x	x		143	132	119
Gillnets and entangling nets with mesh sizes ≥ 150mm and < 220mm	x	x	x	140	130	117
Gillnets and entangling nets with mesh sizes ≥ 110mm and < 150mm	x	x	x	140	140	126
Trammel nets with mesh size < 110mm. The vessel shall be absent from port no more than 24h.	x		x	205	205	185*

*** For member states whose quotas less than 5% of the Community share of the TACs of both plaice and sole, the number of days at sea shall be 205**

**** If member states opt for an overall kilowatt-days regime, then the maximum number of days at sea per vessel could be different to that set out for 2008 (see text below and EC 40/2008 for details).**

Additional provisions were introduced for 2008 (points 8.5-7, Annex IIa, EC 40/2008) to provide Member States greater flexibility in managing their fleets, in order to encourage a more efficient use of fishing opportunities and stimulate fishing practices that lead to reduced discards and lower fishing mortality of both juvenile and adult fish. This measure allowed a Member State that fulfilled the requirements laid out in

EC 40/2008 to manage a fleet (i.e. group of vessels with a specific combination of geographical area, grouping of fishing gear and special condition) to an overall kilowatt-days limit for that fleet, instead of managing each individual vessel in the fleet to its own days-at-sea limit. The overall kilowatt-days limit for a fleet is initially calculated as the sum of all individual fishing efforts for vessels in that fleet, where an individual fishing effort is the product of the number of days-at-sea and engine power for the vessel concerned. This provision allowed Member States to draw up fishing plans in collaboration with the Fishing Industry, which could, for example, specify a target to reduce cod discards to below 10% of the cod catch, allow real-time closures for juveniles and spawners, implement cod avoidance measures, trial new selective devices, etc.

Incentives of up to 12 additional days at sea per vessel were in place for 2008 to encourage vessels to sign up to a Discard Reduction Plan (points 12.9-10, Annex IIa, EC 40/2008). The plan focused on discarding of cod or other species with discard problems for which a management/recovery plan is adopted, and was to include measures to avoid juvenile and spawning fish, to trial and implement technical measures for improving selectivity, to increase observer coverage, and to provide data for monitoring outcomes. For vessels participating in a Cod Avoidance Reference Fleet Programme in 2008 (points 12.11-14, Annex IIa, EC 40/2008), a further 10-12 additional days at sea was possible (over and above that for the Discard Reduction Plan). Vessels participating in this program were to meet a specific target to reduce cod discards to below 10% of cod catches, and be subject to observer coverage of at least 10%.

Under the provisions laid down in point 8.5 of Annex IIa (EC 40/2008), Scotland implemented a national kilowatt-days scheme known as the 'Conservation Credits Scheme'. The principle of this two-part scheme involved credits (in terms of additional time at sea) in return for the adoption of and adherence to measures that reduce mortality on cod and lead to a reduction in discard numbers. The initial, basic scheme was implemented from the beginning of February 2008 and essentially granted vessels their 2007 allocation of days (operated as hours at sea) in return for: observance of Real Time Closures (RTC), observance of a one net rule, adoption of more selective gears (110mm square meshed panels in 80mm gears or 90mm square meshed panels in 95mm gear), agreeing to participate in additional gear trials, and participation in an enhanced observer scheme.

For the first part of 2008, the RTC system was designed to protect aggregations of larger, spawning cod (>50cm length). Commercial catch rates of cod observed on board vessels was used to inform trigger levels leading to closures. Ten closures occurred to the beginning of May and protection agency monitoring suggested good observance. The scheme was extended for the remainder of the year to protect aggregations of all sizes of cod. A joint industry/ science partnership (SISP) had a number of gear trials programmed for 2008 examining methods to improve selectivity and reduce discards, and an enhanced observer scheme was announced by the Scottish Government.

Observance of the above conditions also gave eligibility for vessels to participate in the second, enhanced, part of the Conservation Credits scheme.

Changes in fleet dynamics

The introduction of the one-net rule as part of the Scottish Conservation Credit Scheme and new Scottish legislation implemented in January 2008 were both likely to improve the accuracy of reporting of Scottish landings to the correct mesh size range, although

some sectors of the Scottish industry have been granted derogations to continue carrying two nets (seiners until the end of January 2009, and others until the end of April 2008). The concerted effort to reduce cod mortality, through implementation of the Conservation Credit Scheme from February 2008, could have lead to greater effort being exerted on haddock, whiting, monk, flatfish and *Nephrops*.

Shifts in the UK fleet in 2007/8 included: (a) a move of Scottish vessels using 100-110mm for whitefish on west coast ground (sub-area VI) to the North Sea using 80mm prawn codends (motivated by fuel costs, and could increase effort on North Sea stocks; the simultaneous requirement to use 110 square mesh panels may mitigate unwanted selectivity implications – see below); (b) a move away from the Farne Deeps *Nephrops* fishery into other fisheries for whitefish because of poor *Nephrops* catch rates (implying increased effort in whitefish fisheries); and (c) a move of Scottish vessels from twin trawls to single rig, and increased use of pair trawls, seines and double bag trawls (motivated by fuel costs). For 2008 in the Scottish fleet, all twin-rig gear in the 80-99mm category have to use a 110mm square mesh panel, but this also applied to single-rig gears from July 2008 onwards, which was likely to have improved whitefish selection. A large number of 110mm square mesh panels have been bought by Scottish fishers at the beginning of 2008 in order to qualify for the Conservation Credit Scheme, which dramatically improved the uptake of selective gear. The ban on the use of multi-rigs in Scotland, implemented in January 2008, may have limited the potential for an uncontrolled increase in effective effort.

The Dutch fleet was reduced, through decommissioning, by 23 vessels from the beginning of 2008, while 5 Belgian beam trawlers (approximately 5% of the Belgian fleet) left the fishery in 2007, both changes implying reductions in effort in the beam trawl sector. The introduction of an ITQ regulation system in Denmark in 2007 might have influenced the effort distribution over the year, but this should not have affected the total Danish effort deployed or the size distribution of catches.

Dutch beam trawlers have gradually shifted to other techniques such as twin trawling, outrigging and fly-shooting, as well as opting for smaller, multi-purpose vessels, implying a shift in effort away from flatfish to other sectors. These changes were likely caused by TAC limitations on plaice and sole, and rising fuel costs. Belgian and UK vessels have also experimented with outrigger trawls as an alternative to beam trawling, motivated by more fuel efficient and environmentally friendly fishing methods.

The increased effort costs in the Kattegat (2.5 days at sea per effort day deployed) in 2008 has led to a shift in effort by Swedish vessels to the Skagerrak and Baltic Sea. There has also been an increase in the number of Swedish *Nephrops* vessels in recent years, attributed to the input of new capital transferred from pelagic fleets following the introduction of an ITQ-system for pelagic species, and leading to further increases in effort. The Swedish trawler fleet operating in IIIa has had a steady increase in the uptake of the *Nephrops* grid since the introduction of legislation in 2004 (use of the grid is mandatory in coastal waters), and given the strong incentives to use the grid (unlimited days at sea). Uptake of the *Nephrops* grid should have resulted in improved selection.

A squid fishery in the Moray Firth has continued to develop using very unselective 40mm mesh when squid species are available on the grounds. Although the uptake was poor in 2007 due to the lack of squid, the potential for high bycatches of young gadoids in future, including those of cod and haddock, remains. This fishery may provide an alternative outlet for the Scottish *Nephrops* fleet seasonally, and hence reduce effort in the *Nephrops* sector.

A.3. Ecosystem aspects

Cod are predated upon by a variety of species through their life history. The Working Group on Multi-species Assessment Methods (ICES-WGSAM 2008) estimated predation mortalities using SMS (Stochastic Multi Species Model) with diet information largely derived from the Years of the Stomach databases (stomachs sampled in the years 1981-1991). Long-term trends have been observed in several partial predation mortalities with significant increases for grey gurnard preying on 0-group cod. In contrast, predation mortalities on age 1 and age 2 cod decreased over the last 30 years due to lower cannibalism. Predation on older cod (age 3-6) increased due to increasing numbers of grey seals in the North Sea.

SMS identified grey gurnard as a significant predator of 0-group cod. The abundance of grey gurnard (as monitored by IBTS) is estimated to have increased in recent years resulting in a rise in estimated predation mortality from 1.08 to 1.76 between 1991 and 2003. A degree of caution is required with these estimates as they assume that the spatial overlap and stomach contents of the species has remained unchanged since 1991. Given the change in abundance of both species this assumption is unlikely to hold and new diet information is required before 0-group predation mortalities can be relied upon.

Several other predators contribute to predation mortality upon 0-group cod, whiting and seabirds being the next largest components. Speirs *et al*. (2010) developed a length-structured partial ecosystem model for cod and nine of its most important fish predators and prey in the North Sea, utilising time series of stock biomass, recruitment and landings, as well as survey data on length distributions and diet data. Their results suggest that herring predation on early life history stages of cod is dynamically important, and that high abundances of herring may lead to the decline of cod stocks, even during periods of declining fishing pressure. Furthermore, they show that the MSY of cod is strongly dependent on herring abundance, and that current levels of cod exploitation may become unsustainable if herring recruitment returns to historic high levels.

The consumption of cod in the North Sea in 2002 by grey seals (*Halichoerus grypus*) has recently been estimated (Hammond and Grellier 2006). For the North Sea it was estimated that in 1985 grey seals consumed 4150 tonnes of cod (95% confidence intervals: 2484-5760 tonnes), and in 2002 the population tripled in size (21-68 000) and consumed 8344 tonnes (95% confidence intervals: 5028-14941 tonnes). These consumption estimates were compared to the Total Stock Biomass (TSB) for cod of 475 000 tonnes and 225 000 tonnes for 1985 and 2002 respectively. The mean length of cod in the seal diet was estimated as 37.1 cm and 35.4 cm in 1985 and 2002 respectively. It should be noted, however, that seal diet analysis must be treated with a degree of caution because of the uncertainties related to modelling complex processes (e.g. using scat analysis to estimate diet composition involves complex parameters, and can overestimate species with more robust hard parts), and the uncertainties related to estimating seal population size from pup production estimates (involving assumptions about the form of density-dependent dynamics). The analysis may also be subject to bias because scat data from haul-out sites may reflect the composition of prey close to the sites rather than further offshore.

The effect of seal predation on cod mortality rates has been estimated for the North Sea within a multi-species assessment model (MSVPA), which was last run in 2007 during

the EU project BECAUSE (contract number SSP8-CT-2003-502482) using revised estimates of seal consumption rates . The grey seal population size was obtained from WGMME (ICES-WGMME 2005) and was assumed to be 68,000 in 2002 and 2003 respectively. Estimates of cod consumption were 9657 tonnes in 2002 and 5124 tonnes in 2003, which is similar to the values estimated by Hammond and Grellier (2006). Sensitivity analysis of the North Sea cod stock assessment estimates to the inclusion of the revised multi-species mortality rates were carried out at the 2009 meeting of the WKROUND. Inclusion of the multi-species mortality rates for older ages of cod had a relatively minor effect on the high levels of estimated fishing mortality rates and low levels of spawning stock biomass abundance. This suggests that the estimates of seal predation will not alter the current perception of North Sea cod stock dynamics (also stated by STECF-SGRST-07-01).

The overlap between predator and prey is a key parameter in multispecies assessment models and is notoriously difficult to parameterise. Kempf *et al*. (2010) attempt this by using overlap indices derived from trawl surveys in a North Sea SMS model in order to investigate the recovery potential of North Sea cod. They found that the spatial-temporal overlap between cod and its predators increased with increasing temperature, indicating that foodweb processes might reduce the recovery potential of cod during warm periods. Furthermore, they found that multispecies scenarios predicted a considerably lower recovery potential than single-species ones.

A recent meeting (2007) of the STECF reviewed the broad scale environmental changes in the north-eastern Atlantic that has influenced all areas under the cod recovery plan (STECF-SGRST-07-01), and concluded that:

- Warming has occurred in all areas of the NW European shelf seas, and is predicted to continue.
- A regime shift in the North Sea ecosystem occurred in the mid-1980s.
- These ecological changes have, in addition to the decline in spawning stock size, negatively affected cod recruitment in all areas.
- Biological parameters and reference points are dependent on the time-period over which they are estimated. For example, for North Sea cod FMSY, MSY and BMSY are lower when calculated for the recent warm period (after 1988) compared to values derived for the earlier cooler period.
- The decline in FMSY, MSY and BMSY can be expected to continue due to the predicted warming, and possible future change should be accounted for in stock assessment and management regimes.
- Modelling shows that under a changing climate, reference points based on fishing mortality are more robust to uncertainty than those based on biomass.
- Despite poor recruitment, modelling suggests that cod recovery is possible, but ecological change may affect the rate of recovery, and the magnitude of achievable stock sizes.
- Recovery of cod populations may have implications to their prey species, including *Nephrops*.

With the exception of the general effects noted above, the overall conclusion from the STECF meeting (STECF-SGRST-07-01) for the North Sea was that there is no specific significant environmental or ecosystem change in the Skagerrak, North Sea and eastern Channel (e.g. the effects of gravel extraction, etc.) affecting potential cod recovery. The

conclusions from the STECF meeting merit further discussion within ICES, which is ongoing (e.g. ICES-WKREF 2007).

B. Data

B.1. Commercial catch

The WG estimate for landings from the three areas (IV, IIIa-Skagerrak and VIId) in 2006 and 2007 were based on annual data, as opposed to quarterly data prior to 2006, because of ongoing difficulties with international data aggregation procedures, particularly with regard to discard raising.

France, Belgium and Sweden, who respectively landed 9%, 5% and 2% of all cod for combined area IV and VIId, do not provide discard estimates for this combined area. Similarly, Belgium and Germany, who each land 2% of all cod in area IIIa, do not provide discard estimates for this area. Norwegian discarding is illegal, so although this nation landed 14% and 6% of all cod in combined area IV and VIId, and area IIIa respectively, it does not provide discard estimates. Although the Netherlands (7% of all cod landed in IV and VIId, 1% in IIIa) does provide discard data for area IV, these are based on very low sample sizes for cod, and are therefore not reliable enough to be raised to fleet level. All percentages quoted in this paragraph refer to landings in 2007.

Discard numbers-at-age were estimated for areas IV and VIId by applying the Scottish discard ogives to the international landings-at-age for years prior to 2006. For 2006, Denmark was excluded from this calculation as they provided their own discard estimates. For 2007, Scottish, Danish, German and England & Wales discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in sub-area IV to account for missing discards. Discard numbers-at-age for IIIa-Skagerrak were based on observer sampling estimates. For 2006 and 2007, Danish and Swedish discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in Division IIIa-Skagerrak to account for missing discards. Although in some cases other nations' discard proportions were available for a range of years, these have not been transmitted to the relevant WG data coordinator in an appropriate form for inclusion in the international dataset.

For cod in IV, IIIa-Skagerrak and VIId, ICES first raised concerns about the mis-reporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid-1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year-class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3000t of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment.

For 1999 and 2000, the WG has no *a priori* reason to believe that there was significant under-reporting of landings. However, the substantial reduction in fishing effort implied by the 2001, 2002 and 2003 TACs is likely to have resulted in an increase in unreported catch in those years. Anecdotal information from the fisheries in some countries indicated that this may indeed have been the case, but the extent of the alleged under-reporting of catch varies considerably. Since the WG has no basis to judge the overall

extent of under-reported catch, it has no alternative than to use its best estimates of landings, which in general are in line with the officially reported landings. An attempt is made to incorporate a statistical correction to the sum of reported landings and discards data in the assessment of this stock. Buyers and Sellers legislation introduced in the UK towards the end of 2005 is expected to have improved the accuracy of reported cod landings for the UK. This has brought the UK in line with existing EU legislation.

Age compositions

Age compositions are currently provided by Denmark, England, Germany, the Netherlands, Scotland and Sweden.

Landings in numbers at age for age groups 1-11+ and 1963-present form the basis for the catch at age analysis but do not include industrial fishery by-catches landed for reduction purposes. By-catch estimates are available for the total Danish and Norwegian small-meshed fishery in Sub-area IV and separately for the Skagerrak.

During the five years 2003-2007, an average of 82% (84% in 2007) of the international landings in number were accounted for by juvenile cod aged 1-3. In 2007, age 1 cod comprised 32% of the total catch by number, and age 2 (the 2005 year class), 55%.

Estimated total numbers discarded have varied between 35 and 55% of the total catch numbers since 1995, but have shown an increase to above 70% in 2006 and 2007, due to the stronger 2005 year class entering the fishery (estimated to be almost the size of the 1999 year class), and a mismatch between the TAC and effort. Historically, the proportion of numbers discarded at age 1 have fluctuated around 80% with no decline apparent after the introduction of the 120mm mesh in 2002. For 2004-2007, it is estimated to be at around 90%. At ages 2 and 3 discard proportions have been increasing steadily and are currently estimated to be 75% and 38% respectively in 2007. Note that these observations refer to numbers discarded, not weight.

Data exploration

Data exploration for commercial catch data for North Sea cod currently involves:

(a) expressing the total catch-at-age matrix as proportions-at-age, normalised over time, so that year classes making above-average contributions to the catches are shown as large positive residuals (and vice-versa for below-average contributions);

(b) applying a separable VPA model in order to examine the structure of the catch numbers-at-age before they are used in catch-at-age analyses, in particular whether there are large and irregular residuals patterns that would lead to concerns about the way the recorded catch has been processed;

(c) performing log-catch-curve analyses to examine data consistency, fishery selectivity and mortality trends over time – the negative slope of a regression fitted to ages down a cohort (e.g. ages 2-4) can be used as a proxy for total mortality.

B.2. Biological Information

Weight at age

Mean catch weight-at-age is a catch-number weighted average of individual catch weight-at-age, available by country, area and type (i.e. landings and discards). For ages 1-9 there have been short-term trends in mean weight at age throughout the time series

with a decline over the recent decade at ages 3-5 that recently seems to have been reversed. The data also indicate a slight downward trend in mean weight for ages 3-6 during the 1980s and 1990s. Ages 1 and 2 show little absolute variation over the long-term.

Using weight-at-age from annual ICES assessments and International Bottom Trawl Surveys, Cook *et al*. (1999) developed a model that explained weight-at-age in terms of a von Bertalanffy growth curve and a year-class effect. They found that the year-class effect was correlated with total and spawning stock biomass, indicating density-dependent growth, possibly through competition. Further evidence for density-dependent growth had previously been found by others (Houghton and Flatman 1981, Macer 1983 and Alphen and Heessen 1984), although they pointed to different mechanisms (Rijnsdorp *et al*. 1991, ICES 2005). Results from Macer (1983) imply that juvenile cod compete strongly with adults, while the data from Alphen and Heessen (1984) suggest strong within-year-class competition during the first three years of life.

Growth rate can be linked to temperature and prey availability (Hughes and Grand 2000, Blanchard *et al*. 2005). Growth parameters of North Sea cod given in ICES (1994) demonstrate that cod in the southern North Sea grow faster than those in the north, but reach a smaller maximum length (Oosthuizen and Daan 1974, ICES 2005). Furthermore, older and larger cod have lower optimal temperatures for growth (Björnsson and Steinarsson 2002), and distributions of cod are known to depend on the local depth and temperature (Ottersen *et al*. 1998, Swain 1999, Blanchard *et al*. 2005)

Differences in mean length by age and sex can also be found for mature vs. immature cod (ICES 2005). For example, Hislop (1984) found that within an age group, mature cod of each sex are, on average, larger than immature cod.

Maturity and natural mortality

In the historic assessments natural mortality for cod is assumed to be constant in time. However, calculations with the SMS key run (Stochastic Multi Species Model; Lewy and Vinther, 2004), carried out by the Working Group on Multi Species Assessment Methods (ICES WGSAM 2008), indicate that predation mortalities (M2) declined substantially over the last 30 years for age 1 and age 2 cod. In addition, calculations with the latest 4M key run (Vinther et al., 2002), carried out during the EU project BECAUSE (contract number SSP8 CT 2003 502482) in 2007, indicate a systematic increasing trend for older ages (3–6) of cod due to seal predation. A review of the WGSAM estimates was carried out at the 2009 WKROUND benchmark assessment of the North Sea cod (ICES-WKROUND 2009), and the variable time series of M, which include the major sources of predation on North Sea cod, was considered appropriate for use in future assessments. The natural mortality values shown in Table 1 are model estimates from multi-species models (SMS and 4M) fitted by the Working Group on Multi Species Assessment Methods (ICES-WGSAM 2008).

The maturity values are applied to all years and are left unchanged from year to year. They were estimated using the International Bottom trawl Survey series for 1981-1985. These values were derived for the North Sea.

Age group	Proportion mature
1	0.01
2	0.05
3	0.23

4	0.62
5	0.86
6	1.0
7+	1.0

Relative fecundity appears to have changed over time, with values in the late 1980s being approximately 20% higher than those in the early 1970s, an increase that coincided with a 4-fold decline in spawning stock biomass (Rijnsdorp *et al*. 1991, ICES 2005).

In an analysis of International Bottom Trawl Survey maturity data, Cook *et al*. (1999) found that proportion of fish mature at age is a function of both weight and age. They used a descriptive model based on both age and weight to reconstruct the historical series of maturity ogives where no observations existed, and calculated new spawning stock sizes that could be compared to those estimated by the conventional assessment. They found that, although accounting for changes in growth and maturity for North Sea cod altered the scale of SSB values, it did not make substantial changes to trajectories over time, and did not substantially alter the estimates of sustainable exploitation rates for the stock.

ICES-WKROUND (2009) also examined systematic changes in age at maturation which has increased in a number of cod stocks. In recent years, North Sea cod has shown changes in maturity with fish maturing at a younger age and smaller size. The variable maturity data leads to a substantial deterioration in model fit, and therefore does not help explain the relationship between SSB and recruitment. ICES-WKROUND (2009) concluded that until further investigations are carried on issues linked to earlier maturity, for example relating the quality of reproductive output of young first time spawners to recruitment success, the constant maturity ogive should be used for future assessments.

Recruitment

Recruitment has been linked not only to SSB, but also to temperature (Dickson and Brander 1993, Myers *et al*. 1995, Planque and Fredou 1999, O'Brien *et al*. 2000) plankton production timing and mean prey size (Beaugrand *et al*. 2003), and the NAO (Brander and Mohn 2004, ICES 2005).

B.3. Surveys

Four survey series are available for this assessment:

- English third-quarter groundfish survey (EngGFS), ages 0-7, which covers the whole of the North Sea in August-September each year to about 200m depth using a fixed station design of 75 standard tows. The survey was conducted using the Granton trawl from 1977-1991 and with the GOV trawl from 1992-present. Only ages 1–6 should be used for calibration, as catch rates for older ages are very low.
- Scottish third-quarter groundfish survey (ScoGFS): ages 1–8. This survey covers the period 1982–present. This survey is undertaken during August each year using a fixed station design and the GOV trawl. Coverage was restricted to the northern part of the North Sea until 1998, corresponding to only the northern-most distribution of cod in the North Sea. Since 1999, it has been extended into the central North Sea and made use of a new vessel and gear. Only ages 1–6 should be used for calibration, as catch rates for older ages are very low.

- Quarter 1 international bottom-trawl survey (IBTSQ1): ages 1–6+, covering the period 1976–present (usually data are available up to the year of the assessment for this survey, whereas it is only available up to the year prior to the assessment year for the other surveys). This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl.
- Quarter 3 international bottom-trawl survey (IBTSQ3): ages 0–6+, covering the period 1991–present. This multi-vessel survey covers the whole of the North Sea using fixed stations of at least two tows per rectangle with the GOV trawl. The Scottish and English third quarter surveys described above contribute to this index.

The recent dominant effect of the size and distribution of the 1996 and, to a lesser extent, the 1999 and 2005 year-classes are clearly apparent from maps of the IBTS distribution of cod (ages 1-3+). However, fish of older ages have continued to decline due to the very weak 2000, 2002 and 2004 year-classes. The abundance of 3+ fish is at a low level in recent years.

An analysis of the third quarter Scottish and English survey data by Parker-Humphries and Darby (WD 24 in ICES-WGNSSK 2006) showed that the extremely high catch rates estimated for ages 2-4 in a single station in the third quarter Scottish survey in 2004 resulted in the estimation of a strong reduction in mortality in 2004 followed by high mortality in 2005. When the station with high catch rates was removed, total mortality was then consistent with values obtained in previous years. The WG agreed that it would be *ad hoc* and statistically inappropriate to remove the station from the calculation of the Scottish index. After reviewing the information available on survey catch rates and spatial distribution, the WG decided to discontinue the use of the English and Scottish surveys on their own in the cod assessment because of the current low catch rates recorded by these surveys and the potential for noise at the oldest ages due to low sampling levels. Instead, the WG decided to use the IBTSQ3 survey, which incorporates both the Scottish and English surveys, together with the IBTSQ1 survey.

An analysis of IBTSQ1 data by Rindorf and Vinther (WD 4 in ICES-WGNSSK 2007) illustrated the increased importance of recruitment from the Skagerrak. Up until 2008 (ICES-WGNSSK 2008) the survey indices from IBTSQ1 and Q3 used in the stock assessment only include catch rates from the three most easterly rectangles of Skagerrak. More of the Skagerrak area should be considered for inclusion in the IBTS standard areas for abundance indices, in order to produce an unbiased abundance index for the management unit (IV, IIIa-Skagerrak and VIId) of cod. Furthermore, the Skagerrak is almost entirely covered by a single vessel in both the IBTSQ1 and Q3 surveys. This is not advantageous as it does not allow for a comparison of cod catchability between vessels, which is essential for comparison of catch rates between roundfish areas. In the North Sea, each rectangle is covered by at least 2 nations to reduce bias in indices.

WKROUND (2009) compared the standard and extended IBTS index for ages 1-5 for IBTSQ1 and 1-4 for IBTSQ3 with an extended are index. The largest changes in abundance were observed at the younger ages, particularly for age 0 in IBTSQ3 (not used in the assessment). Residual plots indicated a slight improvement in fit for the extended indices run compared to the standard indices run. Given the improved fit for the extended indices and other benefits of using these indices (such as better coverage of the stock distribution area) the group recommended that it would be beneficial for North Sea cod to use the extended indices in future assessments.

Data exploration

Data exploration for survey data for North Sea cod currently involves:

a) expressing the survey abundance indices (IBTSQ1 and IBTSQ3) in log-mean standardised form, both by year and cohort, to investigate whether there are any year effects, and the extent to which the surveys are able to track cohort signals;

b) performing log-catch-curve analyses on the abundance indices to examine data consistency and mortality trends over time – the negative slope of a regression fitted to ages down a cohort (e.g. ages 2-4) can be used as a proxy for total mortality;

c) performing within-survey consistency plots (correlation plots of a cohort at a given age against the same cohort one or more years later) to investigate self-consistency of a survey;

d) performing between-survey consistency plots (correlation plots of a given age for IBTSQ1 against the same age for IBTSQ3) to investigate the consistency between surveys;

e) applying a SURBA analysis to the survey data for comparison with models that include fishery-dependent data.

B.4. Commercial CPUE

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable because it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed.

The WG has previously argued that, although they are in general agreement with the survey information, commercial CPUE tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES-WGNSSK 2001), and also changes in gear design and usage, as discussed by ICES-WGFTFB (2006, 2007). Therefore, although the commercial fleet series are available, only survey and commercial landings and discard information are analysed within the assessment presented.

B.5. Other relevant data

The annual North Sea Fishers' Survey presents fishers' perceptions of the state of several species including cod; the survey covers the years 2003-2008, (Laurenson, 2008). In addition, a number of collaborative research projects are reported to the WGNSSK each year. To date the studies providing time series of quantitative information have been relatively local, whereas those with wider coverage have been qualitative. The studies have therefore been used to corroborate assessment results and highlight differences in perception. The studies have proven useful in examining the dynamics of sub-stocks within the North Sea, for instance local recruitment, and thereby in the provision of advice to managers.

C. Historical Stock Development

Available stock assessment models

WKCOD (February 2011) considered two candidate assessment models for North Sea cod, B-Adapt and SAM, with a third model TSA used for exploratory analysis. B-Adapt is a VPA model used until 2010 as a basis for providing advice for North Sea cod, but was considered by WKCOD to be inappropriate for an effort management system that relies on the final year estimate of F, because it provides estimates of F that vary too widely from year to year. WKROUND (January 2009), recommended that SAM be run in parallel to B-Adapt, both models estimating catch multipliers from 1993 onwards to account for "unallocated mortality". WKCOD now recommends SAM, with correlated fishing mortality at age, and using the IBTS Q1 survey as the only tuning index (i.e. omitting the IBTS Q3 survey), as the most appropriate assessment model for North Sea cod for an interim period only. This is so that issues related to changes in survey catchability (the reason IBTS Q3 has been omitted) and discard modelling are further explored, and hopefully in future a more suitable model-data configuration for North Sea cod can be found. A full description of the SAM model can be found in the WKCOD report.

Model used as a basis for advice

The state-space models SAM offers a flexible way of describing the entire system, with relative few model parameters. It allows for objective estimation of important variance parameters, leaving out the need for subjective *ad-hoc* adjustment numbers, which is desirable when managing natural resources.

For North Sea Cod only one survey index (IBTS Q1) is used, for the time being, and the total catch-at-age data. No commercial fleets with effort information are used. The Beverton-Holt recruitment function is used, but there is no visual difference in the results if a Ricker curve, or simply a random walk recruitment is used in its place. Fishing mortality random walks are allowed to be correlated.

For North Sea Cod the model is extended to allow estimation of possible bias (positive or negative) in the reported total catches from 1993 to 2005. The model assumes that reported catches should simply be scaled by a year and possibly age specific factor $S_{a,y}$. This leads to the following updated catch equation for the total catches.

$$\log C_{a,y}^{(\circ)} = -\log S_{a,y} + \log\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right) + \varepsilon_{a,y}^{(\circ)}$$

In the main scenario considered the multiplier $S_{a,y}$ is set according to:

$$S_{a,y} = \begin{cases} 1, & y < 1993 \text{ or } y > 2005 \\ \tau_y, & 1993 \le y \le 2005 \end{cases}$$

It is assumed that the fishing mortalities corresponding to total catches are identical for the two oldest age groups $F_{a=6,y} = F_{a=7+,y}$ in order to make the model identifiable.

The total vector of model parameters for this model is:

$$\vartheta = (Q_{a=1,2,3,4,5}^{(s=1)}, \sigma_R^2, \sigma_S^2, \sigma_F^2, \sigma^2_{\circ,a=1,2,3^+}, \sigma^2_{s=1,a=1,2^+},$$

$$\tau_{1993}, \tau_{1994}, \ldots, \tau_{2009}, \alpha, \beta, \rho)$$

The Q parameters are catchabilities corresponding to the survey fleet. The three variance parameters σ_R^2, σ_S^2, and σ_F^2 are process variances for recruitment, survival, and development in fishing mortality respectively. The remaining σ^2 parameters are describing the variance of different observations divided into fleet and age classes. Finally the τ parameters are the scaling factors for the total catches, α and β are the parameters of the Beverton-Holt recruitment function, and ρ is the correlation parameter for the random walks on the fishing mortalities.

Model used: SAM (with correlated fishing mortality at age)

Software used: Source code and all scripts are freely available at http://www.stockassessment.org [Username: guest; Password: guest]

Model Options chosen:

A configuration file is used to set up the model run once the data files, in the usual Lowestoft format, have been prepared. The file has the following form:

```
# Min Age (should not be modified unless data is modified accordingly)
1
# Max Age (should not be modified unless data is modified accordingly)
7
# Max Age considered a plus group (0=No, 1=Yes)
1
# The following matrix describes the coupling
# of fishing mortality STATES
# Rows represent fleets.
# Columns represent ages.
1       2       3       4       5       6       6
0       0       0       0       0       0       0
# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
1
# Coupling of catchability PARAMETERS
0       0       0       0       0       0       0
1       2       3       4       5       0       0
# Coupling of power law model EXPONENTS (if used)
0       0       0       0       0       0       0
```

```
0       0       0       0       0       0       0
# Coupling of fishing mortality RW VARIANCES
1       1       1       1       1       1       1
0       0       0       0       0       0       0
# Coupling of log N RW VARIANCES
1       2       2       2       2       2       2
# Coupling of OBSERVATION VARIANCES
1       2       3       3       3       3       3
4       5       5       5       5       0       0
# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time)
2
# Years in which catch data are to be scaled by an estimated parameter
# first the number of years
13
# Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
# Then the model config lines years cols ages
 1   1   1   1   1   1   1
 2   2   2   2   2   2   2
 3   3   3   3   3   3   3
 4   4   4   4   4   4   4
 5   5   5   5   5   5   5
 6   6   6   6   6   6   6
 7   7   7   7   7   7   7
 8   8   8   8   8   8   8
 9   9   9   9   9   9   9
10  10  10  10  10  10  10
11  11  11  11  11  11  11
12  12  12  12  12  12  12
13  13  13  13  13  13  13
# Define Fbar range
2       4
```

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1963-present	-	Y
Canum	Catch at age in numbers	1963-present	1-7+	Y
Weca	Weight at age in the commercial catch	1963-present	1-7+	Y
West	Weight at age of the spawning stock at spawning time.	Weca used for West	Weca used for West	Weca used for West
Mprop	Proportion of natural mortality before spawning	1963-present	1-7+	N
Fprop	Proportion of fishing mortality before spawning	1963-present	1-7+-	N
Matprop	Proportion mature at age	1963-present	1-7+	N
Natmor	Natural mortality	1963-present*	1-7+	Y

*Updated values for natural mortality will only be provided every 2 years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	IBTS-Q1	1983-final year of catch data + 1	1-5

Recruitment estimation;

Estimation of recruitment is an integrated part of the model. Recruitment parameters are estimated within the assessment model. Currently the assumed parametric structure is a Beverton-Holt model.

D. Short-Term Projection

Due to the uncertainty in the final year estimates of fishing mortality, the WG agrees that a standard (deterministic) short-term forecast is not appropriate for this stock. Therefore, stochastic projections are performed, from which short-term projections are extracted. The stochastic projections are carried out by starting at the final year's estimates, and the covariance matrix of those estimates. 5000 samples are generated from the estimated distribution of the final years estimates. Those 5000 replicates are then simulated forward according to the model and subject to different scenarios.

Model used: SAM (with correlated fishing mortality at age)

Software used: Source code and all scripts are freely available at http://www.nscod.stockassessment.org [Username: guest; Password: guest]

Initial stock size:

Starting populations are simulated from the estimated distribution of the final years estimates (including covariances).

Maturity:

Average of final three years of assessment data (constant for North Sea cod).

Natural mortality:

Average of final three years of assessment data.

F and M before spawning:

Both taken as zero.

Weight at age in the catch:

Average of final three years of assessment data.

Weight at age in the stock:

Same as weight at age in the catch.

Exploitation pattern:

Fishing mortalities taken as a three year average scaled to the final year.

Intermediate year assumptions:

Multiplier reflecting intended changes in effort (and therefore F) relative to the final year of the assessment

Stock recruitment model used:

Recruitment is re-sampled from the 1997-most recent year classes.

Procedures used for splitting projected catches:

The final year landing fractions isused in the prediction period.

E. Medium-Term Projections

Medium-term projections are not carried out for this stock.

F. Long-Term Projections

Long-term projections are not carried out for this stock.

G. Biological Reference Points

The Precautionary Approach reference points for cod in IV, IIIa (Skagerrak) and VIId have been unchanged since 1998. They are:

	Type	Value	Technical basis
Precautionary approach	Blim	70 000 t	Bloss (~1995)
	Bpa	150 000 t	Bpa = Previous MBAL and signs of impaired recruitment below 150 000 t.
	Flim	0.86	Flim = Floss (~1995)
	Fpa	0.65	Fpa = Approx. 5th percentile of Floss, implying an equilibrium biomass > Bpa.
Targets	Fy	0.4	EU/Norway agreement December 2009

Unchanged since 1998

Yield and spawning biomass per Recruit F-reference points:

	Fish Mort	Yield/R	SSB/R
	Ages 2-4		
Average last 3 years	0.70	0.34	0.45

Fmax	0.19	0.62	3.36
F0.1	0.13	0.59	4.73
Fmed	0.84	0.28	0.30

Estimated by ICES in 2010, based on the assessment performed in 2009 (ICES-WGNSSK 2009), and making the same assumptions about input values underlying the MSY analysis presented in Section 14.6 (ICES-WGNSSK 2010).

H. Other Issues

No other issues.

I. References

Alphen, J. v., and Heessen, H. J. L. 1984. Variation in length at age of North Sea cod. ICES CM 1984/G:36.

Andrews, J.M., Gurney, W.S.C., Heath, M.R., Gallego, A., O'Brien, C.M., Darby, C., and Tyldesley, G. 2006. Modelling the spatial demography of Atlantic cod (*Gadus morhua*) on the European continental shelf. Can. J. Fish. Aquat. Sci. 63: 1027-1048.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S., and Reid, P.C. 2003. Plankton effect on cod recruitment in the North Sea. Nature, 426: 661–664.

Bedford, B.C., 1966. English cod tagging experiments in the North Sea. International Council for the Exploration of the Sea (CM Papers and Reports), CM 1966/G:9, 28 pp.

Björnsson, B., and Steinarsson, A. 2002. The food-unlimited growth rate of Atlantic cod (*Gadus morhua*). Can. J. Fish. Aquat. Sci. 59: 494–502.

Blanchard, J.L., Mills, C., Jennings, S., Fox, C.J., Rackham, B.D., Eastwood, P.D., and O'Brien, C.M. 2005. Distribution-abundance relationships for North Sea Atlantic cod (Gadus morhua): observation versus theory. Canadian Journal of Fisheries and Aquatic Sciences, 62: 2001–2009.

Brander, K. M. 1994. The location and timing of cod spawning around the British Isles. ICES Journal of Marine Science, 51: 71–89.

Cook, R.M., Kunzlik, P.A., Hislop, J.R.G. and Poulding, D. 1999. Models of Growth and Maturity for North Sea cod. J. Northw. Atl. Fish. Sci. 25: 91-99.

Daan, N. 1978. Changes in cod stocks and cod fisheries in North Sea. Rapports et Procès-verbaux des Réunions du Conseil International pour l'Exploration de la Mer, 172, 39–57.

Dickson, R.R., and Brander, K.M. 1993. Effects of a changing windfield on cod stocks of the North Atlantic. Fisheries Oceanography 2: 124–153.

Fox, C.J., Taylor, M., Dickey-Collas, M., Fossum, P., Kraus, G., Rohlf, N., Munk, P., van Damme, C.J.G., Bolle, L.J., Maxwell, D.L., and Wright, P.J. 2008. Mapping the spawning grounds of North Sea cod (Gadus morhua) by direct and indirect means. Proc. R. Soc. B. 275: 1543-1548.

Fryer R.J., 2002. TSA: is it the way? Appendix D in report of Working Group on Methods on Fish Stock Assessment. ICES CM 2002/D:01.

Greenstreet, S.P.R., Fraser, H.M., and Piet, G.J. 2009. Using MPAs to address regional-scale ecological objectives in the North Sea: modelling the effects of fishing effort displacement. ICES Journal of Marine Science, 66: 90–100.

Gudmundsson, G. (1987). Time series models of fishing mortality rates. ICES C.M. d:6.

Gudmundsson, G. (1994). Time series analysis of catch-at-age observations. Appl.~Statist. 43 117-126.

Hammond, P.S. and Grellier, K. 2006. Grey seal diet composition and prey consumption in the North Sea. Final report to Scottish Executive Environment and Rural Affairs Department and Scottish Natural Heritage; 2006.

Heath, M.R., Kunzlik, P.A., Gallego, A., Holmes, S.J., and Wright, P.J. 2008. A model of meta-population dynamics for North Sea and West of Scotland cod – the dynamic consequences of natal fidelity. Fisheries Research 93: 92-116.

Hedger, R., Mckenzie, E., Heath, M., Wright, P., Scott, E., Gallego, A., and Andrews, J. 2004. Analysis of the spatial distributions of mature cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) abundance in the North Sea (1980e1999) using generalised additive models. Fisheries Research, 70: 17-25.

mmer-Hansen, J. and P. Wright. Sub-structuring of cod populations within the North Sea – evidence from genetic data. WD2 presented to ICES WGNSSK, 2013.

op, J.R.G. 1984. A comparison of the reproductive tactics and strategies of cod, haddock, whiting and Norway pout in the North Sea. In: Fish reproduction-strategies and tactics, pp. 311–330. Ed. by Potts and Wootton. Academic Press, London: 424 pp.

Holmes, S.J., Wright, P.J., and Fryer, R.J. 2008. Evidence from survey data for regional variability in cod dynamics in the North Sea and West of Scotland. ICES Journal of Marine Science 65: 206-215.

Houghton, R.G., and Flatman, S. 1981. The exploitation pattern, density-dependent catchability and growth of cod (*Gadus morhua*) in the west-central North Sea. Journal du Conseil International Pour l'Exploration de la Mer, 39: 271–287.

Horwood, J., O'Brien, C., and Darby, C. 2006. North Sea cod recovery? ICES J. Mar. Sci. 63: 961–968.

Hughes, N.R. and Grand, T.C. 2000. Physiological ecology meets the ideal-free distribution: predicting the distribution of size-structured fish populations across temperature gradients. Environ. Biol. Fishes 59: 285-298.

Hutchinson, W.F., Carvalho, G.R., & Rogers, S.I. 2001. Marked genetic structuring in localised spawning populations of cod Gadus morhua in the North Sea and adjoining waters, as revealed by microsatellites. Marine Ecology Progress Series. 223: 251-260.

ICES. 1994. Spawning and life history information for North Atlantic cod stocks. ICES Cooperative Research Report 205: 150 pp.

ICES 2005. Spawning and life history information for North Atlantic cod stocks. ICES Cooperative Research Report 274: 152pp.

ICES-NSRWG 1971. Report by the North Sea Roundfish Working Group on North Sea Cod. ICES/Demersal Fish Comm F:5: 1-35.

ICES-WGFTFB 2006. Report of the Working Group on Fish Technology and Fish Behaviour. ICES CM 2006/FTC:06.

ICES-WGFTFB 2007. ICES - FAO Working Group on Fishing Technology & Fish Behaviour [April 2007 report not yet available].

ICES-WGMME 2005. Report of the Working Group on Marine Mammal Ecology (WGMME). ICES CM2005/ACE:05.

ICES-WGNSSK 2001. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 19-28 June 2001, Hamburg, Germany. ICES CM 2002/ACFM:01.

ICES-WGNSSK 2003. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 9-18 September 2003, Boulogne-sur-Mer, France. ICES CM 2004/ACFM:07.

ICES-WGNSSK 2004. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 7-16 September 2004, Bergen, Norway. ICES CM 2005/ACFM:07.

ICES-WGNSSK 2006. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5–14 September 2006, ICES Headquarters. ACFM:35: 1160pp.

ICES-WGNSSK 2007. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak – Combined Spring and Autumn (WGNSSK), 1-8 May 2007, ICES Headquarters and September 2007 by correspondence. ICES CM 2007/ACFM:18&30: 960pp.

ICES-WGNSSK 2008. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Spring and Autumn (WGNSSK), 7-13 May 2008, ICES Copenhagen and By Correspondence. ICES CM 2008\ACOM:09: 921pp

ICES- WGNSSK 2009. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Combined Spring and Autumn (WGNSSK), 6 - 12 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:10: 1028pp.

ICES-WGNSSK 2010. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5 -11 May 2010, ICES Headquarters, Copenhagen. ICES CM 2010/ACOM:13: 1058pp.

ICES-WKREF 2007. Workshop on limit and target reference points [2007 report not yet available].

ICES-WGSAM 2008. Report of the Working Group on Multi Species Assessment Methods (WGSAM). ICES CM 2008/RMC:06

ICES-WGSAM. 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 10–14 October 2011, Woods Hole, USA. ICES CM 2011/SSGSUE:10. 229 pp.

ICES-WKCOD 2011. Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011), 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51: 94pp.

Kempf, A., Dingsør, G.E., Huse, G., Vinther, M., Floeter, J., and Temming, A. 2010. The importance of predator–prey overlap: predicting North Sea cod recovery with a multispecies assessment model. ICES Journal of Marine Science, 67: 1989–1997.

Knutsen H., Jorde P.E., Andre C., Stenseth N.C. 2003. Fine-scaled geographical population structuring in a highly mobile marine species: the Atlantic cod. Molecular Ecology, 12, 385-394.

Knutsen H., Olsen E.M., Jorde P.E., Espeland S.H., Andre C., Stenseth N.C. 2011. Are low but statistically significant levels of genetic differentiation in marine fishes 'biologically meaningful'? A case study of coastal Atlantic cod. Molecular Ecology, 20, 768-783.

Lewy, P., and Nielsen, A. 2003. Modeling stochastic fish stock dynamics using Markov Chain Monte Carlo. ICES Journal of Marine Science 60:743--752.

Lewy, P., and Kristensen, K. 2009. Modelling the distribution of fish accounting for spatial correlation and overdispersion. Can. J. Fish. Aquat. Sci. 66: 1809-1820.

Macer, C.T. 1983. Changes in growth of North Sea cod and their effect on yield assessments. ICES CM 1983/G:8.

Metcalfe, J.D. 2006. Fish population structuring in the North Sea: understanding processes and mechanisms from studies of the movements of adults. Journal of Fish Biology 69 (Supplement C): 48-65.

Myers, R.A., Mertz, G., and Barrowman, N.J. 1995. Spatial scales of variability on cod recruitment in the North Atlantic. Canadian Journal of Fisheries and Aquatic Sciences, 52(9): 1849–1862.

Neat, F., and Righton, D. 2007. Warm water occupancy by North Sea cod. Proc. R. Soc. B. 274: 789-798.

Neat F.C., Bendall V., Berx B., Wright P.J., and Righton D. (in prep.) Movements, mixing and environmental experience of cod on the north west European shelf.

Nielsen E., Hansen M., Ruzzante D., Meldrup D., and Gronkjaer P. 2003. Evidence of a hybrid-zone in Atlantic cod (Gadus morhua) in the Baltic and the Danish Belt Sea revealed by individual admixture analysis. Molecular Ecology, 12, 1497-1508.

Nielsen E.E., Wright P.J., Hemmer-Hansen J., Poulsen N.A., Gibb L.M., and Meldrup D. 2009. Micro geographical population structure of cod *Gadus morhua* in the North Sea and west of Scotland: the role of sampling loci and individuals. Marine Ecology-Progress Series, 376, 213-225.

O'Brien, C.M., Fox, C.J., Planque, B., and Casey, J. 2000. Climate variability and North Sea cod. Nature, 404: 142.

Oosthuizen, E., and Daan, N. 1974. Egg fecundity and maturity of North Sea cod, Gadus *morhua*. Netherlands Journal of Sea Research 8: 378–397.

Ottersen, G., Michalsen, K., and Nakken, O. 1998. Ambient temperature and distribution of north-east cod. ICES J. Mar. Sci. 55: 67–85.

Perry, A.L., Low, P.J., Ellis, J.R., and Reynolds, J.D. 2005. Climate Change and Distribution Shifts in Marine Fishes. Science, 308 (5730), 1912-1915.

Planque, B., and Fredou, T. 1999. Temperature and the recruitment of Atlantic cod (Gadus morhua). Canadian Journal of Fisheries and Aquatic Sciences 56: 2069-2077.

Poulsen N.A., Hemmer-Hansen J., Loeschcke V., Carvalho G.R., and Nielsen E.E. 2011. Microgeographical population structure and adaptation in Atlantic cod Gadus morhua: spatio-temporal insights from gene-associated DNA markers. Marine Ecology-Progress Series, 436, 231-243.

Righton, D., Quayle, V.A., Hetherington, S. and Burt, G. 2007. Movements and distribution of cod (*Gadus morhua*) in the southern North Sea and English Channel: results from conventional and electronic tagging experiments. J. Mar. Biol. Ass. U.K. 87: 599-613.

Righton, D., Quayle, V.[A.], Neat, F., Pedersen, M.[W.], Wright, P.[J.], Armstrong, M.[J.], Svedang, H., Hobson, V.J. and Metcalfe, J.D. 2008. Spatial dynamics of Atlantic cod (Gadus morhua) in the North Sea: results from a large-scale electronic tagging programme. ICES CM 2008/P:04: 32pp.

Righton D.A., Andersen K.H., Neat F., Thorsteinsson V., Steingrund P., Svedäng H., Michalsen K., Hinrichsen H.H., Bendall V., Neuenfeldt S., Wright P., Jonsson P., Huse G., van der Kooij J., Mosegaard H., Hüssy K., and Metcalfe J. (2010) Thermal niche of Atlantic cod *Gadus morhua*: limits, tolerance and optima. Marine Ecology-Progress Series, 420: 1-13.

Rijnsdorp, A.D., Daan, N., van Beek, F.A. and Heessen, H.J. 1991. Reproductive variability in North Sea plaice, sole and cod. Journal du Conseil International Pour l'Exploration de la Mer. 47: 352-375.

Riley, J. D., and Parnell, W. G. 1984. The distribution of young cod. Flødevigen Rapportserie, 1: 563–580.

Rindorf, A. and Lewy, P. 2006 Warm, windy winters drive cod north and homing of spawners keeps them there. Journal of Applied Ecology, 43, 445-453.

Speirs, D.C., Guirey, E.J., Gurney, W.S.C., and Heath, M.R. 2010. A length-structured partial ecosystem model for cod in the North Sea. Fisheries Research, 106: 474–494.

STECF-SGRST-07-01. 2007. Evaluation of the report of the STECF-SGRST (07-01) Working Group on evaluation of the cod recovery plan, Hamburg 26-30 March, 2007.

Swain, D.P. 1999. Changes in the distribution of Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence: effects of environmental change or change in environmental preferences? Fish. Oceanogr. 8: 1–17.

Wieland, K., Fenger Pedersen, E.M., Olesen, H.J. and J.E. Beyer. 2009. Effect of bottom type on catch rates of North Sea cod (*Gadus morhua*) in surveys with commercial fishing vessels. Fish. Res. 96: 244–251.

Wright P., Neat F., and Righton D. 2011a. WD7: The IBTS surveys and North Sea cod movements and population structure. In: Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011), 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51.

Wright PJ, Millar CP, Gibb FM (2011b) Intrastock differences in maturation schedules of Atlantic cod, Gadus morhua. ICES Journal of Marine Science, 68: 1918-1927.

Table 1 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Natural mortality by age-group.

	Age						
Year	1	2	3	4	5	6	7+
1963	1.107	0.789	0.233	0.202	0.2	0.2	0.2
1964	1.147	0.804	0.241	0.202	0.2	0.2	0.2
1965	1.184	0.819	0.248	0.202	0.2	0.2	0.2
1966	1.217	0.831	0.254	0.202	0.2	0.2	0.2
1967	1.242	0.839	0.261	0.202	0.2	0.2	0.2
1968	1.260	0.843	0.266	0.202	0.2	0.2	0.2
1969	1.273	0.844	0.271	0.202	0.2	0.2	0.2
1970	1.282	0.842	0.275	0.202	0.2	0.2	0.2
1971	1.287	0.838	0.277	0.201	0.2	0.2	0.2
1972	1.290	0.832	0.279	0.201	0.2	0.2	0.2
1973	1.291	0.826	0.280	0.201	0.2	0.2	0.2
1974	1.292	0.819	0.280	0.200	0.2	0.2	0.2
1975	1.293	0.811	0.280	0.200	0.2	0.2	0.2
1976	1.296	0.803	0.280	0.200	0.2	0.2	0.2
1977	1.301	0.795	0.282	0.200	0.2	0.2	0.2
1978	1.306	0.787	0.284	0.200	0.2	0.2	0.2
1979	1.311	0.779	0.286	0.200	0.2	0.2	0.2
1980	1.314	0.771	0.290	0.200	0.2	0.2	0.2
1981	1.314	0.762	0.293	0.200	0.2	0.2	0.2
1982	1.310	0.754	0.296	0.200	0.2	0.2	0.2
1983	1.301	0.746	0.298	0.201	0.2	0.2	0.2
1984	1.287	0.738	0.300	0.201	0.2	0.2	0.2
1985	1.269	0.730	0.300	0.201	0.2	0.2	0.2
1986	1.248	0.724	0.300	0.201	0.2	0.2	0.2
1987	1.226	0.719	0.299	0.202	0.2	0.2	0.2
1988	1.204	0.716	0.297	0.202	0.2	0.2	0.2
1989	1.183	0.715	0.296	0.202	0.2	0.2	0.2
1990	1.164	0.715	0.295	0.202	0.2	0.2	0.2
1991	1.149	0.716	0.295	0.202	0.2	0.2	0.2
1992	1.135	0.717	0.297	0.202	0.2	0.2	0.2
1993	1.124	0.716	0.302	0.203	0.2	0.2	0.2
1994	1.113	0.714	0.309	0.204	0.2	0.2	0.2
1995	1.102	0.711	0.319	0.205	0.2	0.2	0.2
1996	1.090	0.705	0.331	0.207	0.2	0.2	0.2
1997	1.077	0.698	0.346	0.209	0.2	0.2	0.2
1998	1.064	0.691	0.363	0.211	0.2	0.2	0.2
1999	1.051	0.683	0.381	0.214	0.2	0.2	0.2
2000	1.040	0.678	0.400	0.217	0.2	0.2	0.2
2001	1.032	0.676	0.417	0.220	0.2	0.2	0.2
2002	1.028	0.676	0.434	0.223	0.2	0.2	0.2
2003	1.027	0.679	0.449	0.225	0.2	0.2	0.2
2004	1.029	0.684	0.462	0.227	0.2	0.2	0.2
2005	1.032	0.688	0.472	0.229	0.2	0.2	0.2
2006	1.036	0.692	0.480	0.230	0.2	0.2	0.2
2007	1.038	0.695	0.484	0.231	0.2	0.2	0.2
2008	1.039	0.696	0.487	0.232	0.2	0.2	0.2
2009	1.039	0.697	0.489	0.232	0.2	0.2	0.2
2010	1.038	0.698	0.490	0.233	0.2	0.2	0.2
2011*	1.038	0.698	0.490	0.233	0.2	0.2	0.2

***A new key run was performed in 2011 with data up to 2010 (ICES-WGSAM 2011), so 2011 M-values are assumed equal to 2010.**

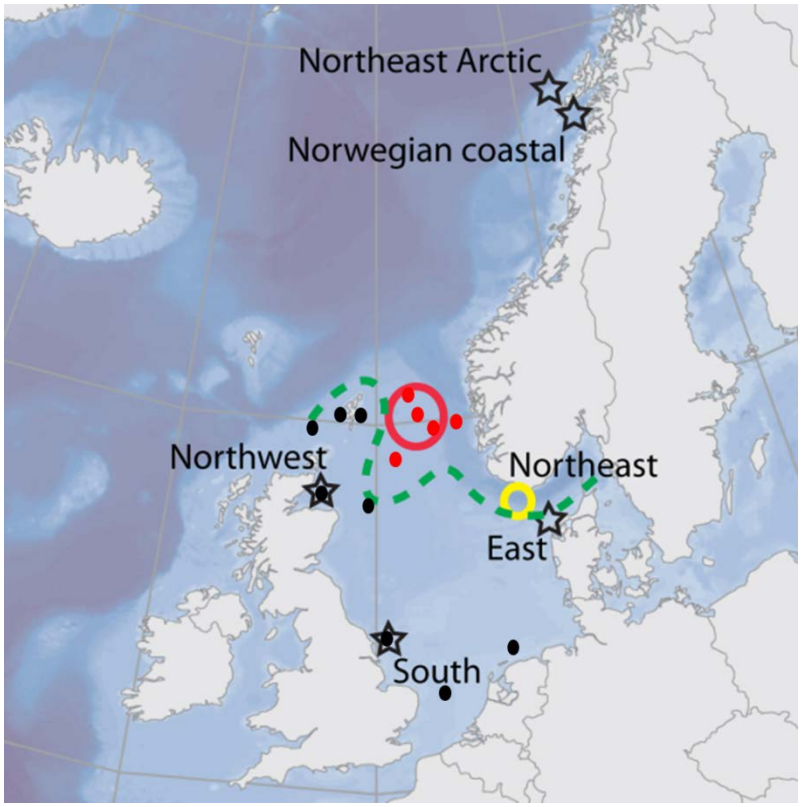


Figure 1. Location of samples analysed for genetic variation. Red circle shows Viking Bank where Nielsen *et al.* (2009) identified a genetically unique population. Yellow circle represents the divergent population identified in Poulsen *et al.* (2011) and in this document. Dots represent sample locations for SNPs in UK NERC cod project, which were assigned to different populations. Broken line indicates approximate location of break (100 m contour) between northern and southern populations in the North Sea suggested by Wright *et al.* (2011a).

Stock Annex Saithe in Subarea IV (North Sea)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)
Working Group:	WGNSSK
Date:	January 2012
Revised by:	WKBENCH/ Irene Huse

A General

A.1 Stock definition

The saithe stock is defined to be a single stock in ICES Subarea IV, Division IIIa and Subarea VI. The stock assessment is done accordingly.

A.3 Fishery

Saithe in Subarea IV, Division IIIa and Subarea VI (referred to here as *North sea saithe* for brevity) are mainly taken in a direct trawl fishery in deep water along the Northern Shelf edge and the Norwegian Trench. Norwegian, French, and German trawlers take the majority of the catches. In the first quarter of the year the fisheries are directed towards mature fish in spawning aggregations, while concentrations of immature fish (age 3-4) often are targeted during the rest of the year. A small proportion of the total catch is taken in a limited purse seine fishery along the west coast of Norway targeting juveniles (age 2-4). In the Norwegian coastal purse seine fishery inside the 4 nm limit (south of 62°N), the minimum landing size is 32 cm.

The main fishery developed in the beginning of the 1970s. The fishery in Subarea VI consists largely of a directed French, German, and Norwegian deep-water fishery operating on the shelf edge, and a Scottish fishery operating inshore. In recent years the French fishery has deployed less effort along the Norwegian Trench. There seems to have been a temporal change in the Norwegian fishery, and more of the effort is now in the 2nd quarter. The German fleet in the last few years has concentrated almost all of its effort in the shallow waters south of southern Norway. These changes may have changed the exploitation pattern in the fishery.

Since the fish are distributed inshore until they are about 3 years old, discarding of young fish is assumed to be a small problem in this fishery. However, low prices and mixed catches might lead to high grading. In trawler fleets that are targeting saithe, the quota is less limiting, and the problem may be less in these fleets. Norwegian legislation requires the Norwegian trawlers to move out of the area when the boat quotas are reached, and in addition, the fishery is closed if the seasonal quota is reached.

In 2009 the landings were estimated to be around 105 529 t in Subarea IV and Division IIIa, and 6963 t in Subarea VI, which both are well below the TACs for these areas (125 934 and 13 066 t respectively). Significant discards are observed only in Scottish trawlers. However, as Scottish discarding rates are not considered representative of the majority of the saithe fisheries, these have not been used in the assessment. Ages 1 and 2

are mainly distributed close to the shores and are very scarce in the main fishing areas for saithe.

Conservation schemes and technical conservation measures

Management of saithe is by TAC and technical measures. The available kw-days at sea for community vessels are restricted via the cod management plan (Council regulation 1342/2008). Only some vessels were exempted from these effort restrictions in 2009 due to low bycatch (<1.5%) of cod. In the Norwegian zone (south of 62°N) the current minimum landing size is 40 cm, while in the EU zone it is 35 cm. Discards are not allowed in the Norwegian zone. Minimum mesh size in the in the Norwegian zone is 120 mm for Norwegian trawlers, and 110 mm for community vessels.

A.4 Ecosystem aspects

The geographical distributions of juvenile (< age 3) and adult saithe differ. Typical for all saithe stocks are the inshore nursery grounds. Juvenile saithe in the North Sea are therefore mainly distributed along the west and south coast of Norway, the coast of Shetland and the coast of Scotland. At around age 3, the individuals gradually migrate from the coastal areas to the northern part of the North Sea (57°N - 62°N).

The age at first maturity is between 4 and 6 years, and spawning takes place in January-March at about 200 m depth along the Northern Shelf edge and the western edge of the Norwegian Trench. Larvae and post-larvae are widely distributed in Atlantic water masses across the northern part of the North Sea, and around May the 0-group appears along the coasts (of Norway, Shetland and Scotland). The mechanisms behind the 0-group's migration from oceanic to coastal areas remain unknown, but it seems like they are actively swimming towards the coasts. The west coast of Norway is probably the most important nursery ground for saithe in the North Sea.

When saithe exceeds 60-70 cm in length the diet changes from plankton (krill, copepods, fish larvae) to fish (mainly Norway pout, blue whiting, haddock and herring). Large saithe (>70 cm) have a highly migratory behaviour and the feeding migrations extend from far into the Norwegian Sea to the Norwegian coast.

Tagging experiments by various countries have shown that exchange takes place between all saithe stock components in the northeast Atlantic. In particular, exchange between the saithe stock north of 62°N (Northeast Arctic saithe) and saithe in the North Sea has been observed.

A sharp decline in the mean weight at age was observed from the mid-1990s, but now seems to be halted. There is insufficient information to establish whether this decline is linked to changes in the environment. The reduced growth rates have an effect on stock productivity and the consequences need to be further explored. However, there are no indications that the observed decline in weight at age is density dependent. The same reduction in growth rate is also observed for saithe in Faroese and Norwegian waters north of 62 °N (Figure 1).

The impact of a large saithe stock on prey species such as Norway pout and herring is unknown. Poor spatial and temporal sampling of stomach data of saithe makes the estimation of the saithe diet uncertain.

B Data

B.1 Commercial catch

Landings-at-age data by fleet are supplied by Denmark, Germany, France, Norway, UK (England), and UK (Scotland) for Subarea IV and only UK (Scotland) for Subarea VI.

In the data provided, landings from the industrial fleet are only specified when saithe is delivered separately, and therefore bycatch of saithe that has not been separated from the bulk catch will not be reported as saithe.

B.2 Biological

Weight at age

Weights at age in the landings are measured weights from the various national observer programs, reference fleet and market sampling programs. These weights are also used as stock weights. There has been a decreasing trend in mean weights from the mid-1990s for ages 4 and older, but the decline now seems to be halted.

Natural mortality

A natural mortality rate of 0.2 is used for all ages and years

Maturity

Following maturity ogive is used for all years:

Age	1	2	3	4	5	6	7+
Proportion mature	0.0	0.0	0.0	0.15	0.7	0.9	1.0

The maturity at age ogive was modelled during WKBENCH 2011, with age as a continuous variable and sampling year as an additional effect. The age at 50 % maturity has since 1992 varied between less than 4 (2001) to more than 7 years (1996), but the current, fixed maturity ogive could also not be rejected on statistical grounds

B.3 Surveys

3 Surveys are available:

- Norwegian acoustic survey, 1995-present (NORACU)
- IBTS quarter 3, age range: 1991-present (IBTS-Q3)
- Norwegian acoustic survey for saithe, 2006-present (NORASS)

The NORACU is an acoustic survey that since 2008 has been together with the IBTS Q3 and acoustic herring survey in the North Sea. The IBTS Q3 is coordinated by ICES, and is a bottom trawl survey for young fish in the North Sea. Both NORACU and IBTS Q3 shows a marked decline for saithe the last years (Figure 2). The NORASS is an acoustic survey covering part of the sea mountains at the coast of Norway south of 62 °N. This is the distribution area for young saithe at the east side before it migrates into the North Sea.

B.4 Commercial CPUE:

3 Commercial tuning series are available:

- French demersal trawl, age range: 3-9, year range 1990-present ("FRATRB")
- German otter trawl, age range: 3-9, year range 1995- present ("GEROTB")
- Norwegian bottom trawl, age range: 3-9, year range 1980- present ("NORTRL")

(Part 1 : 1980-1992, part 2 : 1993- present)

After the 2011 benchmark only age 6-9 are used from the commercial CPUE indexes. All the three commercial indexes are based on trawl data. The Norwegian fleet has in the latest years included some pelagic trawling. The spatial distribution of the catches from the German and Norwegian fleet shows some changes (Figure 3), and the geometric.

C Assessment: data and methods

Model used: XSA (Darby and Flatman, 1994

Software used: FLXSA (http://flr-project.org/OLD/doku.php?id=pkg:flxsa)

Model Options chosen: Max iterations: 75. From 2011: SOP correction.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1967-present	3-10+	Yes
Canum	Catch at age in numbers	Variable, depending on country	3-10+	Yes
Weca	Weight at age in the commercial catch	Variable, depending on country		
West	Weight at age of the spawning stock at spawning time.	NA		
Mprop	Proportion of natural mortality before spawning	NA		
Fprop	Proportion of fishing mortality before spawning	NA		
Matprop	Proportion mature at age	See section B2 - maturity		No
Natmor	Natural mortality	See section B2 – Natural mortality		No

Tuning data:

Type	Name	Year range	Age range
FRATRB	French demersal trawl	1990-present	6-9
GEROTB	German otter trawl	1995- present	6-9
NORTRL	Norwegian bottom trawl	1980- present	6-9
NORACU	Norwegian acoustic survey	1995-present	3-6

IBTS-Q3	International bottom trawl survey in the North Sea, 3th quarter	1992-present	3-5
NORASS	Norwegian acoustic survey for saithe	2006-present	2-4

XSA settings:

Age range:	**3-10+**
Catch data:	1967-2010
Fbar:	3-6
Time series weights:	Tricubic over 20 years
Power model for ages:	No
Catchability plateau:	Age 7
Survivor est. shrunk towards the mean F:	5 years / 3 ages
S.e. of mean (F-shrinkage):	1.0
Min. s.e. of population estimates:	0.3
Prior weighting:	No
Number of iterations before convergence:	53 (in 2011)

D Short-term Projection

Because the assessment on which the advice is based is currently a fully deterministic XSA, the short term projection can normally be done in FLR using FLSTF. Weight-at-age in the stock and weight-at-age in the catch are taken to be the mean of the last 3 years. The exploitation pattern is taken to be the mean value of the last three years. Population numbers at ages 4 and older are XSA survivor estimates, numbers at age 3 are taken from the geometric mean for the years 1988 – assessment year.

Model used:

Software used: FLSTF (http://flr-project.org/OLD/doku.php?id=pkg:flstf)

Initial stock size: Population numbers at ages 4 and older are XSA survivor estimates, numbers at age 3 are taken from the geometric mean for the years 1988 – assessment year.

Maturity:

F and M before spawning:

Weight at age in the stock: Mean of the last 3 years

Weight at age in the catch: Mean of the last 3 years

Exploitation pattern: mean value of the last three years

Intermediate year assumptions:

E Medium-Term Projections

No medium-term projections are done for this stock.

F Long-Term Projections

No long- term projections are done for this stock.

G Biological Reference Points

	Type	Value	Technical basis
MSY	MSY Btrigger	200 000 t	Default value Bpa
Approach	FMSY	0.30	Stochastic simulation using hockey-stick stock-recruitment
Precautionary approach	Blim	106 000 t	Bloss = 106 000 t (estimated in 1998).
	Bpa	200 000 t	affords a high probability of maintaining SSB above Blim
	Flim	0.6	Floss the fishing mortality estimated to lead to stock falling below Blim in the long term.
	Fpa	0.4	implies that Beq > Bpa and P(SSBMT < Bpa) < 10%.

Precautionary reference points were derived in 2006 and are:

$F_{0.1}$	0.10	F_{lim}	0.60
F_{max}	0.22	F_{pa}	0.40
F_{med}	0.35	B_{lim}	106 000 t
F_{high}	>0.49	B_{pa}	200 000 t

In 2010 the working group estimated the FMSY to be 0.3. The FMSY should be reanalyzed if changes are found in the maturity.

These reference points refer to an Fbar from ages 3 to 6. The proportion of catches taken by purse seine decreased significantly in the early 1990s. This caused a change in the exploitation pattern as the purse-seiners mainly targeted young saithe. Therefore, it may be more appropriate to use a reference F that does not include age 3. The influence on the maturity ogive from the observed decrease in the weight at age is unknown, but it is reasonable to believe that the spawning capacity of the stock will be affected.

H Other Issues

The settings in final XSA assessment for the years 2007 to 2010, are listed below. In 2011 WKBENCH meeting a new surveys series were included (NORASS, ages 3-4), and ages 3-5 of commercial tuning series were excluded. The NORTRL was reintroduced in the assessment (excluded after 2007 due to changes in catch log residuals).

Year of assessment:	2008	2009	2010	2011
Assessment model:	XSA	no change	No assessment	XSA
Fleets:	FRATRB (age: 3-9, 1990 onwards)	no change	Not available	FRATRB (age: 6-9, 1990 onwards)
	GEROTB (age: 3-9, 1995 onwards)	no change		GEROTB (age: 6-9, 1995 onwards)
				NORTRL (age: 6-9, 1992 onwards)
	NORACU (age: 3-6, 1996 onwards)	no change	Not available	NORACU (age range: 3-6, 1996 onwards)

	IBTS Q3 (age: 3-5, 1992 onwards)	no change	Uncertain, no Norwegian effort	IBTS Q3 (age: 3-5, 1992 onwards)
				NORASS (age: 3-4, 2006 onwards)
Age range:	3-10+	no change		no change
Catch data:	1967-2007	1967-2008	1967-2009	1967-2010
Fbar:	3-6	no change		no change
Time series weights:	Tricubic over 20 years	no change		no change
Power model for ages:	No	no change		no change
Catchability plateau:	Age 7	no change		no change
Survivor est. shrunk towards the mean F:	5 years / 3 ages	no change		no change
S.e. of mean (F-shrinkage):	1.0	no change		no change
Min. s.e. of population estimates:	0.3	no change		no change
Prior weighting:	No	no change		no change
Number of iterations before convergence:	47	47	No assessment was done	53

I. References

Darby, C. D and S. Flatman. 1994. Lowestoft VPA Suite Version 3.1. User Guide. MAFF: Lowestoft.

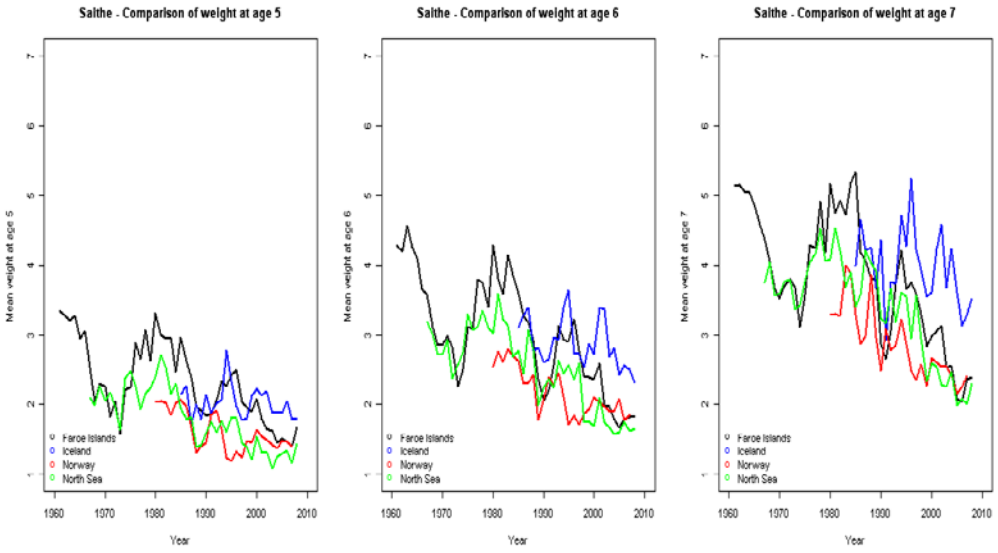


Figure 1. Weight at age by stock: The reduction of weight at age seems to be of importance for three out of four stocks, while one (Icelandic) does not show the same decline. (i Homrum, E. 2011, in prep).

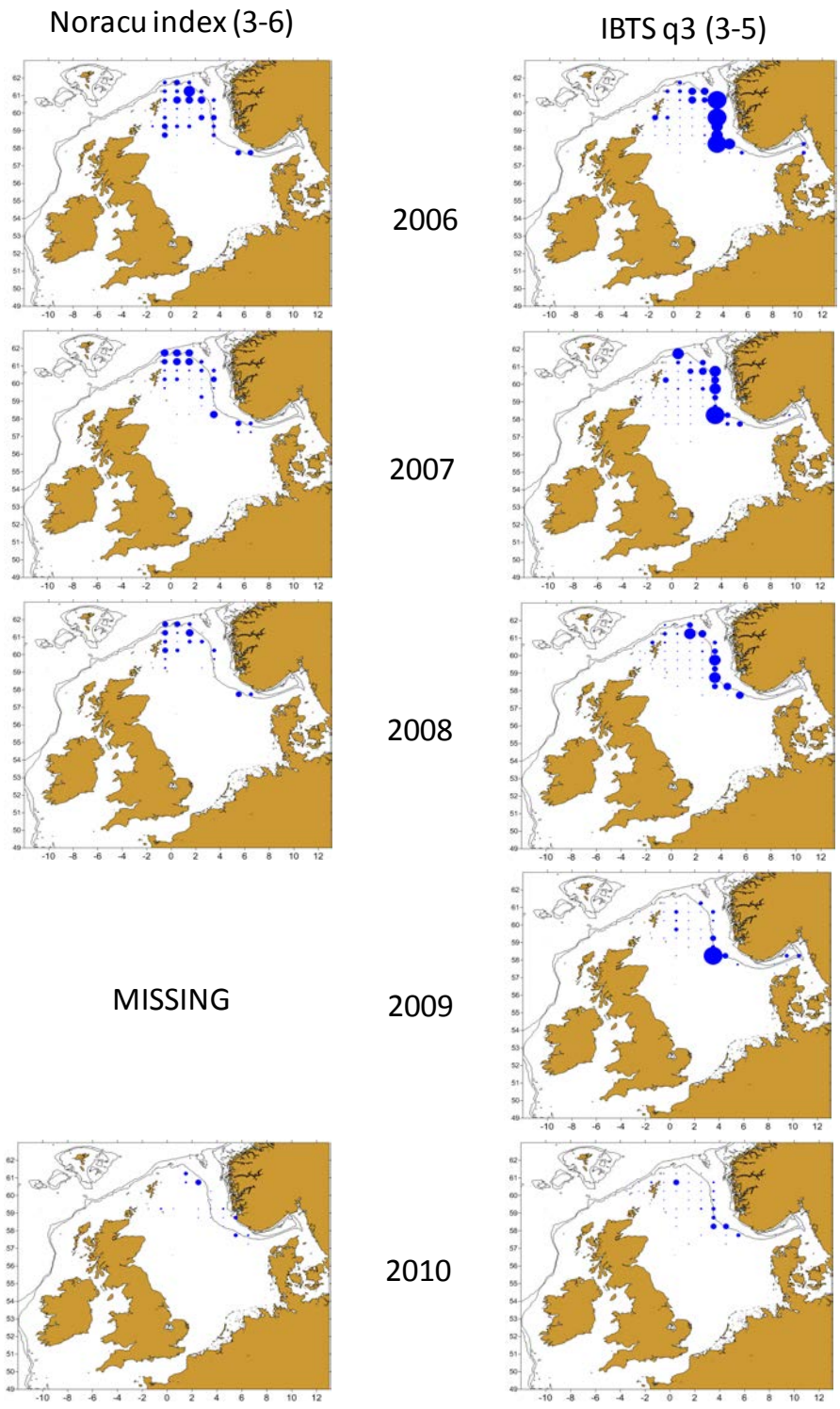


Figure 2. NORACU (left column) and IBTS Q3 (right column) indexes from 2006 to 2010

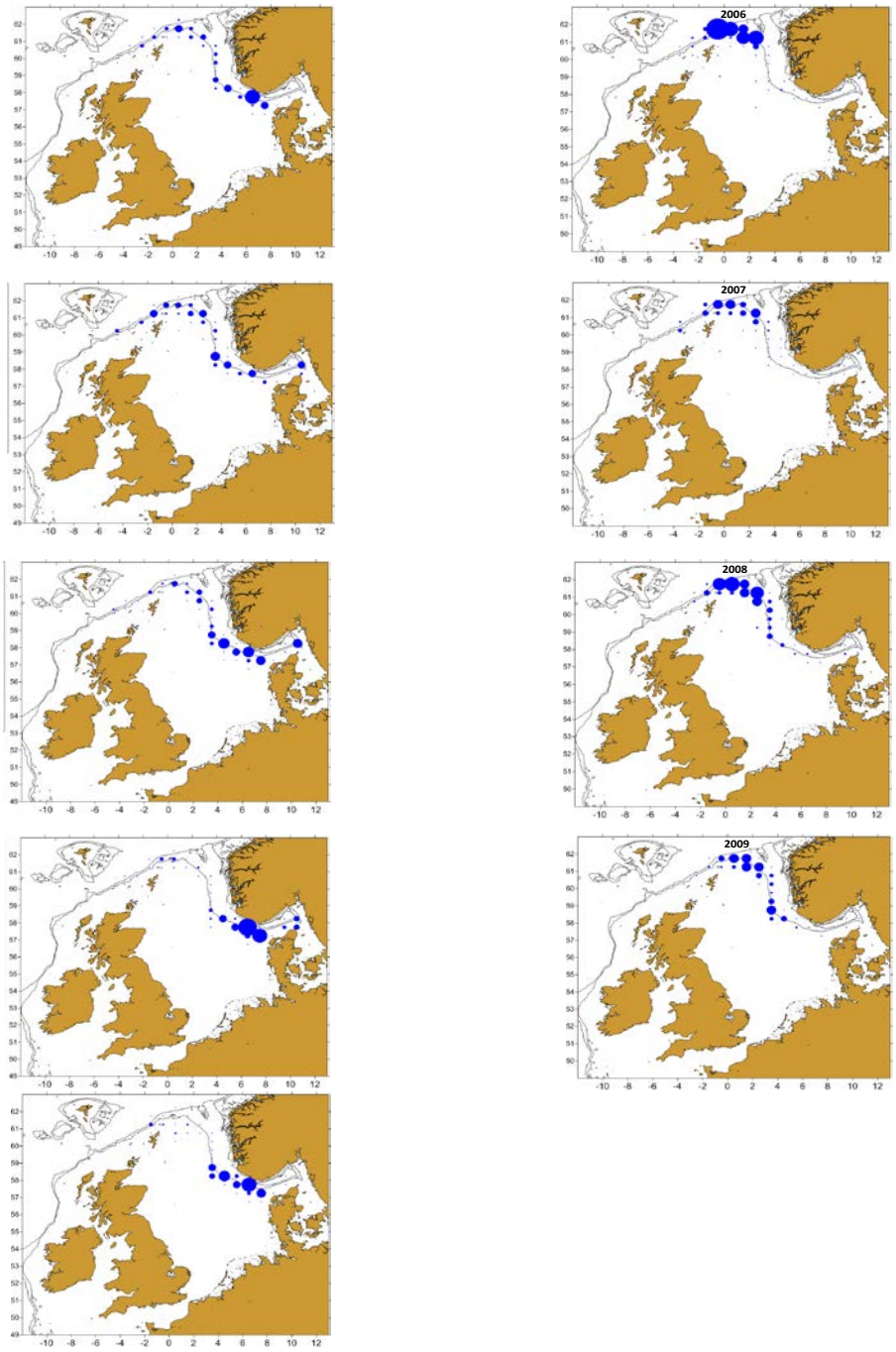


Figure 3. Spatial distribution of the catches for the GEROTR (left column) and NORTRL (right column) indexes from 2006 to 2010.

Stock Annex–Sandeel in IV

Quality Handbook Annex__SAN-NSEA

Stock-specific documentation of standard assessment procedures used by ICES

Working Group	North Sea Demersal Working Group
Updated	09/09/2010 Steen Christensen (sc@aqua.dtu.dk)

General

Stock definition

For assessment purposes, the European continental shelf was divided into four regions for sandeel assessment purposes up to 1995: Division IIIa (Skagerrak), northern North Sea, southern North Sea, and Shetland Islands and Division VIa. These divisions were based on regional differences in growth rate and evidence for a limited movement of adults between divisions (e.g. ICES CM 1977/F:7, ICES CM 1991/Assess:14.). The two North Sea divisions were revised in 1995, and it was decided to amalgamate the two stocks into a single stock unit with two fleets, one fleet in the northern North Sea and one in the southern North Sea. The Shetland sandeel stock was assessed separately. ICES assessments used these stock definitions from 2005 to 2009.

However, larval drift models (Proctor *et al*., 1998; Christensen *et al*., 2007, 2008 and 2009) and studies on growth differences (e.g. Boulcott *et al*., 2007) indicate that the assumption is invalid and that the total stock is divided in several sub-populations as first proposed by Wright *et al*. (1998). On the basis of the latest information ICES (ICES CM 2009\ACOM:51) suggested that the North Sea should be divided into six sandeel assessment areas as indicated in Figure 4.2. ICES assessment used these stock definitions from 2010 onwards (ICES 2010, (WKSAN 2010)).

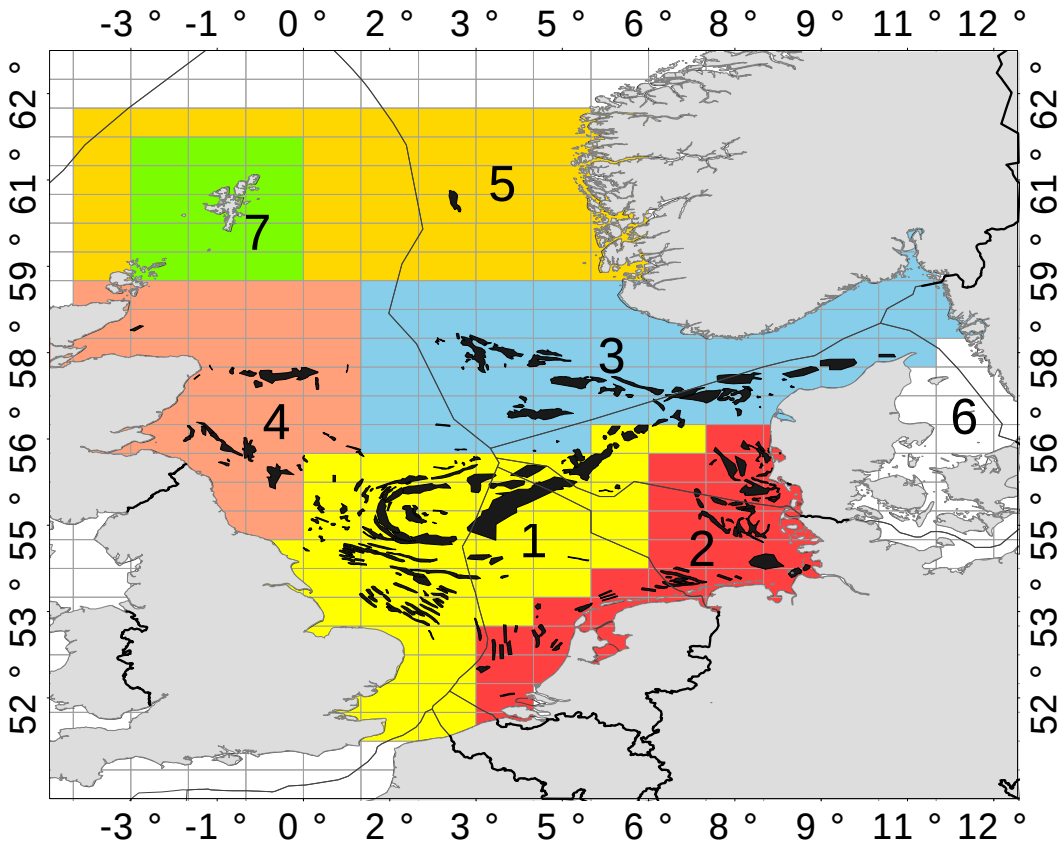


Figure 4. 2. Sandeel fishing banks (black areas), EEZ borders, and assessment areas: eastern area (red), northern area (blue), southern area (yellow), western area (dark orange), Shetland area (green) and Viking bank area (light orange).

Fishery

Technical measures for the sandeel fishery include a minimum percentage of the target species at 95% for meshes <16 mm, or a minimum of 90% target species and maximum 5% of the mixture of cod, haddock, and saithe for 16 to 31 mm meshes.

Most of the sandeel catch consists of the lesser sandeel *Ammodytes marinus*, although small quantities of other *Ammodytoidei* spp. are caught as well. There is little bycatch of protected species (ICES WGNSSK 2004).

The fishery is seasonal. The geographical distribution of the sandeel fishery varies seasonally and annually, taking place mostly in the spring and summer. In the third quarter of the year the distribution of catches generally changes from a dominance of the west Dogger Bank area back to the more easterly fishing grounds.

The sandeel fishery developed during the 1970s, and landings peaked in 1999 with 1.2 million tons. There was a significant shift in landings in 2003. The average landings of the period 1994 to 2002 was 880 000 tons whereas the average landings of the period 2003 to 2009 was 288 000 tons.

As indicated in Figure 3.2, Denmark is the main contributor to the sandeel landings. Up to 2002 Denmark in average contributed 73% of the total landings and after 2002 83%.

Figure 3.3 indicates the sandeel landings by assessment area (Figure 3.1). The Figure indicates that in average 84% of the total landings came from the areas 1 and 3 in the

period 1994 to 2009. However, there has been a significant shift in the relative contribution of the two areas over the period. Up to 2002 area 1 and 3 contributed 46 and 37% respectively whereas their contributions were 65 and 20% in the period 2003 to 2009.

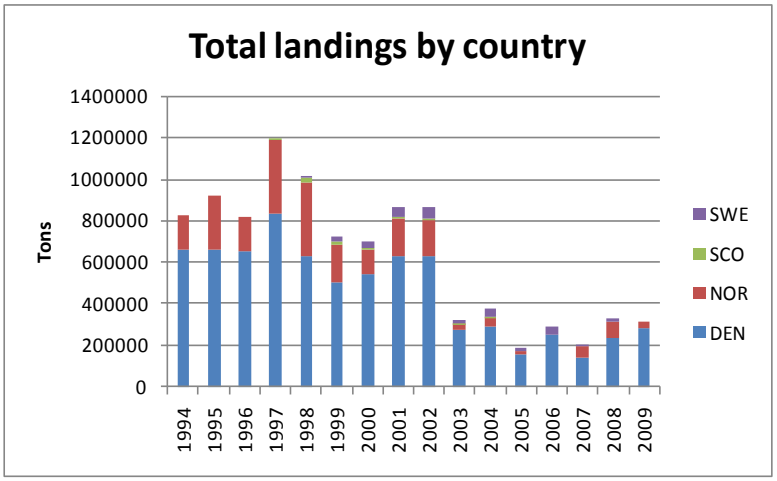


Figure 3.2.

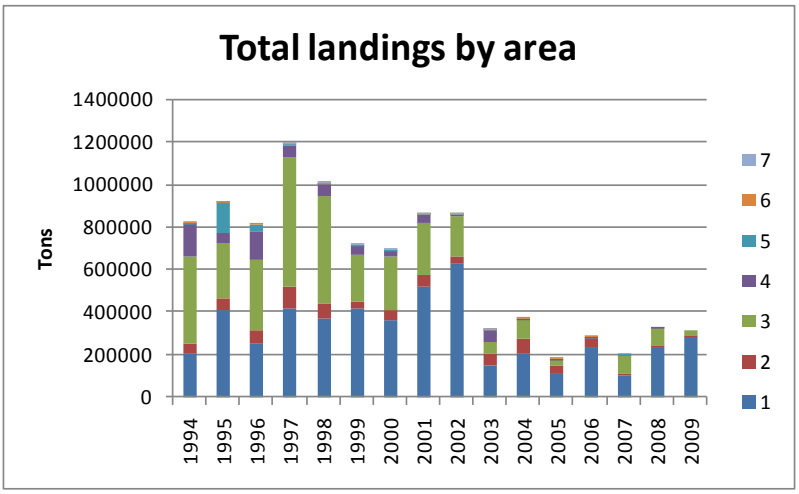


Figure 3.3.

The third most important area for the sandeel fishery is area 2. In the period 2003 to 2009 landings from this area contributed 12% of the total landings in average. The contribution of area 2 over the entire period is 9% in average.

Area 4 has contributed about 6% of the total landings since 1994 but there has been a few outstanding years with particular high landings (1994, 1996 and 2003 contributing 19, 17 and 20% of the total landings respectively). In the periods 1994 to 2002 and 2003 to 2009 the average contributions from area 4 was 8 and 3% respectively. There has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000.

The spatial distribution of sandeel landings is considered as a good representation of stock distribution, except for areas where severe restrictions on fishing effort is applied (i.e. the Firth of Forth, Shetland areas, and Norwegian EEZ in 2006 and 2009). Up to

2002 and particularly prior to 1998, most landings of sandeels in March were taken from the eastern North Sea banks whilst sandeel landings in April–June were mainly from the west Dogger Bank. In some years a relatively large part of the sandeel landings are taken from the central and eastern North Sea along the Danish west coast. From 1991, grounds off the Scottish east coast have been targeted particularly in June. However, since 2000 the banks in the Firth of Forth area have been closed to fishing.

In the Northern North Sea, mainly NEEZ, the change in the spatial pattern was significantly different from southern part. The highest landings from a single statistical square were taken in 1995 on the Vikingbank, the most northerly fishing ground for sandeel in the North Sea. However, in 1996 landings from the Vikingbank dropped substantially, and since 1997 have been close to nil. The marked reduction in landings around 2000 in NEEZ was accompanied by a marked contraction of the fishery to a small area in the southern part of NEEZ, the Vestbank area. In this area landings remained high in 2001 and 2002 due to the strong 2001 year class. However, the 2001 year-class was only abundant in the Vestbank area, which resulted in a highly concentrated fishery and the decimation of the year-class before it reached maturity in 2003. This may have led to the collapse of the sandeel fishery in NEEZ. In the EU EEZ any contraction of the fishery has been less apparent.

The sandeel fishing season was unusual short in both 2005 and 2006, starting later and ending earlier than in previous years. The late start of the fishery was partly because the Danish fishery first opened the 1st April, in accordance with a national regulation introduced in 2005. Further, weekly data on the oil content of sandeels in the commercial landings, provided by Danish fish meal factories, indicated a late onset of sandeels feeding season in both 2005 and 2006 and that sandeels therefore became available to the fishery later than usual. Landings in the second half year of both 2005 and 2006 were on a low level compared to previous years. Only 14 000 tonnes were recorded in 2005 and 17 000 tonnes in 2006.

There has been a significant reduction in fishing effort in the sandeel fishery in recent years (Figure 3.4 and 3.5).

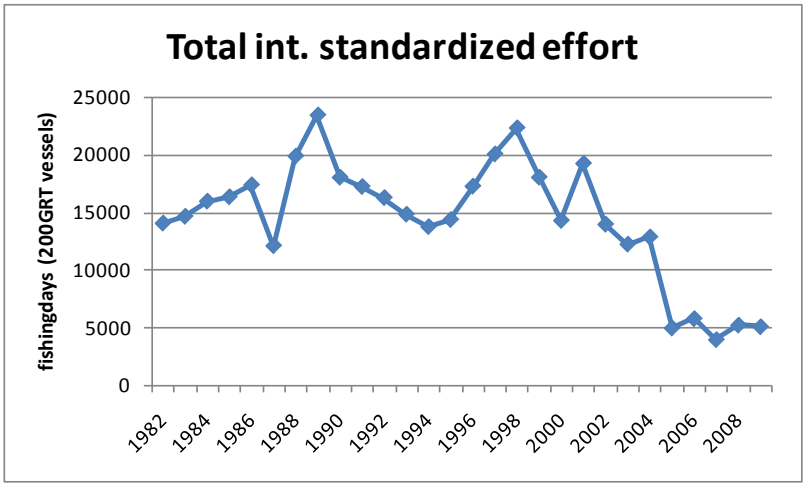


Figure 3.4.

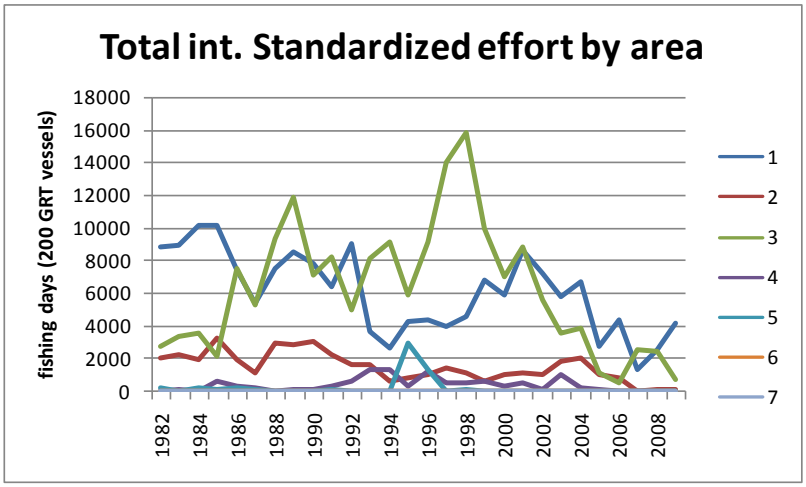


Figure 3.5.

The number of Danish vessels fishing sandeel declined about 50% (from 200 to 84 vessels) from 2004 to 2009. The introduction of an ITQ system in Denmark in 2007 is considered to have contributed to further reducing the fleet capacity and accelerating a change towards fewer and larger vessels. In addition, in 2008, when the TAC was not reached, high fuel prices and low prices of fish meal were claimed by the industry to have limited the fishery.

Also for the Norwegian fleet a drastic decline in number of vessels fishing sandeels has been observed in recent years. Of the 41 Norwegian vessels that fished sandeel in 2007, nine participated for the first time. Since 1998 25 of the 41 vessels entered the fishery during this ten year period, nine vessels were rebuilt (either extended or had larger engines installed) whereas only seven vessels remained unaltered. In addition, there is likely to be a continuous increase in efficiency due to improvement in fishing gear, instruments, etc.

Ecosystem aspects

Sandeels are small, short-lived, lipid-rich, shoaling fish. As such, they represent high quality food for many predatory fish, seabirds and marine mammals (Greenstreet *et al.*, 1997, 1998; Brown *et al.*, 2001; Stafford *et al.*, 2006; Macleod *et al.*, 2007; Daunt *et al.*, 2008). They are especially important in the diet of top predators during the summer, as sandeels then spend much time feeding during the day on zooplankton but burying in the sand at night (Freeman *et al.*, 2004; Engelhard *et al.*, 2008; Greenstreet *et al.*, 2010). At other times of year they mainly remain buried in the sand, where they are inaccessible to many predators such as surface-feeding seabirds, though they continue to be eaten by some predatory fish, seals, and diving seabirds which apparently can dig them out of the sand (Hammond *et al.*, 1994). Although the larvae drift with currents, and following metamorphosis may select on a local scale where to settle on the basis of sediment composition, they do not show extensive horizontal movements after that life-history stage (Gauld, 1990; Wright, 1996; Pedersen *et al.*, 1999; Christensen *et al.*, 2008, Jensen *et al.*, in press).

Top-down effects on sandeels

Demonstrating top-down effects of predators on sandeel stocks is difficult as it is not amenable to experimentation, but relies on detection of correlations; due to different

spatial distributions of key predators it is also quite likely that the relative strength of top-down versus bottom-up control of sandeel abundance may vary between different parts of the North Sea (Frederiksen *et al*., 2007). However, we can assess the likelihood of such top-down effects from information on the amounts of sandeel consumed by different predators; it is unlikely that predators taking only small amounts of sandeel would exert significant top-down effects. Predation rates of seabirds and marine mammals on sandeels are trivial by comparison with predation rates by large fish, as shown by the MSVPA analysis. There is no evidence for depletion of sandeels by seabirds or marine mammals, even locally at major breeding colonies. However, some predatory fish consume very large amounts of sandeels. There is evidence that sandeel stocks increased in abundance in the North Sea following major reductions in the stocks of cod, haddock, whiting, herring, and mackerel, apparently a top-down effect resulting from reduced predation by these fish (Sherman *et al*., 1981).

Bottom–up effects on sandeels

There is strong evidence that sandeel stocks are affected by bottom-up processes involving climate and changing plankton stocks. A study of early larval survival suggested that the match between hatching and the onset of zooplankton production may be an important contributory factor to year-class variability in this species (Wright and Bailey, 1996). Frederiksen *et al*. (2005) used Continuous Plankton Recorder (CPR) data to develop an index of sandeel larval abundance for the Firth of Forth area. The sandeel larval index was strongly positively related to the abundance of phyto- and zooplankton, suggesting strong bottom-up control of sandeel larval survival (Frederiksen *et al*., 2005). Van Deurs *et al*. (2009) showed for the "North Sea sandeel" in ICES area IV 1983–2006 (with anomalous data from 1996 excluded) that a positive spawning stock–recruitment relationship is decoupled in years associated with high abundances of age-1 sandeels, and that survival success of early larvae depends on the abundance of *Calanus finmarchicus* but not *C. helgolandicus* or total Calanus density (again measured by CPR). They postulated that 0-group sandeels compete with older sandeels for copepods and so recruitment is reduced by the presence of high abundance of older (normally predominantly 1-group) sandeels. This conclusion contradicts an earlier finding by Arnott and Ruxton (2002) who studied the same sandeel area but for 1983–1999 only, and found a significant positive relationship between sandeel recruitment and total Calanus density over that time period. It is suggested by Van Deurs *et al.* (2009) that this changed pattern of correlation reflects coincidence of the switch in Calanus species at the same time as a run of poor recruitment years of sandeels after 1999. Van der Kooij *et al*. (2008) showed that sandeel distribution and abundance on the Dogger Bank was best explained by seabed substrate, temperature and salinity. However, contrary to the authors' expectation, their data showed that sandeel local abundance was not strongly related to zooplankton local density.

Top–down effects of sandeels on zooplankton

There appears to be no information on sandeels depleting zooplankton densities over their grounds.

Bottom–up effects of sandeels on higher predators: seabirds

Seabirds are long-lived animals with a low reproductive output. Life-history theory predicts that seabirds should buffer their adult survival rates against fluctuations in their food supply (Boyd *et al*., 2006), and since food-fish are short-lived animals with

high but also variable recruitment rates (Jennings *et al*., 2001), it is inevitable that seabirds will experience large changes in the abundance of the food fish on which they depend. They must, therefore, have evolved the ability to cope with variation in food abundance. The literature indicates that, seabird breeding success does show a close correlation with food fish abundance (Furness and Tasker, 2000; Rindorf *et al*., 2000; Davis *et al*., 2005; Frederiksen *et al*., 2005), whereas breeding numbers and adult survival may not track these short-term fluctuations (Boyd *et al*., 2006). Nevertheless, several recent studies do show a trade-off between adult survival rate (Frederiksen *et al*., 2008b) and reproductive performance, as a result of adults increasing investment when food supply declines and so incurring costs (e.g. Davis *et al*., 2005). But variation in breeding success is much greater, and easier to measure, and so is likely to provide a much clearer signal of food shortage (Furness, 2002; Mitchell *et al*., 2004; Mavor *et al*., 2006).

Most species of seabirds in the North Sea suffered delayed breeding and widespread reproductive failures in 2003, 2004, 2005 and 2006 (Frederiksen *et al*., 2004; Mavor *et al*., 2005, 2006, 2007; Reed *et al*., 2006). The most severe problems, including total failures of some species, occurred in Shetland and Orkney in the northernmost part of the North Sea. Although bad weather during the chick-rearing period was partly to blame at some colonies, the main proximate cause of the breeding failures was a lack of high-quality food (Davis *et al*., 2005; Wanless *et al*., 2005). Most seabirds in the North Sea feed mainly on sandeels during the breeding season (Wanless *et al*., 1998; Furness and Tasker, 2000; Furness, 2002). Since the 1970s, sandeels have been the dominant mid-trophic pelagic fish in the North Sea, and around Shetland no other high-lipid prey fish occur in sufficient numbers to support successful breeding of most piscivorous seabirds (Furness and Tasker, 2000). There is thus little doubt that the observed seabird breeding failures were linked to low availability of sandeel prey (Frederiksen *et al*., 2004).

Furness and Tasker (2000) reviewed the ecological characteristics of seabirds in the North Sea and ranked species from highly sensitive (e.g. terns, kittiwake, Arctic skua) to insensitive (e.g. northern gannet) to reductions in sandeel abundance. They argued that the most sensitive seabirds would be those with high foraging costs, little ability to dive below the sea surface, little 'spare' time in their daily activity budget, short foraging range from the breeding site, and little ability to switch diet. This prediction was supported by empirical data from studies at Shetland (Furness and Tasker, 2000; Poloczanska *et al*., 2004) and at the Isle of May, east Scotland (Frederiksen *et al*., 2004). As one example, Figure 3.1a shows breeding success of kittiwakes on the Isle of May during years of sandeel fishing in the area and in years without sandeel fishing. Breeding success of kittiwakes in both periods varied with sea surface temperature, but was considerably lower when there was a sandeel fishery in the area where these birds were foraging. In Shetland, breeding success of kittiwakes and Arctic skuas (Figure 3.1b) shows very low success during periods of low Shetland sandeel stock biomass (late 1980s and 2000 onwards). Arctic skuas in Shetland feed almost exclusively on sandeels, although they obtain these by stealing them from terns, kittiwakes and auks, and so the link between their breeding success and sandeel stock size is indirect (Davis *et al*., 2005). We can estimate the amount of sandeels consumed by Arctic skuas from data on the numbers and energy requirements of these birds. The annual consumption of sandeels by Arctic skuas at Shetland in the period 1980–2000 is estimated to have been around 65 tonnes per year. This contrasts strongly with the observation that Arctic skua breeding success at Shetland fell to less than half of the level seen in years of high

sandeel abundance when the sandeel stock biomass was below about 30 000 tonnes. The data indicate that Arctic skuas require a sandeel stock biomass about 460 times greater than the amount that they consume, in order to be able to gain energy at a rate sufficient to sustain a good level of breeding success. This seems to be the extreme case, with much lower ratios for kittiwake and even lower for guillemots. Throughout this period, breeding success of gannets remained consistently high in Shetland as those birds were able to switch to feed on adult herring and mackerel, fish too large to be caught (or swallowed) by kittiwakes or Arctic skuas.

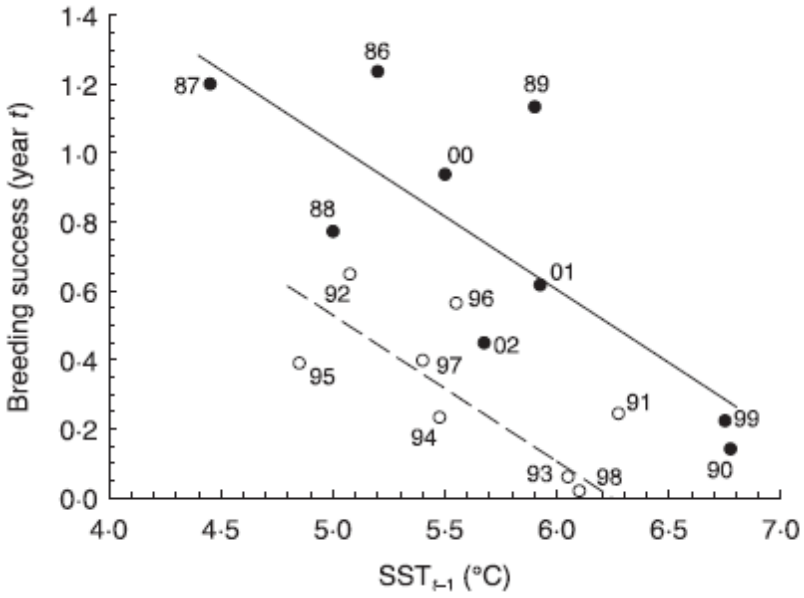


Figure 3.1a. Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Bankie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years. From Frederiksen *et al.*, 2004.

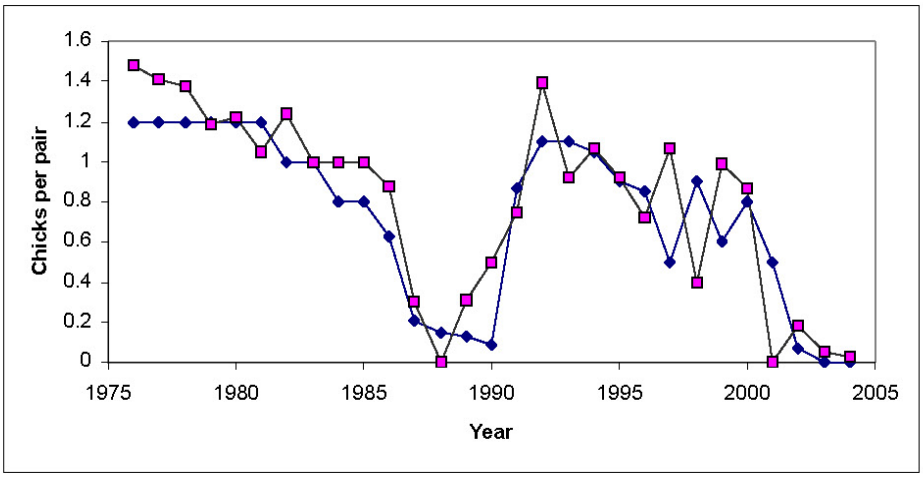


Figure 3.1b. Breeding success of black-legged kittiwakes (pink) and Arctic skuas (blue) at Foula, Shetland, during 1976–2004, showing a close correlation between the success of the two species in this time-series, and periods of particularly low success in 1987–1990 and in 2001–2004.

In 2004, breeding success was exceptionally low for most seabird species on the Isle of May, despite sandeel larvae being abundant in the spring of 2003 so this low breeding success was unexpected. Detailed studies showed that the energy content of both sandeels and sprat fed to seabird chicks in 2004 was extremely low, indicating poor food availability for the fish (Wanless *et al*., 2005). Data from chick-feeding puffins and CPR samples also indicate that the size-at-date of both larval, 0 group and older sandeels has declined substantially since 1973, although it is unclear what the cause of this decline might be (Wanless *et al*., 2004). There is thus evidence that both abundance and quality of seabird prey is under bottom-up control in this region, and this is likely to have affected seabird breeding success.

Bottom–up effects of sandeels on higher predators: fish

Sandeel is an important prey species for a range of natural predators (Hislop *et al*., 1991; WGSAM 2008). Of these, the species most likely to be affected are the species for which the sandeel make up a large proportion of the diet. In the North Sea, this would include whiting, haddock, mackerel, starry ray and grey gurnard (Figure 3.3b). These species all have a diet composition consisting of at least 10% sandeel. However, the proportion only exceeds 20% in the diets of western mackerel and starry ray. Of these two, the diet of western mackerel refers only to the time they spend in the North Sea, and hence the overall average percentage is likely to be lower.

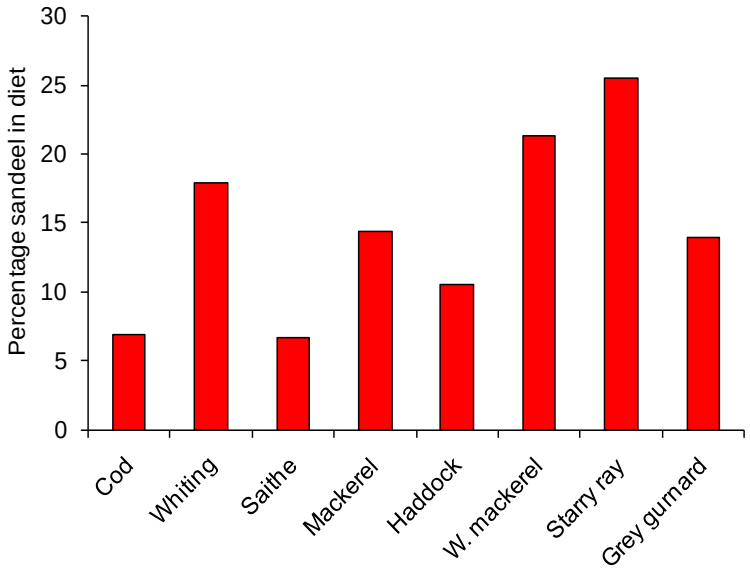


Figure 3.3b. Proportion of the diet consisting of sandeel for different predatory fish (ICES 1997).

Whiting might also be affected by a decline in sandeel availability. However they might also switch prey to consume greater quantities of herring and sprat, since populations of these species have increased in recent years, as has the apparent spatial overlap between whiting and sprat distributions. Two sources of recent data are available to test this hypothesis, from research carried out in the Firth of Forth region as part of the EU FP6 IMPRESS project (1997–2003), and from research carried out on western Dogger Bank ('MF0323' project; 2004–2006).

Three gadoid populations (cod haddock, whiting) were sampled at 19 evenly spaced stations in the Firth of Forth (including Wee Bankie and Marr Bank) on seven research cruises. The contribution of sandeels to the diet of the three gadoid predators varied markedly from year to year, although the importance of sandeels in particular years was consistent across all three species. No evidence of any beneficial effect of the local sandeel fishery closure in 2000 on the abundance or biomass of any of the three gadoid predators was apparent, however, there was evidence that fish condition was greater in years when the proportion of sandeel prey in the diet of each predator was higher (Figure 3.3c; see also Greenstreet 2006).

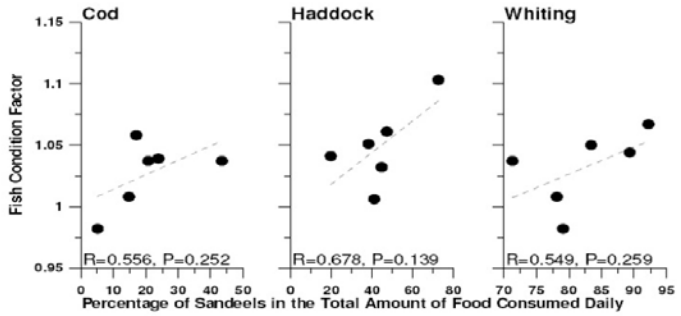


Figure 3.3c. Relationship between the body condition of gadoid predators in the Firth of Forth, and the quantity of sandeels consumed (from Greenstreet *et al.*, 2006).

Between 2004 and 2006, CEFAS conducted investigations into sandeels and their predators on the Dogger Bank ('MF0323' project). Two survey grids were sampled each containing 48 stations, the grids were separated by 28 km. The northernmost survey grid ('grid 1'), on an area known as the 'North-West Riff', was characterised as having high sandeel abundance and was an important area for the sandeel fishing fleet. The southernmost grid ('grid 2') on an area known as 'The Hills' was characterised by much lower sandeel abundance, and was less important to the sandeel fishery. Predator stomachs (mostly whiting, plaice, lesser weeverfish, grey gurnard, haddock, and mackerel) were sampled on six research cruises. The diets of all species were found to vary markedly and consistently between the two sampling grids (Pinnegar *et al.*, 2006). Sandeels were much more important to predators (especially whiting and lesser weeverfish) at grid 1, and this coincides with the greater abundance of sandeels at grid 1, as determined by dredge survey during the night.

Clear seasonal differences were observed in predator diets for all species. Diets were much more diverse during autumn as compared to those in spring. Whiting ate substantially more crabs and sprat during the autumn period as well as hyperid amphipods, and much less sandeel at both sampling grids. Sandeels bury themselves in the sediment during autumn and winter months and are thus less accessible to predators, even though they were more abundant in real terms than was the case during the spring. Preliminary analyses (G. Engelhard, unpublished data) suggest that for some predators, most notably lesser weeverfish *Echiichthys vipera*, body 'condition' was slightly better at the high-sandeel site (grid 1) compared to the low-sandeel site (grid 2). An examination of interannual variability in fish body condition revealed that plaice and weever condition was better in sandeel-rich years and at the sandeel-rich survey grid. Whiting and haddock condition was better in sandeel-rich years, but no site difference was apparent in these mobile species which forage over a large area. Grey gurnard and greater sandeel (*Hyperoplus lanceolatus*) condition appeared not to be significantly linked to sandeel numbers, but positively linked to per-capita sandeel

consumption (condition was better when more sandeels were observed to have been consumed). Thus it was concluded that various predatory fish species do have better condition in years/sites where sandeels are more abundant. In a parallel study carried out in August and October 2006, whiting were sampled aboard commercial fishing vessels all along the North East coast of England (from Flamborough to the Firth of Forth, including the Dogger Bank). It was noted by the crew that the fish caught over areas of hard ground with empty stomachs during the August survey were very thin and of poor condition (Stafford *et al*., 2006). Where stomachs were not empty, the main contents were small crustaceans in August and fish in October. Fish consumed were often non-commercial prey species such as pipefish or hagfish, although gadoids and clupeoids were also consumed. The data show changes from the 1981 and 1991 ICES 'year of the stomach' sampling exercises, when far more sandeel and clupeoids and far less crustaceans were consumed. The authors of this study (Stafford *et al*., 2006) speculate that the limited availability of sandeels in 2006 may have been responsible for the poor body condition of the fish in that year and the selection of nutritionally poor prey items such as snake pipefish.

Other impacts on sandeels

Hassel *et al*. (2004) showed that seismic shooting can kill sandeels, and may impact commercial catches on banks where seismic shooting is occurring. There are concerns that marine wind farms could possibly affect sandeels by altering sediment around turbines and possibly by noise/vibrations. Van Deurs *et al*. (2008) reported that they found no adverse effects of beam trawling on sandeels where beam trawling was carried out over sandeel grounds.

Implications for ecosystem-based management

Due to the stationary habit of post-settled sandeels, a patchy distribution of the sandeel habitat (Holland *et al*., 2005), and a limited interchange of the planktonic stages between the spawning areas, the sandeel stock in IV consists of a number of sub-populations (Pedersen *et al*., 1999; Christensen *et al*., 2008). Within these sub-populations, fishing for sandeels may deplete numbers on particular banks. Recent evidence indicates that although closures can lead to rapid recovery of sandeel numbers in some cases (Greenstreet *et al*., 2010), in others, banks may not be recolonised for some years. Although hydrographical features and the general distribution pattern of the sandeel spawning populations are responsible for most of the variation in recolonisation (Christensen *et al*., 2008), possibly some of the variation in recolonisation of banks after depletion may reflect habitat preferences of sandeels that are seeking sites to settle, with optimal substrate being more attractive (Wright *et al*., 2000). This pattern may also result from some local movement of settled sandeels between adjacent but especially within banks from poorer habitat to preferred habitat (Jensen *et al*., in press). There was evidence for such relocation in Shetland, for example, where high fishery catches continued to be taken from Mousa even when all surrounding banks had become depleted, and breeding success of seabirds such as terns and kittiwakes had fallen close to zero due to shortages of sandeels around most of Shetland. Predators dependent on sandeels (such as kittiwakes) may therefore be adversely affected by local or regional depletion of sandeels. Serial depletion of banks in an area seems to be a particular risk. There is a need for sandeel stock assessment and management to take these risks into account. Exact local densities of sandeels needed to sustain healthy populations of

predators are not known, and no doubt vary according to a range of ecological conditions and predator communities. But research has shown that certain top predators show particularly strong responses to depletion of sandeels. In particular, kittiwake breeding success tends to correlate strongly with abundance of sandeels over about a 50 km foraging radius around kittiwake colonies. In regions where kittiwakes feed predominantly on sandeels while breeding, which is the case in the North Sea, poor breeding success of these "indicator" seabirds can be used as evidence that the local stock of sandeels is depleted. Such evidence is less direct than can be obtained from dredge or acoustic surveys, but may help to identify problem areas where sandeel aggregations need to be allowed to recover. Sandeel stock assessments and subsequent management should also aim to avoid depletion of stocks to levels where damage to ecosystems becomes evident through its impact on dependent predators. Though the actual level at which these adverse effects occur is presently unknown in most cases, it is clear that a stock below the level where recruitment is impaired will significantly increase the probability of effects on top predators and is hence highly unlikely to be compatible with an ecosystem approach to fisheries.

Northeast UK closure

Due to their importance in North Sea food webs, ICES has advised that management should ensure that sandeel abundance be maintained high enough to provide food for a variety of predator species. During the early 1990s a sandeel fishery developed in Area 4, off the Firth of Forth. The landings from this fishery peaked at over 100 000 t in 1993 and then subsequently fell. The Firth of Forth area is important for breeding seabirds and the removal of such large quantities of sandeels within their foraging range soon became a matter of concern. In 1999, the UK called for a moratorium on sandeel fishing adjacent to seabird colonies along the UK coast and in response the EU requested advice from ICES. An ICES Study Group was convened in 1999 in response to this request with two terms of reference (ICES 1999):

a) assess whether removal of sandeel by fisheries has a measurable effect on sandeel predators such as seabirds, marine mammals, and other fish species;

b) assess whether establishment of closed areas and seasons for sandeel fisheries could ameliorate any effects. Identify possible seasons/areas as specifically as possible.

This study group noted that there was suggestion of a negative effect of the Firth of Forth fishery on the local sandeel abundance in 1993 which coincided with a particularly low breeding success of seabirds, especially kittiwakes. The study group concluded that there were two reasons for continued concern about this area that provided the basis for a precautionary closure:

1) sandeels supported a number of potentially sensitive seabird colonies (Lloyd *et al*., 1991).

work on population structure indicated that sandeels in this region are reproductively isolated from the main fished aggregations in the North Sea (Wright *et al*., 1998).

The ICES study group noted that, as sandeel assessments are only conducted for the North Sea, there was no reliable information on the state of the sandeel aggregations near the Firth of Forth, which forms part of area division 4 (see Figure 4). Given available information the study group proposed that kittiwake breeding success was the best practical indicator of sandeel availability at least to seabirds and threshold levels of the breeding success of this species should be used to guide futures decisions on re-

opening. After ICES Advisory committees and STECF acceptance of the study group's advice, the EU advised that the fishery should be closed whilst maintaining a commercial monitoring. However, the EU did not accept the use of kittiwake breeding success as a harvest control threshold. A three year closure, from 2000 to 2002, was decided and the Commission was requested to produce annual reports to the Council on the effects of the restrictions in the sandeel fishery in the Firth of Forth area. On the basis of the second of these reports (Wright *et al*., 2001) and uncertainty over the impact of the closure the commission proposed a further three year extension of the closure. The wording of the Act is stated in article 29a of: "Council Regulation (EC) no 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms". A further scientific review of the closure was made by STECF in 2007, together with other EU fishery closures. That group proposed that it would be prudent to wait for enhanced recruitment and productivity in the area before any re-opening is considered.

Evaluating changes in sandeel abundance in the region has been difficult due to the lack of a single reliable sampling method for assessing sandeel abundance. Nevertheless, the various research (acoustic, trawl and dredge) and commercial abundance indices suggested an initial increase in sandeel abundance during the period of the closure (Greenstreet *et al*., 2006). This increase began with a relatively large recruitment in the first year of the closure, which would not have been related to any recovery in the spawning stock. Dredge surveys in 1999 and 2000 indicated a detectable decrease on total mortality on 1+ sandeels following the closure. A further indication that sandeel abundance increased in the region came from the observation that in 2003, when landings in the North Sea as whole had severely declined, 39 060 tonnes were taken in the ICES rectangle adjacent to the closed area near Marr and Berwick banks.

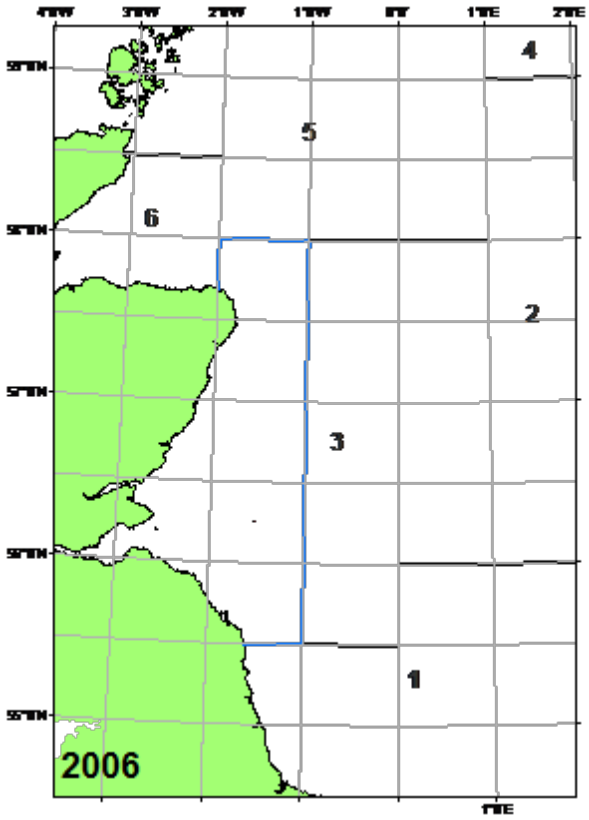


Figure 4. Chart showing the closed area (blue line).

Kittiwake breeding success has tended to be higher since the fishery closure than in the preceding five years. However, poor breeding success in 2004 seen along the whole of the east U.K. coast appears partly related to environmental factors affecting the incoming year class of sandeels. Evidence from studies published since the ICES (1999) study group suggest that the breeding success of this species is not a reliable indicator of sandeel availability to some other coastal seabirds. For example, a downward trend in guillemot breeding success throughout the 1990s has not been reversed by fishery closure (but that species feeds extensively on sprats as well as sandeels in this area). After a series of very poor breeding seasons for seabirds since 2004 on the Isle of May, Firth of Forth, the 2009 season was the most successful in recent years, matching evidence of increased sandeel abundance from the dredge survey. Of six seabird species studied intensively, European shag had its highest productivity on record with only razorbill having productivity below average. All other species studied had their most productive season for at least four years. Sandeels remained the main food of young Atlantic puffins, razorbills and kittiwakes. Comparatively few 1+ group sandeels were present in food samples during the chick-rearing period in 2009, however 0-group appeared in large numbers and were substantially longer than in recent years, again matching dredge results. Kittiwakes had a good season with productivity (0.70 chicks per incubated nest) the highest since 2005 and well above the long-term average. The proportion of sandeel in kittiwake diet (89% by biomass) in 2009 was the highest since 2005.

However, the concern over a possible local impact of sandeel fishing expressed in 1999 has not fundamentally changed. On re-opening, the sandeel aggregations in the North-east closure could be subject to significant depletion unless there were revised management controls. As originally agreed by the Commission, STECF would have to

convene an international meeting of scientists to come up with a consensus on criteria for re-opening.

Data

Age composition and mean individual weight

Data available

Data available included Danish and Norwegian samples from harbour sampling and Danish samples taken by skippers on board vessels and frozen immediately (available from 1999 onwards). The Danish samples cover both age and length distributions whereas the Norwegian samples cover only length distribution prior to 1997 and both age and length samples after 1997. Sandeel measured for length distribution were weighed in the Danish samples whereas only aged sandeel were weighed from the Norwegian samples. To obtain weight-at-length for Norwegian samples, the parameters of the weight–length relationship.

$$W = aL^b$$

were estimated using the sandeel weighed in the Norwegian age samples after 1997 and Danish length–weight relationships before 1997 and weight-at-length estimated for sandeel which were not weighed. All data are combined in the analyses, corresponding to the assumption that the composition of catches taken in a given year and month did not differ between countries and that no differences in age reading existed.

Estimating age–length keys

Only age readings of *Ammodytes marinus* and unidentified sandeel Ammodytes spp. are used. The method suggested by Rindorf and Lewy (2001) is used to assure that the estimation is optimized when sampling is sparse. This method is used to estimate an age–length-key for each combination of year, time and area (Table 4.1.1). When the number of fish aged is too low to allow a reliable estimation on square level (confidence limits of the estimate exceeds +/-25%), higher aggregation levels are used (Table 1). When a given age is not observed in an age sample, this is assumed to reflect an absence of this age only if the number of fish sampled of this age or older exceeds ten. Otherwise, the absence of the particular age is assumed to be a result of low sampling efforts, and the probability of being of the particular age compared to the probability of being older taken from a higher aggregation level. The probability of being of a given age is set to zero at lengths outside the interval of lengths observed for this age +/-2 length groups (1 cm groups from 6 to 20 cm, 2 cm groups between 20 and 30 cm). Overdispersion (Rindorf and Lewy, 2001) was not estimated.

Estimating age distributions and mean weight-at-age

The number of *A. marinus* of each age (0 to 4+) per kg and the mean weight per individual of each age in each length distribution sample is estimated by combining the age–length key and the length distribution specific to square and period. The average number of sandeel per age per kg and their mean weight in a given rectangle in each month was estimated as the average of that recorded in individual samples when at least five samples were available. Mean weight was only estimated when the total catch of a given age in the square exceeded ten. If the total North Sea sampling resulted in less than ten sandeel of a particular age, the mean weight for the North Sea as a whole

was used. When less than five length samples were taken, the next aggregation level (Table 4.1.2) was used. Hence, for each rectangle, month and year, the average number of *A. marinus* per age and kg caught was estimated and the level noted. No correction was made for differences in condition between on-board samples and harbour samples.

Estimating catch in ton per square per month

Before 1989, only logbook information stating the catch in directed Danish sandeel fishery is known. As the large majority of the catch in the sandeel fishery consists of sandeel, the distribution of catches in the directed sandeel fishery on squares and months were assumed to represent the distribution of sandeel catches. The total catch in tonnes was derived from the report of the working group on the assessment of Norway pout and sandeel (ICES, 1995) and distributed on squares and month in the particular year according to the distribution of catches derived from Danish logbooks. From **1989 to 1993**, the landings of sandeel per square and month from the Danish fishery are available at DTU-AQUA. These were used to distribute total landings to square and month. From **1994 to 1998**, international sandeel catches in ton per square per year are available. These catches were distributed to months according to the monthly distribution of Danish catches in the square in the given year. If no Danish catches were recorded from the square, the monthly distribution of the total catches in the ICES division was used. **After 1999**, international sandeel catches in ton per square per month and year are available.

All catches were scaled in order to sum to official ICES landing statistics.

Estimating catch in numbers and mean weight

The catch in numbers per age (1000s), month and square of sandeel is estimated as the product of sandeel catches in kg and the number-at-age of sandeel per kg in the particular square. The total number in a larger area and longer time period is estimated as the sum over individual squares and months in this area. The mean weight (kg) is estimated as the weighted average mean weight (weighted by catch in numbers of the age group in the square and month).

The text table below shows which country supplies which kind of data:

	Data			
Country	Caton (catch in weight, month square)	Length samples from catches	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)
Denmark	x	x	x	x
Norway	x	x	x	
UK/Scotland	x			
Sweeden	x			
Farao Islands	x			

Biological

Both the proportion of natural mortality before spawning (M_{prop}) and the proportion of fishing mortality before spawning (F_{prop}) are set to 0.

The values of natural mortalities for sandeel used in the assessment are based on MSVPA model output, and have been kept constant since 1989 (ICES CM 1989/Assess:13). However, the benchmark assessment group (ICES, 2010) considered that since there were updated estimates of half-yearly natural mortality available from WGSAM, these should be used in the assessment. The most recent estimate of natural mortality was done in 2008 by the Working Group on Multispecies Assessment Methods (WGSAM) in the so-called North Sea key-run (ICES, 2008). Compared to the MSVPA results used as basis for M in the assessment the WGSAM results are based on almost twice as many stomachs observations including both additional stomach samples for the main predators (cod, haddock, whiting, Saithe and mackerel) and additional predators (horse mackerel, grey gurnard, *Raja radiata*, and ten bird species). Figure 3.5 shows the partial predation mortality (M2) of sandeel by year as estimated by WGSAM. It is clear that there has been a significant increase in M since the late 1990s. The natural mortalities by age as estimated by WGSAM show almost equal values for the two half-years, while the M used by the assessment are much higher in the first half year. As the trends in natural mortality were only apparent in the end of the time period where the uncertainty is greatest, it was decided not to use annual estimates of M. Instead, the average over the period 1982 to 2007 for each age and half-year was used.

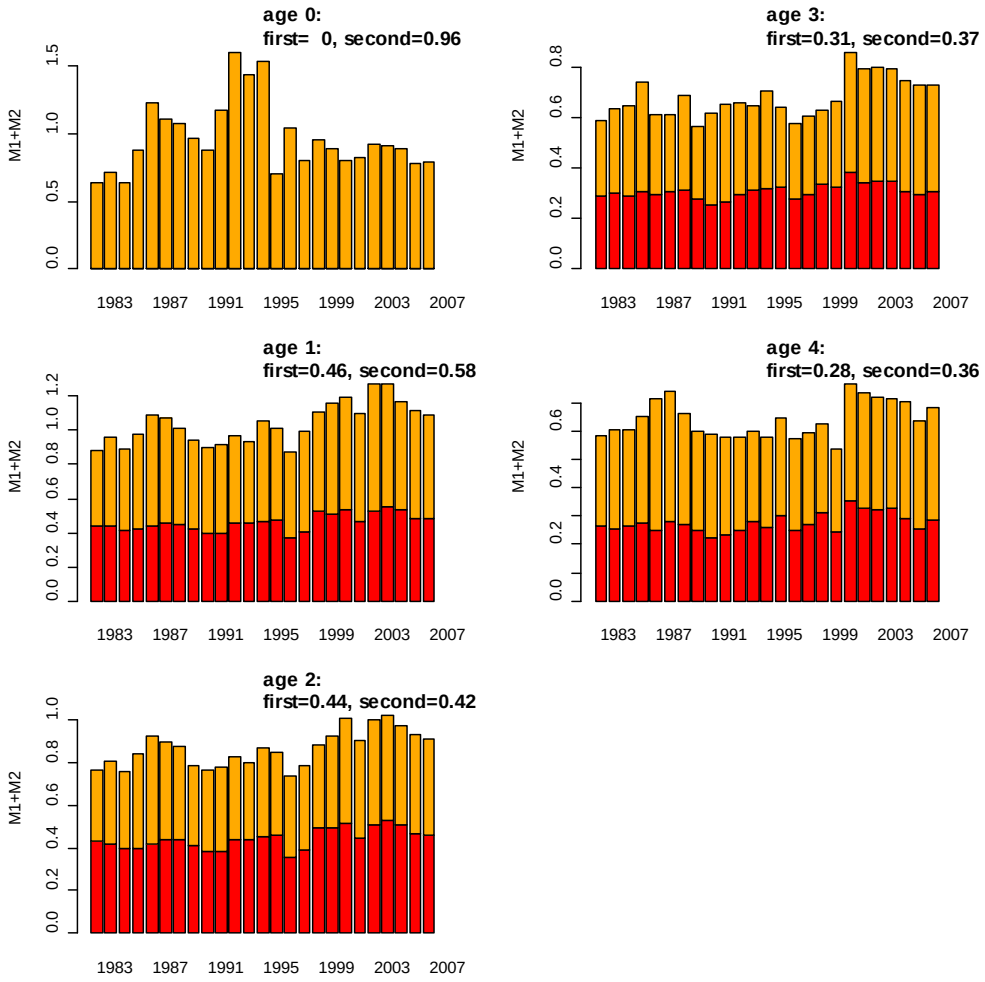


Figure 3.5. Natural mortalities of sandeel by half year. Mean values (1982–2007) for first and second half year are presented in the headings.

Past estimates of spawning stock size assumed a knife edge age-at-maturity, with all sandeels spawning at age 2. A model of maturity in relation to size, age and area found that this assumption did not hold for all sub-population areas (Boulcott *et al*., 2007). The data used in this publication were collected during dredge surveys in 1999 and 2004. Data from 1999, indicated that a significant proportion of sandeels from area 3 were mature by age 1. In area 4, sandeels were found to mature at a smaller size than other areas but because of their low growth rate, the proportion mature by age 2 was still less than 1. Unpublished data for area 4 from 2000 were consistent with the published results. A time-series (2004–2009) of spatially resolved maturity data from the December dredge survey for areas 1–3 is held by the Danish institute. The working paper of Steen (WDA1 in Appendices) evaluates the assumption of knife edge maturity from these data. Whilst most sandeels from the time-series were mature at age 2, there was sufficient deviation from the knife edge age-at-maturity assumption for the benchmark group to decide that annual differences should be considered in area based assessments (see Section 5). For area 4, only the age maturity key of Boulcott *et al*. (2007) was applied, as there was no time-series of data available.

Surveys

Since 2004 DTU Aqua (formerly DIFRES) has carried out a survey with a modified scallop dredge to measure the relative abundance of sandeel in the seabed (REF). The Danish dredge survey is conducted in late November–early December when the 0-group sandeel have been recruited to the settled population and the entire population is assumed to reside in the seabed.

Since 2004, in total 828 hauls have been at fixed positions on known sandeel habitats at known fishing banks in the North Sea from the little Fisher Bank in the Northeastern North Sea, to the Dogger Bank in the Southwestern North Sea (Figure 4.2.1.1). From 2006 additional positions were sampled in the Norwegian EEZ.

As a varying number of hauls have been made at the different positions over the years, calculation of the annual stratified average catch rates (total number caught by hour) for each area was done in a three step procedure: first, for each year, the average catch rate of each position was calculated as the average of the catch rates of all hauls (stations) made on this position, then the average catch rate of each ICES square was calculated as the average of the catch rates of its positions, and finally the average catch rate of each area was calculated as the average of the catch rates of its ICES squares. In other words, the annual average catch rate by area is calculated by:

$$\overline{CPUE}_{a} = \frac{\sum_{sq} \overline{CPUE}_{a,sq}}{n_{a,sq}} \quad (1)$$

where

$$\overline{CPUE}_{a,sq} = \frac{\sum_{pos} \overline{CPUE}_{a,sq,pos}}{n_{a,sq,pos}} \quad (2)$$

where

$$\overline{CPUE}_{a,sq,pos} = \frac{\sum_{st} \overline{CPUE}_{a,sq,pos,st}}{n_{a,sq,pos,st}} \quad (3)$$

where n: number of hauls, a: area, sq: square, pos: position and st: station.

Descriptions of the survey and consistency analysis are given in WP on survey and ICES benchmark report.

Commercial cpue

Until 2009 the sandeel assessment was calibrated by the commercial cpue indices. With the introduction of the dredge survey from 2010 commercial cpue are no longer used for calibration.

Other relevant data

None.

Estimation of historical stock development

The Seasonal XSA (SXSA) developed by Skagen (1993) was up to 2001 used for stock assessment of sandeel in IV. Annual XSA was tried in 2002 WG where it was concluded that the two approaches gave similar results. For a standardization of methodology, it was decided to shift to XSA in 2003. From 2004 to 2009 SXSA was used again for the final assessment. In 2010 the SMS model was used as the assessment in 2009 indicated that the SXSA was sensitive to model settings and changes in effort distribution (ICES, 2009).

Previous whole-area assessments of Sandeel showed no consistent relationship between effort and F but, when moving towards a more biologically plausible assessment area, there is evidence that fishing effort may be used as a reasonable proxy for fishing mortality (Benchmark report, ICES 2010). This relationship has been used by the SMS model as the driver for estimating F. The SMS model has options to estimate rates for technical creeping and thereby take into account that the efficiency has increased in the sandeel fishing fleet. The results show that the new model fits to data in a reasonable way, and give results without retrospective bias. The model can be applied for assessment with just catch and effort, and for assessment where additional fisheries independent data are available.

Methodology

The SMS model, presently used for the ICES assessment of blue whiting (WGWIDE), and for the North Sea and Baltic Sea multispecies (WGSAM), was modified slightly to estimate fishing mortality from observed effort. In the original SMS version, fishing mortality, $F_{y,q,a}$ was modelled as an extended separable model including a seasonal, age and year effect. The new version substitutes the year effect by observed effort.

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $YearEffect_y$ (1, original version)

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $Effort_{y,q}$ (2, new version)

where

indices A*1* and *A2* are groups of ages, (e.g. ages 0, 1–2, 3–4) and *Y* is grouping of years (e.g. 1983–1998, 1999–2009). The SMS-effort defines that the years included in the model can be grouped into a number of period clusters (*Y*), for which the age selection and seasonal selection are assumed constant. Fishing mortality is assumed proportional to effort. The grouping of ages for age selection, *A1*, and season selection, *A1*, can be defined independently.

An example of parameterization with maximum annual effort at 1.0 is shown below. (Unique parameters in bold).

	Season effect A1=age 0 and age 1–4									
	First half year					Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4	Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.426	0.426	0.426	0.426	1.0*	0.5*	0.5*	0.5*	0.5*
1999–2009	0.00*	0.337	0.337	0.337	0.337	1.0*	0.5*	0.5*	0.5*	0.5*

*** kept constant**

	Age effect A2=age 0, age 1, age2 and age 3–4									
	First half year					Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4	Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.488	1.024	1.248	1.248	0.014	0.772	0.847	0.585	0.585
1999–2009	0.00*	0.772	0.857	0.585	0.585	0.010	0.176	0.195	0.133	0.133

"Catchability"-at-age, or more correctly the relation between effort and F by age group, is included in the AgeEffect parameter.

There are two additional options for the SMS-effort version, where technical creeping is taken into account.

$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{Effort}_{y,q} * (y\text{-firstYear})^{\text{commonCreep}(Y)} \quad (3)$$

$$F_{y,q,a} = \text{SesonEffect}(Y,A1) * \text{AgeEffect}(Y,A2,q) * \text{Effort}_{y,q} * (y\text{-firstYear})^{\text{ageCreep}(Y,A1)} \quad (4)$$

Equation (3) uses a common creeping exponent for all ages by one or more year clusters (Y), e.g. the efficient increase by 3.8% per year in the first year range, and 2.8% per year in the second. Equation (4) is more flexible as it allows an age dependent creeping exponent. If we assume that we only use one year cluster (the whole year range) an example could be that the technical creep for age 1 is 5.5% per year, while age 2 has a negative exponent, -2.7% (equivalent to parameter=0.973). As the product of effort and "technical creep" express both the fishing power and the directivity towards a specific age group, such an example indicates that there has been an overall increase in (standardised) fishing power, but the fishery has been less directed towards older sandeel in recent years.

SMS is a statistical model where three types of observations are considered: Total international catch-at-age; research survey cpue (and stomach content observations, which are not used here). For each type a stochastic model is formulated and the likelihood function is calculated. As the three types of observations are independent the total log likelihood is the sum of the contributions from three types of observations. A stock–recruitment (penalty) function is added as a fourth contribution.

Catch-at-age

Catch-at-age observations are considered stochastic variables subject to sampling and process variation. Catch-at-age is assumed to be lognormal distributed with log mean equal to log of the standard catch equation The variance is assumed to depend on age and season and to be constant over years. To reduce the number of parameters, ages

and seasons can be grouped, e.g. assuming the same variance for age 3 and age 4 in one or all seasons. Thus, the likelihood function, L_C, associated with the catches is

$$L_{CATCH} = \prod_{a,y,q} \frac{1}{\sigma_{CATCH\ a,q}\sqrt{2\pi}} \exp\left(-\frac{(\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2}{2\sigma^2_{CATCH\ a,q}}\right)$$

Where

$$E(\log(C_{a,y,q})) = \log\left(\frac{F_{a,y,q}}{Z_{a,y,q}} N_{a,y,q}(1-e^{-Z_{a,y,q}})\right)$$

Leaving out the constant term, the negative log-likelihood of catches then becomes:

$$l_{CATCH} = -\log(L_{CATCH}) \propto NOY \sum_{a,q} \log(\sigma_{CATCH\ a,q}) + \sum_{a,y,q} (\log(C_{a,y,q}) - E(\log(C_{a,y,q})))^2 / (2\sigma^2_{CATCH\ a,q}))$$

Survey indices

Similarly, the survey indices, *cpue(survey,a,y,q)*, are assumed to be log-normally distributed with mean

$$E(\log(CPUE_{survey,a,y,q})) = \log(Q_{survey,a} \overline{N}_{SURVEY\ a,y,q})$$

where Q denotes catchability by survey and $\overline{N}_{SURVEY}$ mean stock number during the survey period. Catchability may depend on a single age or groups of ages. Similarly, the variance of log *cpue*, $\sigma(survey, a)$, may be estimated individually by age or by clusters of age groups. The negative log likelihood is on the same form as for catch observations:

$$l_{SURVEY} = -\log(L_{SURVEY}) \propto \sum_{survey,a} NOY_{survey} \sum_{survey,a} \log(\sigma_{SURVEY\ survey,a}) +$$
$$\sum_{survey,a,y} (\log(CPUE_{survey,a,y}) - E(\log(CPUE_{survey,a,y}))^2 / (2\sigma^2_{SURVEY\ survey,a}))$$

Stock–recruitment

In order to enable estimation of recruitment in the last year for cases where survey cpue and catch from the recruitment age is missing (e.g. saithe) a stock–recruitment relationship $R_y = R(SSB_y \mid \alpha, \beta)$ penalty function is included in the likelihood function. Assuming that recruitment takes place at the beginning of the third quarter of the year and that recruitment is lognormal distributed the parameters the log penalty contribution, l_{SR}, equals

$$l_{SR} = -\log(L_{SR}) \propto NOY\ \log(\sigma_{SR}) + \sum_y ((\log(N_{a=0,y,q=3}) - E(\log(R_y)))^2 / 2\sigma^2_{SR})$$

where

$E(\ln(R_y)) = \ln(\alpha\ SSB_y \exp(-\beta\ SSB_y))$ for the Ricker case. Other stock–recruitment relations (Beverton and Holt and "Hockey stick") and stock-independent geometric mean recruitment have also been implemented. As indicated in equation (26) recruitment-at-age zero in the beginning of the third quarter was considered.

Total likelihood function and parameterisation

The total negative log likelihood function, l_{TOTAL}, is found as the sum of the four terms:

$$l_{TOTAL} = l_{CATCH} + l_{SURVEY} + l_{STOM} + l_{SR}$$

Initial stock size, i.e. the stock numbers in the first year and recruitment over years are used as parameters in the model while the remaining stock sizes are considered as functions of the parameters.

The parameters are estimated using maximum likelihood (ML) i.e. by minimizing the negative log likelihood, l_{TOTAL}. The variance/covariance matrix is approximated by the inverse Hessian matrix. The variance of functions of the estimated parameters (such as biomass and mean fishing mortality) has been calculated using the delta method.

The SMS model was implemented using the AD Model Builder (ADMB Project 2009), freely available from ADMB Foundation (www.admb-project.org). ADMB is an efficient tool including automatic differentiation for Maximum likelihood estimation of many parameters in nonlinear models.

Settings of the SMS model is implicated in the Text Table 1 and the configuration file for Area 1 in Appendix AA.

Text Table 1. Settings of the SMS model.

Option	Area 1	Area 2	Area 3
Data first year	1983	1983	1983
Time step	Half-year	Half-year	Half-year
First age	Age 0	Age 0	Age 0
Last age	Age 4+	Age 4+	Age 4+
Spawning time	Start of 1st half-year	Start of 1st half-year	Start of 1st half-year
Recruitment time	Start of 2nd half-year	Start of 2nd half-year	Start of 2nd half-year
Age range for use of catch data in likelihood	Age 0 – age 4+	Age 0 – age 4+	Age 0 – age 4+
Last age with age dependent selection	Age 3	Age 3	Age 3
Objective function weighting (catch, survey, S/R)	1.0, 0.5, 0.01	1.0, 0.25, 0.01	1.0, 0.5, 0.01
Minimum CV of catch observations	0.2	0.2	0.2
Minimum CV of survey observations	0.2	0.2	0.2
Minimum CV of S/R relation	0.2	0.2	0.2
Catch observations: variance group	Age 0, ages 1 & 2 combined and ages 3 & 4 combined	Age 0, ages 1 & 2 combined and ages 3 & 4 combined	Age 0, ages 1 & 2 combined and ages 3 & 4 combined
Treatment of zero catch observations	Not used in likelihood	Not used in likelihood	Not used in likelihood
Year ranges for constant exploitation pattern	1983–1988, 1989–1998 & 1999-	1983–1998 & 1999-	1983–1988, 1989–1998 & 1999-
Ages for seasonal exploitation pattern	Age 0, and ages 1–4+ combined	Age 0, and ages 1–4+ combined	Age 0, and ages 1–4+ combined

Option	Area 1	Area 2	Area 3
Ages for calculation of mean F	Age 1 & age 2	Age 1 & age 2	Age 1 & age 2
Exclusion of catch data (no or very small catches are available)	2007 second half year	2007 second half year	2007 second half year
Catch Variance	Calculated within SMS	Calculated within SMS	Calculated within SMS
Survey variance	Free parameter	Free parameter	Free parameter
S/R variance	Calculated within SMS	Calculated within SMS	Calculated within SMS
Inflexion point (Blim)	160 000	70 000	100 000
Survey information			
Survey	Area 1: Dredge survey December 2004 Age 0 & age 1	Area 1 (copy) :Dredge survey December 2004 Age 0	Area 3:Dregde survey December 2004 Age 0 & age 1
Half year	2	2	2
Time: Alfa & beta	0.75, 1.0	0.75, 1.0	0.75, 1.0
Last age with age dependent selection	Age 1	Age 0	Age 1
Ages for separate variance estimate	Age 0 and age 1	Age 0	Age 0 and age 1
Power model	Not applied	Not applied	Not applied

Short-term projection

Analysis presented at the benchmark assessment (ICES, 2010) showed consistently large retrospective patterns in the assessments unless the dredge survey is included. Including the dredge survey largely removes this pattern, making it possible to produce unbiased estimate of terminal stock size. Further, the dredge survey shows high consistency both internally and externally in all areas, though the consistency in area 3 was somewhat lower than in the other areas. Though there is currently no coverage of area 2 in the dredge survey, recruitment in area 2 is highly correlated with that in area 1 and it is therefore possible to use the dredge catch rate in area 1 in the assessment of area 2. In area 3, the consistency of the survey is less and the CV of the SMS predictions is greater. Hence, producing an updated assessment following the December survey should provide reliable estimates of stock size in the areas where the relationship between the assessed stock size and dredge catch rate is tight (areas 1 and 2) but less reliable estimates for area 3. The dredge survey in area 4 cannot be used to produce pre-season assessments until the relationship between stock size and dredge catch in the area can be estimated from a longer time series than is presently available.

The benchmark assessment (ICES 2010) recommends that

Two forecasts are provided. The assessment done in September does not include a reliable estimate of recruitment in the second half of the assessment year and forecast will be based on assumptions of recruitment as outlined Table 2a. Another forecast is provided in January of the TAC year when data from the dredge survey are processed and included in the updated assessment. An example of such forecast with known recruitment in the assessment year is shown in Table 2b;

The forecast will be deterministic and be based on half yearly data;

Proportion mature in TAC year is based on latest information from dredge survey;

Proportion mature in year following TAC year is computed as the long-term average (unless a distinct or trend is suspected);

WECA and WEST are computed as averages of last three years;

Exploitation pattern as estimated by SMS for most recent year;

Initial stock size start of TAC year is estimated by SMS assessment;

0-group in start of second half of the TAC year is obtained from long-term geometric mean.

Table 2a. Example of forecast provided in September, where recruitment in the assessment year is unknown. This forecast is based on the escapement strategy of reaching $BMSY_{escapement}$ (100 kt) in the year after the TAC year. (Please note that catch options are not based on real stock estimates).

Area-2 Sandeel						
Basis: Fsq=F(2010)=0.143; Yield(2010)=31; Recruitment(2011)= geometric mean = 2 billions; SSB(2011)=232						
F- multiplier	Basis: Recruitment(2010)	F(2011)	Landings(2011)	SSB(2012)	%SSB change	%TAC change
1.792	Geometric mean* 0	0.256	52	100	-57%	64%
2.326	Geometric mean* 0.2	0.332	68	100	-57%	115%
2.859	Geometric mean* 0.4	0.408	84	100	-57%	167%
3.389	Geometric mean* 0.6	0.484	100	100	-57%	219%
3.916	Geometric mean* 0.8	0.559	117	100	-57%	271%
4.437	Geometric mean* 1	0.633	134	100	-57%	325%

Table 2b. Example of forecast provided in January, where recruitment in the assessment is known. This forecast provides catch options for a range of F multipliers and for MSY (reaching $BMSY_{escapement}$ (100 kt) in the year after the TAC year). (Please note that catch options are not based on real stock estimates).

Area-2 Sandeel						
Basis: Fsq=F(2010)=0.143; Yield(2010)=31; Recruitment(2010)=2 billions; Recruitment(2011)= geometric mean = 2 billions; SSB(2011)=232						
F multiplier	Basis	F(2011)	Landings(2011)	SSB(2012)	%SSB change	%TAC change
0	F=0	0	0	141	-39%	-100%
0.25	Fsq*0.2	0.036	8	135	-42%	-74%
0.5	Fsq*0.5	0.071	16	129	-45%	-49%
0.75	Fsq*0.8	0.107	24	123	-47%	-25%
1	Fsq*1	0.143	31	117	-49%	-2%
1.25	Fsq*1.2	0.178	38	112	-52%	20%
1.5	Fsq*1.5	0.214	45	107	-54%	42%
1.886	MSY	0.269	55	100	-57%	73%

Medium-term projections

Not done.

Long-term projections

Not done.

Biological reference points

Inspection of the stock–recruitment plots from area 1, 2 and 3 revealed a decrease in recruitment at low SSB in all areas (Figure 6.4.1). However, no clear plateau was visible and this was reflected in a very flat surface of the likelihood when attempting to estimate an inflection point. Hence, the group considered that the relationship in all areas fell into the category where there is a relationship between R and SSB but no clear plateau. In this category, SGPRP advised that B_{lim} should be set after evaluation of historic patterns (SGPRP 2003, Figures. 6.4.2 to 6.4.4). The group did not consider the lack of plateau to have occurred through a consistent fishing down of the stock and hence did not think that there was evidence that B_{lim} was above the range of observed SSBs. It was also considered that a period of continuous low recruitment has only occurred around year 2000 and only in areas 2 and 3. After 2000, there has been a very low SSB in all areas but this followed the poor recruitment years rather than the opposite. For area 1 and 2, B_{lim} was therefore set as the median biomass in these years of low SSB (2000–2006) giving the values 160 000 tonnes for area 1 and 70 000 tonnes for area 2. In area 3, the drop in recruitment was also followed by a drop in SSB, but the level in the low period was more variable. For this area, B_{lim} was set at 100 000 tonnes, encompassing the lowest eight SSBs recorded. The level was set at the highest SSB observed in the period 2001–2007 (the period of low SSBs) rather than the median as there has been no really good recruitment years in the latter half of the period.

For short-lived species such as Sandeel, the ICES interpretation of the MSY concept uses B_{pa} estimates as the value for $B_{msy\text{-}trigger}$. This means that should advice follow the same escapement strategy as previously used the fishing opportunities for year y must be set at a level which ensures that B_{msy} is achieved in year y+1. No fishery should be allowed if this level of escapement can be achieved.

Table 3. Summary of Biomass reference points for areas 1–3.

Area	Blim	SSB CV	Bpa
1	160 000	18%	215 000
2	70 000	23%	100 000
3	100 000	40%	195 000

The total of the B_{lim} estimates from areas 1, 2 and 3 is 330 kt and substantially below the historical level of 430 kt determined for the whole North Sea. This is partially due to not having areas 4 and 5 included. However, stock biomasses from these areas represent only a small fraction of the total their contribution to the combined total B_{lim} will be equally small. The difference is therefore mainly caused by two changes in the procedure used. Firstly, the new SMS assessments generate lower estimates of SSB compared to the old data and methodology and secondly, the revised maturity.

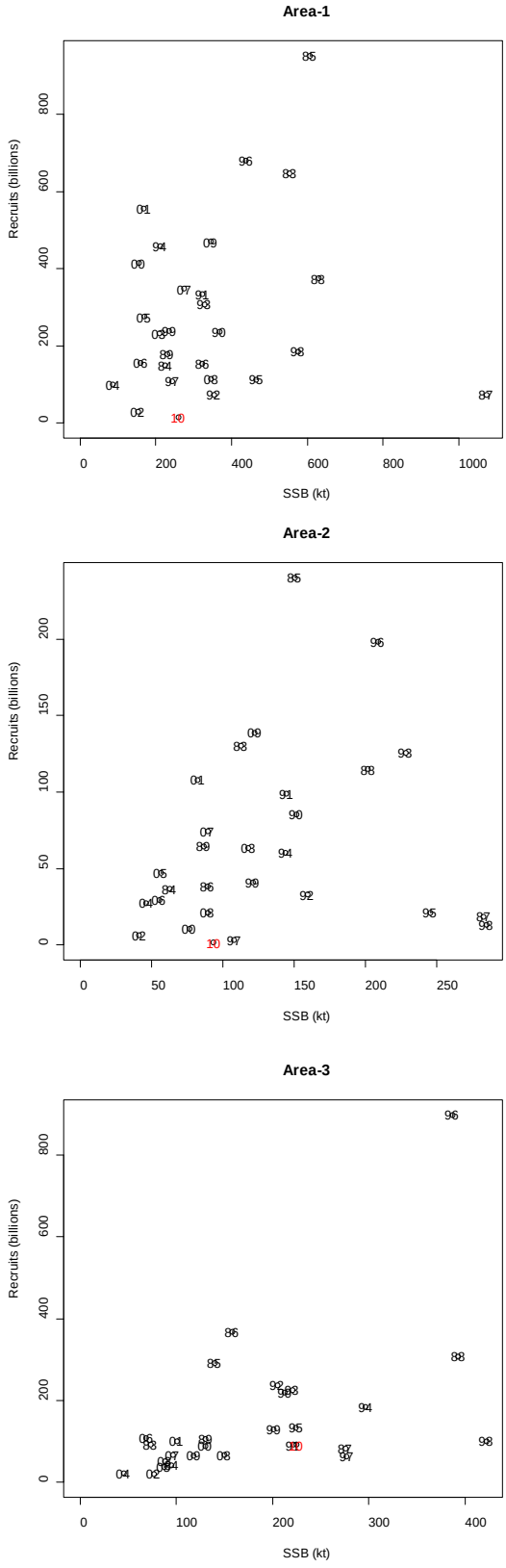


Figure 4. Stock–recruitment relationship in areas 1 to 3. Note that the recruit estimate for 2010 is based on very little input data and is therefore highly unreliable.

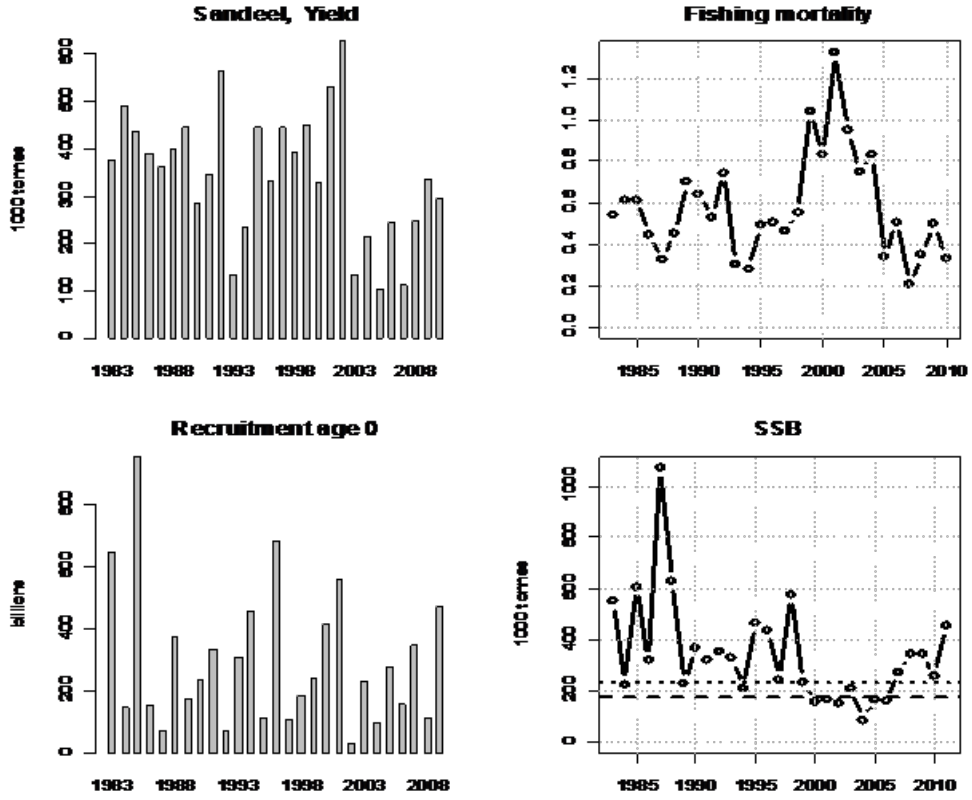


Figure 5. Stock summary for area 1.

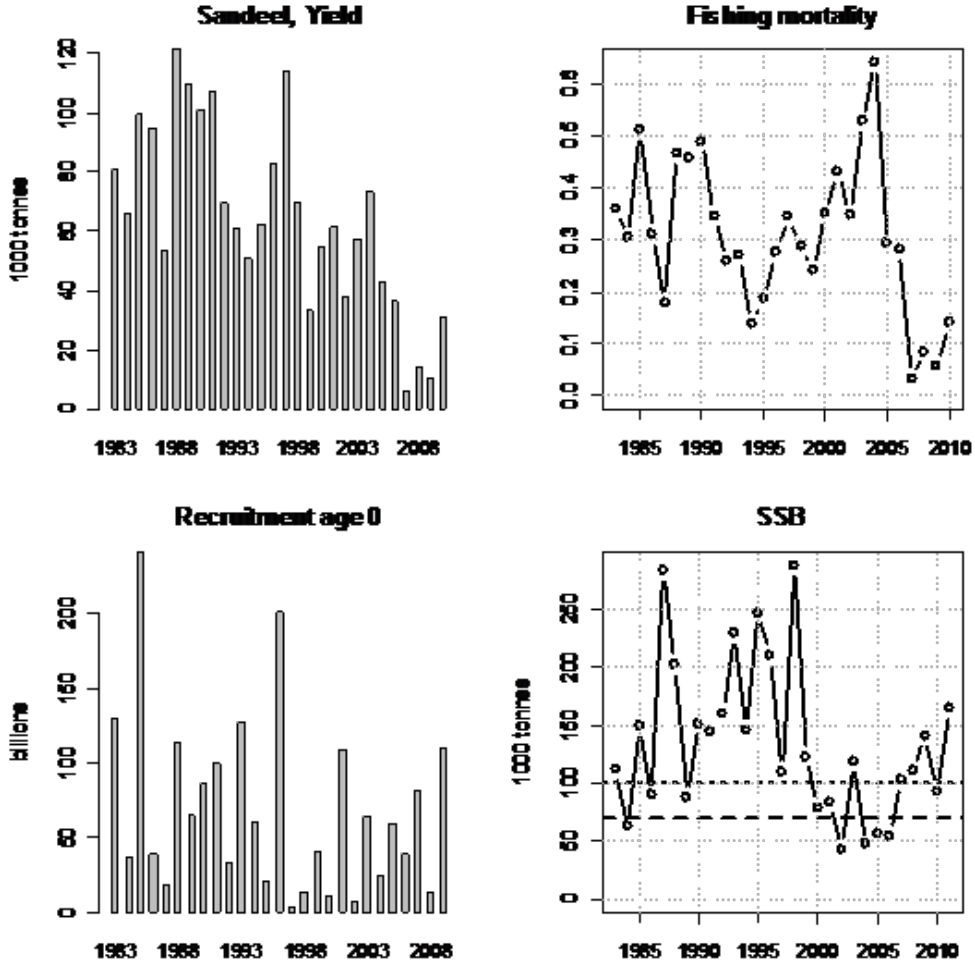


Figure 6. Stock summary for area 2.

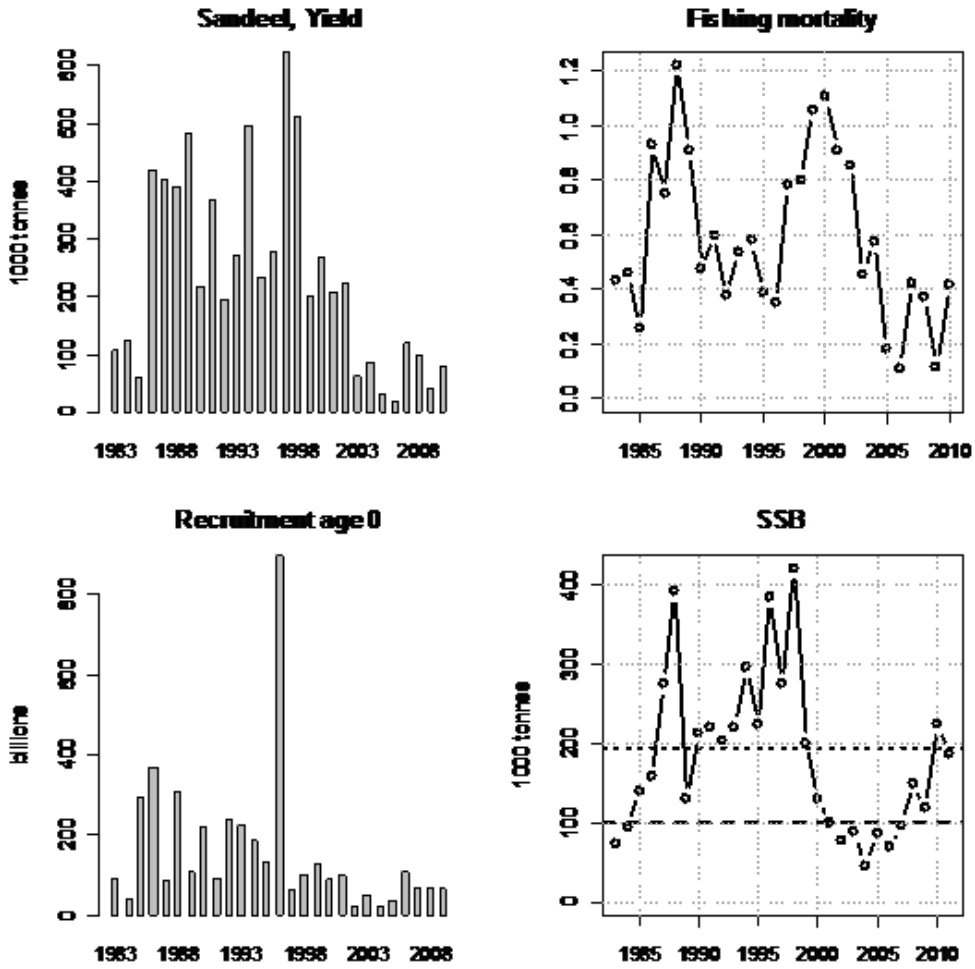


Figure 7. Stock summary for area 3.

The total of the B_{lim} estimates from areas 1, 2 and 3 is 330 kt and substantially below the historical level of 430 kt determined for the whole North Sea. This is partially due to not having areas 4 and 5 included. However, stock biomasses from these areas represent only a small fraction of the total their contribution to the combined total B_{lim} will be equally small. The difference is therefore mainly caused by two changes in the procedure used. Firstly, the new SMS assessments generate lower estimates of SSB compared to the old data and methodology and secondly, the revised maturity estimates provide lower SSBs at the same biomass of 2+-year olds. Further, the previous B_{lim} level was set in 1998 at the lowest observed spawning–stock since there was no indication of a relationship between SSB and recruitment at the time. Since then the stocks have been through a period of lower SSB, some of which have still produced reasonable recruitments, and it is these observations which now inform the selection of reference points.

In-season monitoring of sandeel

The sandeel fishery and stock are in most years dominated by 1-group sandeel for which very little information exists before the fishery is opened. Commercial cpue is a poor predictor of 0-group recruitment and reliable indices from surveys were not available until 2010 when the Danish dredge survey data from area 1 and 3 was applied.

Since 2004, therefore, information on the 1-group abundance has been obtained from in-season monitoring of the fishery in the start of the fishery (1 April to around 5 May).

The methodology for in-season monitoring has been unchanged since 2007 and is described in detail in ICES CM 2007/ACFM:38.

The benchmark meeting (WKSAN 2010) considered that the rise in importance and reliability of the dredge survey has potential area specific implications for the in-season monitoring programme:

Area 1

Statistics show that the dredge survey is sufficiently robust to provide an estimate of the incoming 1-group such that the fishing opportunities for the coming year can be established in January. Although this relationship appears to be robust it may be prudent to continue some level of real-time monitoring in years where the dredge survey result is outside the bounds of the current observations particularly at the lower bound. There will be regular samples passed to DTU-Aqua as part of the standard monitoring process every year, but the requirement for real-time monitoring would only occur when the dredge survey is beyond historically observed bounds.

Area 2

There appears to be a sufficiently robust relationship between the recruitments in areas 1 and 2 to be able to use the same data sources and procedures from area 1 for the estimation of the incoming year class. There should, however, be an increase in the sampling coverage within this area.

Area 3

Pre-season estimates of the incoming year class appears less robust for this area and it is therefore appropriate that in-season monitoring (e.g. acoustic monitoring and age-based commercial cpue) to continue in area 3. The internal and external consistency of the acoustic survey is yet unknown and the consistency of commercial and dredge data is less in area 3 than in the other areas.

Area 4

Whilst it is important to continue the Scottish dredge survey the overlap between this and the commercial time-series is too short to provide robust estimates of incoming 1-group strength. There has been little or no information for this area from the in-year monitoring system in recent years due to the low commercial effort level expended in the area.

The dredge survey information is sufficient to provide TAC advice in Areas 1 and 2, without requiring the in-season processing and incorporation of in-season monitoring in most cases. Increasing the coverage and time-series length of dredge surveys in other areas may lead to a similar reduction or elimination of the need for in-year processing in those areas.

Other issues

Recent investigations (Greenstreet *et al*., 2006) showed the biomass of age 1+ sandeels increased sharply in the Firth of Forth area in the first year of the closure and remained higher in all four of the closure years analysed, than in any of the preceding three years, when the fishery was operating. Further, the biomass of 0-group sandeels in three of the four closure years exceeded the biomass present in the three years of commercial

fishing. The closure appears to have coincided with a period of enhanced recruit production.

References

Arnott, S.A., Ruxton, G.D. 2002. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Marine Ecology Progress Series 238:199–210.

Boulcott P., Wright P.J., Gibb F., Jensen H. and Gibb I. 2006. Regional variation in the maturation of sandeels in the North Sea. ICES Journal of Marine Science. 64: 369–376.

Boyd, I.L., Wanless, S., and Camphuysen, C.J. eds. 2006. *Top predators in marine ecosystems: their role in monitoring and management.* Cambridge University Press, Cambridge.

Brown, E. G., Pierce, G. J., Hislop, J. R. G., Santos, M. B. 2001. Inter-annual variation in the summer diets of harbour seals *Phoca vitulina* at Mousa, Shetland (UK). Journal of the Marine Biological Association of the UK, 81: 325–337.

Christensen A., Hochbaum U., Jensen H, Mosegaard H, St. John M., and Schrum C. Hydrodynamic backtracking of fish larvae by individual-based modelling. Accpeted by MEPS.

Christensen A., Jensen H., Mosegaard H., St. John M., and Schrum C. Sandeel larval transport patterns in North Sea from an individual-based hydrodynamic egg and larval model. Submitted.

Christensen, A., Jensen, H., Mosegaard, H., St John, M., Schrum, C. 2008. Sandeel (*Ammodytes marinus*) larval transport patterns in the North Sea from an individual-based hydrodynamic egg and larval model. Canadian Journal of Fisheries and Aquatic Sciences, 65: 1498–1511.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C., Harris, M. P. 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 65: 362–381.

Daunt F., Wanless S, Greenstreet S.P.R., Jensen H., Hamer K.C. Hamer and Harris P.H. The impact of fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Submitted.

Davis, S.E., Nager, R.G., Furness, R.W. 2005. Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology, 86, 1047–1056.

Engelhard, G.H., van der Kooij, J., Bell, E.D., Pinnegar, J.K., Blanchard, J.L., Mackinson, S., Righton, D.A. 2008. Fishing mortality versus natural predation on diurnally migrating sandeels *Ammodytes marinus.* Marine Ecology Progress Series 369: 213–227.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P., Wilson, L.J. 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41, 1129–1139.

Frederiksen, M., Wright, P.J., Heubeck, M., Harris, M.P., Mavor, R.A., Wanless, S. 2005. Regional patterns of kittiwake *Rissa tridactyla* breeding success are related to variability in sandeel recruitment. Marine Ecology Progress Series 300:201–211.

Frederiksen, M., Furness, R.W., Wanless, S. 2007. Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Mar. Ecol. Prog. Ser. 337, 279–286.

Frederiksen, M., Jensen, H., Duant, F., Mavor, D.R. Wanless, S. 2008. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Ecological Applications, 18: 701–710.

Frederiksen M., Jensen. H., Daunt F., Mavor R.A., and Wanless S. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Submitted.

Freeman, S., Mackinson, S., Flatt, R. 2004. Diel patterns in the habitat utilisation of sandeels revealed using integrated acoustic surveys. Journal of Experimental Marine Biology and Ecology 305: 141–154.

Furness, R.W. 2002. Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. ICES Journal of Marine Science 59:261–269.

Furness, R. W., Tasker, M. L. 2000. Seabird–fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 202: 253–264.

Gauld, J. A. 1990. Spawning and fecundity in the lesser sandeel, *Ammodytes marinus* (Raitt), in the north-western North Sea. Journal of Fish Biology, 36: 611–613.

Gauld A. 1990. Movements of lesser sandeels (*Ammodytes marinus* Raitt) tagged in the northwestern North Sea. J. Cons. int. Explor. Mer. 46: 229–231.

Greenstreet, S. P. R. 2006. Does the prohibition of industrial fishing for sandeel have any impact on local gadoid populations? In Management of Marine Ecosystems, pp. 223–235. Ed. by I. L. Boyd, S. Wanless, and C. J. Camphuysen. Cambridge University Press, Cambridge, UK.

Greenstreet, S. P. R., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I. M., Fraser, H. M., Scott, B., *et al*. 2006. Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63: 1530–1550.

Greenstreet, S. P. R., Bryant, A. D., Broekhuizen, N., Hall, S. J., Heath, M. R. 1997. Seasonal variation in the consumption of food by fish in the North Sea and implications for foodweb dynamics. ICES Journal of Marine Science, 54: 243–266.

Greenstreet, S. P. R., McMillan, J. A., Armstrong, F. 1998. Seasonal variation in the importance of pelagic fish in the diet of piscivorous fish in the Moray Firth, NE Scotland: a response to variation in prey abundance? ICES Journal of Marine Science, 55: 121–133.

Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M., Gibb, I.M. 2010. Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. ICES Journal of Marine Science 67: 971–984.

Hammond, P. S., Hall, A. J., Prime, J. H. 1994. The diets of grey seals around Orkney and other island and mainland sites in north-eastern Scotland. Journal of Applied Ecology 31: 340–350.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Østensen, Ø., Fonn, M., Haugland, E. K. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES Journal of Marine Science 61: 1165–1173.

Hislop, J. R. G., Robb, A. P., Bell, M. A., Armstrong, D. W. 1991. The diet and food consumption of whiting (*Merlangius merlangus*) in the North Sea. ICES Journal of Marine Science, 48: 139–156.

Holland, G. J., Greenstreet, S. P. R., Gibb, I. M., Fraser, H. M., Robertson, M. R. 2005. Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 303: 269–282.

ICES 1986. Report of the Industrial Fisheries Working Group. ICES C.M. 1986/Assess:15.

ICES 1987. Report of the Industrial Fisheries Working Group. ICES C.M. 1987/Assess:17.

ICES 1988. Report of the Industrial Fisheries Working Group. ICES C.M. 1988/Assess:15.

ICES 1989. Report of the Industrial Fisheries Working Group. ICES C.M. 1989/Assess:13.

ICES 1990. Report of the Industrial Fisheries Working Group. ICES C.M. 1990/Assess:13.

ICES 1991. Report of the Industrial Fisheries Working Group. ICES C.M. 1991/Assess:14.

ICES 1992. Report of the Industrial Fisheries Working Group. ICES C.M. 1992/Assess:9.

ICES 1994. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1994/Assess:7.

ICES 1995. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1995/Assess:5.

ICES 1999. Report of the Study group on effects of sandeel fishing. ICES 1999/ACFM:19.

ICES-ACFM 2005. Report of the ICES Advisory Committee on Fishery Management, Advi-sory Committee on the Marine Environment and Advisory Commit tee on Ecosystems, 2005. ICES ADVICE 2005 AVIS DU CIEM Volumes IV.

ICES-AGSAN 2007. Report of the Ad Hoc Group on Sandeel. ICES CM 2007/ACFM:38.

ICES WGECO 2004. Report of the Working Group on the Ecosystem Effects of Fishing Activities. ICES C.M. 2004/ACE:0*, Ref. D,E,G.

ICES WGNSSK 1996. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1996/Assess:6.

ICES WGNSSK 1997. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1997/Assess:6.

ICES WGNSSK 1998. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1998/Assess:7.

ICES WGNSSK 1999. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1999/ACFM:8.

ICES WGNSSK 2000. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2000/ACFM:7.

ICES WGNSSK 2001. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 2. ICES C.M. 2001/ACFM:7.

ICES-WGNSSK 2003. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2003/ACFM:2.

ICES-WGNSSK 2005. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2005/ACFM:07.

ICES-WGNSSK 2006. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2006/ACFM:09.

ICES WGNSSK 2007. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak.ICES CM 2007/ACFM:35.

ICES-SGMSNS 2005. Report of the Study Group on Multispecies Assessments in the North Sea (SGMSNS). ICES CM 2005/D:06.

ICES-SGRECVAP 2006. Report of the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP). ICES CM 2006/LRC:03.

Jensen H.; Rindorf A.; Horsten M.B.; Mosegaard H.; Brogaard P.; Lewy P.; Wright P.J.; Ken-nedy F.M.; Gibb I.M.; Ruxton G.; Arnott S.A. and Leth J.O. 2001. Modelling the population dy-namics of sandeel (Ammodytes marinus) populations in the North Sea on a spatial resolved level. DG XIV no. 98/025.

Jensen H., Mosegaard H., Rindorf A., Dalskov J. and Brogaard P. 2002. Indsamling af detaljerede oplysninger om tobisfiskeriet i Nordsøen. DFU rapport no. 97-02.

Jensen and Vinther. 2003. Estimation of fishing effort for the Danish sandeel fishery in the North Sea based on catch per unit effort data. Working document for the 2003 ICES WGNSSK meeting in Bolougne.

Jensen H. and Rolev A.M. 2004. The Sandeel fishing grounds in the North Sea. Information about the foraging areas of the lesser sandeel Ammodytes marinus in the North Sea. Working document prepared for the BECAUSE project, November 2004.

Jensen, H., Rindorf, A., Wright P. J., Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science. (in press).

Jennings, S., Kaiser, M.J., Reynolds, J.D. 2001. *Marine fisheries ecology*. Blackwell, Oxford.

Lewy, P. and M. Vinther. 2004. A stochastic age–length-structured multispecies model applied to North Sea stocks. ICES CM 2004/FF:20.

Macleod, C.D., Santos, M.B., Reid, R.J., Scott, B.E., Pierce, G.J. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters 3: 185–188.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2005. *Seabird numbers and breeding success in Britain and Ireland, 2004.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2006. *Seabird numbers and breeding success in Britain and Ireland, 2005.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2007. *Seabird numbers and breeding success in Britain and Ireland, 2006.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mitchell, P.I., Newton, S.F., Ratcliffe, N., Dunn, T.E. 2004. Seabird populations of Britain and Ireland. T and AD Poyser, London.

Pedersen, S. A., Lewy, P., Wright, P. 1999. Assessments of the lesser sandeel (*Ammodytes marinus*) in the North Sea based on revised stock divisions. Fisheries Research, 41: 221–241.

Pinnegar, J.K., van der Kooij, J., Engelhard, G.H., Blanchard, J.L., Warr, K.J., Righton, D. 2006. Small-scale variability in fish diet and whether or not this reflects local patterns of prey availability. ICES CM 2006/F:07.

Poloczanska, ES, Cook, RM, Ruxton, GD and Wright, PJ. 2004. *Fishing vs. natural recruitment variation in sandeels as a cause of seabird breeding failure at Shetland: a modelling approach.* Ices Journal Of Marine Science, 61. pp. 788–797.

Pope, J. G. 1980. Some consequences for fisheries management of aspects of the behaviour of pelagic fish. Rapp. P.-v. Reun. Cons. Explor. Mer 177, 466–476.

Proctor, R., Wright, P.J. and Everitt, A. 1998. Modelling the transport of larval sandeels on the north west European shelf. Fisheries Oceanography.7, 347–354.

Reed, T.E., Wanless, S., Harris, M.P., Frederiksen, M., Kruuk, L.E.B., Cunningham, E.J.A. 2006. Responding to environmental change: plastic responses vary little in a synchronous breeder. Proceedings of the Royal Society Series B, 273, 2713–2719.

Rindorf, A., Wanless, S., Harris, M. P. 2000. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 202: 241–252.

Sherman, K., Jones, C., Sullivan, L., Smith, W., Berrien, P., Ejsymont, L. 1981. Congruent shifts in sandeel abundance in western and eastern North Atlantic ecosystems. Nature, 291: 486–489.

Stafford, R., Whittaker, C., Velterop, R., Wade, O., Pinnegar, J. 2006. Final Report, Programme 13: North Sea Whiting Stomach Contents. *Fisheries Science Partnership: 2006/07.* 25pp.

STECF 2004. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2003 Year-class of North Sea Sandeel".

STECF 2005a. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2004 Year-class of North Sea Sandeel".

STECF 2005b. REPORT of the STECF Ad-Hoc Working Group on Sandeel Fisheries. No-vember 7th–9th 2005, Charlottenlund. Denmark.

STECF 2006. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2005 Year-class of North Sea Sandeel".

Ulltang, Ø. 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and re-quiring a new approach Rapp. P.-v. Reun. Cons. Explor. Mer 177, 489–504.

Van der Kooij, J., Scott, B.E., Mackinson, S. 2008. The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. Journal of Sea Research 60: 201–209.

Van Deurs, M., van Hal, R., Jensen, H., Tomczak, M.T., Dolmer, P. 2008. A spatially and temporally explicit analysis of beam-trawling on sandeel fishing grounds in the North Sea. Working Document to ICES AGSAN2.

Van Deurs, M., van Hal, R., Tomczak, M.T., Jónasdóttir, S.H., Dolmer, P. 2009. Recruitment of lesser sandeel *Ammodytes marinus* in relation to density dependence and zooplankton composition. Marine Ecology Progress Series 381: 249–258.

Wanless, S., Harris, M. P., Greenstreet, S. P. R. 1998. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. ICES Journal of Marine Science, 55: 1141–1151.

Wanless, S., Wright, P.J., Harris, M.P., Elston, D.A. 2004. Evidence for decrease in size of lesser sandeels *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 279, 237–246.

Wanless, S., Harris, M.P., Redman, P., Speakman, J. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 294, 1–8.

Wright, P. J. 1996. Is there a conflict between sandeel fisheries and seabirds? In:, Aquatic predators and their prey, pp. 154–165. Ed. by S. P. R. Greenstreet and M. L. Tasker. Fishing News Books, Blackwell Science, Oxford. 191 pp.

Wright, P.J. and Bailey, M.C. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology 126, 143–152.

Wright, P. J., Jensen, H., Tuck, I. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 44: 243–256.

Wright P., Verspoor E., Andersen C., Donald L., Kennedy F., Mitchell A., Munk P., Pedersen S.A., Jensen H., Gislason H. and Lewy P. 1998. Population structure in the lesser sandeel (*Ammodytes marinus*) and its implications for fishery-predator interactions. DG XIV no. 94/071.

Wright P.J., Jensen H., Mosegaard H., Dalskov J. and Wanless S., 2002. European Commis-sion's annual report on the impact of the Northeast sandeel fishery closure and status report on the monitoring fishery in 2000 and 2001.

Appendix A. Configuration file for Area 1

SMS.dat option file

the character "#" is used as comment character, such that all text and numbers after # are skipped by the SMS program

```
#
# Produce test output (option test.output)
#  0 no test output
#  1 output file SMS.dat and  file fleet.info.dat as read in
#  2 output all single species input files as read in
#  3 output all multi species input files as read in
#  4 output option overview
#
# 11 output between phases output
# 12 output iteration (obj function) output
# 13 output stomach parameters
# 19 Both 11, 12 and 13
#
# Forecast options
# 51 output HCR_option.dat file as read in
# 52 output prediction output summary
# 53 output prediction output detailed
0
# Single/Multispecies mode (option VPA.mode)
# 0=single species mode
# 1=multi species mode, but Z=F+M (used for initial food suitability parameter estimation)
# 2=multi species mode, Z=F+M1+M2
0
## first year of input data (option first.year)
1983
## last year of input data (option last.year)
2010
## last year used in the model (option last.year.model)
2010
##  number of seasons (option last.season). Use 1 for annual data
2
## last season last year (option last.season.last.year). Use 1 for annual data
2
## number of species (option no.species)
1
```

```
# Species names, for information only. See file species_names.in
## first age all species (option first.age)
0
## recruitment season (option rec.season). Use 1 for annual data
2
## maximum age for any species(max.age.all)
4
## various information by species
# 1. last age
# 2. first age where catch data are used (else F=0 assumed)
# 3. last age with age dependent fishing selection
# 4. Last age included in the catch at age likelihood (normally last age)
# 5. plus group, 0=no plus group, 1=plus group
# 6. predator species, 0=no, 1=VPA predator, 2=Other predator
# 7. prey species, 0=no, 1=yes
# 8. Stock Recruit relation, 1=Ricker, 2=Beverton & Holt, 3=Geom mean,
#                       4= Hockey stick, 5=hockey stick with smoother,
#                       >100= hockey stick with known breakpoint (given as input)
##
4 0 3 4 1 0 0  170000
## adjustment factor to bring the beta parameter close to one (option beta.cor)
      1e+08
## year range for data included to fit the R-SSB relation (option SSB.R.year.range)
# first (option SSB.R.year.first) and last (option SSB.R.year.last) year to consider.
# the value -1 indicates the use of the first (and last) available year in time series
# first year by species
        -1
# last year by species
        2009
## Objective function weighting by species (option objective.function.weight) (de-
fault=1)
# first=catch observations,
# second=CPUE observations,
# third=SSB/R relations
```

fourth=stomach observations SPECIAL SANDEEL -1=Creep by year, -2=Creep by age-group

##

1 0.5 0.01 0

parameter estimation phases for single species parameters

phase.rec (stock numbers, first age) (default=1)

1

phase.rec.older (stock numbers, first year and all ages) (default=1)

1

phase.F.y (year effect in F model) (default=1)

1

phase.F.q (season effect in F model) (default=1)

1

phase.F.a (age effect in F model) (default=1)

1

phase.catchability (survey catchability) (default=1)

1

phase.SSB.R.alfa (alfa parameter in SSB-recruitment relation) (default=1)

1

phase.SSB.R.beta (beta parameter in SSB-recruitment relation) (default=1)

-1

minimum CV of catch observation used in ML-estimation (option min.catch.CV) (default=0.2)

0.20

minimum CV of catch SSB-recruitment relation used in ML-estimation (option min.SR.CV) (default=0.2)

0.2

use seasonal or annual catches in the objective function (option combined.catches)

do not change this options from default=0, without looking in the manual

0=annual catches with annual time steps or seasonal catches with seasonal time steps

1=annual catches with seasonal time steps, read seasonal relative F from file F_q_ini.in (default=0)

0

use seasonal or common combined variances for catch observation (option seasonal.combined.catch.s2)

seasonal=0, common=1 (use 1 for annual data)

```
  0
##
# catch observations: number of separate catch variance groups by species
 3
#  first age group in each catch variance group
0 1 3     #  Sandeel
##
# catch observations: number of separate catch seasonal component groups by species
  2
#  first ages in each seasonal component group by species
0 1       #  Sandeel
## first and last age in calculation of average F by species (option avg.F.ages)
1 2
## minimum 'observed' catch, (option min.catch). You cannot log zero catch at age!
#
# value 0 = Ignore data point in likelihood
# negative value gives percentage (e.g. -10 ~ 10%) of average catch in age-group for
# input catch=0
# negative value less than -100 substitute all catches by the option/100 /100 *average
# catch in the age group for catches less than (average catch*-option/10000
#
# if option>0 then will zero catches be replaced by catch=option
#
# else if option<0 and option >-100 and catch=0 then catches will be replaced by catch=average(catch at age)*(-option)/100
# else if option<-100  and catch < average(catch at age)*(-option)/10000 then catches will be replaced by catch=average(catch at age)*(-option)/10000
#  Sandeel
0
##
# catch observations: number of year groups with the same age and seasonal selection
    3
#  first year in each group
1983 1989 1999
## year season combinations with zero catch (F=0) (option zero.catch.year.season)
```

0=no, all year-seasons have catchs, 1=yes there are year-season combinations with no catch. Read from file zero_catch_seasons_ages.in

default=0

1

season age combinations with zero catch (F=0) (option zero.catch.season.ages)

0=no, all seasons have catchs, 1=yes there is seasons with no catch. Read from file zero_catch_seasons_ages.in

default=0

1

Factor for fixing last season effect in F-model (default=1) (fix.F.factor))

1

Uncertanties for catch, CPUE and SSB-R observations (option calc.est.sigma)

values: 0=estimate sigma as a parameter (the right way of doing it)

1=Calculate sigma and truncate if lower limit is reached

2=Calculate sigma and use a penalty function to avoid lower limit

catch-observation, CPUE-obs, Stock/recruit

2 0 2

##

Read HCR_option file (option=read.HCR) default=0

0=no 1=yes

0

#

Stock Annex–Sandeel in IV

Quality Handbook	Annex_ FU 34 – Devil's Hole
Stock-specific documentation of standard assessment procedures used by ICES	
Stock	Devil's Hole Nephrops (FU 34)
Working Group	WGNSSK
Date:	(27 Feb. 13)
Revised by	(WKNEPH2013/Helen Dobby & Adrian Weetman)

A. General

A.1. Stock definition

Nephrops are dependent on particular types of seabed sediment with a preference for fine muddy sediments (silt & clay content of 10-100%) suitable for excavating burrows (Farmer, 1975; Afonso-Dias, 1998). Therefore, there is a close relationship between the distribution of *Nephrops* stocks and sediment type. A British Geological Survey (BGS) map of the North Sea (Figure A.1) shows a number of patches of muddy sand (10-50 % silt and clay) in the central North Sea, to the south of the Fladen (total area 4000 km^2). This area is known as the Devil's Hole and consists of a number of narrow trenches, typically 1 – 2 km wide, running in a north-south direction with an average length of 20-30 km. These trenches fall across seven ICES rectangles: 41-43F0, 41-43F1 and 40F0.

In other areas, the sediment maps have been shown to be inaccurate (Campbell et al., 2009 and Dobby et al., 2013 – WD submitted to WKNEPH2013) and this has resulted in the spatial extent of *Nephrops* being defined using maps of fishing activity (vessel monitoring system data) instead of sediment data. A comparison of the sediment map and VMS data associated with a landing of at least 30 % *Nephrops* by weight (filtered for speeds of < 3.8 knots and 70-99 mm mesh) suggests that the spatial extent of *Nephrops* in this area (at least at densities suitable for fishing) is somewhat less than that apparent from the BGS map (Figure A.2).

Estimating the area of the spatial extent of the *Nephrops* habitat from VMS data has been carried out using the alpha-convex hull method to identify a polygon encompassing the VMS pings (using the alphahull library in R – Figure A.3). Mesquita et al. (2010) explored the sensitivity of alternative values for the alpha parameters and concluded that a value of alpha=0.01 enclosed the major areas of fishing activity, but excluded those with a low intensity of VMS pings.

While considering the fished area, a number of additional areas of fishing activity were identified to the south of the previously defined area – in statistical rectangles 39F0 and 40F0. These contribute only a small amount in terms of total area and landings (< 5 % of 41-43F0-F1) and are therefore currently not included in the spatial extent of the stock.

The spatial extent across rectangles 41-43F0-F1 is estimated as 1753 km^2 (based on union of VMS polygons estimated on an annual basis - See WKNEPH 2013 report for details).

A.2. Fishery

The fishery in this area is prosecuted largely by Scottish vessels operating out of ports in the northeast of Scotland, but occasionally making landings into northeast England. The fleet consists of large *Nephrops* trawlers which have the capability of operating in such offshore areas. The fishery increased during the mid-2000s (Figure A.4) and at it's peak around five vessels operating out of Peterhead and another 12 from Fraserburgh were regularly visiting the areas. These vessels also fish the Fladen on a regular basis and visit the other more inshore functional units in times of poor weather or poor *Nephrops* catch rates in the offshore areas. The fishery is a mixed fishery with vessels typically landing a range of demersal fish species such as cod, haddock and whiting, in addition to *Nephrops*. Although there does not appear to be strong seasonal patterns in the fishery, *Nephrops* landings are generally lowest in quarter 1. Landings by vessels from other nations comprise < 5 % of the total.

A TAC is set for *Nephrops* in ICES Subarea IIa and IV (EC waters) which in 2012 was set at 21929 tonnes with an additional allowance of 1200 tonnes in Norwegian waters. The minimum landings size (MLS) for *Nephrops* in Subarea IV (EC) is 25 mm.

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90 mm square mesh panel in trawls from 80 to 119 mm, where the rear of the panel should be not more than 15 m from the cod-line. The length of the panel must be 3 m if the engine power of the vessel exceeds 112 kW, otherwise a 2 m panel may be used. Under UK legislation, when fishing for *Nephrops*, the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4 mm for mesh sizes 70-99 mm, while EU legislation restricts twine thickness to a maximum of 8 mm single or 6 mm double.

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90 mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller than 100 mm in the North Sea south of 57°30'N – check this. Separate Scottish legislation (SSI 405/2000) prohibits the use of more than two nets by any Scottish fishing boat wherever it may be; or by any relevant UK fishing boat within the Scottish zone.

B. Data

B.1. Commercial catch

Landings and effort data from logbooks are available from the Scottish fleet. Other nations supply landings data. As in other *Nephrops* functional units, the reliability of the landings data is likely to have improved since the introduction of UK buyers and sellers legislation in 2006.

The following table shows the nations supplying data for this FU.

Country	Landings weight	Landings length composition	Discards length composition	Length composition in catch
Denmark	X			
Netherlands	X			
UK(E & W)	X			
UK (Scotland)	X	X	X	X

Length compositions of Scottish landings and catch (both landed & discarded components) are obtained during market sampling and on-board observer sampling respectively. In 2011, length frequency samples of marketable and discarded *Nephrops* have been limited to a single observer trip and sampling was also relatively poor in 2010. Table B.1 shows the number of samples by year.

Within MSS, sampled *Nephrops* landings length frequencies are raised to trip level and then to fleet level. Since 2011, these fleets have been defined according to aggregations of metiers as agreed under the WGNSSK/WGMIXFISH data call and uploaded to Intercatch where the international raised data are calculated.

The recent length frequency information (Table B.2) are considered of insufficient quality for deriving an exploitation pattern for use in per-recruit analysis. Instead the mean weights in the landings have been calculated over the years 2007-10 (31.76 g) for use in the *Nephrops* data limited approach (Table B.3). This should be used until there is evidence to indicate that this has changed such as when adequate data are available.

Data on the landed and discarded component of catches obtained from observer trips have been used to estimate a discard rate. Annual rates have been averaged over 2008-11 (WKNEPH 2013) to provide an estimate of discard rate (12.9 %) to be used in the data limited approach to the provision of advice.

B.2. Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Parameters applied in to inform the catch forecast process were taken as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years (Morizur, 1982). Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

The calculations of mean weight make use of the length weight parameters of Fladen *Nephrops* (FU7). In future, it is likely that the assessment will require other biological parameters (as in the full UWTV survey approach). WKNEPH 2013 considered that it would be most appropriate to use those from the Fladen – an offshore geographical neighbouring FU.

Parameter	Value	Source
MALES		
Length/weight - a	0.0003	Howard and Hall (1983)
Length/weight - b	3.25	Howard and Hall (1983)
Growth - L∞	66 mm	Adapted from Bailey and Chapman (1983)
Growth - k	0.16 yr-1	Adapted from Bailey and Chapman (1983)
Size at maturity	25 mm	Adapted from Bailey (1984)
Natural Mortality - M	0.3	Morizur (1982)
FEMALES		
Length/weight - a	0.00074	Howard and Hall (1983)
Length/weight - b	2.91	Howard and Hall (1983)
Immature growth - L∞	66 mm	Adapted from Bailey and Chapman (1983)

Immature growth - k	0.16 yr-1	Adapted from Bailey and Chapman (1983)
Immature natural mortality - M	0.3	Morizur (1982)
Size at maturity	25 mm	Adapted from Bailey (1984)
Mature growth - L∞	56 mm	Adapted from Bailey and Chapman (1983)
Mature growth - k	0.10 yr-1	Adapted from Bailey and Chapman (1983)
Mature natural mortality - M	0.2	Based on Morizur (1982) ; assuming lower rate for mature females

Discard survival

The patchy nature of the ground at the Devil's Hole and the behaviour of the fleet (moving between suitable *Nephrops* patches) may mean that discarded *Nephrops* are not returned to the sea over suitable sediment. In such circumstances, it is assumed that there is no discard survival. This is in line with previous assumptions for the Farn Deeps.

B.3. Surveys

Prior to 2009, UWTV surveys were conducted at the Devil's Hole on an opportunistic basis. Station locations on these early surveys were randomly selected from the BGS sediment map. Since 2009, the survey has used a fixed station design, with station locations chosen from the set of 2008 VMS pings (Figure B.1).

On average, about 15-20 stations have been considered valid each year in the recent period which equates to approximately 9 stations per 1000km^2 (towards the lower end of station densities across surveyed FUs). A range of density estimates covering recent values are raised to a stock area of 1753 km^2 based on the analysis of VMS data to calculate a range of abundances for use in the DL approach. General survey protocols and analysis methods for underwater TV survey data are similar for each of the Scottish surveys and follow guidelines established by SGNEPS (ICES, 2008, 2009). In the recent period, the relative standard error for the Devil's Hole density estimate has fluctuated around the level recommended as adequate by SGNEPS and averaged over 2009-2011 is 0.22 (recommended < 0.2).

Relative to absolute conversion factor

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as absolute (required for both the *Nephrops* data limited approach and the full UWTV survey approach), it is necessary to correct for these potential biases. These are based on simulation studies, preliminary experimentation and expert opinion.

For the Devil's Hole, the footage, in terms of burrow complex diameter appears very similar to those apparent at the Fladen. The edge effect was therefore estimated as 1.45 (from Campbell et al., 2009). Burrow detection rates were believed to be relatively high due to the excellent water clarity and burrow identification was believed to be 100% due to a lack of other burrowing fauna. The cumulative correction factor for the Devil's Hole was calculated as 1.4. This is higher than the correction factor in other FUs.

	Edge effect	detection rate	species identification		occupancy	Cumulative bias
FU34	1.45	0.95	1	1	1.4	

B.4. Commercial CPUE

LPUE data were available for Scottish *Nephrops* trawls. These data are available from 2000 onwards. The effort & lpue are not standardized and therefore do not account for changes in efficiency, seasonality or other factors that could influence the trend in lpue over time. (Table B.4 and Figure B.2).

C. Assessment: data and method

WKNEPH concluded that for the time being, advice should be provided for *Nephrops* in FU34 on the basis of the data limited approach (see below and category 4.1.4 of ICES DLS approach). This can provide an indication of the level of medium-term average F in relation to F_{MSY} (borrowed from neighbouring stocks with similar characteristics) and this may also provide guidance on the level of abundance relative to MSY $B_{trigger}$.

In terms of stock trends, there are currently insufficient length frequency data for use in constructing indicators. There is a commercial LPUE series extending back to 2000 which should be used (with caution) to monitor stock trends.

Input data required: **Recent absolute (bias corrected) density estimate from UWTV survey**

In the range 0.2 – 0.3 m^{-2} but should account for the most recent estimates if different

Spatial extent

1753 km^2

Landings mean weight

31.76 g (average 2007-2010)

Discard rate in number

12.9 % (average annual rate 2008-2011)

Discard survival

0 %

Model and software: see spreadsheet derived at WGNSSK 2012 ('FINAL version of Nep-IV nonTVstocks included in advice.xls'. Steps in formulating the data limited table:

1. Use absolute density & spatial extent to derive *Nephrops* abundance for a range of densities (see above)

2. Convert potential landings weight into numbers using landings mean weight for a range of total landings (10 year average, half of 10 year average, maximum of time series)
3. Convert landings numbers into total removals by dividing by (1 – discard rate in number)
4. Divide total removals (from 3) by *Nephrops* abundance (from 1) to obtain a matrix of harvest rates which can be compared to F_{MSY}.

D. Short-Term Projection

Not relevant – uses *Nephrops* data limited approach.

E. Medium-Term Projections

Not relevant – uses *Nephrops* data limited approach.

F. Long-Term Projections

Not relevant – uses Nephrops data limited approach

G. Biological Reference Points

No reference points have been calculated for this functional unit. The *Nephrops* data limited approach compares calculated harvest rates to the range of Fmsy harvest rates estimated for other North Sea Functional Units (8-15 %)

H. Other Issues

H.1. Historical overview of previous assessment methods (this subsection is optional. See example below.)

The Devil's Hole was designated as a separate FU in 2010. ICES first provided advice for this FU in 2012. Prior to this, the landings were collated as part of the total North Sea *Nephrops* landings 'outside FUs'.

In 2012, the advice was provided on the basis of the *Nephrops* data limited approach using parameter values taken from FU7 with conclusions on stock trends drawn from LPUE data. For 2013 onwards, more appropriate parameter values have been derived from data collected from FU34.

Year	Mean weight in landings (g)	Discard rate (%)	Area (km2)	Correction factor
2012	28 (FU7)	5 (FU 7)	1100	1 (no bias assumed)
2013	31.76 (FU34)	12.9 (FU 34)	1753	1.4

The data limited approach makes use of average densities from the UWTV survey. A number of changes have been made to survey design as knowledge of the grounds has improved. These are documented below.

Data	Pre 2009	2009–2012
UWTV survey	Opportunistic surveys with stations randomly positioned according to BGS sediment map	Fixed stations drawn from 2008 Scottish Nephrops VMS points

I. References

Afonso-Dias, M. 1998. Variability of Nephrops norvegicus (L.) populations in Scottish waters in relation to the sediment characteristics of the seabed. PhD thesis, University of Aberdeen. 282 pp.

Bailey, N. 1984. Some aspects of reproduction in *Nephrops*. ICES, Doc. Shellfish Comm., CM 1984/K:33 (mimeo).

Bailey, N., and Chapman, C. J. 1983. A comparison of density, length composition and growth of two *Nephrops* populations on the west coast of Scotland. ICES CM 1983/K:42.

Campbell, N., Allan, L., Weetman, A., and Dobby, H. 2009a. Investigating the link between Nephrops norvegicus burrow density and sediment composition in Scottish waters. ICES J. Marine Science, 66(9): 2052–2069.

Campbell, N, Dobby, H., and Bailey, N. 2009b. Investigating and mitigating uncertainties in the assessment of Scottish Nephrops norvegicus populations using simulated underwater television data. – ICES Journal of Marine Science, 66: 000–000.

Farmer, A. S. D. 1975. Synopsis of data on the Norway lobster Nephrops norvegicus (Linnaeus, 1758). FAO Fisheries Synopsis No. 112, pp. 1–97.

Howard F.G. and Hall, W.B. 1983. Some observations on the biometrics of *Nephrops norvegicus* (L.) in Scottish waters. ICES, Doc.ShellfishComm.,CM1983/K:36.

ICES. 2008. Report of the Workshop and training course on Nephrops Burrow Identification; (WKNEPHBID). ICES CM: 2008/LRC: 03 Ref: ACOM.

ICES. 2009. Report of the Study Group on Nephrops Surveys; (SGNEPS). ICES CM: 2009/LRC: 15 Ref: ACOM

ICES 2010. Report of the Study Group on Nephrops Surveys (SGNEPS). ICES CM 2010/SSGESST: 22. Ref: SCICOM, ACOM

Mesquita,C., Dobby, H. and Campbell, N. The use of sediment data vs. VMS in defining Nephrops TV survey boundaries and areas in North Minch and South Minch. Working Document for the Study Group on Nephrops Surveys (SGNEPS), 9–11 November, 2010

Morizur, Y. 1982. Estimation de la mortalité pour quelques stocks de langoustine, Nephrops norvegicus. ICES CM 1982/K:10

Pateiro-Lopez, B., and Rodriguez-Casal, A. 2009. alphahull: Generalization of the convex hull of a sample of points in the plane. R package version 0.2-0. http://CRAN.R-project.org/package=alphahull.

Pateiro-Lopez, B., and Rodriguez-Casal, A. 2010. Generalizing the Convex Hull of a Sample: The R Package alphahull. Journal of Statistical Software, 34 (5): 1-28.

Table B.1. Number of catch and landed samples obtained from Devils Hole (FU 34) by MSS.

	Date Landed – Year						
Type	2006	2007	2008	2009	2010	2011	Grand Total
Observer samples*			30	3	14	12	59
Market samples	1	5	1	5	1		13

Table B.2 *Nephrops*, Devil's Hole (FU 34): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish landings, 2006-2011.

	Landings			
	< 35 mm CL		> 35 mm CL	
Year	Males	Females	Males	Females
2006	29.7	29.8	39.7	38.1
2007	30.4	28.7	40.5	39.2
2008	31	30.5	40.3	39.6
2009	31.7	31.1	41.3	40.6
2010	32.2	29.9	39.6	39.4
2011	31.7	30.7	43.7	40.4

Table B.3 *Nephrops*, Devil's Hole (FU34): Mean weight (g) in the landings, 2006-2011.

Year	Male	Female	Overall
2006	27.03	17.53	22.93
2007	31.19	16.94	26.27
2008	36.83	21.82	30.08
2009	46.83	24.01	39.62
2010	38.22	18.94	31.07
2011	63.25	25.47	42.05
Average (07-10)			31.76

Table B.4. ***Nephrops*, Devils Hole (FU 34): landings, effort (days fishing) and LPUE (kg/day) for UK bottom trawlers landing in Scotland and fishing *Nephrops* with codend mesh sizes of 70 mm or above, 2000-2011.**

Year	Landings	Effort	LPUE
2000	185	3391	54
2001	270	3142	86
2002	343	2022	169
2003	674	2614	258
2004	489	1551	315
2005	379	1545	245
2006	448	1440	311
2007	715	1824	392
2008	937	1673	560
2009	1306	1921	680
2010	730	1465	498
2011	423	1041	406

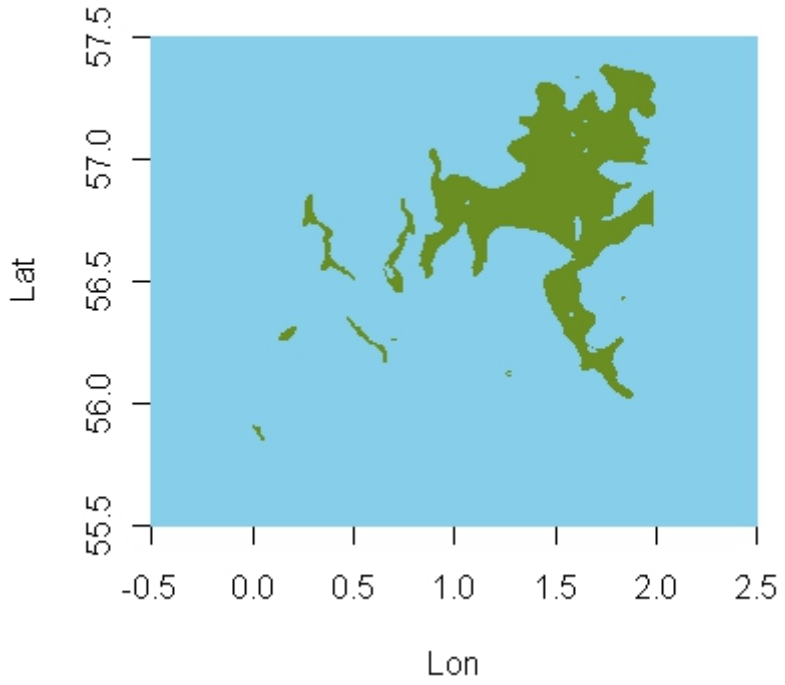


Figure A.1. Distribution of muddy sediment in the central North Sea according to British Geological Survey maps.

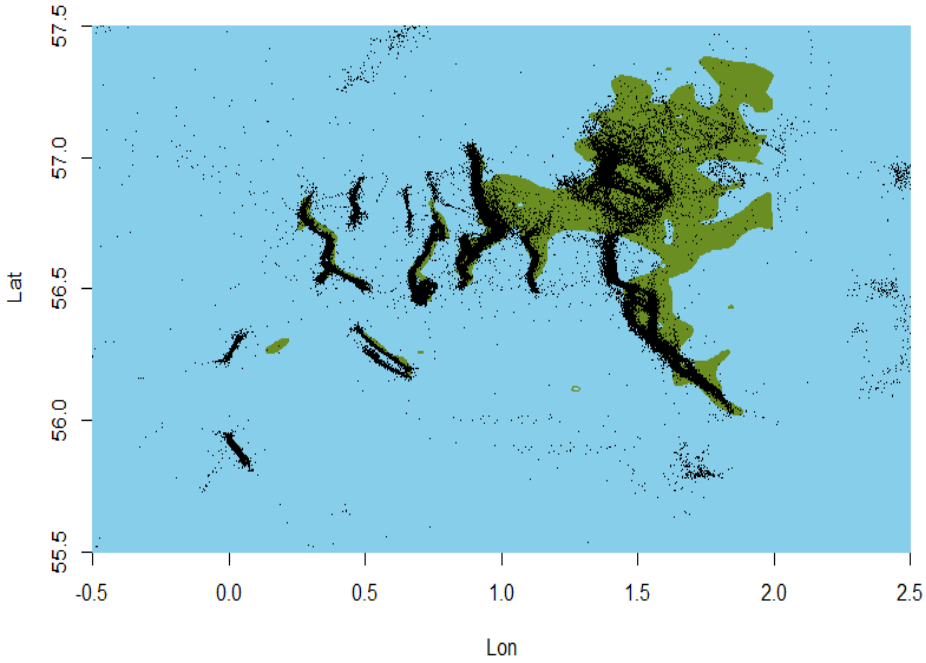


Figure A.2. Comparison of BGS sediment map with VMS data from Scottish trawlers (2007-2011) filtered for landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.

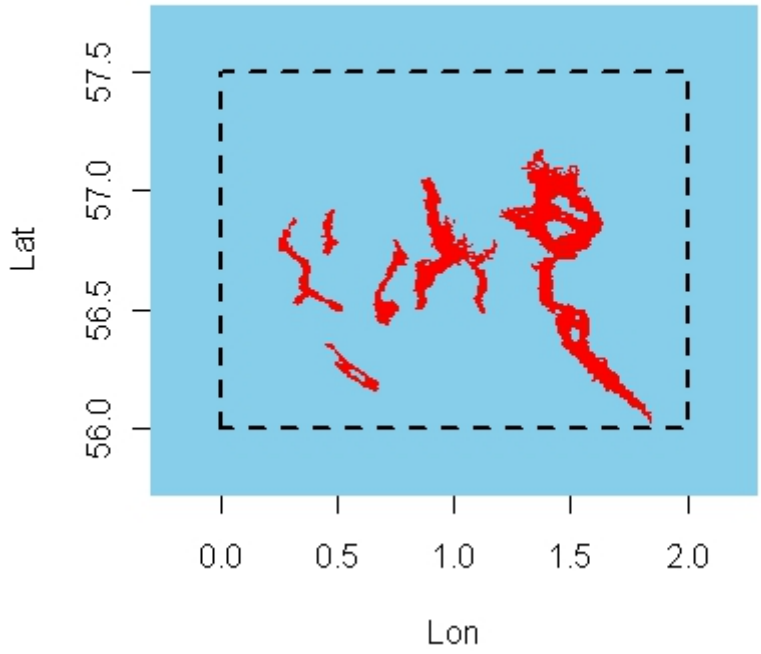


Figure A.3. The area of the spatial extent of the *Nephrops* habitat from VMS data calculated using the alpha-convex hull method.

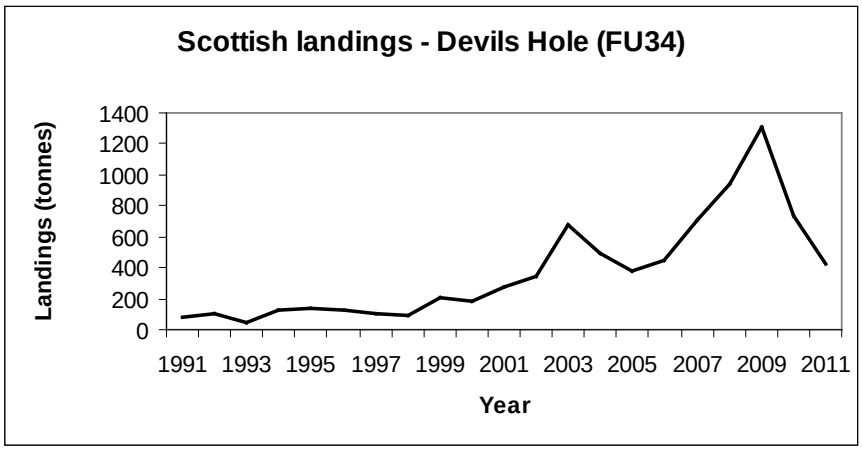


Figure A.4. *Nephrops*, **Devil's Hole (FU 34). Scottish landings from 1991 to 2011.**

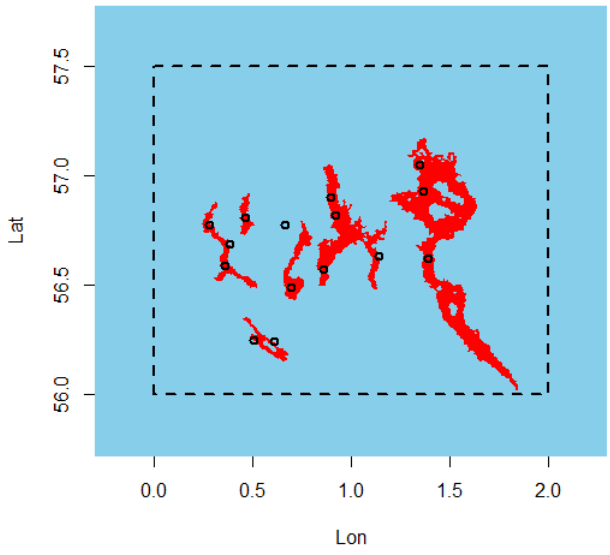


Figure B.1. Fixed UWTV survey station locations (2009 onwards) compared with estimate of spatial extent of *Nephrops* **at Devils' Hole.**

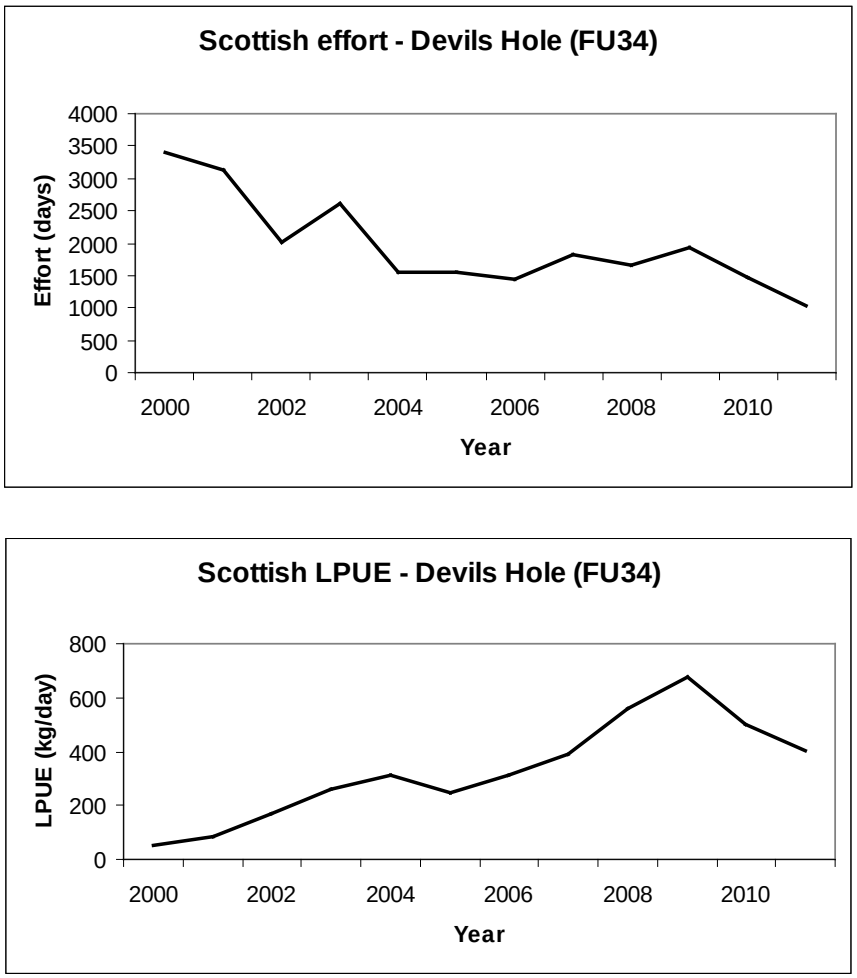


Figure B.2. ***Nephrops*****, Devil's Hole (FU 34). Effort (days) and LPUE (kg/day by Scottish trawlers).**

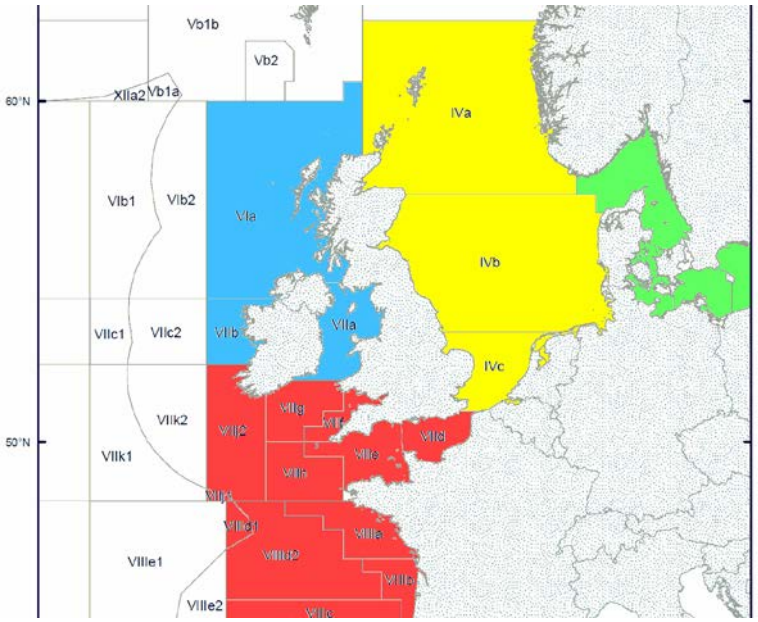
Stock Annex - Turbot in ICES Subarea IV (North Sea)

Stock	Turbot in ICES Subarea IV (North Sea)
Working Group	WGNSSK
Date	November 2012
Revised by	IBPNew/Jan Jaap Poos.

A. General

A.1. Stock definition

Genetic studies within restricted geographical areas had illustrated the presence of distinct turbot populations in the Baltic and Irish Seas using neutral markers (e.g. Delbare and Declerck, 1999; Nielsen, 2004). Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al.* (in prep). The neutral marker panel confirmed the break-up between the Baltic and Northeast Atlantic clusters. Within the latter, a more detailed pattern of genetic differentiation could be observed when gene-associated markers were also included in the analysis; results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/**fisheries-genetics**). This full analysis suggests a break between the southern and central parts of the North Sea, making turbot from the southern North Sea genetically more similar to those from the Western Waters. However, because it is unknown whether there are also differences in life history within the North Sea, and information on the number and location of spawning aggregations is missing, the break between IVc and VIId is insufficiently supported to be recommended for management purposes. Additionally, it is logistically difficult to split the North Sea into several management and assessment units. The proposed stock structure is represented in the figure below.



Stock structure of turbot in the Northeast Atlantic as proposed by IBP New 2012.

A.2. Fishery

In the 1950s the UK was the biggest contributor to the landings, with almost 50% of the landings coming from this country. In that early period, the landings fluctuated around 6000 tons per year. Currently, the landings are around 2700 tons per year. Most of the landings stem from the Netherlands that contributes between 50 and 60%. Within the Netherlands most of the landings come from the 80 mm beam trawl fleet fishing for flatfish species sole and plaice. Also in most other countries turbot is caught in mixed fisheries trawls. The second largest contributor to the landings in the last decade is Denmark. In Denmark there is a directed fishery for turbot using gillnets.

Within the Netherlands, most of the landings come from the Southern Bight and the German Bight. In Belgium, turbot is mainly caught in mid-class (301–900 Hp) and large (>900 Hp) beam trawlers. These vessels are mostly flatfish directed (particularly towards plaice and sole, together with the associated bycatch species such as turbot, brill, dab, lemon sole, anglerfish and some roundfish. In Denmark turbot is taken only as bycatch in Danish fisheries. In the North Sea, where most of the Danish landings of turbot are taken, the gillnet fishery accounts for almost half of the landings.

Little information is known about discarding in the different fisheries catching turbot. The only available information comes from the Dutch beam trawl fleet in the period 2002–2007. It indicates very low estimates of discarding. No information is available for the period 1975–2002. In at least part of that period an EU-wide minimum landings size (MLS) of 30 cm was enforced. However, this minimum landings size was abandoned and member states have their own MLS rules and regulations. For example, Belgium now has a MLS of 30 cm, while in the Netherlands a minimum size of 25 cm exists, set by the producer organizations. Hence, despite the indications of low discarding in the Dutch fleets in the last decade, more MLS discarding may occur in other fleets, or have occurred in other periods.

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001; EC Council Regulation No 51/2006; e.g. N°40/2008, annex IIa). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammelnets could fish between 140 and 205 days per year.

Several technical measures are applicable to the flatfish fishery in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55 N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the plaice fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100 mm is required. In addition to this, since 2002 a small part of North Sea plaice fishery is affected by the additional cod recovery plan (EU regulation 2056/2001) that prohibits trawl fisheries with a mesh size <120 mm in the area to the north of 56°N.

The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9 m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed

in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation.

B. Data

B.1. Commercial catch

The landings of turbot are available through the EuroStat database. This database holds the officially recorded landings for all countries landing turbot in the North Sea. There are no records for the Dutch landings in the EuroStat database between 1984 and 1987. However, for the North Sea these missing landings have been estimated in a Dutch/Belgian research project, and have been used to fill in the gaps (Boon and Delbare, 2000). In the 1950s the UK was the biggest contributor to the landings, with almost 50% of the landings coming from this country. In that early period, the landings fluctuated around 6000 tons per year. Currently, the landings are around 2700 tons per year. Most of the landings stem from the Netherlands that contributes between 50 and 60%. Within the Netherlands most of the landings come from the 80 mm beam trawl fleet fishing for flatfish species sole and plaice. Also in most other countries turbot is caught in mixed fisheries trawls. The second largest contributor to the landings in the last decade is Denmark. In Denmark there is a directed fishery for turbot using gillnets.

There is no long-term continuous programme for age sampling of landings in any of the countries. Therefore, the age structure of the landings is estimated using data from different sources in different time periods. Starting in 1975, there is a four year time period for which the age structure of the landings have been estimated by Weber (1979). The age structure is estimated from market samples taken in Cuxhaven and Hamburg and research vessel surveys. Most of the samples represent landings in the Eastern part of IVb. The structure is based on a total of 9360 length and 6389 weight measurements combined with 6788 age samples. Samples are combined with the quarterly landings for England, the Netherlands and Germany and subsequently with the overall landings on an annual basis. The second dataset spans the period 1981–1990, is derived from landings in the Netherlands and available in the "Datubras" project report (Boon and Delbare, 2000). A stratified sampling scheme was used to collect the samples, using quarters, auctions, and market categories as stratification levels. Between 398 and 862 age samples were taken annually for age-determination of fish. Most of the samples represent Area IVb and IVc. The Dutch data are subsequently raised to the total international landings. The third dataset spans the period 2000–2002. It was supplied by Cefas and based on the UK landings of turbot. These were raised on an annual basis to the total landings. The fourth and final dataset stems again from the Netherlands. It spans the years 1998 and 2004–2011. The age structure is estimated from stratified sampling accounting for auctions, quarters and market categories. These are raised to total Dutch landings by quarter. Between 494 and 1921 age samples were taken per year. The total Dutch landings are subsequently raised to the total international landings per year.

Little information is known about discarding in the different fisheries catching turbot. The only available information comes from the Dutch beam trawl fleet in the period 2002–2007. It indicates very low estimates of discarding. No information is available for the period 1975–2002. In at least part of that period an EU-wide minimum landings size (MLS) of 30 cm was enforced. However, this minimum landings size was abandoned and member states have their own MLS rules and regulations. For example, Belgium now has a MLS of 30 cm, while in the Netherlands a minimum size of 25 cm

exists, set by the producer organizations. Hence, despite the indications of low discarding in the Dutch fleets in the last decade, more MLS discarding may occur in other fleets, or have occurred in other periods. Because of the indications of low discarding, the landings-at-age are assumed fully representative of the catch-at-age. The resulting catch-at-age matrix has two important characteristics. First, there appear to be some strong cohorts in the data and second, there is an apparent increase in the relative amount of two-year old fish being caught in the last decade. This shift is likely the result of the change in MLS regulations described above, while the recent data come from the Dutch landings only. This fleet has seen a decrease in MLS in the early 2000s. An alternative explanation for the apparent increase in two-year old being caught could be an error in the age-reading. However, no upward shift in the weight of fish at ages 2 and 3 was observed that would result from such an age-reading error.

B.2. Biological

Weight-at-age

Weight-at-age data in the catch for this stock are available for most but not all of the years during which there is age sampling of the landings (Figure 1.6.15). Data are available for the period 1981–1990 from the DATUBRAS database (Boon and Delbare, 2000), and then again for the years 1998, and 2004 to present from Dutch market sampling. Stock weights are estimated as the catch weights in Q2, coinciding with peak spawning of the stock. Hence stock weights estimates are available for the same time period, but excluding the years 2005 and 2006 where no samples were available in the second quarter. In addition to this average weights-at-age for the stock during the period 1976–1979 are available from Weber (1979). For both the catch and stock weights, estimated values for ages 6 and greater tend to show large interannual fluctuations, due to the limited number of fish sampled at these ages. The vast majority of landings are for ages 4 and younger and this is reflected in the number of samples for these ages.

With no data except a single year available in the 1990s (1998) to infer the trend in weight-at-age over the period 1991 to 2003, the group decided to use a constant annual weight-at-age vector over the entire period as input to the stock assessment models. This was determined as the mean weight-at-age using all data available over the whole period.

Future work on the use of catch and stock weight is recommended. First, the trends of individual weights in time can be described using a statistical model. Such a model could either describe the trends in time as a function of age only, or describe the growth in a cohort, estimating smooth trends in the parameters describing the growth of each cohort. Second, the variability of weight-at-age that is now removed from the assessment (by taking means of weights by age over the entire study period) could be added to the assessment results, by using the residual variance of the estimates of the means. This information about the variance could be used in combination with the MCMC estimates from the assessment to describe the combined effect of uncertainty in estimated numbers and the uncertainty in estimated weights.

B.3. Surveys

Two survey-series catching turbot are available. The Beam Trawl Survey (BTS ISIS), and the Sole Net Survey (SNS). The BTS index uses a beam trawl to catch demersal species. The index is based on the catch in one of the two nets. The BTS-ISIS index is based on catches between 52 and 239 individuals per year. The number of individuals used to generate an age–length key can be larger than the number of individuals used

for the index, because the index is based on only the catch in one of the two nets, while age samples can be taken from both nets.

The procedure to create an age structured index series from the BTS-ISIS was updated prior to the working group. Previously, the each individual fish caught was linked to an age–length key based on its length. The age–length key was based on all age samples in the BTS survey since 1991. The updated procedure first links the individual fish from which otoliths are taken to the length sample. This allows direct ageing of the fish in the cpue. Those fish for which no direct age sample is available are then assigned to ages using the age–length key based on all fish in the period 1991–2011.

B.4. Commercial cpue

In addition to the survey based indices, there is also an index based on the Dutch 80 mm beam trawl fleet lpue. The potential bias in this lpue series as an indicator for stock abundances because of spatial targeting of the fleet has been addressed in Hammen *et al*., 2011. There, a procedure was developed to obtain an age-structured index from the lpue, while trying to remove the spatial aspects of targeting. The resulting index series shows an increase of older ages over time, and a fairly good cohort structure.

C. Assessment: data and method

Model used: An age-structured assessment model in ADMB using spline smoothers. The .tpl file for the assessment is

Software used:

```
// ADMB code for simple catch-at-age model with CAA matrix and three indices
// Turbot assessment

DATA_SECTION
 init_int    nyrs
 init_int    nages
 init_int    minFbar
 init_int    maxFbar
 init_int    F_time_knots
 init_matrix obs_catch_at_age(1,nyrs,1,nages)
 init_matrix catch_weights(1,nyrs,1,nages)
 init_matrix stock_weights(1,nyrs,1,nages)
 init_int    nyrs_surv1
 init_int    nages_surv1
 init_number time_surv1
 init_matrix obs_surv1(1,nyrs_surv1,1,nages_surv1)
 init_int    nyrs_surv2
 init_int    nages_surv2
```

```
 init_number time_surv2
 init_matrix obs_surv2(1,nyrs_surv2,1,nages_surv2)
 init_int    nyrs_surv3
 init_int    nages_surv3
 init_number time_surv3
 init_matrix obs_surv3(1,nyrs_surv3,1,nages_surv3)
 init_number M
 init_vector maturity(1,nages)
 init_matrix bs1(1,4,1,7)
 init_matrix bs2(1,F_time_knots,1,nyrs)
 vector Fvec(1,11806)

PARAMETER_SECTION
 init_number logsigmaC(1)
 init_number logsigmaU1(1)
 init_number logsigmaU2(1)
 init_number logsigmaU3(1)
 init_vector sigma_offset(2,nages,1)
 init_vector log_sel_coff1(1,4,1)
 init_vector log_sel_coff2(1,4,1)
 init_vector log_sel_cofU1(1,4,1)
 init_vector log_sel_cofU2(1,4,1)
 init_vector log_sel_cofU3(1,4,1)
 init_vector log_temp_coff(1,F_time_knots,2)
 init_vector log_initpop(1,nyrs+nages-1,1)
 vector sigmaC(1,nages)
 vector sigmaU1(1,nages_surv1)
 vector sigmaU2(1,nages_surv2)
 vector sigmaU3(1,nages_surv3)
 vector effort_devs(1,nyrs)
 vector log_self1(1,nages)
 vector log_self2(1,nages)
 vector log_selU1(1,nages_surv1)
 vector log_selU2(1,nages_surv2)
 vector log_selU3(1,nages_surv3)
 vector TSB(1,nyrs)
```

```
  sdreport_vector SSB(1,nyrs)
  vector VB(1,nyrs)
  matrix F(1,nyrs,1,nages)
  matrix S(1,nyrs,1,nages)
  matrix N(1,nyrs,1,nages)
  matrix U1(1,nyrs_surv1,1,nages_surv1)
  matrix U2(1,nyrs_surv2,1,nages_surv2)
  matrix U3(1,nyrs_surv3,1,nages_surv3)
  matrix C(1,nyrs,1,nages)
  number f_c
  number f_s1
  number f_s2
  number f_s3
  sdreport_vector Fbar(1,nyrs)
  number Fmax
  number YPRmax
  number TAC
  objective_function_value f

PRELIMINARY_CALCS_SECTION
  // Add small constants (half of minimum) to observations, so log(0) doesn't explode
  obs_catch_at_age = obs_catch_at_age + 0.35;
  obs_surv1 = obs_surv1 + 0.0005;
  obs_surv3 = obs_surv3 + 0.015;
  // Create a sequence of Fbar values to evaluate YPR, in order to calculate Fmax:
  // Fvec <- c(0,10^-(9:5),seq(0.0001,1,0.0001),seq(1.001,2,0.001),seq(2.01,10,0.01))
  Fvec(1) = 0;
  Fvec(2) = 1e-9;
  for (int i=3; i<=7; i++)        Fvec(i) = Fvec(i-1) * 10;
  for (int i=8; i<=10006; i++)    Fvec(i) = Fvec(i-1) + 0.0001;
  for (int i=10007; i<=11006; i++) Fvec(i) = Fvec(i-1) + 0.001;
  for (int i=11007; i<=11806; i++) Fvec(i) = Fvec(i-1) + 0.01;

PROCEDURE_SECTION
  get_sigmas();
  get_mortality_and_survival_rates();
```

```
 get_numbers_at_age();
 get_catch_at_age();
 get_surv1_at_age();
 get_surv2_at_age();
 get_surv3_at_age();
 calculate_biomass();
 evaluate_the_objective_function();
 if (mceval_phase())
 {
  get_fmax();
  write_mcmc();
 }

REPORT_SECTION
 report << "Likelihoods" << endl;
 report << "f, f_c, f_s1, f_s2, f_s3" << endl;
 report << f << endl;
 report << f_c << endl;
 report << f_s1 << endl;
 report << f_s2 << endl;
 report << f_s3 << endl << endl;
 report << "Sigma parameters" << endl;
 report << "logsigmaC, logsigmaU1, logsigmaU2, logsigmaU3, sigma_offset" << endl;
 report << logsigmaC << " " << logsigmaU1 << " " << logsigmaU2 << " " << logsigmaU3
<< endl;
 report << sigma_offset << endl << endl;
 report << "Selectivity spline coefficients" << endl;
 report << "log_sel_coff1, log_sel_coff2, log_sel_cofU1, log_sel_cofU2, log_sel_cofU3"
<< endl;
 report << log_sel_coff1 << endl;
 report << log_sel_coff2 << endl;
 report << log_sel_cofU1 << endl;
 report << log_sel_cofU2 << endl;
 report << log_sel_cofU3 << endl << endl;
 report << "Annual F spline coefficients" << endl;
 report << "log_temp_coff" << endl;
```

```
report << log_temp_coff << endl << endl;
report << "Sigmas" << endl;
report << "sigmaC, sigmaU1, sigmaU2, sigmaU3" << endl;
report << sigmaC << endl;
report << sigmaU1 << endl;
report << sigmaU2 << endl;
report << sigmaU3 << endl << endl;
report << "CAA Selectivities" << endl;
report << "log_self1, log_self2" << endl;
report << log_self1 << endl;
report << log_self2 << endl << endl;
report << "U Selectivities" << endl;
report << "log_selU1, log_selU2, log_selU3" << endl;
report << log_selU1 << endl;
report << log_selU2 << endl;
report << log_selU3 << endl << endl;
report << "Annual F multiplier" << endl;
report << "effort_devs" << endl;
report << effort_devs << endl << endl;
report << "Initial population" << endl;
report << "recruitment, firstyear" << endl;
report << exp(log_initpop(1,nyrs)) << endl;
report << exp(log_initpop(nyrs+1,nyrs+nages-1)) << endl;
report << endl;
report << "Observed numbers in catch" << endl;
report << "obs_catch_at_age" << endl;
report << obs_catch_at_age << endl;
report << "Estimated numbers in catch" << endl;
report << "C" << endl;
report << C << endl << endl;
report << "Observed survey1" << endl;
report << "obs_surv1" << endl;
report << obs_surv1 << endl;
report << "Estimated survey1" << endl;
report << "U1" << endl;
report << U1 << endl << endl;
```

```
report << "Observed survey2" << endl;
report << "obs_surv2" << endl;
report << obs_surv2 << endl;
report << "Estimated survey2" << endl;
report << "U2" << endl;
report << U2 << endl << endl;
report << "Observed survey3" << endl;
report << "obs_surv3" << endl;
report << obs_surv3 << endl;
report << "Estimated survey3" << endl;
report << "U3" << endl;
report << U3 << endl << endl;
report << "Estimated numbers of fish" << endl;
report << "N" << endl;
report << N << endl << endl;
report << "Estimated fishing mortality" << endl;
report << "F" << endl;
report << F << endl << endl;
report << "Estimated Fbar" << endl;
report << "Fbar(" << minFbar << "-" << maxFbar << ")" << endl;
report << Fbar << endl << endl;
report << "Estimated SSB" << endl;
report << "SSB" << endl;
report << SSB << endl << endl;
report << "Estimated TSB" << endl;
report << "TSB" << endl;
report << TSB << endl << endl;
report << "Maturity" << endl;
report << "maturity" << endl;
report << maturity << endl << endl;
report << "Catch weights" << endl;
report << "catch_weights" << endl;
report << catch_weights << endl << endl;
report << "Stock weights" << endl;
report << "stock_weights" << endl;
report << stock_weights << endl << endl;
```

```
 report << "Natural mortality" << endl;
 report << "M" << endl;
 report << M << endl;

FUNCTION dvariable dnorm(const dvariable& x, const dvariable& mu, const dvariable& sd)
 return 0.5 * (log(2*M_PI*sd*sd) + square(x-mu)/(sd*sd));

FUNCTION get_sigmas
 sigmaC(1) = mfexp(logsigmaC);
 for (int a=2; a<=nages; a++)
  sigmaC(a) = mfexp(logsigmaC + sigma_offset(a));
 sigmaU1(1) = mfexp(logsigmaU1);
 for (int a=2; a<=nages_surv1; a++)
  sigmaU1(a) = mfexp(logsigmaU1 + sigma_offset(a));
 sigmaU2(1) = mfexp(logsigmaU2);
 for (int a=2; a<=nages_surv2; a++)
  sigmaU2(a) = mfexp(logsigmaU2 + sigma_offset(a));
 sigmaU3(1) = mfexp(logsigmaU3);
 for (int a=2; a<=nages_surv3; a++)
  sigmaU3(a) = mfexp(logsigmaU3 + sigma_offset(a));

FUNCTION get_mortality_and_survival_rates
 // Calculate selectivity from sel_coffs, where selectivity is same for last two ages
 log_self1(1,7) = elem_div(exp(log_sel_coff1*bs1), 1+exp(log_sel_coff1*bs1));
 log_self1(8) = log_self1(7);
 log_self1(9) = log_self1(7);
 log_self2(1,7) = elem_div(exp(log_sel_coff2*bs1), 1+exp(log_sel_coff2*bs1));
 log_self2(8) = log_self2(7);
 log_self2(9) = log_self2(7);
 effort_devs = exp(log_temp_coff * bs2);

 // F = outer_prod(effort_devs,log_self);
 for (int t=1; t<=28; t++)
  for (int a=1; a<=nages; a++)
   F(t,a) = effort_devs(t) * log_self1(a);
```

```
 for (int t=29; t<=nyrs; t++)
  for (int a=1; a<=nages; a++)
   F(t,a) = effort_devs(t) * log_self2(a);
 for (int t=1; t<=nyrs; t++)
  Fbar(t) = mean(row(F,t)(minFbar,maxFbar));
 S = mfexp(-(F+M));

FUNCTION get_numbers_at_age
 for (int t=1; t<=nyrs; t++)
  N(t,1) = mfexp(log_initpop(t));
 for (int a=2; a<=nages; a++)
  N(1,a) = mfexp(log_initpop(nyrs+a-1));
 for (int t=1; t<nyrs; t++)
  for (int a=1; a<nages; a++)
   N(t+1,a+1) = N(t,a) * S(t,a);

FUNCTION get_catch_at_age
 C = elem_prod(elem_div(F,(F+M)), elem_prod(1-S,N));

FUNCTION get_surv1_at_age
 log_selU1 =  elem_div(exp(log_sel_cofU1*bs1), 1+exp(log_sel_cofU1*bs1));
 int offset = nyrs - nyrs_surv1;
 for (int t=1; t<=nyrs_surv1; t++)
  for (int a=1; a<=nages_surv1; a++)
   U1(t,a) = log_selU1(a) * N(offset+t,a) * mfexp(-time_surv1*(F(offset+t,a)+M));

FUNCTION get_surv2_at_age
 log_selU2 =  elem_div(exp(log_sel_cofU2*bs1), 1+exp(log_sel_cofU2*bs1));
 int offset = nyrs - nyrs_surv2;
 for (int t=1; t<=nyrs_surv2; t++)
  for (int a=1; a<=nages_surv2; a++)
   U2(t,a) = log_selU2(a) * N(offset+t,a) * mfexp(-time_surv2*(F(offset+t,a)+M));

FUNCTION get_surv3_at_age
 log_selU3(1,7) = elem_div(exp(log_sel_cofU3*bs1), 1+exp(log_sel_cofU3*bs1));
 log_selU3(8) = log_selU3(7);
```

```
 log_selU3(9) = log_selU3(7);
 int offset = nyrs - nyrs_surv3;
 for (int t=1; t<=nyrs_surv3; t++)
  for (int a=1; a<=nages_surv3; a++)
   U3(t,a) = log_selU3(a) * N(offset+t,a) * mfexp(-time_surv3*(F(offset+t,a)+M));

FUNCTION  calculate_biomass
 SSB = maturity * trans(elem_prod(N, stock_weights));
 TSB = rowsum(elem_prod(N, stock_weights));
 for (int t=1; t<=28; t++)
  VB(t) = log_self1 * elem_prod(N(t), catch_weights(t));  // biomass vulnerable to fleet1
 for (int t=29; t<=nyrs; t++)
  VB(t) = log_self2 * elem_prod(N(t), catch_weights(t));  // biomass vulnerable to fleet2

FUNCTION evaluate_the_objective_function
 f_c = 0.0;
 f_s1 = 0.0;
 f_s2 = 0.0;
 f_s3 = 0.0;
 // Commercial catch-at-age
 for (int t=1; t<=4; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=7; t<=16; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=24; t<=24; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=26; t<=28; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 for (int t=30; t<=nyrs; t++)
  for (int a=1; a<=nages; a++)
   f_c += dnorm(log(C(t,a)), log(obs_catch_at_age(t,a)), sigmaC(a));
 // Survey 1
```

```
for (int t=1; t<=nyrs_surv1; t++)
  for (int a=1; a<=nages_surv1; a++)
    f_s1 += dnorm(log(U1(t,a)), log(obs_surv1(t,a)), sigmaU1(a));
// Survey 2
for (int t=1; t<=28; t++)
  for (int a=1; a<=nages_surv2; a++)
    f_s2 += dnorm(log(U2(t,a)), log(obs_surv2(t,a)), sigmaU2(a));
for (int t=30; t<=nyrs_surv2; t++)
  for (int a=1; a<=nages_surv2; a++)
    f_s2 += dnorm(log(U2(t,a)), log(obs_surv2(t,a)), sigmaU2(a));
// Survey 3
for (int t=1; t<=nyrs_surv3; t++)
  for (int a=1; a<=nages_surv3; a++)
    f_s3 += dnorm(log(U3(t,a)), log(obs_surv3(t,a)), sigmaU3(a));
// Add all components
f = f_c + f_s1 + f_s2 + f_s3;

FUNCTION get_fmax
 int i = 0;                      // element in Fvec being evaluated
 bool found = false;             // whether Fmax is found
 dvector sel = value(log_self2);  // selectivity to use, not necessarily between 0 and 1
 dvector f(1,nages);             // F at age when Fvec(i) is applied
 dvector z(1,nages);             // Z = F+M
 dvector n(1,nages);             // equilibrium population
 dvector c(1,nages);             // equilibrium catches
 dvector w = row(catch_weights,nyrs);  // catch weights to use
 double ypr = -1;                // highest YPR found so far
 double proposal;                // YPR being evaluated
 n(1) = 1;
 while (!found)
 {
  i++;
  f = Fvec(i) / mean(sel(minFbar,maxFbar)) * sel;
  z = f + M;
  for (int a=2; a<=nages; a++)
    n(a) = n(a-1) * exp(-(f(a-1)+M));
```

```
  for (int a=1; a<=nages; a++)
    c(a) = f(a)/z(a) * n(a) * (1-exp(-z(a)));
  proposal = sum(elem_prod(c, w));
  if (proposal > ypr)
  {
    ypr = proposal;
  }
  else
  {
    i--;  // move i back to optimum
    found = true;
  }
 }
 Fmax = Fvec(i);
 YPRmax = ypr;

FUNCTION write_mcmc
 // Likelihoods
 if (mcmc_lines == 0)
 {
  mcmc_like << "f f_c f_s1 f_s2 f_s3" << endl;
 }
 mcmc_like << f << " " << f_c << " " << f_s1 << " " << f_s2 << " " << f_s3 << endl;
 // Parameters
 if (mcmc_lines == 0)
 {
  mcmc_par << "logsigmaC logsigmaU1 logsigmaU2 logsigmaU3 ";
  for (int a=2; a<=nages; a++)       mcmc_par << "sigma_offset." << a << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_coff1." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_coff2." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof1." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof2." << i << " ";
  for (int i=1; i<=4; i++)           mcmc_par << "log_sel_cof3." << i << " ";
  for (int i=1; i<=5; i++)           mcmc_par << "log_temp_coff." << i << " ";
  for (int i=1; i<=nyrs+nages-1; i++) mcmc_par << "log_initpop." << i << " ";
  mcmc_par << endl;
```

```
}
mcmc_par << logsigmaC << " " << logsigmaU1 << " " << logsigmaU2 << " " << logsigmaU3;
mcmc_par << sigma_offset;
mcmc_par << log_sel_coff1;
mcmc_par << log_sel_coff2;
mcmc_par << log_sel_cofU1;
mcmc_par << log_sel_cofU2;
mcmc_par << log_sel_cofU3;
mcmc_par << log_temp_coff;
mcmc_par << log_initpop << endl;
// Fbar
mcmc_f << Fbar << endl;
// Selectivities
if (mcmc_lines == 0)
{
 for (int a=1; a<=nages; a++)      mcmc_sel << "log_self1." << a << " ";
 for (int a=1; a<=nages; a++)      mcmc_sel << "log_self2." << a << " ";
 for (int a=1; a<=nages_surv1; a++) mcmc_sel << "log_selU1." << a << " ";
 for (int a=1; a<=nages_surv2; a++) mcmc_sel << "log_selU2." << a << " ";
 for (int a=1; a<=nages_surv3; a++) mcmc_sel << "log_selU3." << a << " ";
 mcmc_sel << endl;
}
mcmc_sel << log_self1;
mcmc_sel << log_self2;
mcmc_sel << log_selU1;
mcmc_sel << log_selU2;
mcmc_sel << log_selU3 << endl;
// Recruitment
mcmc_rec << column(N,1) << endl;
// Biomass
mcmc_ssb << SSB << endl;
// Sigma
if (mcmc_lines == 0)
{
 for (int a=1; a<=nages; a++) mcmc_sigma << "sigmaC." << a << " ";
```

```
  for (int a=1; a<=nages_surv1; a++) mcmc_sigma << "sigmaU1." << a << " ";
  for (int a=1; a<=nages_surv2; a++) mcmc_sigma << "sigmaU2." << a << " ";
  for (int a=1; a<=nages_surv3; a++) mcmc_sigma << "sigmaU3." << a << " ";
  mcmc_sigma << endl;
 }
 mcmc_sigma << sigmaC << " " << sigmaU1 << " " << sigmaU2 << " " << sigmaU3 << endl;
 // Reference points
 if (mcmc_lines == 0)
 {
  mcmc_ref << "Fmax " << endl;
 }
 mcmc_ref << Fmax << endl;
 // Counter
 mcmc_lines++;

GLOBALS_SECTION
 #include "admodel.h"
 int mcmc_lines = 0;
 ofstream mcmc_like("like.mcmc");
 ofstream mcmc_par("par.mcmc");
 ofstream mcmc_f("f.mcmc");
 ofstream mcmc_sel("sel.mcmc");
 ofstream mcmc_rec("rec.mcmc");
 ofstream mcmc_ssb("ssb.mcmc");
 ofstream mcmc_sigma("sigma.mcmc");
 ofstream mcmc_ref("ref.mcmc");
```

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Canum	Catch-at-age in numbers	1975–1978, 1981–1990, 1998, 2000–2002, 2004–now	1–9	Yes
Weca	Weight-at-age in the commercial catch	1981–1990, 1998, 2000–2002, 2004–now	1–9	Averaged

West	Weight-at-age of the spawning stock at spawning time.	1981–1990, 1998, 2000–2002, 2004–now	1–9	Averaged
Mprop	Proportion of natural mortality before spawning	1975–now	1–9	No, assumed 0
Fprop	Proportion of fishing mortality before spawning	1975–now	1–9	No, assumed 0
Matprop	Proportion mature at age	1975–now	1–9	No, assumed constant over years
Natmor	Natural mortality	1975–now	1–9	No, assumed constant over ages and years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	BTS ISIS	1985–now	1–7
Tuning fleet 2	SNS	1975–now	1–7
Tuning fleet 3	NL Beam trawl fleet	2002–now	1–9

D. Short-term projection

To be determined.

G. Biological reference points

	Type	Value	Technical basis
MSY	MSY Btrigger	xxx t	Explain
Approach	FMSY	0.29–0.37 year-1	95% confidence bounds FMAX as proxy for FMSY
	Blim	xxx t	Explain
Precautionary	Bpa	xxx t	Explain
Approach	Flim	Xxx	Explain
	Fpa	Xxx	Explain

H. Other Issues

The final assessment we propose uses an lpue series for tuning. For species with strong targeting, this may lead to biased estimates of stock abundance. However, given the low catches of older fish in the survey time-series, the lpue series is probably the best indicator for stock abundance of older fish. The effects of targeting were removed as much as possible by using a method described in van der Hammen *et al*. (2011). Future research should confirm if the age-structured lpue time-series used in the assessment is a reliable indicator for age structured stock abundance.

The BTS ISIS age-structured survey time-series used in the assessment has been revised prior to the benchmark working group. Previously, the length structured catch per unit of effort was age structured using an age–length key that was composed of all sampled individuals in the time-series. The update linked the age estimates to length estimates

for individual fish, where possible. The SNS survey is not updated and still uses an age–length key that is composed of all individuals in the time-series. Future research should study if using age–length keys collated by year do not give better results in the assessments. Using age–length keys by year has the advantage that the information of age structure within a year is better preserved. Such a procedure would also be more like the assessment procedure used for the other flatfish species sole and plaice.

Currently, the average weights-at-age are used in the assessment as an estimate of the weights-at-age within a given year. Hence, the interannual variability of weights is not accounted for in the assessment or the derived reference points. One method of including the variability of weights is to add the weight-at-age estimation as a likelihood component to the assessment model. In that way, the MCMC procedure that is used to estimate confidence bounds in F, SSB, and reference points can be used to show the uncertainties in these properties including the uncertainty in the weight-at-age estimates that are now not accounted for.

There is little knowledge of the natural mortality of this stock. For other flatfish species we have natural mortality estimates that are empirically derived from the cease in fishing during WWII. Using the statistical relationship as estimated by Gislason *et al*. (2010), we derived estimates for natural mortality that are higher than those for sole and plaice. The reason for these high estimates are the high K and L_∞. The benchmark group then decided to use M=0.2 per year, as is used for many other fish in the ICES areas. A simple exploration of the assessment model indicated that the model itself is not very informative about M, but that higher M values lead to a slightly lower log-likelihood. Further exploration of M for turbot would improve the appropriateness of the ICES advice that will result from using the assessment.

The data collected prior to 2003 clearly shows a lower selectivity for the younger ages in the landings-at-age table compared to the more recent period. By interpreting the landings-at-age data as catch-at-age information, the change in landings of young fish was interpreted by the benchmark working group as an increase in the catchability for those ages. This can be justified, with the knowledge of the abandoning of the 30 cm MLS by the EC. The alternative explanation for the change in catch-at-age table is that those age were discarded previously and hence an unobserved part of the catch-at-age prior to 2000. Having more catch-at-age information available from different countries would provide more insight in the landings-at-age and discards-at age, and possibly give more insight in what caused the changes in the landings-at-age information that is now available from single countries only.

I. References

Boon, A.R., and Delbare, D. 2000. By-catch species in the North Sea flatfish fishery (data on turbot and brill) preliminary assessment DATUBRAS, study 97/078. Final RIVO report C020/00. 107 pp.

Weber, W. 1979. On the turbot stock in the North Sea. ICES C.M. 1979/G:12.

Stock Annex: Turbot in IIIa

Stock	Turbot in IIIa
Working Group	WGNEW
Date	02 October 2012
Authors	M. Cardinale, H. Svedäng, A-B. Florin

A. General

A.1. Stock definition

Turbot (*Psetta maxima* L.) is distributed in ICES Area IIIa (Skagerrak and Kattegat). The stock has historically been composed by two major spawning components, one in the Eastern Skagerrak and the other in the southern part of the Kattegat (Cardinale *et al*., 2009). Nielsen *et al*. (2004) show a sharp cline in genetic differentiation when going from the low saline Baltic Sea to the high saline North Sea, where samples from Skagerrak and Kattegat are in the transition zone. This suggests that the Skagerrak and Kattegat populations are inherently different from the turbot in the North Sea. Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al*. (in prep). The neutral marker panel confirmed a break-up between the Baltic and Northeast Atlantic clusters. Within the latter, a more detailed pattern of genetic differentiation could be observed, when gene-associated markers were also included in the analysis (results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/fisheries-genetics). Nevertheless, in the presence of strong natal homing, high residency and limited migration (see Section H1 for references and details) as is the case for turbot, the question whether populations (i.e. aggregation of adult fish during spawning) are genetically distinguishable is not crucial to the existence of self-sustaining population units and for management (Waples *et al*., 2008). Accordingly, the existence of separated spawning aggregations is a key factor regulating the dynamic of the populations (Svedäng *et al*., 2010) and thus they should be managed accordingly (Cardinale *et al*., 2011a).

A.2. Fishery

In the North Sea, turbot has been considered a highly prized fish ("prime") since the middle of the 1800s. Historically, it has been exploited within a multispecies fishery targeting turbot together with brill (*Scophthalmus rhombus*) and sole (*Sole solea*) (Mackinson, 2002). In IIIa, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale *et al*., 2009), while today turbot is only caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur in specific areas and seasons.

International landing series from IIIa between 1950 and 2010 are presented in Figure A.1. Over the period 1950–1989, these landings ranged around 300 t per year. The landings declined from over 300 t per year in 1989 to less than 100 t per year in 2011. Denmark landed on average 83% of the IIIa turbot. Other countries contributing to the total landings were - in descending order of importance - the Netherlands (mainly because of a peak in the second half of the seventies), Sweden, Norway, Belgium, Germany and the UK.

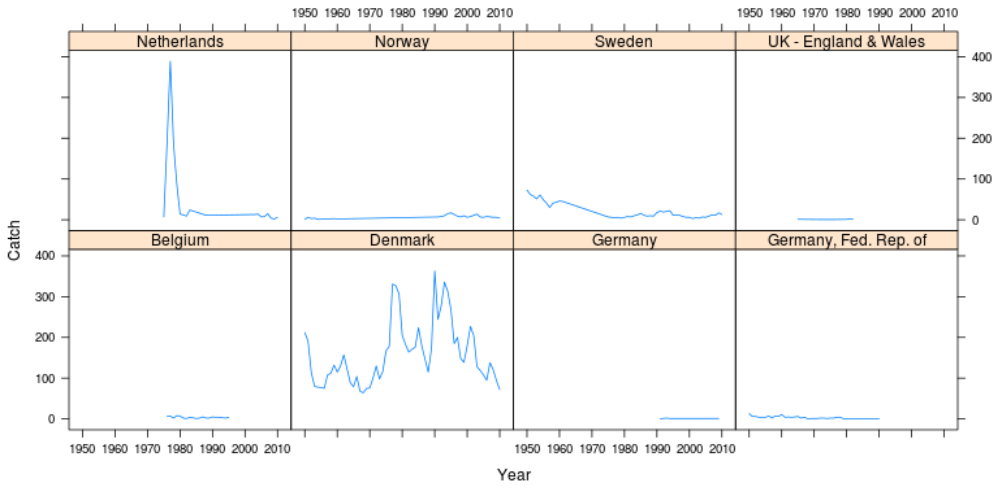


Figure A.1. Landings of turbot by country from 1950 to 2011 in IIIa. UK- Eng+Wales includes N. Ireland in 1991 (0.5 t), while Sweden reported aggregated catches for IIIa and IVa+b in 1973 (9.0) and 1974 (7.0).

A.3. Ecosystem aspects

Discards: Discarding of turbot in IIIa is considered negligible due to the high value of the species. Also, survival rates of discarded turbot are likely to be high. A Minimum Landing Size of 30 cm (as independently installed by various authorities) leads to the landing of many immature individuals and in particular females, while increasing the MLS to higher lengths leads to higher discarding percentages.

B. Data

B.1. Commercial catch

Commercial catch data are obtained from national laboratories of nations exploiting turbot in IIIa. Landings data are available by countries since 1901 from official ICES sources. Information on the size structure of the catches might be available at the national laboratories level for the most recent part of the time-series but they have never been compiled.

Sampling of commercial catch: Sampling of commercial catch is conducted by the national institutes according to the EU Data Collection Framework (DCF). However, due to the small amount of annual landings, sampling of commercial catches is sparse and also several countries might be exempted to sample turbot in IIIa. Sweden has not sampled turbot in IIIa in the last decades. In the past, biological samples of turbot from the Danish fisheries in IIIa have been taken both from landed catches and through the national at-sea-sampling programme.

The DCF exemptions to the general DCF sampling rules are:

2) Concerning lengths: the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

2.1) the relevant quotas must correspond to less than 5% of the Community share of the TAC or to less than 100 tonnes on average during the previous three years;

2.2) the sum of all quotas of Member States whose allocation is less than 5% must account for less than 15% of the Community share of the TAC.

If the condition set out in point (1.1) is fulfilled, but not the condition set out in point (1.2), the relevant Member States may set up a coordinated programme to achieve the implementation of the sampling scheme described above for their overall landings, or another sampling scheme, leading to the same precision.

1. Concerning ages: the national programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

2.3) the relevant quotas correspond to less than 10% of the Community share of the TAC or to less than 200 tonnes on average during the previous three years;

2.4) the sum of all quotas of Member States whose allocation is less than 10%, accounts for less than 25% of the Community share of the TAC.

If the condition set out in point (2.1) is fulfilled, but not the condition set out in point (2.2), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until the 31st of January of every year to take into account the exchange of quotas between Member States.

Due to the relatively small numbers of turbot in commercial catches (per trip) and the high commercial value of this species, it is very difficult to collect data on biological variables in sufficient numbers for a meaningful analysis. Fishermen very often do not allow observers to take turbot otoliths on board of commercial vessels (even when informing them that it is possible to sample the otoliths through the operculum in this species, making it unnecessary to cut open the heads and thus not influencing the appearance of individual fish and their value to buyers in this way) or set aside sampling gonads for maturity staging (although the fish are gutted on board anyhow). Neither has buying turbot as part of the market sampling been considered an option for most countries either, because of the high prices. However, including the biological sampling in MS national proposals as a part of the DCF should solve this problem. On surveys, catches of turbot are generally even lower than on commercial vessels. Furthermore, turbot is a coastal, shallow water species meaning that offshore surveys such as the regular International Bottom-trawl Survey misses important habitat for turbot.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers. However, it remains to be investigated how many samples have been collected in the past and are available at the national laboratories level, which can be compiled for stock assessment purposes. It is also important that ages have been read using the same preparation techniques (section and stained, WKART, Workshop of age reading in turbot 2008 (ICES 2008)).

Mean weights-at-age in the stock and proportions of mature individuals (maturity ogive) are derived from the IBTS and Havfisken survey (see Section B.3.2). Also, a workshop has taken place in IJmuiden in 2012 (WKMSTB, Workshop on Maturity Stag-

ing of turbot and brill (ICES 2012)). The workshop agreed on a common six point maturity scale for turbot across laboratories, and proposed optimal sampling strategy to estimate accurate maturity ogives.

Natural mortality

Natural mortality (M) at age will be estimated using biological information on growth, length–weight relationship and maximum size using the PRODBIOM software (Abella *et al.*, 1997; Cardinale *et al.*, 2011b). Alternatively, the same M as used in the North Sea assessment might be used, that was estimated from literature data using the equation of Gislason *et al.* (2010).

B.3. Surveys

B.3.1 International Bottom-trawl Survey

The International Bottom-trawl Survey (IBTS) started out as the International Young Herring Survey (IYHS) in 1966 (Heessen *et al.*, 1997). The survey was standardized gradually from 1977, and is considered to be fully standardized from 1983 onwards, where it became known as the International Bottom-trawl Survey (IBTS). The surveys are carried out in 1st quarter (February) and in 3rd quarter (August–September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. Size information of the turbot catches is available and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

B.3.2 KASU Bottom-trawl Survey

The KASU survey is a standard BITS (Baltic International Trawl Survey), another group of standardized surveys. The trawl is a standard TV3-520 with rubber discs of 10 cm diameter on the groundrope and with a trawl speed at 3 knots. This trawl targets flatfish better than IBTS and is designed to provide annual abundance indices for cod, plaice and sole. This survey takes place in the Kattegat and Belt Sea twice a year in February and November, and is conducted by a Danish vessel, Havfisken from DTU Aqua. KASU time-series start in 1996 for the first quarter and 1994 for the fourth quarter data.

KASU data have been revised in 2006, due to changes in the database combined with a change of extraction programs in 2005. The revision of last year indices highlighted data treatment errors and the new time-series is considered improved compared to the old one.

Size information of the turbot catches is available from KASU and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

Data storage: The data are initially tabulated in an excel sheet where the data are scrutinised for consistency and quality, and the different correction factors that standardize the data among nations is applied. In the case of IIIa, only Sweden has conducted the IBTS survey so the standardization does not apply.

Index Calculation: An aggregated and standardized survey catch per unit of effort has been calculated up to 2009 by Cardinale *et al.*, (2009) using IBTS survey data and historical data from Swedish trawl surveys since 1926. In the absence of age information for the surveys, statistical age slicing procedures (Scott *et al.*, 2011) might be used to

derive the number of fish per age class using length–frequency information from the survey.

B.4. Commercial cpue

Not used in this stock. However, data on catches and size of turbot should be available from the Danish sole fisherman survey, and also possibly from the Kattegat cod fisherman surveys (2009–2011).

B.5. Other relevant data

None.

C. Historical stock development

C.1. Choice of stock assessment model

The turbot in IIIa has never been assessed before.

C.2. Model used as basis for advice

The choice of the assessment model will be contingent on the amount and quality of the available data.

C.3. Assessment model configuration

The choice of the assessment model configuration will be contingent on the amount and quality of the available data.

D. Short-term projection

Short-term projections are not carried out for this stock.

E. Medium-term projections

Medium-term projections are not carried out for this stock.

F. Long-term projections

Long-term projections are not carried out for this stock.

G. Biological reference points

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point and fishing mortality for this stock.

Precautionary reference points

There are no ICES precautionary reference points for biomass and fishing mortality for this stock.

H. Other issues

H.1 Biology of the species in IIIa

Turbot lives on sandy, rocky or mixed bottoms and is one of the few marine fish species that also inhabits brackish waters. Turbot is a batch spawner and in marine waters eggs

are pelagic Spawning only occurs in marine waters (pelagic eggs), where it is a batch spawner (Murua and Saborido-Rey, 2003). The spawning season generally ranges from April to August. Turbot is one of the fastest growing flatfish. During the juvenile phase growth rates are high, turbot can reach 30 cm in three years. Growth curves of males and females diverge markedly from about age three and onwards, females growing larger than males (Molander, 1964; Jones, 1974). During the first years of life females grow from 8 to 10 cm a year. Females older than ten years still grow 1 or 2 cm a year. Turbot is a typical visual feeder and adults feeds mainly on highly mobile prey like other bottom-living fishes small pelagic fish and also, to a lesser extent, on larger crustaceans and bivalves. Due to their large mouthsize compared to other flatfishes they eat macrofauna (>1 mm) from the beginning of their benthic lives. The diet of the juveniles has been shown to consist of copepods, shrimps, barnacle larvae and gastropod mollusc larvae (Jones, 1973).

Turbot is a rather sedentary species, although more long distance migratory patterns have been observed. In the North Sea, migrations from the nursery grounds in the southeastern part to the more northern areas have been recorded (ICES 2012). Nevertheless, tagging studies from three different parts of the Baltic Sea all showed that adult turbot are very stationary, have high spawning site fidelity and that 95% of the fish moved less than 30 km from tagging site, although a few individual specimens showed displacements of 100s of km (Johansen, 1916; Aneer and Westin, 1990; Florin and Franzen, 2010). Thus, turbot generally occur in spatially separated stock units as it spawns at specific localities in shallow areas during summer (Molander, 1964; Curry-Lindahl, 1985; Voigt, 2002; Iglesias *et al*., 2003; Florin and Franzén, 2010) and with restricted movements as adults (Aneer and Westin, 1990; Støttrup *et al*., 2002; Florin and Franzén, 2010), and exhibit strong spawning site fidelity (Florin and Franzén, 2010). Inspection of historical data from the Skagerrak–Kattegat area also indicates spatially separate stock structure, at least in terms of spawning components, which is persistent over time (Cardinale *et al*., 2009).

H.2 Stock dynamics, regulation and catches through 20th century

According to time-series of standardized survey cpue (Cardinale *et al*., 2009), the reduction of turbot in IIIa occurred at the beginning of the industrialized fishery, which is usually considered to be the main cause of the decline of several stocks of many demersal species stocks in IIIa (Cardinale *et al*., 2012), showing instead that the pre-industrial fishery had already had a significant impact on the stock. Historical survey data shows that biomass of turbot in IIIa has declined at about 86% since 1925 with regard to initial values; the maximum individual body size has decreased around 20 cm from the beginning of the time-series (Cardinale *et al*., 2009). Moreover, the northern stock component within Area IIIa has been eradicated. These trends are likely to be underestimated due to the conservative approach used by assuming a low level of "technical creeping" for such a long period of time, suggesting that the actual reduction in biomass might have been between 92% and 95% (Cardinale *et al*., 2009). These results indicated a depleted status of the stock in IIIa and also different stock dynamics within the area (i.e. in comparison between the Skagerrak and the Kattegat) and also when compared to the estimated trends for the North Sea (ICES 2012).

An alternative interpretation to the overexploitation hypothesis is that the quantity and quality of the turbot nursery grounds has deteriorated due to pollution (in particular due to eutrophication) and increased frequency of hypoxia events occurring in the shallow sandy coastal waters of Denmark and Sweden (Pihl *et al*., 2005), affecting the productivity of the stock. However, the decline of biomass was also accompanied by a

large decrease in average maximum length, with large individuals, more abundant at the onset of the last century, being the first to be fished out with the beginning of the industrialized fishery. Thus, the above considerations corroborate the hypothesis that observed trends in length and stock size over the first part of the last century are a result of overexploitation.

H.3 Current fisheries

There is no direct or target fisheries of turbot in IIIa. The species is caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur for short period during the year in specific areas and seasons.

H.4 Management and ICES advice

Management plan

Hitherto, no management plan has been considered for turbot in IIIa.

I. References

Abella, A., Caddy, J.F., Serena, F. 1997. Do natural mortality and availability decline with age? An alternative yield paradigm for juvenile fisheries, illustrated by the hake *Merluccius merluccius* fishery in the Mediterranean. Aquat. Liv. Res. 10: 257–269.

Aneer G. and Westin L. 1990. Migration of turbot (*Psetta maxima* L.) in the northern Baltic proper. Fisheries Research 9, 307–315.

Cardinale, M., Linder, M., Bartolino, V., Maiorano, L. 2009. Conservation value of historical data: reconstructing stock dynamic of turbot (*Psetta maxima*) during the last century in the Eastern North Sea. Marine Ecology Progress Series, 386: 197–206.

Cardinale, M.; Bartolino, V.; Llope, M.; Maiorano, L.; Sköld, M.; Hagberg, J. 2011a. Historical spatial baselines in conservation and management of marine resources. Fish Fish. 12, 289–298.

Cardinale M., Raetz H.-J. and Aymen Charef. 2011b. Scientific, Technical and Economic Committee for Fisheries (STECF) - Report of the Assessment of Mediterranean Sea stocks - part 2 (STECF-11–14) (Luxembourg: Publications Office of the European Union; ISBN 978-92-79-22171-2.

Cardinale, M., Svedäng, H., Bartolino, V., Maiorano, L., Casini, M., Hjelm, J. Linderholm H. 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. Journal of Applied Ichthyology, 1–12, doi: 10.1111/j.1439-0426.2012.01937.x.

Curry-Lindahl, K. 1985. Våra fiskar. Havs- och sötvattensfiskar i Norden och övriga Europa. PA Nordstedt & Söner Förlag, Stockholm.

Florin A.-B. and Franzén F. 2010. Spawning site fidelity in Baltic Sea turbot (*Psetta maxima*). Fish Res 102, 207–213.

Gislason H., Daan N., Rice J.C., Pope J.G. 2010. Size, growth, temperature and the natural mortality of marine fish. *Fish and Fisheries* **11,** 149–158.

Heessen, H.J.L., Dalskov, J. and Cook, R.M. 1997. The International Bottom Trawl Survey in the North Sea, the Skagerrak and Kattegat. ICES CM 1997/Y:31. 23pp.

ICES. 2008. Report of the Workshop on Age Reading of Turbot (WKART), 24–27 June 2008, Oostende, Belgium. ICES CM 2008/ACOM:35.

ICES. 2012a. Report of the Workshop on Sexual Maturity Staging of Turbot and Brill (WKMSTB), 5–9 March, IJmuiden, The Netherlands. ICES CM 2012/ACOM:56.

ICES. 2012b. Report of the Working Group on Assessment of New MoU Species (WGNEW), 5–9 March 2012, ICES HQ, Copenhagen, Denmark. ICES CM 2012/ACOM:20. 258 pp.

Iglesias, J., Ojea, G., Otero, J.J., Fuentes, L. and Ellis, T. 2003. Comparison of mortality of wild and released reared 0-group turbot, *Scophthalmus maximus*, on an exposed beach (Ría de Vigo, NW Spain) and a study of the population dynamics and ecology of the natural population. Fisheries Management and Ecology, 10, 51–59.

Johansen, A.C. 1916. Marking experiments with sole (*Solea vulgaris Quensel*) and turbot (*Rhombus maximus* L.) in the Kattegat and Baltic waters. Meddelelser fra Kommissionen for Havundersøgelser, Serie: Fiskeri; Bind V, Nr. 3: 1–18.

Jones, A. 1973. Ecology of young turbot, *Scophthalmus maximus* L., at Borth, Cardiganshire, Wales. J. Fish Biol. 5: 367–383.

Mackinson, S. 2002. Representing trophic interactions in the North Sea in the 1880s, using Ecophath Mass-balance approach. in: S. Gue´nette, V. Chistensen, D. Pauly. (Eds). Fisheries impacts on North Atlantic ecosystems: models and analyses. Fish. Centre Res. Rep. 9:35–98.

Molander, A.R. 1964. Underordning plattfiskar. In: Andersson, K.A. (Ed.), Fiskar och fiske i norden. 1, Natur och kultur, Stockholm, pp. 90–113 (in Swedish).

Murua, H. and Saborido-Rey F. 2003. Female reproductive strategies of marine fish species of the North Atlantic. J. Northwest Atl. Fish. Sci. 33:23–31.

Nielsen E.E., Nielsen P.H., Meldrup D. and Hansen M.M. 2004. Genetic population structure of turbot (*Scophthalmus maximus* L.) supports the presence of multiple hybrid zones for marine fishes in the transition zone between the Baltic Sea and the North Sea. Mol Ecol 13, 585–595.

Phil L, Modin J, Wennahage H. 2005. Relating plaice (*Pleuronectes platessa*) recruitment to deteriorating habitat quality: effects of macroalgal blooms in coastal nursery grounds. Can J Fish Aquat Sci 62: 1184–1193.

Scott. F, Osio. C,M, Cardinale. 2011. Comparison of age slicing methods. STECF Mediterranean Subgroup.

Støtterup, J.G., Sparrevohn, C.R., Modin, J. and Lehmann, K. 2002. The use of releases of reared fish to enhance natural populations- A case study of turbot *Psetta maxima* (Linné, 1758). Fish. Res. 59, 161–180.

Svedäng, H., Stål, J., Sterner, T. and Cardinale, M. 2010. Consequences of subpopulation structure on fisheries management: Cod (*Gadus morhua*) in the Kattegat and Öresund (North Sea). Reviews in Fisheries Science 18(2), 139–150.

Voigt, H.R. 2002. Piggvaren i våra kustvatten. Fiskeritidskrift för Finland, 1, 25–27 (in Swedish).

Waples, R.S.; Punt, A.E.; Cope, J.M. 2008. Integrating genetic data into management of marine resources: how can we do it better? Fish Fish. 9, 423–449.

Stock Annex Whiting in 47d

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Whiting in Subarea IV and Division VIId
Working Group:	WGNSSK
Date:	March 2013
Revised by	WKROUND (Coby Needle)

A. General

A.1. Stock definition

The areas included in this whiting assessment are Subarea IV (North Sea) and Division VIId (eastern English Channel). The rationale for this is based more on negotiated management units and the doctrine of relative quota stability, rather than biology or ecosystem characteristics.

Whiting are known to aggregate in some localised areas, but for the most part are caught as part of a mixed fishery operating throughout the entire year. Adult whiting are widespread in the North Sea (although with a patchy distribution), while high numbers of immature fish occur off the Scottish coast, in the German Bight and along the coast of the Netherlands.

Tagging experiments, and the use of a number of fish parasites as markers, have shown that the whiting found to the north and south of the Dogger Bank form two virtually separate populations (Hislop and MacKenzie 1976). It is also possible that the whiting in the northern North Sea may contain "inshore" and "offshore" populations, while there is evidence of links between the northern North Sea whiting stock and the neighbouring stock in Division VIa (currently conceptually separated by an *ad hoc* line at 4° west). The report of the SGSIMUW (ICES-SGSIMUW 2005) documented much of the early the work performed on whiting stock identity issues.

The 2013 benchmark assessment meeting (ICES-WKROUND 2013) explored the problem of whiting stock definition in more detail. The evidence for links between Divisions VIa and IVa is compelling, and the required data compilation for any proposed joint assessment would be tractable. However, the precise location of any north-south split in the North Sea itself is more difficult to determine. Furthermore, the generation of time-series of international catch data for the separate areas would also be very difficult. The issue of stock definition for whiting is to be revisited at a future date.

A.2. Fishery

For North Sea whiting, there are three distinct areas of major catch: a northern zone, an area off the eastern English coast; and a southern area extending into the English Channel.

Northern area

In the northern area, roundfish are caught in otter trawl and seine fisheries, with a 120 mm minimum mesh size since 2002. These are mixed demersal fisheries with more specific targeting of individual species in some areas and/or seasons. Cod, haddock and whiting form the predominant roundfish catch in the mixed fisheries, although there can be important bycatches of other species, notably saithe and anglerfish in the

northern and eastern North Sea and *Nephrops* in the more offshore *Nephrops* grounds. The minimum mesh size in *Nephrops* trawls is 80mm but a range of larger mesh sizes and selection grids are also sometimes used when targeting *Nephrops*. Whiting is an important species for the Scottish fleet, with many vessels actively targeting whiting during some fishing trips. Technological developments have included a shift towards pair trawling and the development of double bag trawls which reduce costs compared to twin trawling. A number of vessels use 90 mm mesh gears with a 120 mm square mesh panel close to the codend, a configuration which releases cod.

Eastern English coast

Whiting are an important component in the mixed fishery occurring along the English east coast. Industry reports suggest better catch rates are achieved here here than implied by the overall North Sea assessment.

General

Whiting are a by-catch in some *Nephrops* fisheries that use a smaller mesh size, although landings are restricted through by-catch regulations. They are also caught in flatfish fisheries that use a smaller mesh size. Industrial fishing with small-meshed gear is permitted, subject to by-catch limits of protected species including whiting. Regulations also apply to the area of the Norway pout box, preventing industrial fishing with small meshes in an area where the by-catch limits are likely to be exceeded.

Historically, by-catch of whiting by industrial fisheries for reduction purposes was an important part of the catch, but due to the recent reduced fishery for sandeel and Norway pout the impact of this fishery on the whiting stock is considered much reduced.

A.3. Ecosystem aspects

Whiting is a key species in the trophodynamics of the North Sea, both as predator and as prey, and also exhibits strong cannibalism. Information on the natural mortality exerted on whiting by predation and cannibalism, and the mortality exerted by whiting on other species, is evaluated through biennial runs of the stochastic age-length structured multispecies model (SMS; Lewy & Vintner 2004) provided by ICES WGSAM, most recently in 2011.

B. Data

B.1. Commercial catch

Human consumption landings

For North Sea catches, human consumption landings data and age compositions are provided by Scotland, England, France, the Netherlands, Belgium, Norway and Germany. For eastern Channel catches, human consumption landings data and age compositions are supplied by England and France.

Industrial bycatch

Since 1991 the age composition of the Danish industrial by-catch has been directly sampled, whereas it was calculated from research vessel survey data during the period 1985–1990. Norway provides age composition data for its industrial by-catch. Whiting industrial by-catch has been relatively low since 1996 due to the limited fishery for Norway pout and a reduced sandeel fishery in several years.

In 2006 the samples used to raise Danish industrial bycatches (accounting for 98% of the industrial bycatch that year) were taken from Norwegian vessels whose catches have a different age structure. The data for 2006 have been replaced with an estimate $\hat{n}_{a,y}$ given by

$$\hat{n}_{a,y} = \hat{N}_y \hat{p}_a,$$

where $\hat{p}_a$ is the mean proportion at age over the years 1980 to 2005, and $\hat{N}_y$ is estimated to give a sums of products correction (SOP) factor of 1 by

$$\hat{N}_y = \frac{W_y}{\sum_a \hat{p}_a \hat{w}_a},$$

where W_y is the reported weight of industrial bycatch. Here $\hat{w}_a$ have been estimated by taking the mean weights at age in the industrial bycatch over the period 1995 to 2005 (zero weights are taken as missing values).

Discards

Discard rates for unsampled whiting fleet components in Subarea IV and Division VIId were obtained from samples provided by Denmark, Germany, France and the UK.

Compilation of international catch at age

From 2012, international catch data (landings, discards, industrial bycatch) have been collated within the InterCatch system provided by ICES. Age compositions for landings and discards are calculated as weighted means across contributing fleets, where the weights are the landed yield for the fleets. The resultant age compositions are then applied to unsampled fleets as deemed appropriate by the stock coordinator, following best-pratice advice from ICES. Scottish discard data are submitted to this system on an annual basis, as sampling rates are thought to be insufficient to justify the quarterly data provided by most countries. The protocol applied within InterCatch is to divide these discards equally among the four quarters, which is a tractable solution but may introduce bias.

Years included in the time-series

In 2002, the assessment working group (WGNSSK) decided to truncate the catch data to start from 1980. This was due to the very large change in estimated recruitment levels around 1980 that was present in the assessment. The working group could not determine whether this was due to a shift in the recruitment regime or because discard data for years prior to 1978 were not measured but estimated according to a discard ogive. This may not have been representative of discarding during the earlier period. Biological reference points for this stock had originally been established on the basis of the truncated series, so this represented no change with respect to them.

Following ICES-WKROUND (2009), the time-series of catch data was truncated further to start from 1990. The incentive for this decision was the comparison of a catch-at-age based assessment (XSA) with a survey-based assessment (SURBA). The SURBA run indicated that estimated SSB in the earlier part of the time-series (during the 1980s) was low and then rose to a higher level in the 1990s before returning to the low level in the 2000s and beyond. Conversely, the XSA run suggested that the maximum SSB occurred during the 1980s (following three large year-classes), and that the stock trend has roughly been downwards ever since. In other words, the survey and catch data

generated very different perceptions of stock dynamics before 1990. All data sources were consistent after 1990, which was therefore chosen as a cut-off point.

ICES-WKROUND (2013) revisited the issue of the length of the assessment time-series in considerable depth. Sensisitivity analyses showed that catch data would need to be reduced by around 75% for the years prior to 1990 for the survey-based and catch-based assessments to concur, and no reason for this discrepancy could be found. The truncation was therefore retained in the interests of parsimony.

B.2. Biological

Weights at age

Weight at age in the stock is assumed to be the same as weight at age in the catch. Unrepresentative sampling of industrial bycatch in 2006 and 2007 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values). Survey data could potentially be used to estimate stock weights, although care would need to be taken as the principal IBTS survey is thought to have relatively low catchability for older whiting which may therefore not be very well sampled.

Natural mortality

Natural mortality-at-age *M* is currently defined from the most recent key run of the stochastic age-length structured multispecies model (SMS; Lewy and Vintner 2004) produced biennially for the North Sea ecoregion by ICES-WGSAM.

Maturity

The maturity ogive is based on North Sea IBTS quarter 1 data, averaged over the period 1981-1985. The calculation was carried out at some point during the mid-to-late 1980s, although there is no information available to WKROUND to allow a determination of whether the estimates are based on combined sex or females only, and exactly how the calculation was done. The maturity ogive used in both the assessment and forecast is:

Age	1	2	3	4	5	6	7	8+
Maturity Ogive	0.11	0.92	1.00	1.00	1.00	1.00	1.00	1.00

Spawning occurs in spring. Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to zero.

B.3. Surveys

The first quarter International Bottom Trawl Survey (IBTS-Q1) is undertaken in February and March of each year, and covers depths of roughly 35 m to 200 m in the whole of the North Sea basin (Figure. B.3.1). The IBTS indices combine haul data from multiple vessels belonging to national institutes. As such they use a higher density of survey stations than the constituent national surveys, with several hauls per statistical rectangle.

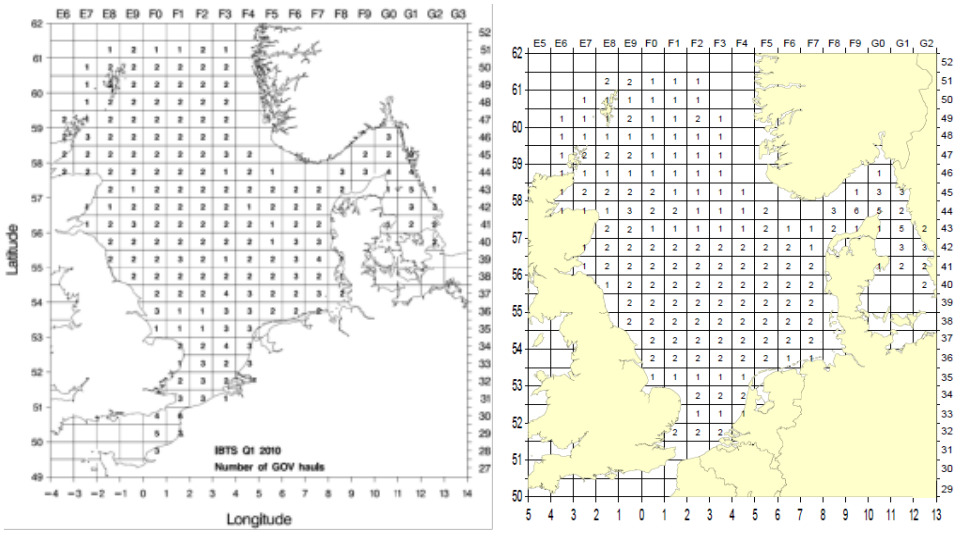


Figure B.3.1. Number of GOV trawl hauls per ICES rectangle in the IBTS Q1 survey in 2010 (left hand plot) and the IBTS Q3 survey in 2009 (right hand plot). Source: ICES IBTSWG reports.

In previous assessments the Scottish third quarter Groundfish Survey (Sco-IBTS-Q3) and English third quarter Groundfish Survey (EngGFS-IBTS-Q3) were used as independent surveys. The Sco-IBTS-Q3 is carried out in August each year, and covers depths of roughly 35 m to 200 m in the North Sea to the north of the Dogger Bank. It samples at most one survey station per statistical rectangle. In 1998 the coverage of this survey was extended into the central North Sea, but the index available to the Working Group has been modified so as to cover a consistent area throughout the time-series. The English third quarter Groundfish Survey (EngGFS-IBTS-Q3) is carried out in August each year, and samples at most one station per rectangle. It covers depths of roughly 35 m to 200 m in the whole of the North Sea basin. In 1991 the EngGFS-IBTS-Q3 changed fishing gear from the Granton trawl to the GOV trawl. For this reason the English groundfish survey is treated as two independent series.

The time-series of the survey indices of whiting supplied by the French Channel Groundfish Survey (CGFS) was revised in 2002. In 2001, the Eastern Channel was split into five zones. Abundance indices were first calculated for each zone, and then averaged to obtain the final CGFS index. This procedure was not thought to be entirely satisfactory, as the level of sampling was inconsistent across geographical strata. In 2002, it was thought more appropriate first to raise abundance indices to the level of ICES rectangles, and then to average those to calculate the final abundance index. Previous to the 2002 WG, only the hauls in which whiting were caught were used to derive abundance indices. This procedure biased estimates, and therefore, the indices supplied from 2002 are calculated on the basis of all hauls. However lack of internal consistency of this series means it has not been used in the assessment to date.

There is an unresolved problem in that the surveys available provide a different indication of stock trends before 1990 compared to an assessment based on catch data.. The IBTS indices combine haul data from multiple vessels belonging to national institutes and periodically these vessels are replaced. In 1998 FRS (Aberdeen) introduced a new survey vessel; it was considered at the time that no evidence existed to say the new vessel had different catchabilities to the old vessel (Zuur *et al*. 2001). This is now generally considered not to be the case. ICES-WKROUND (2009) investigated the possibility that changes in survey catchability over the period from the mid 1980s to the mid 1990s accounts for this mismatch. The required change in catchability was estimated

to be approximately a factor of two. Details of the investigations can be found in the benchmark report. Evidence for a change in catchability was not found (although the meeting recommended further work) but the following was concluded with respect to survey data.

Only IBTS-Q1 and IBTS-Q3 indices should be used. The Sco-IBTS-Q3 and EngGFS-IBTS-Q3 are incorporated into the IBTS-Q3 survey which is involves several other fleets and is likely to better represent the North Sea as a whole (Figure B.3.1).

The IBTS-Q1 survey should only be used from 1984 because the gear employed was not standardised before this date.

The IBTS-Q1 and IBTS-Q3 data can be downloaded from the DATRAS website at http://datras.ices.dk/Data_products/Download/Download_Data_public.aspx.

B.4. Commercial CPUE

Effort data are available for two Scottish commercial fleets: seiners (SCOSEI) and light trawlers (SCOLTR), both for the years 1978-2006. Non-mandatory reporting of fishing effort for these fleets means that they cannot be viewed as reliable for use for catch-at-age tuning.

Effort data are available for two French commercial fleets: otter trawl (FRATRO) 1986-2006 and beam trawl (FRATRB) 1978-2001. The same comment on non-mandatory reporting of fishing effort applies to these fleets.

B.5. Other relevant data

The North Sea Fishers' Survey presents fishers' perceptions of the state of several species including whiting. The survey covers the years 2003 to the present.

C. Assessment: data and method

The following outlines the method currently used for North Sea whiting. WKROUND considered that recent trends in the North Sea and eastern Channel whiting stock are appropriately estimated by the current assessment and are suitable for providing management advice. The assessment uses survey data and catch data from 1990 ignoring any issues prior to 1990. The outstanding issues and proposed directed research are detailed in ICES-WKROUND (2009, 2013).

The state-space model (SAM: Nielsen 2010) used for North Sea whiting offers a flexible way of describing the entire stock dynamic with relatively few model parameters. It allows for objective estimation of important variance parameters, leaving out the need for subjective *ad-hoc* adjustment numbers, which is desirable when managing natural resources. It also allows for error in input data and provides estimates of uncertainty in summary statistics. WKROUND were not able to undertake sensitivity analyses of run settings to determine the most appropriate settings to use for SAM, and so SAM has been retained as an exploratory analysis only for the time being. FLXSA has been retained as the baseline assessment method.

Model used: FLXSA. A SURBAR run (with smoothing parameter λ set to 5.0) and a SAM/FLSAM run will also be conducted to provide corroboration of the FLXSA run. The appropriate settings to use for the SAM/FLSAM run are to be determined as part of an inter-benchmark process during 2013-14.

Software used: The baseline software is FLXSA.

Model Options chosen:

Tolerance (tol):
1e-09

Maximum allowed iterations (maxit):
1000

Minimum standard error for surveys (min.nse): 0.3

Time series weighting in years (tsrange):
100

Time series weighting power (tspower): 0

Years of catch data to use (window): 100

Max age of power relationship in selection (rage): 0

First age of full selection (qage): 5

F shrinkage tolerance (Fse):
2.0

No. at age shrinkage; last # years (shk.yrs): 3

No. at age shrinkage; oldest # ages (shk.ages): 4

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1990-	NA	Yes
Canum	Catch at age in numbers	1990-	1-8+	Yes
Weca	Weight at age in the commercial catch	1990-	1-8+	Yes
West [assumed equal to Weca]	Weight at age of the spawning stock at spawning time.	1990-	1-8+	Yes
Mprop	Proportion of natural mortality before spawning	1990-	1-8+	No
Fprop	Proportion of fishing mortality before spawning	1990-	1-8+	No
Matprop	Proportion mature at age	1990-	1-8+	No
Natmor	Natural mortality	1990-	1-8+	Yes

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	IBTS-Q1	1990-	1-5 (age 6+ not used)
Tuning fleet 2	IBTS-Q3	1990-	1-5 (ages 0 and 6+ not used)

D. Short-Term Projection

Model used: Determinsitic short-term catch forecast

Software used: FLSTF package (version 1.4-1) with FLCore (version 2.2) and R (version 2.8.1).

Initial stock size: Point estimate from FLXSA assessment.

Maturity: Three-year average at age.

F and M before spawning: Fixed at 0.0.

Weight at age in the stock: Final historical year values at age.

Weight at age in the catch: Final historical year values at age, by catch component (landings, discards, industrial bycatch).

Exploitation pattern: Three-year average exploitation pattern by catch component, scaled to last historical year.

Intermediate year assumptions: TAC constraint applied if deemed to be appropriate by the assessment WG, otherwise none. Recruitment in intermediate year given by application of RTC3 regression analysis on survey data.

Stock recruitment model used: Geometric mean over all available years in the historical assessment.

Procedures used for splitting projected catches: The partial F at age for each catch component is estimated by splitting the forecast F at age using the mean proportion in the catch of each catch component over the last three historical years.

E. Medium-Term Projections

Regular medium-term projections are not undertaken for this stock. Forward stochastic simulations of a similar nature are conducted as part of management strategy evaluations for North Sea whiting, but as these are done every three or four years and outwith the assessment Working Group, they are not considered further here.

F. Long-Term Projections

See comments for medium-term projections above.

G. Biological Reference Points

ICES-WKROUND (2013) attempted to generate estimates of F(msy), and determined the sensitivity of the estimate to three factors:

1) The assumed stock-recruit model [Ricker, Beverton-Holt, Changepoint];

2) The assessment model used [SAM, XSA];

3) The length of catch time-series [1978-2011, 1990-2011].

F(msy) proved extremely difficult to estimate with any precision for any combination of these factors, to the extent that no reliable value could be determined. ICES-WKROUND (2013) concluded that management reference points (including F(msy) and B(trigger)) should be determined as part of a future management strategy evaluation.

	Type	Value	Technical basis
MSY	MSY Btrigger	To be determined	Explain
Approach	FMSY	To be determined	Explain

	Blim	To be determined	Explain
Precautionary	Bpa	To be determined	Explain
Approach	Flim	To be determined	Explain
	Fpa	To be determined	Explain

H. References

Bromley, P. J., Watson, T. and Hislop, J. R. G. (1997) Diel feeding patterns and the development of food webs in pelagic 0-group cod (*Gadus morhua* L.), haddock (*Melanogrammus aeglefinus* L.), whiting (*Merlangius merlangus* L.), saithe (*Pollachius virens* L.), and Norway pout (*Trisopterus esmarkii* Nilsson) in the northern North Sea. *ICES J. Mar. Sci.* **54** (5): 846-853.

Hislop, J. R. G. and MacKenzie, K. (1976). Population studies of the whiting *Merlangius merlangus* (L.) of the northern North Sea. *J. Cons. int. Explor. Mer* **37** (1): 98-110.

ICES-SGSIMUW (2005). Report of the Study Group on Stock Identity and Management Units of Whiting (SGSIMUW), 15–17 March 2005, Aberdeen, UK. ICES CM 2005/G:03. 50 pp.

ICES-WKROUND (2009). Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND). ICES CM 2009/ACOM:32

ICES-WKROUND (2013). Report of the ICES Benchmark Workshop on Roundfish Stocks 2013. 8–10 January 2013 in Galway, Ireland; 4–8 February 2013 in Aberdeen, Scotland. ICES CM 2013/ACOM:XXXX.

Lewy P. and Vinther M. (2004) A stochastic age–length-structured multispecies model applied to North Sea stocks. ICES CM/FF 2004:20-33.

Nielsen, A. (2010). State-space fish stock assessment model. http://www.stockassessment.org.

Zuur, A.F, Fryer, R.J. and Newton, A.W. (2001). The comparative fishing trial between *Scotia II* and *Scotia III*. Fisheries Research Services (FRS) Marine Laboratory Rep. No. 03/01.

Annex 03 – Stock Annexes – Part 2

Stock Annex: FU32 Norwegian Deep

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Norwegian Deep *Nephrops* (FU32)
Date:	07/05/2012 (WGNSSK2012)
Revised by	Guldborg Søvik

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10 – 100 % to excavate its burrows, which means that the distribution of suitable sediment defines the species' distribution. Adult *Nephrops* only undertake small-scale movements (a few 100 m) but larval drift may occur between separate mud patches in some areas. No information is available on the extent of larval mixing between the *Nephrops* stock in FU 32 and the neighbouring stocks in Skagerrak (FU 3) and Fladen Ground (FU 7).

FU 32 (the Norwegian Deep) is located in the eastern part of ICES Division IVa. Its western boundary is adjacent to the Fladen Ground area, while the Norwegian coast constitutes its eastern boundary. *Nephrops* has been caught on most trawl stations of the Norwegian annual shrimp survey covering the area (Figure A1-1). This indicates that the species is widely distributed in FU 32, but the exact distribution of the stock is not known.

A.2. Fishery

Traditionally, Danish and Norwegian fisheries have exploited this stock, while exploitation by UK vessels has been insignificant. Since 2000, Sweden have landed small amounts (Table A2-1, Figure A2-1). Denmark accounts for the majority of landings from FU 32: from the mid-1990s the Danish share of the landings has been between 80 and 90 %, except for the years 2008-2010. The Danish landings have decreased since 2005, to only 282 t in 2010, but increased slightly in 2011 to 322 t. The decreased Danish landings are probably due to economic reasons, for instance increased fuel prices. The number of Danish fishing vessels has also decreased. In 2011 Danish fishers reported lower amounts of *Nephrops* on the fishing grounds in FU32. Norwegian landings have decreased by 50% from 2008 to 2011. As a substantial part of the Norwegian *Nephrops* landings are taken as bycatch in shrimp trawls, the very poor shrimp fishery in the Norwegian Deep in recent years may be part of the explanation for the low Norwegian *Nephrops* landings.

Denmark

A description of the Danish *Nephrops* fisheries in Subareas IIIa and IV (including the one in the Norwegian Deep) was given in the 1999 WGNEPH report (ICES, WGNEPH 1999a). Danish VMS data show that the Danish vessels fish exclusively in the western part of the Norwegian Deep (Figure A2-2). Due to changes in the management regime (mesh size regulations regarding target species) in the Norwegian zone of the northern

North Sea in 2002, there was a switch to increasing Danish effort targeting *Nephrops* in the mixed fisheries in the Norwegian Deep. However, a distinction between the fishing effort directed at *Nephrops,* roundfish or anglerfish is not always clear. The mesh size in the trawls catching *Nephrops* is >100 mm. The use of twin trawls has been widespread for many years.

Norway

Nephrops is fished all year round by the Norwegian fleet. The *Nephrops* fishery north of 60 °N (with 16-36% of the Norwegian FU 32 landings (2001-2011)) is mainly a creel fishery, with some landings from *Nephrops* trawls (Figure A2-3). The fleet consists mainly of small vessels < 11 m (Figure A2-4), which also take the largest proportion of the landings (Figure A2-5). The fishery south of 60 °N, on the other hand, is mainly a trawl fishery (*Nephrops* trawls and bycatch from shrimp trawls), with some landings from creels. Here, the fleet structure changed from 2007 to 2011, with an increase in small vessels and a decrease in larger ones, resulting in the 2011 fleet being dominated by vessels < 15 m (Figure A2-4). This is reflected in the 2011 landings being landed mainly by vessels < 15 m, in contrast to the 2007-2010 landings caught largely by vessels 21-27.99 m long. The Norwegian *Nephrops* trawl fishery in FU 32 is actually a mixed fishery. In 2011 *Nephrops* made up respectively 10 and 35 % of the landings from this gear south and north of 60 °N. Landings per ICES statistical rectangle was available for the first time in 2009. These data are not precise, but are the best available for illustrating the spatial distribution of the Norwegian fishery in FU 32. In 2009-2010 the fishery had its main distribution west of Stavanger (Figure A2-3), while this was less obvious in 2011. According to the logbooks in 2011 most vessels undertake 1-3 hauls per day, with an average duration of each haul of approximately 9 hrs. Most fishing trips last 1-5 days. The recreational fishery for *Nephrops* along the Norwegian coast has increased in recent years. The extent of this fishery is now being investigated through interviews with fishers.

Regulations

After negotiations between Norway and EU the management regime (mesh size regulations regarding target species) in the Norwegian zone of the northern North Sea was changed in 2002 with minimum legal mesh size being set to 120 mm for all trawl fisheries. Before 2002 fishing for *Nephrops* was allowed using mesh sizes down to 70 mm, but as *Nephrops* is considered bycatch in a mixed fishery using ordinary bottom trawl, the special regulations regarding this species were removed in 2002.

The minimum legal size is 40 mm CL, which is higher than the minimum landing size of 25 mm CL in the rest of the North Sea (EU legislation). This is part of an agreement between Norway, Sweden and Denmark and is set mainly due to market reasons. Size can also be measured as total length, with a minimum legal size of 130 mm. Norwegian *Nephrops* landings may have up to 10 % in numbers below MLS. Discarding of *Nephrops* is not illegal in the Norwegian EEZ.

It is illegal to fish with more than two trawls south of 62 ^{0}N.

A.3. Ecosystem aspects

Nephrops lives in burrows in suitable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder (in the burrows) (Loo *et al*., 1993).

Sediment maps for the Norwegian Deep (Figure A3-1) indicate that the area of suitable sediment for *Nephrops* is larger than the current extent of the fishery, and there may be

possibilities of expansion into new grounds on which *Nephrops* is not currently exploited or only slightly exploited. These grounds are mainly found along the Norwegian coast as the Danish fishery takes place along the western slope of the Norwegian Deep (Figure A2-2).

Nephrops directed trawl fisheries are characterised by large amounts of non-commercial bycatch and *Nephrops* below MLS. However, in FU 32 *Nephrops* is fished together with demersal fish in a mixed fishery, and directed trawl fishery for *Nephrops* seems to be less common. The amount of *Nephrops* below MLS is small in the Danish and Norwegian fisheries in FU 32 due to the legislated mesh size of 120 mm. The *Nephrops* discard mortality from trawl fishing is considered to be high (75 %, Wileman *et al*. 1999), while it is basically zero in creel fisheries.

B. Data

B.1. Commercial catch

Onboard sampling of Danish catches (split into discard and landings components) are carried out by Danish observers, providing information on length distribution and sex ratio (Figure A2-1). For 2008-2009 sex specific data do not exist as the observers pooled data on males and females. Due to changes in the Danish at-sea-sampling programme implemented in the second quarter of 2011, where observer trips are randomly drawn from all fishing trips, the number of Danish fishing trips in FU 32 with onboard sampling was a single one in the first quarter of 2011. This is due to the very few Danish fishing trips in FU 32.

Onboard sampling of catches as part of inspections (not split into discard and landings components) have been carried out by the Norwegian coast guard, mainly on Danish trawlers, since 2005. There were, however, no data in 2010 and very limited data in 2005 and 2009. The coast guard tend to measure catches by total length. This results in fewer *Nephrops* below MLS compared with measuring by CL as a MLS of 130 mm total length actually corresponds to a CL of 38 mm, not 40 mm (the official MLS for CL). Upon request by the Norwegian Institute of Marine Research the coast guard measure CL, but seemingly include some of the animals of 39 mm length in the 40 mm length group, probably in order to make the outcome of the inspection independent of measuring method.

Since 2003 the Danish at-sea-sampling programme has provided data for discard estimates (Figure A2-1). However, the samples have not covered all quarters. There were no discards data for 2008 and 2011.

B.2. Biological

No biological data exist for this stock.

B.3. Surveys

No survey abundance index is available for this stock. The annual Norwegian shrimp survey covers most of the area, however, the catches of *Nephrops* in the survey trawl (Campelen 1800/35 bottom trawl with rockhopper gear, cod end mesh size is 22 mm with 6 mm lining net) are too small and variable to provide a reliable abundance index. This is partly due to the survey being designed to cover shrimp grounds. The survey data only give an impression of the distribution of *Nephrops* in FU 32 (Figure A1-1).

B.4. Commercial LPUE

A landings-per-unit-effort time-series is available from the Danish trawl fleet (Figure A2-1). LPUE is estimated using officially recorded effort (days fished). There is no account taken of any technological creep in the fleet.

Norwegian log books from FU 32 are incomplete regarding *Nephrops* recordings, with log book catches constituting 12-40% of the landings in 2001-2011. Therefore, the landings-per-unit-effort time-series from the Norwegian fleet in FU 32 are not utilized. Furthermore, the recordings of the various gears seems to be inconsistent, both between years as well as between the landings statistics and the logbooks. For instance, there are no records on the use of *Nephrops* trawls in the 2006-2011 logbooks, while a substantial part of the landings in the same time period are recorded as caught by *Nephrops* trawl in the official landings statistics. Electronic logbooks were introduced in Norway in 2011 and made compulsory for all vessels ≥ 15 m. This will provide the working group with consistent data for part of the fleet. However, as a large portion of the Norwegian fleet landing *Nephrops* in FU 32 consists of vessels < 15 m, especially north of 60 °N (Figure A2-4), the Norwegian logbook data available for analysis will continue to be limited.

The state of the stock is assessed based on the Danish LPUE.

C. Historical Stock Development

None

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

None specified.

H. Other Issues

I. References

Loo, L-O., S. Baden & M. Ulmestrand, 1993. Suspension feeding in adult *Nephrops* norvegicus (L.) and Homarus gammarus (L.) (Decapoda). Netherland Journal of Sea Research. 31:3, 1-6.

Wileman, D.A., G. I. Sangster, M. Breen, M. Ulmestrand, A. V. Soldal and R.R. Harris, 1999. Roundfish and *Nephrops* survival after escape from commercial fishing gear. EC Contract No: FAIR-CT95-0753. Final Report 1999. 125 p + appendix.

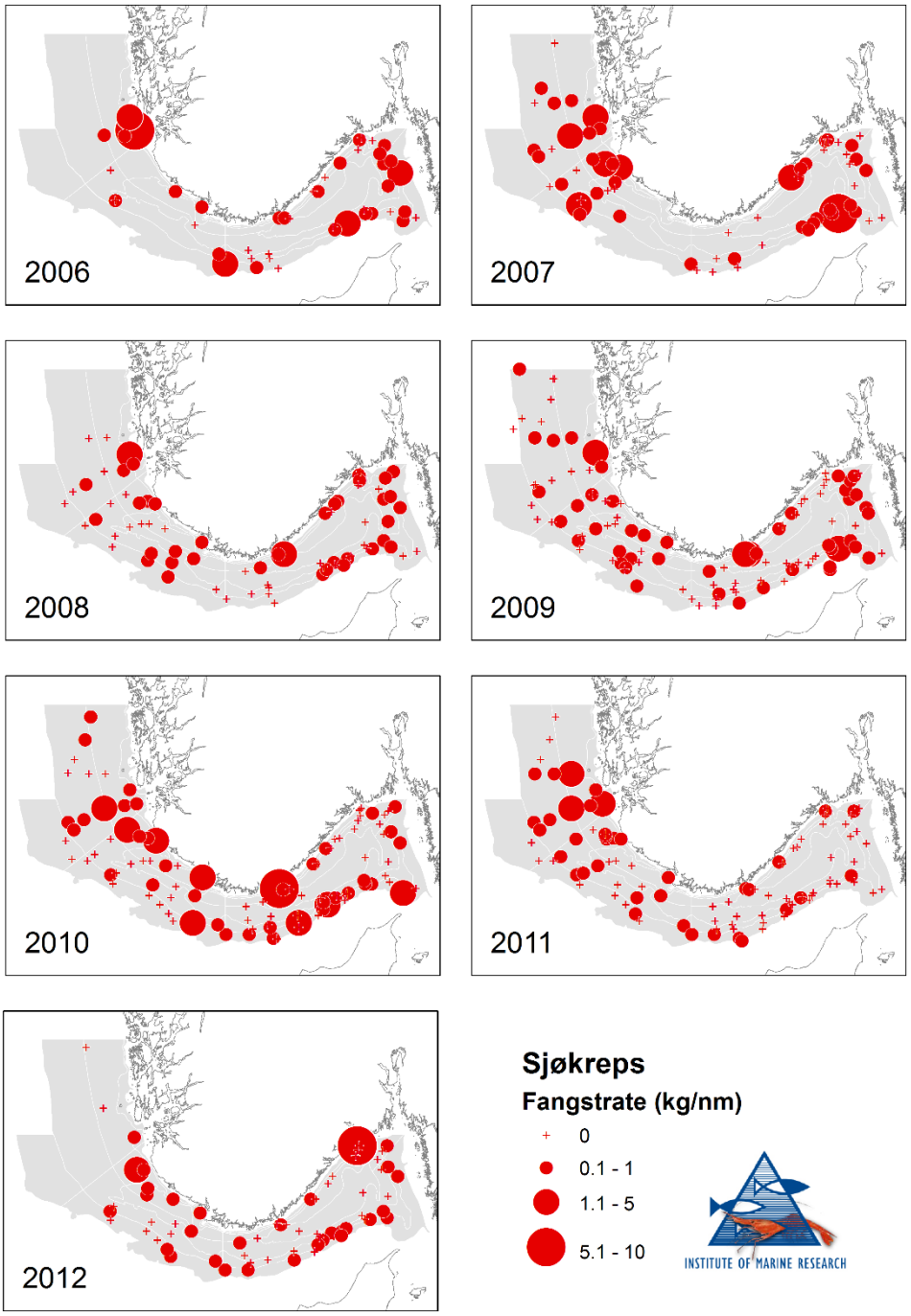


Figure A1-1. *Nephrops* **Norwegian Deep (FU 32). Catches (kg/nm trawled) from the Norwegian shrimp survey, January-February 2006-2012.**

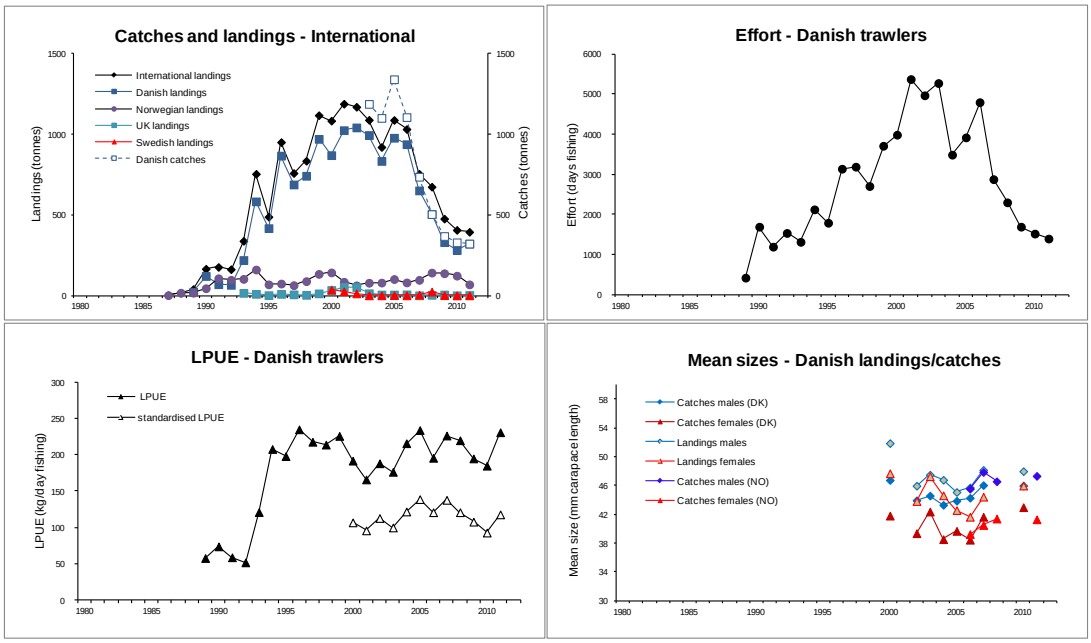


Figure. A2-1. *Nephrops* Norwegian Deep (FU 32). Long term landings, Danish effort, Danish LPUE and Danish mean sizes of catches and landings.

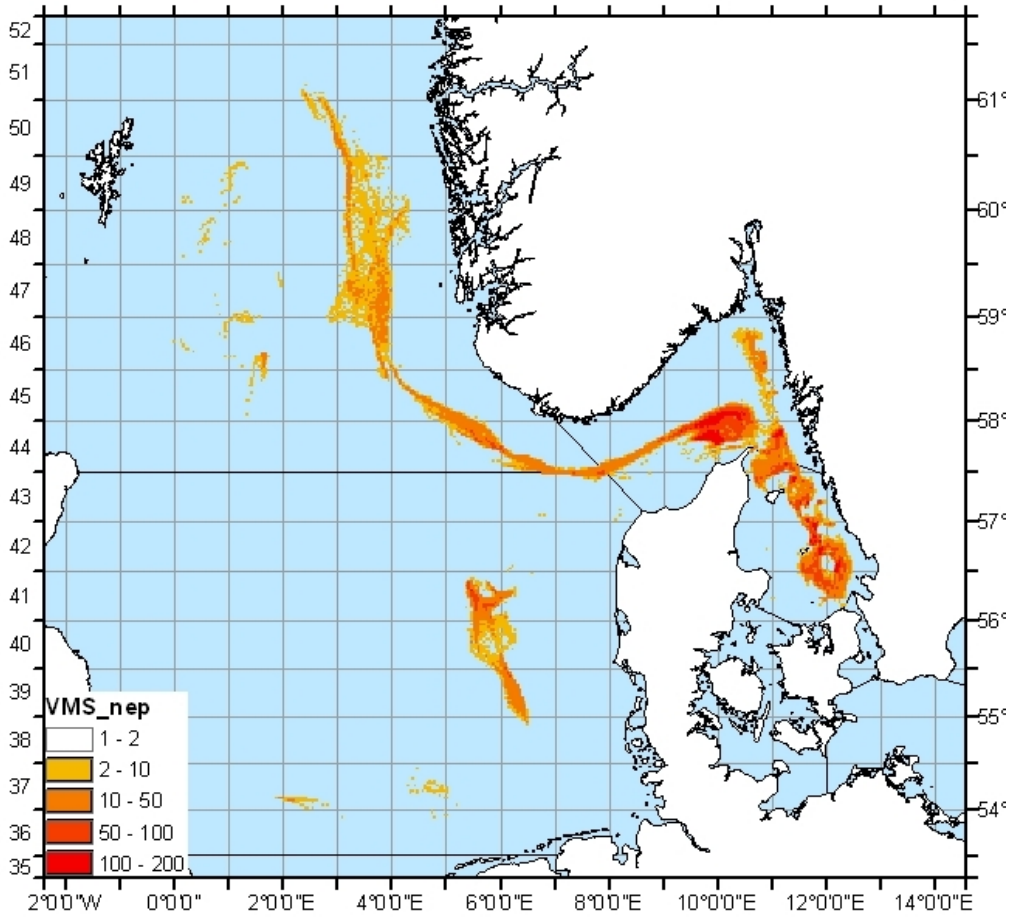


Figure A2-2. *Nephrops* **Norwegian Deep (FU 32). VMS data showing the spatial distribution of the Danish and Swedish fleet fishing for** *Nephrops* **in Skagerrak, Kattegat, and the North Sea. The Swedish vessels are mainly fishing in Kattegat and the northeastern part of Skagerrak.**

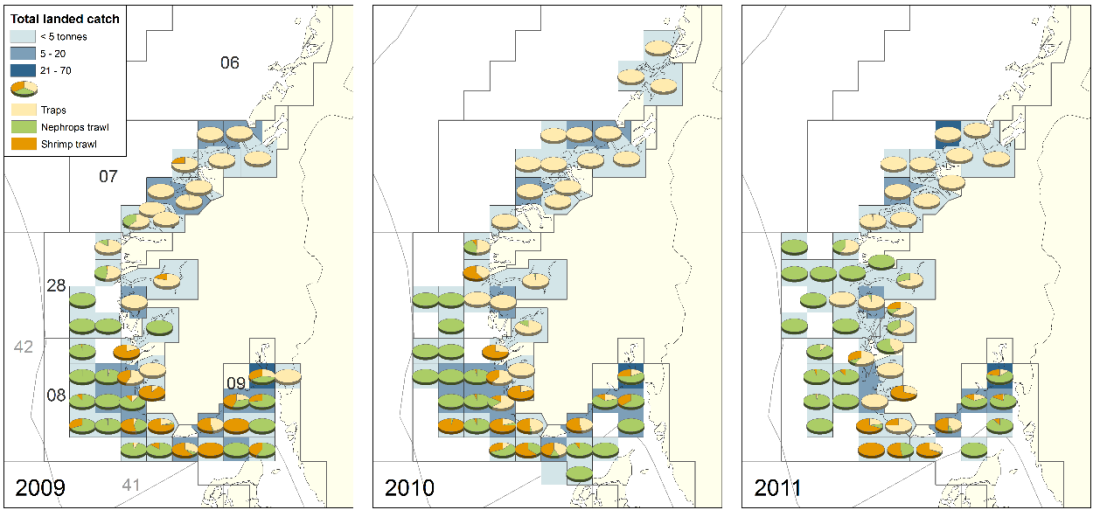


Figure A2-3. *Nephrops* **Norwegian Deep (FU 32). Norwegian landings per gear type and ICES statistical rectangle in 2009-2011. The numbers are area codes from the Norwegian Directorate of Fisheries, where 08 refers to FU 32 south of 60 °N, and 28 refers to FU 32 north of 60 °N. Data from the Norwegian Directorate of Fisheries.**

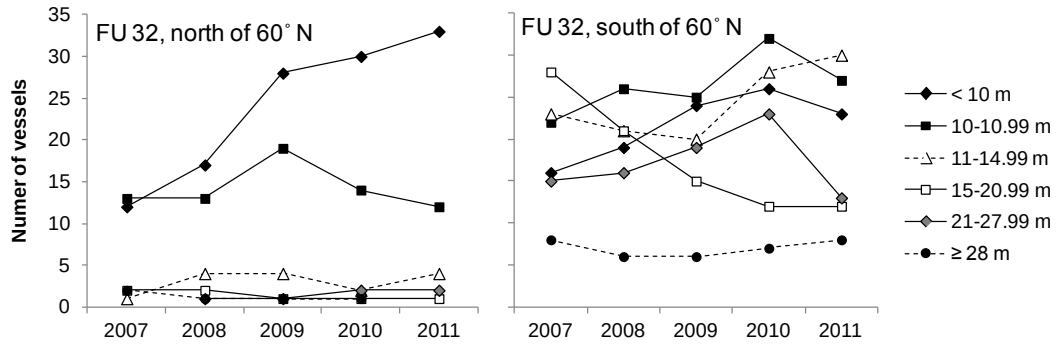


Figure A2-4. ***Nephrops*** **Norwegian Deep (FU 32). The Norwegian fleet landing** ***Nephrops*****, per length group in 2007-2011, north and south of 60 °N. Data from the Norwegian Directorate of Fisheries.**

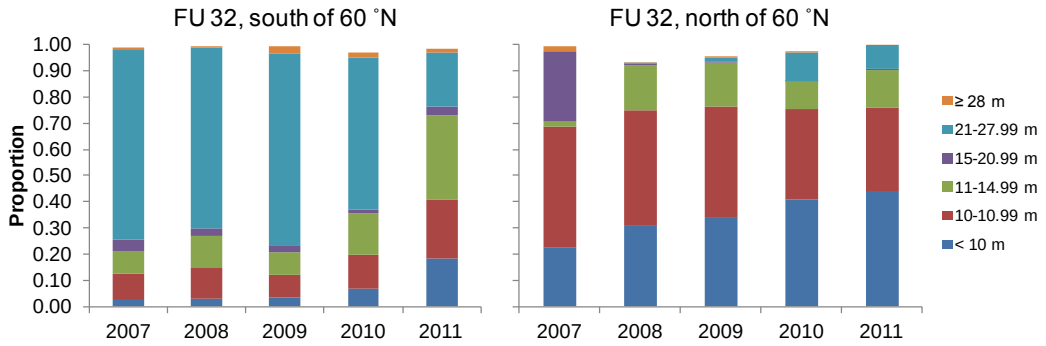


Figure A2-5. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings (proportion) in 2007-2011 per vessel length group, north and south of 60 °N. Not all columns add up to one due to lack of lengths for some vessels. Data from the Norwegian Directorate of Fisheries.**

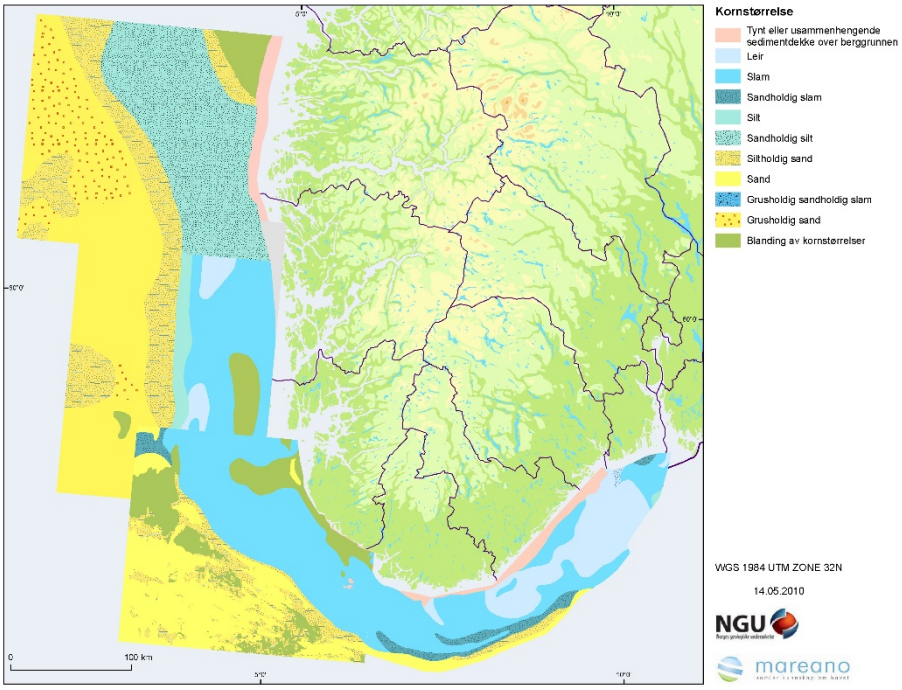


Figure A3-1. Sediment map of the Norwegian Deep and Skagerrak. Map from www.mareano.no.

Table A2-1. *Nephrops* Norwegian Deep (FU 32). International landings, and Danish effort (days) and LPUE (kg/day), 1993-2011.

Year	Landings	Effort	LPUE
1993	339	1317	121
1994	755	2126	208
1995	489	1792	198
1996	952	3139	235
1997	760	3189	218
1998	836	2707	214
1999	1119	3710	226
2000	1085	3986	192
2001	1190	5372	166
2002	1171	4968	188
2003	1090	5273	177
2004	922	3488	216
2005	1089	3919	234
2006	1033	4796	196
2007	755	2878	226
2008	675	2301	220
2009	477	1694	195
2010	407	1522	185
2011	395	1398	231

Stock Annex: FU6, Farn Deeps

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Farn Deeps *Nephrops* (FU06)
Date:	18/05/2010
Revised by	Ewen Bell/Jon Elson

General

Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10 – 100% to excavate its burrows, and this means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small-scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. In the Farn Deeps area the *Nephrops* stock inhabits a large continuous area of muddy sediment extending North from 54° 45′ - 54° 35′N and 0° 40′ - 1° 30′N with smaller patches to the east and west.

The extent of the mud covers the following statistical rectangles.

38-40 E8-E9; 37E9

Fishery

In 2001 the cod recovery plan was introduced and the number of vessels recorded in this fishery and landing into England increased from around 160 in 2000 to and fluctuated around 200 between 2001 and 2003. In 2004 the number returned to around 160 vessels but stepped up to 230 vessels in 2006. Although a small increase was apparent in the number of the local fleet turning to *Nephrops* the increase in the number of visiting Scots, Northern Irish and other English vessels was greater. Visiting Scottish vessels consistently make up about 30 to 40% of the fleet during the season and account for between 20 and 30% of the landings by weight. Since 2000 there has been an increase in the effort of vessels targeting *Nephrops* using multi rig trawls. In 2004 they accounted for about 10% of the landings by weight and 20% by 2006. Over 25% of the entire fleet uses multi rigs mainly through an influx of up to 19 Northern Irish and 30 Scottish multi riggers visiting the area - coming into the fishery for the frst time over the last two years. Both single and multi trawl fleets were affected by Technical Conservation Measures and Cod recovery plans. The single trawl fleet in general switched from a 70mm to an 80 mm cod end mesh in 2002. Multi rigged vessels targeting prawns use 95mm cod end mesh. The average vessel size of the visitors has remained relatively stable but average horse power has increased. With decommissioning the average size and power of the local fleet has declined slightly. Currently the average size of the local fleet is 11m with an average engine power of around 140 kW.

The fishery is exploited throughout the year, with the highest landings made between October and March. Fishing is usually limited to a trip duration of one day with 2 hauls of 3-4 hours being carried out. The main landing ports are North Shields, Blyth, Amble and Hartlepool where, respectively, on average 45, 32, 10 and 7% of the landings from this fishery are made.

The minimum landing size for *Nephrops* in the Farn Deeps is 25mm CL. Discarding generally takes place at sea, but can continue alongside the quay. Landings are usually made by category for whole animals, often large and medium and a single category for tails. However, landings to merchants of one category of unsorted whole and occasionally one of tails is becoming more common. Depending on the number of small, the category of tails is often roughly sorted as whole and left on deck for tailing later. This category is only landed once tailed. The local enforcement agency is discouraging the practice of tailing after tying up alongside.

Regulations

UK legislation (SI 2001/649, SSI 2000/227) requires at least a 90mm square mesh panel in trawls from 80 to 119mm, where the rear of the panel should be not more than 15m from the cod-line. The length of the panel must be 3m if the engine power of the vessel exceeds 112 kW, otherwise a 2m panel may be used. Under UK legislation, when fishing for *Nephrops*, the cod-end, extension and any square mesh panel must be constructed of single twine, of a thickness not exceeding 4mm for mesh sizes 70-99mm, while EU legislation restricts twine thickness to a maximum of 8mm single or 6mm double.

Under EU legislation, a maximum of 120 meshes round the cod-end circumference is permissible for all mesh sizes less than 90mm. For this mesh size range, an additional panel must also be inserted at the rear of the headline of the trawl. UK legislation also prohibits twin or multiple rig trawling with a diamond cod end mesh smaller that 100mm in the north Sea south of 57o30'N.

Legislation on catch composition for fishing N or S of 55° along with other cod recovery measures may have affected where and when effort is targeted which in turn could affect catch length distributions. This latitude bisects the Farn Deeps *Nephrops* fishery.

Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

Data

Commercial catch

Three types of sampling occur on this stock, landings sampling, catch sampling and discard sampling providing information on size distribution and sex ratio. Landing and catch sampling occurs at North Shields, Blyth, Amble and Hartlepool.

Historically, estimates of discarding were made using the difference between the catch samples and the landings samples. For the period prior to 2002, catch length samples and landings length samples are considered to be representative of the fishery. An estimate of retained numbers at length was obtained for this period from the catch sample using a discard ogive estimated from data from the 1990s, a raising factor was then determined such that the retained numbers at length matched the landings numbers at length. This raising factor was then applied to the estimate of discard numbers at length.

More recently, there has been concern that the landings sampling may be missing portions of the landings landed as tails (as opposed to whole individuals) thus leading to an artificial inflation of the estimated discards. On-board discard sampling has been of

sufficient frequency since 2002 to enable the estimation of discards from these data. There are two modes of operation for "tailing" in the FU6 *Nephrops* fishery, some vessels tail at sea, others tail at the quayside. Discard estimates from the latter category only sample those animals discarded at sea, the undersize individuals discarded at the quayside are not sampled, consequently the proportion of discards at sizes below MLS for this tailing practice are very low (Figure B.1.1). Discard trips, which saw discarding of less than 50% of individuals below MLS, were ignored. Annual discard ogives showed no systematic change, therefore a single ogive was constructed from the pooled data from 2002–2007 (Figure B.1.2). This was then applied to the catch data to produce estimates of landings at length.

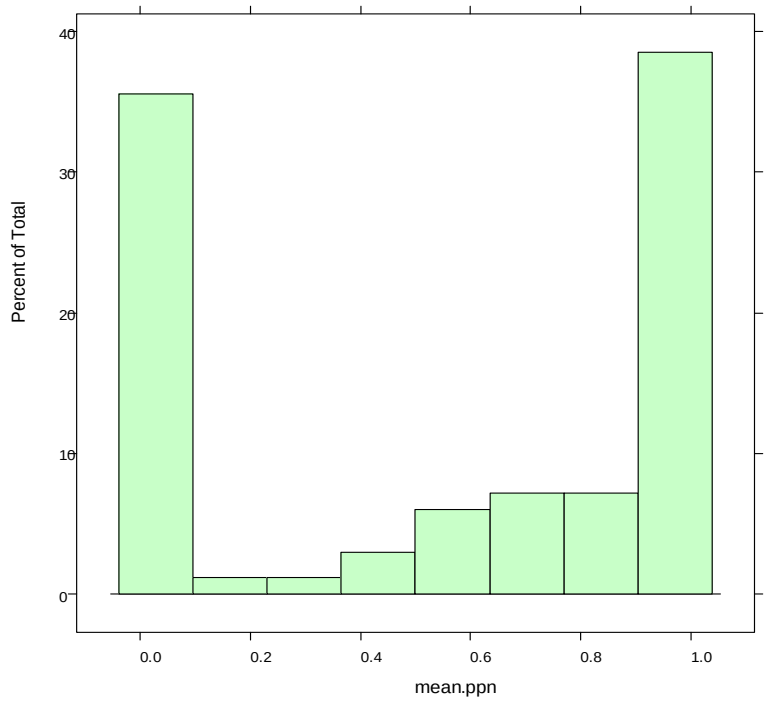


Figure B.1.1. Farn Deeps (FU 6): Histogram of proportion individuals <26mm discarded.

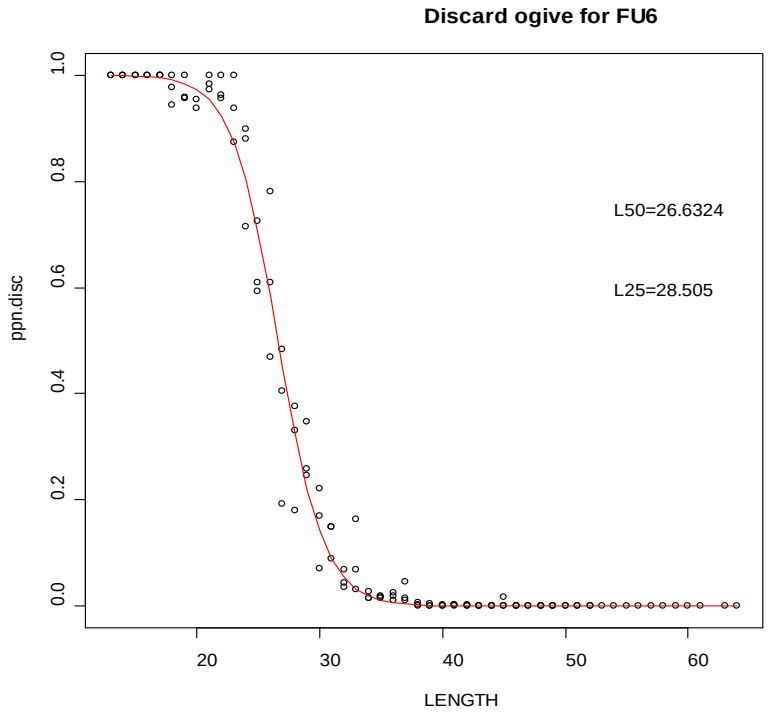


Figure B.1.2. Farn Deeps (FU 6): Discard ogive selected for FU6 *Nephrops*, trip level data pooled to year 2002-2007

Biological

Mean weights-at-age for this stock are estimated from fixed weight-length relationships derived from samples collected from this fishery (Macer unpublished data).

A natural mortality rate of 0.3 was assumed for all age classes and years for males and immature females, with a value of 0.2 for mature females based on Morizur, 1982. The lower value for mature females reflects the reduced burrow emergence while ovigerous and hence an assumed reduction in predation.

The size at maturity for females was recalculated at ICES-WKNEPH 2006 to be 24.8mm CL 24 mm CL was used in assessments prior to 2009. A sigmoid maturity function is now used: L25 = 24.5mm, L50 = 25mm

Growth parameters are estimated from observations from this fishery (Macer, unpublished data) and comparison with adjacent stocks.

The time-invariant values used for proportion mature at age are: males age 1+: 100%; females age 1: 0%; age 2+: 100%. The source of the value for females is based on observations on 50% berried CL.

Discard survival (previously set at 25 %) was set to zero from 1991.

Summary:

Growth :

Males; L_∞ = 66mm, k = 0.16

Immature Females; L_∞ = 66mm, k = 0.16

Mature Females; L_∞ = 58mm, k = 0.06,

Size at maturity L25=24.5mm, L50=25mm.

Weight length parameters:

Males a = 0.00038, b = 3.17

Females a= 0.00091, b = 2.895

Discards

Discard survival rate: 0%.

Discard proportion: 25.0%

Surveys

Abundance indices are available from the following research-vessel surveys:

Underwater TV survey: years 1996 – present. Surveys have been conducted in Spring and/or Autumn each year but only consistently in Autumn from 2001. In 2008 there was an historical revision of burrow density estimates from the TV survey. Previous estimates of burrow density had assumed that station density was independent of burrow density based analysis that showed there was no evidence of differences in trends in burrow density between the different strata in the fishery (ICES WGNEPH, 2000). The assumption led to an unstratified mean density being used and multiplied by the total area to arrive at overall abundance. Analysis of burrow density by rectangle has since shown that the distribution of stations is positively correlated with burrow density and therefore the unstratified mean density will overestimate burrow density. In order to compensate for the bias in sampling density, burrow abundance estimates are made for each rectangle and then summed to give the new total.

The procedure was revised again in 2011 and a geostatistical approach was taken, working the survey data back to 2007 in order to completely remove the bias between station density and burrow density. The procedure is run using the R statistical package with the gstat, maptools, and spatstat libraries

A boundary file was created using the VMS and BGS sediment data on the MapInfo GIS system and is used to delimit the boundaries of the kriged map.

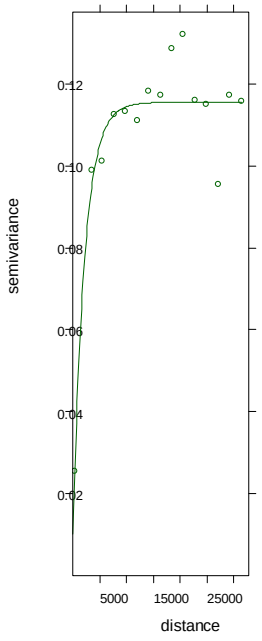
Mean density per station and the geographical coordinates (transformed from latitude and longitude into metres displacement from 54.67275 N, -1.332769 E) are first fitted with a variogram model. The following commands are used to fit the variogram (the data is held in dataframe "recounts7")

```
gstat.recount <- gstat(id="BurrowDensity",formula=BurrowDensity~1, locations=~lon.m+lat.m, data=recounts7)

vario.recount <- variogram(BurrowDensity~1 , locations=~lon.m+lat.m, data=recounts7)

fit.vario.recount <- fit.variogram(vario.recount, model=vgm(0.1, "Exp", 15000, 0.03))

plot(vario.recount, fit.vario.recount)
```



A Kriged estimate of density is then produced for a 500*500m grid of points lying inside the boundary with the following code.

```
coordinates(recounts7)=~lon.m+lat.m


#and the grid we're going to produce

pred.lat <- seq(from=y.range[1], to=y.range[2], by=500)

pred.lon <- seq(from=x.range[1], to=x.range[2], by=500)
```

recount.grid <- data.frame(lat.m=rep(pred.lat, each=length(pred.lon)), lon.m=rep(pred.lon, times=length(pred.lat)))

pos <- point.in.polygon(recount.grid$lon.m, recount.grid$lat.m, boundary$dist.lon, boundary$dist.lat)

recount.grid <- recount.grid[pos>0,]

gridded(recount.grid)=~lon.m+lat.m

coordinates(boundary)=~dist.lon+dist.lat

#krig it

krige.recount <- krige(BurrowDensity~1, recounts7, recount.grid, model=fit.vario.recount)

res <- (sum(krige.recount$var1.pred*250000)/1000000) /bias# each cell represents a 500m*500m block = 250000 sq m, divide by 1million to get the index in millions

By bootstrapping the recount data with replacement it is possible to estimate the uncertainty on the survey abundance estimate. Typically this comes out at a ~2% confidence interval.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are as follows.

Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
<=2009	1.3	0.85	1.05	1	1.2

Commercial CPUE

Catch-per-unit-effort time-series are derived from the recorded effort for English vessels using gears 7, 13, 14, 15 and 96 (unspecified otter, *nephrops*, twin-*nephrops*, triple *nephrops* and quad-*nephrops* gears), using mesh in the range of 70-99mm is used in conjunction with their reported landings.

There is no account taken of any technological creep in the fleet.

The registered buyers and sellers legislation brought in by the UK in 2006 changed the reporting procedure, which effectively breaks the continuity in the series at that point. The accuracy of the reported landings has significantly improved since then but there is currently little that can be done to determine and correct for any differences in the two series.

Other relevant data

Historical Stock Development

1. Survey indices are worked up annually resulting in the TV index.

2. Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

3. Generate mean weight in landings. Check the time series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in the future).

Short-Term Projection

4. The catch option table will include the harvest ratios associated with fishing at $F_{0.1}$ and Fmax. These values have been estimated by the Benchmark Workshop (see section 9.2) and are to be revisited by subsequent benchmark groups. The values are FU specific and have been put in the Stock Annexes.

5. Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

6. Multiply the survey index by the harvest ratios to give the number of total removals.

7. Create a landings number by applying a discard factor. This conversion factor has been estimated by the Benchmark Workshop and is to be revisited at subsequent benchmark groups. The value is FU specific and has been put in the Stock Annex.

8. Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

Medium-Term Projections

None

Long-Term Projections

None

Biological Reference Points

Harvest ratios equating to fishing at F0.1 F35% spawner per recruit and Fmax were calculated in WKNeph (2009) and subsequently revised by WGNSSK 2011. These calculations assume that the TV survey has a knife-edge selectivity at 17mm and that the supplied length frequencies represented the population in equilibrium.

2011 values

		Fbar 20-40mm		Harvest Rate	% Virgin Spawner per Recruit	
		Female	Male		Female	Male
F0.1	Comb	0.05	0.16	7.21%	67.46%	36.61%
F0.1	Female	0.11	0.34	12.68%	48.97%	20.18%
F0.1	Male	0.05	0.14	6.38%	70.80%	40.61%
F35%	Comb	0.10	0.30	11.46%	52.56%	22.75%
F35%	Female	0.21	0.62	18.74%	34.84%	12.13%
F35%	Male	0.06	0.18	8.00%	64.42%	33.29%
Fmax	Comb	0.11	0.32	12.08%	50.70%	21.39%
Fmax	Female	0.23	0.69	20.02%	32.51%	11.06%
Fmax	Male	0.08	0.23	9.47%	59.08%	28.12%

2009 values for comparison

		Fbar 20-40mm		Harvest Rate	% Virgin Spawner per Recruit	
		Female	Male		Female	Male
F0.1	Comb	0.06	0.17	8.20%	63.00%	38.60%
F0.1	Female	0.12	0.33	14.20%	45.60%	22.20%
F0.1	Male	0.05	0.15	7.10%	67.10%	43.50%
F35%	Comb	0.11	0.3	12.90%	48.90%	24.80%
F35%	Female	0.18	0.5	19.40%	35.00%	14.80%
F35%	Male	0.07	0.2	9.30%	59.50%	34.80%
Fmax	Comb	0.11	0.3	13.20%	48.30%	24.30%
Fmax	Female	0.19	0.51	19.90%	34.30%	14.40%
Fmax	Male	0.09	0.24	10.90%	54.60%	29.90%

The TV abundance estimate for 2007, the first year of low stock abundance and concern over recruitment is used as MSY $B_{trigger}$. Using the geostatistical method of estimating abundance this equates to an abundance of 802 million individuals over 17mm carapace length.

Other Issues

References

Stock Annex: FU7, Fladen Ground

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Fladen Ground *Nephrops* (FU 7)
Date:	09 March 2009 (WKNEPH2009)
Updated:	16 May 2011
Revised by	Sarah Clarke/Carlos Mesquita/Helen Dobby

A General

A.1 Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Fladen Ground is located towards the centre of the northern part of Division IV and is defined by statistical rectangles 44-49E9-F1 and 45-46E8. Its eastern boundary is adjacent to the Norwegian Deeps area, while its western boundary borders the Moray Firth functional unit (FU9). There is some evidence for overlap of habitat at the boundary of these areas. The ground represents one of the largest areas of soft muddy sediments in the North Sea and there are wide variations in sediment composition across the ground. *Nephrops* is distributed throughout the area and is associated with various benthic communities reflecting the variations in physical environment.

A.2 Fishery

The Fladen fishery (FU7), the largest Scottish *Nephrops* fishery, takes a mixed catch with haddock, whiting, cod, monkfish and flatfish such as megrim, also making an important contribution to vessel earnings. The Fladen *Nephrops* fleet comprises vessels from 12m up to 35m fishing mainly with 80mm twin-rig. The fleet has a diverse range of boats, and includes some of the largest most modern purpose built boats in the Scottish fleet and vessels which have recently converted to *Nephrops* fishing.

The area supports well over 100 vessels and the majority of the fleet (80%) fish out of Fraserburgh, with the other important ports being Peterhead, Buckie, Macduff, and Aberdeen. Boats fish varying lengths of trip between 3 days (small boats) and 8-9 day trips (larger vessels). During 2006 and 2007 around 20 vessels joined the fleet and 5 ongoing new boat builds have the capability to fish at Fladen. Some whitefish vessels have converted to *Nephrops* twin-rigging.

The Fladen fishery generally follows a similar pattern every year, with different areas of the Fladen grounds producing good fishing at different times of the year (boats fish the north of the ground in winter, then move east towards the sector line in the summer). During 2004-5 this seasonal pattern was less apparent with fishing being good throughout the year on a range of grounds. There was also no lull in catch rates which traditionally happens in April-May. In 2006 however, there was a return to a more usual pattern of fishing with catches poor for most of the spring and slowly getting better throughout the summer. Some participating vessels explored slightly different areas to fish in 2006, particularly on the eastern edge of the ground. Bad weather at the

start of 2006 and part of 2007 also contributed to the slower start to the fishery in these years. In some years, high squid abundance in the Moray Firth attracts Fladen vessels but in the last two years this was not so evident compared to 2005.

Other developments include the capability of freezing at sea and in one case, processing at sea. A recent tendency towards shorter trip lengths and improved handling practice is associated with market demand for high quality *Nephrops* which appears to have increased dramatically. The implementation of buyers and sellers legislation in 2006 has reduced the problem of underreporting and prices have risen, while weighing at sea has improved the accuracy of reported landings.

A.3 Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B Data

B.1 Commercial catch

Length compositions of Scottish landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling have increased since 2000 and are considered adequate for providing representative length structure of removals at the Fladen Ground. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE and CPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests a rapid increase since 2003. It is likely, however, that improved reporting of landings data) in recent years particularly arising from 'buyers and sellers legislation has contributed to the increase. The high levels have been maintained since 2003. In addition, effort recording in terms of hours fished is non-mandatory and therefore it is unclear whether these trends and those that are discussed below are actually indicative of trends in LPUE.

Males consistently make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary. In earlier years effort was generally highest in the latter part of the year in this fishery, but the pattern varies between years, and the seasonal pattern does not appear as strong in recent years. LPUE of both sexes remained relatively constant up to 2002, and in common with the overall figure has shown a marked increase since then. This suggests that exploitation (or other external factors) are not disproportionately affecting one sex or the other. LPUE is fairly similar through the year for males but for females there is no consistent pattern in these data.

LPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the size above which the effects of discarding practices were not expected to occur and the size below which recruitment events might be observed in the length composition. The data show a rise in LPUE in all categories since 2001. There is, however, no apparent lag between the increased LPUEs of <35mm animals and >35mm animals which one might expect if the reason was increasing abundance.

B.2 Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Parameters applied in a preliminary length-based assessment and age (with length) based simulation to inform the catch forecast process were as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

SUMMARY

Von Bertalanffy growth parameters are as follows:

Males; L_∞ = 66mm, k = 0.16

Immature Females; L_∞ = 66mm, k = 0.16

Mature Females; L_∞ = 56mm, k = 0.10,

Size at maturity = 25mm

Weight length parameters:

Males a = 0.0003, b = 3.25

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%.

Discard proportion: 3 year average (13.8% at benchmark WG)

B.3 Surveys

TV surveys using a stratified random design are available for FU 7 since 1992 (missing survey in 1996). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*.

On average, about 60 stations have been considered valid each year with over 70 stations in the last three years. Data are raised to a stock area of 28153 km^2 based on the stratification. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground has a range of mud types from soft silty clays to coarser sandy muds, the latter predominate (Figure B3–1). Most of the variance in the survey is associated with this variable sediment which surrounds the main centres of abundance. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground but in 2007, higher densities were also recorded in the more northerly parts of the ground. In general the confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Fladen are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU 7: Fladen	<=2009	1.45	0.9	1	1	1.35

B.4 Commercial CPUE

Scottish *Nephrops* trawl gears: Landings, discards and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

B.5 Other relevant data

C Historical Stock Development

Survey indices are worked up annually resulting in the TV index.

Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

Generate mean weight in landings. Check the time series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in the future).

D Short-Term Projection

Catch options are now provided for a range harvest ratios associated with potential F_{msy} proxies which are obtained from per-recruit analysis (See below on reference points).

Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

Multiply the survey index by the harvest ratios to give the number of total removals.

Create a landings number by applying a discard factor. A conversion factor was estimated by the Benchmark Workshop, however subsequent WGs have found the discard rate to have changed substantially and a 3 year mean value has since been adopted. The value is FU specific and has been put in the Stock Annex.

Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E Medium-Term Projections

None presented

F Long-Term Projections

None presented

G Biological Reference Points

Under the new ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of stock overfishing) have been explored and proposed for each functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{msy} directly and hence proxies for F_{msy} are determined. Three candidates for F_{msy} are $F_{0.1}$, $F_{35\%SpR}$ and F_{max}. Owing to the strong difference in relative exploitation rates between the sexes, values for each of the candidates are determined for males, females and the two sexes combined. These calculations assume that the TV survey has a knife-edge selectivity at 17mm. The appropriate F_{msy} candidate has been determined for each Functional Unit independently according to the perception of stock resilience, factors affecting recruitment, population density and the nature of the fishery (relative exploitation of the sexes and historical Harvest Rate vs stock status).

At the 2010 WG, preliminary estimates of these reference points were provided, based on per-recruit analysis which made use of catch-at-length frequency data which had been made available to the Benchmark WG in 2009. These are presented below.

WGNSSK 2010		Fbar(20–40 mm) M	Fbar(20–40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.14	0.10	9.4	41.7	48.9	44.7
	F	0.19	0.14	11.7	34.5	41.9	37.6
	T	0.16	0.11	10.2	39.1	46.3	42.1
Fmax	M	0.27	0.19	15.4	25.8	33.1	28.9
	F	0.40	0.29	20.9	17.6	24.2	20.3
	T	0.30	0.22	17.0	23.1	30.2	26.0
F35%SpR	M	0.19	0.14	11.7	34.5	41.9	37.6
	F	0.25	0.18	14.8	27.1	34.5	30.1
	T	0.21	0.15	12.7	31.7	39.1	34.8

At the 2011 WG, the analysis was updated using data from 2008-10 to account for the apparent changes in the discard pattern in this fishery. The complete range of the current per-recruit F_{msy} proxies is given in the table below:

WGNSSK 2011		Fbar(20–40 mm) M	Fbar(20–40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.14	0.09	9.5	40.3	47.6	43.3
	F	0.19	0.12	12.1	32.6	40.0	35.7
	T	0.16	0.10	10.3	37.8	45.2	40.9
Fmax	M	0.28	0.18	16.2	23.6	30.8	26.5
	F	0.49	0.32	24.1	13.5	19.5	16.0
	T	0.33	0.21	18.5	20.0	26.9	22.8
F35%SpR	M	0.18	0.11	11.4	34.5	41.9	37.6
	F	0.24	0.15	14.4	27.1	34.5	30.1
	T	0.20	0.13	12.4	31.7	39.1	34.8

The 2011 analysis results in $F_{0.1}$ and F_{max} occurring at a higher level of fishing mortality and higher harvest rate (maximising yield-per-recruit NOT catch). The small reduction in $F_{35\%SpR}$ harvest rates appears to be the result of a small change in the estimated selection pattern.

For this FU, the absolute density observed on the UWTV survey is low (average of just over 0.2 m^{-2}) suggesting the stock may have low productivity. In addition, the expansion of the fishery in this area is a relatively recent phenomenon and as a result the population has not been well-studied and biological parameters are considered particularly uncertain. Furthermore, historical harvest ratios in this FU have been below that equivalent to fishing at $F_{0.1}$. For these reasons, it is suggested that a more conservative proxy is chosen for F_{msy} such as $F_{0.1(T)}$ which is estimated to be 10.3 %.

The $B_{trigger}$ point for the FU (bias adjusted lowest observed UWTV abundance) is calculated as 2767 million individuals.

H Other Issues

I References

Table B1-1. *Nephrops*, Fladen (FU 7): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	304	8.6	35.3	304	8.6	35.3	na	na	na
1982	382	12.2	31.3	382	12.2	31.3	na	na	na
1983	548	15.4	35.6	548	15.4	35.6	na	na	na
1984	549	11.4	48.2	549	11.4	48.2	na	na	na
1985	1016	26.6	38.2	1016	26.6	38.2	na	na	na
1986	1398	37.8	37.0	1398	37.8	37.0	na	na	na
1987	1024	41.6	24.6	1024	41.6	24.6	na	na	na
1988	1306	41.7	31.3	1306	41.7	31.3	na	na	na
1989	1719	47.2	36.4	1719	47.2	36.4	na	na	na
1990	1703	43.4	39.2	1703	43.4	39.2	na	na	na
1991	3024	78.5	38.5	410	11.4	36.0	2614	67.1	39.0
1992	1794	38.8	46.2	340	9.4	36.2	1454	29.4	49.5
1993	2033	49.9	40.7	388	9.6	40.4	1645	40.3	40.8
1994	1817	48.8	37.2	301	8.4	35.8	1516	40.4	37.5
1995	3569	75.3	47.4	2457	52.3	47.0	1022	23.0	44.4
1996	2338	57.2	40.9	2089	51.4	40.6	249	5.8	42.9
1997	2713	76.5	35.5	2013	54.7	36.8	700	21.8	32.1
1998	2291	60.0	38.2	1594	39.6	40.3	697	20.5	34.0
1999	2860	76.8	37.2	1980	50.3	39.4	880	26.5	33.2
2000	2915	92.1	31.7	2002	62.9	31.8	913	29.2	31.3
2001	3539	108.2	32.7	2162	65.8	32.9	1377	42.4	32.5
2002	4513	109.6	41.2	2833	58.9	48.1	1680	50.7	33.1
2003	4175	53.7	77.7	3388	42.8	79.2	787	10.9	72.2
2004	7274	56.1	129.8	6177	47.5	130.2	1097	8.6	127.6
2005	8849	61.3	144.4	6834	43.4	157.5	2015	17.9	112.7
2006	9469	65.7	144.1	7149	50.2	142.4	2320	15.5	149.7
2007	11054	69.6	158.8	8232	52.2	157.7	2822	17.4	162.2

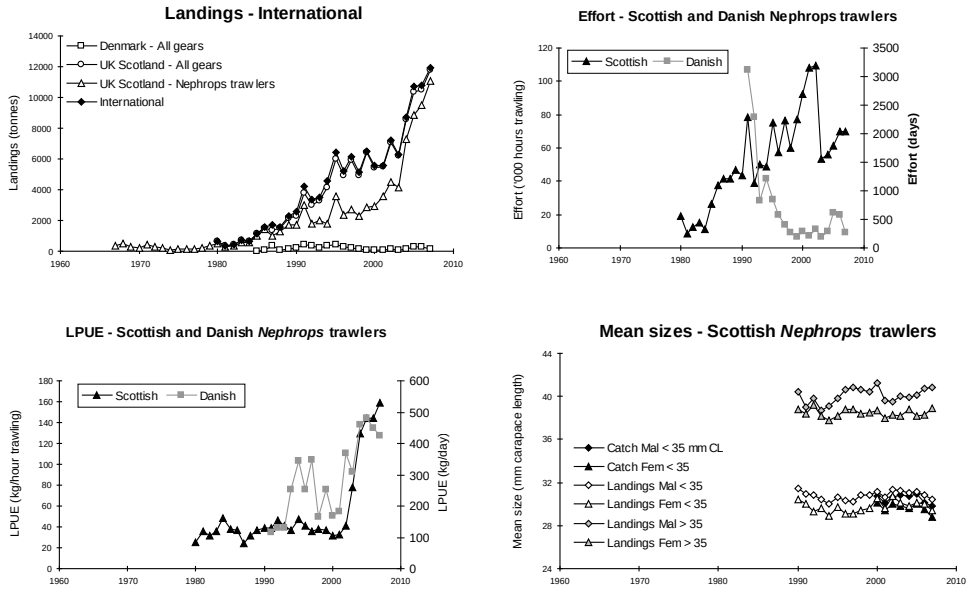


Figure B1-1. *Nephrops*, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.

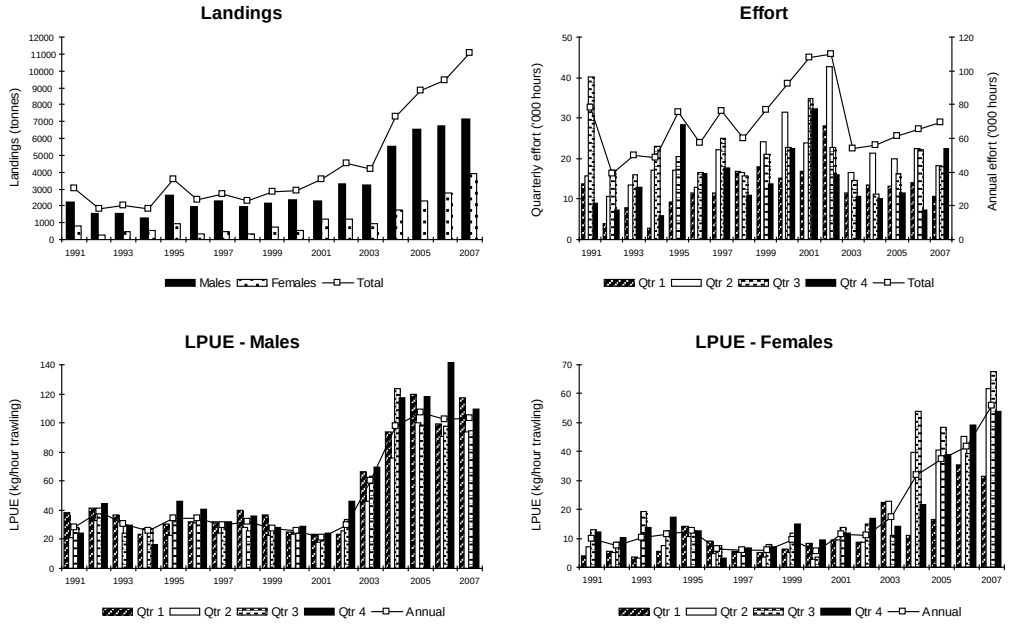


Figure B1-2. ***Nephrops*****, Fladen (FU 7), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

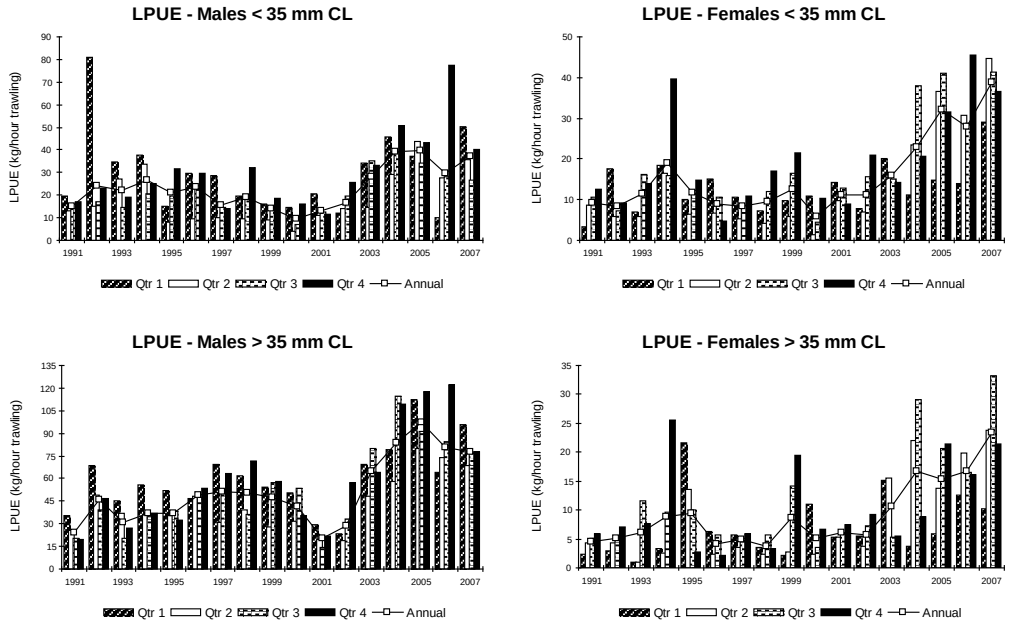


Figure B1-3. ***Nephrops*****, Fladen (FU 7), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

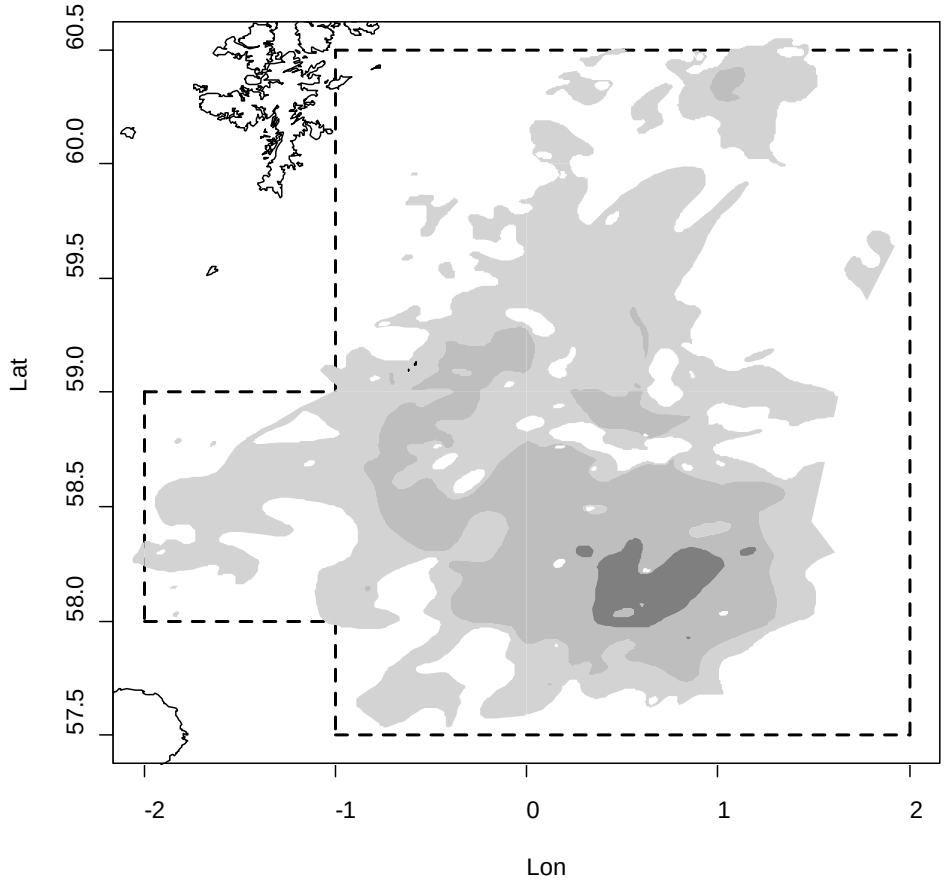


Figure B3–4. Distribution of *Nephrops* sediments in the Fladen Ground (FU 7). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex: FU8, Firth of Forth

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Firth of Forth *Nephrops* (FU 8)
Date:	09 March 2009 (WKNEPH2009)
Updated:	16 May 2011
Revised by	Sarah Clarke/Carlos Mesquita/Helen Dobby

A General

A.1 Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Firth of Forth is located close inshore to the Scottish coast, towards the west of the central part of Division IV and defined by statistical rectangles 40-41E7 and 41E6. The mud substrate in the Firth of Forth area is mainly muddy sand and sandy mud, and there is only a small amount of the softest mud. The population of *Nephrops* in this area is composed of smaller animals. Earlier research suggested that residual currents moving southward from this area transport some larvae to the Farn Deeps – recent larval surveys have not been undertaken, however, and it is unclear how significant this effect is. Outside the functional unit, a *Nephrops* population is found on a smaller patch of mud beyond the northern boundary, off Arbroath.

A.2 Fishery

The *Nephrops* fishery is located throughout the Firth but is particularly focussed on grounds to the east and south east of the Isle of May. Grounds located further up the Firth occur in areas closer to industrial activity and shipping.

Most of the vessels are resident in ports around the Firth of Forth, particularly at Pittenweem, Port Seton and Dunbar. Some vessels, normally active in the Farn Deeps, occasionally come north from Eyemouth and South Shields. During 2006 and 2007 the number of vessels regularly fishing in the Firth of Forth was been around 40 (23 under 10m and 19 over 10m vessels). This number varies seasonally with vessels from other parts of the UK increasing the size of the fleet. Local boats sometimes move to other grounds when catch rates drop during the late spring *Nephrops* moulting period. Traditionally, Firth of Forth boats move south to fish the Farn Deeps grounds. Single trawl fishing with 80 mm mesh size is the most prevalent method. Some vessels utilise a 90mm codend. A couple of vessels have the capability for twin rigging. Night fishing for *Nephrops* is commonest in the summer. Day fishing is the norm in winter. A very small amount of creeling for *Nephrops* takes place, this is mostly by crab and lobster boats.

Nephrops is the main target species with diversification by some boats to squid, and also surf clams. Only very small amounts of whitefish are landed. The area is characterised by catches of smaller *Nephrops* and discarding is sometimes high. The latest information for 2007 suggests that large catches of small *Nephrops* were taken. In the past,

small prawns generally led to high tail:whole prawn ratios in this fishery but in recent years a small whole prawn 'paella' market developed.

In 2006, buyers and sellers regulations led to increased traceability and improved reporting of catches. This continued and improved further in 2007 and the reporting of landings is now considered to be much more reliable.

A.3 Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B Data

B.1 Commercial catch

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are considered adequate for providing representative length structure of removals in the Firth of Forth. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE and CPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests that the stock is currently very abundant but the recent improvements in reporting of landings (due to 'buyers and sellers' legislation) may mean this is an artefact generated by more complete landings data. In addition, effort recording in terms of hours fished is non-mandatory which will also affect the trends in LPUE.

Males consistently make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary. Effort is generally highest in the 3rd quarter of the year in this fishery, but although the pattern was fairly stable in the early years, the pattern does not appear as strong in recent years and is 2007 was fairly evenly spread throughout the year. LPUE of both sexes has fluctuated through the time series and is currently at a high level. The comments about the quality of landings data are relevant here too. LPUE is generally higher for males in the 1st and 4th quarters, and for females in the 3rd quarter – the period when they are not incubating eggs.

CPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the size above which the affects of discarding practices were not expected to occur and the size below which recruitment events might be observed in the length composition. The data show a slight peak in CPUE for smaller individuals (both sexes) in 1999, with a decline after this, followed by a steady increase in both sexes from 2002 onwards. The CPUE for larger individuals showed a similar pattern with higher values in the most recent years.

B.2 Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Assumed biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

SUMMARY

Growth parameters

Males; L_∞ = 66mm, k = 0.163

Immature Females; L_∞ = 66mm, k = 0.163

Mature Females; L_∞ = 58mm, k = 0.065,

Size at maturity = 26mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00085, b = 2.91

Discards

Discard survival rate: 25%.

Discard rate: 3 year average (34.6% at Benchmark WG)

B.3 Surveys

TV surveys using a stratified random design are available for FU 8 since 1993 (missing surveys in 1995 and 1997). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops*. On average, about 40 stations have been considered valid each year with more stations sampled in the last three years. The survey in 2006 was conducted in December so that densities may not be strictly compatible with the remainder of the series. Abundance data are raised to a stock area of 915 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground is predominantly of coarser muddy sand (Figure B3–1). Depending on the year, high variance in the survey is associated with different strata and there is no clear distributional or sedimentary pattern in this area. Abundance is generally higher towards the central part of the ground and around the Isle of May. In recent years higher densities have been recorded over quite wide areas. Confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Firth of Forth are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU 8: Firth of Forth	<=2009	1.23	0.9	1.05	1	1.18

B.4 Commercial CPUE

Scottish *Nephrops* trawl gears: Landings, discards and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

B.5 Other relevant data

C Historical Stock Development

Survey indices are worked up annually resulting in the TV index.

Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

Generate mean weight in landings. Check the time series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in the future).

D Short-Term Projection

Catch options are provided for a range harvest ratios associated with potential F_{msy} proxies which are obtained from per-recruit analysis (See below on reference points).

Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

Multiply the survey index by the harvest ratios to give the number of total removals.

Create a landings number by applying a discard factor. A conversion factor was estimated by the Benchmark Workshop, however subsequent WGs have found the discard rate to have changed substantially and a 3 year mean value has since been adopted.

Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E. Medium-Term Projections

None presented

F. Long-Term Projections

None presented

G. Biological Reference Points

Under the new ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of stock overfishing) have been explored and proposed for each functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{msy} directly and hence proxies for F_{msy} are determined. Three candidates for F_{msy} are $F_{0.1}$, $F_{35\%SpR}$ and F_{max}. Owing to the strong difference in relative exploitation rates between the sexes, values for each of the candidates are determined for males, females and the two sexes combined. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm. The appropriate F_{msy} candidate has been determined for each Functional Unit independently according to the perception of stock resilience, factors affecting recruitment, population density and the nature of the fishery (relative exploitation of the sexes and historical Harvest Rate vs stock status).

At the 2010 WG, preliminary estimates of these reference points were provided and used in the provision of advice, based on per-recruit analysis which made use of catch-at-length frequency data which had been made available to the Benchmark WG in 2009. These are presented below.

WGNSSK 2010		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.13	0.06	7.5	42.3	64.5	51.7
	F	0.29	0.13	14.2	23.0	44.8	32.2
	T	0.16	0.07	8.7	37.3	60.0	46.9
Fmax	M	0.24	0.11	12.3	26.9	49.5	36.5
	F	0.54	0.24	23.4	12.1	29.0	19.2
	T	0.31	0.14	15.0	21.6	43.0	30.6
F35%SpR	M	0.18	0.08	9.7	34.1	57.0	43.8
	F	0.42	0.19	19.3	15.8	35.0	23.9
	T	0.26	0.12	13.1	25.1	47.4	34.5

At the 2011 WG, the analysis was updated using data from 2008-10 to account for the apparent changes in the discard pattern in this fishery. The complete range of the current per-recruit F_{msy} proxies is given in the table below:

WGNSSK 2011		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29.0
	T	0.17	0.07	9.4	34.6	56.6	43.9
Fmax	M	0.25	0.11	12.7	25.3	46.8	34.4
	F	0.64	0.28	26.7	9.1	22.9	14.9
	T	0.34	0.14	16.3	18.8	38.5	27.1
F35%SpR	M	0.17	0.07	9.4	34.6	56.6	43.9
	F	0.39	0.17	18.3	16.0	34.5	23.9
	T	0.25	0.11	12.7	25.3	46.8	34.4

The reduction in discard rate results in $F_{0.1}$ and F_{max} occurring at a higher level of fishing mortality and higher harvest rate in this new analysis (maximising yield-per-recruit NOT catch). The small reduction in $F_{35\%SpR}$ harvest rates appears to be the result of a small change in the estimated selection pattern.

For this FU, the absolute density observed n the UWTV survey is relatively high (average of ~ 0.8 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) has been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that $F_{max(T)}$ is chosen as the F_{msy} proxy which is estimated to be 16.3 %.

The $B_{trigger}$ point for this FU (bias adjusted lowest observed UWTV abundance) is calculated as 292 million individuals.

H. Other Issues

I. References

Table B1-1. *Nephrops*, Firth of Forth (FU 8): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	945	42.6	22.2	945	42.6	22.2	na	na	na
1982	1138	51.7	22.0	1138	51.7	22.0	na	na	na
1983	1681	60.7	27.7	1681	60.7	27.7	na	na	na
1984	2078	84.7	24.5	2078	84.7	24.5	na	na	na
1985	1908	73.9	25.8	1908	73.9	25.8	na	na	na
1986	2204	74.7	29.5	2204	74.7	29.5	na	na	na
1987	1582	62.1	25.5	1582	62.1	25.5	na	na	na
1988	2455	94.8	25.9	2455	94.8	25.9	na	na	na
1989	1833	78.7	23.3	1833	78.7	23.3	na	na	na
1990	1901	81.8	23.2	1901	81.8	23.2	na	na	na
1991	1359	69.4	19.6	1231	63.9	19.3	128	5.5	23.3
1992	1714	73.1	23.4	1480	63.3	23.4	198	8.5	23.3
1993	2349	100.3	23.4	2340	100.1	23.4	9	0.2	45.0
1994	1827	87.6	20.9	1827	87.6	20.9	0	0.0	0.0
1995	1708	78.9	21.6	1708	78.9	21.6	0	0.0	0.0
1996	1621	69.7	23.3	1621	69.7	23.3	0	0.0	0.0
1997	2137	71.6	29.8	2137	71.6	29.8	0	0.0	0.0
1998	2105	70.7	29.8	2105	70.7	29.8	0	0.0	0.0
1999	2192	67.7	32.4	2192	67.7	32.4	0	0.0	0.0
2000	1775	75.3	23.6	1761	75.0	23.5	14	0.3	46.7
2001	1484	68.8	21.6	1464	68.3	21.4	20	0.5	40.0
2002	1302	63.6	20.5	1286	63.3	20.3	16	0.3	53.3
2003	1115	53.0	21.0	1082	52.4	20.6	33	0.6	55.0
2004	1651	63.2	26.1	1633	62.9	26.0	18	0.4	49.7
2005	1973	66.6	29.6	1970	66.5	29.6	3	0.1	58.8
2006	2437	61.4	39.7	2432	61.0	39.9	5	0.4	14.2
2007	2622	57.6	45.5	2601	57.1	45.6	21	0.5	43.2

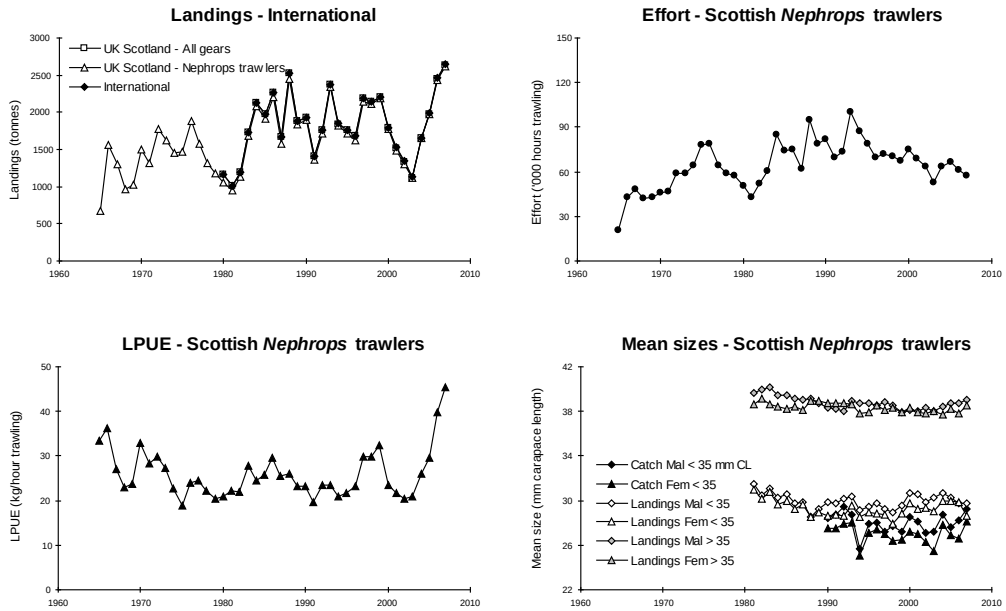


Figure B1-1. *Nephrops*, Firth of Forth (FU 8), Long term landings, effort, LPUE and mean sizes.

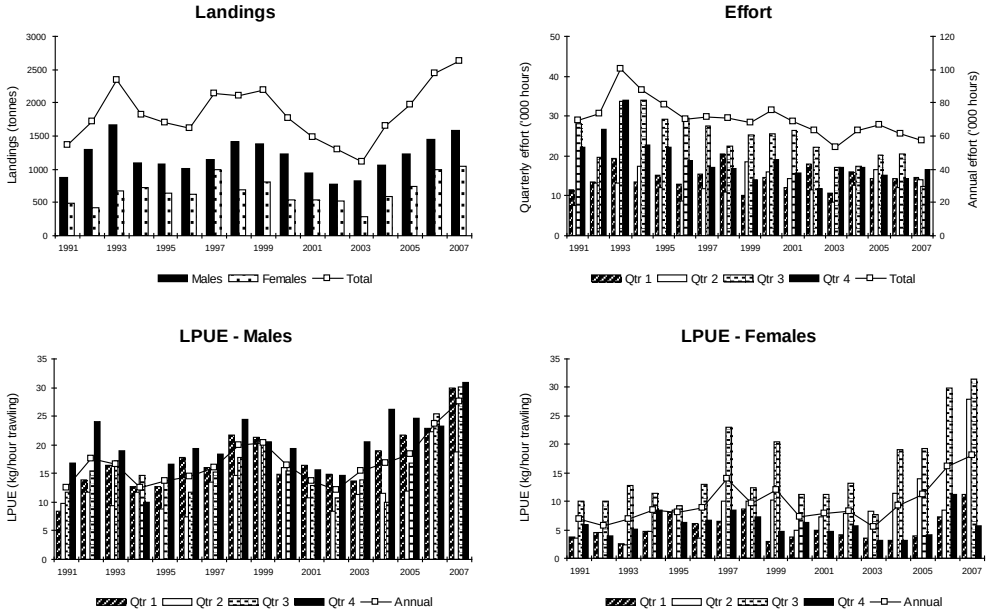


Figure B1-2. ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

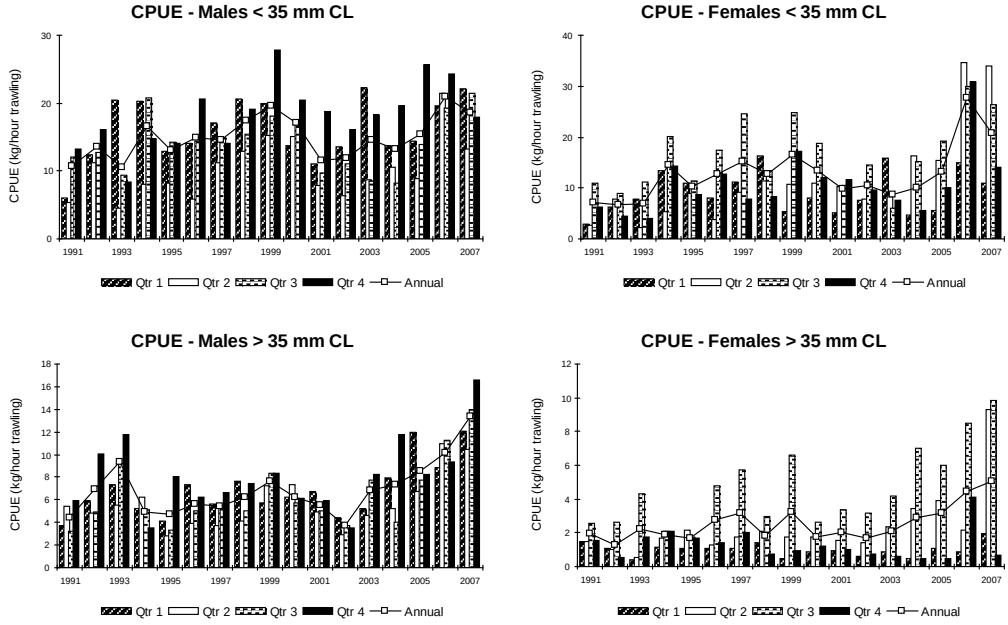


Figure B1-3. ***Nephrops*****, Firth of Forth (FU 8), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

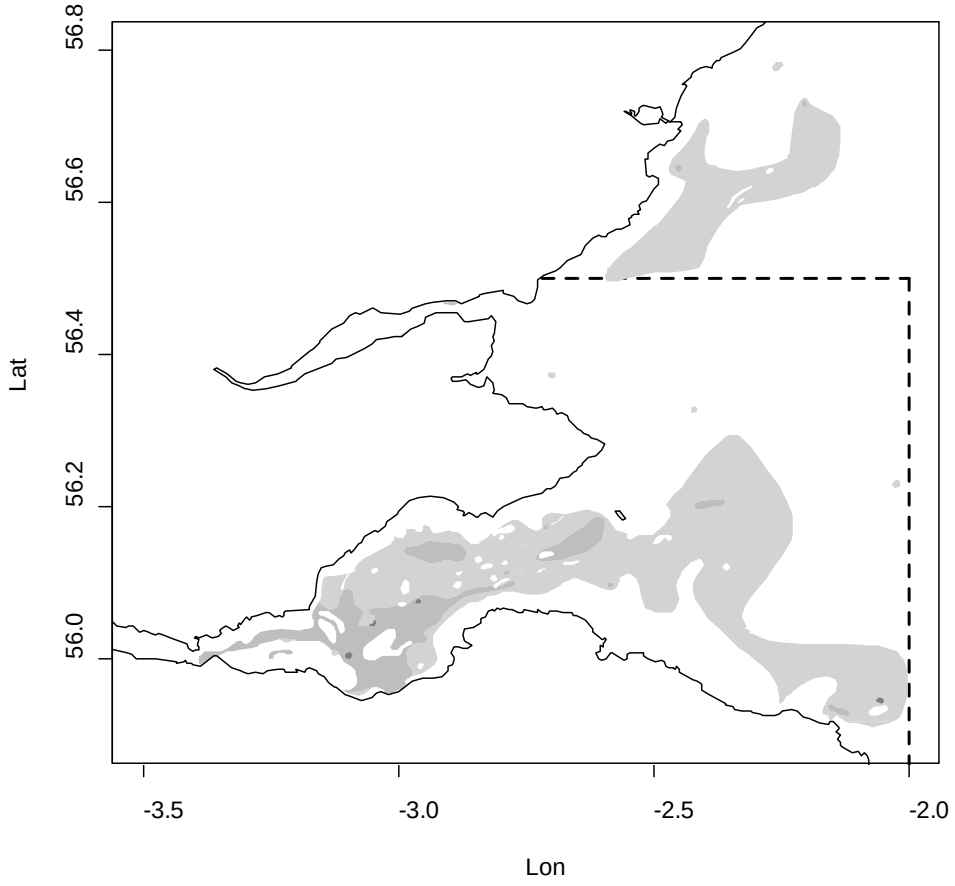


Figure B3–1. Distribution of *Nephrops* sediments in the Firth of Forth (FU 8). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex: FU9, Moray Firth

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Moray Firth *Nephrops* (FU 9)
Date:	09 March 2009 (WKNEPH2009)
Updated:	16 May 2011
Revised by	Sarah Clarke/Carlos Mesquita/Helen Dobby

A General

A.1 Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Moray Firth is located to the north west of Division IV and consists of statistical rectangles 44-45E6-E7 and 44E8. In common with other *Nephrops* fisheries the bounds of the Functional Unit are defined by the limits of muddy substrate. The major *Nephrops* fisheries within this management area fall within 30 miles of the UK coast. The Moray Firth (FU9) is a relatively sheltered inshore area, that supports populations of juvenile pelagic fish and relatively high densities of squid at certain times. The Moray Firth borders the Fladen functional unit (FU7) and there is some evidence of *Nephrops* populations lying across this boundary.

A.2 Fishery

The Moray Firth area is fished by a number of the smaller class of *Nephrops* boat (12-16m) regularly fishing short trips from Buckie, Helmsdale, Macduff and Burghead. Most boats still fish out of Burghead, and are about 15 in number; leaving and returning to port within 24 hours (day boats). Many of the smaller boats are now only manned by one or two people. Several of the larger *Nephrops* trawlers fish the outer Moray Firth grounds on their way to or from the Fladen grounds (especially when they are fishing the Skate Hole area). Also in times of bad weather many of the larger *Nephrops* trawlers which would normally be fishing the Fladen grounds fish the Moray Firth grounds. In recent years a squid fishery has been seasonally important in the Moray Firth. Squid appear to the east of the Firth and gradually move west during the Summer, increasing in size as they shift. During the autumn the movement is reversed. A large fishery took place in 2004 that attracted a number of *Nephrops* vessels and in 2005, additional vessels joined in the seasonal fishery, but catches were noticeably down in 2006. In 2007 however the fishery for squid improved again and a number of boats switched effort until around October, with some boats fishing squid until December.

A.3 Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B Data

B.2 Commercial catch

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are considered adequate for providing representative length structure of removals in the Moray Firth. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests that the stock increased in the early- 1980s, declined to a stable level over the next 12 years or so and has recently increased to its highest level in 2007. It is thought that gear efficiency changes have occurred over time, particularly in relation to multiple trawl gears but this has not been quantified. Additionally, improved reporting of landings data in recent years arising from 'buyers and sellers' legislation is likely to also to have contributed to the increase in LPUE. Furthermore, effort recording is non-mandatory in terms of hours fish and therefore it is unclear whether these trends and those that are discussed below are actually indicative of trends in LPUE.

Males generally make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary, and females landings exceeded males in 1994. Effort is generally highest in the 3rd quarter of the year in this fishery, but the pattern varies between years, and the seasonal pattern does not appear as strong in recent years. LPUE of both sexes remained relatively constant up to 2002, but has shown an increase since then. LPUE is generally higher for males in the 1st and 4th quarters, and for females in the 3rd quarter – the period when they are not incubating eggs.

CPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the general size limit for discarded animals. The data show a slight peak in CPUE for smaller individuals (both sexes) in 1995, with a slight decline after this and relatively stable values from 2001 onwards. There is a peak in catches of small males in 2006 quarter 4 but taken annually the pattern is relatively stable. The CPUE for larger males shows relatively stable levels during the late 1990's, and slightly higher levels in the most recent years, particularly from 2003 onwards. CPUE for large females declined in 2005 but have risen again over the past two years, and showed a significant large value in 2007 quarter 3.

Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Assumed biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

SUMMARY

Growth parameters:

Males; L_∞ = 62mm, k = 0.165

Immature Females; L_∞ = 62mm, k = 0.165

Mature Females; L_∞ = 56mm, k = 0.06,

Size at maturity = 25mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%

Discard rate: 3 year average (7.4% at benchmark WG)

B.3 Surveys

TV surveys are available for FU 9 since 1993 (missing survey in 1995). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops.*

On average, about 36 stations have been considered valid each year, and are raised to a stock area of 2195 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground is predominantly of coarser muddy sand (Figure B3–1) and most of the variance in the survey is associated with a patchy area of this sediment to the west of the ground. Abundance has generally been higher towards the west of the ground but in recent years higher densities have been recorded throughout, and are quite evenly distributed at the east and west ends in 2006 and 2007. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Moray Firth are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU 9: Moray Firth	<=2009	1.31	0.9	1	1	1.21

B.4 Commercial CPUE

Scottish *Nephrops* trawl gears: Landings at age and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this

fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

B.5 Other relevant data

C Historical Stock Development

Survey indices are worked up annually resulting in the TV index.

Adjust index for bias (see section B3). The combined effect of these biases is to be applied to the new survey index.

Generate mean weight in landings. Check the time series of mean landing weights for evidence of a trend in the most recent period. If there is no firm evidence of a recent trend in mean weight use the average of the three most recent years. If, however, there is strong evidence of a recent trend then apply most recent value (don't attempt to extrapolate the trend further in the future).

D Short-Term Projection

Catch options are provided for a range harvest ratios associated with potential F_{msy} proxies which are obtained from per-recruit analysis (See below on reference points).

Create catch option table on the basis of a range of harvest ratios ranging from 0 to the maximum observed ratio or the ratio equating to F_{max}, whichever is the larger. Insert the harvest ratios from step 4 and also the current harvest ratio.

Multiply the survey index by the harvest ratios to give the number of total removals.

Create a landings number by applying a discard factor. A conversion factor was estimated by the Benchmark Workshop, however subsequent WGs have found the discard rate to have changed substantially and a 3 year mean value has since been adopted. The value is FU specific.

Produce landings biomass by applying mean weight.

The suggested catch option table format is as follows.

			Implied fishery	
	Harvest rate	Survey Index	Retained number	Landings (tonnes)
	0%	12345	0	0.00
	2%	"	247	123.45
	4%	"	494	246.90
	6%	"	741	370.35
	8%	"	988	493.80
F0.1	8.60%	"	1062	530.84
	10%	"	1235	617.25
	12%	"	1481	740.70
Fmax	13.50%	"	1667	833.29
	14%	"	1728	864.15
	16%	"	1975	987.60
	18%	"	2222	1111.05
	20%	"	2469	1234.50
	22%	"	2716	1357.95
Fcurrent	21.5%	"	2654	1327.09

E Medium-Term Projections

None presented

F Long-Term Projections

None presented

G Biological Reference Points

Under the new ICES MSY framework, exploitation rates which are likely to generate high long-term yield (and low probability of stock overfishing) have been explored and proposed for each functional unit. Owing to the way *Nephrops* are assessed, it is not possible to estimate F_{msy} directly and hence proxies for F_{msy} are determined. Three candidates for F_{msy} are $F_{0.1}$, $F_{35\%SpR}$ and F_{max}. Owing to the strong difference in relative exploitation rates between the sexes, values for each of the candidates are determined for males, females and the two sexes combined. These calculations assume that the TV survey has a knife-edge selectivity at 17 mm. The appropriate F_{msy} candidate has been determined for each Functional Unit independently according to the perception of stock resilience, factors affecting recruitment, population density and the nature of the fishery (relative exploitation of the sexes and historical Harvest rate vs stock status).

At the 2010 WG, preliminary estimates of these reference points were provided, based on per-recruit analysis which made use of catch-at-length frequency data which had been made available to the Benchmark WG in 2009. These are presented below:

WGNSSK 2010		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.17	0.1	7.9	39.8	64.1	49.4
	F	0.43	0.2	17.1	17.4	39.5	26.1
	T	0.21	0.1	9.5	34.0	58.8	43.7
Fmax	M	0.32	0.1	13.6	23.4	47.4	32.9
	F	1.10	0.4	33.1	6.2	18.7	11.1
	T	0.45	0.2	17.9	16.5	38.1	25.0
F35%SpR	M	0.21	0.1	9.5	34.0	58.8	43.7
	F	0.51	0.2	19.7	14.4	34.8	22.4
	T	0.29	0.1	12.7	25.2	49.5	34.7

At the 2011 WG, the analysis was updated using length frequency data from 2008-10 to account for the apparent changes in the selection and discard patterns. For these reasons and a change in the relative availability of females as estimated by the LCA, there is a slight decrease in the estimated MSY harvest ratio proxies compared to those previously calculated. The complete range of the current per-recruit Fmsy proxies is given in the table below:

WGNSSK 2011		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
F0.1	M	0.13	0.07	7.16	42.35	61.48	49.89
	F	0.24	0.12	11.61	27.45	47.01	35.16
	T	0.14	0.07	7.84	39.46	58.93	47.13
Fmax	M	0.26	0.13	12.31	25.80	45.16	33.42
	F	0.68	0.36	23.82	11.42	25.16	16.83
	T	0.34	0.18	14.92	20.79	39.10	28.01
F35%SpR	M	0.17	0.09	9.11	34.69	54.48	42.48
	F	0.41	0.22	17.12	17.62	34.83	24.40
	T	0.24	0.13	11.79	27.02	46.53	34.71

Moderate absolute densities are generally observed on the UWTV survey of this FU. Harvest ratios (which are likely to have been underestimated prior to 2006) appear to have been above $F_{35\%SpR}$ and in addition there is a long time series of relatively stable landings (average reported landings ~ 1500 tonnes, above those predicted by currently fishing at $F_{35\%SPR}$). For these reasons, it is suggested that $F_{35\%SPR(T)}$ is chosen as the F_{msy} proxy.

The new F_{msy} proxy harvest ratio is 11.8 % compared to 12.7 % used last year.

The $B_{trigger}$ point for this FU (bias adjusted lowest observed UWTV abundance) is calculated as 262 million individuals.

H. Other Issues

I. References

Table B1-1. *Nephrops*, Moray Firth (FU 9): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	1298	36.7	35.4	1298	36.7	35.4	na	na	na
1982	1034	28.2	36.7	1034	28.2	36.7	na	na	na
1983	850	21.4	39.7	850	21.4	39.7	na	na	na
1984	960	23.2	41.4	960	23.2	41.4	na	na	na
1985	1908	49.2	38.8	1908	49.2	38.8	na	na	na
1986	1933	51.6	37.5	1933	51.6	37.5	na	na	na
1987	1723	70.6	24.4	1723	70.6	24.4	na	na	na
1988	1638	60.9	26.9	1638	60.9	26.9	na	na	na
1989	2102	69.6	30.2	2102	69.6	30.2	na	na	na
1990	1700	58.4	29.1	1700	58.4	29.1	na	na	na
1991	1284	47.1	27.3	571	25.1	22.7	713	22.0	32.4
1992	1282	40.9	31.3	624	24.8	25.2	658	16.1	40.9
1993	1505	48.6	31.0	783	28.1	27.9	722	20.6	35.0
1994	1178	47.5	24.8	1023	42.0	24.4	155	5.5	28.2
1995	967	30.6	31.6	857	27.0	31.7	110	3.6	30.6
1996	1084	38.2	28.4	1057	37.4	28.3	27	0.8	33.8
1997	1102	47.7	23.1	960	42.5	22.6	142	5.1	27.8
1998	739	34.4	21.5	576	28.1	20.5	163	6.3	25.9
1999	813	35.5	22.9	699	31.5	22.2	114	4.0	28.5
2000	1343	49.5	27.1	1068	39.8	26.8	275	9.7	28.4
2001	1188	47.6	25.0	913	37.0	24.7	275	10.6	25.9
2002	1526	35.5	43.0	649	27.2	23.9	234	7.9	29.6
2003	1718	41.1	41.8	737	25.3	29.1	135	3.6	37.5
2004	1818	36.9	49.3	1100	29.2	37.7	123	2.5	49.2
2005	1526	37.6	40.6	1309	34.0	38.5	217	3.6	60.3
2006	1718	41.1	41.8	1477	37.4	39.5	241	3.7	65.1
2007	1818	36.9	49.3	1503	32.4	46.4	315	4.5	70.0

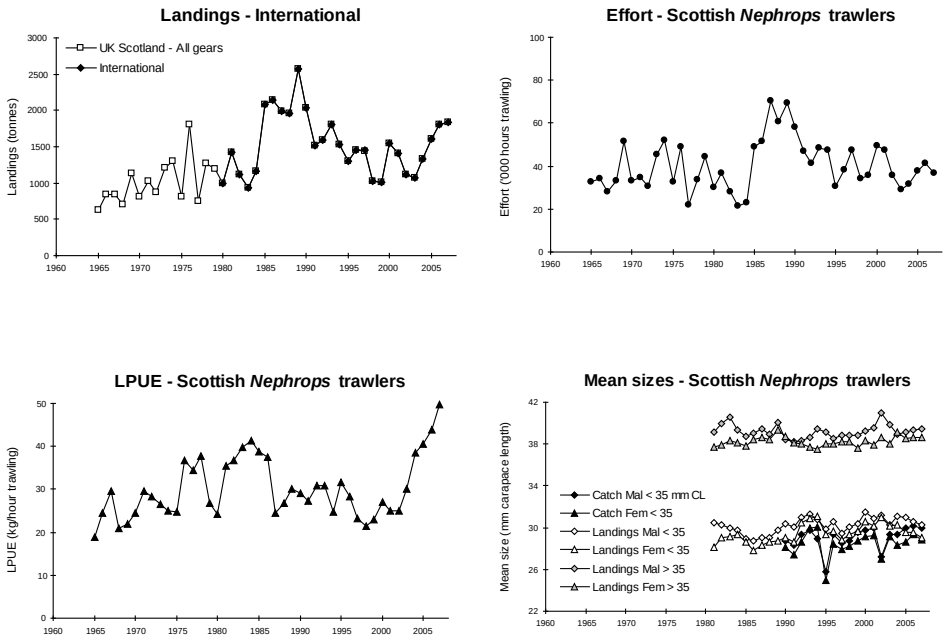


Figure B1-1. ***Nephrops*****, Moray Firth (FU 9), Long term landings, effort, LPUE and mean sizes.**

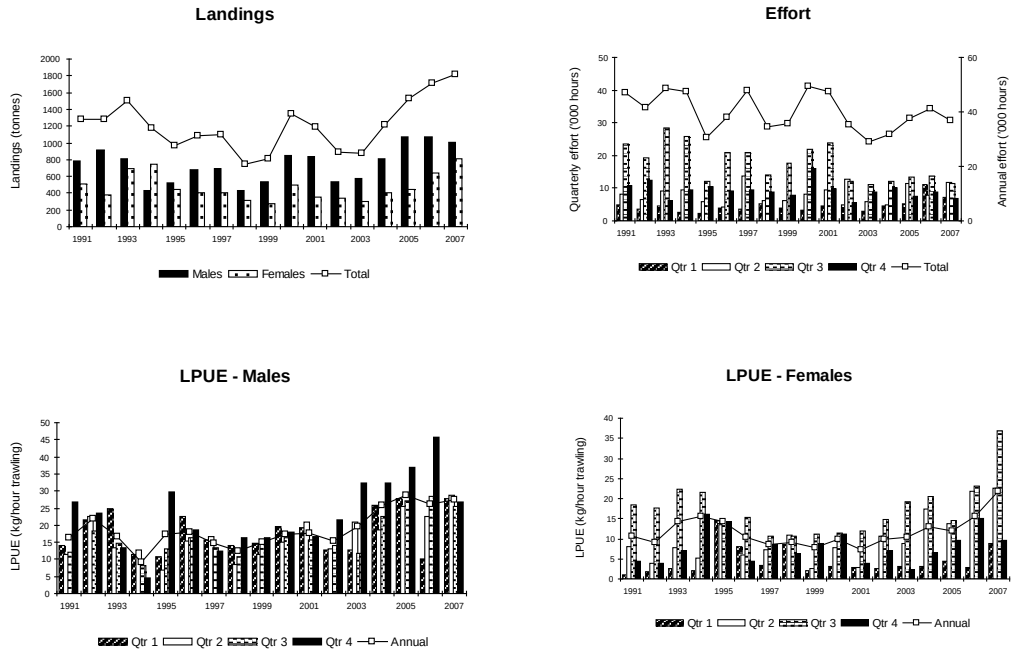


Figure B1-2. ***Nephrops*****, Moray Firth (FU 9), Landings, effort and unstandardised LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

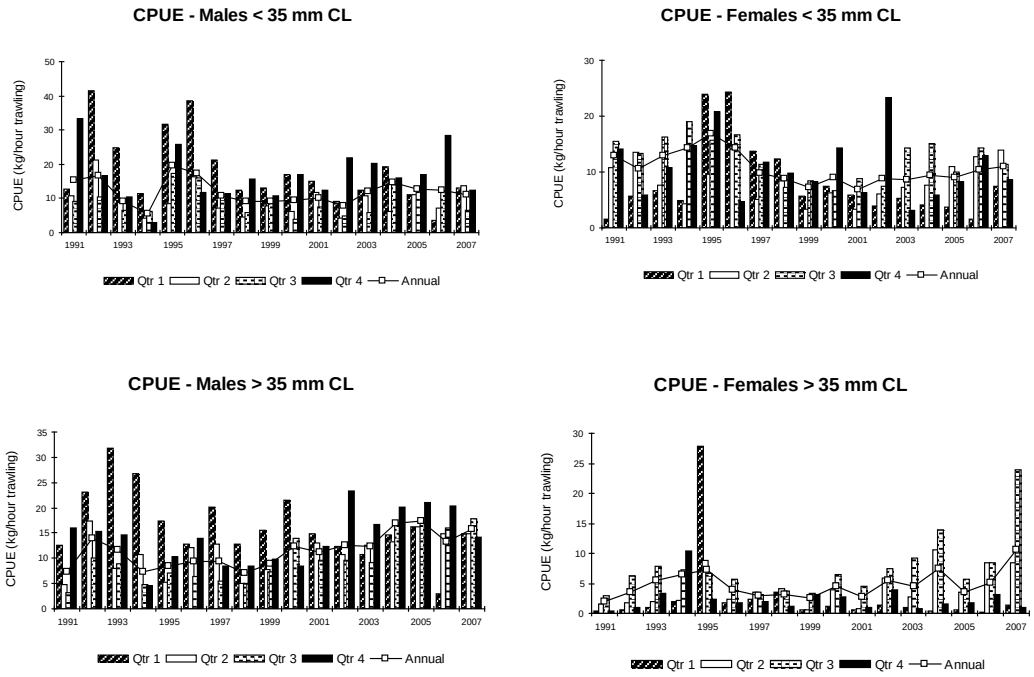


Figure B1-3. ***Nephrops*****, Moray Firth (FU 9), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

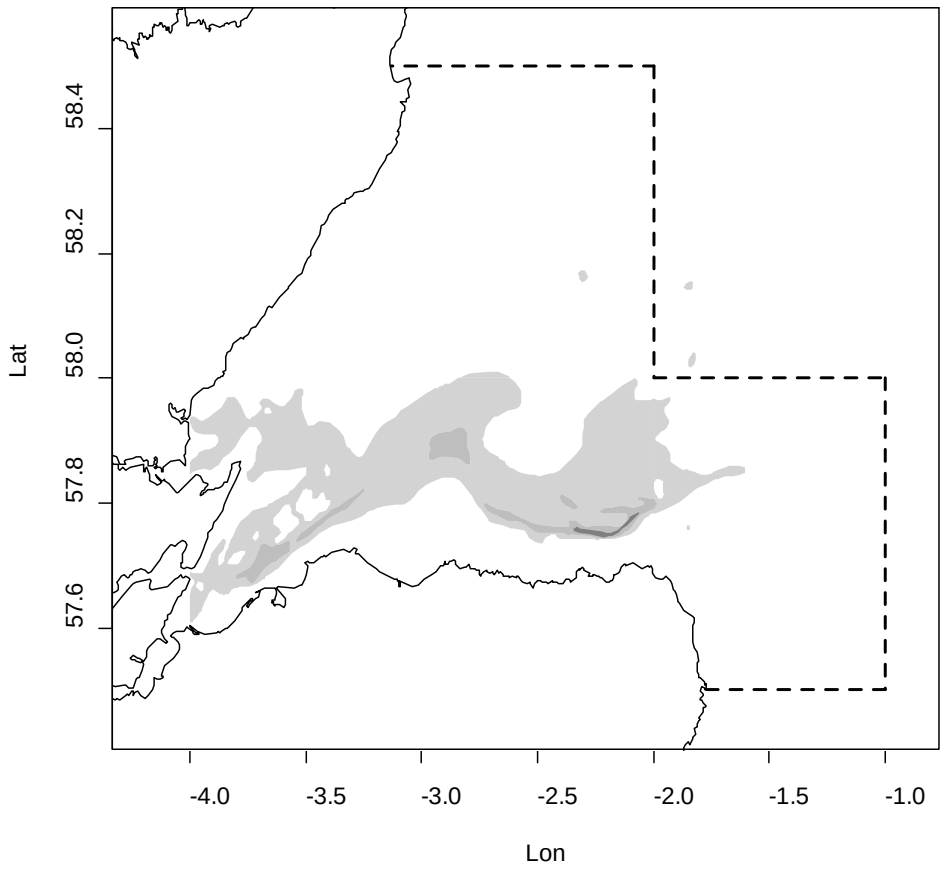


Figure B3–1. Distribution of *Nephrops* sediments in the Moray Firth (FU 9). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex Noup *Nephrops* (FU 10)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	nep-10
Working Group:	WGNSSK
Date:	April 2013
Revised by	WGNSSK /Helen Dobby

A. General

A.1. Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Noup is located to the far north west of Division IV adjacent to ICES VIa and closer to the influence of the west of Scotland waters. In common with other *Nephrops* fisheries the bounds of the Functional Unit are defined by the limits of muddy substrate. This small stock is one of the most isolated Functional Units. Particle tracking models suggest that plankton is transported from the west coast and passes across this area.

The Noup consists of a single ICES statistical rectangle: 47E6. The spatial extent of the *Nephrops* stock in this area is 409 km^2.

A.2. Fishery

The Noup grounds are regularly fished by 3-4 boats (16-24m) from Scrabster. They mainly target a mixed fish (mainly flat fish and monkfish) and *Nephrops* fishery using 100mm (twin-rig) to stay within the catch composition regulations. Boats land an average of around 1.5 tonnes of *Nephrops* from a 6-7 day trip. Occasionally some of the Fraserburgh *Nephrops* fleets fish the Noup grounds although this did not happen in 2005 - 2007, as many of the boats who used to make the journey have been decommissioned. The Noup ground has previously produced a period of good fishing every year but the area has not been important in the last couple, of years.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Given that the levels of market sampling are low and discard sampling is not available, the length structure of removals in the fishery is not considered to be well represented by the available data. Table B1-1 shows the landings, effort and LPUE data for single trawls, multiple trawls and combined while Figure B1-1 illustrates the long term commercial LPUE data. The low levels of sampling for this fishery mean it is not realistic

to draw conclusions from changes in size composition or sex ratio. For the data limited approach, the mean weight in landings and discard rate is assumed to be the same as the Moray Firth (FU 9) as this is the closest functional unit to the Noup. Figures B1-2 and B1-3 show landings and effort, and LPUE data, respectively. Due to the very low levels of effort, small changes are likely to have very large effects and for this reason some data points in Figure B1-3 have been removed.

B.2. Biological

No data available

B.3. Surveys

Underwater TV surveys are available for this stock in 1994 and 1999 and were also carried out in 2006 and 2007, where 7 and 9 stations were successfully surveyed in each year respectively and raised to a stock area of 339 km^2 (Figure B3–1). These two most recent surveys give consistent estimates of population size which are slightly lower than the 1999 value. All of these are lower than the very high value observed in 1994.

Relative to absolute conversion factor

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as absolute (required for both the *Nephrops* data limited approach and the full UWTV survey approach), it is necessary to correct for these potential biases. For other FUs, these are based on simulation studies, preliminary experimentation and expert opinion.

For the Noup, the footage, in terms of burrow complex diameter, water clarity and presence of other burrowing fauna, appears very similar to that of the Fladen and therefore the same overall conversion factor is used – 1.35.

B.4. Commercial CPUE

Landings and effort data for Scottish *Nephrops* trawl gears are used to generate a LPUE index. LPUE is estimated using officially recorded effort (days absent). The effort & LPUE are not standardized and therefore do not account for changes in efficiency, seasonality or other factors that could influence the trend in LPUE over time.

For more information see section B.1

B.5. Other relevant data

C. Assessment: data and method

Advice should be provided for *Nephrops* in FU10 on the basis of the data limited approach (see below and category 4.1.4 of ICES DLS approach). This can provide an indication of the level of medium-term average F in relation to F_{MSY} (borrowed from neighbouring stocks with similar characteristics) and this may also provide guidance on the level of abundance relative to MSY $B_{trigger}$.

In terms of stock trends, there are currently insufficient length frequency data for use in constructing indicators. There is a commercial LPUE series extending back to 2000 which should be used (with caution) to monitor stock trends.

Input data required: **Recent absolute (bias corrected) density estimate from UWTV survey**

In the range 0.1 – 0.2 m^{-2} - to cover the range of density estimates

Spatial extent

409 km^2

Landings mean weight

24 g (from Moray Firth FU 9)

Discard rate in number

12 % (from Moray Firth FU 9)

Discard survival

25 % (from Fladen FU 7)

Model and software: see spreadsheet derived at WGNSSK 2012 ('FINAL version of Nep-IV nonTVstocks included in advice.xls'.

Steps in formulating the data limited table:

1. Use absolute density & spatial extent to derive *Nephrops* abundance for a range of densities (see above)
2. Convert potential landings weight into numbers using landings mean weight for a range of total landings (10 year average, half of 10 year average, maximum of time series)
3. Convert landings numbers into total removals by dividing by (1 – discard rate in number)
4. Divide total removals (from 3) by *Nephrops* abundance (from 1) to obtain a matrix of harvest rates which can be compared to F_{MSY}.

D. Short-Term Projection

Not relevant – uses *Nephrops* data limited approach.

E. Medium-Term Projections

Not relevant – uses *Nephrops* data limited approach.

F. Long-Term Projections

Not relevant – uses *Nephrops* data limited approach

G. Biological Reference Points

No reference points have been calculated for this functional unit. The *Nephrops* data limited approach compares calculated harvest rates to the range of Fmsy harvest rates estimated for other North Sea Functional Units (8-16 %)

H. Other Issues

I. References

Table B1-1. *Nephrops*, Noup (FU 10): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	13	0.4	34.3	13	0.4	34.3	na	na	na
1982	12	0.5	24.7	12	0.5	24.7	na	na	na
1983	9	0.3	30.7	9	0.3	30.7	na	na	na
1984	75	2.0	36.9	75	2.0	36.9	na	na	na
1985	2	0.1	25.0	2	0.1	25.0	na	na	na
1986	46	0.7	62.6	46	0.7	62.6	na	na	na
1987	12	0.7	18.1	12	0.7	18.1	na	na	na
1988	23	1.0	34.3	23	1.0	34.3	na	na	na
1989	24	0.9	25.8	24	0.9	25.8	na	na	na
1990	101	2.9	34.6	101	2.9	34.6	na	na	na
1991	110	4.8	22.9	23	0.9	25.6	87	3.9	22.3
1992	56	1.8	31.1	33	1.4	23.6	23	0.4	57.5
1993	200	4.8	41.7	152	3.6	42.0	48	1.2	39.0
1994	308	8.4	36.7	273	7.6	36.0	35	0.8	42.1
1995	162	3.9	41.5	139	3.5	39.9	23	0.4	63.2
1996	180	4.4	40.9	174	4.2	41.4	6	0.2	30.0
1997	185	5.3	34.9	172	4.9	35.1	13	0.4	32.5
1998	183	3.2	57.2	171	3.0	57.0	12	0.2	60.0
1999	211	4.1	51.8	196	3.8	53.0	15	0.3	54.9
2000	196	2.0	98.0	161	1.8	89.4	35	0.2	175.0
2001	89	1.7	52.4	82	1.4	58.6	7	0.3	23.3
2002	81	0.6	133.9	185	2.1	88.1	59	1.2	49.2
2003	258	0.5	551.3	217	2.3	94.3	41	0.4	102.5
2004	175	2.2	79.5	144	2.2	65.2	31	0.0	-
2005	81	0.6	135.0	58	0.6	98.3	23	0.0	-
2006	44	0.3	146.7	42	0.4	94.6	2	0.0	-
2007	47	0.6	78.3	43	0.6	71.3	4	0.0	-

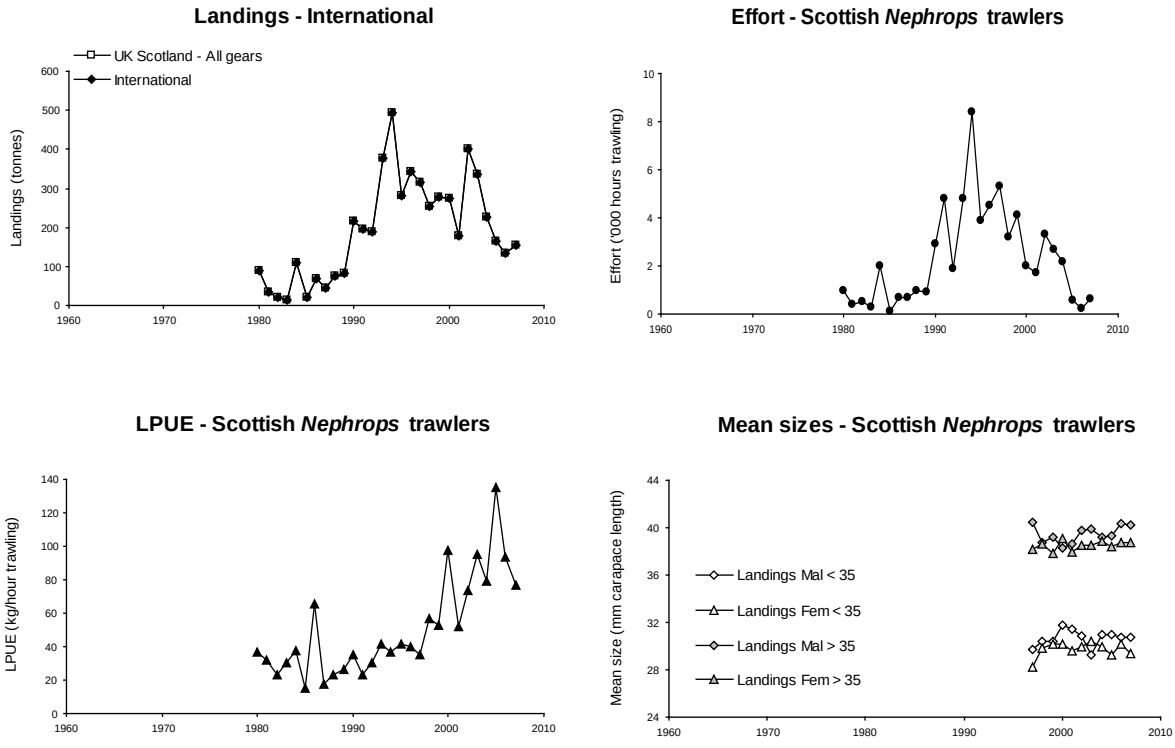


Figure 3.4.1.11 *Nephrops*, Noup (FU 10), Long term landings, effort, LPUE and mean sizes.

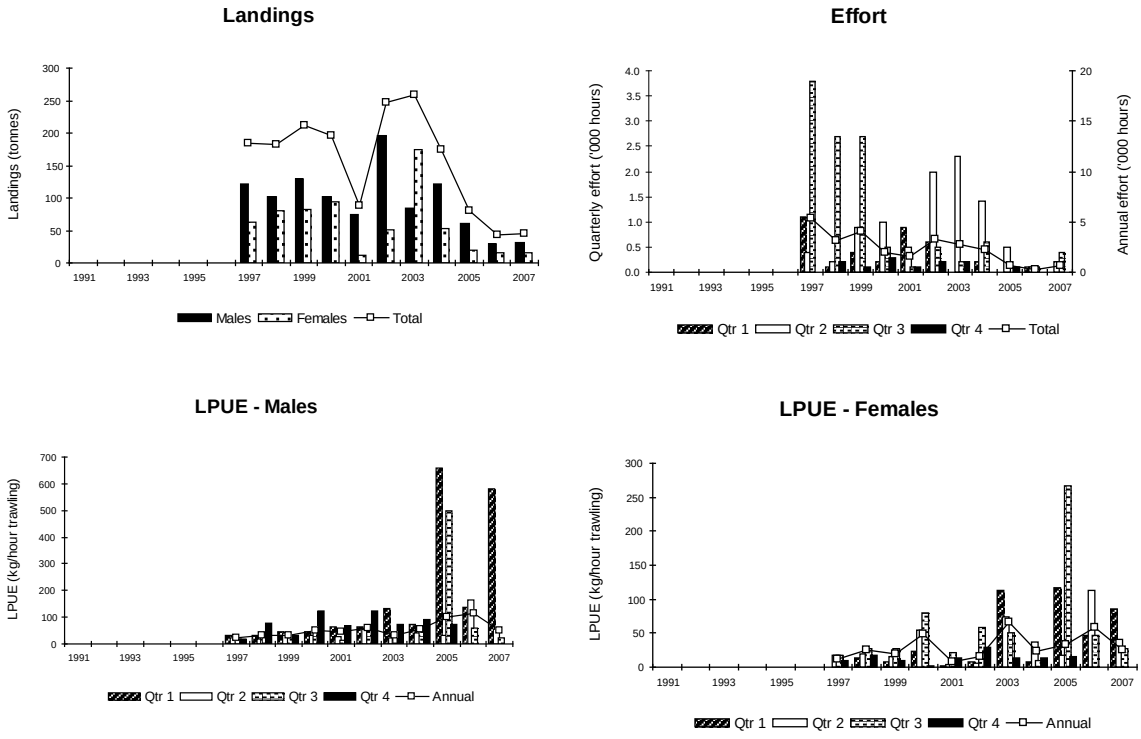


Figure 3.4.1.12 ***Nephrops*****, Noup (FU 10), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

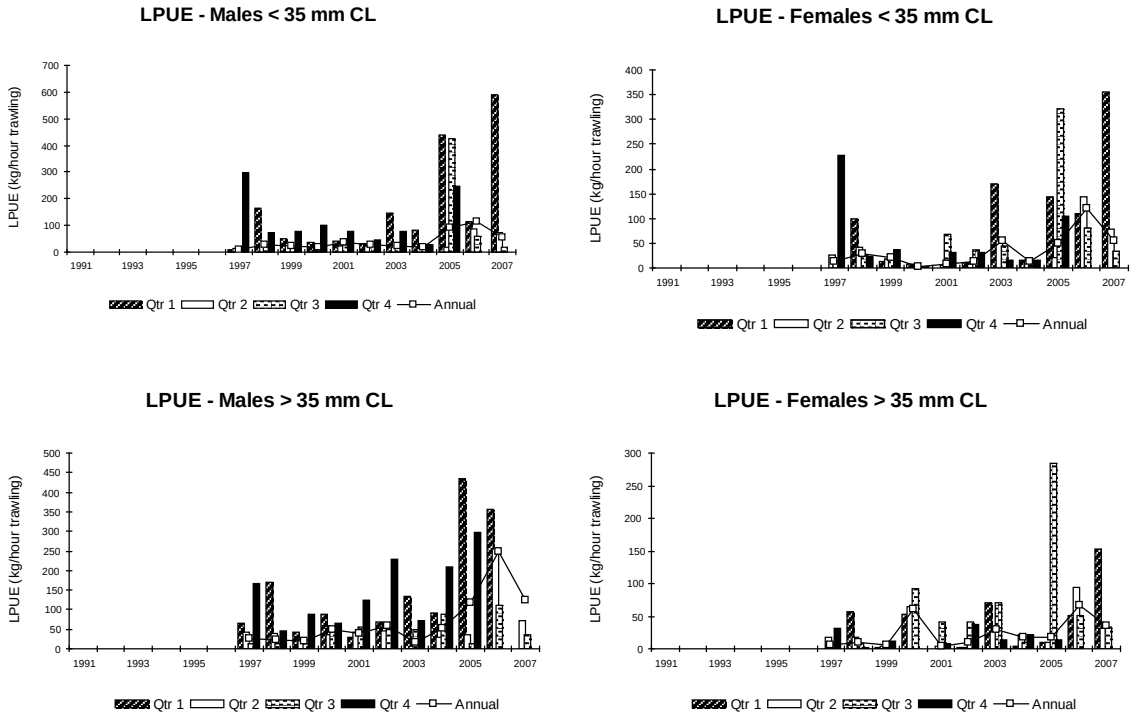


Figure 3.4.1.13 ***Nephrops*****, Noup (FU 10), LPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

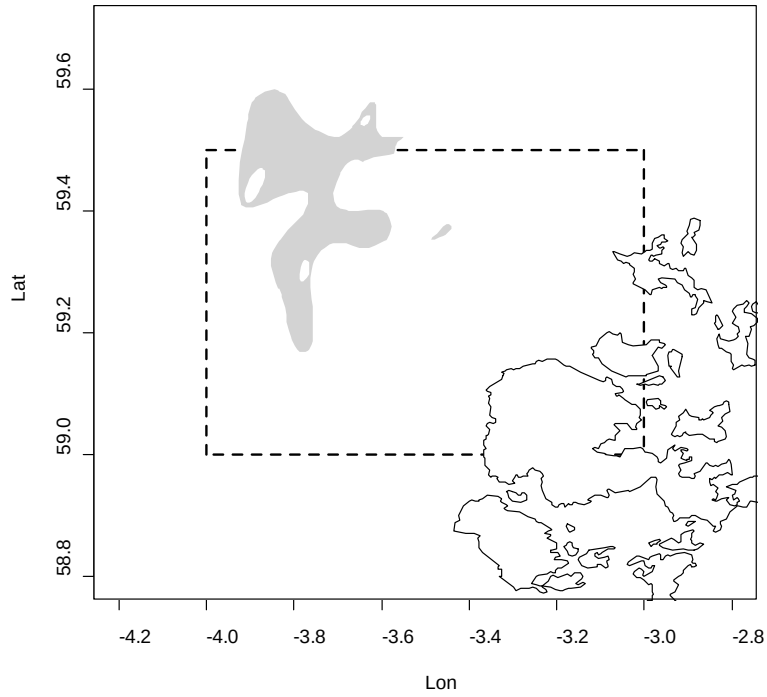


Figure B3–1. Distribution of *Nephrops* sediments in Noup (FU 10). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex WGNSSK – Norway pout

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Norway pout in the North Sea and Skagerrak (ICES Area IV and IIIa); nop34

Working Group: WG on the Assessment of Demersal Stocks in the North Sea and Skagerrak

Date: May 2013

A. General

A.1. Stock definition

Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen, Lambert, Bastardie, Sparholt and Vinther, 2012; Lambert, Nielsen, Larsen and Sparholt, 2009).

It is distributed from the west of Ireland to Kattegat, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt 1968; Sparholt, Larsen and Nielsen 2002b; Lambert *et al.* 2009). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al.* 2009). Figures 1 and 2 show geographical distribution of the stock obtained from the ICES IBTS surveys. The IBTS Surveys only cover areas within the 200 m depth zone. However, very few Norway pout are caught at depths greater than 200 m in the North Sea and Skagerrak on shrimp trawl survey (Sparholt *et al*. 2002b). For the Norwegian Trench, Albert (1994) found Norway pout at depths greater than 200 m, but very few deeper than 300 m.

At present, there is no evidence for separating the North Sea component into smaller stock units (Lambert *et al.* 2009). Norway pout in the eastern Skagerrak is only to a very small degree a self-contained stock. The main bulk drifts as larvae from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen 1968). ICES ACFM (October 2001) asked the ICES WGNSSK to verify the justification of treating ICES Division VIa as a management area for Norway pout (and sandeel) separately from ICES areas IV and IIIa. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in a Working Document to the 2000 meeting of the ICES WGNSSK Working Group (Larsen, Lassen, Nielsen and Sparholt, ,2001 in ICES C.M.2001/ACFM:07), gave no evidence for a stock separation in the whole northern area. This conclusion is supported by the results in Lambert *et al.*,(2009).

Spawning distribution: Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway in coastal waters (along the 120 m isocline) (Lambert *et al.,* 2009). Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.*, (2001), gave no evidence for a stock separation in the whole northern area. This conclusion is supported by the depth distribution limits of the species (Sparholt *et al.*, 2002b and sections below). Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in a recent paper (Lambert *et al.*, 2009) indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year is observed to be around 95%.

Larvae and juvenile distribution: The species is not generally considered to have specific nursery grounds, but pelagic 0-group fish remain widely dispersed in the northern North Sea close to spawning grounds (Lambert *et al*., 2009). The main bulk drifts as larvae from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen 1968). The IBTS CPUE map (Figure 2) shows, however, a relative high CPUE in the Skagerrak area in the third quarter, where the 0-group dominates the catches.

Adult migration: There is an adult spawning migration out of Skagerrak and Kattegat as no spawning occurs in this area. Otherwise there is no indication of adult migration. Based on IBTS data, the main aggregations of settled fish are distributed around the 150 m contour, with a slight preference for deeper water for the older fish.

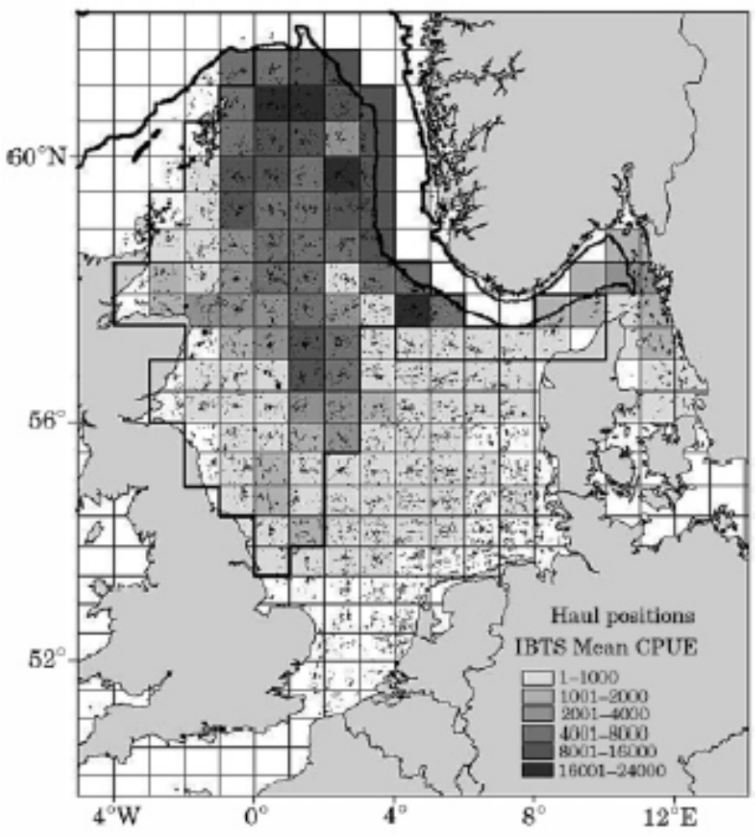


Figure 1 Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al*., 2002b].

A.2. Fishery

The fishery is nearly exclusively carried out by Danish and Norwegian (large) vessels using small-mesh trawls in the north-western North Sea especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. The average quarterly spatial distribution of the Norway pout catches during a ten year period from 1994-2003 is shown in **Figures** 2-3. The Norway pout fishery is a mixed commercial, small meshed fishery. Norway pout is caught in small meshed trawls (16-31 mm) in a mixed fishery among other with blue whiting, i.e. in addition to the directed Norway pout fishery by Denmark and Norway, the species is also taken as by-catch in the Norwegian blue whiting fishery. The fishery in more recent times is mainly carried out by Denmark (~70-80%) and Norway (~20-30%) at fishing grounds in the northern North Sea especially at Fladen Ground and along the edge of the Norwegian Trench. Norway pout is landed for reduction purposes (fish meal and fish oil). In recent years Denmark has performed the main Norway pout landings compared to Norway, while the long term average show more equal catches between the countries. There is a tendency towards the more recent Danish landings mainly originates from the Fladen Ground area compared to the Norwegian Trench area.

Landings have been low since 2001, and the 2003-2004 landings were the lowest on record. Effort in 2003 and 2004 were historically low and well below the average of the 5 previous years. The effort in the Norway pout fishery was in 2002 at the same level as in the previous eight years before 2001. The targeted Norway pout fishery was closed in 2005, in the first half year of 2006, all of 2007, and during the first half year 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery, as well as in a small experimental fishery in 2007. The fishery was open for the second half year of 2006 and in all of 2008 to 2010 based on the strong 2007-2009 year classes being around or above the long term average level. However, the Norwegian part of the Norway pout fishery was only open from May to August in 2008 during that year. In the recent open periods the fishing effort and catches have been low in 2008 and 2009, but increased in 2010, and were low again in second half 2011 and second half 2012. The fishery has in these periods mainly been based on the 2008, 2009, and 2012 year classes being around or above the long term average level. The TAC was not taken in 2008, 2009, 2010 and 2012, while the small TAC in 2011 was taken. This was likely due to high fishing (fuel) costs in all years as well as bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch). There was only a quota uptake of 27% of the 100 kt TAC in 2012 (of which 71 kt was EU quota) which besides the high (fuel) costs also was due to late opening of the fishery by the end of quarter 3 in 2012.

By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2)), and recent by-catch numbers in the Danish and Norwegian small meshed fisheries are given in section 2 of the WGNSSK report. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years to a present very low level of by-catch of other species. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard

and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (parly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found further below in the **Stock Annex**.

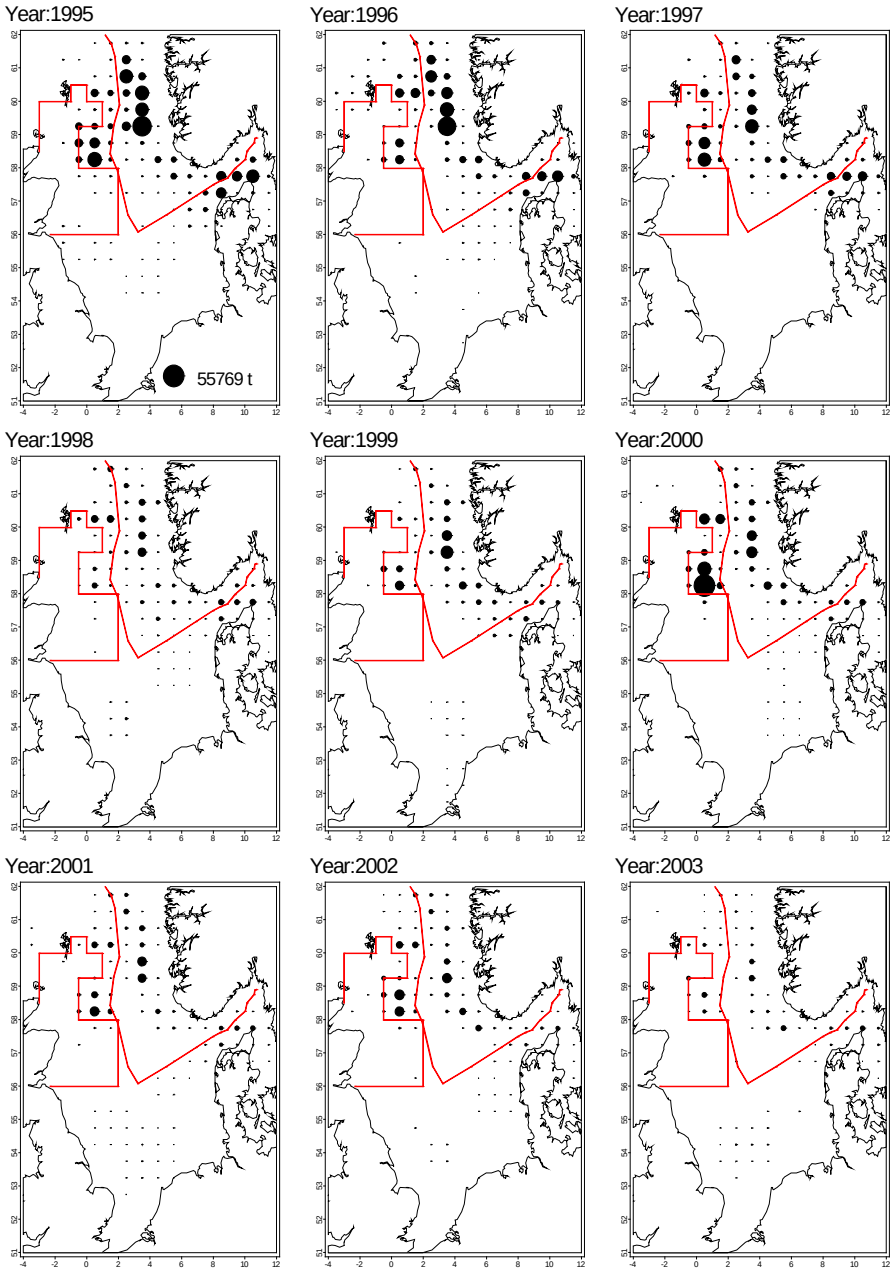


Figure 2. Landings of Norway pout by year and ICES rectangles for the period 1995-2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map.

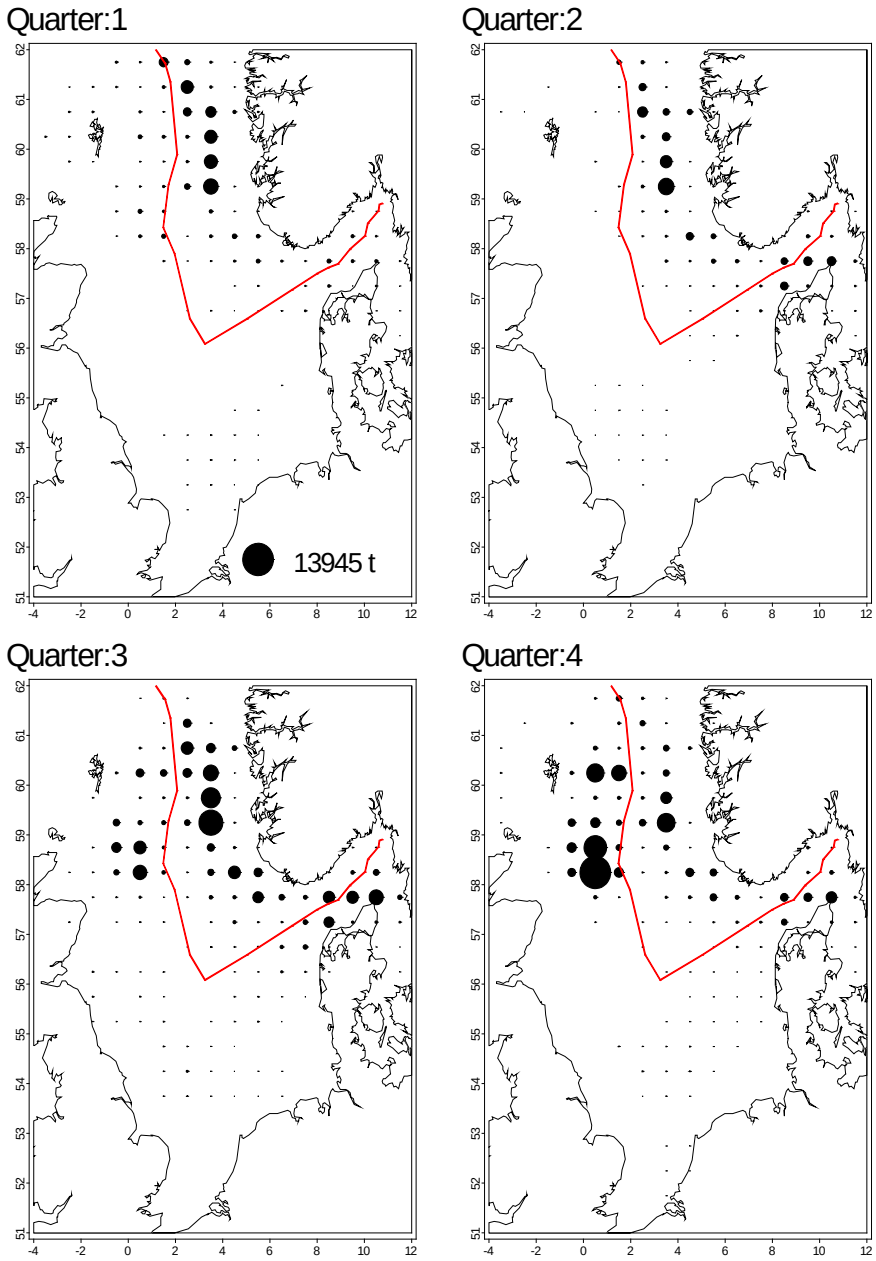


Figure 3. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994-2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map

With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The Norway pout fishery is regulated by technical measures such as minimum mesh size in the trawls, fishing area closure in the Norway pout box in the North-Western part of the North Sea, and by-catch regulations to protect other species. An overview of relevant technical regulations for the Norway pout fishery and stock is given below in section f. By-catch in the fishery is described in detail in Annex 1.

A.3. Ecosystem aspects

Summary: Norway pout is a short-lived species and most likely a one-time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and total stock biomass (TSB) rapidly because of the short life span of the species (Nielsen *et al.*, 2012; Sparholt *et al.*, 2002a, 2002b; Lambert *et al.*, 2009). Furthermore, 20% of age 1 is estimated mature and is included in the SSB. Therefore, the recruitment in the year after the assessment year influences the SSB in the following year. Also, Norway pout is to a limited extent exploited from age 0. Only limited knowledge is available on the influence of environmental factors, such as temperature, on the recruitment. On this basis Norway pout should be managed as a short-lived species.

General: In relation to an ecosystem based approach to fisheries management (CFP), spatial planning and EU Directives such as the Marine Strategy Framework Directive there will for this quality handbook be produced plots using coupled VMS and Logbook data for the Norway pout fishery by metier with recent distributions in effort, landings, and fishery capacity in the Norway pout fishery together with GIS Plots of recent stock distributions based on research survey data. This is also relevant for the fishery section with inclusion of description of recent developments in the Danish and Norwegian Norway pout fishery.

Stock Identity: Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen *et al.*, 2012, Lambert *et al*,, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt 1968; Sparholt *et al.*, 2002b). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert *et al*., 2009).

Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al* (2009) show that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al.* (2001), gave no evidence for a stock separation in the whole northern area, and this conclusion is supported by the results in Lambert *et al.* (2009).

Ecological role: The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by high recruitment variation and variation in predation mortality (or other natural mortality causes) due to the short life span of the species (Nielsen *et al.* 2012; ICES-WGSAM 2011; Lambert *et al.* 2009; Sparholt, Larsen and Nielsen 2002a,b). Norway pout natural mortality is likely influenced by spawning and maturity having implications its age specific availability to predators in the ecosystem and the fishery (Nielsen *et al.*, 2012). With present fishing mortality levels in recent years the status of the stock is more determined by natural processes and less by the fishery, and in general the fishing mortality on 0-group Norway pout is low (Nielsen *et al.* 2012; ICES WGNSSK Reports). There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. This stock is

among other important as food source for other species (e.g. saithe, whiting, haddock, cod and mackerel) and predation mortality is significant (ICES-WGSAM 2011; ICES-SGMSNS 2006). Especially the more recent high abundance of saithe predators and the more constant high stock level of western mackerel as likely predators on smaller Norway pout are likely to significantly affect the Norway pout population dynamics. Interspecific and intraspecific density patterns in Norway pout mortality has been documented (Nielsen *et al*., 2012). However, interspecific density dependent patterns in Norway pout growth and maturity were not found in relation to stock abundance of those predators but rather in relation to North Sea cod and whiting stock abundance (Lambert *et al*., 2009). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES-WGSAM 2011), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used. Growth and mean weight-at-age for the above mentioned predators seems independent of the stock size of Norway pout (ICES WGSAM 2011). Finally, there has been found intra-specific density dependence in Norway pout mortality, growth and maturity at age (Nielsen *et al.* 2012; Lambert *et al.* 2009)

The Review Group (2007) asked the WG to provide guidance on how to deal with the objective of keeping a certain amount of biomass for predators. If a minimum biomass is found to be required, then natural mortality could not be kept constant in the prediction (if it does during the assessment period). It was suggested that variable M be examined to determine the amount of biomass removed via predation, to serve as a baseline biomass requirement for predators.

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment, which include variable natural mortalities at age. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al*., 2012; Lambert *et al*., 2009; ICES WGSAM 2011)). In section B.2 a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment. The inter-benchmark (IBPNorwayPout, ICES 2012c) group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the most recent multispecies stock assessment performed by ICES.

Fisheries impacts on the ecosystem: In order to protect other species (cod, haddock, saithe, whiting, and herring as well as mackerel, monkfish, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, by-catch regulations, minimum mesh size, and minimum landing size (**Stock Quality Handbook**. By-catch of saithe, cod, haddock, whiting, and other species at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2). Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years.

B. Data

B.1. Commercial catch and effort data

The assessment uses the combined catch and effort data from the commercial Danish and Norwegian small meshed trawler fleets fishing mainly in the northern North Sea. Standardized effort data for both the Norwegian and Danish commercial fishery vessels are included in the assessment commercial fishery tuning fleet up until 2006.

For the Danish and Norwegian commercial landings sampling procedures of the commercial landings, which vary between the countries, were described in detail in the report of the WGNSSK meeting in September 2004 (ICES WGNSSK (2005) ICES C.M. 2005/ACFM:07).

From 2002 onwards, an EU regulation (1639/2001) was endorsed which affects the market sampling procedures. First, each country is obliged to sample all fleet segments, including foreign vessels landing in their country. Second, a minimum number of market samples per tonnes of landing are required. The national market sampling programmes have been adjusted accordingly. In general there is set a level of minimum 1 sample per 1000 tonnes landed for Norway pout in the North Sea and Skagerrak.

Sampling and reporting from Norwegian vessels fishing Norway pout and blue whiting has been slightly changed in 2009 and onwards. Previously, all catch reported as Norway pout included by-catch of other species which was used as input in the assessment. These data was also the basis for the Norwegian official catch statistics reported to among other ICES. The procedure up until 2009 was that if a catch (landing) from a fishing trip consisted of more than 50 % of Norway pout in weight then the full catch consisting of all species was reported as Norway pout for this landing, i.e. by-catch was included in the reported Norway pout catch. In 2009 and onwards, each catch (landing) per trip is evaluated (sorted) according to species, and the actual catch per species for each landing is reported. This makes the actual catch numbers of Norway pout from Norway more precise. Norway pout caught both in the Norway pout fishery as well as in the blue whiting fishery are from 2009 included in the assessment, and by-catch of other species are excluded. There has not been made an analysis and thorough evaluation of the effect of this change in Norwegian sampling procedure with respect to relative change in the reported catch at age and weight at age. However, the Norwegian assessment experts evaluate that this will have only minor effect on the catch at age in number and the weight at age used in the assessment as the by-catch and the actual catch has balanced each other out previously. With respect to effort data (see below), only effort is reported for Norwegian trips with landings consisting of more than 50% Norway pout in weight for 2009 and onwards. Consequently, the procedure in estimating and reporting (average) effort data from Norway has remained unchanged according to previous years standard procedure for estimating effort data.

Method of effort standardization of the commercial fishery tuning fleet

Results and parameter estimates by period from the yearly regression analysis on CPUE versus GRT for the different Danish vessel size categories are used in the effort standardization of both the Norwegian and Danish commercial fishery vessels included in the assessment tuning fleet with data up until 2006.

Background descriptions of the commercial fishery tuning series used (including data up to 2006) and methods of effort standardization of the commercial fishery between different vessel size categories and national commercial fleets are given in the 2004 working group report (ICES WGNSSK (2005) ICES CM 2005/ACFM: 07) and the 1996

working group report (ICES CM 1997/Assess:6). Previous to the 2001 assessment the effort has been standardized by vessel category (to a standard 175 GRT vessel) only using the catch rate proportions between vessel size categories within the actual year. In 2002, a new regression standardization method was introduced (see methodological description below), and the assessment was run both with and without the new standardization method (regression). The differences in results of output SSB, TSB and F between the two assessment runs were small.

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up to 2006) different analyses have been made in relation to this in the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to and discussed by the working group in 2004 and presented in the 2004 working group report in section 12 (ICES CM 2005/ACFM:07).

Since 2002, the assessments have used output of the regression analyses using time series from 1987(1994)-most recent assessment year, where the regressions have been applied to the Danish and Norwegian commercial fishery. Effort standardization of both the Danish and the Norwegian part of the commercial fishery tuning series is performed by applying standardization factors to reported catch and effort data for the different vessel size categories. The standardization factors are obtained from regression of CPUE indices by vessel size category over years of the Danish commercial fishery tuning fleet. The number of small vessels in the Danish Norway pout fishing fleet has decreased significantly and the relative number of large vessels has increased in the more recent years. Furthermore, there were found no trends in CPUE between vessel categories over time. For these reasons the CPUE indices used in the regression has been obtained from pooled catch and effort data over the years 1994-present assessment year by vessel category in order to obtain and include estimates for all vessel categories also for the latest years where no observations exists for the smallest vessels groups.

The conclusion of the discussion in the working group of these analysis results was that further analysis and exploration of data is necessary before suggesting an alternative standardization method and alternative division of commercial fishery tuning fleets (potentially) to be used in the assessment. This should be done in a coming benchmark assessment of the stock. Among other it should be further investigated whether it is possible to split the Danish and Norwegian commercial tuning fleet, and also effects of excluding the commercial tuning fleets from the assessment should be further exploited. See also comments to future benchmarking further below.

Parameter estimates from regressions of ln(CPUE) versus ln(average GRT) by period together with estimates of standardized CPUE to the group of Danish 175 GRT industrial fishery trawlers is shown for the period 1994-2006 in this quality control handbook below.

The regression model used in effort standardisation is the following:

Regression models: $CPUE=b*GRT^{a}$ => $\ln(CPUE)=\ln(b)+a*\ln((GRT-50))$

Parameter estimates from regressions of ln(CPUE) versus ln(average GRT) by period together with estimates of standardized CPUE to the group of Danish 175 GRT industrial fishery trawlers is used to standardize effort in the commercial fishery tuning fleet

used in the Norway pout assessment. Parameter estimates for the period 1994-2006 is the following:

Year	Slope	Intercept	R-Square	CPUE(175 tonnes)
1994-2006	0.18	14.05	0.77	32.76

Norwegian effort data

In 1997, Norwegian effort data were revised as described in sections 13.1.3.1 and 1.3.2 of the 1997 working group report (ICES CM 1998/Assess:7). Furthermore, in the 2000 assessment Norwegian average GRT and Effort data for 1998-99 were corrected because data from ICES area IIa were included for these years in the 1998-99 assessments. Observed average GRT and effort for the Norwegian commercial fleets are given in the input data to the yearly performed assessment. This information has been put together in the report of the ICES WGNSSK meeting in 2004 (ICES WGNSSK (2005), ICES CM 2005/ACFM:07). No Norwegian effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Norwegian effort data for the directed Norway pout fishery in 2008 has not been prepared because the fishery has been on low level, and data for 2010, 2011 and 2012 has not been prepared because of introduction of selective grids in the Norwegian fishery since 2010. See also comments on benchmarking further below.

Danish effort data

In each yearly assessment the input data as CPUE data by vessel size category and year for the Danish commercial fishery in area IVa is given. This is based on fishing trips where total catch included at least 70 % Norway pout and blue whiting per trip, and where Norway pout was reported as main species in catch in the logbook per fishing day and fishing trip. There has been a relative reduction in the number and effort of small vessels and an increase for the larger vessels in the fleet in the latest years. Furthermore, it appears clearly that there is big difference in CPUE (as an indicator of fishing power) between different vessel size categories (BRT). Accordingly, standardization of effort is necessary when using a combined commercial fishery tuning fleet in the assessment including several vessel categories. Minor revisions (updating) of the Danish effort and catch data used in the effort standardization and as input to the tuning fleets have been made for the 2001 assessment. No Danish effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 as well as the first part of 2011 and 2012 due to closure of the fishery.

Exploration of methods for effort standardization

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up until 2006) different analyses have been made in relation to the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to the working group and were discussed here in 2004 (ICES CM 2005/ACFM:07).

Analysis of variance (GLM-analyses) of catch, effort and log transformed CPUE data on trip basis for the Danish commercial fishery for Norway pout during the period 1986 to 2004 showed statistical significant differences in catch rates between different GT-groups, years, quarters of years (seasons), and fishing areas, as well as statistical significant first order interaction effects between all of these variables. The detailed patterns in this variation are not clear and straight forward to conclude on.

It has so far not been possible to obtain disaggregated effort and catch data by area and vessel size (GT-group) from the Norwegian Norway pout fishery to perform similar analyses for the Norwegian fishery.

Also it is not possible to regenerate the historical time series (before 1996) of catch numbers at age in the commercial fishery tuning fleet by nation which is only available for the combined Danish and Norwegian commercial tuning fleet. The reason for this is partly that there is no documentation of historical allocation of biological samples (mean weight at age data) to catch data (catch in weight) in the tuning fleet in order to calculate catch number at age for the period previous to 1996 for both nations, and partly because it seems impossible to obtain historical biological data for Norway pout (previous to 1996) from Norway. Alternative division of the commercial fishery tuning fleet would, thus, need new allocation of biological data to catch data for both the Danish and Norwegian fleet, and result in a significantly shorter Norwegian commercial fishery tuning fleet time series, and a historically revised Danish commercial fishery tuning fleet with new allocation of biological data to catch data. Revision of the tuning fleet would, furthermore, need analyses of possible variation in biological mean weight at age data to be applied to different fleets, as well as of the background for and effect of this possible variation.

Future benchmark should evaluate usefulness of including recent commercial fishery tuning time series in the assessment from Danish and Norwegian commercial fishery. This should take into consideration influence on cpue and targeting in the Norway pout fishery based on the several fishing closures (several real time management closures) in recent years, introduction of selective devices in recent years being different for Norwegian and Danish fishery, different targeting in Danish and Norwegian Norway pout fisheries (Norway pout, blue whiting), as well as yearly changes in fleet efficiency given changes in vessel sizes targeting Norway pout over time.

Standardized effort data

The resulting combined and standardized Danish and Norwegian effort for the commercial fishery used in the assessment is presented in the input data to the yearly performed assessment, as well as the combined CPUE indices by age and quarter for the commercial fishery tuning fleet.

The seasonal variation in effort data is one reason for performing a seasonal VPA.

B.2. Biological data

Age reading

There are no reports of age reading problems of Norway pout otoliths, and no indications of low quality of the age length keys used in the assessment of this stock.

Age compositions

Age compositions by age and quarter of year are available from Norway and Denmark (except for Norway in 2007 and 2008). Only very few biological samples were taken from the low Norway pout catches in 2005 and 2011, as well as in first half year 2006, 2007, and 2012. Danish data are in the InterCatch database, but not Norwegian data yet. As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches, the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery. As no age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches the catch at age numbers

from Danish fishery is calculated from Danish total catch weight divided by mean weight at age from the Norwegian fishery in 2010.

Weight at age

Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. In general, the mean weights at age in the catches are variable between seasons of year. Historical levels and variation in mean weight at age in catch by quarter of year is shown in Figure 12.2.1 in the 2004 benchmark assessment in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005), ICES CM 2005/ACFM:07) and has been yearly/half yearly up-dated since then (ICES-WGNSSK Reports).

As no age composition data for Norwegian landings have been provided for 2007 and 2008 because of small catches the catch at age numbers from Norwegian fishery are calculated from Norwegian total catch weight divided by mean weight at age from the Danish fishery. Mean landings weight at age from Danish and Norwegian fishery from 2005-2008 as well as for 2011are uncertain because of the few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005-2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight at age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight at age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight at age data is available from both Danish and Norwegian fishery in 2009 and second half 2010, second half 2011, and second half 2012. There is, furthermore, referred to section B.1. concerning modifications in Norwegian sampling procedures of catch at age data from 2009 and onwards also (potentially) affecting Norwegian mean weight at age data slightly.

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the ICES IBPNorwayPout inter-benchmark report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009). See also conclusions from the benchmarking and on revision of input population dynamic parameters used in the assessment described under natural mortality and maturity at age in the section below. The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. No major revision of mean weight at age in the stock has been performed compared to the values used in previous assessments. Danish data are in the InterCatch database, but not Norwegian data.

Maturity and natural mortality

Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al*. (2001) as a working document to ICES C.M.2001/ACFM:07, indicated variation in maturity between years and sexes, especially for the 1-group.

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES

WGSAM 2011)). Proportion mature and natural mortality by age and quarter used in the assessment is given in **Table** 5.2.6 of the yearly ICES WGNSSK report.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment as well as in the present assessment is based on results from a recent paper (Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments then variable natural mortality between ages have been introduced in the 2012 Inter-benchmark assessment and the present assessment. The revision of the natural mortality parameter is based on results in Nielsen *et al*. (2012) and the ICES WGSAM 2011 multi-species assessment report. It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the most recent multispecies stock assessment performed by ICES. The revised values are shown in **Table** 5.2.6.

Summary of Inter-benchmark with revised weight, maturity and natural mortality parameters at age included in the assessment

Evaluations performed

The ICES IBPNorwayPout inter-benchmark exercise evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight at age in the stock) for the Norway pout stock in the North Sea and Skagerrak. The natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originate from results published in Nielsen *et al*. (2012), Lambert *et al*. (2009), Sparholt *et al.* (2002a,b), as well as from the multi-species assessment working group ICES WGSAM 2011. In particular, natural mortality estimates for Norway pout originating from the new key run of the multi-species SMS model were applied here. Five scenarios were considered, a Baseline Scenario following the current assessment approach and four additional scenarios which explored alternative biological inputs as presented in **Table** 5.2.5.1.

Baseline:

The May 2011 assessment is selected as the Baseline assessment. The settings of the Baseline are constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The following alternative scenarios were tested in the benchmark exercise:

Scenario1:

Natural mortality (M) change: Average Z at age used as a proxy for M, computed for ages 1-3 in the years 2004, 2005, 2007 and 2008 (years with low fishing mortality) based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1-Q1 cohorts as averages for these 4 years based on the approach in Nielsen *et al.* (2012, Fig. 1). Yearly Ms are divided by 4 to obtain quarterly Ms, and M at age 0 is set equal to that for age 1. In Scenario 1 the same maturity ogive and mean weight at age is used as in the Baseline assessment.

Scenario 2:

Natural mortality (M) change*:* Same M inputs as Scenario 1. Maturity ogive change: Maturity at age 1 is set to 0.2 from Lambert *et al.* 2009, Fig. 4. Maturity at age 2 is set to 100 %. Mean weight at age in stock (MWA) change: The settings are based on results from commercial fishery during the period 1983 to 2006 as presented in Lambert *et al.* (2009, Fig. 8.). The long term trends in MWA have been calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery and compared to Lambert *et al.* (2009) Fig. 8 values and were found to be consistent. The revised Mean Weight at Age (MWA) in the stock used in the benchmark assessment are for the 1-, 2- and 3-groups taken as the long term averages from the commercial data. Data for MWA by quarter for age 0 are kept constant as used in the Baseline. MWA is recorded from commercial fishery catch data, but not during the IBTS, from which only length data are available.

Scenario 3:

Natural mortality (M) change*:* Average Z at age (being a proxy for M) for ages 1-3 for the full year range 1983-2005 from Q1-Q1 IBTS revised indices from Nielsen *et al.* (2012) Figure 1 (as presented in Table 2 below). Yearly Ms divided by 4 to obtain average quarterly M's. M at age 0 set equal to that for age 1. Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

Scenario 4:

Natural mortality (M) change*:* M1+M2 from the multi-species SMS model from the new key run presented in the ICES WGSAM 2011 Report. Averages of the SMS estimates of quarterly M1+M2 have been used for the full year range used in the SMS key run. Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

The change in natural mortality in Scenario 1, where survey based average Zs in the 4 years with very low or no fishing mortality has been used as a proxy for M, results in applying M-values of similar magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the age and quarter invariant values used in the Baseline assessment (0.4 by age and quarter). The total mortality on the cohort (and the age specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality is very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) results in a slightly lower total stock biomass (TSB) and R and nearly the same SSB and Fbar(1-2) as the, Baseline. This is expected given these modest age specific changes in M. between Baseline and Scenario 1. The maturity ogive in Scenario 1 is the same as the Baseline with only 10% of age 1 mature, resulting in SSB similar to the Baseline. Because the catch at age data used in the Baseline and in all tested scenarios is the same, and because natural mortality on the main fished part of the population, i.e. age 1-3, is slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in Scenario 1 (and 2)), this results in the recruitment being a little bit lower while fishing

mortality is similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time is observed for Scenario 1 and the Baseline.

Scenario 2 has the same natural mortality change used as in Scenario 1 but the maturity ogive and MWA vector are different. The maturity ogive has been changed to 20% mature of the 1-group, and the revised MWA in the stock is applied, obtained from long term averages measured from the commercial fishery catch. The changes in MWA are minor compared to the Baseline and do not have much impact. The change in the maturity ogive, where 20% are mature compared to value of 10% in the Baseline results in a higher SSB in Scenario 2 compared to the Baseline (and Scenario 1) as would be expected. The same trends in R and TSB as well as F are observed in Scenario 2 as in Scenario 1 and the reason for this is the same as described above under Scenario 1. Also recruitment is somewhat lower under Scenario 2. In combination, higher SSB and lower R under Scenario 2 implies a lower overall recruitment rate (R/SSB). Overall, the same perception of the stock dynamics (fluctuations) over time is observed for Scenario 2 and the Baseline.

Scenario 3 operates with bigger changes in mortality by age compared to the baseline. In this scenario the M-value for the 0- and 1-groups is around 0.25 and the M for the older age groups are significantly higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA vector is in Scenario 3 as was used in Scenario 2. Much higher mortality on the old, large fish together with fishing mortality results in a high total mortality on the older fish, and consequently, there needs to be more recruits to sustain this mortality (as the same number of fish is caught in all scenarios). This results in higher R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment for Scenario 3 are different over time compared to the Baseline.

Scenario 4 uses the multi-species model estimates of M where the quarterly mortality is higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This results in similar TSB and SSB as the Baseline but a perception of slightly higher recruitment and fishing mortality.

Conclusions

The independent reviewers considered that the new values for biological inputs constituted an improvement to the assessment of Norway pout and they support the use of Scenario 2 as the new Baseline for the stock assessment. They expressed some concern regarding the estimation of mortality rates from survey data without accounting for the survey catchability at age. Ideally natural mortality should be estimated within the stock assessment model simultaneously with estimates of survey catchability, but in most cases the data are inadequate to do this. Evidence of density dependence in Norway Pout mortality, growth and maturation rates suggests that using fixed estimates in stock assessments could lead to biases and this is worthy of further investigation. The reviewers note that the stock-recruit scatter was relatively uninformative but considered that the values being used for biological reference point should still apply. Consideration could also be given to a higher target escapement level given the importance of Norway Pout as a forage species in the ecosystem.

The Benchmark group concluded that revisions to natural mortality, maturity and mean weight at age should be included in the final benchmark assessment based on the approach in Lambert *et al*. (2009) and Nielsen *et al.* (2012). It is not recommended that Z values be used as proxies for M values for the full year range since 1983 (Scenario

3) as this average includes fishing mortality which, especially in the early part of the period, has been relatively high, i.e. this gives a biased over-estimation of M. Both Scenarios 2 and 4 were found worthy of further consideration in the Benchmark. The results of Scenarios 2 and 4 are not significantly different from the baseline scenario, and both scenarios give the same perception of the stock dynamics (fluctuations) over time as is observed for the baseline.

The population dynamic parameters and approach used in Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on A1 are higher than those based on Z estimates from the IBTS index. This difference in perception could occur if the catchability on A1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout is not lower than for the older age groups (although this is somewhat contrary to the catchability estimates at age for IBTS coming out of both the Baseline and the Scenario 2 SXSA assessment model estimates), and that there is no age specific migration out of the assessment area (being the whole North Sea and Skagerrak-Kattegat).

Scenario 4 uses results of M from the SMS model assessment which has a number of characteristics and assumptions as well. The SMS assumes constant residual mortality at age (M1), i.e. natural mortality due to other reasons than predation. This is in contradiction to potential spawning mortality as discussed in Nielsen *et al.* (2012) which would result in M increasing with age. Also, the SMS smoothes mortality out between ages 1-3, i.e. does not fully consider potential differences in natural mortality between these ages, because the model uses rather wide size intervals in its prey-predator preference model (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2012). This means that the mortalities between age 1, age 2 and age 3 tend to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 is saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS uses the saithe (predator) biomass estimates from the ICES WGNSSK single stock assessment (ICES WGNSSK 2011), and this assessment is very uncertain. Consequently, the SMS natural mortality estimates on Norway pout are dependent on uncertain assessment estimates of saithe in the North Sea which also influences age specific mortalities on Norway pout.

In comparison with the analysis of IBTS survey data , SMS estimates of total yearly M (and also Z) are higher for age 0 and 1 and lower for age 2 and 3 Norway pout (Nielsen *et al.* 2012). Even if the catchability in the surveys was lower for age group 1 then it is difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared to the observed age 2 and age 3 survey based mortality estimates. In Nielsen *et al.* (2012) it is argued that migration in or out of the area is very unlikely, so the lower estimates of Z from SMS at age 2 and especially age 3 compared to estimates from the the IBTS data (Nielsen *et al.* 2012) is difficult to explain.

In conclusion the benchmark group agreed that Scenario 2 is preferred based on the available information, and recommends Scenario 2 be used as the new baseline assessment for the Norway Pout stock.

Possible revision of the natural mortality parameter in the assessment has also been evaluated in the September 2006 benchmark assessment in response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea. In summary no conclusions could be reached from the exploratory runs then using different natural mortalities from previous primary literature (Sparholt *et al*., 2002a,b; ICES 2006) as the mortality between age groups was contradictive and

inconclusive between periods (variable) from the different sources used showing different trends with no obvious biological explanation. On that basis it was in the 2006 benchmark assessment decided that the final assessment continues using the constant values for natural mortality at age. The background for these conclusions and the benchmarking in 2006 was that exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 assessments (Norway pout benchmark assessments) with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt et al., 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model (ICES SGMSNS 2006) in the 2006 assessment (ICES CM 2006/ACFM:35). These revised natural mortalities are given in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005); ICES CM2005/ACFM:07) and the ICES WGNSSK 2006 report including the described inter-benchmark assessments. Furthermore, estimates of total mortality based on the SURBA assessment model estimates (2005 SURBA run for Norway pout, ICES C.M. 2006/ACFM:35) using all survey time series included in the baseline assessment (ICES CM 2007/ACFM:18 and 30) covering the period 1983-2005 indicated that for the period up to 1990-1995 Z estimated from SURBA and Sparholt *et al.*, 2002a,b is at the same level for both the 1-2 group and 2-3 group, and there also seems to be age specific differences in Z. In the period from 1995 and onwards the Z-estimates from SURBA are lower compared to the constant M values obtained from Sparholt *et al.*, 2002a,b. In later years from 2002-03 SURBA estimates of Z increased again compared to the period 1995-2001. In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. Previous evaluation of total mortality Z in recent years, where fishing mortality has been very low and where total mortality accordingly approximately equals natural mortality, has been performed and is shown in the September 2007 report (ICES CM 2007/ACFM:18 and 30, **Table** 5.2.12). This evaluation has been based on catch curve analysis on recent (IBTS Q1 and Q3) survey estimates for Norway pout. The results indicate somewhat different levels of Z between different survey time series mirroring the results from the 2006 benchmark assessment.

B.3. Assessment tuning fleet data and indices (general)

Revision of assessment tuning fleets (survey CPUE data and commercial fishery CPUE data) in the 2004 benchmark assessment (see also section B.1 and B.5 concerning the commercial fishery tuning fleet):

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described here in the stock quality handbook as well as in the benchmark assessment in the working group report from 2004.

Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohorte analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under section 12.3 of the 2004 benchmark assessment (ICES WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES WGNSSK (2005)) Figures 12.2.3-12.2.8 and Tables 12.2.9-12.2.12.

For an overview over the resulting tuning data time series and fleets included and used in the assessment during different time periods (by year and age) in the assessment see Table 5.3.1 in section 5 over tuning in the assessment report. The table is also given in up-dated form here under section C.

B.4. Survey data

Survey index series of abundance of Norway pout by age and quarter are for the assessment period available from the IBTS (Q1 and Q3) and the EGFS (Q3) and the SGFS (Q3). The SGFS data from 1998 onwards should be used with caution due to new survey design (new vessel from 1998 and new gear and extended survey area from 1999). The 0-group indices from this survey have accordingly not been used in the assessment tuning fleet for this survey previous to the 2004 benchmark assessment. The index for the 0-group from SGFS changed with an order of magnitude in the years after the change in survey design compared to previous years (Table 12.2.8, ICES WGNSSK (2005)). The EGFS data from previous to 1992 should be used with caution as the survey design shifted in 1992. This change in survey design has until 2004 been accounted for by simply multiplying all indices with a factor 3.5 for all age groups in the years previous to 1992 in order to standardize it to the later indices. The EGFS survey indices for Norway pout has been revised in the 2004 assessment compared to the previous years assessment for the 1996, 2001, 2002, and 2003 indices. In previous years assessments (before 2004) the full EGFS survey time series for all age groups have been included as an assessment tuning fleet. Time series for IBTS Q3 are only available from 1991 and onwards. The 3rd quarter IBTS and the EFGS and SGFS are not independent of each other as the two latter is a part of the first. Accordingly, the following changes have been made for the survey tuning index series in the 2004 benchmark assessment (also shown in the tuning series overview table in section C):

1) The IBTS Q3 for the period 1991- onwards has been included in the assessment. This survey has a broader coverage of the Norway pout distribution area compared to the EGFS and SGFS isolated. However, as this survey index is not available for the most recent year to be used in the seasonal assessment it has been chosen to exclude the 0- and 1-group indices from the IBTS Q3 in order to allow inclusion of the 0- and 1-group indices from the SGFS and EGFS which are available for the most recent year in the assessment. (Not relevant in relation to spring assessments) Accordingly, the IBTS Q3 tuning fleet for age 2 and age 3 has been included in the assessment as a new tuning fleet. The SXSA demands at least two age groups in order to run which is the reason for including both age 0 and age 1 under the EGFS and SGFS tuning fleets and not including age 1 in the IBTS Q3 tuning fleet.

2) The SGFS for age group 0 and 1 for the period 1998 and onwards has been used as tuning fleet in the assessment. The short time series is due to the change in survey design for SGFS as explained above. The quarter 3 0-group survey index for SGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment.

3) The EGFS for age group 0 and 1 for the period 1992 and onwards has been used as tuning fleet in the assessment. The shorter time series is due to the change in survey design for EGFS as explained above. Furthermore, there is a good argument for excluding the age 2-3 of the EGFS as the within survey correlation between the age groups 1-2 and 2-3 is very poor while the within correlation between age groups 0-1 is good. The quarter 3 0-group survey index for EGFS

is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment.

4) The IBTS Q1 tuning fleet has remained unchanged compared to previous years assessment.

From 2009 and onwards the SGFS changed it survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted sub-area averages.

For an overview of the time series included and used by year and age in the assessment see Table 5.3.1 in section 5 of the assessment report. The table is also given in up-dated form here under section C.

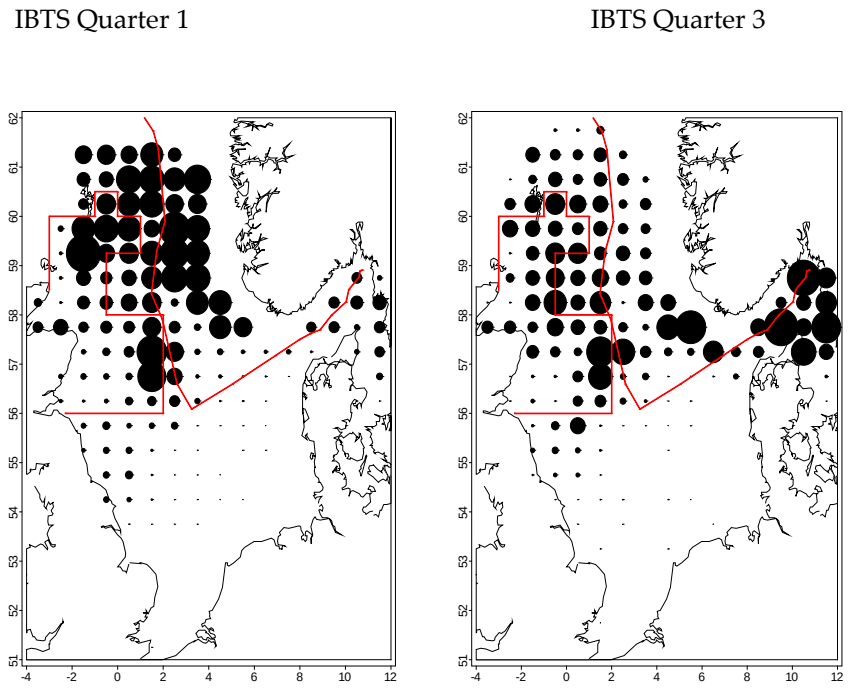


Figure 4 IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually.

B.5. Commercial CPUE data

Combined CPUE indices by age and quarter for the Danish and Norwegian commercial fishery tuning fleet (including data up to 2006) is calculated from effort data obtained from the method of effort standardization of the commercial fishery tuning fleet described under section B.1 (and B.3) and vessel category specific catches by area. CPUE is estimated on a quarterly basis for the Danish and Norwegian commercial fleets.

The resulting combined, commercial fishery CPUE data by age and quarter is presented in the input data to the yearly performed assessment. The commercial fleet data

(up to 2006) are used in tuning of the assessment based on the combined and standardized Danish and Norwegian effort data and on the catch data for the commercial fishery

See also section B.1 and B3 concerning the commercial fishery tuning fleet.

Commercial fishery tuning fleets:

In addition to the analyses of the commercial fishery assessment tuning fleet (including data up to 2006) as described above (effort standardization) the quarterly CPUE indices of the commercial fishery tuning fleet were analyzed during the 2004 benchmark assessment:

1. The indices for the 0-group in 3rd quarter of the year have been excluded from the commercial fishery tuning fleet. The main argumentation for doing that is that this age group indicate clear patterns in trends in catchability over the assessment period as shown in the single fleet/quarter assessment runs in section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Secondly, there is no correlation between the commercial fishery 3rd quarter 0-group index and the commercial fishery 4th quarter 0-group index, and no correlation between the 3rd quarter commercial fishery 0-group index in a given year with the 1-group index of the 3rd quarter commercial fishery the following year.
2. The 2nd quarter indices for all age groups have been excluded from the commercial fishery tuning fleet. This is mainly because of indications of strong trends in catchability over time in the assessment period for this part of the tuning fleet for all age groups as indicated by single fleet tuning runs in the section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Also, the within quarter and between quarter correlation indices are in general relatively poor. The cohorte analyses of the 2nd quarter commercial fishery indices indicate as well relative changes over time.

For an overview of the time series included and used by year and age in the assessment see Table 5.3.1 in section 5 of the assessment report. The table is also given in up-dated form here under section C.

C. Assessment: data and method

Model and Software used (current assessment):

The SXSA (Seasonal Extended Survivors Analysis: Skagen (1993)) has been used to estimate quarterly stock numbers and fishing mortalities for Norway pout in the North Sea and Skagerrak as the standard assessment method. The catch at age analysis was carried out according to the specifications given in the present stock quality handbook. The SXSA program is available from ICES. This model is used for the final assessment as standard software.

The assessment is analytical using catch-at-age analysis based on quarterly catch and CPUE data. The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the seasonal assessment taking into account the seasonality in fishery, use seasonal based fishery independent information, and using most recent information about recruitment. The seasonal variation in effort data is one reason for performing a seasonal VPA. The assessment provides stock status and year class strengths of all year classes in the stock up to the first quarter of the assessment year (spring assessment) and second quarter of the assessment year (autumn assessment). The real time assessment method with up-date every half year also

gives a good indication of the stock status the 1st January the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

The SMS program available from Morten Vinther, DIFRES, Copenhagen (Exploratory run, 2004 and 2005, April 2006 and September 2006). Used in exploratory runs.

The XSA program from ICES. Used in exploratory runs.

The SURBA program available from Coby Needle, MARLAB, Aberdeen; Used in an exploratory run, 2005.

The XSA and SURBA models and software cannot perform quarterly based assessment.

Model Options chosen (current assessment):

In the options chosen in the SXSA for the Norway pout assessment the catchability, r, per age and quarter and fleet is assumed to be constant within the assessment period where the estimated catchability is a geometric mean over years by age, quarter and tuning fleet. In the 2004 benchmark assessment exploration of trends in tuning fleet catchabilities was investigated by single fleet runs with the SXSA. The accepted assessment with revised tuning fleets in the 2004 benchmark assessment assume constant catchability.

Tuning is performed over the period 1983 to present producing log residual (log(Nhat/N)) stock numbers and survivor estimates by year, quarter, age and tuning fleet. The contributions from the various age groups to the survivor estimates by year and quarter and fleet are in the SXSA combined to an overall survivors estimate, shat, estimated as the geometric mean over years of log(shat) weighted by the exponential of the inverse cumulated fishing mortality as described in Skagen (1993).

The parameter settings and options of the SXSA and SMS have been the same in all recent years of the assessment, except that recruitment season to the fishery has been backshifted from 3rd quarter of the year to 2nd quarter of the year when running SXSA in the autumn in order to gain benefit from the most recent 0-group indices from the 3rd quarter surveys (SGFS and EGFS as explained above) in the assessment. This procedure is still followed. This was not necessary in the SMS assessment. (In the May 2007 assessment with SXSA this backshifting has not been performed).

No time taper or shrinkage is used in the catch at age analysis in general. The four surveys and the seasonally (by quarter) divided commercial fleets (the latter only including data up to year 2006) in are all used in the tuning.

The following parameters are used:

Year range:	1983 -
Seasons per year:	4
The last season in the last year is season:	3
Youngest age:	0
Oldest true age:	3
Plus group: plus group in SMS (4+-group in SXSA)	No
Recruitment in season:	3
Spawning in season:	1

Single species mode:	Yes, number of species = 1
The following tuning fleets are included:	
Fleet 1: Q1:Age1-3; Q2:None; Q3:Age1-3; Q4:Age0-2)	commercial q134
Fleet 2:	ibtsq1 (Age 1-3)
Fleet 3:	egfsq2 (Age 0-1)
Fleet 4:	sgfsq2 (Age 0-1)
Fleet 5:	ibtsq3 (Age 2-3)
Data are input from the following files:	
Catch in numbers:	canum.qrt
Weight in catch:	weca.qrt
Weight in stock:	west.qrt
Natural mortalities:	natmor.qrt
Maturity ogive:	propmat.qrt
Tuning data (CPUE):	tun…..xsa
Weighting for rhats:	rweigh.xsa

SXSA: In the SXSA the following options are / were used:

The following options were used:

1: Inv. catchability:	2
(1: Linear; 2: Log; 3: Cos. filter)	
2: Indiv. shats:	2
(1: Direct; 2: Using z)	
3: Comb. shats:	2
(1: Linear; 2: Log.)	
4: Fit catches:	0
(0: No fit; 1: No SOP corr; 2: SOP corr.)	
5: Est. unknown catches:	0
(0: No; 1: No SOP corr; 2: SOP corr; 3: Sep. F)	
6: Weighting of rhats:	0
(0: Manual)	
7: Weighting of shats:	2
(0: Manual; 1: Linear; 2: Log.)	
8: Handling of the plus group:	1
(1: Dynamic; 2: Extra age group)	

Factor (between 0 and 1) for weighting the inverse catchabilities at the oldest age versus the second oldest age (factor 1 means that the catchabilities for the oldest age are used as they are): 0

Specification of minimum value for the survivor number (this is Used instead of the estimate if the estimate becomes very low): 0

Iteration until convergence (setting 0): 0

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	Not relevant in SXSA	0-3+	Yes
Canum	Catch at age in numbers	1983-present	0-3+	Yes
Weca	Weight at age in the commercial catch	1983-present	0-3+	Yes
West	Weight at age of the spawning stock at spawning time.	1983-present	0-3+	No
Mprop	Proportion of natural mortality before spawning	Not relevant in SXSA		
Fprop	Proportion of fishing mortality before spawning	Not relevant in SXSA	0-1	Yes
Matprop	Proportion mature at age	1983-present	1-3+	No, 10%age 1, 100% 2+
Natmor	Natural mortality	1983-present	0-3+	No, 0.4 per quarter per age group

Tuning data used in the present and historical assessments:

Table 5.3.1 **Norway pout IV & IIIaN (Skagerrak). Tuning fleets and indices used in the final 2004 benchmark assessment as well as in the 2005-2013 assessments compared to the 2003 assessment.**

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-13 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	3rd quarter (SXSA)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	1st quarter (SXSA)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)
FLT01: comm Q1					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT01: comm Q2			NOT USED	NOT USED	NOT USED
	Year range	1982-2003			
	Quarter	2			
	Ages	1-3			
FLT01: comm Q3					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	3	3	3	3
	Ages	0-3	1-3	1-3	1-3
FLT01: comm Q4					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	4	4	4	4
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)
FLT02: ibtsq1					
	Year range	1982-2003	1982-2006	1982-2006	1982-2013
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2012
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT04: sgfs					
	Year range	1982-2003	1998-2006	1998-2006	1998-2012
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED			
	Year range		1991-2005	1991-2005	1991-2012
	Quarter		3	3	Q3
	Ages		2-3	2-3	2-3

SMS model used as the standard assessment model during the period 2005-2007 with the following options:

SMS-Model (2005-2007): The following tuning fleet options were used in the SMS model (summary from fleet_info.dat):

Minimum CV of CPUE observations: 0.2

Fleet specific options:

1-2, First year last year,

3-4. Alpha and beta - the start and end of the fishing period for the fleet given as fractions of the season (or year if annual data are used)

5-6 First and last age,

7. last age with age dependent catchability,

8. last age for stock size dependent catchability (power model), -1 indicated no ages uses power model

9. season for survey,

10. number of variance groups for estimated catchability by species and fleet

1 commercial q1: 1983 2004 0 1 1 3 3 -1 1 3

1 commercial q3: 1983 2004 0 1 1 3 3 -1 3 3

1 commercial q4: 1983 2004 0 1 0 2 2 -1 4 3

2 IBTS q1: 1983 2006 0 1 1 3 3 -1 1 3

3 EGFS q 3: 1992 2005 0 1 0 1 1 -1 3 2

4 SGFS q3: 1998 2006 0 0 0 1 1 -1 3 2

5 ibts_q3: 1991 2005 0 1 2 3 3 -1 3 2

Variance groups:

Fleet: 1 season 1: 1 2 3

Fleet: 1 season 3: 1 2 3

Fleet: 1 season 4: 0 1 2

Fleet: 2: 1 2 3

Fleet: 3: 0 1

Fleet: 4: 0 1

Fleet: 5: 2 3

SMS-Model: The following SMS model settings were used in the SMS model (2005-2007) - (summary from SMS.dat):

SSB/R relationship: Geometric mean

Object function weighting:

First=catch observations 1.0

Second=CPUE observations 1.0

Third=SSB/R relations 1.0

Minimum CV of commercial catch at age observations option min.catch.CV): 0.20

Minimum CV of S/R relation (option min.SR.CV): 0.20

No. of separate catch sigma groups by species: 4 (one variance group by age)

Exploitation pattern by age and season: Age 0 (3rd-4th quarter)

Age 1 (1st, 3rd, 4th quarter)

Ages 2-3 (1st, 3rd, 4th quar ter)

If tuning survey index has the value 0 then 5% of the average of the rest of the observations are used because the logarithm to zero can not be taken:

Minimum "observed" catch, negative value gives percentage (-10 ~ 10%) of average catch in age-group

if option>0 and catch=0 then catch=option

if option<0 then catch=average(catch at age)*(-option)/100 -5

Assuming fixed exploitation pattern by age and season

Number of years with zero catch: 2 (2005, 2006)

SMS model used as the standard assessment model during the period 2005-2007:

SMS (**S**tochastic **M**ulti **S**pecies model; Lewy and Vinther, 2004) is an age-structured multi-species assessment model which includes biological interactions. However, the model can be used with one species only. In "single species mode" the model can be fitted to observations of catch-at-age and survey CPUE. SMS uses maximum likelihood to weight the various data sources assuming a log-normal error distribution for both data sources. The likelihood for the catch observation is then as defined below:

$$L_C = \prod_{a,y,q} \frac{1}{\sigma_{catch}(aa)\sqrt{2\pi}} \exp(-(\ln(C(a,y,q)) - \ln(\hat{C}(a,y,q)))^2 / (2\sigma^2_{catch}(aa)))$$

where C is the observed catch-at-age number, $\hat{C}$ is expected catch-at-age number, y is year, q is quarter, a is age group, and aa is one or more age groups.

SMS is a "traditional" forward running assessment model where the expected catch is calculated from the catch equation and F-at-age, which is assumed to be separable into an age selection, a year effect and a season (year, half-year, quarter) effect.

As an example, the F model configuration is shown below for a species where the assessment includes ages 0–3+ and quarterly catch data and quarterly time step are used:

$$F = F(a_a) \times F(y_y) \times F(q_q),$$

with F-components defined as follows:

$F(a)$:

Age 0	**Fa0**
Age 1	Fa1
Age 2	Fa2
Age 3	Fa3

$F(q)$:

	Q1	**q2**	**q3**	**q4**
Age 0	0.0	0.0	Fq	0.25
Age 1	Fq1,1	Fq1,2	Fq1,3	0.25
Age 2	Fq2,1	Fq2,2	Fq1,3	0.25
Age 3	Fq3,1	Fq3,2	Fq3,3	0.25

$F(y)$:

Y1	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**	**Y8**	**Y9**	**…**
1	Fy2	Fy3	Fy4	Fy5	Fy6	Fy7	Fy8	Fy9	….

The parameters $F(a_a)$, $F(y_y)$ and $F(q_q)$ are estimated in the model. $F(q_q)$ in the last quarter and $F(y_y)$ Fy in the first year are set to constants to obtain a unique solution. For annual data, the $F(q_q)$ is set to a constant 1and the model uses annual time steps.

One $F(a)$ vector can be estimated for the whole assessment period, or alternatively, individual $F(a)$ vectors can be estimated for subsets of the assessment periods. A separate $F(q)$ matrix is estimated for each $F(a)$ vector.

For the CPUE time series the expected CPUE numbers are calculated as the product of an assumed age (or age group) dependent catchability and the mean stock number in the survey period.

The likelihood for CPUE observations, L_S, is similar to L_C, as both are assumed lognormal distributed. The total likelihood is the product of the likelihood of the catch and the likelihood for CPUE ($L = L_C * L_{CPUE}$,). Parameters are estimated from a minimisation of -log(L).

The estimated model parameters include stock numbers the first year, recruitment in the remaining years, age selection pattern, and the year and season effect for the separable F model, and catchability at age for CPUE time series.

SMS is implemented using ADmodel builder **(Otter Research Ltd.), which is a software** package to develop non-linear statistical models. The SMS model is still under development, but has extensively been tested in the last year on both simulated and real data.

SMS can estimate the variance of parameters and derived values like average F or SSB from the Hessian matrix. Alternatively, variance can be estimated by using the built-in functionality of the AD-Model builder package to carry out Markov Chain Monte Carlo simulations (Gilks *et al*. 1996), MCMC, to estimate the posterior distributions of the parameters. For the historical assessment, period uniform priors are used. For prediction, an additional stock/recruitment relation including CV can be used.

Comparison of SXSA and SMS model output and assessment model evaluation:

The September 2006 limited benchmarking considered the most appropriate assessment model to be used and considered in order to describe the dynamics of the stock.

Previously, the SXSA (Seasonal Extended Survivors Analysis) model has been used in the assessment of Norway pout. The method is described in the quality control handbook.

The SMS is like the SXSA a seasonal based model being able to deal with assessment of a short lived species (where there are only few age groups in the VPA) and seasonality in fishing patterns.

The SMS (Stochastic Multi Species model; see section 1.3.3 and the stock quality handbook) objective functions (in "single species mode") for catch at age numbers and survey indices at age time series are minimized assuming a log-normal error distribution for both data sources. The expected catch is calculated from the catch equation and F at age, which is assumed to be separable into a year effect, an age selection, and an age-season selection. The SMS assumes constant seasonal and age-dependent F-pattern. SMS uses maximum likelihood to weight the various data sources. For years with no fishery (here 2005 and 2006 in this assessment) SMS simply set F to zero and exclude catch observations from the objective function. In such case only the survey indices are used in the model. The SXSA needs catch input for all quarters, all years, and in years with no catch infinitive small catch values have to be put into the model as an approximation. SXSA handles catch at age observation as exact, i.e. the SXSA does not rely on the assumption of constant exploitation pattern in catch at age data as for example the SMS does. As a stochastic model, SMS uses catch observations as observed with noise, but assumes a separable F. Both assumptions are violated to a certain degree.

SMS being a stochastic model can estimate the variance of parameters and derived values like average F and SSB. The SXSA is a deterministic model.

The Norway pout assessment includes normally catches from the first and second quarter of the assessment year. SMS uses survey indices from the third quarter of the assessment year under the assumption that the survey is conducted the very beginning of the third quarter. SXSA model has not that option and data from the third quarter of the assessment year can only be used by "back-shifting" the survey one quarter back in time.

The SMS model has so far assumed recruitment in 3rd quarter of the year and not in the start of the 2nd quarter of the year which the SXSA use. Actual recruitment is in the 2nd quarter of the year. Consequently, the assumed natural mortality of 0.4 for the 0-group in first and second quarter of the year is not included in the SMS compared to use of this in 2nd quarter of the year for the SXSA for the 0-group.

The diagnostics and results of the exploratory runs for comparison between SXSA and SMS assessment are shown in the WGNSSK September 2006 report (ICES WGNSSK, 2007). The models give comparable results and the same perception of the Norway pout stock dynamics, which have been documented in the 2004 benchmark assessment, the September 2005 and April 2006 update assessments (see above), as well as in the September 2006 exploratory runs. However, as SMS is a stochastic model it also provides uncertainties of the results. Accordingly, SMS was in September 2006 chosen as the new standard assessment model for Norway pout. However, it was decided that near future assessments should also include a comparative, exploratory SXSA assessment.

Comparison of output from a seasonal based assessment model (the SXSA model) and an annual based model (the XSA model):

In the 2004 benchmark assessment of the Norway pout stock a comparison of the output, performance and weighting of tuning tuning fleets of the seasonal based SXSA model and the annual based XSA model was performed. The results are in detail presented in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005)). The differences in results of output SSB, TSB and F between the two assessment runs were small. Both model runs gave in general similar weighting to the different tuning fleets used. This was based on comparison of runs of the accepted assessment (by the WG and ACFM) in 2003.

Summary of conclusions from the exploratory catch at age analyses in the 2004 benchmark assessments:

A number of exploratory runs were carried out as part of the benchmark assessment in 2004 in order to evaluate performance of stock indices as tuning fleets and also to compare performance of the seasonal XSA (SXSA) to the 'conventional' XSA. The exploratory runs are described in the 2004 working group report. The conclusions of the explorative runs in the 2004 benchmark assessment were the following:

1. Catch and CPUE data for the assessment of Norway pout are very noisy, but internally consistent. The assessment, using SMS, gave very similar results irrespective of the CPUE time series used. Four of the seven CPUE series are data from the commercial fishery and these data are already included in the catch data. Therefore, these commercial fleets will not give a signal very different from the catch data. None of the scientific surveys had a clear signal different form the signal in the catch data.

2. A comparison of the revised 2004 assessment with new tuning fleets compared to the previous 2003 assessment showed that the estimates of the SSB, recruitment and the average fishing mortality of the 1- and 2-group for the revised, accepted assessment were in general consistent with the estimates of previous years assessment. Only historical F seemed to slightly deviate from the previous years assessment.
3. The overall performance and output for the XSA model was similar to the SXSA model, so the working group in 2004 decided to continue using SXSA. Both methods did overall not show insensible to the tuning fleet indices used in the assessment.

In the up-date assessment in 2005 output of the SXSA model was compared to output from the SMS and SURBA model to evaluate the use of the SXSA model in a situation with having zero catches in the terminal year of the assessment. The results showed similar output of the different models and the same perception of the stock. The results are in detail presented in the 2005 ICES WGNSSK Report (ICES WGNSSK (2006)).

Analysis of output from SXSA and SMS and to evaluate the effect on the assessment of no catches in 2005 and 2006:

Due to closure of the Norway pout fishery and no catches in 2005 and in the first part of 2006 there has been made exploratory and comparative assessment runs using different assessment models (SXSA, SMS) to evaluate the effect on the assessment of this situation during the April 2006 assessment. This has been considered necessary to evaluate the effect of the absolute value of the artificial catch numbers on the on the SXSA output and to use a modified version of SMS that allows for no fishing in the end of the assessment period, where the SMS assessment uses identical input data as the SXSA assessment. Also the aim has been to evaluate how the SMS reacts to a situation with several years of no catches.

In the April 2006 assessments exploratory runs of SXSA was made where the artificial catch numbers in 2005 and 2006 was 4-doubled (but still low, from 400 t per quarter of year to 1600 t per quarter) compared to the very low catch levels used in the accepted assessment. The results of these comparative runs are not shown, however, the resulting output of the assessments were identical giving the same perception of the stock status and dynamics. Furthermore, in the September 2005 up-date assessment a SXSA assessment was performed with the change of using catch numbers in the first and second quarter of 2005 corresponding to 50% of the 2004 quarter 1 and 2 catch numbers (instead of 10% of the catches in the accepted assessment). The results of these comparative runs are shown in Figure 5.3.8 of the September 2005 report (ICES-WGNSSK 2006). The resulting outputs of these assessments were identical giving the same perception of the stock status and dynamics. From these SXSA runs it can be concluded that the absolute values of the artificial (small) catches does not practically affect the assessment output.

In April 2006 a SMS run was made with an assumption of no catches in 2005-2006. SMS was modified to exclude the likelihood of catch observation for 2005-2006 (and 2007) from the objective function. CPUE observations for 2005 and 2006 were, however, used in the model and objective function. By letting the model include 2007 as terminal year it is possible to forecast stock status under the assumption of no fishery in 2006-2007, and recruitments that follows the SMS recruitment function (geometric mean).

It appeared that the diagnostics of the SMS looked very similar to the one produced for the 2005 assessment As it was also shown in the 2004 benchmark assessment, the SMS

model results in a rather similar weighting of the catch at age data as well as the tuning fleets as the SXSA model does. As seen in the previous years assessments, the SMS model tends to estimate lower SSB and higher F compared to results of the SXSA model, however, the perception of the stock status and dynamics are very much similar from the results of both model runs. Recruitment estimates of the two models cannot be directly compared as the SMS gives recruitment in third quarter of the year while the SXSA gives recruitment in the second quarter of the year.

D. Short-Term Projection

Model and Software used:

A deterministic short-term forecast is given for the stock. This was done for the Norway pout stock for the first time in 2004. From April 2006 deterministic short-term prognoses were performed for the Norway pout stock. From 2006 and onwards there have been given seasonal (real time) short term forecast.

The purpose of the forecast is to calculate the catch of Norway pout in the forecast year which would result in SSB at or above $\mathbf{B}_{pa}$ = MSY $\mathbf{B}_{escapement}$ (=150 000 t) the following 1st of January. The forecast is based on an escapement management strategy but also providing output for the long term fixed E or F management strategy and a long term fixed TAC strategy for Norway pout (see ICES WGNSSK Report ICES CM 2007/ACFM:30 section 5.3, and ICES AGNOP Report ICES CM 2007/ACFM:39, and the ICES AGSANNOP Report ICES CM 2007/ACFM:40, and Vinther and Nielsen (2012, 2013), as well as section 5.10 and 5.11 of the ICES WGNSSK Reports).

Intermediate year assumptions:

The forecast was calculated as a stock projection up to the 1st of January following the forecast year using full assessment information for the assessment year (and first part of forecast year).

Initial stock size:

The projection up to 1st of January following the forecast year is based on the SXSA assessment estimate of stock numbers at age in the assessment year and the start of the forecast year.

Stock recruitment model used:

The forecast is using the geometric mean recruitment for the stock-recruitment relationship. However, usually the recruitment in the year after the assessment year is assumed to be at 25% level (25 percentile) of the long term geometric mean of the SXSA recruitment estimates. This level has been chosen to take into account that the frequency of strong year classes seems to have decreased in the recent 10-15 year period compared to previously.

Exploitation pattern:

The forecast uses relevant recent exploitation pattern according to temporal changes in this, i.e. according to changes in exploitation between seasons and between ages. The forecast has previously assumed a forecast year fishing pattern scaled to long term seasonal exploitation pattern for 1991-2004 (standardized with yearly Fbar to F(1,2)=1) which has been used in e.g. the 2007 and 2008 ICES WGNSSK Reports (ICES CM 2007/ACFM:30; ICES CM 2008/ACOM:09) and in the ICES AGNOP Report as well (ICES CM 2007/ACFM:39). The 2012 forecast (May 2012) assumes a forecast year fishing pattern scaled to the average standardized exploitation pattern (F) for 2008, 2009

and 2010 (all years included and standardized with yearly Fbar to F(1,2)=1). The forecast in September 2012 and April 2013 assumes a forecast year fishing pattern scaled to the long term (1983-2011) average standardized exploitation pattern (F) (F from all years included except for the closure periods and standardized with yearly Fbar to F(1,2)=1) and observed fishing mortality from SXSA for the assessment year (and first part of forecast year). The background for selecting the long term average exploitation pattern is that the exploitation pattern between seasons (and ages) has been variable over years also between recent years with strong year classes, and the long term exploitation pattern indicate that main catches are taken in quarter 4 which is also the case for the most recent period. The same long term exploitation pattern has been used in the management strategy evaluations of Norway pout long term management plans performed with the SMS model in autumn 2012 and spring 2013. See further details of the settings in the ICES WGNSSK Report.

Natural mortality:

A 2012 Inter-benchmark assessment revised the values for the natural mortality, maturity-at-age and weight-at-age used in the assessment and the forecast (see above and ICES, 2012c). Accordingly, the mortality at age in the stock age used in the SXSA assessment has also been used in the forecast for the forecast year.

Maturity:

A 2012 Inter-benchmark assessment revised the values for the natural mortality, maturity-at-age and weight-at-age used in the assessment and the forecast (see above and ICES, 2012c). Accordingly, the revised maturity at age used in the SXSA assessment has also been used in the forecast for the forecast year. Twenty percent of age 1 is mature and is included in SSB. Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year.

Weight at age in the catch:

Observed mean weights at age from the sampling and assessment are used for the assessment year. Mean weight at age in the catch in the forecast year (as well as in the assessment year where direct observations are not available from the SXSA and sampling) there has been estimated quarterly and age based average means of mean weight at age in catch from recent running 5 year averages (for the 5 latest years with covering observations).

Weight at age in the stock:

A 2012 Inter-benchmark assessment revised the values for the natural mortality, maturity-at-age and weight-at-age used in the assessment and the forecast (see above and ICES, 2012c). Accordingly, the revised constant weight at age in the stock by year and quarter of year used in the SXSA assessment has also been used in the forecast for the forecast year.

Management table and projections:

A management table is presented from the forecast. The objective set in relation to this is to set the fishing mortality and catch on a level that maintain spawning stock biomass above B_{MSY} = MSY $B_{escapement}$ = B_{pa} by 1st of January one - two years after the assessment year with a high probability (95% level).

Catch predictions for 0- and 1-groups are important as the fishery to some extent (traditionally) target the 0-group already in 3rd and 4th quarter of the year as well as the 1-group in the 1st quarter of the following year. In the 2004 benchmark assessment, it was

shown that survey indices in the 3rd quarter seems to predict strong 0-group year classes relatively well when comparing with 0-group indices from commercial fishery (4th quarter) and to 1-group survey indices in surveys and fishery the following spring (year).

The deterministic forecast is naturally affected by that: (a) the potential catches are largely dependent on the size of a few year classes, (b) the large dependence on the strength of the recruiting 0-group year classes, (c) precision of the used mean weight at ages, and d) the added uncertainty (in assessment and potential forecast) arising from variations in natural mortality. However, the forecast is not dependent on any assumption about the strength of the new year class.

E. Biological Reference Points

E.1 Reference Points

From 2010 and onwards:

	Type	Value	Technical basis
MSY	MSY Bescapement	150 000 t	= Bpa
Approach	FMSY	Undefined	None advised
	Blim	90 000 t	Blim = Bloss, the lowest observed biomass in the 1980s
Precautionary	Bpa	150 000 t	= Blim e0.3*1.65
Approach	Flim	Undefined	None advised
	Fpa	Undefined	None advised

(unchanged since: 2010)

Biomass based reference points have been unchanged since 1997 given MSY $B_{escapement}$ = B_{pa}. No F-based reference points are advised for this stock.

Norway pout is a short lived species and most likey an one time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt *et al.* 2002a,b; Lambert *et al.*, 2009). Furthermore, 20 % of age 1 is considered mature and is included in SSB (Lambert *et al.*, 2009). Therefore, the recruitment in the year after the assessment year does influence the SSB in the following year. Also, Norway pout is to limited extent exploited already from age 0. All in all, the stock is very dependent of yearly dynamics and should be managed as a short lived species.

On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$. B_{lim} is defined as B_{loss} and is based on the observations of stock developments in SSB (especially in 1986 and 1989) been set to 90 000 t. MSY $B_{escapement}$ = B_{pa} has been calculated from

$B_{pa} = B_{lim}\, e^{0.3*1.65}$ (SD).

A SD estimate around 0.3-0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2-0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS, 1999). The relationship between the Blim and MSY $B_{escapement}$ = B_{pa} (90 000 and 150 000 t) is 0.6.

An Inter-benchmark in spring 2012 (IBPNorwayPout, ICES 2012c) used revised estimates of natural mortality, maturity at age and mean weight at age in the assessment. The benchmark group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem.

A segmented regression with current data was fit in relation to the benchmarking process (ICES 2012c). It is obvious that the Norway pout, being a short-lived species, has no well-defined break point (inflection) in the SSB-R relationship and therefore there is not clear point at which impaired recruitment can be considered to commence (i.e. SSB does not impact R negatively, and that there is a relatively high recruitment observed at Bloss as well as more observations above than below the inflection point). The statistics from the segmented regression (ICES, 2012c) shows that the inflection point is rather badly estimated (high value of b), poor convergence, and that the maximum likelihood method cannot estimate the inflection (and the slope before inflection) well. Results therefore suggest that B_{loss} be retained as the B_{lim} reference point = 90 kt and B_{pa} as MSY $B_{escapement}$ reference point = 150kt.

Higher escapement targets could be considered in the future based on the importance of Norway Pout as a forage species in the ecosystem.

The Blim = Bloss = 90kt is based on the lowest observed SSBs in the 1980s around 88kt in 1986 and 85kt in 1989 according to the previous baseline assessment. Even though lower biomasses (SSB) were observed for the stock in the period 2004-2006 (84kt in 2004, 54kt in 2005, 76kt in 2006 according to the previous baseline assessment) then the ICES WGNSSK working group at that time advised not to change the reference points because of the status of Norway pout being an important forage fish species in the North Sea. In the scenario 2 benchmark assessment (ICES 2012a,c) the SSB in 1986 is around 109 kt and in 1989 around 112 kt. A Blim set to 110 kt on this basis instead of the 90 kt would result in a MSY Bescapement = Bpa =180kt instead of 150kt where Bpa = Blim e0.3*1.65 and Blim = Bloss = 110 kt.

Previous to 2010:

Precautionary Approach reference points:

ICES considers that:	ICES proposes that:
Blim is 90 000 t	Bpa be established at 150 000 t. Below this value the probability of below average recruitment increases.
Note:	

Technical basis:

Blim = Bloss = 90 000 t.	Bpa = Blim e0.3-0.4*1.65 (SD).
Flim None advised.	Fpa None advised.

Biomass based reference points have been unchanged since 1997.

B_{lim} is defined as B_{loss} and is based on the observations of stock developments in SSB (especially in 1989 and 2005) been set to 90 000 t. B_{pa} has been calculated from

$B_{pa} = B_{lim}\, e^{0.3\text{-}0.4*1.65}$ (SD).

A SD estimate around 0.3-0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2-0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS 1999). The relationship between the B_{lim} and B_{pa} (90 000 and 150 000 t) is 0.6.

B_{lim} is 90 000 t, the lowest observed biomass

F_{lim} None advised.

F_{pa} None advised.

E.2 Management

There is no specific management objective set for this stock. With present fishing mortality levels the status of the stock is more determined by natural processes and less by the fishery. The European Community has decided to apply the MSY approach (earlier the precautionary approach) in taking measures to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing on marine ecosystems.

Long term management strategies have been evaluated for this stock by ICES (see below), and an overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found below in the Stock Annex.

There is consistent bi-annual information available to perform real time monitoring and management of the stock. This can be carried out both with fishery independent and fishery dependent information as well as a combination of those. Real time advice (forecast) and management has been carried out every half year since 2006. In recent years the escapement strategy has been practiced in reality in management even though there is no decision on management strategy on the stock or recommendation of a specific strategy from the industry side. (There is performed a May assessment and forecast followed up by an in year September assessment and forecast).

Norway pout is a short lived species and most likey an one time spawner. The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Recruitment is highly variable and influences SSB and TSB rapidly due to the short life span of the species. (Basis: Nielsen *et al.*, 2012; Sparholt *et al.* 2002a,b; Lambert *et al.*, 2009). On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$. (See also the Inter-benchmark assessment from 2012, ICES, 2012c).

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflects the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES WGSAM 2011; ICES-SGMSNS 2006).

The fishery is targeting Norway pout and blue whiting. By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al.*, 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2)), and recent by-catch

numbers in the Danish and Norwegian small meshed fisheries are given in section 2 of the WGNSSK report. Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. In managing this fishery, by-catches of cod, haddock, whiting, saithe, herring, and blue whiting should be taken into account, and existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present very low level of by-catch of other species in the Norway pout fishery appears from the WGNSSK Report sections 2 and 5. Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012). Sorting grids are at present used in the Norwegian and Danish fishery, but modification of the selective devices and their implementation in management is ongoing. The sorting grids are partlhy implemented for the Danish and Norwegaian fishery (especially for the larger vessels). ICES suggests that these devices (or modified forms of those) are used in the fishery. The introduction of these technical measures should be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in this **Stock Annex** (below). Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained.

From the results of the forecast presented in the May 2013 assessment it can be seen that if the objective is to maintain the spawning stock biomass above a reference level of MSY $B_{trigger} = B_{pa}$ by 1st of January 2014 then a catch of 457 kt can be taken in 2013 in the directed Norway pout fishery corresponding to a F=0.77 in 2013 according to the variable TAC escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 134 000 t can be taken in 2013. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2013 (corresponding to a F around 0.12) according to the long term management strategies evaluated in 2007. In recent years the escapement strategy has been practiced in reality in management.

E.3 Long term management strategies and management plans evaluations 2006–2007 and 2012–2013

ICES has evaluated and commented on three management strategies in 2007, following requests from managers – fixed fishing mortality (F=0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The 2007 evaluation showed that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES did not recommend any particular one of the strategies.

ICES has again in September-October 2012 and April-May 2013 (Vinther and Nielsen, 2012, 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information. In September 2012 ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September); 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F

(only with one yearly September assessment); 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy. As a follow up on this ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1st November – 31st October rather than from 1st January to 31st December, and one annual advice from September assessment. The 2012-13 evaluation showed that management strategies 2-4 are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES do not recommend any particular one of the strategies 2-4.

E.3.1 Summary of the management plan evaluations performed in 2006–2007

In autumn 2006 and during 2007 the management plans and harvest control rules for Norway pout were evaluated by ICES based on an EU request with respect to by-catches in the fishery and evaluation of recent initiatives to introduce more selective fishing methods in the Norway pout fishery. See addendum below to this Stock Quality Handbook (Stock Annex).

On this basis, ICES has evaluated and commented on three management strategies, following requests from managers – fixed fishing mortality (F=0.35), Fixed TAC (50 000 t), and a variable TAC escapement strategy. The evaluation shows that all three management strategies are capable of generating stock trends that stay at or above B_{pa} = B_{pa} = MSY $B_{escapement}$ = B_{MSY}, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be precautionary.

ICES does not recommend any particular one of the strategies. The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. The variable TAC escapement strategy as evaluated in 2007 has higher long term yield compared to the fixed fishing mortality strategy (and the fixed TAC strategy), but at the cost of a substantially higher probability of having closures in the fishery. If the continuity of the fishery is an important property, the fixed F (equivalent to fixed effort) strategy will perform better.

There should be no shift in management strategies between years. In recent years the escapement strategy has been practiced.

A detailed description of the long term management strategies and management plan evaluations can be found in the Stock Annex and in the ICES AGNOP 2007 (ICES CM 2007/ACFM:39), ICES WGNSSK 2007 (ICES CM 2007/ACFM:30) and the ICES AGSANNOP (ICES CM 2007/ACFM:40) reports as well as in Vinther and Nielsen (2012, 2013).

E.3.1.1 Background

On basis of an joint EU and Norwegian Requests in autumn 2006 with respect to Norway pout management strategies and by-catches in the Norway pout fishery as well as on basis of the work by ICES WGNSSK in autumn 2006 and spring 2007 during the ICES AGNOP 2007 (ICES CM 2007/ACFM:39) ACFM has already by May 2007 evaluated detailed output from management plans and harvest control rules evaluations considering two different management strategies for Norway pout, i.e. the real time escapement management strategy and the long term fixed F or E management strategy. This has been based on use of advanced stochastic simulation models and results from here supplied by DTU-Aqua. The fixed TAC long term management strategy was not evaluated in depth by the ICES AGNOP as it was not considered realistic at that time because of substantial loss in yield, but have later in autumn 2007 associated to the ICES WGNSSK in autumn 2007 (ICES CM 2007/ACFM:30) been evaluated and presented with the two other management strategies. Furthermore, in addition to the ICES response on the EC and Norway joint request on management measures for Norway pout, Denmark has, in autumn 2007, requested ICES to provide a full evaluation of the fixed TAC strategy for Norway pout including an estimation of the long term TAC which would be sustainable with a low probability (5%) of the stock falling below B_{lim}. An ICES ACFM subgroup considered the documentation during the autumn 2007 ACFM meeting and found that some further studies would be required in order to

provide a well documented answer. All this was provided through the ICES AGSANNOP Report (ICES CM 2007/ACFM:40).

E.3.1.2 Long Term Harvest Control Rules

ICES and DTU-Aqua have now provided comprehensive evaluation for 3 types of long term management strategies for the stock which all have been accepted by ICES:

- Escapement strategy
- Long term fixed fishing mortality or fishing effort strategy, and
- Long term fixed TAC strategy,

The conclusions from the evaluation methods used for the three strategies are the following:

Escapement strategy

ICES evaluated an escapement strategy defined as follows: 1) an initial TAC that would be set for the first half of the TAC year, based on a recruitment index, and 2) a TAC for the second half of the year which would be based on a survey assessment conducted in the first half of the TAC year and the setting TAC for the second half of the year based on an SSB escapement rule. This escapement strategy shall generally assure an SSB above B_{pa}, i.e. with a target of obtaining an SSB that is truly above B_{lim} with a high probability (95%). In practice this Harvest Control Rule (HCR) is an escapement strategy with an additional maximum effort. The conclusion is that the equilibrium median yield is around 110 kt, and there is a 50 % risk for a closure of the fishery in the first half-year and a 20–25% risk of a closure in the second half-year. The distribution of F shows that the fishery will mostly alternate between a low and a high effort situation. When the fishery has been closed in the second half-year, there is around 20 % probability for another closure in the following year.

The robustness of the HCR to uncertainties in stock size indicates that annual assessment might not be necessary for this stock; an annual survey index could be sufficient.

Caveats to the evaluation of the escapement strategy:

- The sensitivity of the parameters in the HCR used for TAC in the first half-year has not been fully evaluated;
- Non-random distribution of residuals in the surveys may give biased perceptions and need to be included in the evaluation.

Effort control strategy

The effort control scenario with a fixed F indicates that an F of around 0.35 is expected to give a low (5 %) probability of the stock going below B_{lim}. The scenario appears robust to implementation uncertainties, and a target F below 0.35 and an implementation noise CV around 25 % is expected to give a long-term yield around 90 kt and no closures of the fishery would be needed. This management strategy is not dependent on an yearly assessment because it assumes a direct link between fishing effort and fishing mortality which is also apparent from the historical assessment of this stock.

Caveats to the evaluation of the effort control strategy:

- A regime shift towards a lower recruitment level will not be detected by this approach and there is a risk of over-fishing in such a situation with a fixed effort approach;

- Implementation of a fixed standardized effort (which is not measurable) can be difficult;
- Effort management in by-catch fisheries (e.g. by-catch of Norway pout in blue whiting fishery) is difficult to regulate;
- Effort – F relationships are known to suffer from technological creep and this aspect needs to be tested in the evaluation.

Fixed TAC strategy

The scenario with fixed TAC indicates that a long term TAC on around 50 kt will be sustainable with a low (5 %) probability of the stock going below B_{lim}. ICES concludes that a fixed TAC rule for Norway pout would be in accordance with the precautionary approach provided the fixed TAC is not greater than 50 kt and F does not exceed the value of 0.5, and provided measures are in place to reduce TAC in the exceptional case of a low recruitment in a number of consecutive years. The evaluations indicate that if a target TAC below 50 kt is implemented no closures of the fishery would be needed.

Caveats to the evaluation of the fixed TAC strategy:

- A regime shift towards a lower recruitment level will not be detected by this approach and there is a risk of overfishing in such a situation with a fixed TAC approach;
- For a short-lived species with highly variable recruitment such as Norway pout, a catch-stabilizing strategy (fixed TAC) is likely to imply a substantial loss in long-term yield compared to other strategies if the risk of SSB falling below B_{lim} is to remain reasonably low. This strategy is also sensible in relation to potential risks of regime shifts in the stock-recruitment-relationship.

E.3.1.3 Conclusions from the 2007 management strategy evaluations

Not any particular of the management strategies presented above is recommended. All strategies that have a low risk of depleting the stock below B_{lim} are considered to be in accordance with the precautionary approach and being sustainable. The choice between different strategies depends on the requirements that fisheries managers and stakeholders have regarding stability in catches or the overall level of the catches. It should be noted that this is a long term management strategy evaluation and it is accordingly not possible to switch between strategies from year to year. Often switching between different long term strategies will be in conflict with the basic assumptions behind the evaluations of them.

The evaluation shows that all three types of management strategies (escapement, fixed effort, fixed TAC) are capable of generating stock trends that stay away from B_{lim} with a high probability.

The escapement strategy has a higher long-term yield (110 kt) compared to the fixed effort strategy (90 kt) and the fixed TAC strategy (50 kt) but at the cost of having closures in the fishery with a substantially higher probability. If the continuity of the fishery is an important property, then the fixed effort strategy performs better.

The simulations deal with observation error and implementation error of the management strategies but do not take into account process error in relation to natural mortality, maturity-at-age, or mean weight-at-age in the stock, which could have a significant impact.

The fixed effort strategy does not rely critically on the results of stock assessment models in any particular year. On the other hand, that strategy is very dependent on the possibility of actually implementing an effort scheme, including an account of the by-catch fisheries (e.g. for blue whiting) and ways to deal with effort creep.

The fixed effort strategy and the fixed TAC strategy are likely to imply a substantial loss in long-term yield compared to the escapement strategy if the risk of SSB falling below B_{lim} is to remain reasonably low. These strategies are also sensible in relation to potential risks of regime shifts in the stock-recruitment-relationship.

E.3.2 Summary of the management plan evaluations performed in 2012–2013

ICES has again in September-October 2012 and April-May 2013 (Vinther and Nielsen, 2012, 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information.

E.3.2.1 Background

ICES has again in September-October 2012 and April-May 2013 (Vinther and Nielsen, 2012, 2013) evaluated and commented on long term management strategies for the stock using up-dated stock information.

On basis of an additional request from the EU Commission and Norway 8th February 2012 received by ICES in final form in May 2012 (EU 2012) there is proposed and asked for additional evaluations of modified and alternative harvest control rules for Norway pout in the North Sea and Skagerrak.

Request 2012:

The European Union and Norway jointly request ICES in the autumn 2012 to advice on the management of Norway Pout in ICES Subarea IV (North Sea) and ICES Division Ilia (Skagerrak-Kattegat) and to evaluate the following options:

1. *Whether a management strategy is precautionary if TAC is constrained to be within the range of 20,000 - 250,000 tonnes, or another range suggested by ICES, based on the existing escapement strategy;*
2. *A management strategy with a fixed initial TAC in the range of 20,000 - 50,000 tonnes. The final TAC is to be set by adding to the preliminary TAC around (50%) of the amount that can be caught in excess of 50,000 tonnes, based on a target F of 0.35;*
3. *A management strategy with a fixed initial TAC in the range of 20,000- 50,000 tonnes. The final TAC is to be set by adding to the preliminary TAC around (50 %) of what can be caught in excess of 50,000, based on the escapement strategy.*

Interpretation of the request from 2012

The request from the EU Commission and Norway is not clear, but ICES has interpreted the request in the following way:

1. Management Strategy 1: Here it is asked to evaluate a Management Strategy (MS) on the basis on the existing ICES escapement strategy for Norway pout; however with absolute TAC constraints that include a minimum TAC higher than zero and a ceiling of the TAC. The present management system is based on two yearly assessments (advices) from ICES; one in September with survey indices from the IBTS Quarter 3 survey including 0-group index, and one in May with updates from the IBTS Quarter 1 survey. The timing of the actual use of the advice into TAC regulations has varied in the most recent years. In

some years the September advice has been used in regulation of the (in year) 4th quarter fishery while the process in other years has been delayed such that the September assessment will just be used for the TAC in the 1st half year. The May advice has been used in regulation of the (in year) 3rd quarter (and in some years the 4th quarter) fishery.

ICES has chosen just to evaluate the option where the September assessment is used for advice for the next calendar year. This option is the less robust of the two alternatives as TAC for the fourth quarter is set from the May assessment without knowing the recruitment index from the third quarter.

2. Management Strategy 2: This MS has a fixed initial TAC for the first 6 months of the year followed by an update of the TAC for the full year by the end of June. This TAC advice will be based on the ICES assessment of Norway pout made in May. The TAC for the whole year is based on a fixed F strategy.

By having a fixed TAC for the first six months irrespective of the state of the stock, there is no reason to update (simulate) the assessment in September.

3. Management Strategy 3: As MS2, but here the within year update is based on the escapement strategy.

The difference between MS1 and MS3 is mainly the use of the initial fixed TAC in MS3, which is assumed to be taken (or possible lost) within the first six months of the year for MS3. However, it is assumed that the (minimum) TAC from MS1 is valid for the whole calendar year, irrespective of the May assessment results.

Request 2013:

On basis of a request from the EU Commission 8th February 2013 there is proposed and asked for additional evaluations of modified and alternative harvest control rules for the Norway pout stock in the North Sea and Skagerrak.

EU request to ICES on changing the TAC year for Norway pout.

In 2012, the EU and Norway submitted a request to ICES to evaluate various measures for the management of Norway pout. ICES responded to this request in October 2012.

The first option that ICES evaluated was a management strategy based on the existing ICES escapement strategy for Norway pout (catch should not exceed an amount that allows stock biomass to be above 150 000 tonnes at the beginning of the following year), modified to include absolute constraints on the annual TAC (a minimum TAC higher than zero and a ceiling on the TAC).

For this management strategy, ICES evaluated only the option whereby the September assessment is used for the TAC for the next calendar year (with an in-year update in May, but not in September). It was noted that this option, where the TAC for quarter 4 is set from the May assessment without knowing the recruitment indices from the third quarter, is less robust than the alternative, which has an additional in-year update in September.

In this light, ICES is asked to evaluate again a management strategy for the Norway pout stock based on the existing ICES escapement strategy, but where the TAC year is changed to 1st November – 31st October rather than from 1st January – 31st December. In this case, the TAC for quarter 4 and for quarters 1 to 3 of the following year would be fixed on the basis of the September assessment, with no update in May.

Interpretation of the request from 2013

The request from the EU Commission is not clear. After consultation with the Commission (e-mail Gilles Doignon, 19 March 2013) ICES has interpreted the request in the following way:

It is requested to evaluate a Management Strategy (MS) on the basis on the existing ICES escapement strategy for the Norway pout stock; however with absolute TAC constraints that include a minimum TAC higher than zero and a ceiling of the TAC as included in the 2012 request. The TAC year is requested to be 1st November – 31st October rather than 1st January – 31st December. The advice is annually and will be based on the ICES assessment and advice in September-October.

The request specifies that the TAC should be set in accordance with the ICES escapement strategy, which targets a SSB at spawning time above the MSY $B_{escapement}$ after the fishery has taken place. For Norway pout it is assumed that spawning takes place in the beginning of quarter 1 which has been documented by Lambert *et al*. (2009) and Nielsen *et al.* (2012). The proposed TAC year (Year, …), 1 November – 31 October, includes thereby one spawning period, but SSB in the following year is highly dependent on the fishery in January-October in the TAC year. By having a TAC year that does not align to the annual life-cycle for the species the default ICES escapement strategy cannot be used. We have, however, considered several alternative methods to set the TAC with the aim of having SSB above Blim at spawning time (start of Q1, i.e. 1st January) with a high (95%) probability (see the next section).

E.3.2.2 Long Term Harvest Control Rules Evaluated and Methods for Evaluation

In September 2012 ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012):

1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September);

2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment);

3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy.

The difference between the MSE 1 and 2-3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2-3), while the minimum TAC in MSE 1 can be applied all year.

As a follow up on this ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013):

4) A long term minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1st November – 31st October rather than from 1st January to 31st December, and one annual advice from September assessment.

Method used for the MSE in 2012 and 2013

The proposed harvest control rules of a management plan for Norway pout in the North Sea and Skagerrak were evaluated using a simulation framework (SMS) in accordance with the ICES guidelines (ICES, 2008; ICES 2013) for management strategy evaluation. The SMS has previously been used for Management Strategy Evaluation (MSE) of the short lived species sandeel and Norway pout (ICES, 2007a,b; ICES, 2012c) and multispecies assessments (ICES, 2008). The SMS allows the use of quarterly time steps, which is not the case for the standard software packages used in ICES MSE.

The SMS does not include a full assessment cycle with an explicit stock assessment and a short term forecast using a Harvest Control Rule (HCR) to calculate the TAC. Instead, it is assumed that the true stock size can be "observed" with some bias and noise and it is this "perceived" stock that makes the basis for the use of a HCR and estimation of a TAC. The true stock size is assumed known in the first projection year and is later updated annually by recruitment and catches derived from application of the HCR on the "perceived" stock.

The SMS method has been extended with options to mimic the requested HRC. Appendix, Chapter 6, Section 1 (Reference ??) gives an overview of the extensions.

Risk to B_{lim} (the probability of real SSB being below B_{lim}) is calculated in both the short and long term. For the individual years 2014–2017 the risk to B_{lim} is calculated as the number of times, across 10000 iterations, that SSB in year y is below B_{lim} (1st of January) divided by number of iterations (10000). This is referred to as prob1 (risk type 1) in the ICES guidelines to MSE (ICES, 2013). Long term risk is defined as the maximum probability that SSB is below Blim, where the maximum (of the annual probabilities) is taken over the years 2017–2028 (Prob3, risk type 3 in the ICES MSE guidelines)

E.3.2.3 Conclusions from management strategy evaluations

In September 2012 ICES evaluated 3 additional management strategies within the escapement strategy (Vinther and Nielsen, 2012): 1) A long term minimum TAC > 0 together with a maximum TAC (only with one yearly assessment in September) with the result that a minimum TAC up to 27 kt (revised to 20 kt in the 2013 evaluation) and a maximum TAC of 100-250 kt will be long term sustainable; 2) A long term fixed initial TAC the first 6 months of the year followed by an date where the TAC for the whole year is set based on a fixed F (only with one yearly September assessment) with the result that an initial TAC between 25-50 kt and a fixed F=0.35 (corresponding to median catch of 60 kt) is long term sustainable; 3) Similar to 2, but here with a within year update assessment and advice based on the escapement strategy, and the result here is that an initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference between the MSE 1 and 2-3 is that the initial fixed TAC is assumed to be taken (or possibly lost) within the first six months of the year (MSE 2-3), while the minimum TAC in MSE 1 can be applied all year. As a follow up on this ICES evaluated in April 2013 one additional management strategy within the escapement strategy (Vinther and Nielsen, 2013): 4) A long termi minimum TAC > 0 and a maximum TAC, but where the TAC year is from 1st November – 31st October rather than from 1st January to 31st December, and one annual advice from September assessment, with the result that a minimum TAC up to 20 kt with maximum TAC of 100 kt (Fmax/cap=0.8) or with maximum TAC of 200 kt (Fmax/cap=0.6) will be will be long term sustainable with some level of F control according to those Fcap levels.

The 2012-13 evaluation showed that management strategies 2-4 are capable of generating stock trends that stay at or above B_{pa} = MSY $B_{escapement}$, i.e. away from B_{lim} with a high probability in the long term and are, therefore, considered to be in accordance with the MSY and precautionary approach. ICES do not recommend any particular one of the strategies 2-4.

Main results from the 2012 MSE (Vinther and Nielsen, 2012):

The proposed Management Strategies (Options 1, 2 and 3) from the 2012 evaluations are in accordance with the sustainability criteria under the precautionary approach given a minimum TAC of maximum 27 kt (revised to 20 kt in the 2013 evaluation) and an assumption about future fishing mortality or fishing effort within the range of the values observed for the last decade.

Application of an initial TAC up to 50 kt, is possible for option 2 and 3. This higher initial TAC (compared to the minimum TAC under option 1) is mainly due to the scenario assumption that the initial TAC for option 2 and 3 has to be taken within the first half-year while the minimum TAC can be taken within the full year for option 1. With the assumption of an upper limit on realised fishing mortality (Cap F) by half-year, the realised catch can be higher with option 1 which increases the risk of overfishing in years with a low stock size.

The risk for SSB below B_{lim} for option 1 and 3 is not sensitive to the choice of maximum TAC. However, both a high minimum TAC and a high maximum TAC make the risk to B_{lim} more sensitive to the scenario assumption of a Cap F. A high minimum TAC in combination with a high maximum TAC might require effort management to ensure that fishing mortality remains within the range of the values observed for the last decade.

The management strategy evaluations and simulations confirm the general observation that a fixed F strategy will provide a lower long term yield than an escapement strategy for such a short lived species like Norway pout. The "cost" of the escapement strategy is a much more variable fishing mortality from one year to the next. Stability in landings is also lower for the escapement strategy.

MS1: The long term performance of MS1 is robust to the choice of minimum TAC given a maximum TAC at 200 kt and a Cap F at 0.6. The probability of a SSB below B_{lim} is in the range 0–10% for fixed TACs in the range 0–50 kt, and a higher than 5% long term probability for SSB below B_{lim} is estimated for a minimum TAC of around 27 kt (revised to 20 kt in the 2013 evaluation). Realized long-term F, SSB and yield is not sensitive to the choice of minimum TAC option giving values of long term SSB around 175 kt, F around 0.45 and yield around 90 kt. Given a minimum TAC at 27 kt (revised to 20 kt in the 2013 evaluation), the actual choice of maximum TAC affect the Prob($SSB<B_{lim}$) very little and is less than 5% for the range 100 -250 kt of maximum TAC. The highest long term median yield is obtained with a maximum TAC at around 100 kt, however the highest long-term mean yield is obtained with a maximum TAC at around 250 kt. A high (250 kt) or unlimited maximum TAC is sensitive to the assumption of a Cap F at 0.6, while e.g. a maximum TAC at 100 kt is robust to that assumption.

MS2: The long term performance of MS2 has a probability of $SSB<B_{lim}$ of more than 5%, irrespective of the minimum TAC, if 100% of the TAC for the second half year, based on fixed F at 0.35, is applied. If around 70% of the predicted catch calculated for second half year is applied as the TAC, there is a prob($SSB<B_{lim}$) of less than 5%. Given the 70% of calculated catch used for TAC in the second half year, the MS2 is not sensitive to the choice of the initial TAC in the first half-year in the range of 25 kt 50 kt. The long term values of SSB, yield and F, using the 25 kt initial TAC and 70% of the predicted catch (annual F=0.35) applied for the second half year is a median yield at 60 kt, a median F at 0.26, with low variation from one year to the next. This option is not sensitive to the actual choice of Cap F for a initial TAC at 25 kt, but very sensitive for a initial TAC at 50 kt.

MS3: The long term performance of MS3 with fixed initial TAC for the first half-year only, and TAC for the second half year based on the escapement strategy, is not sensitive to the choice of initial TAC (up to 50 kt) but sensitive to the assumptions about Cap F. Application of the higher initial TAC is more sensitive to the assumption of a Cap F. Long term yield have a median value at 90 kt and a median F at 0.46, with large variations between years.

The MSE simulations presented are based on a long row of assumptions of constant values for key parameters such as the fishing pattern, mean weights, maturity and natural mortality at age. Likewise, it is assumed that the estimated stock recruitment relationship is valid for future recruitments. However, this represents the normal ICES procedure to MSE and we have not made additional sensitivity analyses. Given these assumptions the presented scenario results should be regarded more as a sensitivity analysis than as absolute performance in relation to e.g. yield and the probability of SSB above B_{lim}.

The applicability of the fixed minimum TAC within the precautionary framework depends on the assumption on when the fishery will actually cease due to low catch rates (and stock size). In this evaluation of the management strategies it has been assumed that the real fishing mortality cannot exceed values of fishing mortalities (Cap F=0.6) observed for the last 10 years. The sensitivity to the value of Cap F is in general moderate for the presented options, but it is obvious that if the fleet makes a determined attempt to catch the full minimum TAC even though the catch rates are low and the state of the stock is poor, the management strategy will not be precautionary. Given the good historical relation between fishing effort and fishing mortality in the Norway pout fishery, an upper limit on effort will effectively set an upper limit on fishing mortality.

Norway pout is a semi-pelagic species which is widely and rather evenly distributed in the Northern North Sea and it does not show very dense schooling behavior. The fact that the stock does not occur in large, very dense schools lower the risk for continuation of the fishery at low stock size, i.e. it is likely impossible to maintain high catch rates at low stock size. This indicates that the fishery will stop at low stock size.

The Norway pout box (EU Regulation 850/98 Article 26) also contributes to protection of a low Norway pout stock as this box covers a significant part of the distribution area of the stock. This protection supports the validity of the assumption of a Cap F, as Norway pout cannot be fished within that area. By-catch regulation (EU Regulation 850/98 Article 26) including maximum by-catch rates of other gadoids will also limit the fishery of Norway pout at a low stock size.

Main results from the 2013 MSE (Vinther and Nielsen, 2013):

The proposed Management Strategy (4) is in accordance with the sustainability criteria under the precautionary approach given a minimum TAC of maximum 20 kt and an assumption about future fishing mortality (and fishing effort) stays within the range of the values observed [0.0; 0.6] for the last decade.

A maximum TAC can be sat at levels up to around 200 kt. Such high maximum TAC is however very sensitive to the assumption of an upper limit on realised fishing mortality (Cap F at 0.6) and will require a strict effort control, especially if the present effort level is increased significantly.

A maximum on F used in setting the TAC from the escapement strategy might be an alternative to effort control. Such maximum F should be around 0.6 for an HCR with

maximum TAC at 200 kt or up to 0.8 if a maximum TAC at 100 kt is chosen. Median yield is almost the same for the two options.

The changes in the TAC year to 1st November - 31th October could not be implemented fully in the Management Strategy Evaluation. However the present evaluation (using a TAC year 1st October-30th September) is considered sufficient to show that the suggested shift in TAC year has a very limited influence on long-term yield, stock sizes and risk to Blim.

The MSE simulations presented are based on a long row of assumptions of constant values for key parameters such as the fishing pattern, mean weights, maturity and natural mortality at age. Some of the assumptions have been documented in Lambert *et al.* (2009) and Nielsen *et al.* (2012). Likewise, it is assumed that the estimated stock recruitment relationship is valid for future recruitments. However, this represents the normal ICES procedure to MSE and we have not made additional sensitivity analyses. Given these assumptions the presented scenario results should be regarded more as a sensitivity analysis than as absolute performance in relation to e.g. the probability of SSB above B_{lim}.

Some general conclusion from the evaluation of the option 4 can, however, be made in relation to sustainability according to the precautionary approach for the different management strategies. The applicability of the fixed TAC within the precautionary framework depends on the assumption on when the fishery will actually cease due to low catch rates (and stock size). This is implemented as a Cap F option in the MSE scenarios. The sensitivity to the value of CAP F is in general low for the different presented options, but it is obvious that if the fleet makes a determined attempt to catch the full minimum TAC even though the catch rates are low and the state of the stock is poor, then the MS will not be precautionary.

Norway pout is a semi-pelagic species which is widely and rather evenly distributed in the Northern North Sea (Lambert *et al.*, 2009; Nielsen *et al.*, 2012; Spartholt *et al.*, 2002a,b; ICES, 2012a incl. Stock Annex) and it does not show very dense schooling behavior. The fact that the stock does not occur in large, very dense schools lower the risk for continuation of the fishery at low stock size, i.e. it is likely impossible to maintain high catch rates at low stock size. This indicates that the fishery will stop at low stock size.

The present fishery regulation will also contribute to maintain a low fishing mortality at low stock sizes. The Norway pout box in the North-Western part of the North Sea (closure to reduce by-catch rates of other gadoids) contains a significant proportion of the Norway pout stock which is out of reach of the fishery. In addition, the present by-catch regulation to protect other species including maximum by-catch rates of other gadoids will be difficult to obey with low stock size of Norway pout and probably bring the fishery to an end in such situations. Furthermore, selective devices have been introduced in the fishery to reduce by-catches of other species (Eigaard *et al.*, 2012)

The main fishery for Norway pout is a targeted fishery where Norway pout constitutes the main catch (ICES, 2012a, incl. Stock Annex). Even though Norway pout is caught together with blue whiting in deep waters in some years in the Norwegian fishery, the by-catches of Norway pout has not been high in the Blue whiting fishery historically (including years when the Norway pout fishery has been closed) (ICES, 2012a). By-catch of Norway pout can therefore be ignored.

The sensitivity analyses presented show in general that SSB is maintained above B_{lim} with a high (95%) probability. This is partly because the assumed assessment uncertainty is lower than the uncertainty used to set B_{pa} from B_{lim}. The ratio between B_{lim} and B_{pa} reflects that given a CV at 30% of the estimate of SSB, there will be less than 5% risk that the real SSB is below B_{lim} for an assessment estimate of SSB at Bpa. This is a rather high uncertainty margin given the very stable assessment with limited retrospective noise (ICES, 2012a). Assessment results using the SMS models shows that SSB in the first year after the terminal year can be estimated with a CV at 18-20%. This value was used in the simulations and is lower than the assumed 30% CV.

The limited time gap, 3 months, between the most recent assessment estimates and the TAC period contributes also to the robustness of the scenarios. Most TAC advices from ICES make use of one so-called "intermediate year", which is the time period between the last assessment year and the TAC year. For Norway pout the TAC advice is mainly given with a shorter delay between the terminal year of the assessment and the TAC period.

Comparison with the 2012 MSE

The results from the scenarios presented in this paper follow the results from the MSE evaluations made in the Autumn 2012 (Vinther and Nielsen, 2012). The minimum sustainable TAC in the most recent evaluation is around 20 kt whereas the minimum TAC in the 2012 evaluation was around 27 kt for comparable options. The difference is probably due to the shift in the TAC year and the fact that the SSB at the 1st January (after fishing in November-December on the TAC for Nov-October) is not used in setting the TAC. This might increase the risk to Blim, such that a decrease in the minimum TAC becomes necessary. Using the SSB after having taken the TAC in the second calendar year (January-October) as target in the escapement strategy seems however to work quite well.

F. Other Issues

Suggestions for future investigations:

An Inter-benchmark was carried out in spring 2012 (IBPNorwayPout, ICES, 2012c) evaluating revised estimates of natural mortality, maturity at age and mean weight at age in the assessment. This has lead to a revised assessment, and a summary of the results is given in the present report as well as in the Stock Annex, and the details of the inter-benchmarking are given in the IBPNorwayPout Report (ICES, 2012c). The benchmark group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem.

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. However, some detailed information on distribution of different life stages will be very welcome. For example precise indications on spawning sites and spawning periods (i.e. observations of fish with running roe or just post-spawned fish); information/data on detailed distribution changes of different size groups e.g. on the Fladen Ground (outer bank, inner bank according to age; schools of size groups or mixing; vertical distribution patterns) over the fishing seasons and changes herein will be welcome (especially 1st, 3rd and 4th quarter). Potential distribution patterns regarding when and where it is possible to obtain the cleanest Norway pout fishery, i.e. with

minimum by-catch would be important, as well as information on potential diurnal changes in distribution, density, and availability. Potential changes in the southern borders of its distribution range in the North Sea would also be relevant to obtain according to a potential temperature effect of climate driven sea warming. Detailed sampling of Norway pout individuals from the commercial fishery in quarter 1 will be welcome in order to establish more precisely the exact spawning sites (areas) and precise spawning time based on biological examination of maturity stages of these sampled individuals.

Future benchmark should evaluate usefulness of including recent commercial fishery tuning time series in the assessment from Danish and Norwegian commercial fishery. This should take into consideration influence on cpue and targeting in the Norway pout fishery based on the several fishing closures (several real time management closures) in recent years, introduction of selective devices in recent years being different for Norwegian and Danish fishery, different targeting in Danish and Norwegian Norway pout fisheries (Norway pout, blue whiting), as well as yearly changes in fleet efficiency given changes in vessel sizes targeting Norway pout over time.

New research findings on developments in by-catch reducing gear devices should be further evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Recent developments in relation to implementation of seasonal stochastic assessment models not dependent on constant exploitation patterns (F-patterns between years and ages) should be considered for the assessment of the stock. Future benchmark should promote that a quarterly based SAM assessment model is developed which can be applied for the stock assessment. Another possibility is to evaluate survey based assessment and/or more simple assessment methods, i.e. assessment of stock status based exclusively on survey indices can also be considered. In such an approach the robustness of and consistency in survey indices should be further evaluated.

F.1 Overview of some recent management measures and regulations relevant for the Norway pout fishery and stock (from STCEF, 2005):

0. Existing by-catch regulations:

In the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries by-catch regulations in the Norway pout fishery have been established (e.g. EU Regulation No 850/98 (EU, 1998)). The by-catch regulations in force at present for small meshed fishery (16-31mm in mesh size) in the North Sea is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other by-catch species. Provisions regarding limitations on catches of herring which may be retained on board when taken with nets of 16 to 31 mm mesh size are stipulated in EU Community legislation fixing, for certain fish stocks and groups of fish stocks, total allowable catches and certain conditions under which they may be fished. (EU, 1998) At current 40% herring is allowed in the Norway pout fishery.

1. Technical measures by EU:

Mesh size regulations in the North Sea and adjacent areas

Use of towed nets of any size mesh is permitted, however according to the mesh size in use there is an obligation to retain only particular species of fish. These tables are a simplified synopsis of measures in Council Regulation 850/98 and Commission Regulation 2056/2001.

Conditions for use of towed gear (North Sea and West Scotland)		
Mesh size	Main target species in North Sea	Synopsis of required catch percentages
b.) 16 to 31mm	Norway pout, sprat	Minimum 60% of one species of Norway pout, sardine, sandeel, anchovy, eels, smelt and some non-human consumption species (with no more than 5% of cod, haddock or saithe, and some upper limits on the percentages of other species such as mackerel, squids, flatfish, gurnards, Nephrops), or at least 90% of any two or more of those species.

Areas closed to some fishing activities

During the 1960s a significant small meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large by-catches, especially of haddock and whiting. In order to reduce by-catches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small meshed trawls were banned. The "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56° N and west of 1° W (see Figure 6.2).

(It is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box. Before closure, the Danish and Faeroes fisheries mainly took place in the northwestern North Sea and the Norwegian fishery in the Norwegian Trench (ICES 1977). Based on IBTS samples for the period 1991-2004 (Figure 6.2), 30.0% and 27.5% of Norway pout numbers were estimated to be inside the Norway pout box for the first and third quarter, respectively. It should be noted that the IBTS survey does not cover depths >200 m along the Norwegian Trench, and that no fishery inside the Norway pout box may contribute to overestimation of the abundance relative to area outside).

Area	Characteristics, Location and Seasonality	Purpose	Defined in Regulation (EC):
North-West of Scotland	Annual, closed to all fishing except static gear and pelagic fishing	Reduction of fishing mortality on VIa cod	Annex III 27/2004 (annual measure in place since 2004).
Norway pout box	Prohibited to retain more than 5% of the catch as Norway pout if they are caught within an area boounded by 56°N and the UK coast, 58°N 2°E, 58°N 0°30' W, 59°15' N 0°30'W, 59°15' N 1° E, 60° N 1° E, 60°N 0°, 60°30'N 0°, 60°30'N and the coast of the Shetland Islands, 60°N and the coast of the Shetland Islands, 60°N 3°W, 58°30'N 3°W 58°30'N and the coast of the mainland UK.	Protection of juvenile gadoids (cod, haddock) caught in mixtures with Norway pout)	Article 26 of Regulation 850/98

Minimum landing sizes

These sizes are defined in Annex XII to Regulation 850/1998, though some changes are in effect for 2005 by means of the TAC and quota regulation (Regulation 27/2005). Here sizes for some of the main commercial species only are stated.

Species	Minimum Landing Size in 2005, as North Sea/IIIa	Regulation
Norway pout	None	850/1998

Quotas relevant to the European Community

Quotas have been established by the Community as follows for the relevant species. These figures refer to Total Allowable Catches in Community waters and to quotas for the Community in Norwegian waters.

Year	Sandeel, IIa+IIIa+IV EC zone	Sandeel, IVa, Norway zone	Norway Pout IIa+IIIa+IV, EC zone	Norway pout, Norway zone	Angler–fish, IIa+IVa, EC zone	Angler–fish, IVa Norway Zone
2000	1020000	150000	220000	500001	17660	in 'others'
2001	1020000	150000	211200	500001	14130	in 'others'
2002	918000	150000	198000	500001	10500	in 'others'
2003	918000	131000	198000	500001	7000	in 'others'
2004	826200	131000	198000	500001	7000	in 'others'
2005	660960	10000	0	50002	10314	1800

[1] Including mixed horse mackerel.

[2] Including mixed horse mackerel, and only as by-catches.

Year	Anglerfish Vb, VI, XII, XIV (EC)	Horse mackerel, IIa (EC), IV(EC)	Horse mackerel, Vb (EC waters), VI, VII, VIIIa,b,d,e, XII, XIV	Industrial fish, IV (Norwegian waters)	Other species, IIa, IV, VIa N of 56°30, allocation to NO, FAR, no restriction for EC.	Other species, Norwegian waters of IV
2000	8000	51000	240000	8001	5400	11000
2001	6400	51000	240000	8001	5400	11000
2002	4770	58000	150000	8001	5400	11000
2003	3180	50267	130000	8001	5400	11000
2004	3180	50267	137000	8001	5400	11000
2005	4686	42727	137000	8001	5120	7000

[1] Of which maximum 400 tonnes of horse mackerel.

Effort limits

Days-at-Sea

Since 2003, the Community has limited the number of days that a fishing vessel can be out of port and fishing in the North Sea and adjacent areas. This is implemented through annexes to the TAC and Quota Regulations (2341/2002, 2287/2003, 27/2005). Days at sea may be transferred between vessels with an adjustment for differences in engine power between the vessels. Additional days have been allocated to some member states in respect of decommissioning taking place since 2001.

The baseline days-at-sea allocations (i.e. before additions to take account of decommissioning) were as follows:

Gear type	Otter trawl, 100mm (90mm in IIIa) or over	Beam trawls, 80mm or over	Static demersal nets	Demersal longlines	Otter trawls 70–99mm (70–89mm in Skagerrak)	Trawl fishery 16–31mm
Typical target species	Cod, haddock, whiting	Plaice and sole	Cod, turbot	Cod	Nephrops	Norway pout, sandeel
2003	9	15	16	19	25	23
2004	10	14	14	17	22	20
2005	10 *	13	13	16	21	19

(*) - including one additional day allowable where administrative sanctions are in place.

2. Technical measures by Norway

TACs and effort limits

Norway has no national quotas on anglerfish, sandeel, Norway pout or horse mackerel, for Norwegian vessels in the Norwegian economic zone. These fisheries are regulated by technical measures and effort regulations.

Technical Measures

The Norwegian technical regulations are generally designed to avoid catches of non-targeted species and/or fish below the minimum size. The discard ban on commercially important species is considered a cornerstone of this policy. Other important elements are the surveillance, monitoring and inspections at sea by the Coastguard, the obligation to change fishing grounds, prohibition against fishing for particular species during specific periods or in specific areas, and the development of, and the requirement to use selective fishing gear. The philosophy behind the Norwegian technical regulations is to enable the fishermen to meet their obligation to avoid illegal catches.

The technical regulations are summarised in "Regulations relating to sea-water fisheries" of 22 December 2004.This stipulates the discard ban, the percentage composition of the catch that may be legally caught according to area and type of fishing gear being used, the characteristics of fishing gear that may be used in the fishery on certain species or in different areas, the minimum catching sizes and specific measures to limit catches of fish under the minimum catching size, regulations of mesh design, mesh sizes, selectivity devices etc.

When fishing demersal species for human consumption in the North Sea with trawl or Danish seine, it is prohibited to use gear where the mesh size of any part of the gear is less than 120 mm. In the Norwegian saithe fishery in the EU zone 110 mm may be used in accordance to the EU regulation in the EU zone.

In the North Sea gill net fisheries for cod, haddock, saithe, plaice, ling, pollack and hake it is prohibited to use gill nets where the full mesh size is less than 148 mm. In the fishery for anglerfish the minimum mesh size is 360 mm and in the halibut fishery the minimum mesh size is 470 mm.

Only the most relevant regulations with regard to anglerfish, sandeel, Norway pout and horse mackerel will be highlighted below.

Norway has since 2010 implemented a regulation with demand of use of selection grids with larger bar widths (40 mm?) in trawls used for fishing Norway pout and blue whiting in order to reduce by-catches of other species, especially saithe.

Sandeel and Norway pout (Norway)

Summary of the Norwegian regulations for sandeel and Norway pout:

- The sandeel fishery is closed from 25 June to 31 March
- Norway pout may only be fished as bycatch in the mixed industrial fishery in all areas under Norwegian fisheries jurisdiction
- Two areas (the Patch bank and the Egersund bank) in the Norwegian economic zone are closed to fishing for Norway pout, sandeel, and blue whiting
- Licensing scheme for vessels fishing with small mesh trawl
- Reduction capacity scheme for vessels fishing with small mesh trawl.

ACFM recommended that effort in 2005 should not exceed 40 % of the effort in 2004. Based upon this advice, the sandeel season in the Norwegian economic zone was further shortened in 2005. The sandeel season, defined as the period when smaller mesh size than 16 mm can be used, was 8 months (March – October) in 2003 and earlier. This season was reduced to April – September in 2003 and to the period 1 April to 23 June in 2005.

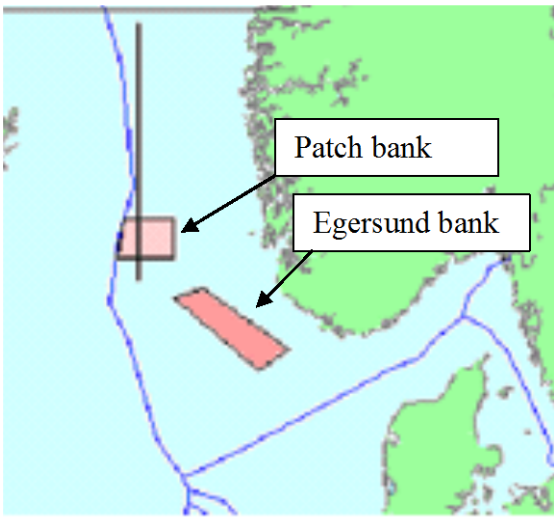
Furthermore, as a consequence of the advice on effort reduction Norway and the EU agreed to reduce the exchange of sandeel quotas dramatically compared with previous

years. Due to the same reason, Norway did not allocate a traditional quota of sandeel to the Faeroes in 2005.

As a result of the recommendation from ACFM, Norway and the EU have agreed that Norway pout only may be fished as bycatch in 2005. Consequently, Norway pout was excluded from the exchange of quotas between Norway and the Faroes in 2005.

Areas closed to fishing for Norway pout, sandeel and blue whiting:

Two areas in the Norwegian economic zone have been closed for fishing on Norway pout, sandeel and blue whiting. The approach has been to close areas were the probability of illegal by-catches of juveniles and not-targeted species, such as cod, saithe, haddock, are considered unacceptable high. This measure could therefore also be mentioned as a measure to protect juveniles of other species than Norway pout and sandeel. As of 1 January 2002 the Patch bank was permanently closed. Before the closure of the Patch bank an annual average of approximately 2.000 tonnes of Norway pout were fished in this area by Norwegian vessels. As from 1 May 2005 a seasonal closure of the Egersund bank in the period 1 December to 31 May was determined (map below). Other areas are under evaluation for permanent or seasonal closure.



Capacity reduction scheme for vessels fishing for sandeel and Norway pout

A small mesh trawl license is required to use a smaller mesh size than 16 mm in the directed fishery for sandeel in the season 15 April – 23 June. The same licence is required in order to participate in the mixed industrial fishery for blue whiting and Norway pout.

The number of vessels holding such a license has been reduced substantially the latter years as a result of the capacity reduction scheme put in place in 2002. The potential number of participating vessel was about 75 vessels in 2001. By May 2005 the number of potential participants has been reduced to about 50. In 2004 38 vessels participated in the sandeel fishery. The number of participating vessels so far in 2005 was 22 as of 24 May 2005.

3. Additional Technical measures by Denmark

Additional Danish regulations of the industrial fisheries can be found in section 5, sandeel, STCEF Report 2005).

There is a recommendation from ICES and ongoing Danish initiatives and sea trials aiming at implementing selective grids in the trawls used for Danish Norway pout fishery in the North Sea and in Skagerrak-Kattegat (IIIa). It is expected that a regulation introducing such selective devices will be implemented soon. The difficulty here is to develop a robust selective grid with smaller grid bar widths which have to be used in the Danish trawls in order to reduce by-catch of especially other smaller gadoids (in the areas where the Danish fishery operate) compared to the Norwegian trawls where the main aim is to reduce the by-catch of especially larger saithe in the areas where the Norwegian fishery operate.

G. References

Albert, O. T. 1994. Biology and ecology of Norway pout [Trisopterus esmarki, Nilsson, 1885] in the Norweigian Deep, ICES Journal of Marine Science, 51: 45-61

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O. R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fisheries Research, 68: 99–112.

Eigaard, O. and Nielsen, J.R. 2009. Reduction of by-catch in a small meshed trawl fishery through gear developments facilitating ecosystem based fisheries management. ICES C.M.2009/M:22, 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

ICES 1977. Review of the Norway pout and sandeel within the NEAFC convention area. Appendix to ICES report C.M. 1977/F:7.

ICES 1996. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES C.M. 1996/Assess:6.

ICES 1998. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 1997. ICES CM 1998/Assess :7

ICES 1999. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 1998. ICES CM 1999/ACFM :8

ICES 2006. ICES SGMSNS Report

ICES 2011 WGNSSK Report

ICES 2011. ICES WGSAM Report

ICES. 2012a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 27 April–10 May 2012. ICES CM 2012/ACOM:??.

ICES 2012b (EU Request on new management plan evaluations on Norway pout)

ICES 2012c. ICES IBPNorwayPout Inter-benchmark assessment report.

ICES. 2013. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 24 - 30 April 2013. ICES CM 2013/ACOM:13.

Lambert, G*., Nielsen, J.R..*[1], Larsen, L., and H. Sparholt. 2009. Maturity and Growth population dynamics of Norway pout (*Trisopterus esmarkii*) in the North Sea, Skagerrak and Kattegat.

ICES J. Mar. Sci. 66 (9): 1899-1914; doi:10.1093/icesjms/fsp153. (*Authorship equal; [1]Corresponding author)

Larsen, L.I., Lassen, H., Nielsen, J.R., and Sparholt, H. 2001. Working Document to the 2000 meeting of the WGNSSK. ICES C.M.2001/ACFM:07).

Nielsen, J.R., and Madsen, N. 2006. Gear technological approaches to reduce un-wanted by-catch in commercial Norway pout fishery in the North Sea. Working Document No. 23 to the 2006 meeting of the WGNSSK, 11 pp. ICES C.M.2006/ACFM:35

Nielsen, J.R.*[1], Lambert, G.*, Bastardie, F., Sparholt, H., and M. Vinther. 2012. Do Norway pout (Trisopterus esmarkii) die from spawning stress? Mortality of Norway pout in relation to growth, maturity and density in the North Sea, Skagerrak and Kattegat. ICES J. Mar. Sci. 69(2): 197-207. *Authorship equal; [1]Corresponding author. Doi:10.1093/icesjms/fss001

Poulsen, E.M. 1968. Norway pout: Stock movement in the Skagerrak and in the north-eastern North Sea. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer, 158: 80-85.

Raitt, D.F.S. 1968. The population dynamics of Norway Pout in the North Sea. Marine Research 5 : 1-23.

Skagen, D. 1993. Revision and extension of the Seasonal Extended Survivors Analysis (SXSA). Working document for Norway pout and Sandeel Working Group. Unpublished

Sparholt, H., Larsen, L.I., Nielsen, J.R. 2002a. Verification of multispiesces interactions in the North Sea by trawl survey data on Norway Pout (*Trisopterus esmarkii*). ICES Journal of Marine Science 59:1270-1275.

Sparholt, H., Larsen, L.I., Nielsen, J.R. 2002b. Non-predation natural mortality of Norway pout (*Trisopterus esmarkii*) in the North Sea. ICES Journal of Marine Science 59:1276-1284.

STCEF, 2005. Report of the *ad hoc* scientific working group on management measures for sandeel, Norway pout, anglerfish and horse mackerel in the North Sea and Skagerrak. Charlottenlund, Denmark, 23 to 27 May 2005. STCEF Working Group Report, EU Commission.

Vinther, M. and Nielsen, J.R. 2012. Evaluations of management strategies for Norway pout in the North Sea and Skagerrak Report (NOP-MSE). ICES NOP-MSE Report 2012. ICES CM 2012/ACOM:69.

Vinther, M. and Nielsen, J.R. 2013. Evaluations of management strategies for Norway pout in the North Sea and Skagerrak. Working document to ICES WGNSSK, May 2013. ICES CM2013/ACOM: xx.

Appendix 1. By-catch in Norway pout fisheries and possible reduction of by-catch (Not up-dated since May 2009).

This section needs to be up-dated with information on implementation on new sorting grids in the Norwegian and Danish Norway pout fishery in 2010-2013 as well as with the most recent results published in Eigaard, Hermann and Nielsen (2012).

The fishery is targeting Norway pout and blue whiting. Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. In managing this fishery, by-catches of cod, haddock, whiting, saithe, herring, and blue whiting should be taken into account, and existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009). ICES suggests that these devices (or modified forms of those) should be brought into use in the fishery. In 2010 grids have been used in the Norwegian fishery.

The introduction of these technical measures should be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in this **Stock Annex.**

By-catches in Norway pout fisheries (2006 Evaluations)

Demersal fisheries in the North Sea are mixed fisheries, with many stocks exploited together in various combinations in different fisheries. Small-mesh industrial fisheries for Norway pout takes place in the northern and north-eastern North Sea and has by-catches of haddock, whiting, herring and blue whiting. Some cod is also taken as a by-catch, predominantly at ages 0 and 1 (ICES, 2006). With respect to un-intended by-catch in the commercial, small-meshed Norway pout trawl fishery in the North Sea and Skagerrak conducted by Denmark and Norway for reduction purposes ICES ACFM writes that management advice must consider both the state of individual stocks and their simultaneous exploitation. Stocks at reduced reproductive capacity should be the overriding concern for the management of mixed fisheries where these stocks are exploited either as a targeted species or as a by-catch (e.g. ICES, 2006).

Existing by-catch regulations:

In the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries by-catch regulations in the Norway pout fishery have been established (e.g. EU Regulation No 850/98 (EU, 1998)). The by-catch regulations in force at present for small meshed fishery (16-31mm in mesh size) in the North Sea is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other by-catch species. Provisions regarding limitations on catches of herring which may be retained on board when taken with nets of 16 to 31 mm mesh size are stipulated in EU Community legislation fixing, for certain fish stocks and groups of fish stocks, total allowable catches and certain conditions under which they may be fished. (EU, 1998) At current 40% herring is allowed in the Norway pout fishery.

Important by-catch species:

By-catch of the following species in the commercial, small meshed Norway pout fishery has been un-wanted and a concern for fisheries management: Cod, Haddock, Saithe, Whiting, Monkfish, Herring, and Blue Whiting, where especially by-catch of juvenile haddock and cod as well as larger saithe has been in focus.

By-catch levels from landings statistics:

In Tables A1 and A2 below are presented recent (2002-2005) by-catch levels by species in Danish and Norwegian small meshed industrial trawl fishery in the North Sea and Skagerrak areas targeting Norway pout. For Norway the landings used for consume purposes in the small meshed fishery can only be allocated to industrial fishery for the last two years. IMR does not have access to logbooks from industrial vessels. The Norwegian data are evaluated rather un-certain.

By-catch levels and factors affecting them from commercial fishing trials 2005:

Danish-Norwegian fishing trials and pilot investigations were performed in autumn 2005 in order to explore by-catch- levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. The results are given in Working Document No. 22 to the WGNSSK (2006) by *Degel, Nedreaas and Nielsen (2006)*. The trial fishery was

performed by two Norwegian commercial trawlers and a Danish commercial trawler traditionally involved in the small meshed industrial trawl fishery in the North Sea and Skagerrak targeting Norway pout. The investigation was in cooperation between the fisheries research institutes DIFRES and IMR. The South Norwegian Trawl Association (SNTA) and the Danish Fishermen's Association (DF) provided the contact to the fishing vessels used.

The fishery was carried out in autumn 2005 within periods and areas of conducting traditional fishery for Norway pout. The Norwegian vessels conducted each a survey to the area vest of Egersund on the edge of the Norwegian Trench. The Danish vessel conducted two surveys at Fladen Ground in and around the closed box for Norway pout fishery in the North Sea. Comparison fishery between one of the Norwegian vessels and the Danish vessel was performed on a spatio-temporally overlapping scale at the Patch Bank, a closed box for Norway pout fishery in an area between the Egersund Bank and Fladen Ground. The Norwegian vessels conducted both day and night fishery while the Danish vessel only fished during day time.

The results (except for the figure and table showing the diurnal variation in the fishery) comprise only hauls from day time fishery conducted with standard trawl gears used in the commercial small meshed industrial fishery targeting Norway pout. The skipper at the Danish vessel decided the positions and fishing design on a smaller fraction of the conducted hauls based on his evaluation of optimizing the fishery economically, while the rest of the hauls were allocated and pre-distributed in two selected ICES statistical squares.

In general the ratio between the Norway pout target species and the sum of by-catch of certain selected species indicate that the by-catch ratio is high in the commercial Norway pout fishery. However, statistical analyses reveal that the fishermen can significantly minimize the by-catch ratio by targeting in the fishery (spatio-temporal targeting, way of fishing, etc.), i.e. when they determine the fishing stations and the fishery performed. The pilot investigations show no general significant spatio-temporal patterns in the by-catch ratio. However, there are from the results obvious geographical and diurnal differences in the species composition of the by-catch between areas and between day and night fishery. The length distributions of the catch rates by species indicate spatial patterns between some of the species caught. These fishing trials and pilot investigations are based on only very few observations, and data are obviously rather uncertain, variable and noisy. In general, it can be concluded that relatively high by-catches can be reduced by specific targeting in the fishery, both with respect to allocation of the fishery in time and space but also in relation to fishermen knowledge about the fishery and resource availability. This demands though that the skippers/fishermen act accordingly when fishing, and a proper at-sea control. The conclusions above relate to using the Turbotrawl and the Expo1300. The few experiments with Jordfraeser and Kolmuletrål 1100 indicate a different species composition, with unchanged or higher by-catch rates of most species and general significant lover catch rates of Norway pout.

With regard to diurnal differences in the catch rates of Norway pout and by-catches of other species, the few results at present indicate significant lower by-catch of Blue whiting during night hauls. The rest of the by-catch species show no diurnal differences

With regard to possible depth differences in the catch rates of Norway pout and by-catches of other species, this matter relates primarily to the areas close to the Norwegian Deep, and more investigations are about to be carried out to document this better.

Technical measures to reduce by-catches.

Regulation of spatio-temporal effort allocation (closed seasons and areas):

The above investigations indicate spatio-temporal differences in catch levels by species in the commercial small meshed fishery for Norway pout as well as an effect of targeting and use of fishing method on the by-catches. However, these patterns are only based on results from pilot investigations. Knowledge about spatio-temporal patterns in catch rates of target species and by-catch species in the fishery are at present not adequate to implement management measures with respect to regulations on spatio-temporal allocation of fishing effort to reduce by-catches.

During the 1960s a significant small meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large by-catches, especially of haddock and whiting. In order to reduce by-catches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small meshed trawls were banned. The "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56° N and west of 1° W. In the Norwegian economic zone, the Patch bank has been closed since 2002. It is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box both with respect to catch rates of target and by-catch species as well as effects on the stocks (EU, 1985; 1987a; 1987b; ICES, 1979). There has not been performed fully covering evaluation of the effect of closed areas in relation to interacting effects of technological development in the fishery including changed selectivity and fishing behaviour over time in relation to by-catch rates. These effects can not readily be distinguished.

Gear technological by-catch reduction devices:

Investigations of gear specific selective devices and gear modifications to reduce unwanted by-catch in the small meshed Norway pout fishery in the North Sea and Skagerrak have been performed in a number of studies. It was recently investigated based on sea trials in year 2000 and reported through an EU Financed Project (EU, 2002), and the results from here have been followed up upon in a scientific paper from DIFRES and CONSTAT, DK (Eigaard and Holst, 2004). Previous investigations of size selective gear devices in the Norway pout trawl fishery in the North Sea was performed by IMR Norway during sea trials in 1997-1999 also published in a scientific paper (Kvalsvik *et al*., 2006), as well as in a number of other earlier studies on the issue. Main results of previous investigations have been reviewed and summarized in Working Document No. 23 to the WGNSSK (2006) by *Nielsen and Madsen (2006)*.

Early Scottish and Danish attempts to divide haddock, whiting and herring from Norway pout by using separator panels, square mesh windows, and grids were all relatively unsuccessful. More recent Faeroese experiments with grid devices have been more successful. A 74 % reduction of haddock was estimated (Zachariassen and Hjalti, 1997) and 80% overall reduction of the by-catch (Anon., 1998).

Eigaard and Holst (2004) and EU (2002) found that when testing a trawl gears with a sorting grid with a 24 mm bar distance in combination with a 108 mm (nominal) square mesh window through experimental, commercial fishery the results showed improved selectivity of the commercial trawl with catch weight reductions of haddock and whiting of 37 and 57%, but also a 7 % loss of Norway pout. The study showed that application of these reduction percents to the historical level of industrial by-catch in the North Sea lowered on average the yearly haddock by-catch from 4.3 to 2.7% of the equivalent spawning stock biomass. For whiting the theoretical reduction was from 4.8 to 2.1%. The purpose of the sorting grid was to remedy the by-catch of juvenile gadoids in the industrial fishery for Norway pout, while the purpose of square mesh window was to

retain larger marketable consume fish species otherwise sorted out by the grid. By-catches in this study was mainly evaluated for haddock, whiting and cod, i.e. not for all above mentioned by-catch species of concern in the Norway pout fishery. However, the experiments have shown that the by-catch of important human consumption species in the industrial fishery for Norway pout can be reduced substantially by inserting a grid system in front of the cod-end. The study also demonstrated that it is possible to retain a major part of the larger marketable fish species like whiting and haddock and at the same time maintain substantial reductions of juvenile fish of the same species. The study also gave clear indications that further improvement of the selectivity is possible. This can be obtained by adjusting the bar distance in the grid and the mesh size in the selective window, but further research would be necessary in order to establish the optimal selective design.

The results reported in Kvalsvik *et al*. (2006) include results for more species of concern in the Norway pout fishery. They carried out experimental fishing with commercial vessels first testing a prototype of a grid system with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars, and then, secondly, testing if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the first experiments, only a bar space of 22mm were used in the later experiments. These showed respectively that a total of 94.6% (weight) of the by-catch species was sorted out with a 32.8% loss of the industrial target species, where the loss of Norway pout was around 10%, and respectively that 62.4% of the by-catch species were sorted out and the loss of target species was 22%, where the loss of Norway pout was around 6%. When testing selectivity parameters for haddock, the main by-catch species, the parameters indicated a sharp size selection in the grid system.

In conclusion, the older experiments indicate that there is no potential in using separator devices and square mesh panels. Recent and comprehensive experiments with grid devices indicate a loss of of Norway pout at around 10% or less when using a grid with a 22-24 mm bar distance. It is also indicated that there is a considerable loss of other industrial species being blue whiting, Argentine and horse mackerel. A substantial by-catch reduction of saithe, whiting, cod, ling, hake, mackerel, herring, haddock and tusk have been observed. The reduction in haddock by-catch is, however, lowered by the presence of smaller individuals. The Danish experiment indicates that it is possible to retain larger valuable consume fish species by using a square mesh panel in combination with the grid. Selectivity parameters have been estimated for haddock, whiting and Norway pout. These can be used for simulation scenarios including estimates of the effect of changing the bar distance in the grid. Selectivity parameters for more by-catch species would be relevant. However, the grid devices have shown to work for main by-catch species.

A general problem by implementing sorting grids in industrial fisheries is the very large catches handled. Durability and strength of the grid devices used under fully commercial conditions are consequently very important and needs further attention. Furthermore, handling of heavy grid devices can be problematic from some vessels. Grid devices are, nevertheless, used in most shrimp fisheries, where catches often are large.

Conclusions from the above section

In conclusion, the commercial, exploratory fishery and provision of recent by-catch information has shown by-catch-ratios to be significant in the fishery, however, spatio-temporal differences in catch levels by species has been observed and by-catches can be reduced through targeting and fishing method. Recent scientific research based on at sea trials in the commercial fishery has shown that use of gear technological by-catch devices can reduce by-catches of among other juvenile gadoids significantly. Accordingly, it is recommended that these gear technological by-catch reduction devices (or modified forms of those) are brought into use in the fishery. Introduction of those should be followed up upon by adequate landings or at sea catch control measures to assure effective implementation of the existing by-catch measures.

References (in relation to by-catch and gear selectivity)

Anon 1998. Report of the study group on grid (grate) sorting systems in trawls, beam trawls and seine nets. ICES CM 1998/B: 2.

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O.R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fish. Res. 68: 99-112.

Eigaard, O., and Nielsen, J. R. 2009. Reduction of bycatch in a small meshed trawl fishery through gear developments facilitating ecosystem-based fisheries management. ICES CM 2009/M:22. 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

EU, 1985. Report of the Working Group on the by-catches in the Norway pout fishery. Submitted to EU STECF, September 1985, DISK. STCF 9 (N. Pout).

EU, 1987a. Bioeconomic evaluation of the Norway pout box. EU Commission. Internal Information on Fisheries: 16.

EU, 1987b. The consequences of increased North Sea herring, haddock and whiting abundances for the fishery for Norway pout in the North Sea. EU Commission Report, Contract No 1946, 12.06.87 between Marine Resources Assessment Group, London, and Danish Institute for Fisheries and Marine Research, Charlottenlund.

EU, 1998. EU Council Regulation (EC) No. 850/98. Official Journal of the European Communities L 125 of 30 March 1998, Vol. 41 of 27th April 1998: 36 pp. ISSN 0378-6988.

EU, 2002. Development and testing of a grid system to reduce by-catches in Norway pout trawls. Final Consolidated Report, EU Study Project No. 98/002: 32pp + 75 pp. EU Commission DG Fisheries, Bruxelles.

ICES 1977. Review of the Norway pout and sandeel within the NEAFC convention area. Appendix to ICES report C.M. 1977/F:7.

ICES, 1979. Report of an ad hoc working group on the Norway pout box problem. ICES C.M. 1979/G:2.

ICES, 2006. ICES ACFM Advice May 2006. Norway pout in the North Sea. International Council for Exploration of the Sea (ICES), Copenhagen, Denmark. Available from http://www.ices.dk/committe/acfm/comwork/report/asp/advice.asp

Kvalsvik, K., Huse, I., Misund, O.A., and Gamst, K. 2006. Grid selection in the North Sea industrial trawl fishery for Norway pout: Efficient size selection reduces by-catch. Fish. Res. 77: 248-263.

Nielsen, J.R., and Madsen, N. 2006. Gear technological approaches to reduce un-wanted by-catch in commercial Norway pout fishery in the North Sea. Working Document No. 23 to the 2006 meeting of the WGNSSK, 11 pp. ICES C.M.2006/ACFM:35.

Zachariassen, K., Jákupsstovu, S.H., 1997. Experiments with grid sorting in an industrial fishery at the Faeroes. Working Paper. FTFB Working Group, ICES. Available from the Fisheries Laboratory of the Faroes, Thorshavn, April 1997.

Table A1. Landings (tons) per species in the Danish small meshed Norway pout fishery in the North Sea by year and quarter. Landings are divided into the part used for reduction purposes and the part used for human consumption purposes. The latter landings are included in catch in numbers of human consumption landings

Year	Species	Purpose	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Blank	Total	% of total catch
2005	Norway pout	Reduction						0	0
2004		Reduction	504		1474	5877		7855	87.5
2003		Reduction		45	1556	6322		7923	87.8
2002		Reduction	2,546		5,603	25,567	9,508	43224	78.6
2005	Blue whiting	Reduction						0	0
2004		Reduction	66					66	0.73
2003		Reduction		19	23	8		50	0.55
2002		Reduction	1966		589	950	1171	4676	8.50
2005	Herring							0	0
2004			11		422	304		737	8.21
2003				1	113	222		336	3.73
2002					217	2337	639	3193	5.81
2005	Cod	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction				1		1.3	0.01
		Hum. Con.	0.3		0.2	0.3		0.8	0.01
2003		Reduction				3		3	0.03
		Hum. Con.			0.5	0.8		1.3	0.01
2002		Reduction				3		3	0.01
		Hum. Con.	2		15.4	22.7		40.1	0.07
2005	Haddock	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	5		49	3		57	0.63
		Hum. Con.	0.2		0.2	0.5		0.9	0.01
2003		Reduction				16		16	0.18
		Hum. Con.			0.1	1.8		1.9	0.02
2002		Reduction			408	1137		1545	2.81
		Hum. Con.	0.7		4.3	9.8		14.8	0.03
2005	Whiting	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	32		59	141		232	2.58
		Hum. Con.	0.4		0.3	0.2		0.9	0.01
2003		Reduction			51	214		265	2.94
		Hum. Con.			0.3	2		2.3	0.03
2002		Reduction			239	1436		1675	3.05
		Hum. Con.			5.4	5.5		10.9	0.02
2005	Saithe	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction						0	0
		Hum. Con.	0.7		5.8	4.2		10.7	0.12
2003		Reduction		0.4	4	22.8		27.2	0.30
		Hum. Con.						0	0
2002		Reduction			45	201		246	0.45
		Hum. Con.	30		84.3	66.3		180.6	0.33
2005	Other human	Hum. Con.						0	0
2004	Cons. Species	Hum. Con.	0.9		2.7	2.5		6.1	0.07
2003		Hum. Con.		0.6	2.2	6.2		9	0.10
2002		Hum. Con.						0	0
2005	All species	All						0	0
2004		All	626		2023	6331		8980	100
2003		All		66	2025	6929		9020	100
2002		All	4511		6815	31887	11767	54980	100

Stock Annex: Plaice IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Working group: North Sea Demersal Working Group

Updated: 17/05/2011 (partially only. A number of chapters needs major revision)

By: Clara Ulrich, DTU Aqua

Last Benchmark: This stock has never been benchmarked under the new ICES benchmark system. Last changes in the assessment methodology were in 2006.

A.General

A.1 Ecosystem Considerations and Stock Definition

The spawning occurs between late February and late March in Kattegat waters mainly at depth between 30 and 40 meters (**Nielsen *et al.*** 2004). **Ulmestrand** (1992) showed that Skagerrak and Kattegat were not significant spawning areas for plaice between 1990 and 1992. But **Nielsen *et al.* (2004)** observed the existence of two spawning areas in Kattegat, one in the Northeastern part and another one, of greater importance in terms of production, in the southern part. Kattegat and especially Skagerrak plaice are thought to be partially recruited from the North Sea plaice stock by passive drifting of eggs and larvae (**Ulmestrand** 1992, **Nielsen *et al.*** 2004). The contribution of North Sea plaice to Northern Kattegat recruits during larval and eggs drift period is increased in periods of strong winds in Kattegat (**Nielsen *et al*** 1998), and this contribution is not regular between years. **Nielsen *et al.* (**2004) and **Cardinale *et al.*** (2009) have evidenced a shift in SSB (spawning stock biomass) in benefit of young spawners. Even if the adult stock is meant to be currently large, young mature fish are less efficient than older ones in gametes producing, so it could depreciate the recruitment of plaice in Kattegat (**Nielsen *et al.*** 2004, **Rijnsdorp *et al.*** 1991). However, large recruitment of plaice have been observed in the past 15 years, and this could be caused by increases in recruitment from Kattegat spawners and/or from spawners of adjacent plaice stocks such as the North Sea (mainly) or the Belt Sea.

Nursery areas are located both along Danish and Swedish coast, but most part of the recruitment is from the Swedish West (of both Skagerrak and Kattegat) coast nurseries, estimated at 77% (**Wennhage, *et al.*** 2007). There is also some information that indicates the possible existence of stock mixing in the Kattegat Skagerrak. Migration of adult plaice between northern Kattegat and Skagerrak and also between the southern Kattegat and the Belt Sea seem to occur based on meristics, genetics and tagging studies (**Simonsen *et al.*** 1988, **Boje *et al.*** 2007, ICES WGNSSK). These migrations could explain inter annual variations in F.

A.2 Fishery (NOT UPDATED)

The fishery is dominated by Denmark, with Danish landings usually accounting for 80 to 90% of the total. Landings are taken year round with a predominance of the period from spring to autumn, by Danish seiners, flatfish gillnetters and beam trawlers. Plaice is also caught within a mixed cod-plaice fishery by otter trawlers, and is a bycatch of other gillnet fisheries. .Plaice is also caught as by-catch in the directed *Nephrops* fishery. Since 1978, landings have declined from 27 000 to 9 000 tonnes in the late nineties.

However, landings in 2001 were the highest since 1992. The fishery exploits traditionally three age classes (ages 4 to 6). The TAC is usually not restrictive.

The use of beam trawl in the Kattegat is prohibited, but allowed in the Skagerrak. Minimum mesh size is 90 mm for towed gears, and 100 mm for fixed gears. The minimum landing size is 27 cm. Danish fleets are prohibited to land females in area IIIa from January 15th to April 30th.

B. Data

B.1 Commercial catch (NOT UPDATED)

ICES official landings are available from Belgium, Norway and Germany, and national statistics are available from Denmark, Sweden and the Netherlands. The age-disaggregated indices were derived by merging logbook statistics supplying catch weight per market category with the age distribution within these categories available from the market sampling. Catch-at-age and mean weight-at-age in the catch information were traditionally provided by Denmark only. For 2003 data were also provided by Sweden, initially for both areas and since 2007 for Kattegat only. The sampling scheme is broken down by quarter, landing harbours, and fishing area. The total international catches-at-age have been estimated for Kattegat and Skagerrak separately since 1984. Raising procedures were historically performed manually, but ICES InterCatch database has been used for 2008 data.

B.2 Biological

Mean Weight at Age

Up to 2005, weights-at-age in the stock were assumed equal to those of the catch. In 2006, the procedure to calculate weight at age was revised (Storr-Paulsen and Hamon, WD#13 to ICES WGNSSK 2006) as follows:

The IBTS data were analysed to complete a weight-at-age in the stock. Weight at age information are directly available from age 2 to 6, older fish are sampled too scared. To complete a weight at age in the stock the survey data needed to be extended to age 11+. The IBTS data showed a large decrease in weight at age for older age groups (age 4, 5 and 6) from 1998 to 2006 (Figure 2). Weight at age information was also available from KASU 1996-2006. Comparing KASU first quarter with the IBTS data revealed that mean weight at age 1 and 2 were very similar, but the decreasing trend at older ages groups were not seen in the KASU survey (Figure 3).

The Danish commercial mean weight-at-age data from sub area IIIa lie within a very narrow weight range for age 2-6 and do not increase very much between ages (Figure 2). From age 7 or 8 until 11+ there is a large average increase in weight between age groups. As no fleet information are available effect of fishing pattern were exposed by comparing weight at age data between different areas and nations (Figure 4).

Mean weight at age in sub area 22 lie for all age groups above the values found in Kattegat and Skagerrak in the time frame1995-2003, but with a decreasing trend. In the later two years mean weight at age in sub area 22 are in the range of the values in Skagerrak and Kattegat.

The commercial samples from the Swedish fleet in Kattegat and Skagerrak are comparable with values from the Danish fleet in the same area. Weight at age information from the Dutch catches is available for 2003 and 2004 and shows a high weight at age for nearly all age classes.

A comparison of weight at age in survey and commercial data reveals for age groups younger than 3 that commercial data are underestimates the mean weight in all years. Between 1991 and1996 mean weight at age for age group 4-6 are closely linked. In 1997-1999 the mean survey estimate are larger for age 5 and 6 than the commercial. The later 3 years mean weight at age estimated in the survey are beyond the values found in the commercial fleets.

One explanation for the discrepancy in growth pattern between age 2-6 and older plaice in the commercial fleet could be the difference in the growth pattern of the two sexes. In the commercial samples, plaice has not been sexed and the growth pattern of the 2 sex are significantly different at older age groups.

Different main target species in the various fleets gives an alternative explanation for the different growth pattern. Large parts of the trawler fleet do not target plaice but *Nephrops* as their main species. They are fishing with a smaller mesh size and are bound to catch smaller plaice. Opposite with the gill-netters, part of the trawlers and Danish seine fleets targeting plaice as main species. They have a larger mesh size and are catching larger fish. This is confirmed by the measure information from the Dutch fleet targeting plaice as main species, with a high mean weight at age.

Mean weight at age from the IBTS has a decreasing trend at older age groups after 1998, this trend is not found in the KASU nor for the North Sea stock (WGNSSK-2005). The inconsistent survey data makes an extension of age groups in the survey mean weight at age difficult. Alternatively, mean weight at age from the commercial fleet for age groups 5-11+ could be used. As age 2 and 3 are underestimated in the commercial fleet comparison can only be made between age 4-6. The last 3 years this correlation between IBTS and commercial data has been very poor (Figure 5). The KASU survey and the mean weight at age in the landings shows a better correlation at age 3-6 in the latter years than the IBTS does (Figure 6). At age 5 and 6 the number of fish caught in the KASU are not very large.

In conclusion, it was decided to compile mean weight at age from the KASU survey age 1-4 with mean weight at age 5-11+ in landings from the Danish fleet in area IIIa and 22 to generate the mean weight at age in stock.

This procedure has not been changed since 2006.

Mortality

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

A fixed natural mortality of 0.1 per year was assumed for all years and ages.

Maturity

Up to 2005, a knife-edge maturity distribution was employed: age group 2 was assumed to be immature, whereas age 3 and older plaice were assumed mature.

The procedure was revised in 2006 (Nielsen and Boje, WD#15 to ICES WGNSSK 2006). A difference in maturity at age are observed between Kattegat and Skagerrak Plaice mature at younger age in Kattegat than in Skagerrak. This could indicate that the two areas belong to different spawning grounds. Although maturity varies from year to year in both areas, no trend is obvious over the time. Therefore it is suggested that a fixed maturity ogive is applied to the stock assessment of plaice in IIIa.

Although it is recognised that the maturity ogive differ between Kattegat and Skagerrak, a combined ogive is suggested weighting the area ogives by catches in the respective areas. The proposed ogive is therefore computed as an average of the two areas weighed by the average catches over the entire period 1993-2005. Even though the resulting ogive does not fit an ideal sigmoid curve, the single maturity proportion by age represents the best estimates available and it is therefore not considered appropriate to smoothen the estimates.

B.3 Surveys

Data from four surveys are available.

NS-IBTS is the standardised national surveys for North Sea, Kattegat and Skagerrak (Anon, 2004). A standard IBTS haul is made with a 36/47 GOV-Trawl, with haul duration at 30 minutes and a trawl speed of 4 knots. The purpose of this survey is to provide an annual abundance index for cod, haddock, juvenile herring, whiting, Norway pout, and the survey provides information on the by-catches species plaice and sole. The rubber discs (20cm in diameter) on the groundrope may lift the ground panel of the trawl and enable flatfish escape.

IBTS in area IIIa is conducted by the Swedish research vessel 'RV Argos', at Fiskeriverket twice a year, in the first and the third quarters and survey indices are available since 1991.

IBTS samplings take place in both the Kattegat and the Skagerrak; final indices are however combined over the whole area. All individuals from the survey in IIIa are chosen in further analysis. To make the estimation comparable length groups always start at 5cm length class. When individuals of a given size are missing, an estimated weight from the weight length relationship of the same year and area is used. For ages 6+ the numbers caught is very low and is therefore excluded from the estimations.

The KASU survey is a standard BITS, which belongs to another group of standardised surveys. The trawl is a standard TV3-520 with rubber discs of 10cm diameter on the groundrope and with a trawl speed at 3knots. This trawl target flatfish better than IBTS and is designed provide an annual abundance indices for cod, plaice and sole. This survey takes place in the Kattegat and Belt Sea twice a year in February and November and is conducted by a Danish vessel, Havfisken from DTU Aqua.

KASU data have been revised this year in 2006 (Folmer, 2006), due to changes in database combined with a change of extraction programs in 2005. The revision of last year indices highlighted data treatment errors and the new time series is considered improved compared to the old one.

KASU time series start in 1996 for the first quarter and 1994 for the fourth quarter data.

Individual weight information are available for age 1-6, the survey area are distributed further to the Danish cost compared to the IBTS (Figure 1).

The KASU weights at age are calculated as the mean weight over all samples from the combined 1st and 4th quarter surveys.

Very few plaice aged 7–9 are caught during the surveys and these ages are removed from the analysis.

B.4 Commercial CPUE (NOT UPDATED)

Three Danish fleets, i.e., trawlers, gillnetters, and Danish seiners, were traditionally available for tuning.

In 2006 effort was made to improve the quality of the commercial tuning fleets used in the assessment, both in terms of data checking, fisheries definition and effort standardisation. Two tuning fleets were retained, the Danish seiners and the Danish gillnetters targeting flatfish with 120 to 220 mm nets (vessels larger than 10m), with effort measured as kW*fishing days. The age-disaggregated indices were derived by merging logbook statistics supplying catch weight per market category with the age distribution within these categories available from the market sampling.

The fishing effort appears to have been fairly stable over the last decade. There has been a decrease in the fishing effort of towed-geared fleets since 1990, but this trend has been reversing since 1998. The fishing effort of gillnetters has steeply increased over 1990-1994, and steadily decreased since then. All commercial fleets show increase in both the yield and the CPUE in 2001. Highest values and increases are observed for the Danish seiners.

B.5 Other relevant data

None.

C. Historical Stock Development

Analytical assessments were performed every year except in 2008, but they have not been accepted since 2005.

D. Deterministic modelling (NOT UPDATED)

Model used: XSA

Software used: IFAP / Lowestoft VPA suite until 2005, FLXSA since 2006.

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978 – last data year	2 – 10+	Yes
Canum	Catch at age in numbers	1978 – last data year	2 – 10+	Yes
Weca	Weight at age in the commercial catch	1978 – last data year	2 – 10+	Yes
West	Weight at age of the spawning stock at spawning time.	1978 – last data year	2 – 10+	Yes
Mprop	Proportion of natural mortality before spawning	1978 – last data year	2 – 10+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1978 – last data year	2 – 10+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1978 – last data year	2 – 10+	No – the same ogive for all years
Natmor	Natural mortality	1978 – last data year	2 – 10+	No – set to 0.1 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Danish Gillnetters	1987 – last data year	2 – 10+
Tuning fleet 2	Danish seiners	1987 – last data year	2 – 10+
Tuning fleet 3	IBTS Q1 backshifted	1991 – last data year	1 – 6
Tuning fleet 4	KASU Q4	1994 – last data year	1 – 6
Tuning fleet 5	KASU Q1	1995 – last data year	1 – 5
Tuning fleet 6	IBTS Q3	1995 – last data year	1 – 6

D.1 Uncertainty analysis

D.2 Retrospective analysis

Performed with FLR packages

E. Short-Term Projection

not run since 2005

Settings previously used :

Software used: WGFRANSW

Initial stock size. Stock sizes for age 3 and older are taken from the estimated number of survivors from the XSA. The age 2 recruitments are taken as the geometric average over the entire period.

Natural mortality: Set to 0.1 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years, scaled by the Fbar (3-6) to the level of the last year

Intermediate year assumptions: TAC constraint

Stock recruitment model used: None, the long term geometric mean recruitment at age 2 is used

Procedures used for splitting projected catches: Not relevant

F.References

Boje, J., Clausen, L.W., Nielsen, E., Rasmussen, H., Ulrich, C., Belgrano, A., Bland, B., Cardinale, M., Svedang, H. (2007). ICES: DIFRES-IMR Meeting on improvement of plaice IIIA assessment. ICES Headquarters, Copenhagen.

Cardinale, M., Hagberg, J., Svëdang, H., Bartolino, V., Gedamke, T., Hjelm, J., Börjesson, P., Norén, F. (2009). Fishing through time: population dynamics of plaice (Pleuronectes platessa) in the Kattegat–Skagerrak over a century. Population Ecology, 52 (2), pp.251-262.

Hoarau, G., Rijnsdorp, A.D., Van Der Veer, H.W., Stam, W.T., Olsen, J.L. (2002). Population structure of plaice (Pleuronectes platessa L.) in northern Europe: microsatellites revealed large-scale spatial and temporal homogeneity. Molecular Ecology, 11 (7), pp. 1165-1176.

Hunter, E., Metcalfe, J.D., Reynolds, D.R. (2003). Migration Route and Spawning Area Fidelity by North Sea Plaice. Proceedings: Biological Sciences, 270 (1529), pp. 2097-2103.

Kell, L.T., Scott, R., Hunter, E. (2004). Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research, 51 (3-4), pp. 287-299.

Kell, L.T. and Bromley, P.J. (2004). Implications for current management advice for North Sea plaice (Pleuronectes platessa L.): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research, 51 (3-4), pp. 301-312.

Nielsen, E., Støttrup, J.G., Heilmann, J., MacKenzie, B.R. (2004). The spawning of plaice Pleuronectes platessa in the Kattegat. Journal of Sea Research, 51 (3-4), pp.219-228.

Nielsen, E., MacKenzie, B.R. (1998). Wind-induced transport of plaice (Pleuronectes platessa) early life-history stages in the Skagerrak-Kattegat, Journal of Sea Research, 39 (1-2), pp. 11-28.

Nielsen, E. and Boje, J. (2006). Maturity at age for plaice in Skagerrak and Kattegat (IIIa). ICES WGNSSK Working Doc 15

Rijnsdorp, A.D., Daan, N., Van Beek, F.A., Hesse, H.J.L. (1991). Reproductive variability in North Sea plaice, sole and cod. Journal du Conseil International pour l'Exploration de la Mer, 47 (3), pp. 352-375.

Simonsen, V., Nielsen, E., Bagge, O. (1988). Discrimination of stocks of plaice in the Kattegat by electrophoresis and meristic characters. ICES CM 1988/G:29

Ulmestrand, M. (1992). The geographical distribution, size composition and maturity stages of plaice Pleuronectes platessa (L.) during spawning season in the Skagerrak and Kattegat. Meddelande från Havsfiskelaboratoriet. 325, 8 pp.

Wennhage, H., Pihl, L., Stål, J. (2007). Distribution and quality of plaice (Pleuronectes platessa) nursery grounds on the Swedish west coast. Journal of Sea Research, 57 (2-3), pp. 218-229

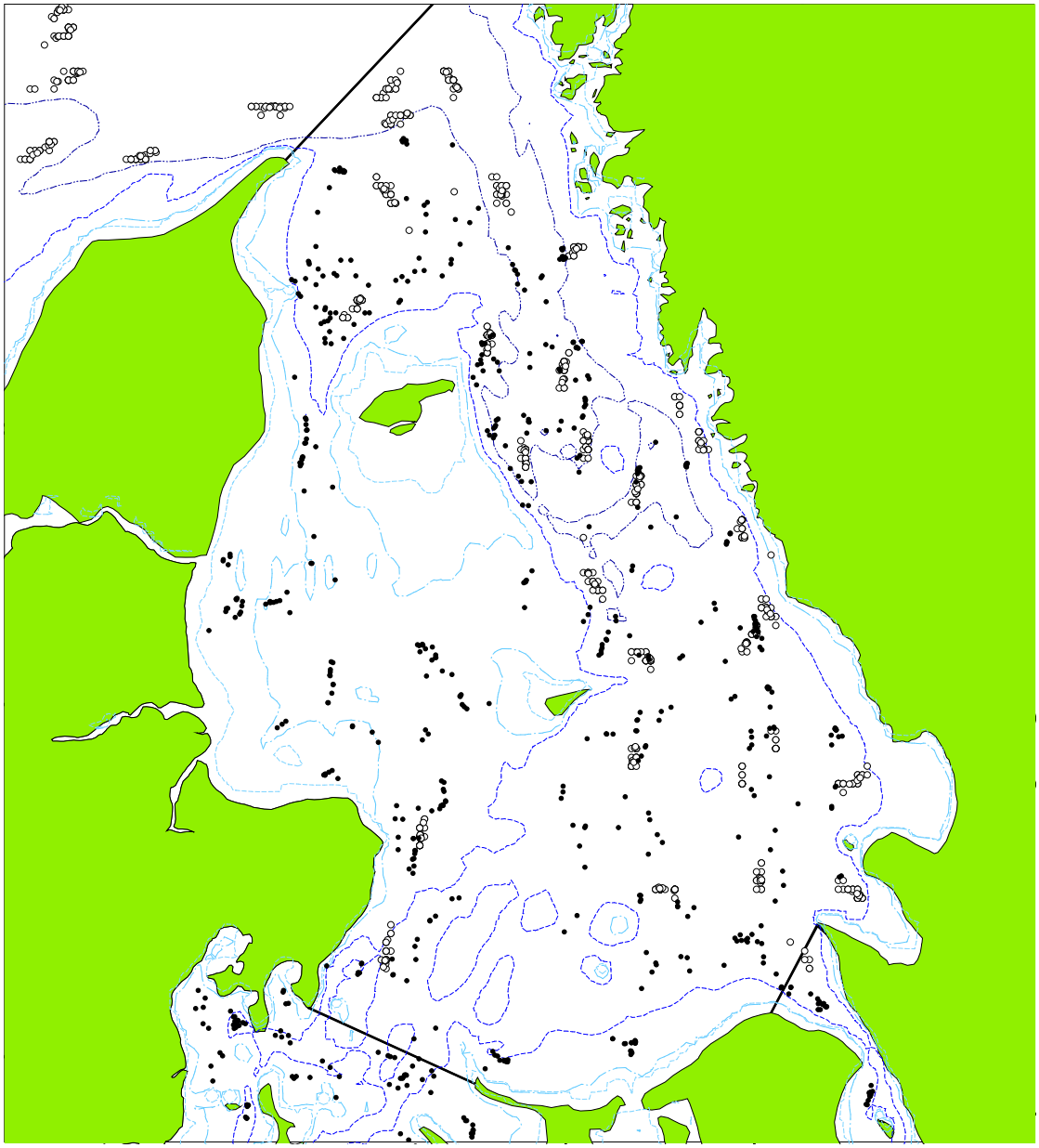


Figure 1. Location for the IBTS (open dots) and KASU stations (black dots).

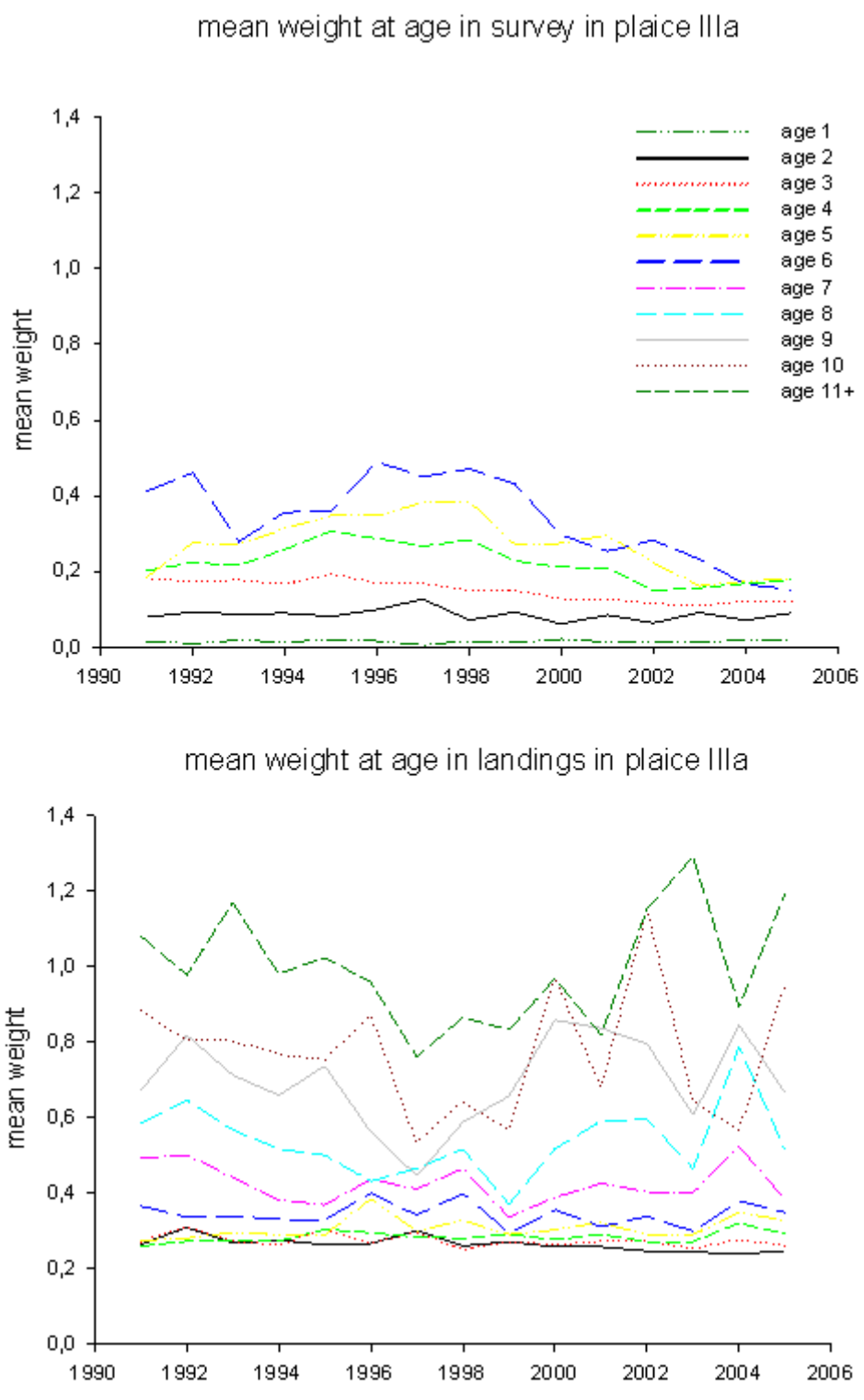


Figure 2: Mean weight at age from IBTS and commercial fleets in IIIa between 1991-2005.

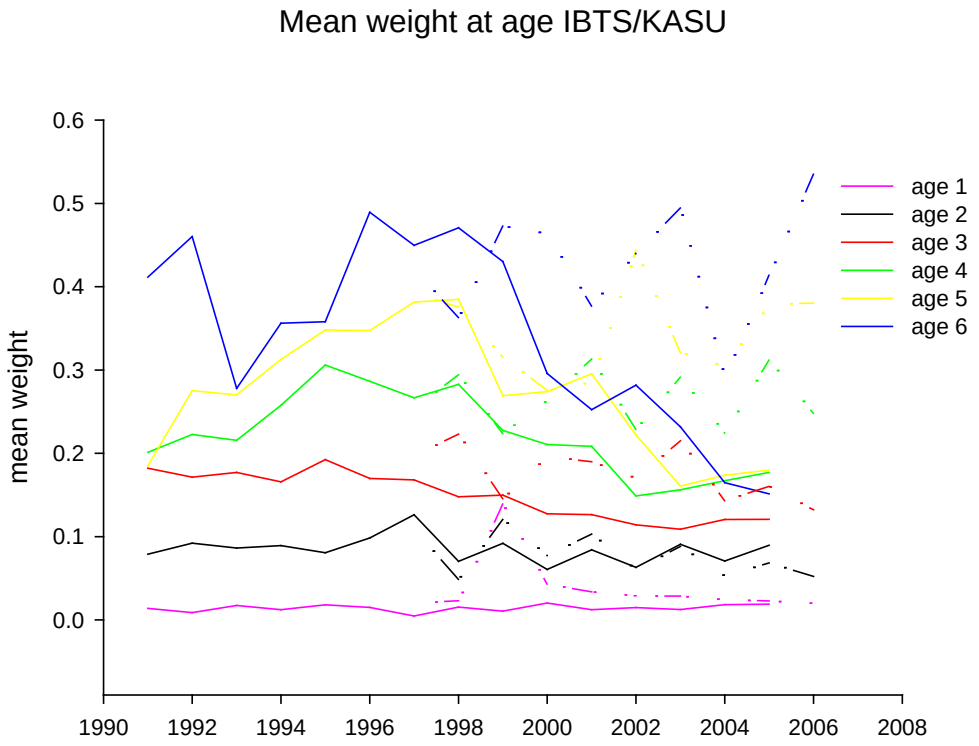


Figure 3. Comparison between IBTS q1 in area IIIa (solid line) 1991-2005 and KASU q1 in IIIa+22 (dotted line) 1996-2006 in area IIIa.

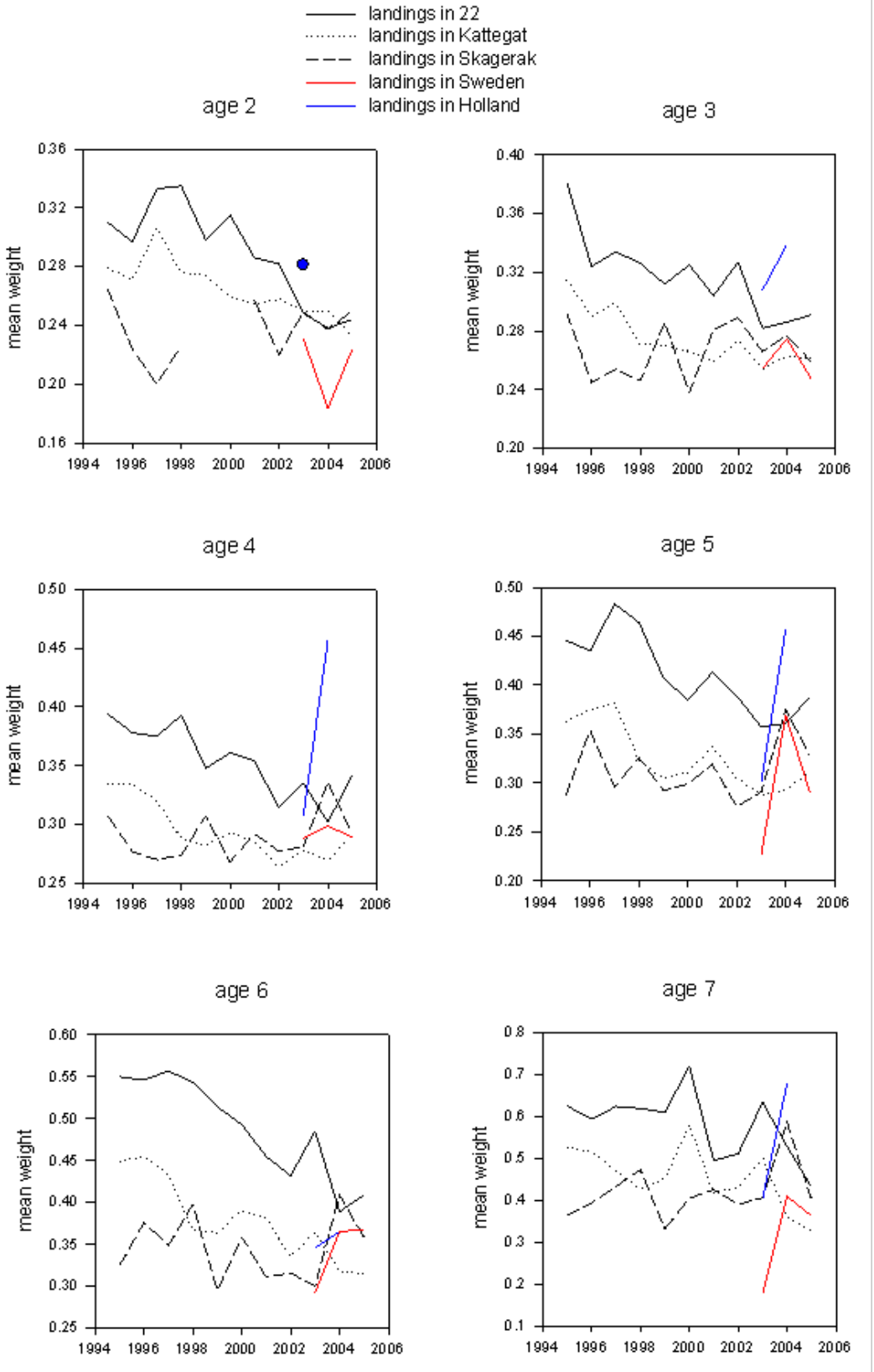


Figure 4: Mean weight at age 2-7 from 5 different commercial fleets.

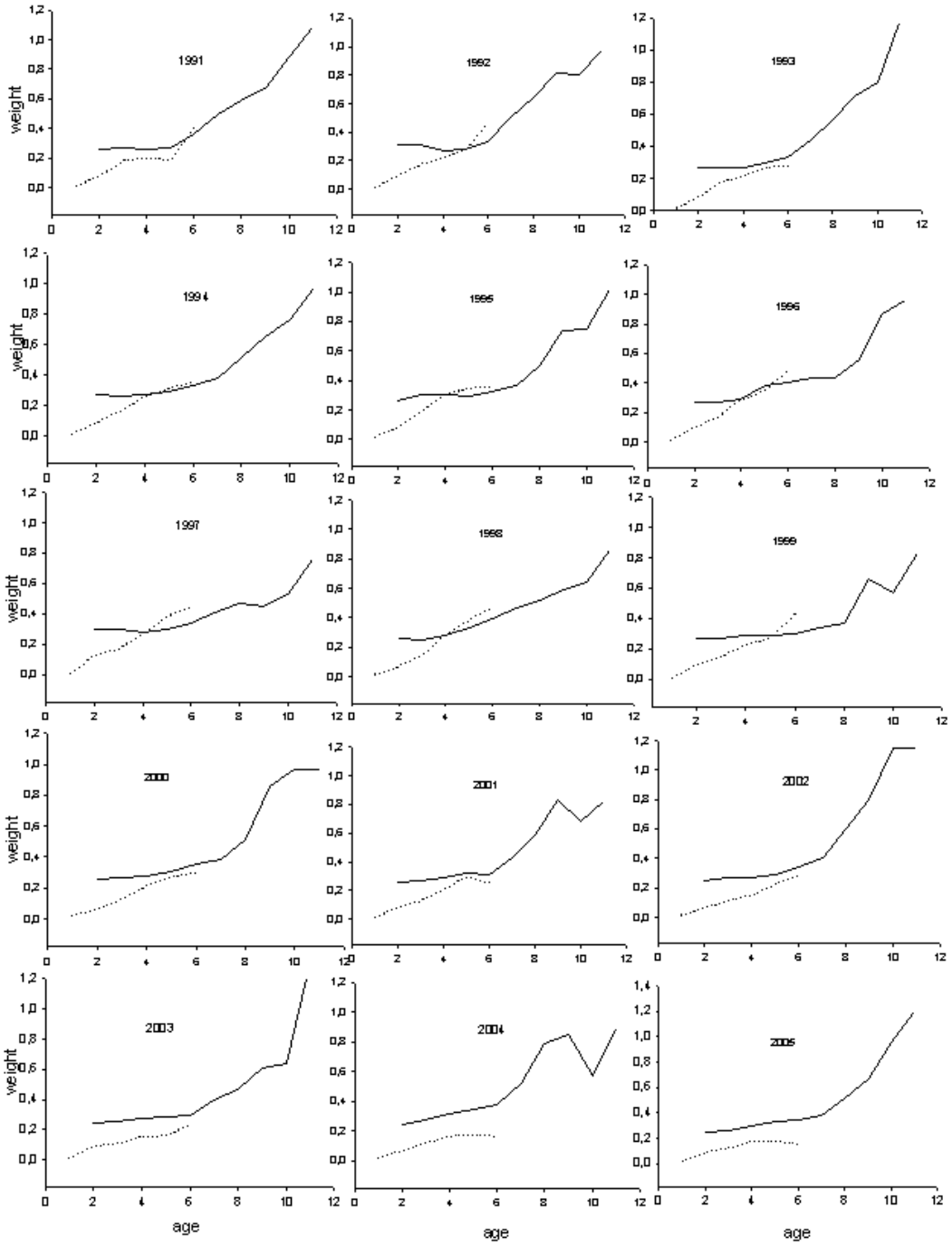


Figure 5. Comparison of mean weight at age between the IBTS survey (dottet line) and commercial samples (solid line) in IIIa in the years 1991-2005

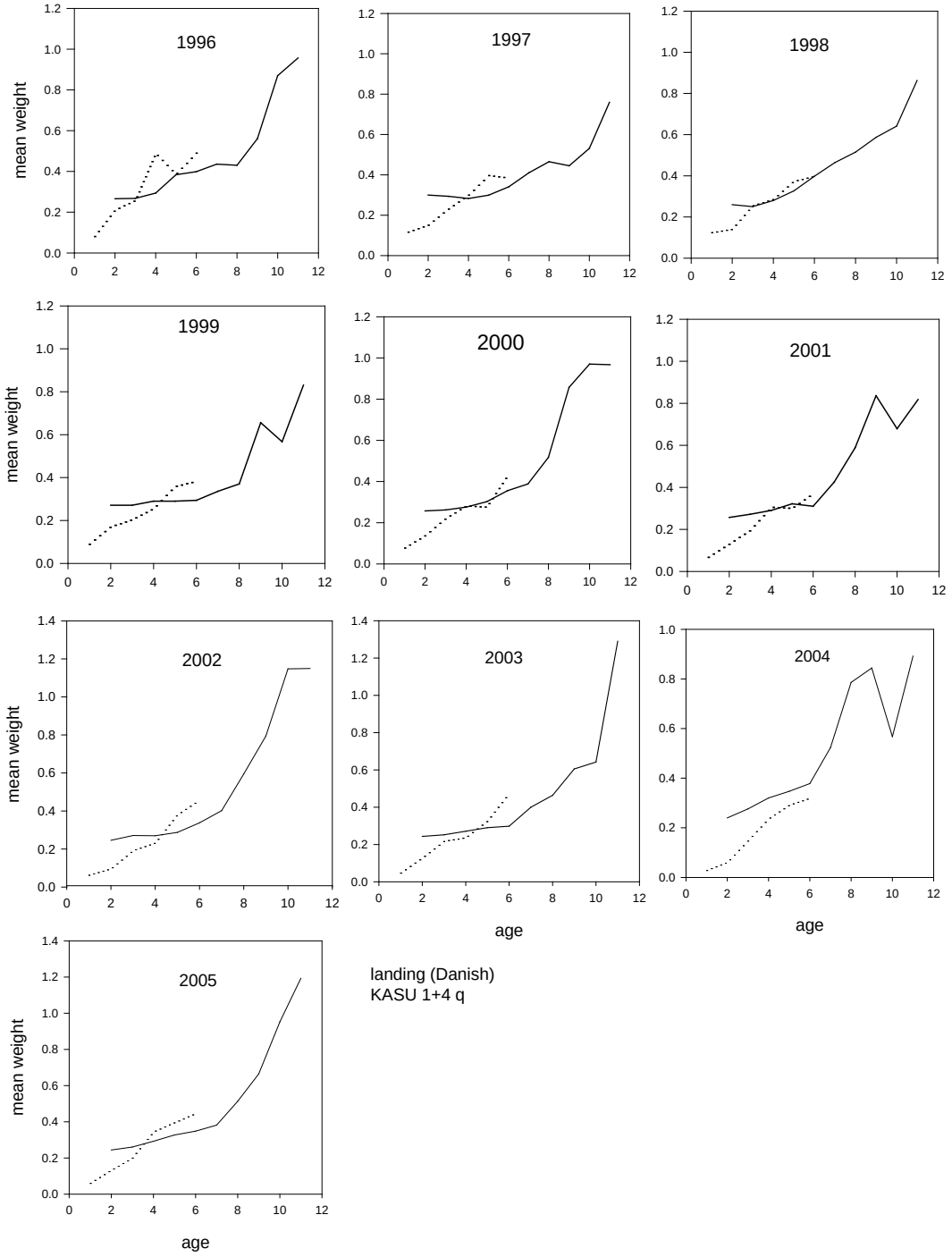


Figure 6. Comparison of mean weight at age between the KASU survey 1+ 4 q (dottet line) and commercial samples (solid line) in IIIa in the years 1996-2005

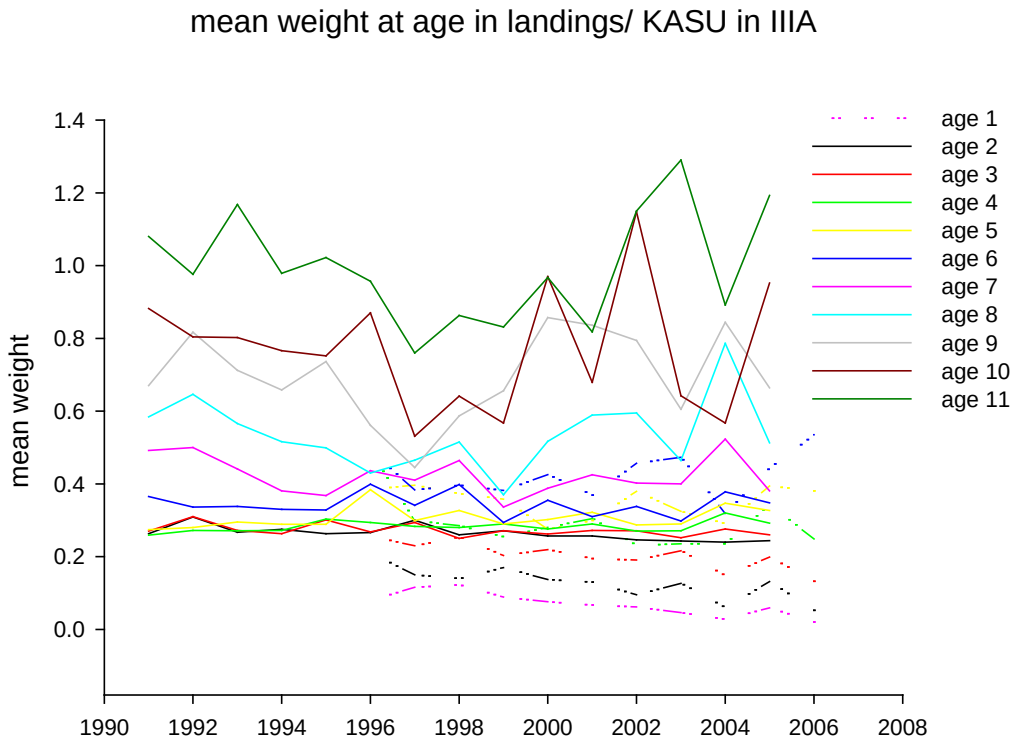


Figure 7. Mean weight at age in KASU 1+4 q and commercial landings from the Danish fleet.

Stock Annex: Plaice in area IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock: North Sea plaice

Working Group: WGNSSK

Date: 7 February 2009

By: Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea plaice is defined to be a single stock in ICES are IV. However, data from data storage tag experiments reveal that about one third of plaice released in the Southern Bight of the North Sea visit the eastern English Channel in December and January. In contrast, analysis of the movements of mark-recapture experiments with plaice of a similar size and released at similar times indicates that only 13% of plaice released in the Southern Bight visit the eastern English Channel at this time (Hunter *et al*., 2004). This difference between DST and mark-recapture experiments is not observed in the central North Sea and German Bight, where the movements of plaice derived from the two approaches are relatively similar (Bolle *et al*., 2005). The differences may possibly be due to the fact that these fish migrate to their spawning grounds by selective tidal stream transport. Studies (Kell *et al*., 2004) have shown that the migration between North Sea and the adjacent areas is more problematic for the smaller adjacent areas than it is for management in IV.

Genetic analysis of plaice population structure in northern Europe using microsatellites and mitochondrial DNA data (Hoarau *et al*., 2004) reveals relatively strong differentiation between "shelf" plaice and those from Iceland and Faeroe, suggesting that deep water may serve as a barrier to movement between these populations. However, within the area of the European continental shelf, only weak differentiation could be detected between North Sea-Irish Sea and other areas (Norway, the Baltic and the Bay of Biscay, Hoarau *et al*., 2004). Although the spatial location of sampling within the North Sea was not sufficient to reveal any sub-structure. The lack of any genetic differentiation between Irish Sea and North Sea plaice populations (Hoarau *et al*., 2004) despite the evidence from mark-recapture studies that indicate extremely low transfer of individuals between these sea areas (0.36% over 17 years, calculated from (Dunn and Pawson, 2002)) shows how differently genetic and tagging studies provide an understanding fish population structure. Nonetheless, it seems unlikely that Irish Sea and North Sea plaice are a single "stock", at least in a fisheries management sense.

A.2 Fishery

North Sea plaice is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea. Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. Due to the minimum mesh size enforced (80 mm in the mixed beam trawl fishery), large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea plaice have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions.

For example, approximately 85% of plaice landings from the UK (England and Scotland) is landed into the Netherlands by Dutch vessels fishing on the UK register. Vessels fishing under foreign registry are referred to as flag vessels. As described by the ICES WGNSSK in 2001(ICES CM 2002/ACFM:01), the fishing pattern of flag vessels can be very different from that of other fleet segments. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box). Also, the decrease in fleet size may partially have been compensated by slight increases in the technical efficiency of vessels. In the Dutch beam trawl fleet indications of an increase of technical efficiency of around 1.65% by year was found over the period 1990 – 2004 (Rijnsdorp *et al*., 2006). Because the commercial tuning series are not currently used in the assessment, these estimates do not affect the current assessment.

The Dutch beam trawl fleet, one of the major operators in the mixed flatfish fishery in the North Sea, has seen a shift towards more inshore fishing grounds, changing the catchability of the fleet. This shift may be caused by a number of factors, such as the implementation of fishing effort restrictions, the increase in fuel prices and changes in the TAC for the target species (Quirijns, 2008). However, the contribution of each of these factors is yet unknown. Other factors affecting the catchability of the fleet include the changes in the fishing speed of the vessels, and discarding marketable fish in certain seasons and areas, as a result of the TAC management (Rijnsdorp, 1991)

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001; EC Council Regulation No 51/2006; e.g N°40/2008, annex IIa). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammel nets could fish between 140 and 205 days per year.

Several technical measures are applicable to the plaice fishery in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55 N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the plaice fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100mm is required. In addition to this, since 2002 a small part of North Sea plaice fishery is affected by the additional cod recovery plan (EU regulation 2056/2001) that prohibits trawl fisheries with a mesh size <120mm in the area to the north of 56°N.

The minimum landing size of North Sea plaice is 27 cm. The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are ex-empted from the regulation. An evaluation of the plaice box has indicated that: From trends observed it was inferred that the Plaice Box has likely had a positive effect on the recruitment of Plaice but that its overall effect has decreased since it was established. There are two reasons to assume that the Plaice Box has a positive effect on the recruitment of Plaice: 1) at present, the Plaice Box still protects the majority of undersized

Plaice. Approximately 70 % of the undersized Plaice are found in the Plaice Box and Wadden Sea, and despite the changed distribution, densities of juvenile Plaice inside the Box are still higher than outside; 2) In the 80 mm fishery, discard percentages in the Box are higher than outside. Because more than 90 % of the Plaice caught in the 80 mm fishery in the Box are discarded, any reduction in this fishery would reduce discard mortality. There is, however, no proof of a direct relationship between total discard mortality and recruitment.

Generally, it is assumed that the majority of discarded animals do not survive (Beek *et al*. 1990; Chopin *et al*. 1996). Reviews of studies that have tested this assumption acknowledge that discard mortality is determined by a range of biological, technical, or environmental factors or 'stressors' (Broadhurst *et al*. 2006). Biological factors relate to e.g. the species, physiology, size, catch weight/ volume, composition; technical stressors relate to e.g. gear design, deployment duration, fishing speed; environmental stressors relate to e.g. temperature, hypoxia, depth, wind force, availability of sunlight.

For the beam trawl fishery, discard mortality is influenced by the duration the organisms are confined in the codend and concurrent injuries (Beek *et al*. 1990; Broadhurst *et al*. 2006). If the fish were brought on board alive, then the processing of the catch on board would also matter. However, in fact, processing on board hardly affects the survival of the discards because approximately 70% of the catch is moribund upon landing already (Beek *et al*. 1990). It is estimated based on experimental studies on board commercial vessels that less than 10% of the plaice and sole discards in the beam trawl fisheries survive the process of discarding (Bult and Schelvis-Smit 2007; Beek *et al*. 1990).

A.3 Ecosystem aspects

Adult North Sea plaice have an annual migration cycle between spawning and feeding grounds. The spawning grounds are located in the central and southern North Sea, overlapping with the distribution area of Sole. The feeding grounds are located more northerly than the sole distribution areas. Juvenile stages are concentrated in shallow inshore waters and move gradually off-shore as they become larger. The nursery areas on the eastern side of the North Sea contribute most of the total recruitment. Sub-populations have strong homing behaviour to specified spawning grounds and rather low mixing rate with other sub-populations during the feeding season (de Veen, 1978, Rijnsdorp and Pastoors, 1995). Genetically, North Sea and Irish Sea plaice are weakly distinguishable from Norway, Baltic and Bay of Biscay stocks using mitochondrial DNA (Hoarau *et al*., 2004).

Juvenile plaice were distributed more offshore in recent years. Surveys in the Wadden Sea have shown that 1-group plaice is almost absent from the area where it was very abundant in earlier years (van Keeken *et al*., 2007). The Wadden Sea Quality Status Report 2004 (Vorberg *et al*., 2005) notes that increased temperature, lower levels of eutrophication, and de-cline in turbidity have been suggested as causal factors, but that no conclusive evidence is available; taking into account the temperature tolerance of the species there is ground for the hypothesis that a temperature rise contributes to the shift in distribution.

A shift in the age and size at maturation of plaice has been observed (Grift *et al*., 2007, Grift *et al*., 2003): plaice become mature at younger ages and at smaller sizes in recent years than in the past. This shift is thought to be a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce

and pass on their genes. This results in a population that consists ever more of fish that are genetically programmed to mature early at small sizes. Reversal of such a genetic shift may be difficult. This shift in maturation also leads to mature fish being of a smaller size at age, because growth rate is reduced after maturation.

B. Data

B.1 Commercial catch

Discard sampling programmes started in the late 1990s to obtain discard estimates from several fleets fishing for flatfish. These sampling programmes give information on discard rates from 1999 but not for the historical time series. Observations indicate that the proportions of plaice catches discarded are high (80% in numbers and 50% in weight: (van Keeken *et al*., 2004)) and have increased since the 1970s (51% in numbers and 27% in weight: (van Beek, 1998)) The discards time series are derived from Dutch, Danish, German and UK discards observations for 2000 – 2007. For the period prior to that, a reconstructed discard time series for 1957 – 1999 exists, based on a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07 Section 9.2.3).

The discard data from the sampling programmes in the individual countries are raised totals, based on samples from onboard observers. These observers generally take length structured samples that are

The UK discards estimates have strong interannual variation, caused by the low sample sizes, and sampling different strata in the UK fleet. For example, the UK discard samples for 2007 were taken mainly from the UK *Nephrops* and otter trawl fishery. These fisheries represent only a small fraction of the total UK plaice landings, and raising the UK discards using only samples from this fleet would potentially lead to incorrect estimates. Since the UK landings represents 24% of the total nominal landings, obtaining accurate discard estimates is crucial. In order to gain better estimates of discards, the proportionality of the English discards to the Dutch discards is calculated in the observations since 2000. The UK estimates are recalculated assuming a constant ratio between the UK and Dutch discard numbers at age:

$$\hat{D}^{UK}_{a,y} = \frac{\sum_{y=2002}^{2007} D^{UK}_{a,y}}{\sum_{y=2002}^{2007} D^{NL}_{a,y}} \times D^{NL}_{a,y} \qquad 1.$$

where $D^{UK}_{a,y}$, $\hat{D}^{UK}_{a,y}$, and $D^{NL}_{a,y}$ are the observed and estimated UK, and observed Dutch discard numbers of year y and age a, respectively

After raising to the fleet total and estimation of discards-at age using age length keys from the Dutch BTS surveys, discard observations at age are thus available from the Dutch, Danish, German and the UK discard sampling programmes. The sampling effort in the Dutch and UK programmes is given in The quality of the estimation of total discards numbers at age depends on the quality of the available discards data, which are derived from low sampling level discards observations within the four countries that have provided discard estimates.

Discards at age were raised from the Dutch and UK sampling programmes by effort ratio (based on hp days at sea for the Dutch fleets, and on trips for the UK fleets). Discards at age from the Danish and German sampling programs were raised by landings. Discards at age for the other fleets for which no estimates were available, were calculated as a weighted average of the Dutch, Danish, German and UK discards at age and raised to the proportion in landings (tonnes). This is the same method as used in the final assessment by WGNSSK 2005 (method B).

A self sampling programme for discards was started by the Dutch beam trawl fishery in 2004, and is still running. This sampling program has a high number of samples, taken on board by the fishermen, estimating the percentage of discards by volume. The program indicates a strong spatial pattern in the discarding of the fleet. The percentage discards estimated in the self sampling program is significantly lower than that in the Dutch sampling programme in the same years (Aarts and van Helmond, 2007).

To reconstruct the number of plaice discards at age before 2000 that are required for an XSA assessment, catch numbers at age are calculated from fishing mortality at age corrected for discard fractions, using a reconstructed population and selection and distribution o-gives (ICES CM 2005/ACFM:07 Appendix 1). Alternatively, the discards previous to 2000 can be estimated using the statistical catch-at-age approach as described in (Aarts and Poos, 2009).

Landings

The landings by country are collected by different countries, segregated by sex for the Netherlands and Belgium (accounting for approximately 50 % of the landings). Age structure is available for the Netherlands, France, Germany, Denmark and Belgium (accounting for approximately 75% of the landings). The total age structured landings are estimated using a weighed procedure for the age structure by country, based on the proportionality of the weight of the total landings.

B.2 Biological

Weight at age

The stock weights of age groups 1-4 are calculated using modeled mean lengths from survey and back-calculation data (see ICES CM 2005/ACFM:07 Appendix 1) and converted to mean weight using a fixed length-weight relationship. Stock weights of the older ages are based on the market samples in the first quarter. Stock weight at age has varied considerably over time, especially for the older ages. Discard weights at age are calculated the same way as the stock weights of age groups 1-4, after which gear selection and discarding ogives are applied. Landing weights at age are derived from market sampling programmes. Catch weights at age are calculated as the weighted average of the discard and landing weights at age. There appear to be cohort effects on landings weight at age, which are also reflected in the stock weights at age. In addition to the cohort effects, there is a long term decline in weight at age for the older ages. The stock weights of the older ages are based on the market samples in the first quarter. In these market samples, the sex ratio for the older ages may be skewed towards one of the sexes. The WG suggests a more in depth study into the causes and consequences of the perceived decreases in stock weights for the next benchmark assessment.

Natural mortality

Natural mortality is assumed to be 0.1 for all age groups and constant over time. These values are probably derived from war-time estimates (Beverton and Holt, 1957).

Maturity

A fixed maturity ogive is used for the estimation of SSB from the assessment in North Sea plaice, assuming maturity-at-age 1 is 0, maturity-at-age 1 and 2 is 0.5, and older ages are fully mature. However maturity at-age is not likely to be constant over time (Grift *et al*. 2003, Grift *et al*. 2007) (Grift *et al*., 2007, Grift *et al*., 2003). The effects of assuming a constant maturity-at-age on the management advice was discussed in a study by (Kell and Bromley, 2004). However, a study of the effect of the fluctuations of natural mortality on the SSB by the WG in 2004 showed that incorporating the historic fluctuations had little effect on SSB estimates in the period 1999-2003.

B.3 Surveys

Three different survey indices can been used as tuning fleets are:

- Beam Trawl Survey RV Isis (BTS-Isis)
- Beam Trawl Survey RV Tridens (BTS-Tridens)
- Sole Net Survey in September-October (SNS)

Additional Survey indices that can be used for recruitment estimates are (Table 8.2.12):

- Demersal Fish Survey (DFS)

The Beam Trawl Survey RV Isis (BTS-Isis) was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea (RV Isis). Since 1996 the BTS-Tridens covers the central part of the North Sea, extending the survey area of the surveys. Both vessels use an 8-m beam trawl with 40 mm stretched mesh codend, but the Tridens beam trawl is rigged with a modified net. Owing to the spatial distribution of both BTS surveys, consider-able numbers of older plaice and sole are caught. Previously age groups 1 to 4 were used for tuning the North Sea plaice assessment, but the age range has been extended to 1 to 9 in the revision done by ACFM in October 2001.

The Sole Net Survey (SNS & SNSQ2) was carried out with RV Tridens until 1995 and then continued with the RV Isis. Until 1990 this survey was carried out in both spring and autumn, but after that only in autumn. The gear used is a 6 m beam trawl with 40 mm stretched mesh cod-ends. The stations fished are on transects along or perpendicular to the coast. This survey is directed to juvenile plaice and sole. Ages 1 to 3 are used for tuning the North Sea plaice assessment; the 0-group index is used in the RCT3. In an attempt to solve the problem of not having the survey indices in time for the WG, the SNS was moved to spring in 2003. However, because of the gap in the spring series these data could not be used in the plaice assessment or in RCT3. In 2004, the SNS was moved back to autumn as before, based on the recommendation of the WGNSSK in 2004.

The 1997 survey results for the 1995 and 1996 year classes (at ages 1 and 2) in the BTS and SNS surveys cannot be used in the assessment, owing to age reading problems in that year. Also, the research vessel survey time series have been revised in May 2006 by WGBEAM (ICES 2006), because of small corrections in data bases and new solutions for missing lengths in the age-length-keys.

When WGBEAM will provide these combined series, those should be used instead in the assessment.

The Demersal Fish Survey (DFS) is the more coastal of the surveys, conducted by several countries. This survey is not used in the assessment, but rather used to estimate

the recruitment of juvenile fish in the RCT3 analysis. The survey estimates abundances for North Sea plaice age 0 and age 1. However, the age 1 has not been used for recruitment estimation since a number of years, and the time series for this age was stopped in 2005. The UK contribution to the DFS survey was revised in 2008, affecting the estimates between 2001 and 2006.

B.4 Commercial LPUE

Commercial age structured LPUE series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are:

- The Dutch beam trawl fleet (since 1989)
- The Dutch beam trawl fleet corrected for spatial effort allocation (since 1997)
- The UK beam trawl fleet excluding all flag vessels (between 1990 and 2002)

Effort has decreased in the Dutch beam trawl fleet since the early/mid 1990s. Up until 2002, the age-classes available in both the Dutch and the UK fleets generally show equal trends in LPUE through time.

The WG used both survey data and commercial LPUE data for tuning until the mid 1990s. The commercial LPUE was calculated as the ratio of the annual landings over the total number of fishing days of the fleet. At that time, however, it was realised that the commercial LPUE data of the Dutch beam trawl-fleet, which dominated the fishery, were likely to be biased due to quota restrictions. Vessels were reported to adjust their fishing patterns in accordance to the individual quota available for that year. Fishers reported to leave productive fishing grounds because they lacked the fishing rights and moved to areas with lower catch rates of the restricted species with a bycatch of non-quota, or less restricted species.

A method that corrects for the spatial effort allocation is to calculate LPUEs at a smaller spatial scale, e.g. ICES rectangles, and then calculate the average of these ICES rectangle-specific LPUEs. Age-information is available at this spatial level since 1997, and LPUE series could be used for tuning an age structured assessment method (alternatively, age-aggregated tuning series could be used in other analytical assessment methods than XSA). Only under the assumption that discarding is negligible for the older ages, the LPUE represents CPUE, and this time-series could be used to tune age structured assessment methods.

Also, age-aggregated LPUE series, corrected for directed fishing under a TAC-constraint (see Quirijns and Poos 2007), by area and fleet component, can be used as indication of stock development. Available are

- The Dutch beam trawl fleet (only large cutters with engine powers above 221 kW)
- The UK beam trawl flag vessels landing in the Netherlands (only large cutters with engine powers above 221 kW)
- Several Danish fleets (trawl, gillnet and seines) mainly operating in the Northern area
- Effort of the Dutch beam trawl fleet and of the English beam trawl vessels landing in the Netherlands, by area and fleet component.

B.5 Other relevant data

To be done

C. Historical Stock Development

There are currently two methods that could be used to provide an assessment of North Sea plaice, being XSA, and a model developed by (Aarts and Poos, 2009). The XSA uses the reconstructed discard set described in the catch section. The Aarts and Poos methods estimates the discards from the mortality signals in the surveys, the landings-at-age and the discards-at-age in the most recent period. WKFLAT 2009 suggest to run both models concurrently, in order to estimate the stability of the Aarts and Poos method.

Model used as a basis for advice

The North Sea plaice is based on the XSA stock assessment. Settings for the final assessment are given below:

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1- 10) + (reconstructed) discards based on NL, DK + UK + GE fleets. Discards reconstruction between 1957-1999), observations since 2000
Tuning indices	BTS-Isis 1985-2007 1-8 BTS-Tridens 1996-2007 1-9 SNS 1982-2007 1-3
Plus group	10
First tuning year	1982
Time series weights	No taper
Catchability dependent on stock size for age <	1
Catchability independent of ages for ages >=	6
Survivor estimates shrunk towards the mean F	5 years / 5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

The Aarts and Poos model

Setting/Data	Values/source
Catch at age	Landings (since 1980, ages 1:9) + discards based on observations since 2000 NL, DK + UK + GE fleets (ages 1:8). No reconstruction
Tuning indices	BTS-Isis 1985-2007 1-8 BTS-Tridens 1996-2007 1-9 SNS 1980-2007 1-3
Plus group	No plus group
First tuning survey year	1980
Catchability independent of ages for ages >=	8 (for catches)
Minimum standard error for likelihood function	0.05
Prior weighting	Not applied

D. Short-term Projection

Because the assessment on which the advice is based is currently a fully deterministic XSA, the short term projection can be done in FLR using FLSTF (1.4.3). Weight-at-age in the stock and weight-at-age in the catch are taken to be the average over the last 3 years. The exploitation pattern was taken to be the mean value of the last three years, scaled to F in 2007. The proportion of landings at age was taken to be the mean of the last three years, this proportion was used for the calculation of the discard and human consumption partial fishing mortality. Population numbers at ages 3 and older are XSA survivor estimates.

Numbers at age 2 are based on RCT3 estimates if the estimates from RCT3 show sufficient consistency.

Numbers at age 1 and recruitment of the incoming year-class are taken from the long-term geometric mean of age 1 assessment estimates, where the most recent 4 years are removed from the time-series. The management options are given for three different assumptions on the F values in the intermediate year;

a) F is assumed to be equal to the estimate for F in the final year of the assessment,

b) F is 0.9 times F in the final year of the assessment, and

c) F is set such that the landings in the intermediate year are equal to the TAC of that year.

E. Medium-Term Projections

Generally, no medium term projections are done for this stock.

F. Long-Term Projections

Generally, no medium term projections are done for this stock.

G.Biological Reference Points

The current reference points were established by the WGNSSK in 2004, when the discard estimates were included in the assessment for the first time. The stock/recruitment relationship for North Sea plaice did not show a clear breakpoint where recruitment is impaired at lower spawning stocks. Therefore, ICES considered that **Blim** be set at 160 000 t and that **Bpa** then be set at 230 000 t using the default multiplier of 1.4. **Flim** was set at **Floss** (0.74). **Fpa** was proposed to be set at 0.6 which is the 5th percentile of **Floss** and gave a 50% probability that SSB is around **Bpa** in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 t. In 2008, a target F was added to the reference points, based on the F stated in the long term management plan for plaice and sole. This target F is supposedly based on an estimates of F_{msy}.

	Type	Value	Technical basis
Precautionary approach	Blim	160 000 t	Bloss = 160 000 t, the lowest observed biomass in 1997 as assessed in 2004.
	Bpa	230 000 t	Approximately 1.4 Blim.
	Flim	0.74	Floss for ages 2–6.
	Fpa	0.60	5th percentile of Floss (0.6) and implies that Beq>Bpa1) and a 50% probability that SSBMT ~ Bpa.

Targets	Fmgt	0.3	EU management plan

(unchanged since 2004, target added in 2008)

The F_{msy}, F_{max} and $F_{0.1}$ should be estimated given the 10 most recent years of the stock assessment.

H. Other Issues

None identified

I. References

AARTS, G. and POOS, J. J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science, 66.

AARTS, G. and VAN HELMOND, A. T. M. 2007. Discard sampling of Plaice (*Pleuronectes platessa*) and Cod (*Gadus morhua*) in the North Sea by the Dutch demersal fleet from 2004 to 2006. ICES Document Report number C120/07. 42 pp.

BEVERTON, R. J. H. and HOLT, S. J. 1957. On the dynamics of exploited fish populations, Her Majesty's Stationery Office, London (UK).

BOLLE, L. J., HUNTER, E., RIJNSDORP, A. D., PASTOORS, M. A., METCALFE, J. D. and REYNOLDS, J. D. 2005. Do tagging experiments tell the truth? Using electronic tags to evaluate conventional tagging data. ICES Journal of Marine Science, 62: 236-246.

DE VEEN, J. F. 1978. On selective tidal transport in the migration of North Sea plaice (*Pleuronectes platessa* L.) and other flatfish species. Netherlands Journal of Sea Research, 12: 115-147.

DUNN, M. R. and PAWSON, M. G. 2002. The stock structure and migrations of plaice populations on the west coast of England and Wales. Journal of Fish Biology, 61: 360-393.

GRIFT, R. E., HEINO, M., RIJNSDORP, A. D., KRAAK, S., B. M. and DIECKMANN, U. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Marine Ecology Progress Series, 334: 213–224.

GRIFT, R. E., RIJNSDORP, A. D., BAROT, S., HEINO, M. and DIECKMANN, U. 2003. Fisheries-induced trends in reaction norms for maturation in North Sea plaice. Marine Ecology Progress Series, 257: 247-257.

HOARAU, G., PIQUET, A. M.-T., VAN DER VEER, H. W., RIJNSDORP, A. D., STAM, W. T. and OLSEN, J. L. 2004. Population structure of plaice (Pleuronectes platessa L.) in northern Europe: a comparison of resolving power between microsatellites and mitochondrial DNA data. Journal of Sea Research, 51: 183-190.

KELL, L. T. and BROMLEY, P. J. 2004. Implications for current management advice for North Sea plaice (*Pleuronectes platessa* L.): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research, 51: 301-312.

KELL, L. T., SCOTT, R. and HUNTER, E. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research, 51: 287-299.

RIJNSDORP, A. D. 1991. Selection differentials of male and female North Sea plaice Pleuronectes platessa L. and changes in maturation and fecundity. *In* The exploitation of evolving populations. Ed. by R. LAW, T. K. A. STOKES and J. M. MCGLADE. Springer Verlag.

RIJNSDORP, A. D., DAAN, N. and DEKKER, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES Journal of Marine Science, 63: 556-566.

RIJNSDORP, A. D. and PASTOORS, M. A. 1995. Modelling the spatial dynamics and fisheries of North Sea plaice (*Pleuronectes platessa* L.) based on tagging data. ICES Journal of Marine Science, 52: 963-980.

VAN BEEK, F. A. 1998. Discarding in the Dutch beam trawl fishery. ICES CM 1998/ BB:5: 1-15.

VAN KEEKEN, O. A., QUIRIJNS, F. J. and PASTOORS, M. A. 2004. Analysis of discarding in the Dutch beamtrawl fleet. 96 p. pp.

VAN KEEKEN, O. A., VAN HOPPE, M., GRIFT, R. E. and RIJNSDORP, A. D. 2007. Changes in the spatial distribution of North Sea plaice (*Pleuronectes platessa*) and implications for fisheries management. Journal of Sea Research, 57: 187-197.

VORBERG, R., BOLLE, L. J., JAGER, Z. and NEUDECKER, T. 2005. Chapter 8.6 Fish. *In* Wadden Sea Quality Status Report 2004.

Beek, F.A. van, Leeuwen, P.I. van, and Rijnsdorp, A.D. (1990) On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research 26: 151-160.

Broadhurst, M.K., Suuronen, P., and Hulme, A. (2006). Estimating collateral mortality from towed fishing gear. Fish and Fisheries 7: 180-218.

Bult, T.P., and Schelvis-Smit, A.A.M. (2007) Een verkenning van de mogelijkheden van outriggen door vissers uitgevoerd, in het kader van het Advies van de "Task Force Duurzame Noordzeevisserij". IMARES Report C022.07, 34 pp.

Chopin, F, Inoue, Y and Arimoto, T (1996) Development of a catch mortality model. Fisheries Research 25: 377-382.

Stock Annex Plaice in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock Plaice in division VIId

Date: 05/03/2010

Revised by Joël Vigneau (Joel.Vigneau@ifremer.fr) and Youen Vermard (Youen.Vermard@ifremer.fr)

Initial Contributors Richard Millner (r.s.millner@cefas.cu.uk) and Joël Vigneau (Joel.Vigneau@ifremer.fr) 05/03/2003

A. General

A.1. Stock definition

The management area for this stock is strictly that for ICES area VIId called the eastern Channel, although the TAC area includes the smaller component of VIIe (western Channel).

Major spawning centres were found in the eastern English Channel, the Southern Bight, the central North Sea and the German Bight. Other less important local spawning centres were found in the western English Channel and off the UK coast from Flamborough Head northwards to Moray Firth (Houghton & Harding 1976, Harding & Nichols 1987 in ICES PGEGGS, 2003c). The regions of plaice spawning are generally confined within the 50-meter depth contour (Harding *et al*. 1978, in ICES PGEGGS, 2003c).

The stocks of plaice in the Channel and North Sea are known to mix greatly (Figure 1), especially during the spawning season (January-February). At this time many western Channel and North Sea plaice may be found in the eastern Channel. The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance.

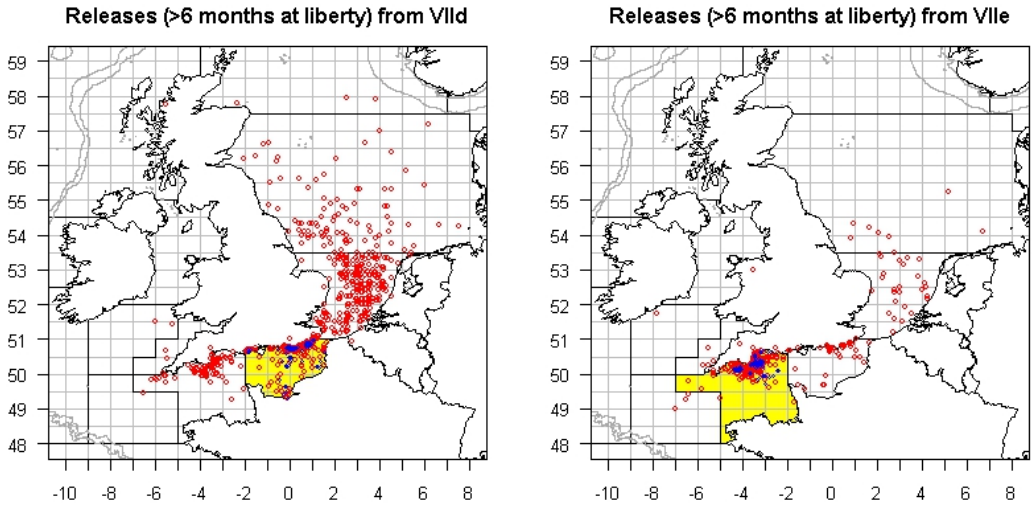


Figure 1 : Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

From tagging experiments, it was possible to derive estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV (Table 1). In summary, 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend the summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern English Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*. 2004).

Release Information		period			WEIGHTED BY INTN CATCH AND SSB pr(recap) after 6 or more months at liberty			
DIV	Sex	Release	Recapture	N	7A	7E	7D	4
VIIe	B	ALL		564	0.001	**0.90**	0.06	0.04
	M	Jan-Mar		2	0	**0.74**	0.26	0
	F			3	0	**0.60**	0.40	0
	M	Apr_Dec		180	0	**0.91**	0.05	0.03
	F			224	0.001	**0.93**	0.03	0.04
	M	Jan-Mar	Apr_Dec	17	0	**0.66**	0.11	0.23
	F			8	0	**0.67**	0.24	0.09
	M	Apr_Dec	Jan-Mar	68	0	**0.83**	0.12	0.05
	F			62	0	**0.88**	0.07	0.06
VIId	B	ALL		990	0.00	0.10	**0.54**	0.36
	M	Jan-Mar		31	0	0.04	**0.73**	0.22
	F			86	0	0.08	**0.58**	0.34
	M	Apr_Dec		144	0	0.10	**0.76**	0.14
	F			180	0	0.09	**0.79**	0.12
	M	Jan-Mar	Apr_Dec	144	0	0.14	**0.35**	0.52
	F			305	0	0.09	**0.33**	0.58
	M	Apr_Dec	Jan-Mar	31	0	0.20	**0.57**	0.23
	F			63	0	0.11	**0.72**	0.17
IVc	B	ALL		812	0	0.01	0.06	**0.93**
	M	Jan-Mar		54	0	0	0.03	**0.97**
	F			17	0	0	0.28	**0.72**
	M	Apr_Dec		172	0	0.01	0.06	**0.92**
	F			235	0	0.01	0.04	**0.95**
	M	Jan-Mar	Apr_Dec	102	0	0	0	**1**
	F			38	0	0	0	**1**
	M	Apr_Dec	Jan-Mar	54	0	0.02	0.05	**0.93**
	F			71	0	0.01	0.18	**0.80**

Table 1 : Summary of estimated movement probabilities for plaice (≥ 270mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

A.2. Fishery

Plaice is mainly caught in beam trawl and gillnet fisheries for sole or in mixed demersal fisheries using otter trawls. There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. The Belgian beam trawlers fish mainly in the 1st and 4th quarters and their area of activity covers almost the whole of VIId south of the 6 mile contour from the English coast. There is only light activity by this fleet between April and September. The second offshore fleet is mainly large otter trawlers from Boulogne, Dieppe and Fecamp. The target species of these vessels are cod, whiting, plaice, gurnards and cuttlefish and the fleet operates throughout VIId. The inshore trawlers and netters are mainly vessels <12m operating on a daily basis within 12 miles of the coast. There are a large number of these vessels (in excess of 400) operating from small ports along the French and English coast. These vessels target sole, plaice, cod and cuttlefish.

The minimum landing size for plaice is 27cm. Minimum mesh sizes for demersal gears permitted to catch plaice are 80mm for beam trawling and 100mm for otter trawlers. Fixed nets are required to use 100mm mesh since 2002 although an exemption to permit 90mm has been in force since that time.

There is widespread discarding of plaice, especially from beam trawlers. The 25 and 50% retention lengths for plaice in an 80mm beam trawl are16.4cm and 17.6cm respectively which are substantially below the MLS. Routine data on discarding is now available, and show plaice discards ratio between 20 and 60% depending on the metier. Discard survival from small otter trawlers can be in excess of 50% (Millner *et al*., 1993). In comparison discard survival from large beam trawlers has been found to be between less than 20% after a 2h haul and up to 40% for a one-hour tow (van Beek *et al* 1989).

A.3. Ecosystem aspects

Biology : Adult plaice feed essentially on annelid polychaetes, bivalve molluscs, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel, spawning occurs from December to March between 20 and 40 m. depth. At the beginning, pelagic eggs float at the surface and then progressively sink into deeper waters during development. Hatching occurs 20 (5-6°C) to 30 (2-2.5°C) days after fertilization. Larvae spend about 40 days in the plankton before migrating to the bottom and moving to coastal waters when metamorphosing (10-17 mm). The fry undergo relatively fast growth during the first year (*Carpentier et al., 2005*).

Environment: This bentho-demersal species prefers living on sand but also gravel or mud bottoms, from the coast to 200 m depth. The sepcies is found from marine to brackish waters in temperate climate (*Carpentier et al., 2005*)..

Geographical distribution : Northeast Atlantic, from northern Norway and Greenland to Morocco, including the White Sea; Mediterranean and Black Seas (*Carpentier et al., 2005*)..

Vaz *et al*. (2007) used a multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature (Vaz *et al*, 2004). One Group was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry. It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

Community evolution over time : (From Vaz *et al*., 2007). The community relationship with its environment was remarkably stable over the 17 y of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

More details on biology, habitat and distribution of plaice in VIId from the Interreg 3a project CHARM II, may be found in Annex 1.

B. Data

B.1. Commercial catch

The landings are taken by three countries France (55% of combined TAC), England (29%) and Belgium (16%). Quarterly catch numbers and weights were available for a range of years depending on country; the availability is presented in the text table below. Levels of sampling prior to 1985 were poor and these data are considered to be less reliable. In 2001 international landings covered by market sampling schemes represented the majority of the total landings

Belgian commercial landings and effort information by quarter, area and gear are derived from log-books. Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium). Quarterly sampling of landings takes place at the auctions of Zeebrugge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours. Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level. The ALK is used to obtain the quarterly age distribution from the length distribution. From 2003, an on-board sampling programme is routinely carried out following the provision of the EU Regulation 1639/2001.

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10m and from sales declaration forms for vessels under 10m. These self declared production data are then linked to the auction sales in order to have a complete and precise trip description. The collection of discard data began in 2003 within the EU Regulation 1639/2001. This first year of collection was incomplete in terms of time coverage, therefore the use of these data should be c considered only from 2005. The length measurements were done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne until 2008. From 2009, concurrent sampling by metier was initiated following the provisions of EU Regulation 95/2008. Otoliths samples are taken by quarter throughout the length range of the landed catch for quarters 1 to 3 and from the October GFS survey in quarter 4. These are aged and combined to the quarterly level and the age-length key thus obtained is used to transform the quarterly length compositions. The lengths not sampled during one quarter are derived from the same year in the nearest available quarter. Weight, sex and maturity at length and at age are obtained from the fish sampled for the age-length keys.

English commercial landings in tonnes by quarter, area and gear are derived from the sales notes statistics for vessels under 12m that do not complete logbooks. For those over 12m (or >10m fishing away for more than 24h), data is taken from the EC logbooks. Effort and gear information for the vessels <10m is not routinely collected and is obtained by interview and by census. No information is collected on discarding from vessels <10m. Discarding from vessels >10m has been obtained since 2002 under the EU Data Collection Regulation.

The gear group used for length measurements are beam trawl, otter trawl and net.

Separate-sex length measurements are taken from each of the gear groupings by trip. Trip length samples are combined and raised to monthly totals by port and gear group. Months and ports are then combined to give quarterly total length compositions by gear group; unsampled port landings are added in at this stage. Quarterly length compositions are added to give annual totals by gear. These are for reference only, as ALK conversion takes place at the quarterly level. Otoliths samples are taken by 2cm length groups separately for each sex throughout the length range of the landed catch. These are aged and combined to the quarterly level, and include all ports, gears and months. The quarterly sex-separate age-length-keys are used to transform quarterly length compositions by gear group to quarterly age compositions.

A minimum of 24 length samples are collected per gear category per quarter. Age samples are collected by sexes separately and the target is 300 otoliths per sex per quarter. If this is not reached, the 1st and 2nd or 3rd and 4th quarters are combined.

The text table below shows which country supplies which kind of data:

Country	Numbers	Weights-at-age
Belgium	1981-present	1986-present
France	1989- present	1989- present
UK	1980- present	1989- present

Data are supplied as FISHBASE files containing quarterly numbers at age, weight at age, length at age and total landings. The files are aggregated by the stock co-ordinator to derive the input VPA files in the Lowestoft format. No SOP corrections are applied to the data because individual country SOPs are usually better than 95%. The quarterly data files by country can be found with the stock co-ordinator The resulting files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format,.

B.2. Biological

Natural mortality : assumed constant over ages and years at 0.1, as for plaice in the North Sea.

Maturity ogive : assumes that 15% of age 2, 53% of age 3 and 96% of age 4 are mature and 100% for ages 5 and older.

Weights at age: prior to 2001, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. From 2001, second quarter catch weights were used as stock weights in order to be consistent with North Sea plaice. The database was revised back to 1990.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

B.3. Surveys

A dedicated 4m beam trawl survey for plaice and sole has been carried out by England using the RV Corystes since 1988. The survey covers the whole of VIId and is a depth stratified survey with most samples allocated to the shallower inshore stations where the abundance of sole is highest. In addition, inshore small boat surveys using 2m beam trawls were undertaken along the English coast and in a restricted area of the Baie de Somme on the French coast. In 2002, The English and French Young Fish Surveys were combined into an International Young Fish Survey. The dataset was revised for the period back to 1987. The two surveys operate with the same gear (beam trawl) during the same period (September) in two different nursery areas. Previous analysis (Riou *et al*, 2001) has shown that asynchronous spawning occurs for flatfish in Division VIId. Therefore both surveys were combined based on weighting of the individual index with the area nursery surface sampled (Cf. Annex 1). Taking into account the low, medium, and high potential area of recruitment, the French YFS got a weight index of 55% and the English YFS of 45%. The UK Young Fish Survey ceased in 2006, disrupting the ability to derive an International YFS.

A third survey consists of the French otter trawl groundfish survey (FR GFS) in October. Prior to 2002, the abundance indices were calculated by splitting the survey area into five zones, calculating a separate index for each zone each zone, and then averaging to obtain the final GFS index. This procedure was not thought to be entirely satisfactory, as the level of sampling was inconsistent across geographical strata. A new procedure was developed based on raising abundance indices to the level of ICES rectangles, and then by averaging those to calculate the final abundance index. Although

there are only minor differences between the two indices, the revised method was used in 2002 and subsequently.

B.4. Commercial CPUE

Three commercial fleets have been used in tuning: UK and Belgian Beam Trawlers and French Otter Trawlers.

The effort of the French otter trawlers is obtained by the log-book information on the duration of the fishing time weighted by the engine power (in KW) of the vessel. Only trips where sole and/or plaice have been caught is accounted for. The effort of the Belgian Beam Trawlers is corrected for engine power.

B.5. Other relevant data

None.

C. Historical Stock Development

Benchmark 2010

This stock was 'benchmarked' at the WKFLAT 2010 meeting where two main issues have been under review, (i) inclusion of a discards time series in the assessment and (ii) an attempt to overcome the problematic retrospective pattern. Solutions explored included making an 'allowance' for migration patterns between the two Channel plaice stocks and the southern North Sea.

The combined assessment of the two Channel plaice stocks was examined. It was agreed that this would require further investigation as the inclusion of the North Sea stock would also need to be considered. Any combining of stocks would a have a wide ranging impact on the assessment and any subsequent management.

The issue of including discard estimates was based on a working document provided to the benchmark workshop, where all on-board samples from Belgium, France and UK from 2002 to 2008 were gathered in an international dataset. An estimate of annual discards at age was produced for the period 2004 – 2008, and the flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) has been tested for reconstructing discards prior to 2004. The model did not succeed in providing reasonable and robust fit. The current discard time series was considered too short and too variable to support proper model fitting. Further work on the data and method used for estimating the 2004-2008 series of discards is necessary before inclusion in the statistical model is considered further.

The persistent retrospective pattern in the assessment without discards was largely reduced, when 65% of quarter 1 catches were removed as well as removal of younger ages (1, 2 and 3) from the survey UK BTS. The patterns in log q residuals, already shown in the previous assessment remained unchanged.

In conclusion, the proposed final settings (detailed below) improve the retrospective pattern, and take into account the acknowledged mixing between neighbouring areas, but the model is not entirely satisfactory in terms of quality of the assessment. The reasons are that the model still does not account for discards, removes younger ages from an internally consistent survey, and does not provide solutions for the patterns in log catchability residuals.

The recommendation from WKFLAT is that **this assessment is useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F**. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.

Since further work on including the discard estimates, on the relevance of the commercial tuning series, and sensitivity of the assessment to the 65% adjustment to the Q1 catch at age need to be examined, the information concerning the settings of the assessment model is only valid for WGNSSK 2010.

Model used: XSA

Software used: IFAP / Lowestoft VPA suite for final assessment; FLR packages and SURBA software for exploratory analysis

Model Options chosen:

1) Tapered time weighting not applied

2) Catchability independent of stock size for all ages

3) Catchability independent of age for ages >= 7

4) Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

5) S.E. of the mean to which the estimate are shrunk = 1.0

6) Minimum standard error for population estimates derived from each fleet = 0.300

7) Prior weighting not applied

8) Input data types and characteristics:

9) Catch data available for 1980-present year. However, there was no French age compositions before 1986 and large catchability residuals were observed in the commercial data before 1986. In the final analyses only data from 1986-present were used in tuning.

10) Removal of 65% of quarter 1 catches in tonnes, catches at age and weight at age for all years

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1980-Last yr	1-10+	No
Canum	Catch at age in numbers	1980-Last yr	1-10+	No
Weca	Weight at age in the commercial catch	1980-Last yr	1-10+	No
West	Weight at age of the spawning stock at spawning time.	1980-Last yr	1-10+	No
Mprop	Proportion of natural mortality before spawning	1980-Last yr	1-10+	No
Fprop	Proportion of fishing mortality before spawning	1980-Last yr	1-10+	No
Matprop	Proportion mature at age	1980-Last yr	1-10+	No
Natmor	Natural mortality	1980-Last yr	1-10+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	UK BeamTrawl	Excluded	
Tuning fleet 2	BE Beam Trawl	1981 – Last yr	2-10+
Tuning fleet 3	FR Otter Trawl	Excluded	
Tuning fleet 4.	UK BTS	1988 – Last yr	4-6
Tuning fleet 5	FR GFS	1988 – Last yr	2-3
Tuning fleet 6	Int YFS	1987-2006	1

D. Short-Term Projection

Short term projection were done using the ICES 2012 recommendations

Model used: Age structured

Software used: FLR package

Initial stock size:

1) the survivors at age 2 and greater from the XSA assessment
2) N at age 1 = geometric mean over a long period (1998, last data year)

Maturity: same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages and all years

Weight at age in the stock: average stock and catch weights over the preceding 3 years.

Weight at age in the catch: average stock and catch weights over the preceding 3 years.

Exploitation pattern: The F vector used will be the average F-at-age in the last 3 years, scaled by the Fbar (2-6) to the level of last year.

Intermediate year assumptions:

Stock recruitment model used: None, the long term geometric mean recruitment at age 1 is used

Procedures used for splitting projected catches:

E. Medium-Term Projections

No Medium-Term Projections can be done for this stock, until the quality of the assessment is improved.

F. Long-Term Projections

No Long-Term Projections can be done for this stock, until the quality of the assessment is improved.

G. Biological Reference Points

Previous Reference Points:

Blim = 5400 t.

Bpa = 8000 t.

Flim = 0.54

Fpa = 0.45

The current assessment is indicative for trends only, therefore the biological reference points are not valid anymore for being used in the advice.

H. Other Issues

I. References

Beek, F.A. van, Leeuwen, P.I. van and Rijnsdorp, A.D. 1989. On the survivalof plaice and sole discards in the otter trawl and beam trawl fisheries in the North Sea. ICES C.M. 1989/G:46, 17pp

Carpentier, A., Vaz, S., Martin, C. S., Coppin, F., Dauvin, J.- C., Desroy, N., Dewarumez, J.- M., Eastwood, P. D., Ernande, B., Harrop, S., Kemp, Z., Koubbi, P., Leader-Williams, N., Lefèbvre, A., Lemoine, M., Loots, C., Meaden, G. J., Ryan, N., Walkey, M., 2005. Eastern Channel Habitat Atlas for Marine Resource Management (CHARM), Atlas des Habitats des Ressources Marines de la Manche Orientale, INTERREG IIIA, 225 pp.

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management,final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom. http://www.ifremer.fr/docelec/doc/2009/rapport-7377.pdf

ICES 2003a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 2002. ICES CM 2003/ACFM:02

ICES 2003b. Report of the Study Group on Precautionary Reference Points For Advice on Fishery Management ICES CM 2003/ACFM:15

ICES, 2003c. Planning Group on North Sea Cod and Plaice Egg Surveys in the North Sea (PGEGGS). Ijmuiden, Netherlands. 24–26 June 2003 ICES CM 2003/G:06 Ref. D. 45 p.

Kell, L.T., Scott, R., and Hunter E. (2004) Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51: 287– 299

Millner, R.S., Whiting, C.L and Howlett, G.J. 1993. Estimation of discard mortality of plaice from small otter trawlers using tagging and cage survival studies. ICES C.M. 1993/G:24, 6pp

Pawson, M.G. (1995) Biogeographical identification of English Channel fish and shellfish stocks. Fisheries Research Technical Report No. 99. MAFF Directorate of Fisheries Research, Lowestoft. http://www.cefas.co.uk/Publications/techrep/tech99.pdf

Riou *et al*. 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel : application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125-135

ICES 2012. Report of the Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). ICES CM 2012/ACOM:36

Appendix 1 – ELEMENTS OF BIOLOGY ON PLAICE VIId.

Excerpts from the project InterReg 3A CHARM Phase II.

Pleuronectes platessa

Linnaeus,1758

Plie commune
European plaice

Embranchement-Phylum : Chordata
Classe-Class : Actinopterygii
Ordre-Order : Pleuronectiformes
Famille-Family : Pleuronectidae



© IFREMER

Biologie - La plie commune adulte se nourrit de polychètes, de mollusques bivalves, de cœlentérés, de crustacés, d'échinodermes et de petits poissons. En Manche, la reproduction s'étale de décembre à mars sur des fonds de 20 à 40 m de profondeur, avec un pic en janvier-février. En général, les œufs flottent tout d'abord à la surface avant de s'enfoncer progressivement dans la colonne d'eau au cours du développement. L'éclosion a lieu environ 20 (à 5-6°C) à 30 jours (à 2-2.5°C) après fécondation. Les larves ont alors une vie pélagique durant une quarantaine de jours avant de se métamorphoser (lorsque 10-17 mm de longueur) et de rejoindre le fond pour migrer vers les eaux littorales. La croissance en première année est assez élevée.

Caractères démographiques - Taille maximale 100 cm ; taille commune 25-45 cm ; taille minimale de capture 22 cm sauf Skagerrak et Kattegat 27 cm (UE) ; longévité maximale 50 ans ; âge et taille à maturité 2-7 ans et 18-35 cm ; paramètres de von Bertalanffy : taille asymptotique L_{inf} =71.65 cm, taux de croissance k = 0.23 an^{-1}, âge théorique t_0 = -0.83 ; paramètres de fécondité *alpha* = 2.33 ovules.cm^{-beta} et *beta* = 3.10 (50 000 à 500 000 ovules par femelle).

Environnement - Espèce bentho-démersale vivant préférentiellement sur les fonds sableux mais aussi graveleux ou vaseux de la côte jusqu'à 200 m de profondeur, et se répartissant dans les eaux salées à saumâtres tempérées.

Répartition géographique - Atlantique nord-est, du nord de la Norvège et du Groenland au Maroc ; mer Méditerranée, dont la mer Noire.

Biology - Adult plaice essentially feed on polychaetes, bivalves, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel spawning occurs from December to March at depths ranging from 20 to 40 m, with a peak in January-February. Initially, pelagic eggs generally float at the surface. They then progressively sink into deeper waters during their development. Hatching occurs around 20 (at 5-6°C) to 30 (at 2-2.5°C) days after fertilisation. Larvae spend about 40 days in the plankton before metamorphosing (when 10-17 mm in length). They then move to the bottom and migrate towards coastal waters. The fry undergoes relatively fast growth during the first year.

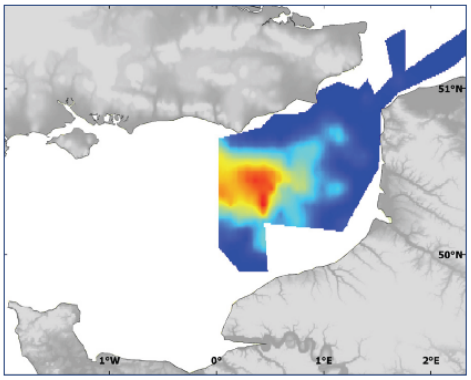
Life history parameters - Maximum length 100 cm; common length 25-45 cm; minimum landing size 22 cm except in Skaggerak and Kattegat 27 cm (EU); maximum lifespan 50 years; age and length at maturity 2-7 years and 18-35 cm; von Bertalanffy para-meters: asymptotic length L_{inf} = 71.65 cm, growth rate k = 0.23 $year^{-1}$, theoretical age t_0 = -0.83; fecundity parameters *alpha* = 2.33 oocytes.cm^{-beta} and *beta* = 3.10 (50,000 to 500,000 oocytes per female).

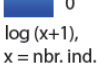
Environment - This bentho-demersal species prefers to live on sand but also on gravely or muddy substrates, from the coast to 200 m in depth. The species is found in marine to brackish temperate waters.

Geographical distribution - North-east Atlantic, from northern Norway and Greenland down to Morocco; Mediterranean including the Black Sea.

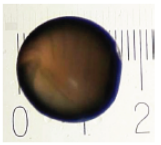
Œufs / Eggs - Pleuronectes platessa

Abondance en janvier (IBTS, 2007)
Abundance in January (IBTS, 2007)



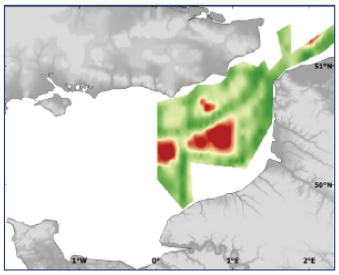


log (x+1),
x = nbr. ind.
/ 20 m³



stade 1
stage 1

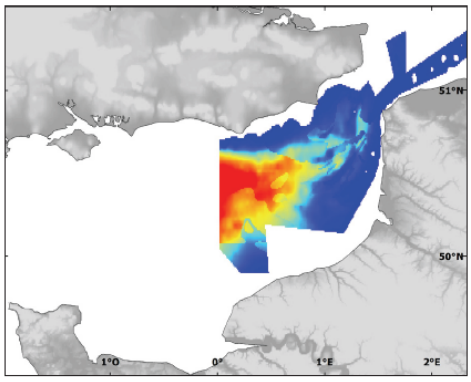
Erreur de krigeage
Kriging error



élevé/*high*

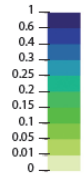
faible/*low*

Habitat préférentiel en janvier (GLM)
Preferential habitat in January (GLM)

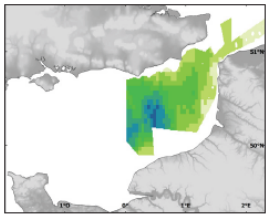


élevé/*high*

faible/*low*



Erreur du modèle / *Model error*



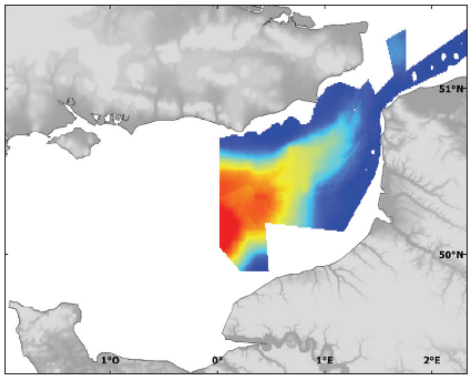
DEP	+2
STR	-
TMP	+
SAL	
CHL	+
SED	

0/1 GLM

DEP	
STR	
TMP	2
SAL	
CHL	
SED	CS M - G - FS - P

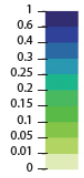
+ GLM

Habitat potentiel en janvier (RQ)
Potential habitat in January (RQ)

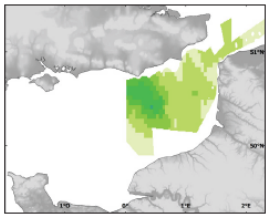


élevé/*high*

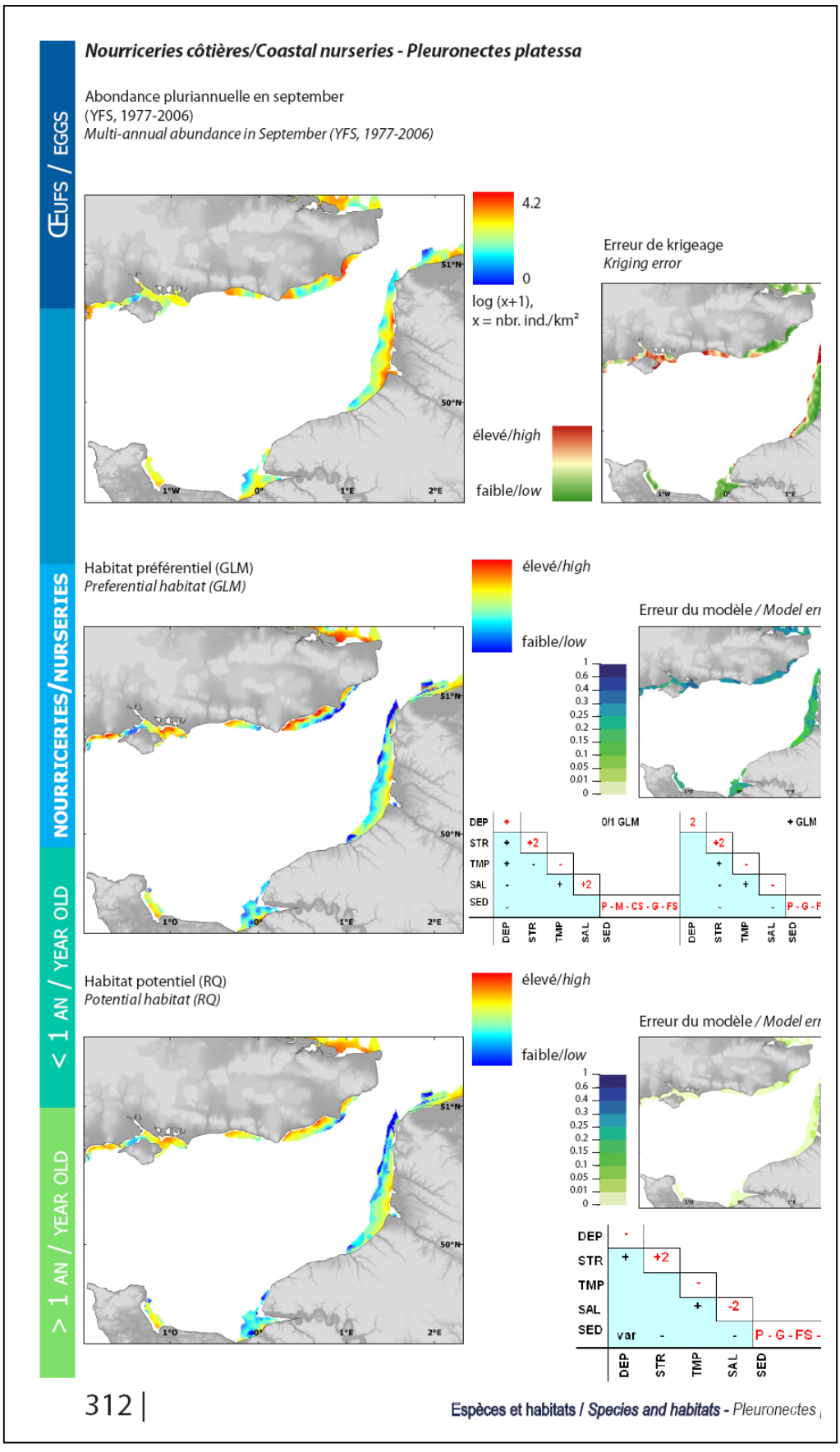
faible/*low*



Erreur du modèle / *Model error*



DEP	+2
STR	-2
TMP	-2
SAL	-2
CHL	+2
SED	CS M - FS - G - P


ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
Nourriceries côtières/Coastal nurseries - Pleuronectes platessa
Abondance pluriannuelle en september
(YFS, 1977-2006)
Multi-annual abundance in September (YFS, 1977-2006)
4.2
0
log (x+1),
x = nbr. ind./km²
élevé/high
faible/low
Erreur de krigeage
Kriging error
Habitat préférentiel (GLM)
Preferential habitat (GLM)
élevé/high
faible/low
Erreur du modèle / Model err
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
P - M - CS - G - FS
P - G - F
Habitat potentiel (RQ)
Potential habitat (RQ)
élevé/high
faible/low
Erreur du modèle / Model err
var
P - G - FS -
51°N
50°N
1°W
0°
1°E
2°E

Pour cette espèce, les données disponibles couvrent presque l'ensemble du cycle de vie (sauf les larves) et les deux saisons pour les individus de moins et plus d'un an.

Œufs

Lors de la campagne IBTS de janvier, la plie est en pleine période de reproduction en Manche orientale. Les œufs de stade 1 récoltés alors suggèrent que les zones de frai sont situées dans les eaux centrales de la Manche orientale, dans des zones relativement profondes. Les abondances sont bien prédites par le modèle d'habitat préférentiel qui situe la zone de frai dans la partie centrale de la Manche donc dans des eaux relativement profondes mais protégées des forts courants de marées. Cependant, l'erreur du modèle est assez importante. Le modèle d'habitat potentiel montre la même zone comme favorable, avec un schéma de distribution un peu plus étendu au niveau des sédiments sableux.

Nourriceries côtières

La carte d'abondance issue des campagnes YFS (septembre) montre une répartition très côtière des individus sur presque toute la zone échantillonnée, avec toutefois des abondances plus fortes en face des baies de Somme, Canche, Authie et Rye. Les modèles d'habitats préférentiel et potentiel sont très semblables et sont en accord avec les abondances des campagnes. Ils favorisent la bande côtière et surtout le large des baies à l'exception notable de la baie de Seine. Les zones optimales pour les nourriceries sont situées dans des zones peu profondes, proches des apports d'eaux douces et froides en cette saison mais qui présentent cependant des sédiments grossiers et où les courants de marées sont relativement forts. Ces zones correspondent vraisemblablement à un front hydrologique côtier potentiellement très productif au niveau benthique.

< 1 an

Les individus de moins d'un an (< 18.0 cm) ont été séparés des autres sur la base de leur taille.

En juillet, les jeunes individus ont été échantillonnés face aux baies de Somme, Canche, Authie, autour de la presqu'île du Cotentin et un peu en baie de Seine, côté français et aux alentours de Dungeness, à l'ouest de l'île de Wight et surtout dans l'estuaire de la Tamise, coté britannique. Ces zones plutôt constantes sont plus ou moins étendues selon l'année d'étude. La carte d'habitat préférentiel n'est pas vraiment en accord avec les distributions observées. Elle favorise des zones très côtières proches des estuaires, sur les côtes française et britannique, hors dans la plupart de ces zones les abondances observées sont très faibles voire nulles. L'incertitude du modèle est plus forte sur les côtes mais très faible dans les zones centrales signifiant qu'il n'y a pratiquement aucune incertitude concernant l'absence de cette espèce à ces endroits. Le modèle d'habitat potentiel propose également des zones côtières mais qui s'étendent plus au large, ce qui est plus en accord avec les distributions observées. Le modèle d'habitat potentiel s'appuie sur de faibles température et tension de cisaillement et sur des sédiments grossiers. L'erreur est nulle sur presque toute la région sauf dans le sud-ouest de la zone étudiée où elle atteint des valeurs assez importantes.

For this species, data are available for almost the entire life cycle (except larvae), and two seasons for individuals of less and more than one year.

Eggs

The IBTS survey takes place during the reproductive period of plaice in the eastern English channel. Stage 1 eggs sampled during the survey indicate that spawning areas were located in the central eastern English channel, in relatively deep areas. Survey abundance levels were accurately predicted by the preferential habitat which showed spawning areas as being located in the central Channel, in fairly deep areas protected from strong tidal currents. Nevertheless, the model errors were high. The potential habitat model showed the same areas as favourable, though favourable habitats included sandy areas.

Coastal nurseries

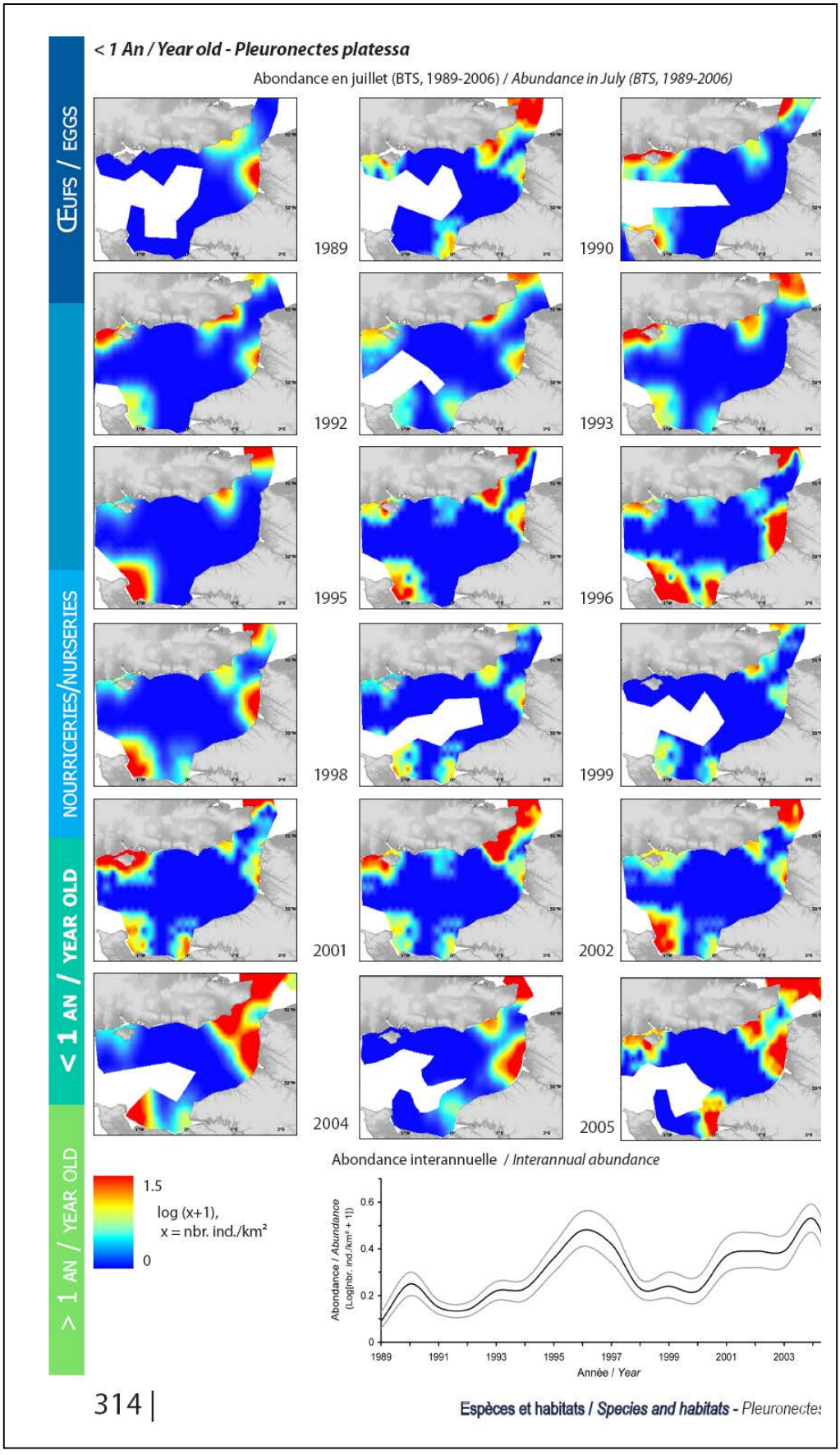
The multi-annual abundance map from the YFS surveys (September) indicates a very coastal spatial distribution of plaice across the sampled area, with some high abundance areas in front of the Bays of Somme, Canche, Authie and Rye. The potential and preferential habitat models are very similar and agree with the survey abundance levels. They both favour the coast and bays, with the exception of the Bay of Seine. Suitable sites for nurseries are located in shallow areas, close to fresh and cool seasonal water inputs. These areas are characterised by coarse sediments and strong tidal currents, i.e. corresponding to a coastal hydrological front, potentially very productive at the benthic level.

< 1 year old

Individuals of less than one year were defined as such on the basis of their length (< 18.0 cm).

On the French side, young individuals were found off the Bays of Somme, Canche, Authie, around the Cherbourg Peninsula and a few in the Bay of Seine, in July. On the British side, they were located around Dungeness, west of the Isle of Wight and especially in the Thames estuary. The areas covered varied in size over time. The preferential habitat model did not really agree with the survey distribution. It favours very coastal zones near to estuaries on both French and British coasts but in most of these areas survey abundance levels were very low and sometimes null. The model uncertainty was higher on the coasts but very low in central areas which means that there is almost no uncertainty about the spatial extent of areas where this species is absent. The potential habitat model highlights coastal areas extending offshore as favourable, which is more coherent with survey distributions. The potential habitat model highlights areas of low temperature, weak bed shear stress and coarse sediments. The model error was almost null across the region except in the south-west, where it could reach high values.

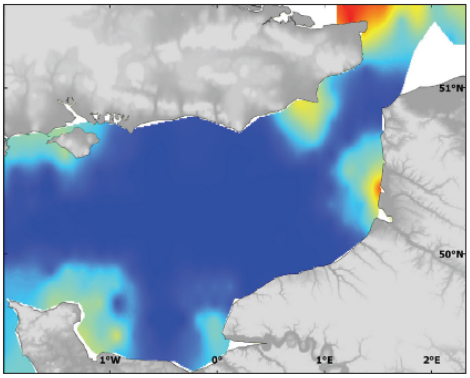
In October, the distribution of young plaice was more spatially restricted than in July, and seemed to be concentrated the Bays of Somme, Canche, Authie and Seine. Some young individuals were also found around the Cherbourg Peninsula. Occurrence areas of young plaice did not change a lot between July and October. The kriging error was more important in the north-west of the study area, where observa-


< 1 An / Year old - Pleuronectes platessa
Abondance en juillet (BTS, 1989-2006) / Abundance in July (BTS, 1989-2006)
ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
1989
1990
1992
1993
1995
1996
1998
1999
2001
2002
2004
2005
1.5
log (x+1),
x = nbr. ind./km²
0
Abondance interannuelle / Interannual abundance
Abondance / Abundance
(Log(nbr. ind./km² + 1))
0
0.2
0.4
0.6
1989
1991
1993
1995
1997
1999
2001
2003
Année / Year

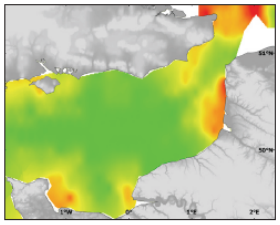
< 1 An / Year old - Pleuronectes platessa

Abondance moyenne en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)



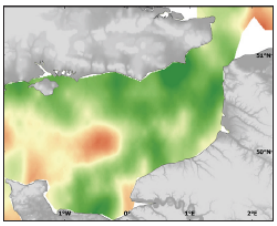


Ecart-type / *Standard deviation*



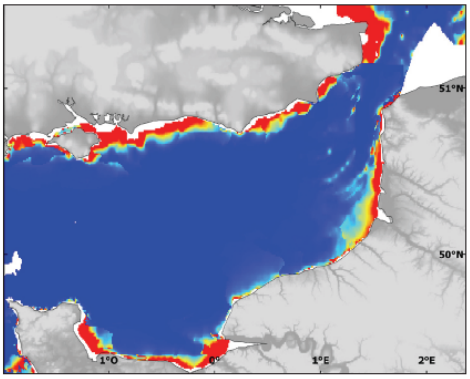
élevé/*high*
faible/*low*

Erreur de krigeage / *Kriging error*

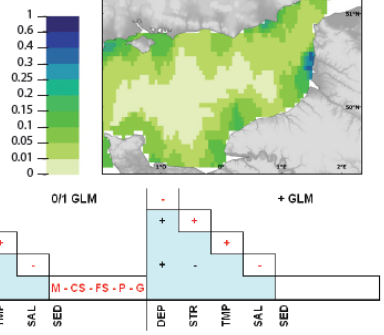


élevé/*high*
faible/*low*

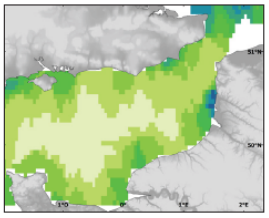
Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)



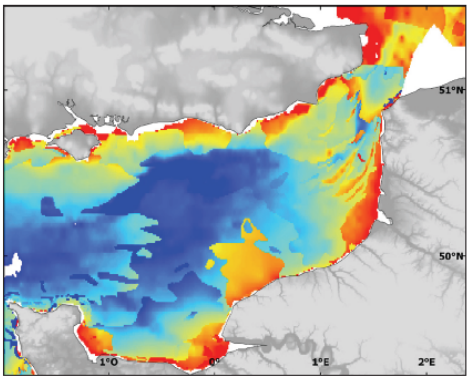
élevé/*high*
faible/*low*



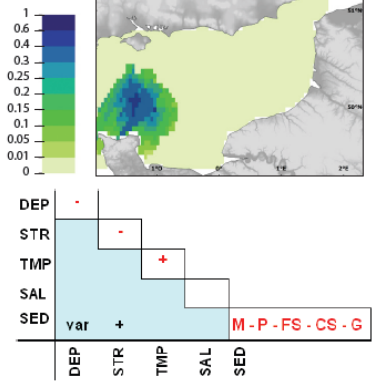
Erreur du modèle / *Model error*



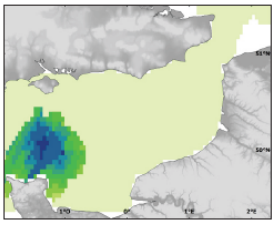
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)

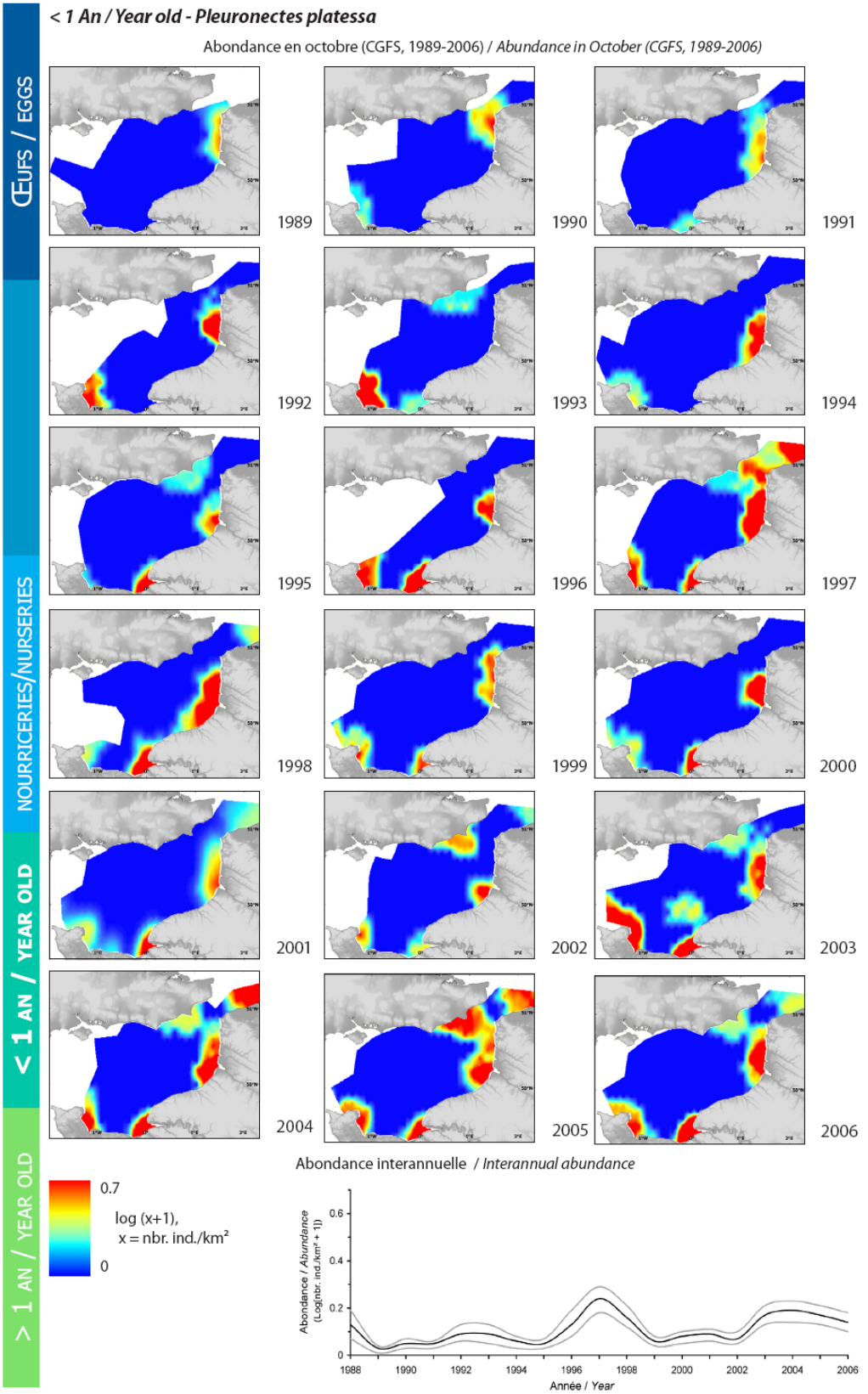


élevé/*high*
faible/*low*



Erreur du modèle / *Model error*



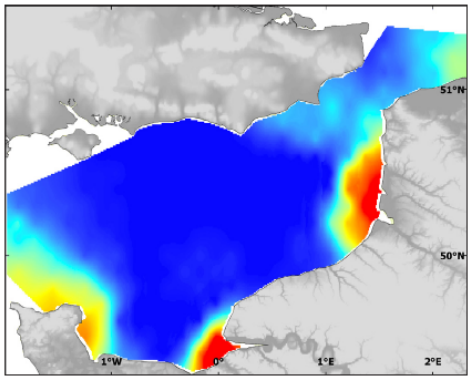


Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

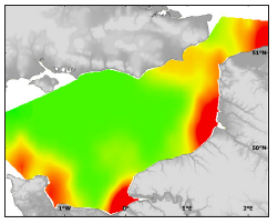
< 1 An / Year old - Pleuronectes platessa

Abondance moyenne
en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)

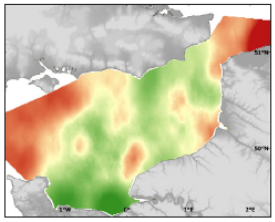




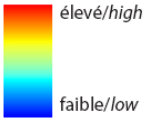
Ecart-type / *Standard deviation*

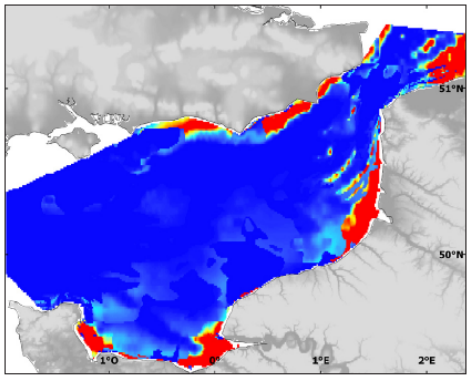


Erreur de krigeage / *Kriging error*

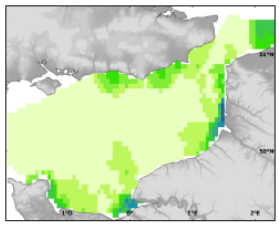


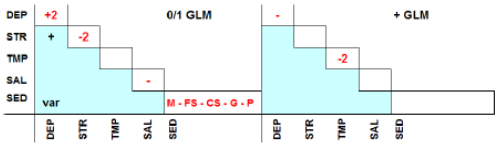
Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)



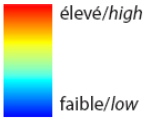


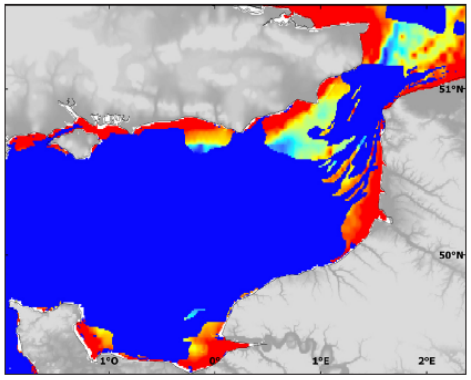
Erreur du modèle / *Model error*



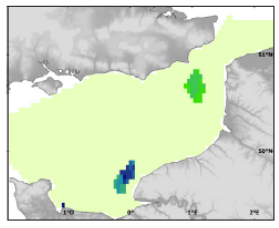


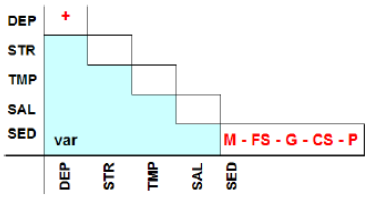
Habitat potentiel enoctobre (RQ)
Potential habitat in October (RQ)





Erreur du modèle / *Model error*





En octobre, la distribution des jeunes plies est moins étendue qu'en juillet et les individus semblent s'être concentrés au large des baies de Somme, Canche, Authie et Seine. On retrouve également des individus au niveau de la presqu'île du Cotentin. Les zones d'occurrence de la plie juvénile ne changent pas vraiment entre les deux saisons. L'erreur de krigeage est plus importante dans le nord-ouest de la zone où l'échantillonnage est plus clairsemé. Comme en juillet, le modèle d'habitat préférentiel favorise des habitats très côtiers au niveau des estuaires, ce qui ici concorde avec la distribution observée. Le modèle d'habitat potentiel se rapproche de celui de l'habitat préférentiel en allant un peu plus au large dans le détroit du Pas-de-Calais et le sud de la mer du Nord.

> 1 an

Les individus de plus d'un an (> 18.1 cm) sont échantillonnés dans les mêmes zones que les plus jeunes mais leur distribution s'étend plus au large.

En juillet, ils sont présents en forte proportion dans tout le détroit du Pas-de-Calais, dans le sud de la mer du Nord et dans les baies de Seine et des Veys. Aucun individu n'a été trouvé dans la partie centrale de la Manche orientale où les eaux sont plus profondes. Le modèle d'habitat préférentiel prédit bien la distribution observée, favorisant les zones à faibles profondeurs mais avec des courants de marées assez importants. Le modèle d'habitat potentiel est beaucoup plus optimiste, étendant les zones favorables, plus au large.

En octobre, la distribution semble se resserrer près des côtes. Beaucoup d'individus sont présents le long des côtes d'Opale ou belge et autour de Dungeness. Des zones d'abondance apparaissent également dans les baies de Seine et des Veys. L'erreur de krigeage est toujours associée aux zones où l'échantillonnage est plus épars. Les modèles d'habitats préférentiel et potentiel sont en accord avec les abondances de campagnes, toutefois l'erreur du modèle d'habitat préférentiel n'est pas négligeable. Le modèle d'habitat potentiel illustre l'affinité de cette espèce pour les fonds sableux à graveleux dans des zones de températures moyennes à faible profondeur et où les courants de marées se font ressentir.

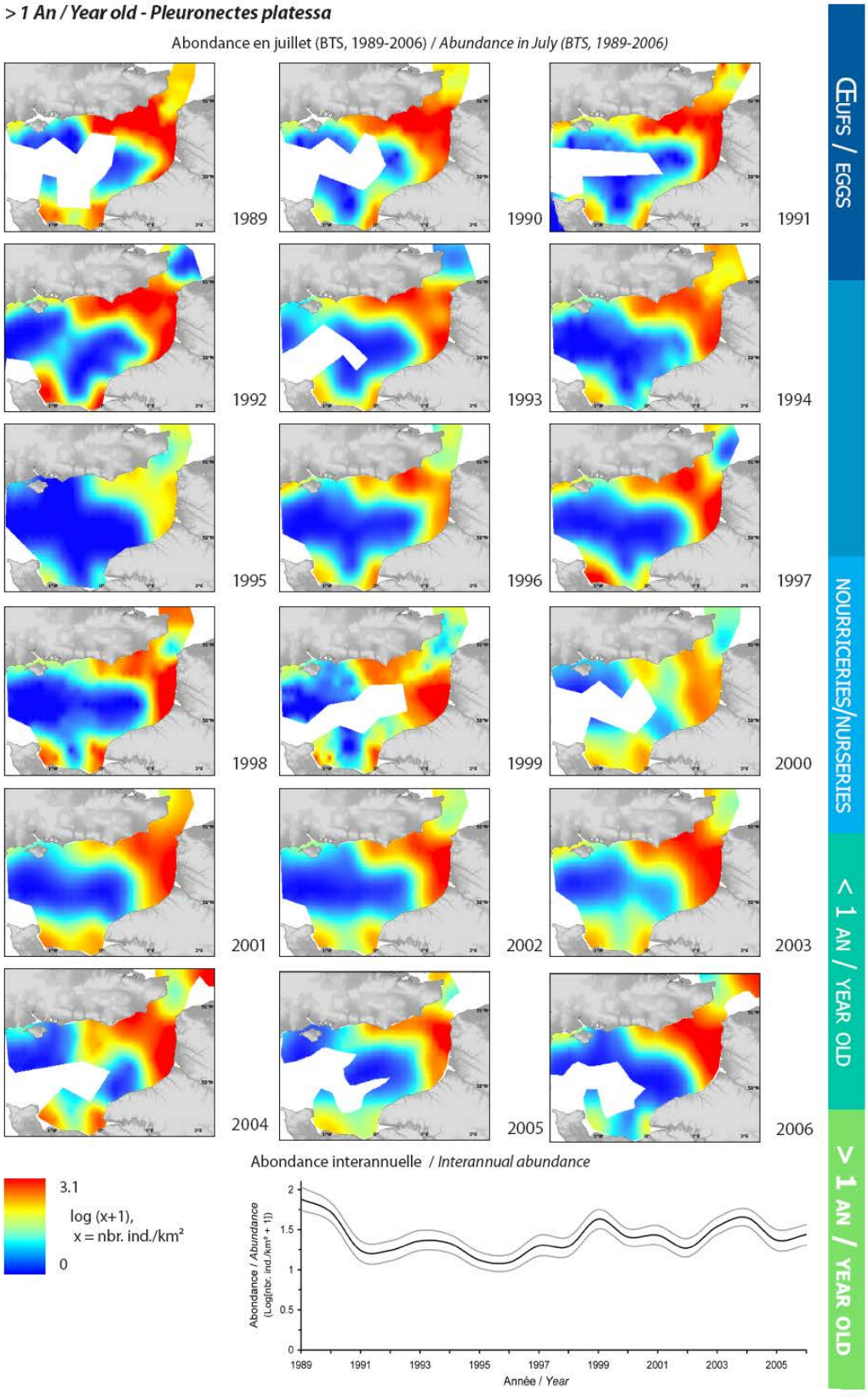
tions were more sparse. As in July, the preferential habitat model strongly favoured coastal areas close to estuaries, which this time agrees with the survey data. The potential habitat model resembles the preferential habitat model but exhibits a more dispersed offshore spatial distribution in the Dover Strait as well as in the southern North Sea.

> 1 year old

Older than one year individuals (length > 18.1 cm) were found in the same areas as younger ones but had a more offshore distribution pattern.

In July, high abundance levels were found in all of the Dover Strait, in the southern North Sea and in the Bays of Seine and Veys. No individual was found in the central Channel where waters are deeper. The preferential habitat model predicts the survey distribution well, favouring shallow waters with quite strong tidal currents. The potential habitat model was more optimistic, extending favourable habitats further offshore.

In October, the distribution pattern seemed to contract along the coasts. Many individuals were found along the Opale and Belgium coasts and around Dungeness. Some patches occured in the Bays of Seine and Veys. The kriging error was again associated with more sparse observations. The preferential and potential habitat models agreed with survey abundance levels though the preferential habitat model error was not negligible. The potential habitat model illustrates the affinity of this species for the sandy to gravely sediment types, shallow areas displaying average temperature conditions and where tidal currents can be strong.



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

ŒUFS / EGGS

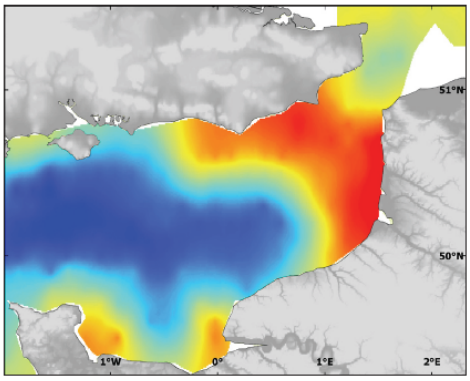
NOURRICERIES/NURSERIES

< 1 AN / YEAR OLD

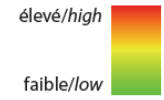
> 1 AN / YEAR OLD

> 1 An / Year old - *Pleuronectes platessa*

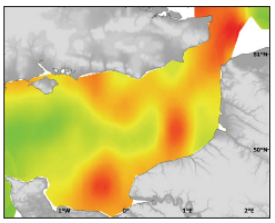
Abondance moyenne
en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)



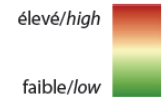


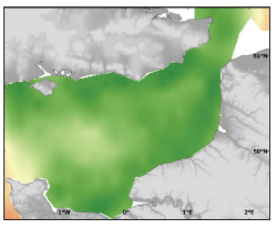


Ecart-type / *Standard deviation*

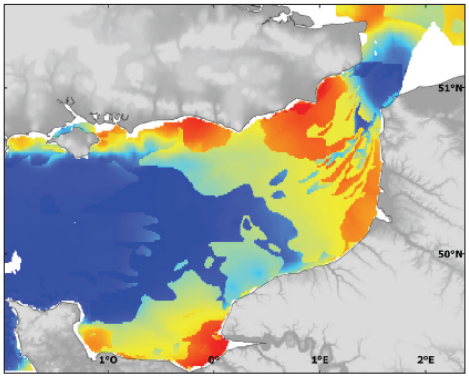


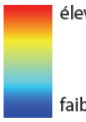
Erreur de krigeage / *Kriging error*



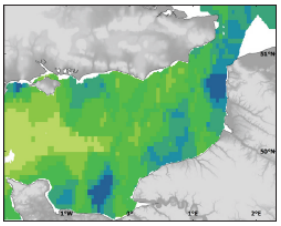


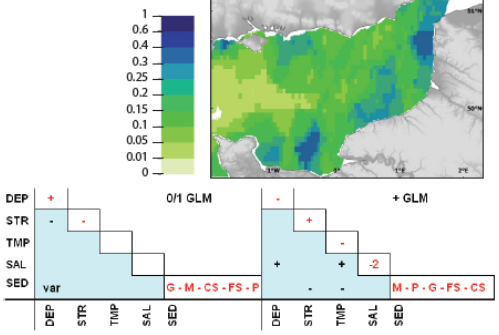
Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)



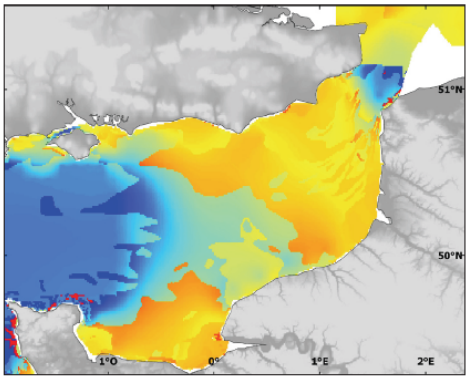


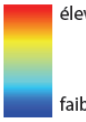
Erreur du modèle / *Model error*





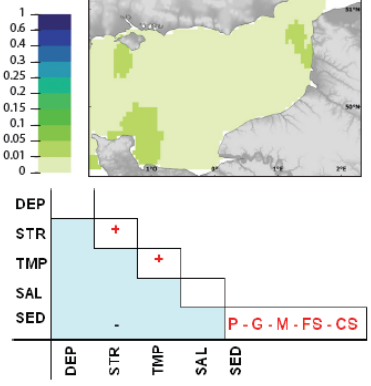
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)

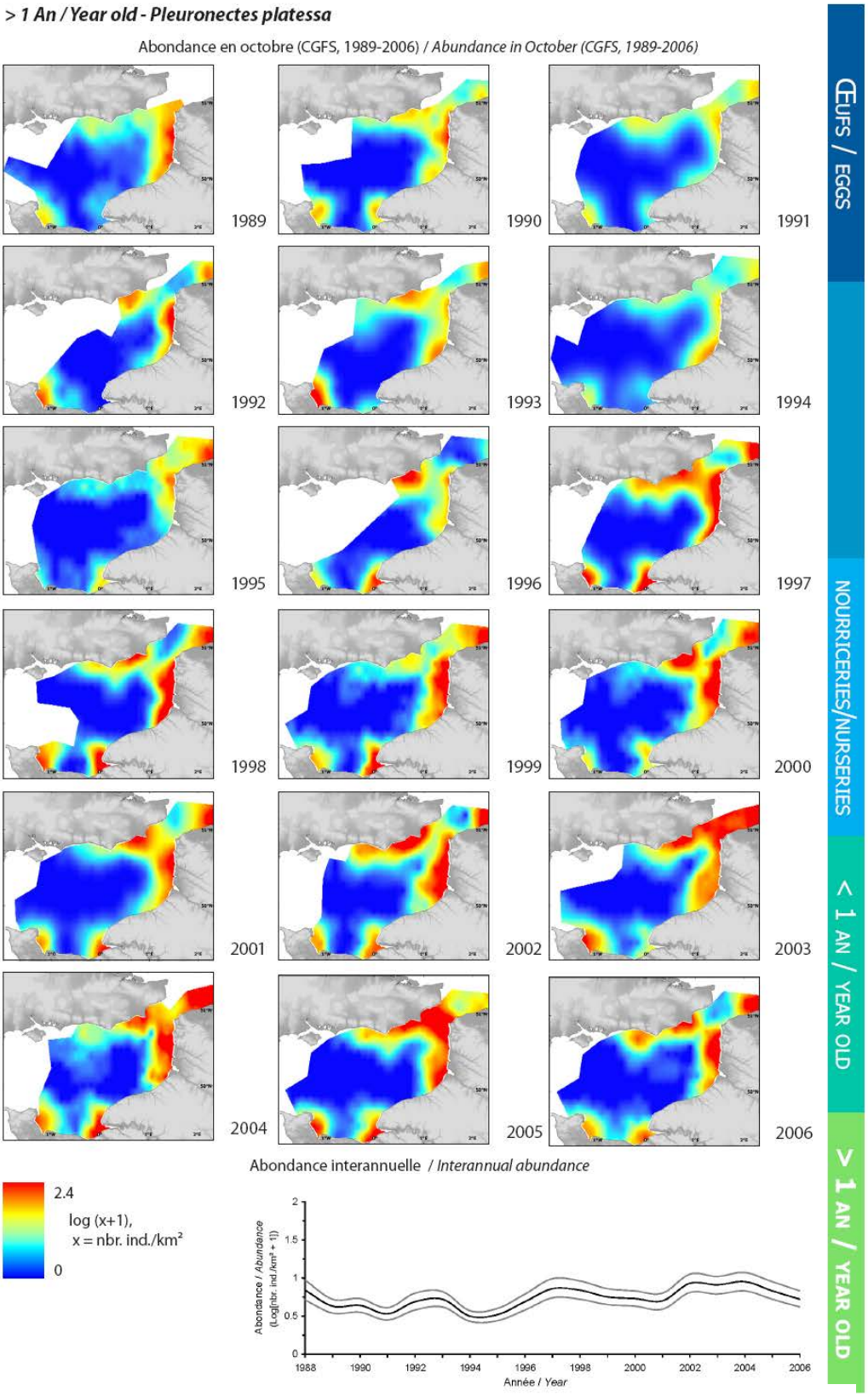




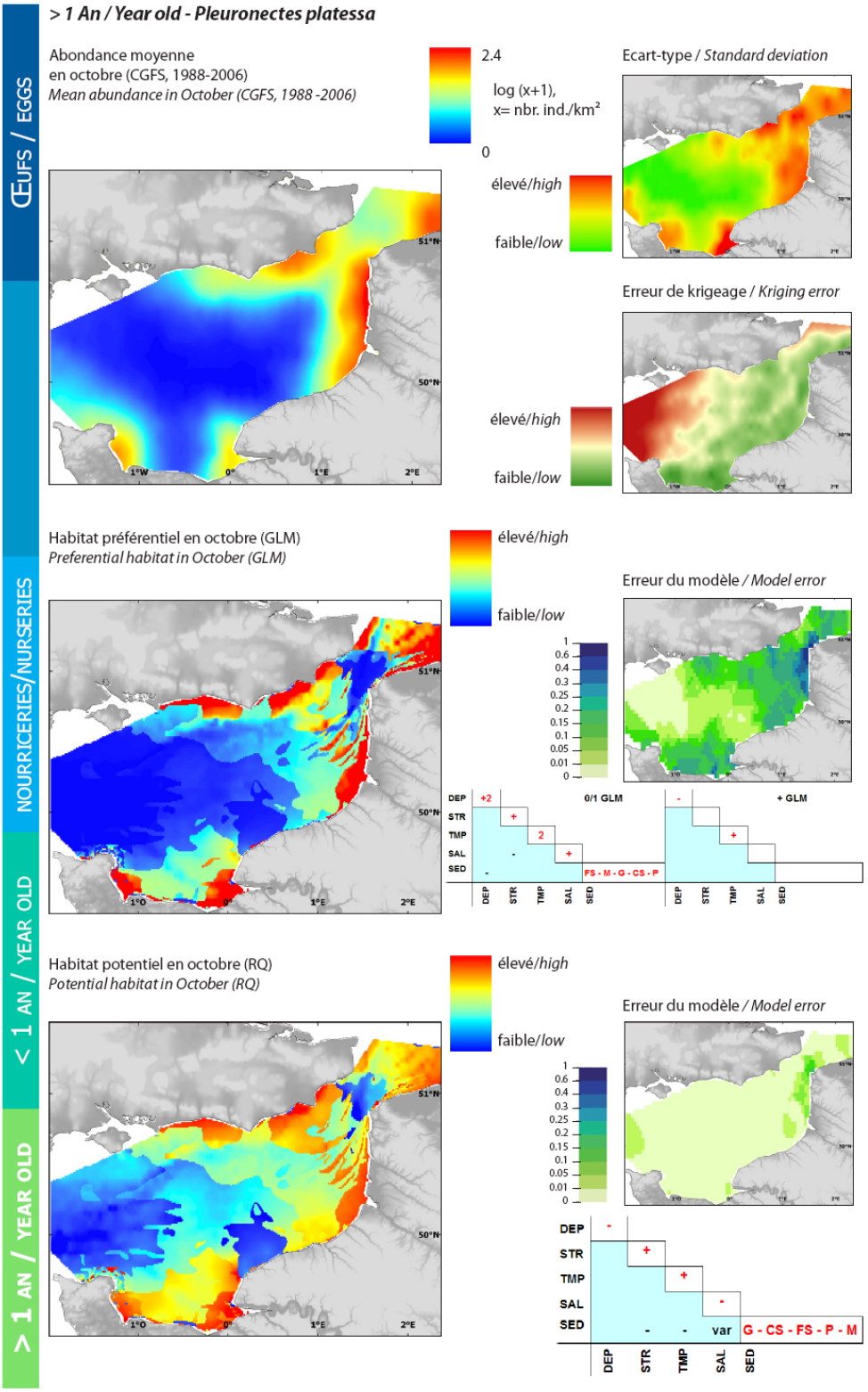
Erreur du modèle / *Model error*







Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*



Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

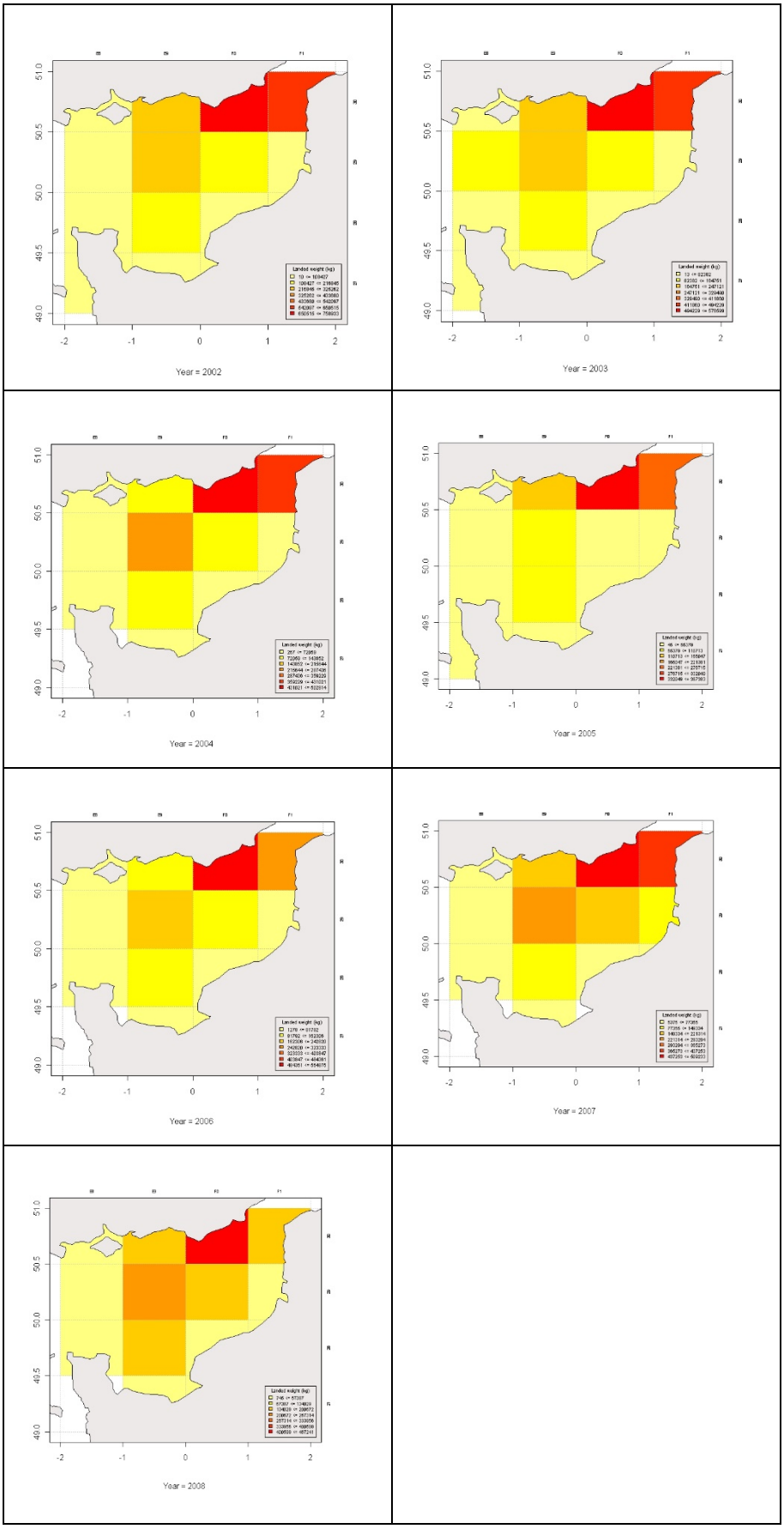


Figure . Plaice in VIId. - International landings from 2002 to 2008.

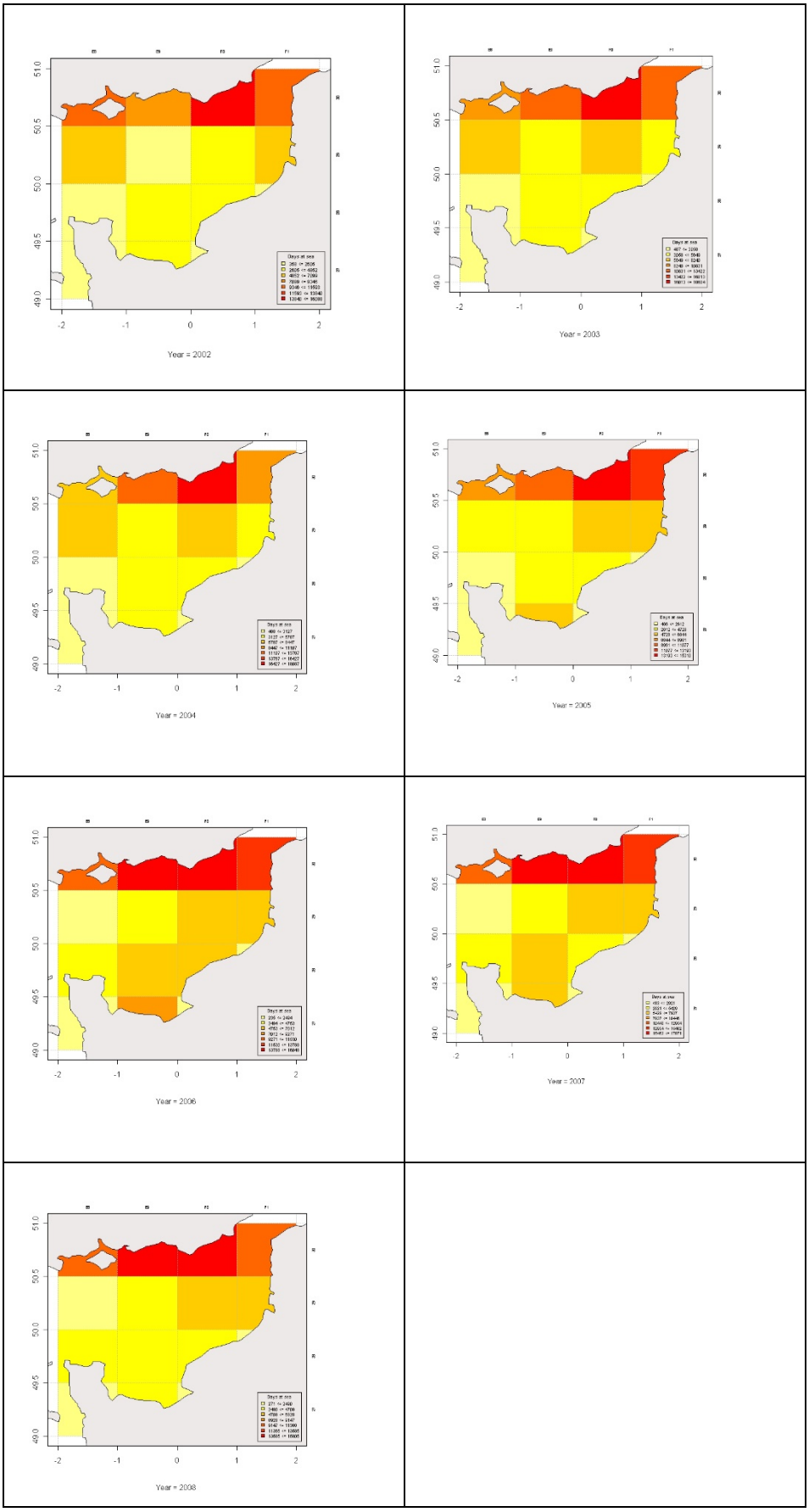


Figure Plaice in VIId - International effort in days at sea from 2002 to 2008.

Stock Annex Pollack in Subarea IV and Division IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock Pollack in Subarea IV and Division IIIa Date: 05/03/2010

Working Group WGNSSK

Date May 2012

Revised by Tore Jakobsen

A. General

A.1. Stock definition

There is little published information on pollack (*Pollachius pollachius*, Linnaeus, 1758) biology. The species is restricted to the Northeast Atlantic with a main distribution from the Portuguese continental coast northwards around the British Isles, into the Skagerrak and along the Norwegian coast where it is fairly common up to the Lofoten Islands, and catches have occasionally been recorded as far north as Bear Island. It is rare at Faroe and Iceland and in the Baltic and was never registered in Spanish landings in IXa South (Gulf of Cádiz).

According to FAO Fishbase pollack is benthopelagic, found mostly close to the shore over hard bottom (Svetovidov, 1986) and wrecks and other obstacles (Quero and Vayne, 1997). It usually occurs at 40-100 m depth but is found down to 200 m. A long time series of hauls with a beach seine on the Skagerrak coast shows that 0-group pollack are regularly found in shallow areas close to the shore, but generally in more exposed areas than 0-group cod. Pollack are therefore protected from the fisheries in the early life stages. A single tagging experiment on young (30-35 cm) pollack on the Norwegian west coast gave only local recaptures (Jakobsen, 1985).

According to Fishbase spawning takes place from January to May, depending on the area, and mostly at 100 m depth. Reinsch (1976) gives main spawning in March–April, taking place in the open waters of Skagerrak and the North Sea as well as in coastal waters, FAO Fishbase gives a maximum length of 130 cm, maximum published weight of 18.1 kg and maximum reported age of 8 years based on Cohen *et al*. (1990). This age, however, seems low compared to the maximum size reported. Female length-at-maturity was considered as 35 cm (Cardinale *et al*. 2012), at the age of 3 years. According to Reinsch (1976), the Pollack grows at approximately 7 cm per year after age 3, reaching nearly 90 cm and 5 kg at age 10. Feeding is mainly on fish, and incidentally on crustaceans and cephalopods.

French observations from the Western Channel/Celtic Sea region may also be relevant for the North Sea/Skagerrak. They mainly support the information in Fishbase, although a higher maximum age (15 years) is found. Growth is thus fairly rapid, approaching 10 cm per year. Pollack move gradually away from the coast into deeper waters as they grow. French observations also show that it is most available for fishing when it forms spawning aggregations. Otherwise its preference for wrecks and rocky bottom makes it difficult to catch them with trawls. For this reason trawl surveys are probably not very well suited for monitoring this species.

Charrier *et al*. (2006) used six microsatellite markers to assess the stock structure of pollack in the NE Atlantic by comparing samples collected in four locations along the Atlantic French coast and from one location off southern Norway. Overall results showed limited genetic differentiation among samples which may be related: i) with the existence of gene flow between spawning units due to the larvae dispersal or ii) with a recent origin of populations which prevents significant genetic drift. However, authors remark that results should be carefully analysed due to the small sample sizes and the limited number of microsatellites used which might have hampered the detection of population differentiation for pollack. There are no morphological studies that could be used to separate stocks for this species.

Data from the fishery indicate three main areas of exploitation: one in the northern North Sea/Skagerrak extending north along the Norwegian coast, one in the Western Channel extending into the Eastern Channel, the Celtic Sea, the Irish Sea, and the northern part of the French west coast (areas VIIe-j & VIII a,b - landings from the intermediate areas VIa and IVc are generally small), and one in the Iberian waters (areas VIIIc and IXa. WGNEW proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including VIId and IIIa). This implies that Pollack in Division IIa also is a separate stock unit, but this is not discussed in the WGNEW report.

In the ICES advice it was decided to deal with Pollack in Division VIId as a part of the Celtic Sea ecosystem.

A.2. Fishery

Pollack is mainly a bycatch in various commercial fisheries. Monthly Norwegian catches, averaged over the years 1992-2011, show that catches peak in the months of March and April, coinciding with the spawning time, and this may be associated with spawning aggregations. In Norway the most important gear are gillnets and otter trawl, responsible for 70 and 14 % of the catches respectively. When catches within and outside the 12-miles zone are compared it is seen that, for 2011, in Division IIIa 97% was from within the 12-miles zone (by gillnet and *Pandalus* trawl). In Subarea IV 66% of the catches were made within the 12-miles zone (again by gillnets), whereas in the area beyond the 12-miles zone the main catches were made by otter trawl. The geographical distribution of pollack in Norwegian otter trawl catches closely corresponds to that of saithe.

Pollack is also often caught in recreational fisheries, but no data about these catches are known to the working group.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the working group. Feeding is reported to be mainly on fish, and incidentally on crustaceans and cephalopods.

B. Data

B.1. Commercial catch

Historical landings statistics for pollack are available from ICES, but they are clearly incomplete in earlier years. The introduction of the EEZs in 1977 represented a change

in reporting and from 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

B.2. Biological

There has been some collection of biological parameters in Subarea IV and Division IIIa by Norway in the most recent years, but the data have not yet been processed.

B.3. Surveys

Pollack is being caught in the IBTS survey in small numbers only. They are distributed mainly over the northwestern North Sea (along the Norwegian Deeps) and into the Skagerrak. Time series of abundance in the IBTS are shown for Subarea IV and Division IIIa separately, for quarter 1 (from 1977 onwards) and quarter 3 (from 1996 onwards).. The catches seem rather irregular, and no clear patterns emerge. A possible exception is the time series for quarter 1 in IIIa that seems to mirror the decrease in abundance of pollack in this area, as also reported in Cardinale *et al.* (2012).

B.4. Commercial CPUE

Not available.

B.5. Other relevant data

C. Assessment: data and method

Only trends in landings and surveys are available as potential indicators of stock trends.

I. References

Cardinale, M., H. Svedäng, V. Bartolino, L. Maiorano, M. Casini and H. Linderholm, 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. J. Appl. Ichthyol. 28(2): 200-208

Charrier, G., Durandc, J.D., Quinioub, L., Larocheb, J. 2011. An investigation of the population genetic structure of pollack (*Pollachius pollachius*) based on microsatellite markers. ICES Journal of Marine Science 63, 1705-1709.

Cohen, D.M., T. Inada, T. Iwamoto and N. Scialabba 1990 FAO Species Catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fish. Synop. 125(10).x+442p. Rome: FAO.

Council Regulation (EU) No 850/1998. Conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

Council Regulation (EU) No 44/2012. Fishing opportunities available in EU waters and, to EU vessels, in certain non- EU waters for certain fish stocks and groups of fish stocks which are subject to international negotiations or agreements.

ICES. 2010. Report of the Planning Group on Recreational Fisheries (PGRFS), 7-11 June 2010, Bergen Norway. ICES CM 2010/ACOM:34. 168 pp.

Jakobsen, T. 1985. Tagging of pollack on the Norwegian west coast in 1979. ICES CM 1985/G:24.

Quero, J.C. and J.J. Vayne. 1997. Les poissons de mer des pêches françaises. Editions Delachaux et Niestlé. 304 pp.

Reinsch, H.H. 1976. Köhler und Steinköhler. 158 p. Ziemsen Verlag, Wittenberg Lutherstadt 1976.

Svetovidov, A. N. 1986. Gadidae. In Fishes of the North-eastern Atlantic and the Mediterranean (Whitehead, P. J. P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E., eds), pp. 680–710. Paris: UNESCO.

Stock Annex – Sole in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division VIId (Easter Channel)
Working Group:	ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Date:	May 2011
Revised by	Willy Vanhee (WKFLAT) updated at WGNSSK-2011

A. General

A.1 Stock definition

The sole in the eastern English Channel (VIId) are considered to be a separate stock from the larger North Sea stock to the east and the smaller geographically separate stock to the west in VIIe. There is some movement of juvenile sole from the North Sea into VIId (ICES CM 1989/G:21) and from VIId into the western Channel (VIIe) and into the North Sea. Adult sole appear to be largely isolated from other regions except during winter, when sole from the southern North Sea may enter the Channel temporarily (Pawson, 1995). The assessment does not take account of these stock movements.

A.2 Fishery

There is a directed fishery for sole by small inshore vessels using trammelnets and trawls, which fish mainly along the English and French coasts and possibly exploit different coastal populations. Sole represents the most important species for these vessels in terms of the annual value to the fishery. The fishery for sole by these boats occurs throughout the year with small peaks in landings in spring and autumn. There is also a directed fishery by English and Belgian beam trawlers who are able to direct effort to different ICES divisions. These vessels are able to fish for sole in winter before the fish move inshore and become accessible to the local fleets. In cold winters, sole are particularly vulnerable to the offshore beamers when they aggregate in localized areas of deeper water. Effort from the beam trawl fleet can change considerably depending on whether the fleet moves to other areas or directs effort at other species such as scallops and cuttlefish. In France, there are some few small beam trawlers operating inshore in a few local areas, and offshore trawlers fishing for mixed demersal species taking sole as a bycatch.

The minimum landing size for sole is 24 cm. Demersal gears permitted to catch sole are 80 mm for beam trawling and 90 mm for otter trawlers. Fixed nets are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

A.3 Ecosystem aspects

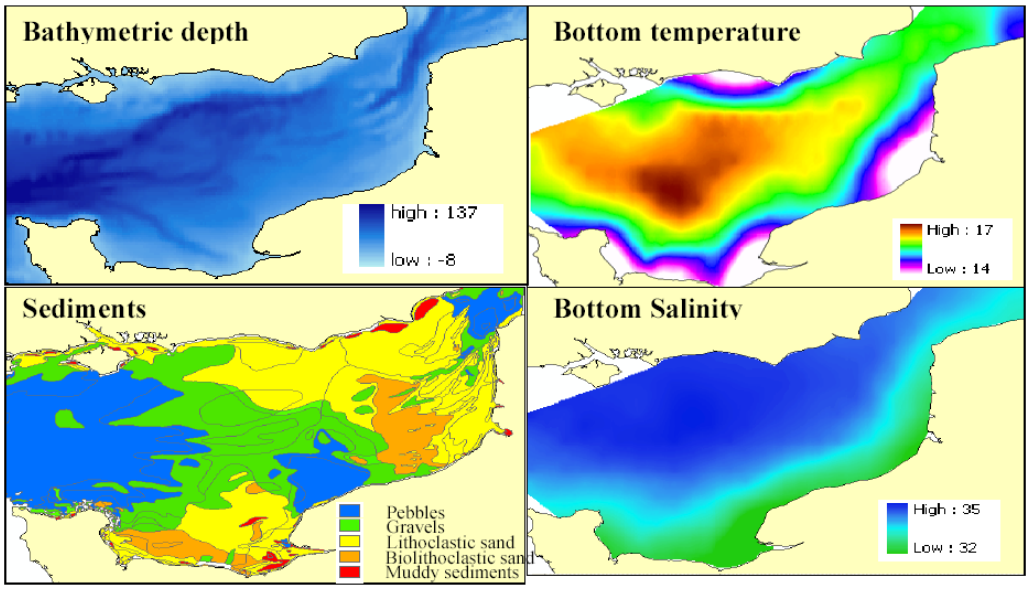


Figure 1. Eastern English Channel physical and hydrological features: Bathymetric depth and simplified sediment types representation. Survey bottom temperature and bottom salinity (averaged for 1997 to 2003) obtained by Kriging. (in Vaz *et al.*, 2004).

Biology: Adult sole feeds on worms, small molluscs and crustaceans. In the English Channel, reproduction occurs between February and April, mainly in the coastal areas of the Dover Strait and in large bays (Somme, Seine, Solent, Mont-Saint-Michel, Start and Lyme Bay). Pelagic eggs hatch after 5 to 11 days leading to larvae that are also pelagic and that will metamorphose into benthic fry after 1 or 2 weeks. Juveniles spend the first 2 or 3 years in coastal nurseries (bays and estuaries) where fast growth occurs (11 cm at 1 year old) before moving to deeper waters.

The spatial distribution of life stages of common sole demonstrates a particular pattern: larval distribution (on spawning grounds) and juvenile distribution (in nursery grounds) overlap. If larvae are found everywhere during spring, the potential habitat for stage 2 larvae is along the Flanders coast and near the Pays de Caux, to the central zone of the English Channel. Older larvae have a more coastal habitat preference, which can be explained by a retention phenomenon linked to estuaries.

Environment: A benthic species that lives on fine sand and muddy seabeds between 0 and 150 meters depth. It ranges from marine to brackish waters in temperatures between 8 and 24°C.

Geographical distribution: Eastern Atlantic, from southern Norway to Senegal, Mediterranean Sea including Sea of Marmara and Black Sea.

Vaz *et al.*, 2007 used multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature. One Group (class 4 in Figure 2 below) was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry.

It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

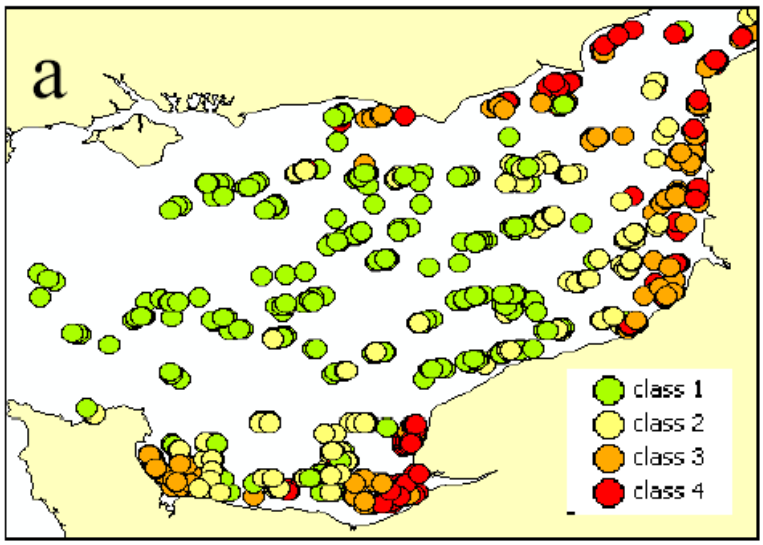


Figure 2. Spatial distribution of Fish Subcommunities in the Eastern Channel from 1988 to 2003. Observed assemblage type at each station, These illustrate the gradation from open sea community to coastal and estuarine communities (In Vaz *et al*., 2004).

Community evolution over time: (From Vaz *et al*., 2007). The community relationship with its environment was remarkably stable over the 17 y of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

B. Data

B.1 Commercial catch

The landings are taken by three countries: France (50%), Belgium (30%) and England (20%). Age sampling for the period before 1980 was poor, but between 1981 and 1984 quarterly samples were provided by both Belgium and England. Since 1985, quarterly catch and weight-at-age compositions were available from Belgium, France, and England.

An initiative for undertaking combined sampling of VIId sole between France, Belgium and the UK has been agreed from January 2008. The result was a framework for the collection of age data in relation to an international ALK. The division VIId has been stratified in three geographical areas and the data collected in line with them for 2008.

It was the intention that these data would be used to provide the assessment advice in 2009. A limited otolith exchange was arranged between the laboratories involved, specifically looking at VIId sole, in order to assess the likely quality of the ALK provided. The reason for restricting the exchange to those involved in the reading of VIId sole

was so that any stock-specific issues could be addressed. The agreement achieved between institutes was 91% across all ages. Due to workload and shortage of manpower, further analysis and the use of a combined ALK was not established yet. If possible this combined ALK will be calculated and proposed for adoption by ACOM before the next assessment.

Belgium

Belgian commercial landings and effort information by quarter, area and gear are derived from logbooks.

Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium).

Quarterly sampling of landings takes place at the auctions of Zeebrügge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours.

Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level.

In 2003 a pilot study started on on-board sampling with respect to discarded and retained catch. Since 2004 it is part of the DCR.

France

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10m and from sales declaration forms for vessels under 10 m. These self declared productions are then linked to the auction sales in order to have a complete and precise trip description.

The collection of discard data has begun in 2003 within the EU Regulation 1639/2001. The first years of collection were incomplete in term of time and métier coverage. It is expected an increase of sampling effort from 2009 designed for the use of the information for assessment purpose, as required by ICES/ACOM.

The length measurements are done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne. Samplings from Grandcamp and Port-en-Bessin are used for raising catches from Cherbourg to Fecamp and samplings from Dieppe and Boulogne are used to raise the catches from Dieppe to Dunkerque.

Otoliths samples are taken by quarter throughout the length range of the landed catch for quarters 1 to 3 and from the October GFS survey in quarter 4. These are aged and combined to the quarterly level and the age–length key thus obtained is used to transform the quarterly length compositions. The lengths not sampled during one quarter are derived from the same year close quarter.

Weight, sex and maturity-at-length and -at-age are obtained from the fish sampled for the age–length keys.

England

English commercial landings in tonnes by quarter, area and gear are derived from the sales notes statistics for vessels under 12 m which do not complete logbooks. For those over 12 m (or >10 m fishing away for more than 24 h), data are taken from the EC logbooks. Effort and gear information for the vessels <10 m is not routinely collected and is obtained by interview and by census. .No information is collected on discarding

from vessels <10 m but it is known to be low. Discarding from vessels >10 m has been obtained since 2002 under the EU Data Collection Regulation and is also relatively low.

Length samples are combined and raised to monthly totals by port and gear group for each stock. Months and ports are then combined to give quarterly total length compositions by gear group; unsampled port landings are added in at this stage. Quarterly length compositions are added to give annual totals by gear. These are for reference only, as ALK conversion takes place at the international level. Age structure from otolith samples are combined to the quarterly level, and generally include all ports, gears and months. For sole the sex ratio from the randomly collected otolith samples are used to split the unsexed length composition into sex-separate length compositions. The quarterly separate age–length-keys are used to transform quarterly length compositions by gear group to quarterly age compositions. At this stage the age compositions by gear group are combined to give total quarterly age compositions.

A minimum of 24 length samples are collected per gear category per quarter. Age samples are collected by sexes separately and the target is 300 otoliths per sex per quarter. If this is not reached, the 1st and 2nd or 3rd and 4th quarters are combined.

Weight-at-age is derived from the length samples using the length/weight relationship W=aL^b, where a and b are reference condition factors for the stock.

The text table below shows which countries supply which kind of data:

Kind of data supplied quarterly

Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition-in-catch
Belgium	x	x	x		x
England	x	x	x		x
France	x	x	x		x

Data are supplied as FISHBASE files containing quarterly numbers-at-age, weight-at-age, length-at-age and total landings. The files are aggregated by the stock coordinator to derive the input VPA files in the Lowestoft format. No SOP corrections are applied to the data because individual country SOPs are usually better than 95%. The quarterly data files by country can be found with the stock co-ordinator.

The resulting files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, either under w:\acfm\nsskwg\2002\data\sol_eche or w:\ifapdata\exim-port\nsskwg\sol_eche.

B.2 Biological

Natural mortality

Natural mortality is assumed constant over ages and years at 0.1.

Maturity

The maturity ogive used is knife-edged with sole regarded as fully mature at age 3 and older as in the North Sea.

Weight-at-age

Prior to 2001 WG, stock weights were calculated from a smoothed curve of the catch weights interpolated to the 1st January. Since the 2002 WG, second quarter catch weights were used as stock weights in order to be consistent with North Sea sole.

Proportion mortality before spawning

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

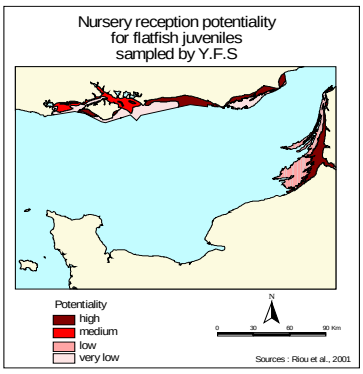
B.3 Surveys

A dedicated 4 m beam trawl survey for plaice and sole has been carried out by England using the RV Corystes since 1988. The survey covers the whole of VIId and is a depth stratified survey with most samples allocated to the shallower inshore stations where the abundance of sole is highest.

In addition, inshore small boat surveys using 2 m beam trawls are undertaken along the English coast and in a restricted area of the Baie de Somme on the French coast. In 2002, the English and French Young Fish Surveys were combined into an International Young Fish Survey. The dataset was revised for the full period back to 1981. The two surveys operate with the same gear (beam trawl) during the same period (September) in two different nursery areas. Previous analysis (Riou *et al*., 2001) has demonstrated that asynchronous spawning occurs for flatfish in Division VIId. Therefore both surveys were combined based on weighting of the individual index with the area nursery surface sampled. Taking into account the low, medium, and high potential area of recruitment, the French YFS got a weight index of 55% and the English YFS of 45% (See table and figure below).

Nursery reception potential used for the combination of FR and UK YFS

Potentiality surface (Km2)	South England	Bay of Somme
High	756	575.1
Medium	484.7	0
Low	30.5	953.1
Very low	993.3	21.3
Total	2264.5	1549.5
Total (Low–Med–High)	1271.2	1528.2



However, the UK component of the YFS was last conducted in 2006. In the absence of any update of the UK component of the YFS index the available time-series of the UK component should still be used in the assessment next to the French component of the YFS index. The lack of information from the UK YFS may impede the recruitment estimates and therefore the forecast.

B.4 Commercial cpue

Three commercial fleets have been used in tuning. The Belgian beam trawl fleet (BEL BT), the UK Beam Trawl fleet (UK BT) and a French otter trawl fleet (FR OT). The two beam trawl fleets carry out fishing directed towards sole but can switch effort between

ICES areas. The UK BT cpue data are derived from trips where landings of sole from VIId exceeded 10% of the total demersal catch-by-weight on a trip basis.

The effort of the Belgian beam trawl fleet is corrected for horse power, based on a study carried out by IMARES and CEFAS in the mid 1990s (no reference available). The study calculated an effort correction for HP applicable to sole and plaice effort in the beam trawls fisheries. The corresponding equations for sole is P=0.000204 BHP^1.23.

This horsepower correction for the commercial Belgian beam trawl fleet should still be applied. However, if a new corrected effort series is available (based on Section 4.2.4.1 in ICES 2009) it should be used under condition that this is reviewed and approved by ICES.

No French commercial tuning data are available for the otter trawl and fixed nets. A first attempt to create an effort series for the French trammel nets has been presented but is not deemed sufficient. If a new effort series is produced this too should be used under condition that they are reviewed and approved by ICES.

B.5 Other relevant data

None.

C. Historical stock development

Model used: XSA

Software used: IFAP/Lowestoft VPA suite

Model Options chosen:

Tapered time weighting not applied

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 7

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Since 2004-S.E. of the mean to which the estimate are shrunk = 2.000

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Catch data available for 1982–present year. However, there were no French age compositions before 1986 and large catchability residuals were observed in the commercial data before 1986. In the final analyses only data from 1986–present are used in tuning.

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1982–last data year	2–11+	Yes
Canum	Catch-at-age in numbers	1982–last data year	2–11+	Yes
Weca	Weight-at-age in the commercial catch	1982–last data year	2–11+	Yes

West	Weight-at-age of the spawning stock at spawning time.	19682–last data year	2–11+	Yes-assumed to be the same as weight-at-age in the Q2 catch
Mprop	Proportion of natural mortality before spawning	1982–last data year	2–11+	No-set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1982–last data year	2–11+	No-set to 0 for all ages in all years
Matprop	Proportion mature-at-age	1982–last data year	2–11+	No-the same ogive for all years
Natmor	Natural mortality	1982–last data year	2–11+	No-set to 0.2 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Belgian commercial BT	1986–last data year	2–10
Tuning fleet 2	English commercial BT	1986–last data year	2–10
Tuning fleet 3	English BT survey	1988–last data year	1–6
Tuning fleet 4	UK YFS	1987–2006	1–1
Tuning fleet 5	French YFS	1987–last data year	1–1

D. Short-term projection

Model used: Age structured

Software used: MFDP

Initial stock size is taken from the XSA for age 3 and older and from RCT3 for age 2, if appropriate. Otherwise the XSA value for age 2 is used. The long-term geometric mean recruitment is used for age 1 in all projection years.

Since 2004 initial stock size for age 2 was taken from XSA.

Natural mortality: Set to 0.1 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight-at-age in the stock: Average weight over the last three years

Weight-at-age in the catch: Average weight over the three last years

Exploitation pattern: Average of the three last years, scaled to the level of Fbar (3-8) in the last year

Intermediate year assumptions: F status quo

Stock recruitment model used: None, the long-term geometric mean recruitment-at-age 1 is used

Procedures used for splitting projected catches: Not relevant

E. Medium-term projections

Not performed for this stock.

In the past an age structured model was used (WGMTERMc software). Medium-term projections were carried out with settings as in short-term projection except for the

weights in the catch and in the stock which are averaged over the last 10 years. Since 2005 medium-term projections have not been done for this stock.

F. Long-term projections, yield-per-recruit

Not performed for this stock.

In the past an age structured model was used (WGMTERMc software). Medium-term projections were carried out with settings as in short-term projection except for the weights in the catch and in the stock which are averaged over the last 10 years. Since 2005 medium-term projections have not been done for this stock.

G. Biological reference points

	Type	Value	Technical basis
Precautionary approach	Blim	Not defined	Poor biological basis for definition
	Bpa	8000 t	Lowest observed biomass at which there is no indication of impaired recruitment. Smoothed Bloss
	Flim	0.55	Floss, but poorly defined; analogy to North Sea and setting of 1.4 Fpa = 0.55. This is a fishing mortality at or above which the stock has displayed continued decline.
	Fpa	0.40	Between Fmed and 5th percentile of Floss; SSB>Bpa and probability (SSBmt<Bpa), 10%: 0.4.
MSY approach	MSY Btrigger	8000 t	Bpa
	FMSY	0.29	Stochastic simulations assuming smooth hockey stick relationship

(unchanged since 1998)

H. Other issues

None.

I. References

CEFAS 1999. PA software users guide. The Centre for Environment, Fisheries and Aquaculture Science, CEFAS, Lowestoft, United Kingdom, 22 April 1999.

Riou *et al*., 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel: application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125–135.

Vas *et al*., 2007, Modelling Fish Habitat Suitability in the Eastern English Channel. Application to community habitat level. ICES CM 2004/ P:26

Stock Annex – Grey Gurnard

Stock specific documentation of standard assessment procedures used by ICES.

Stock Sole in Division VIId (Eastern Channel)

Working Group: ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)

Date: May 2012

Revised by

Grey gurnard

A.1 General biology [1])

Grey gurnard *Eutrigla gurnardus* occurs in the Eastern Atlantic from Iceland, Norway, southern Baltic, and North Sea to southern Morocco, Madeira. It is also found in the Mediterranean and Black Seas.

In the North Sea and in Skagerrak/Kattegat, grey gurnard is an abundant demersal species. In the North Sea, the species may form dense semi-pelagic aggregations in winter to the northwest of the Dogger Bank, in summer it is more widespread. The species is less abundant in the Channel, the Celtic Sea and in the Bay of Biscay.

Grey gurnard is most common on sandy bottoms, but also on mud, shell and rocky bottoms (Wheeler, 1978). Juveniles feed on a variety of small crustaceans. The diet of older specimens consists mainly of larger crustaceans and small fish. Spawning takes place in spring and summer. There do not seem to be clear nursery areas.

The maximum length is 50 cm.

It is a bycatch species in demersal fisheries. Catches are largely discarded.

A.2 Stock ID and possible assessment areas

No studies are known of the stock ID of grey gurnard. Based on IBTS survey data Heessen and Daan (1996) suggested that there may be three sub-populations in the North Sea and Skagerrak/Kattegat: one to north-west of the Dogger Bank, one around Shetland and one in the Skagerrak/Kattegat. A more recent distribution map (based on quarter 1 IBTS data for the period 1977–2005) suggests that there is indeed an area with low abundance between the North Sea and the Skagerrak, but that a more or less continuous distribution exists between the central and north-western North Sea. Grey gurnard from the North Sea may well be separated from grey gurnard in the Channel. Figure 1 shows that the species is almost absent from the southernmost stations of the Southern Bight. In the eastern Channel abundance of grey gurnard seems to be low compared to the North Sea (Figure.2). The distribution in the western Channel is not known. A higher abundance is observed in the Celtic Sea, whereas the species is almost absent from the Bay of Biscay (Figure.3).

---

[1]) Most of the text is copied from the text on grey gurnard in ICES-FishMap (2005)

B. Management regulations

There is no minimum landing size for this species and there is no TAC.

C.Fisheries data

Gurnards were often not sorted by species when landed. This is reflected in the catch statistics where different species of gurnards were often reported into one generic category of "gurnards". Only some countries sometimes report landings of "grey gurnard" (see Table 4.1 for landings data for 1975 - 2008). From this table it is also obvious that the catch statistics are incomplete for several years: some countries reporting no landings at all, other countries reporting exceptionally high landings.

Grey gurnard from the North Sea is mainly landed for human consumption purposes. North Sea landings decreased gradually before World War II. After an initial post-war peak of 4000 t, annual landings stayed well below 2000 t until the early 1980s, when annual catches increased to around 40 000 t (Figure 4.4) because of Danish landings for reduction purposes. In the same period, however, there was some misreporting as well. The Netherlands did not report gurnards during the years 1984–1999. Recent international landings have been very low at around 300 to 500 t per year only.

Historically, grey gurnard is mainly taken as a by-catch in mixed demersal fisheries for flatfish and roundfish. However, the market is limited and the larger part of the catch appears to be discarded. Data for French discard sampling in 2005 and 2006 in different ICES areas are shown in Figure 4.5 and Figure 4.6. Information on discarding in the Dutch beam trawl fleet is shown in Figure 4.7. Owing to the low commercial value of this species, landings data will usually not reflect the actual catches very well.

D.Survey data / recruit series

For the North Sea and Skagerrak/Kattegat, data are available from the International Bottom Trawl survey. The IBTS can provide information on distribution and the length composition of the catches.

Grey gurnard occurs throughout the North Sea and Skagerrak/Kattegat. During winter, grey gurnards are concentrated to the northwest of the Dogger Bank at depths of 50–100 m, while densities are low off the Danish coast, in the German Bight and eastern part of the Southern Bight (Figure 1). The distribution pattern changes substantially in the spring, when the whole area south of 56°N becomes densely populated and the high concentrations in the central North Sea disappear until the next winter. Many gurnards are also caught in the northernmost part of the area throughout the year.

The near absence of grey gurnard in the southern North Sea during winter and the marked shift in the centre of distribution between winter and summer suggests a preference for higher water temperatures (Hertling, 1924; Daan *et al.* 1990).

During winter, grey gurnard occasionally form dense aggregations just above the sea bed (or even in midwater, especially during night time) which may result in extremely large catches. Within one survey, these large hauls may account for 70 percent or more of the total catch of the species. Bottom temperatures in high-density areas usually range from 8 to 13°C (Sahrhage, 1964).

Patterns in distribution of the small and large fish are similar in space and time (Knijn *et al.*, 1993).

Spawning occurs in spring and summer and, perhaps, in autumn (Russel, 1976), and may also explain the observed seasonal movements (Van der Land, 1990). For instance,

the German Bight is invaded from April onwards by fish that apparently spawn there. Emigration to northern, deeper waters commences in September and by November only a few young specimens are left (Hertling, 1924).

Length frequency distributions per year are shown for areas IV and IIIa (Figure 9and Figure 10). Average length frequency distributions for these two areas are given inFigure 11. In Skagerrak Kattegat two modes can be seen, whereas in the North Sea the smaller fish are only found in relatively small numbers.

Time series of abundance of grey gurnard, based on catches of all length classes combined during the IBTS quarter 1 survey in the North Sea (IV) and Skagerrak Kattegat (IIIa) are presented in Figure 12. The time series for the North Sea shows a clear upward trend, especially since the late 1980s. The peak in 1981 is presumably caused by a single very large catch in that year, caused by one of the enormous concentrations of fish that appear in that time of year. Also in Skagerrak Kattegat an increase can be seen since the same time as in the North Sea, but since a maximum was reached in 1993, catches decreased and have fluctuated widely around the same level since then.

E. Biological sampling

Biological data for this species are scarce. In the early 1990s some countries collected otoliths and information on maturity stages during the quarterly IBTS surveys, and Table 4-3 provide an age-length key for females and for males based on sampling by CEFAS in the 4th quarter of 1992. For the same fish, Table 4-4 and Table 4-5 provide information on maturity-at-length.

F. Population biological parameters and other research

The maximum size reported by different authors ranges from 45 (Wheeler, 1978) to 50 cm (N.Daan pers. comm.). In the North Sea, specimens > 45 cm are rarely caught.

The winter catches in the North Sea are dominated by larger specimens, with a maximum abundance at 19–22 cm. In Skagerrak-Kattegat, the length frequency distribution has two clear peaks at 11–12 cm and at 16–18 cm, while larger fish are clearly absent. There are no reliable data on the age composition.

The length distributions are remarkably similar from year to year and do not indicate a clear year-class signal: small individuals are never very abundant. The absence of small fish in the North Sea suggests that the IBTS survey does not adequately cover the nursery grounds. It is possible that juveniles concentrate on rough bottoms, which have usually to be avoided to minimise damage to the fishing gear, or that they remain pelagic (ICES-FishMap).

Average length of 1-year-olds was 13-14 cm and of 2-year-olds 19–20 cm in samples collected during the first quarter of 1977–1978. Highest age reported was nine years. The average length of 8-year-old fish has been estimated at 35 cm (Damm, 1987) and 32 cm (MacDonald *et al.*, 1994). Females grow faster and live longer than males (Damm, 1987). This is supported by a survey in May 1992, where all specimens larger than 32 cm were females (Knijn *et al.*, 1993).

Available von Bertalanffy growth parameters are given in the text table below:

Area	L_∞ (cm)	K (yr-1)	t_0 (yr)	Reference
Brittany males	34.4	0.85	0.14	Baron, 1985
Brittany females	38.0	0.77	0.16	Baron, 1985

Sexual maturity is said to be attained at between two and three years of age (Wheeler, 1978; Baron, 1985a, 1985b), but data from the North Sea from the first half of May 1992 show that specimens from about 15 cm onwards can be mature, males at a somewhat smaller length than females (Knijn *et al.,* 1993). The same can be seen in the data for the 4th quarter of 1992 presented in Table 4-4and Table 4-5. This indicates that maturity may even be reached in 1-year old fish.

Studies in the Baie de Douarnenez (Brittany) have shown that the length at which 50% of males and females were mature were 29.4 and 31.2 cm, respectively (Baron, 1985a, 1985b). These values seem very high compared to the North Sea.

The spawning period is from April to August (Wheeler, 1978). Off the English north-east coast eggs are found from May to August (Harding and Nichols, 1987). The pelagic eggs are 1.3–1.5 mm in diameter, and the larvae hatch at a length of 3–4 mm (Russell, 1976).

Seasonal distribution maps indicate a marked seasonal northwest-southeast migration pattern that is rather unusual. The population is concentrated in the central western North Sea during winter and spreads into the south eastern part during spring to spawn. In the Kattegat and the northern North Sea, such shifts appear to be absent. The withdrawal from the colder coastal waters may reflect the southerly origin of the species (ICES-FishMap).

The lower three rays of the pectoral fins of gurnards are separate and well supplied with sense organs. They are used to 'walking' over the substratum and locating prey buried in the sea bed (Wheeler, 1978). Small crustaceans, such as the brown shrimp *Crangon crangon* and small crabs are major food items in terms of weight for small (< 25 cm) individuals, while stomach contents of larger specimens are dominated by a variety of fish species (De Gee and Kikkert, 1993). The fish component of the diet largely consists of juveniles (0- and 1-group) of commercially exploited species such as cod, whiting, sandeel and sole. Off Jutland, grey gurnard appeared to be a major predator on pelagic 0-group cod during June–July (De Gee and Kikkert, 1993). Specimens in Loch Etive (west coast of Scotland) were found to feed almost exclusively on mysids, euphausiids, and decapod crustaceans (Gordon, 1981). Due to their piscivorous behaviour, grey gurnard appears to play an important role in the ecosystem.

G. Analysis of stock trends / assessment

The information from landings is very poor, due to poor reporting (gurnard species are not always identified in the data, and probably also misreporting has occurred) and also because the low value of the species leads to massive discarding.

The status of the stocks in areas IIIa, IV and VIId,e is not known. Most informative are probably the time series based on the catches from the IBTS survey in the North Sea and in Skagerrak-Kattegat. Especially in the North Sea these show a marked increase since the late 1980s).

H. Data requirements

For management purposes information should be available on catches and on landings. The quality of landings data has been poor for this species because in the past only landings of "gurnards" were reported.

Little is known of the biological parameters of grey gurnard.

From the information presented here, it can be concluded that grey gurnard is of very limited commercial interest. It should be considered to exclude this species from the list of species dealt with by WGNEW.

I. References (not necessarily all mentioned in the text)

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. I La croissance de: *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(2): 127–144.

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. II La reproduction de : *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(3): 255–281.

Daan, N., Bromley, P. J., Hislop, J. R. G., and Nielsen, N. A., 1990. Ecology of North Sea Fish. Netherlands Journal of Sea Research 26(2–4): 343–386.

Damm, U. 1987. Growth of grey gurnard *Eutrigla gurnardus* L. in the North Sea. ICES CM 1987/G:55. 10 pp.

Gee, T. de, and Kikkert, A., 1993. Analysis of the grey gurnard (*Eutrigla gurnardus*) samples collected during the 1991 International Stomach Sampling Project. ICES CM 1993/G:14. 26 pp.

Gordon, J. D. M. 1981. The fish populations of the west of Scotland shelf. Part II. Oceanography and Marine Biology. Annual Review, 19: 405–441.

Harding, D., and Nichols, J. H. 1987. Plankton surveys off the north-east coast of England in 1976: an introductory report and summary of the results. Fisheries Research Technical Report, MAFF Directorate for Fisheries Research, Lowestoft (86), 56 pp.

Heessen, H. J. L. and Daan, N. 1996. Long-term trend in ten non-target North Sea fish species. ICES Journal of Marine Science 53: 1063–1078

Hertling, H. 1924. Über den grauen und den roten Knurrhahn (*Trigla gurnardus* L. und *Trigla hirundo* Bloch). Wissenschaftliche Meeresuntersuchungen Helgoland 15(2), Abhandlung 13: 1–53.

ICES-FishMap 2005. http://www.ices.dk/marineworld/fishmap/ices/pdf/greygurnard.pdf

Knijn, R.J., Boon, T.W., Heessen, H.J.L. and Hislop, J.R.G., 1993. Atlas of North Sea Fishes. ICES Cooperative Research Report. No. 194. (http://www.ices.dk/pubs/crr/crr194/ /CRR194 .PDF)

Land, M. A. van der. 1990. Distribution and mortality of pelagic eggs of by-catch species in the 1989 egg surveys in the southern North Sea. ICES CM 1990/H:19. 11 pp.

MacDonald, D. S., Pope, J. G., Daan, N., and Reynolds J. D. 1994. Impact of fishing on non-target species. Report to the Commission of the European Communities. MAFF Directorate of Fisheries, RIVO and the University of East Anglia, 85 pp.

Russell, F. S. 1976. The eggs and planktonic stages of British marine fishes. Academic Press, London. 524 pp.

Sahrhage, D. 1964. Über die Verbreitung der Fischarten in der Nordsee. I. Juni-Juli 1959 und Juli 1960. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung 17(3): 165-278.

Wheeler, A. 1978. Key to the fishes of northern Europe. Frederick Warne, London. 380 pp.

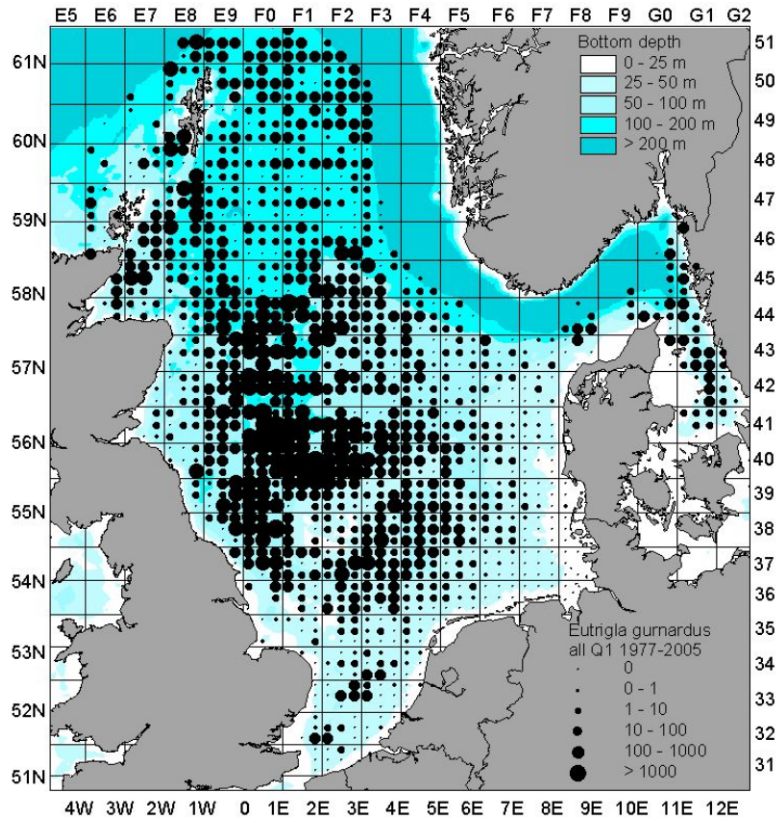


Figure 1. Average annual catch (number per fishing hour for all length classes combined) for grey gurnard in the quarter 1 IBTS survey, 1977–2005 (ICES-FishMap).

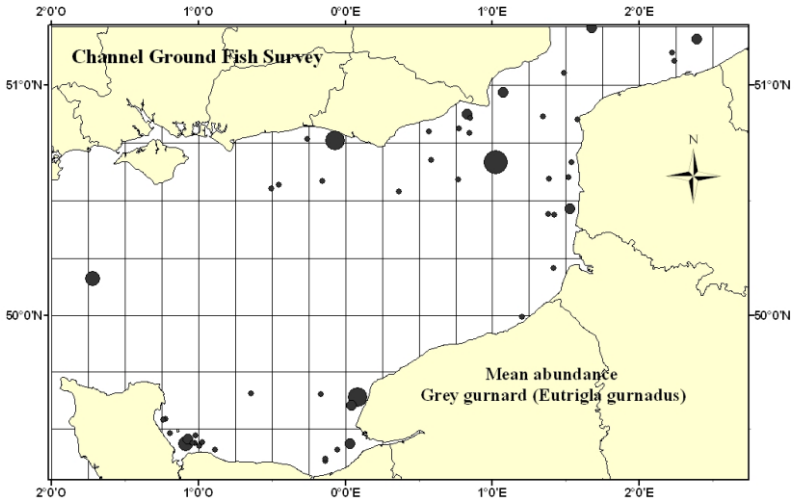


Figure.2. Distribution of grey gurnard in the eastern Channel. CGFS survey 1988–2004

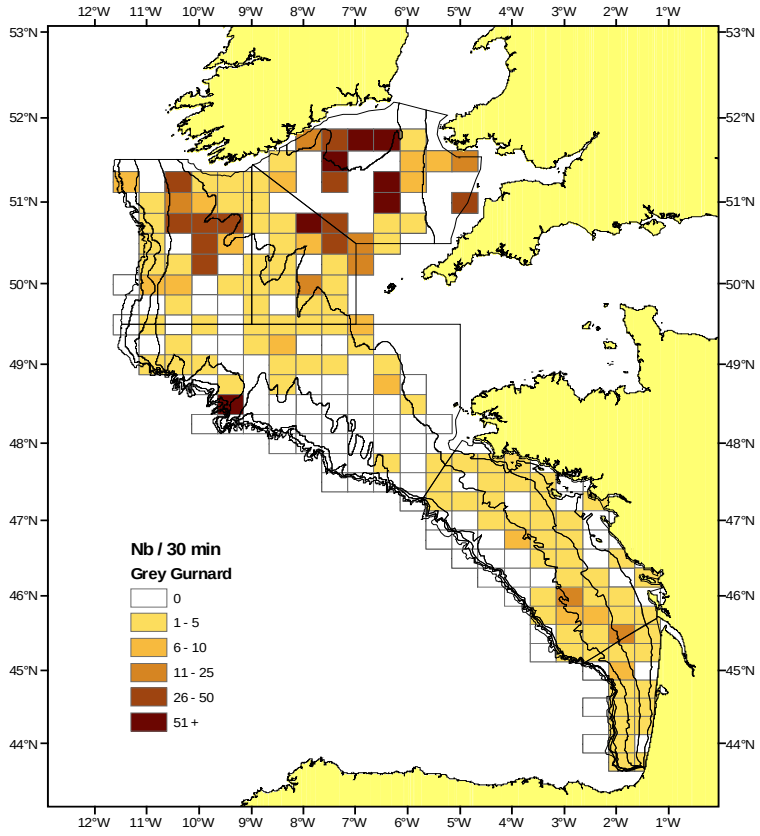


Figure.3. Distribution of grey gurnard in the Celtic Sea and the Bay of Biscay. EVHOE survey, 1997–2004.

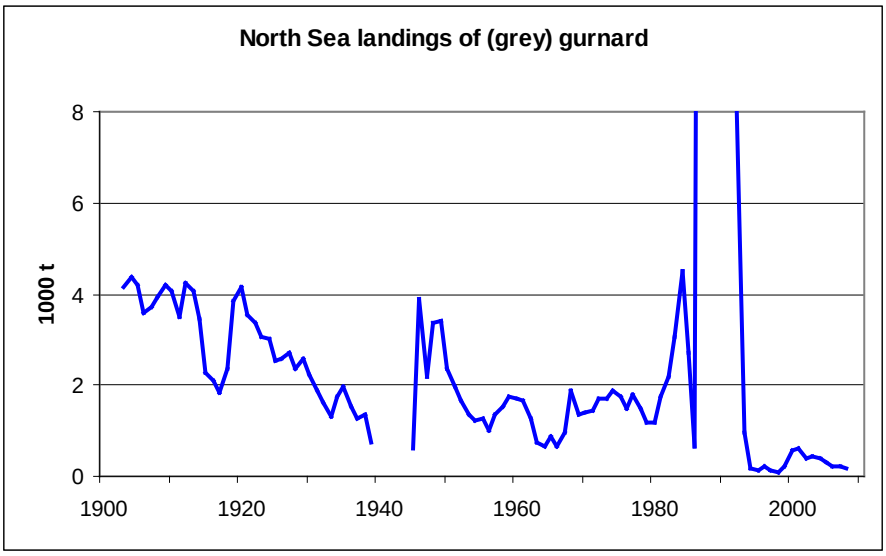


Figure.4. Total international landings of gurnards from the North Sea, probably most of the landings consisted of grey gurnard. See text for further explanation.

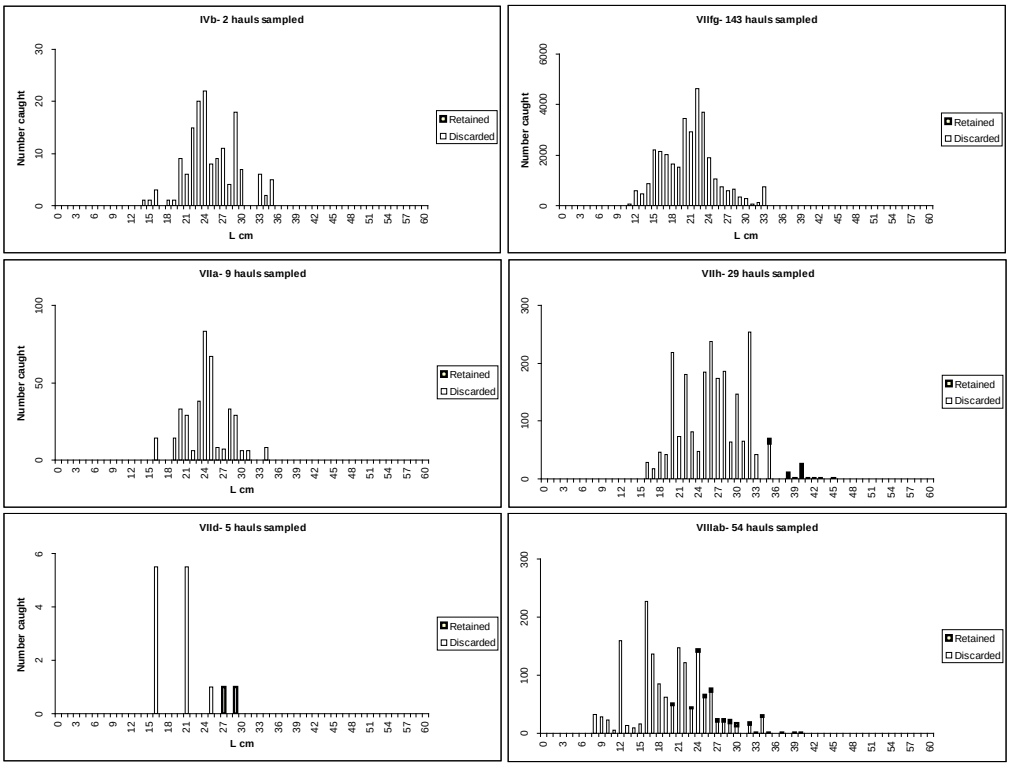


Figure 5 Length composition of French catches of grey gurnard in 2005.

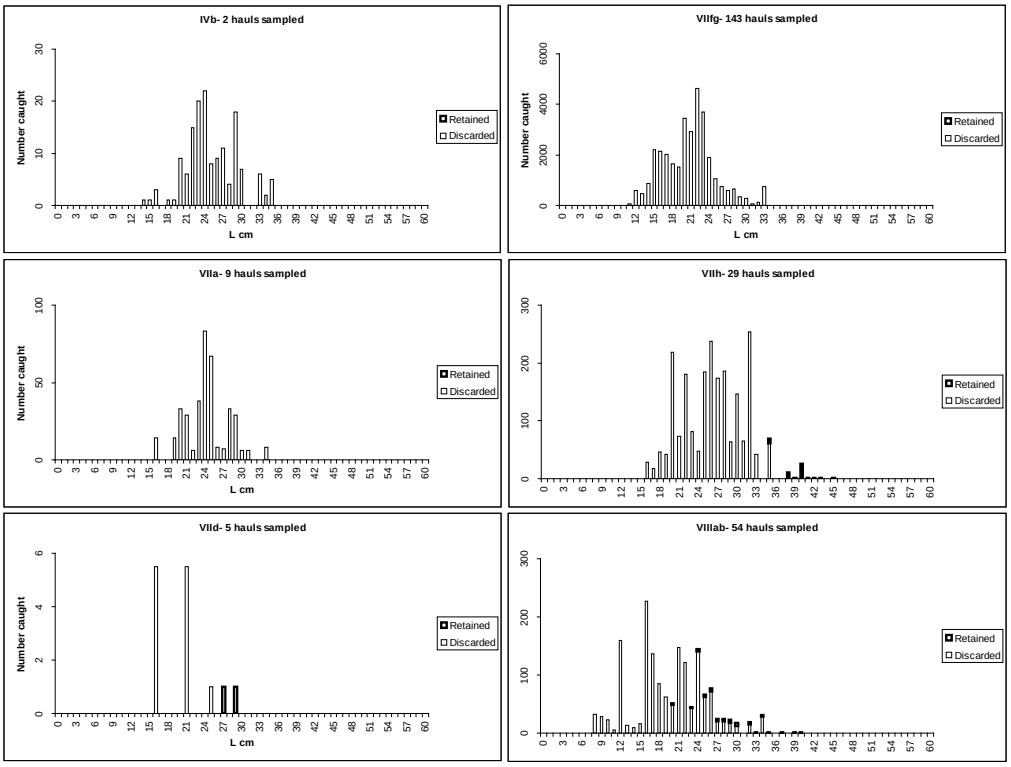


Figure.6 Length composition of French catches of grey gurnard in 2006.

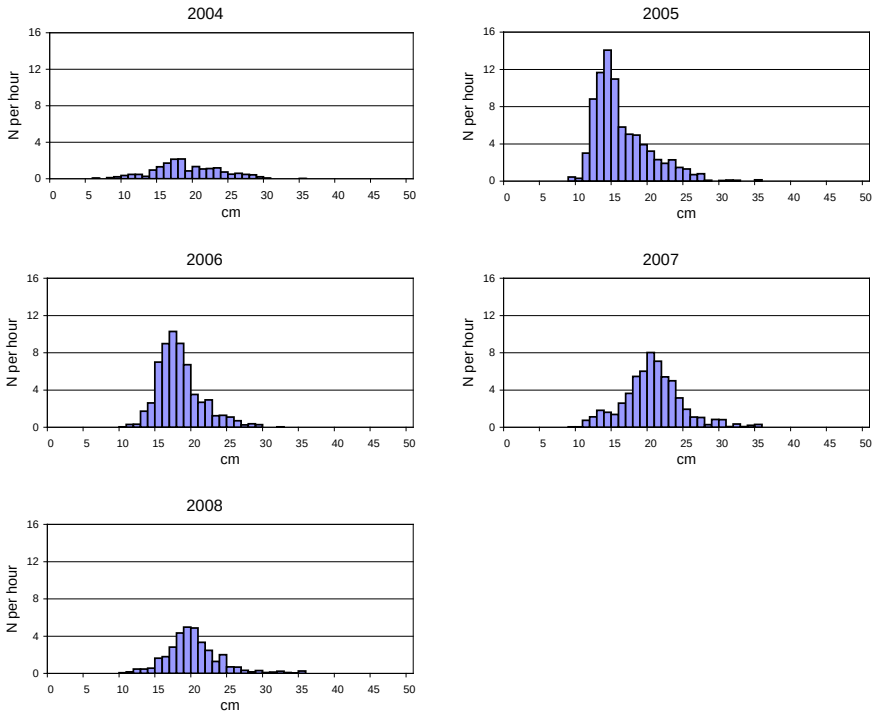


Figure.7 Grey gurnard: number at length discarded per fishing hour by the Dutch beam trawl fishery in the years 2004 to 2008.

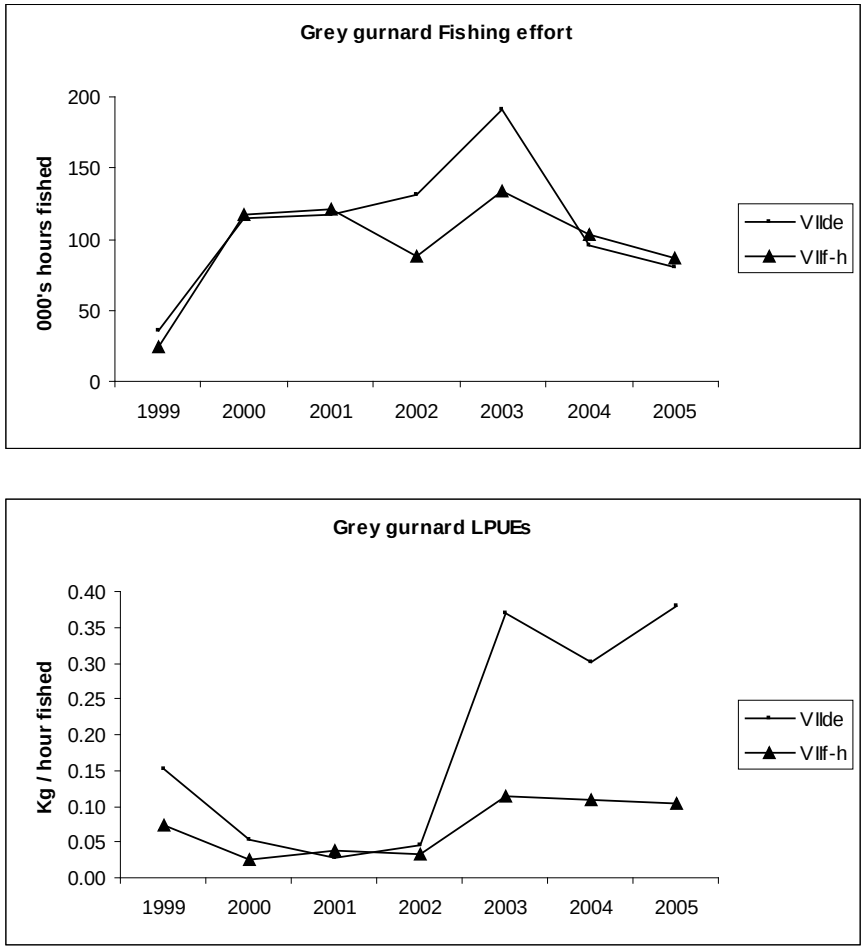


Figure 8. Effort and landings per unit of effort for French single otter trawlers for areas VIId,e and VIIf–h for the years 1999 to 2005.

Eutrigla gurnardus **, IBTS1, average for roundfish areas 1-7**

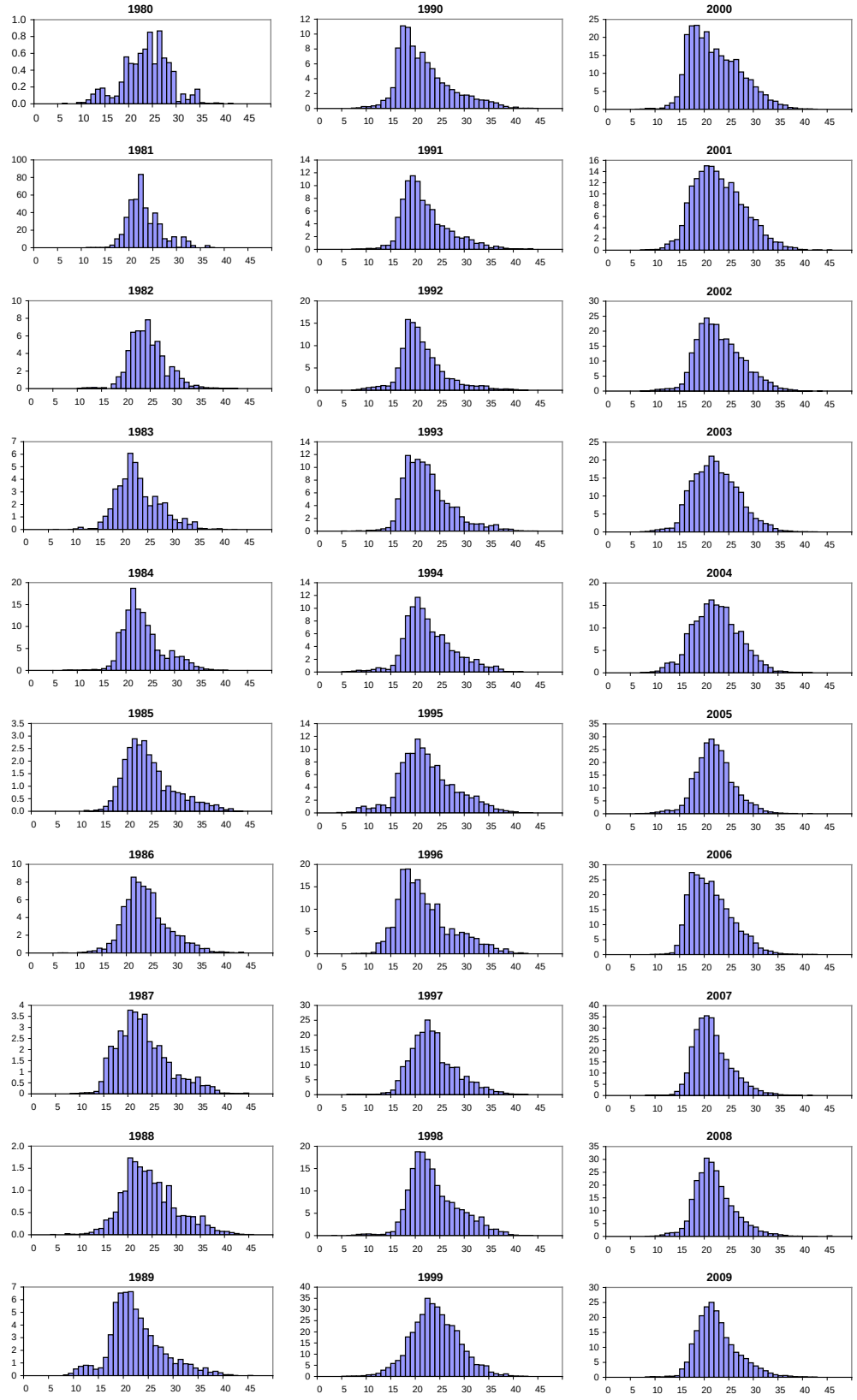


Figure 9 Grey gurnard in IV: number at length during the quarter 1 IBTS survey.

Eutrigla gurnardus **, IBTS1, average for roundfish areas 8 and 9**

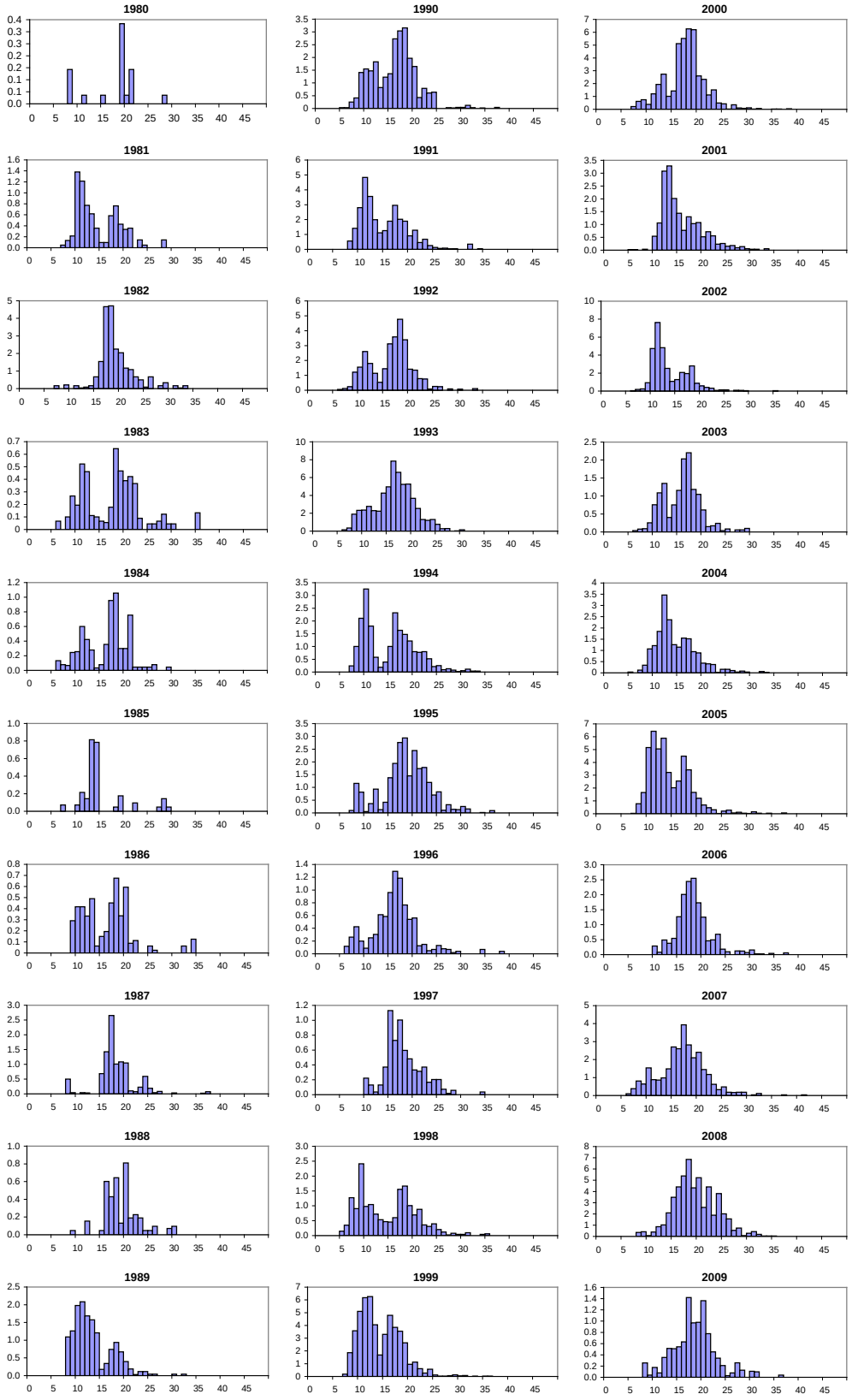


Figure 10 Grey gurnard in IIIa: number at length during the quarter 1 IBTS survey.

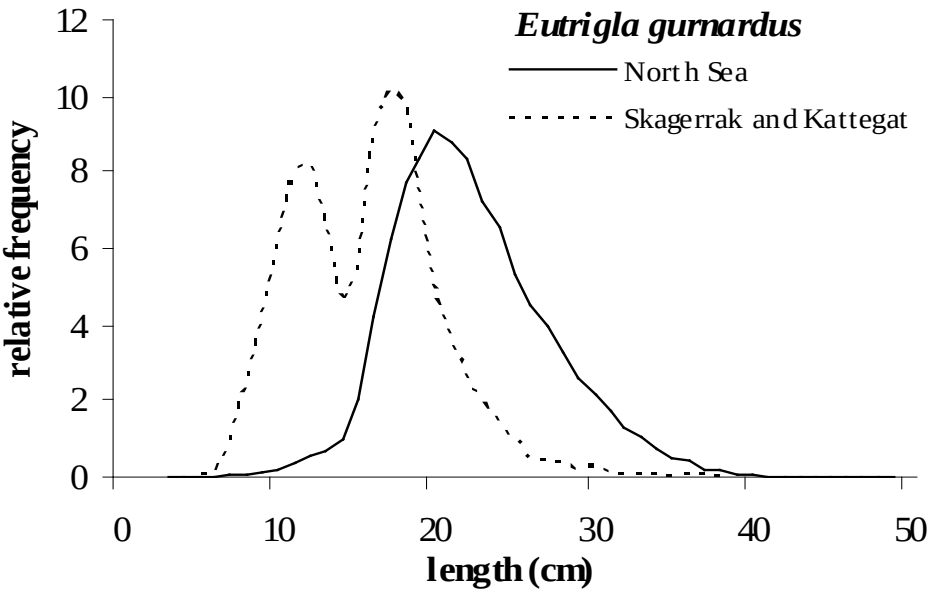


Figure 11. Length frequency distribution of *E. gurnardus* based on the quarter 1 IBTS, 1985–2005 in the North Sea and in Skagerrak/Kattegat. (ICES-FishMap).

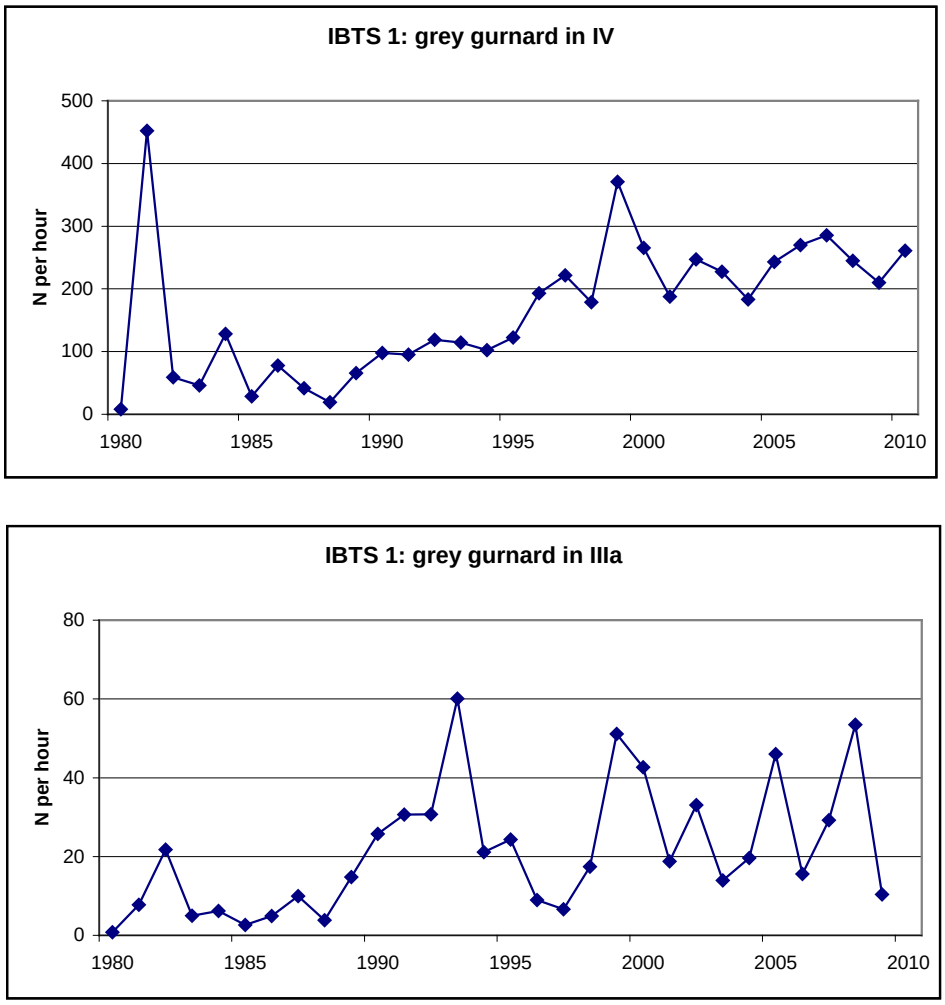


Figure 12. Average catch rate (number per hour for all length classes combined) of grey gurnard in the North Sea (upper panel) and in Skagerrak and Kattegat (lower panel), based on quarter 1 IBTS.

Table -1. Total international landings of grey gurnard from the whole ICES area as reported to FAO for the years 1975–2008.

Country	Bel	Den	Faer	Fra	Icl	Irl	Net	Nor	Por	Russ	Swe	UK E&W	UK Sc	TOTAL
1975	0	0	0	0	0	0	0	0	0	.	14	0	0	14
1976	0	0	0	0	0	0	0	0	0	.	69	0	0	69
1977	0	0	0	0	0	0	0	0	0	.	37	0	0	37
1978	0	0	0	222	0	0	0	0	0	.	54	0	0	276
1979	0	0	0	1,118	0	0	0	0	0	.	49	0	0	1,167
1980	0	0	0	1,172	0	0	0	0	0	.	38	0	0	1,210
1981	0	0	0	0	0	0	0	0	0	.	46	0	0	46
1982	0	360	0	895	0	0	0	0	0	.	43	0	0	1,298
1983	0	1,067	0	852	0	0	0	0	0	.	8	0	0	1,927
1984	0	4,041	0	400	0	0	0	0	0	.	7	0	0	4,450
1985	137	2,358	0	373	0	0	0	0	0	.	9	0	0	2,879
1986	0	314	0	638	0	0	0	0	0	.	10	0	0	962
1987	115	46,598	0	432	0	0	0	0	0	.	6	0	0	47,151
1988	116	38,237	0	655	0	0	0	0	0	.	3	43	0	39,054
1989	119	26,739	0	841	0	0	0	0	0	.	5	.	0	27,704
1990	110	22,076	0	704	0	16	0	0	0	.	3	.	0	22,909
1991	93	14,539	0	443	0	15	0	0	0	.	5	.	4	15,099
1992	118	8,136	0	259	0	17	0	0	0	0	10	.	10	8,550
1993	126	840	0	240	0	10	0	0	<0.5	0	9	.	25	1,250
1994	79	99	0	194	0	0	0	0	<0.5	0	12	.	24	408
1995	58	73	0	204	0	0	0	0	<0.5	0	6	.	21	362
1996	122	70	0	220	1	0	0	0	0	0	4	.	56	473

1997	64	36	0	217	<0.5	0	0	0	0	0	5	.	59	381
1998	50	56	0	159	<0.5	38	0	0	0	0	8	.	0	311
1999	48	86	0	.	0	0	0	0	0	0	132	.	0	266
2000	51	96	0	224	0	0	459	0	0	26,081	5	.	0	26,916
2001	32	289	0	216	0	0	295	<0.5	0	3,155	4	.	46	4,037
2002	64	64	1	179	0	0	286	0	0	60	2	.	41	697
2003	38	92	0	159	0	0	320	<0.5	0	263	7	.	26	905
2004	41	83	0	132	0	0	304	<0.5	<0.5	1,401	5	.	23	1,989
2005	39	73	0	124	0	0	246	0	0	2,456	9	.	22	2,969
2006	25	67	<0.5	103	0	0	165	2	0	138	2	.	27	529
2007	20	38	12	97	0	0	166	5	4	0	3	.	54	399
2008	19	48	15	11	1	0	123	5	8	0	8	.	79	317

Table 2. Age-length key for female grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Females	Age											
Length (mm)	0	1	2	3	4	5	6	7	8	9	10+	Grand Total
110	1											1
120	1											1
130	1											1
150		5										5
160		6	2									8
170		4	4									8
180		2	4		1							7
190		3	3	1	1							8
200		1	5									6
210			1	4								5
220			3	4	1							8
230			1	2	2	1						6
240				1	3							4
250				3	2	1	1					7
260				2	2	2		1				7
270				1	3	3	1					8
280					3	1	1	1			1	7
290					4	1	1	1				7
300					2	1			1			4
310					1		2	1				4
320					1			1	2		1	5
330					1			3	2			6
340					1	1		2		1		5

350					1				2		3	
360				1				1		1	3	
370						1		1			2	
380					2		1		1		4	
390						2	1		1	1	5	
400											0	
410											0	
420										2	2	
430										1	1	
440											0	
450											0	
460										1	1	
Grand Total	3	21	23	18	29	14	9	12	7	5	8	149

Table -2. Age-length key for male grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Males

	Age											
Length (mm)	0	1	2	3	4	5	6	7	8	9	10+	Grand Total
140	1											1
150		3										3
160		1	1									2
170		4										4
180		2	5	1								8
190		1	3	1	1							6
200		1	5									6
210			4	3	1							8
220			1	4								5
230			1	3	3							7
240			1	2		1						4
250			1		1	1	1		1	1		6
260					2	2	1					5
270					1					1	1	3
280					2	2					2	6
290						1	1	1			2	5
300				1	1	1	1		1			5
310					1		1					2
320					1	1				1		3
330					1				2			3
340						1			1			2
350							1	1				2
360							1					1
370										1	1	2
380							1			1		2
390											1	1
400											2	2
410											1	1
Grand Total	1	12	22	15	15	10	8	2	5	5	10	105

Table -3. Maturity data for female grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Females

Length	Immature	Maturing	Mature	Spent	Grand Total
110	1				1
120	1				1
130	1				1
150	5				5
160	5	2		1	8
170	8				8
180	5	1		1	7
190	6	1		1	8
200	4	1		1	6
210	2	3			5
220	3	4		1	8
230	2	1		3	6
240	1	1		2	4
250	2	3		2	7
260	1	3		3	7
270	2	3		3	8
280		3		4	7
290	1	4		2	7
300		2		2	4
310		2		2	4
320		3		2	5
330		5		1	6
340		2		3	5
350		3			3
360		1		2	3
370		2			2
380		3		1	4
390		2	1	2	5
420		1		1	2
430		1			1
460				1	1
Grand Total	50	57	1	41	149

Table 5. Maturity data for male grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Males

Length	Immature	Maturing	Mature	Spent	Grand Total
140	1				1
150	3				3
160	2				2
170		4			4
180	6	1		1	8
190	4	1		1	6
200	3	3			6
210	6	2			8
220	3	1		1	5
230	1	2		4	7
240	1	1		2	4
250	1	2		3	6
260	1	1	1	2	5
270		3			3
280	1	3		2	6
290		1		4	5
300	1	2		2	5
310		1		1	2
320	1	2			3
330				3	3
340		2			2
350		2			2
360		1			1
370				2	2
380				2	2
390		1			1
400		2			2
410		1			1
Grand Total	35	39	1	30	105

Stock Annex: Striped Red Mullet in Divisions IIIa, VIId and Subarea IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Red Mullet in Division IIIa, VIId and Subarea IV
Working Group:	WGNSSK
Date:	May 2012
By	

A General biology

The striped red mullet (*Mullus surmuletus*) is a benthic fish, which is found along the European coasts from the South Norway and North Scotland including the Faroe Islands in the North, to the Strait of Gibraltar in the South. This species is also found in the northern part of western Africa and in the Mediterranean and Black Seas (Quéro & Vayne, 1997). Striped red mullet is considered occasional off Norway, around Ireland, at the north coasts of England and in the West of Scotland (Davis & Edward, 1988; Gibson & Robb, 1997).

Analysis of British commercial landings revealed a strong concentration of this species in the central pit of the western Channel during winter (Dunn, 1999). The scientific survey CGFS (Channel Ground Fish Survey), carried out every year by Ifremer in the eastern Channel since 1988, showed that young individuals are distributed in coastal areas, while adults exhibit preferentially an offshore distribution in the eastern part (Carpentier *et al*., 2009).

Finally, nurseries are located in the Bay of Saint-Brieuc and at the Falklands coasts (Morizur *et al*., 1996). Striped red mullet is accommodated to deep water and elevated temperatures (ICES, 2007b), and tolerates weak and high salinity (corresponding respectively to juvenile and adult habitats) and is rarely found in the transitions zones of intermediate salinity. This species is met mostly on sandy substratum (Carpentier *et al*., 2009). Food of striped red mullet is primarily composed of crustaceans and molluscs.

In the English Channel, the first sexual maturity was identified on fish of 16.2 cm for the male and 16.7 cm for the female (Mahé *et al*., 2005).

A.1 Management regulations

Before 2002, a minimum landing size was set at 16 cm in France. Since, this minimal size requirement has been removed and it resulted on catch of immature individuals (< 14 cm), which has recently been targeted and landed.

A.2 Stock ID and possible management areas

Due to the presence of the striped red mullet in catches all year-round, Dunn (1999) suggested that a single stock should exist within the English Channel, although he could not determine whether this stock was distinct from other western stocks. He also suggested that it might be a newly established stock in the North Sea.

In 2004 and 2005, a study using fish geometrical morphometry was carried out in the Eastern English Channel and the Bay of Biscay. It pointed out a morphological difference on striped red mullets between those from the Eastern English Channel and those from the Bay of Biscay.

In 2010, in the Nespman project, a study based on the shape of the otoliths has been conducted to differentiate stocks. The study area was divided into six geographic sectors: the NS (North Sea; ICES Division IVab), the EEC (Eastern English Channel; ICES Division VIId), the WEC (Western English Channel ; ICES Division VIIe), the CS (Celtic Sea ; ICES Division VIIh), the NBB (North Bay of Biscay ; ICES Division VIIIa) and the SBB (South Bay of Biscay ; ICES Division VIIIb) (Figure 1).

In this work, three techniques have been applied: a Fourier, a PCA and a Geodesic approach (In Benzinou *et al*., submitted). Among these 3, Geodesic approach reached the highest mean correct classification rate (30%). The confusion matrix of Geodesic approach on dataset with six geographic sectors, achieved by K-Nearest Neighbours classifier (*In* Benzinou *et al*., submitted) showed that populations of striped red mullet of Western English Channel and Eastern English Channel could be separated (Table 4).

In the north, it appears a continuum between the North Sea and the Eastern English Channel. In the same way, a continuum has been identified between the north and the south of the Bay of Biscay. Currently, we do not have enough data to separate the Bay of Biscay from the Celtic sea or the Eastern English Channel.

Therefore, for management purposes, two areas could be considered for this species:

- the north area (III, IV &VIId)
- the south area (VI, VIIa,e,g,h,j-VIIIa,b & IXa)

B Fisheries data

According to ICES statistics, in the Atlantic Ocean, fishery of this species was only conducted by Spain and Portugal from 1950 to 1975, then France also part of it. From 1950 to 1975, fishing of striped red mullet was carried out nearby the Spanish coasts and in the Bay of Biscay. From 1990, catches strongly increased, essentially due to France, but also to England and Netherlands fisheries. It could be explained by the beginning of exploitation of the striped red mullet in the English Channel and in the North Sea (Figure 2).

In the Eastern Channel, the main country fishing on striped red mullet was historically France, from 2000, catches are shared by French, Dutch and English fisheries. French fisheries target striped red mullet in spring and autumn, depending on the abundance using bottom trawlers with a mesh size of 70-99 mm in the Eastern Channel and south of the North Sea (Figure 2). In the Eastern English Channel and south of the North Sea, the complementary gears are essentially represented by various trawlers and in Western English Channel by various gears and gillnets. Striped red mullet catches, achieved by these complementary metiers, remain accessory. French trawlers concerned by striped red mullet fishery have a length and a power respectively of about 20 meters and 400 kilowatts yearly average. This has remained stable since 1991. Among this fleet, 71% of the ships which fish in the south of the North Sea show to fish also in the Eastern English Channel. Only 24% of ships fishing in the Western English Channel frequented the Eastern English Channel.

Dutch fisheries are targeting striped red mullet using Scottish seines. This fishery consists of boats between 24-40 meters (most of them being old beam trawlers) fishing most of the time in the North Sea and in the Channel in the winter.

Main areas for the striped red mullet exploitation are areas IV, VIId,e and VIIIa,b. French catches are the most important in the entire zone. Other important countries are the Netherlands and the United Kingdom with regard to the English Channel (VIId,e) and the North Sea (IV), where catches are concentrated in the south (IVb,c). The north of the Bay of Biscay (VIIIa,b) is exploited by France and Spain. The south (VIIIc) is only exploited by Spain. Other countries concerned by this fishery for small catches are Germany, Scotland, Denmark and Ireland.

Since 2008, landings decrease in the north area (IV-VIId) (Figure 3, Figure4 & Figure5). One observed a reverse trend in the south.

This species is not discarded by French vessels. Striped red mullet was rare in the discard samples of Portuguese bottom otter trawl fleet (OTB) in ICES Division IXa and, when present, were found in low strength (Fernandes & Prista, 2012). More investigations on potential discarding should be carried out in other countries areas.

C. Survey data, recruit series

Since 1988, striped red mullet abundance indices are currently available for the Bay of Biscay (EVHOE survey), the Celtic sea (EVHOE survey), the western English Channel (UK-WCBTS survey), the eastern English Channel (CGFS survey), and for the North Sea (IBTS survey Q1 and Q3) (Figure 6).

In the north area (III, IV &VIId), abundance indices (CGFS survey and IBTS surveys Q1 and Q3) of 3 surveys were used. During the last decade, variable abundance during CGFS survey has been observed with 3 large peaks in 2003, 2007 and 2009 (from 50 to 70 per hour, Figure6). For the years 2003 and 2007, a peak of abundance has been observed too, during IBTS survey Q3 in the North sea. Abundance indices of IBTS-Surveys Q3 are higher than these of IBTS-Survey Q1 (Figure 7). Abundance of striped red mullet during of IBTS-Surveys Q3 presented trend to increase from 1990 to 1995 and after this date, abundance trend to decrease. The maps of these surveys show the different spatial distributions with the fish close to the UK coasts during Quarter 1 and in the south-eastern of the North Sea (coasts of Belgium and the Netherlands) during Quarter 3 (Figure 8). Abundance indices of striped red mullet per age class during FR-CGFS from 2006 to 2011 presented Age groups from 0 to 2 only (Figure 9). In consequently, the abundance of this survey give recruitment index. Correlation between Abundance indices of striped red mullet per age class during FR-CGFS and landings in ICES Subareas IV and VIId showed that the landings are strongly correlated to the recruitment (Figure 10). The Age Length Key of striped red mullet in the North Sea during the IBTS-Q1 survey did not show the recruitment only with mainly age groups between 1 and 3 (Figure 11).

In the south area (VI, VIIa,e,g,h,j-VIIIa,b & IXa), abundance indices (EVHOE survey and UK-WCBTS survey) of 2 surveys were used. These 2 surveys do not present trend (Figure 6). There are few peaks of abundance of striped red mullet in Celtic sea and the Bay of Biscay (EVHOE-WIBTS Q4) and the Eastern English Channel (UK-WCBTS Survey). During EVHOE-WIBTS-Q4 Survey, 2001, 2003, 2005 and 2009 present peaks of abundance of striped red mullet (from 16 to 23 per hour, Figure 6). Abundance indices per size class during EVHOE-WIBTS-Q4 show mainly fish between 8 to 17 cm (TL). In consequently, the abundance of this survey gives recruitment index. UK-WCBTS survey in the Eastern English Channel

Since 1979, the PGFS (Portuguese Autumn Groundfish Survey) covers the whole Portuguese continental coast, within depths ranging from 20 to 500m. The PCTS (Portuguese Crustacean Trawl Survey) covers the Southwestern and the South regions of the Portuguese continental coast, with depths ranging from 200 to 750m. Data from these surveys shows that striped red mullet distributes along the Portuguese coast, at depths ranging between 20 and 700 m deep. Some investigations on potential distribution of this species should be carried out in the Spanish coasts between the Portuguese coasts and the Bay of Biscay.

D. Biological sampling

The Netherlands sampled 31 fishes in 2009 during Quarter 3 and 223 fishes in 2010 (month 5: 60; month 6: 60; month 7: 60; month 10: 45) for age estimation in the North Sea. The Azti institute carried out sexual maturity and measures in length in 2009, in the Bay of Biscay.

An inventory of the French data collected from the Bay of Biscay to the North Sea is given in Table 2. French samplings started in 2004 in the Eastern Channel and in south North Sea, and since 2008 in the Bay of Biscay.

A French study on the sampling optimisation (IVc; VIId) was presented in the WGNEW 2010. The results showed a strong yearly adequacy between sampling and catches (Mahé *et al*., 2007).

E. Biological parameters and other research

Since 2004, data (age, length, sexual maturity) are usually collected by France for the Eastern English Channel and the southern North Sea (Table 2). France started to collect data for VIIIa,b at the end of 2007. In 2007-2008, the striped red mullet otolith exchange had for goal to optimise age estimation between countries (ICES, 2009).

In 2011, an Otolith Exchange Scheme has been realised, which was the second exercise for the striped red mullet *Mullus surmuletus*. Four readers of this exchange interpreted an images collection coming from the Bay of Biscay, the Spanish coasts and the Mediterranean coasts (Spain and Italy). A set of *Mullus surmuletus* otoliths (N=75) from the Bay of Biscay presented highest percentage of agreement (82%). On 75 otoliths, 34 were read with 100% agreement (45%) and thus a CV of 0%. Modal age of these fishes was comprised between 0 and 3 years (Mahé *et al*., 2012).

F. Analysis of stock trends / assessment

Currently, age structured analytical stock assessment is not possible due to a too short time series of available data.

By comparing landings from ICES Subareas IV and VIId with the abundance indices of CGFS-survey by age-group, one can noticed that abundance indices of Age-group 1 have the same trend as the landings (Figure 7). This analysis should be supplemented but these results showed that landings were essentially constituted by young fish (Age group 1). These results confirm the analysis of landings composition by age group from 2004 to 2008 from ICES Subareas IV and VIId.

G. Data requirements

Regular sampling of striped red mullet catches must be continued under DCF. Sampling in the Eastern Channel and in south North Sea started in 2004. The effort of sampling (700 otoliths) in these zones is sufficient (ICES, 2007) but must be continued.

Effort of sampling in the North Sea (IVb and IVc), the Western Channel, the Celtic Sea and in the bay of Biscay started in 2009. In 2010 and 2011, a sampling level for age and maturity data was diminished compared to 2009, due to the end of the Nespman project.

Since 2009, a concurrent sampling design carried out, should provide more data (length compositions) than in recent years.

The FR-CGFS and FR-EVHOE surveys would continue to provide abundance indice series at age. However, The FR-CGFS survey is not funded by DCF. In the same way, it does not exists any survey in the Western Channel (VIIe) which extended to French and English waters, whereas catches of the striped red mullet in this geographical area in particular, are as significant as catches in the Celtic sea.

H. References

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management, final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom

Benzinou A, Carbini S, Nasreddine K, Elleboode R, Mahé, K, 2012. Discriminating stocks of striped red mullet (Mullus surmuletus) in the Northwest European seas using three automatic shape classification methods, Fisheries Research, submitted.

Davis, P.S. & Edward, A.J., 1988. New records of fishes from the northeast coast of England, with notes on the rediscovery of part of the type collection of marine fishes from the Dove Marine Laboratory, Cullercoats. Trans. Nat. Hist. Soc. Northumbria, 55 : 39-46.

Dunn, M.R., 1999. The exploitation of selected non-quota species in the English Channel. Lowestoft: 323pp.

Gibson, R.N. & Robb, L., 1997. Occurrence of juvenile red mullet (Mullus surmuletus) on the west coast of Scotland. Journal of the Marine Biological Association of the United Kingdom, 77(3): 911-912.

ICES, 2007b. Report of the Working Group on Fish Ecology (WGFE), 5–9 March 2007, Nantes, France. ICES CM 2007/LRC:03. 217 pp.

Mahé K., Destombes A., Coppin F., Koubbi P., Vaz S., Leroy D. & Carpentier A., 2005. Le rouget barbet de roche Mullus surmuletus (L. 1758) en Manche orientale et mer du Nord, 186pp.

Mahé, K., Elleboode, R., Charilaou, C., Ligas, A., Carbonara, P. & Intini, S., 2012. Red mullet (*Mullus surmuletus*) and striped red mullet (*M. barbatus*) otolith and scale exchange 2011, 30pp.

Quéro, J.C. & Vayne, J.J., 1997. Les poissons de mer des pêches françaises. IFREMER, Ed. Delachaux & Niestlé, 304pp.

Table 1. Striped red mullet. Confusion matrix (in %) for Geodesic approach on dataset (1) achieved by K-Nearest Neighbours classifier (*In* Benzinou *et al.*, submitted). Mean correct classification rate was 30% (25% for PCA approach and 19% for Fourier approach).

Geodesic approach on Dataset (1)						
	Actual Class					
Estimated Class	NS	EEC08	WEC	CS	NBB	SBB
NS	**15**	20	11	8	5	11
EEC08	28	**44**	17	23	5	5
WEC	9	9	**22**	11	7	9
CS	24	15	24	**32**	15	13
NBB	10	5	16	13	**27**	22
SBB	14	7	10	13	41	**40**

Table 2. Striped red mullet. Biological sampling in France.

	Length		Age		Maturity		Individual weight	
Year	Fish number	Sample number	Fish number	Sample number	Fish number	Sample number	Fish number	Sample number
1994	181	23	-	-	-	-	-	-
1995	246	32	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-
2002	65	9	-	-	-	-	-	-
2003	147	17	-	-	-	-	-	-
2004	142	17	372	12	620	12	1401	12
2005	536	10	301	3	196	3	301	3
2006	1941	10	646	4	646	4	646	4
2007	5053	129	740	4	740	4	740	4
2008	4396	124	447	5	447	5	190	2
2009	8648	334	1221	11	1221	11	1076	9
2010	7931	328	779	8	779	8	528	4
2011	8138	326	585	7	445	6	375	4

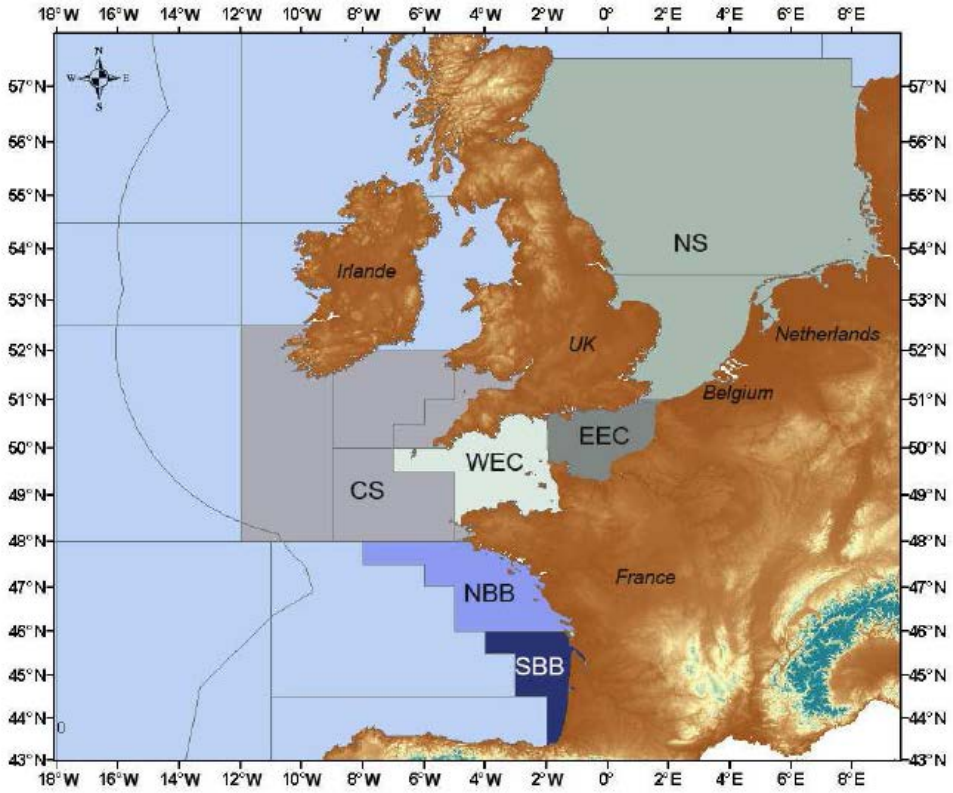


Figure 1. Striped red mullet. Map divided into 6 geographic sectors.

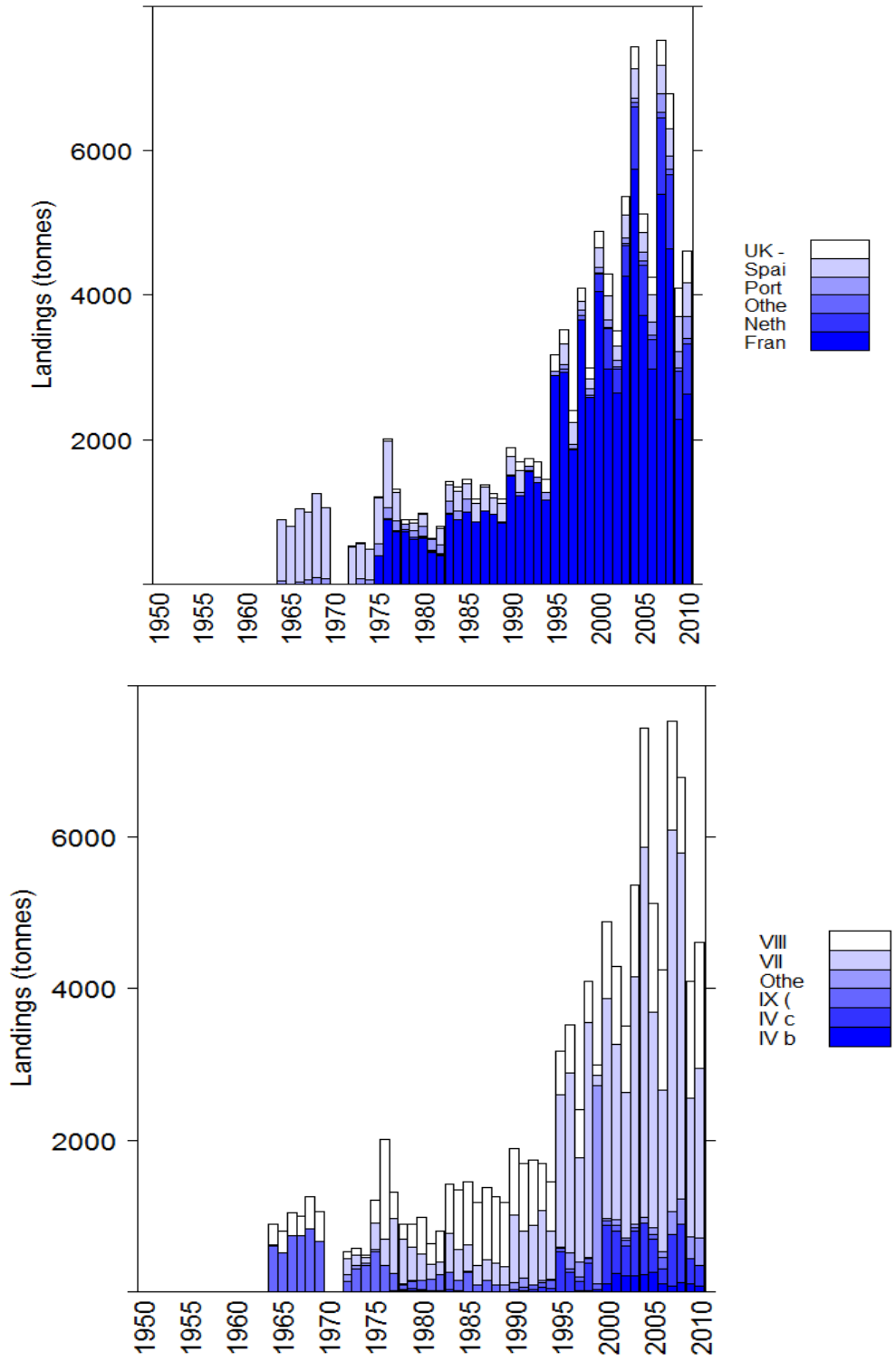


Figure 2. Striped red mullet. Landings per country (top panel) and per ICES area (bottom panel). As officially reported.

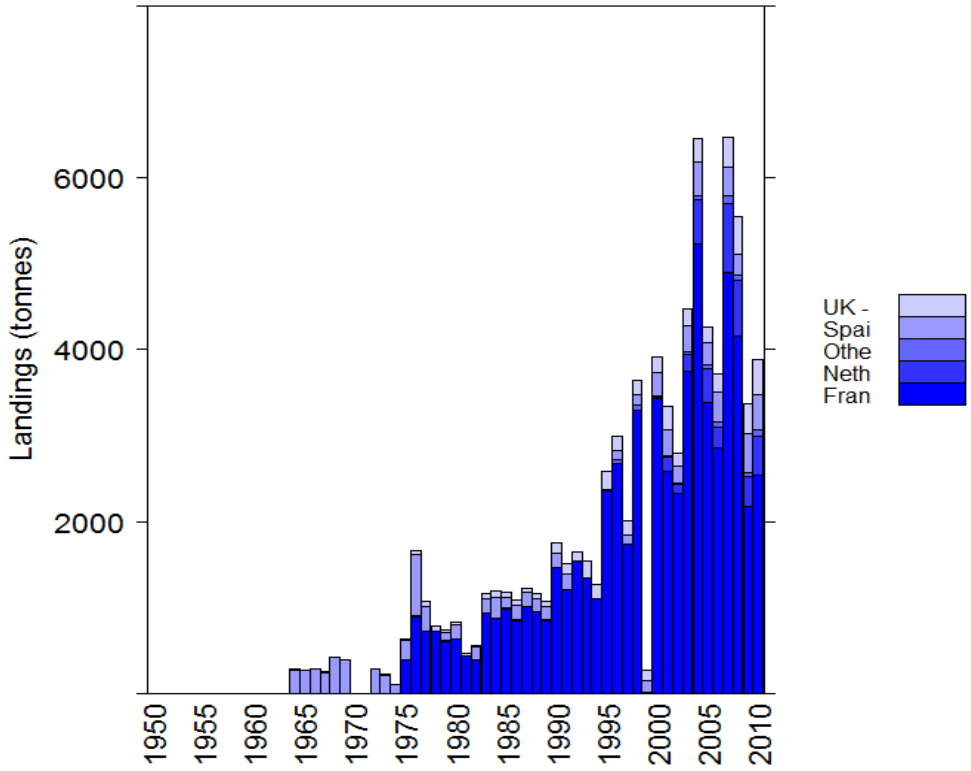


Figure 3. Striped red mullet. Landings in ICES area VIId by country. As officially reported.

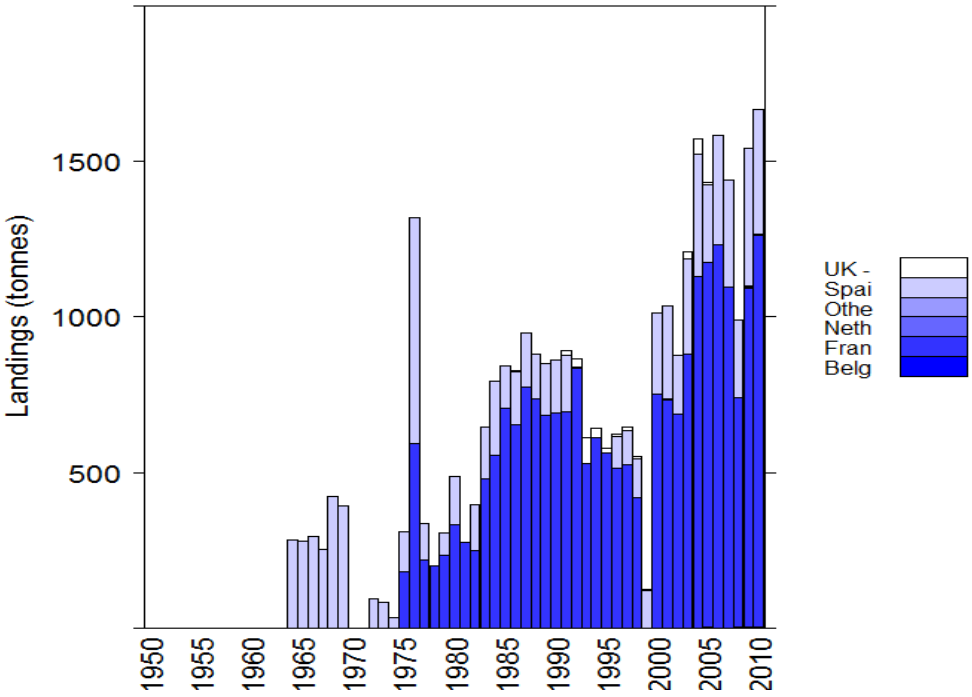


Figure 4. Striped red mullet. Landings in ICES area VIII by countriy. As officially reported.

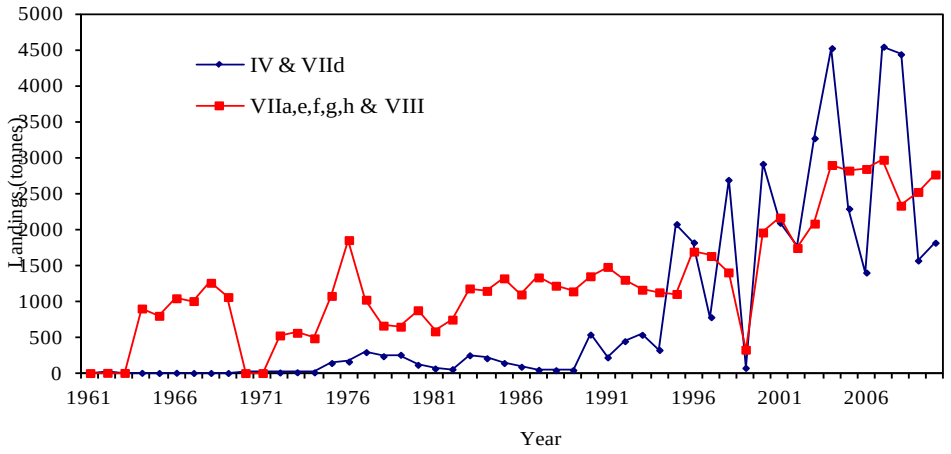


Figure 5. Striped red mullet. Landings from 1960 to 2010 in the north zone (ICES areas : VIId and IV) and in the south zone (ICES areas : VIIa,d,g,h, j & VIII). As officially reported.

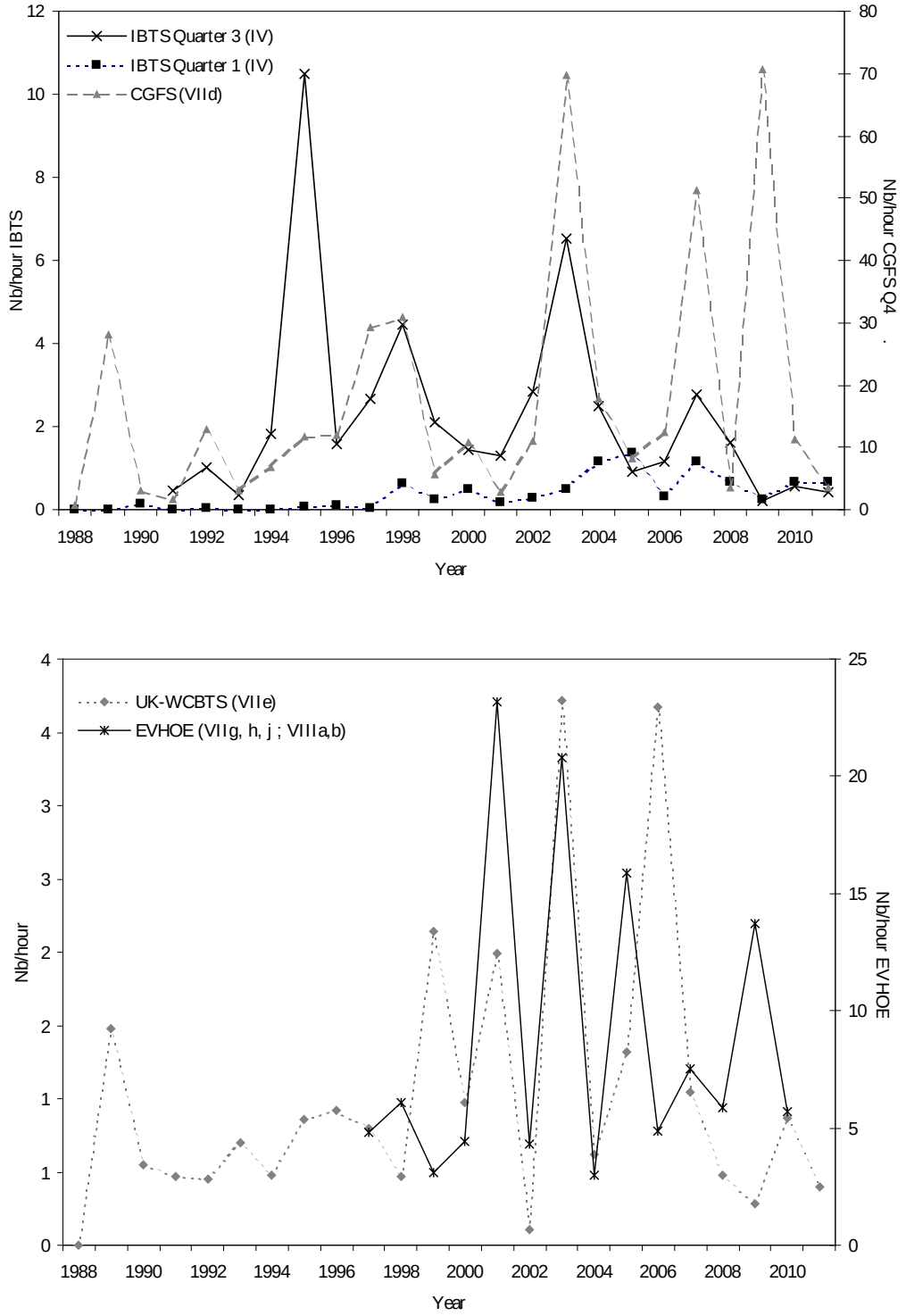
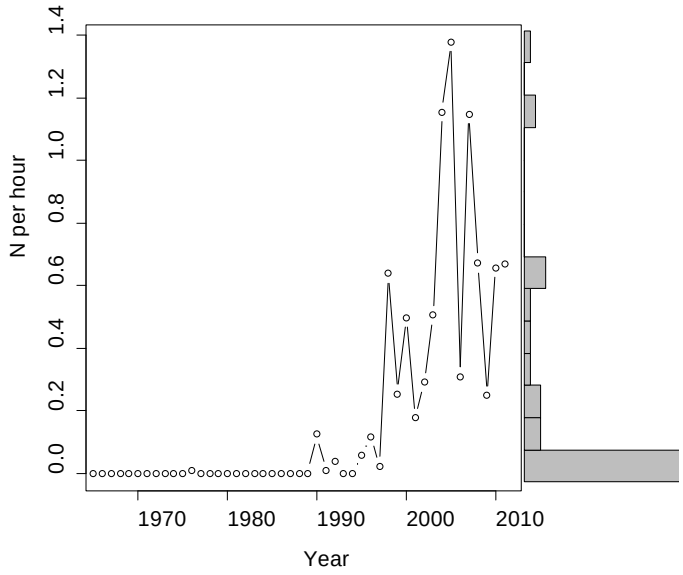
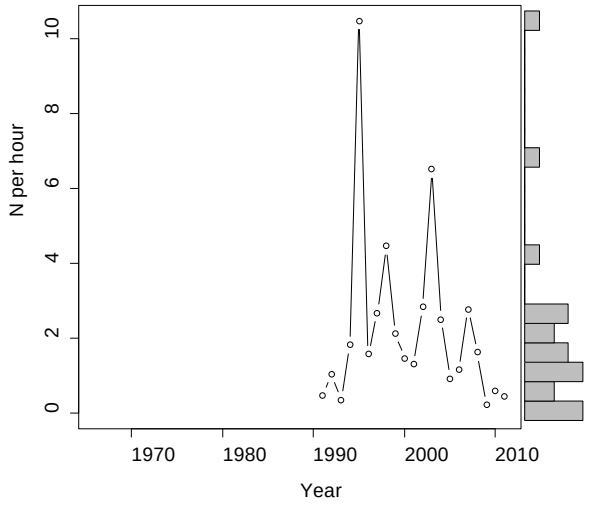


Figure 6. Striped red mullet. Time series of abundance (Nb/hour) of striped red mullet base on Surveys (International Bottom Trawl Survey (IBTS, IV), Channel Ground Fish Survey (FR-CGFS, VIId), UK-WCBTS (VIIe), EVHOE-WIBTS survey (VIIg, h, j ; VIIIa,b) from 1988 to 2011.

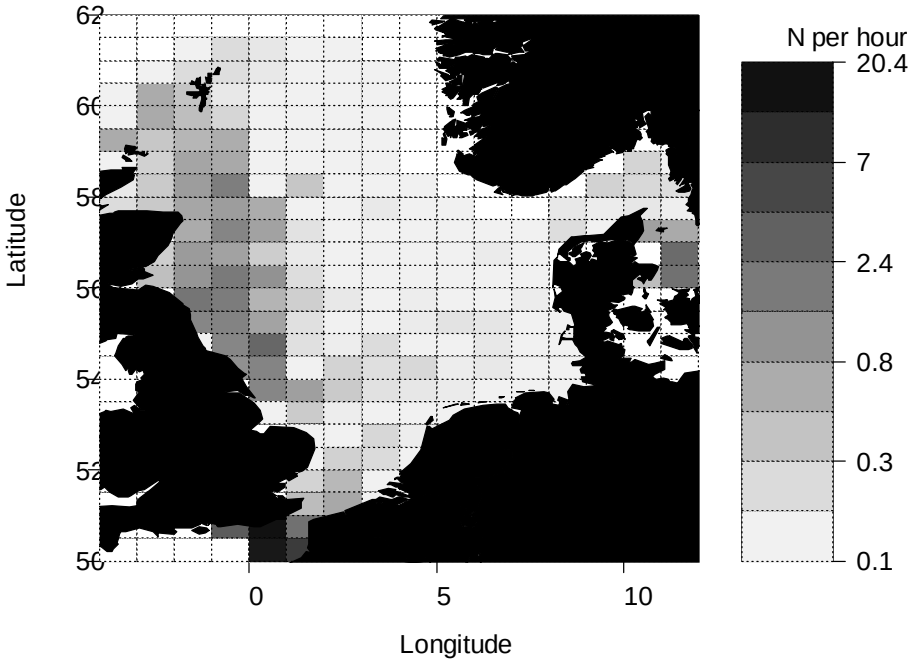


IBTS Q1

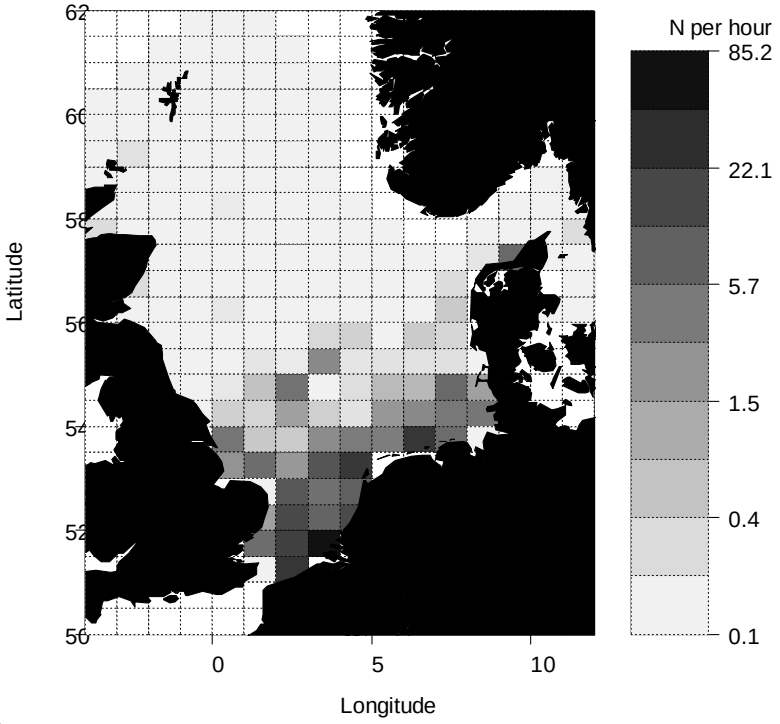


IBTS Q3

Figure 7. Striped red mullet. Time series of abundance (Nb/hour) of striped red mullet base on International Bottom Trawl Survey (IBTS, IV) during Q1 (top panel)and Q3 (bottom panel), Width of grey rectangle is proportional to the occurrence of striped red mullet.



IBTS Q1



IBTS Q3

Figure 8. Striped red mullet. Map of abundance index (Nb/hour) of striped red mullet during the IBTS survey Q1 (top panel) and Q3 (bottom panel).

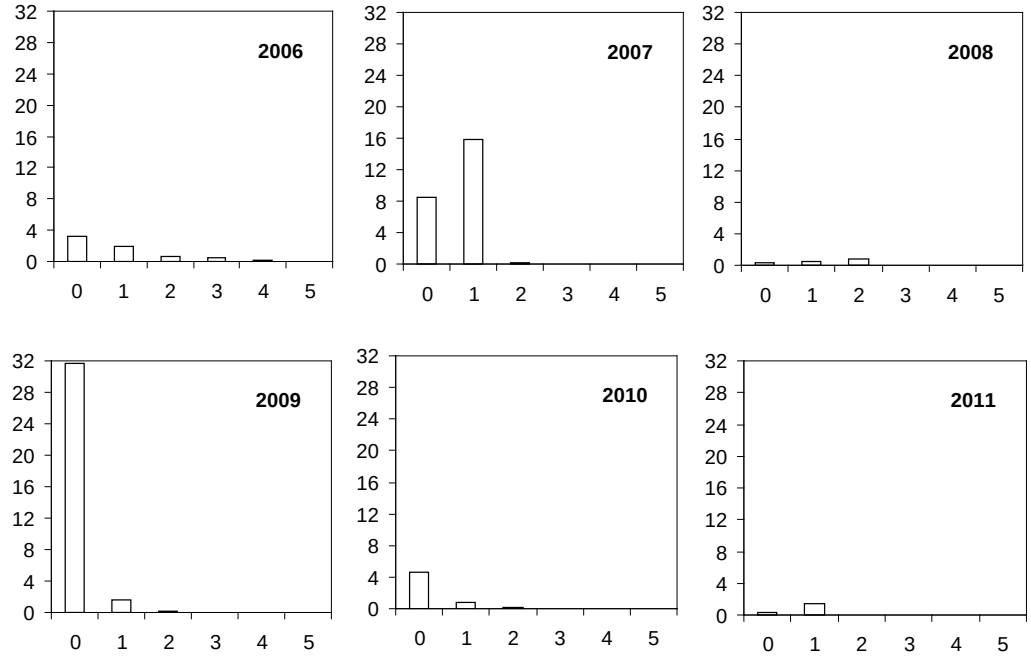


Figure 9. Striped red mullet. Abundance indices (Nb/30 min Trawl) of striped red mullet per age class (Length, cm.) during FR-CGFS from 2006 to 2011.

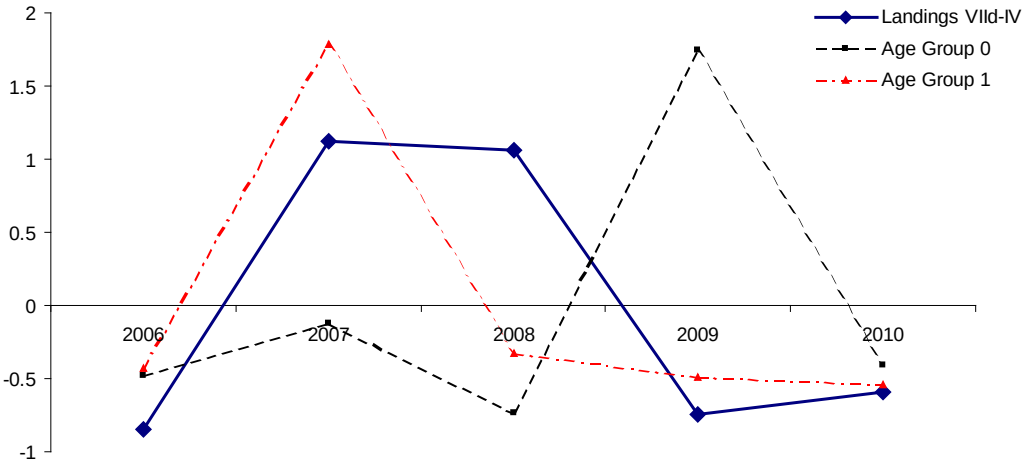


Figure 10. Striped red mullet. Mean standardised of Abundance indices base on CGFS survey (ICES Subarea VIId) from 2006 to 2010 per age class and total landings (ICES Subareas VIId-IV) of striped red mullet.

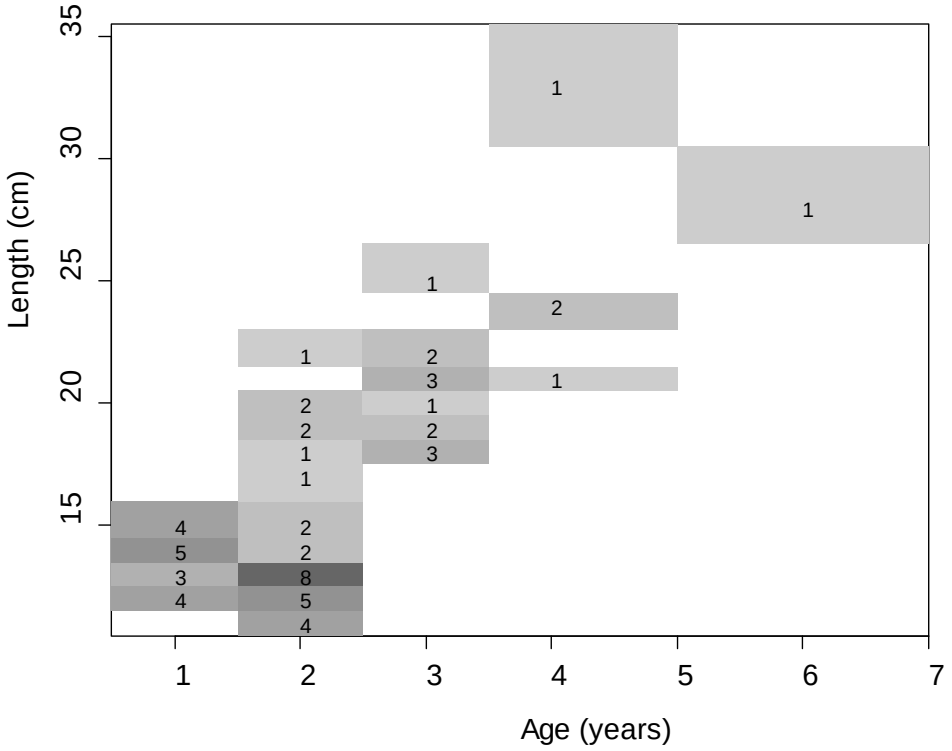


Figure 11. Striped red mullet. Age Length Key of striped red mullet in the north Sea during the IBTS-Q1 survey.

Appendix 1 – ELEMENTS OF BIOLOGY ON Red Mullet VIId.

Excerpts from the project InterReg 3A CHARM Phase II.

Mullus surmuletus

Linnaeus,1758

Rouget barbet de roche
Red mullet

Embranchement-Phylum : Chordata
Classe-Class : Actinopterygii
Ordre-Order : Perciformes
Famille-Family : Mullidae



© IFREMER

Biologie - Le rouget barbet adulte se nourrit de petits crustacés, annélides et mollusques, utilisant ses barbillons mentonniers pour détecter les proies et fouir la vase. En Manche, la période de frai s'étale de mai à juillet. Les œufs pélagiques incubent en 3 à 8 jours selon la température. Après éclosion, les larves pélagiques résorbent leur vitellus en 4 jours et migrent vers la côte en automne. Les juvéniles de plus de 5 cm de long rejoignent les fonds sableux ou coquilliers de plus de 10 m de profondeur. La croissance la première année est particulièrement rapide.

Caractères démographiques - Taille maximale 42 cm ; taille commune 15-35 cm ; taille commerciale minimale 19 cm (UE) ; longévité maximale 11 ans ; âge et taille à maturité 1-2 ans et 16-19 cm ; paramètres de von Bertalanffy : taille asymptotique L_{inf} = 51.35 cm, taux de croissance k = 0.186 an^{-1}, âge théorique t_0 = -1.21 ; paramètres de fécondité *alpha = n/a* et *beta = n/a*.

Environnement - Poisson benthique vivant sur les fonds rocheux, à graviers ou sableux du plateau continental et du bord du talus, entre 10 et 300 m de profondeur. Espèce préférant les eaux marines ayant des températures comprises entre 8 et 24°C.

Répartition géographique - Atlantique est, de la Norvège et du nord des îles britanniques jusqu'au Sénégal et les îles Canaries ; mer Méditerranée et mer Noire.

Biology - Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud. In the English Channel, spawning occurs from May to July. The pelagic eggs incubate in 3 to 8 days, depending on temperature. After hatching, the pelagic larvae absorb their vitellus in 4 days, and they migrate to the coast in the autumn. Juveniles of length greater than 5 cm return to sandy and shelly substrates deeper than 10 m. Growth during the first year of life is particularly fast.

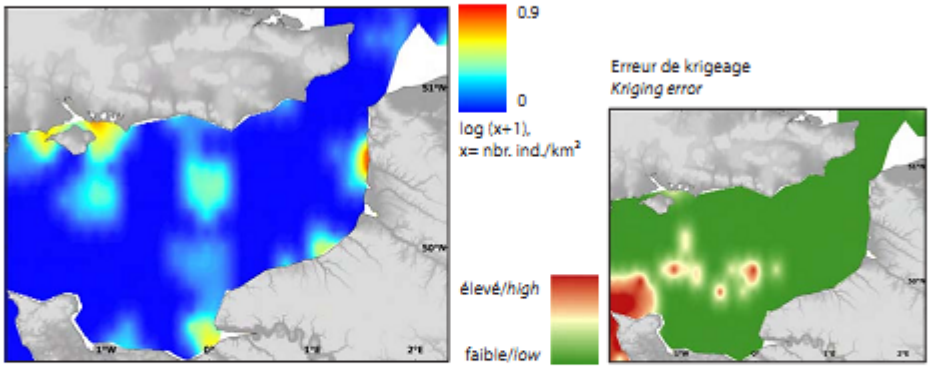
Life history parameters - Maximum length 42 cm; common length 15-35 cm; minimum landing size 19 cm (EU); maximum lifespan 11 years; age and length at maturity 1-2 years and 16-19 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 51.35 cm, growth rate k = 0.186 year^{-1}, theoretical age t_0 = -1.21; fecundity parameters *alpha = n/a* and *beta = n/a*.

Environment - Red mullet is a benthic fish that lives on pebbly, gravelly and sandy substrates of the continental shelf and on the continental slope between 10 and 300 m depth. The species is mostly found in marine waters with temperatures between 8 and 24°C.

Geographical distribution- Eastern Atlantic, from Norway and the northern British Isles, down to Senegal and the Canary islands; also in the Mediterranean and Black Seas.

< 1 An / Year old - Mullus surmuletus

Abondance pluriannuelle
en juillet (BTS, 1989-2006)
Multi-annual abundance in July (BTS, 1989 -2006)



Les rougets barbets de taille inférieure à 17.3 cm ont été considérés comme ayant moins d'un an. Les aires de distribution et les modèles d'habitat (en octobre) ont été faits séparément pour les individus de moins de un an et ceux de plus d'un an. Les rougets barbets sont mal échantillonnés par le chalut à perche utilisé pendant les campagnes BTS et donc il n'est pas possible de montrer les distributions annuelles en cette saison. Les deux cartes de juillet présentent donc les abondances moyennées (ou pluriannuelles) sur les années 1989 à 2006 ; aucun modèle d'habitat n'a satisfait les critères de sélection pour présentation dans l'atlas.

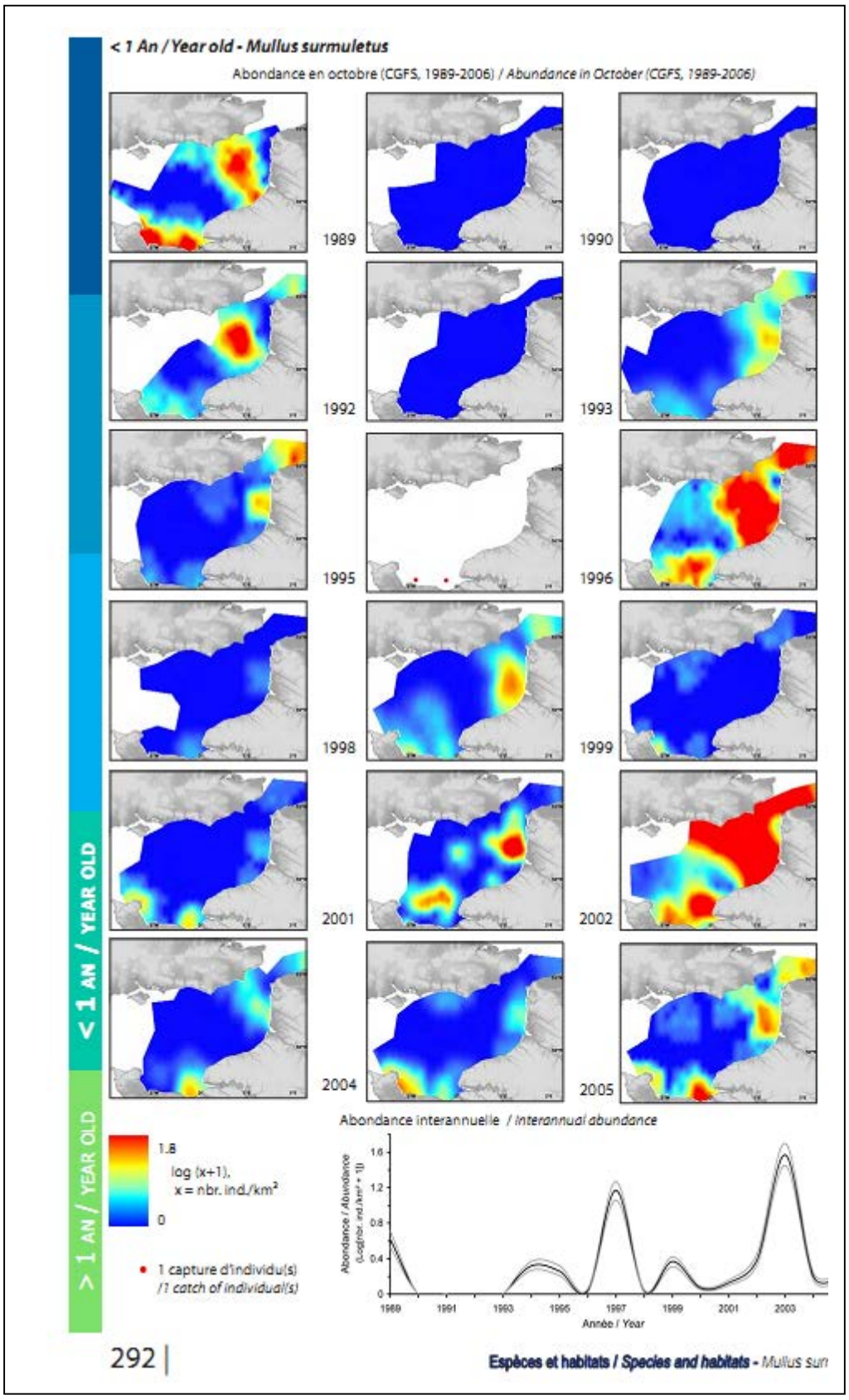
< 1 an

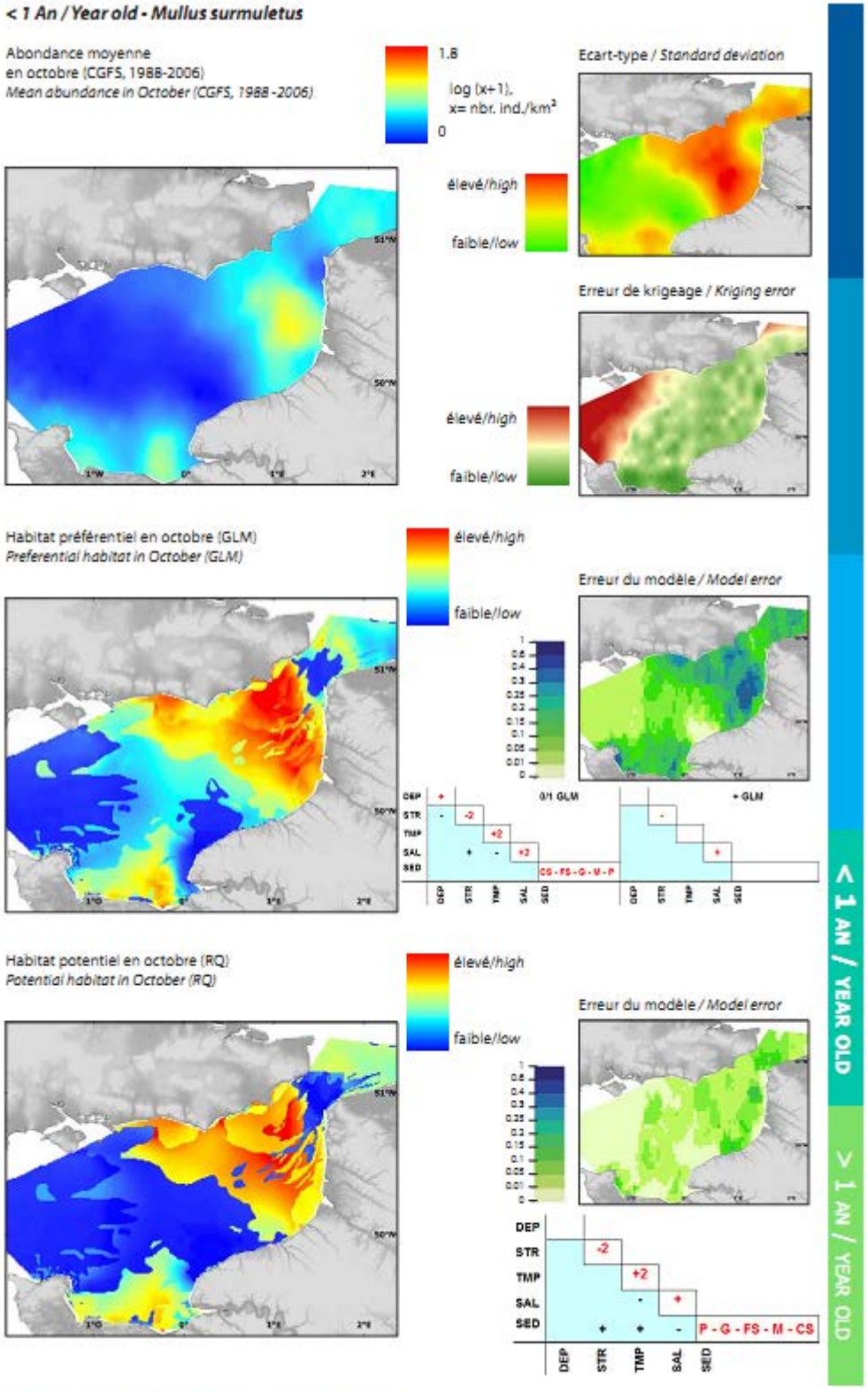
Durant la campagne BTS en juillet, les jeunes de moins d'un an sont présents dans les estuaires et autour de l'île de Wight. Certaines années, très peu de jeunes ont été échantillonnés pendant la campagne CGFS en octobre. Quand ils étaient présents, ils ont surtout été trouvés dans les zones à fonds sableux, au large de la côte d'Opale et de la baie de Seine et dans le sud de la mer du Nord. Le modèle d'habitat préférentiel montre toute la zone du détroit comme étant favorable pour la présence de ce jeune stade, ainsi que la baie de Seine, ce qui est en accord avec les observations de campagnes. Il faut cependant prendre en compte l'erreur du modèle qui est importante dans les zones de fortes abondances. Le modèle d'habitat potentiel est très semblable au modèle d'habitat préférentiel : il favorise les zones à faible influence des courants de marées mais où dominent les graviers et les cailloutis.

Red mullet less than 17.3 cm in length were considered as being less than one year old, and the distribution patterns and habitats (in October) were defined separately for young and older individuals. Red mullets are not representatively sampled by the beam trawl used during the July BTS survey; as a result, annual maps are not shown for this season. The two July maps hence show average (or multi-annual) distribution over 1989-2006; no habitat model passed the selection criteria for inclusion in the atlas.

< 1 year old

In July, young individuals (less than one year old) were present in estuaries and around the Isle of Wight. In some years, very few young individuals were found during the CGFS surveys (October). When they were present, they were mainly found in areas with sandy sediments, off the Opale coast and the Bay of Seine and in the southern North Sea. The preferential habitat model shows the Dover Strait and the Bay of Seine as favourable for this young stage, which agrees with the survey data. Nevertheless, the model error was great in high abundance areas. The potential habitat model was very similar to the preferential habitat model, favouring areas with weak bed shear stress and the presence of gravels and pebbles.


< 1 An / Year old - Mullus surmuletus
Abondance en octobre (CGFS, 1989-2006) / Abundance in October (CGFS, 1989-2006)
1989
1990
1992
1993
1995
1996
1998
1999
2001
2002
2004
2005
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
1.8
log (x+1),
x = nbr. ind./km²
0
1 capture d'individu(s)
/1 catch of individual(s)
Abondance interannuelle / Interannual abondance
Abondance / Abundance
Année / Year
292 |
Espèces et habitats / Species and habitats - Mullus sur



Espèces et habitats / *Species and habitats* - *Mullus surmuletus*

Stock Annex – North Sea Sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock: North Sea sole

Working Group: WGNSSK

Date: 3 March 2010

By: Jan Jaap Poos

A General

A.1 Stock definition

The North Sea sole is defined to be a single stock in ICES area IV. The stock assessment is done accordingly, assuming sole in the North Sea is a closed stock.

A.2 Fishery

North Sea sole is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea (see Figure 1). Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. The minimum mesh sizes enforced in these fisheries (80 mm in the mixed beam trawl fishery) are chosen such that they correspond to the Minimum Landing Size for sole. Due to the minimum mesh size, large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea sole have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box).

In recent times the days at sea regulations, high oil prices, and different patterns in the history of changes in the TACs of plaice and sole have led to a transfer of effort from the northern to the southern North Sea. Here, sole and juvenile plaice tend to be more abundant leading to an increase in discarding of small plaice. A change in efficiency of the commercial Dutch beam trawl fleet has been described by Rijnsdorp *et al.* (2006). This change in efficiency is related to changes in targeting and the change in spatial distribution (Quirijns *et al.* 2008, Poos *et al.* 2010). An analysis of the changes in efficiency by the 2006 North Sea demersal assessment working group showed that the increase in efficiency was especially pronounced between 1990 (the beginning of the time series for which data was available) to 1996-1998, after which the efficiency seemed to decrease slightly. The data for which this could be analyzed spanned 1990 to 2002, so the efficiency changes since 2002 could not be estimated.

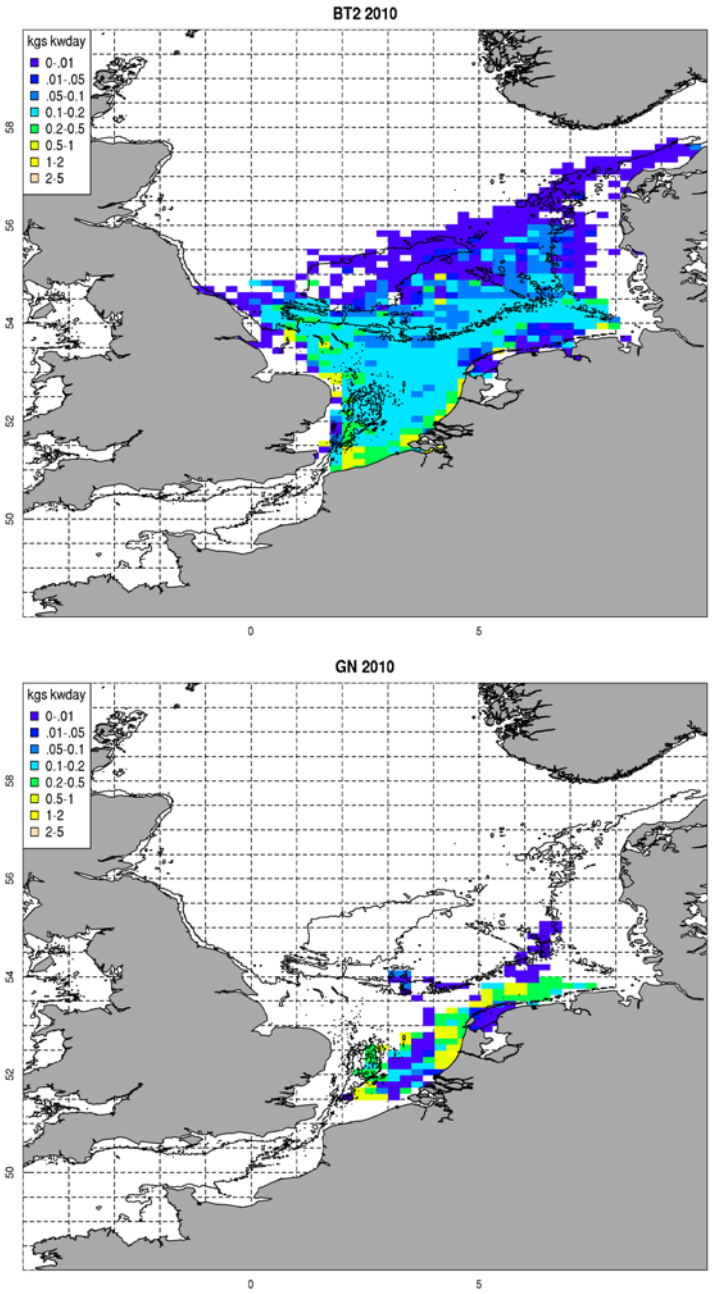


Figure 1. Landing rates (kgs kwday-1) in 2010 by Dutch flagged BT2 (beam trawlers working 80-89mm mesh, top) and GN (gillnetters, bottom). Data are based on combining VMS and logbook data. 40m depth contour also added.

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001, No. 51/2006, No. 41/2007 and No. 40/2008, annex IIa). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammel nets could fish between 140 and 205 days per year.

Several technical measures are applicable to the mixed fishery for flatfish species in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55°N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the sole fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100mm is required.

The minimum landing size of North Sea sole is 24 cm. The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation.

A.3 Ecosystem aspects

Sole growth rates in relation to changes in environmental factors were analysed by Rijnsdorp *et al*. (2004). Based on market sampling data it was concluded that both length at age and condition factors of sole increased since the mid 1960s to a high point in the mid 1970s. Since the mid 1980s, length at age and conditions have been intermediate between the troughs (1960) and peaks (mid 1970s). Growth rates of the juvenile age groups were negatively affected by intra-specific competition. Length of 0-group fish in autumn showed a positive relationship with sea temperature in the 2nd and 3rd quarters, but for the older fish no temperature effect was detected. The overall pattern of the increase in growth and the later decline correlated with tempo-ral patterns in eutrophication; in particular the discharge of dissolved phosphates from the Rhine. Trends in the stock indicators e.g. SSB and recruitment, did not coin-cide, however, with observed patterns in eutrophication.

In recent years no changes in the spatial distribution of juvenile and adult soles have been observed (Grift *et al*. 2004, Verver *et al*, 2001). The proportion of undersized sole (<24 cm) inside the Plaice Box did not change after its closure to large beamers and remained stable at a level of 60 – 70% (Grift *et al.*, 2004). The different length groups showed different patterns in abundance. Sole of around 5 cm showed a decrease in abundance from 2000 onwards, while groups of 10 and 15 cm were stable. The largest groups showed a declining trend in abundance, which had already set in years before the closure.

Mollet *et al* (2007) used the reaction norm approach to investigate the change in maturation in North Sea sole and showed that age and size at first maturity significantly shifted to younger ages and smaller sizes. These changes occurred from 1980 onwards. Size at 50% probability of maturation at age 3 decreased from 29 to 25 cm.

B Data

B.1 Commercial catch

Landings data by country and TACs are available since 1957. The Netherlands has the largest proportion of the landings, followed by Belgium. Discards data is only available from the Netherlands, where a discards sampling programme has been carried out on board 80 mm beam trawl vessels fishing for sole since 2000. The discards percentages observed in the Dutch discard sampling programme were much lower for sole (for

2002 – 2008, between 10 – 17 % by weight) than for plaice. No significant trends in discard percentages have been observed since the start of the programme. Inclusion of a stable time series of discards in the assessment will have minor effect on the relative trends in stock indicators (Kraak *et al.* 2002; Van Keeken *et al.* 2003). The main reason for not including discards in the assessment is that the discarding is relatively low in all periods for which observations are available. In addition, the time series of sampling data is short and gaps in the discard sampling programs render them incomplete.

Age and sex compositions and mean weight at age in the landings have been available for different countries for different years. In the more recent years, age compositions and mean weight at age in the landings have been available on a quarterly basis from Denmark, France, Germany (sexes combined) and The Netherlands (by sex). Age compositions on an annual basis were previously available from Belgium (by sex). Overall, the samples are thought to be representative of around 85 % of the total landings. For the final assessment, the age compositions are combined separately by sex on a quarterly basis and then raised to the annual international total. Alternatively, sex separated landings-at-age and weights-at age can be calculated from the data. Since the mid 1990s, annual Sole catches have been dominated by single strong year classes (e.g. the 2005 year class).

B.2 Biological

Weight at age

Weights at age in the landings are measured weights from the various national market sampling programs. Weights at age in the stock are the 2nd quarter landings weights, as estimated by the Fishbase database computer program used for raising North Sea sole data. Over the entire time series, weights were higher during the 1980s compared to time periods before and after. Estimates of weights for older ages fluctuate more because of smaller samples sizes due to decreasing numbers of older fish in the stock and landings.

Natural mortality

Natural mortality in the period 1957 – 2008 has been assumed constant over all ages at 0.1, except for 1963 where a value of 0.9 was used to take into account the effect of the severe winter (1962 – 1963; ICES-FWG 1979).

Maturity

The maturity-ogive is based on market samples of females from observations in the sixties and seventies. Mollet *et. al*. (2007) described the shift of the age at maturity towards younger ages. A knife-edged maturity-ogive is used, assuming no maturation at ages 1 and 2, and full maturation at age 3.

Surveys

There are 3 trawl surveys that could potentially be used as tuning indices for the assessment of North Sea sole.

- The BTS-ISIS (Beam Trawl Survey)
- The SNS (Sole Net Survey)
- The UK Corystes survey

The BTS-ISIS (Beam Trawl Survey) is carried out in the southern and south-eastern North Sea in August and September using an 8m beam trawl. The SNS (Sole Net Survey) is a coastal survey with a 6m beam trawl carried out in the 3rd quarter. In 2003

the SNS survey was carried out during the 2nd quarter and data from this year were. The research vessel survey time series have been revised by WGBEAM (ICES-WGBEAM, 2009). WKFLAT 2010 decided to use only the BTS-ISIS and the SNS surveys as tuning series, because of lack of information on the raising procedure and spatial coverage of the UK Corystes series. In the assessment, the BTS-ISIS and SNS indices, calculated by WGBEAM, are used for tuning the stock assessment.

B.3 Commercial LPUE

There is one commercial fleet available that can be used as a tuning series for the stock assessment, being the Dutch beam trawl fleet. This fleet takes more than 70% of the landings, and is relatively homogeneous in terms of size and engine power. The data from this commercial fleet can be estimated using two different methods. The first method uses the total landings, and creates the age distribution for these landings by segregating the total landings into market categories, with age distributions being known within market categories through market sampling. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days. Effort nearly doubled between 1978 and 1994 and has declined since 1996. Effort during 2008 was <40% of the maximum (1994) in the series. A decline of circa 25% was recorded in 2008 following the decommissioning that took place during 2008.

Alternatively, the data for the Dutch beam trawl fleet can be raised as described by (WGNSSK 2008, WD1). This allows reviewing the LPUE trends in different areas of the North Sea. The data are based on various sources (WGNSSK 2008, WD1). There is a clear separation in LPUE between areas, with the southern area producing a substantially higher LPUE than the northern area. Average LPUE of a standardized NL beam trawler (1471 kW) over the period 1999 to 2007 was 266 kg day-1, and the data have a significant ($P<0.01$) temporal trend of -6.1 kg day^{-1} $year^{-1}$.

The stock assessment uses the tuning index resulting from using the first method to calculate the commercial index. Owing to the strong changes in catchability in the in the first part of the time series, only the data from 1997 onwards is to be used in the assessment.

C Historical Stock Development

WKFLAT 2010 decided that XSA should be used for providing advice, while also using the SAM models concurrently. There are currently three methods that could be used to provide an assessment of North Sea sole, being XSA, the ANP model (Aarts and Poos, 2009), and the SAM model (WKROUND 2009, WD14). The XSA assumes the catch-at-age matrix is complete and without error. The Aarts and Poos method is a variety of statistical catch-at-age model, that uses splines to estimate the selectivity patterns in the surveys and for the catch-at-age matrix. WKFLAT tested an adaptation of the original ANP model, where the discards estimation procedures were not incorporated. The SAM model is a state-space assessment model, similar to TSA. The advantage of using ANP and SAM would be that they take into account (and show) the uncertainty of the assessment inputs and outputs. The disadvantage of using ANP is that it can only assess the stock status for those years where survey data is available. Once a new benchmark group decides that there is no problem with the operational aspects of using SAM for North Sea sole, we recommend replacing the use of XSA with SAM.

Model used as a basis for advice

The North Sea sole advice is based on the XSA stock assessment. Settings for the final assessment are given below:

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1- 10).
Tuning indices	BTS-Isis 1985-assessment year 1-9 SNS 19701-assessment year 1-4 NL-beam trawl index 1997-assessment year 2-9
Plus group	10
First tuning year	19701
Time series weights	No taper
Catchability dependent on stock size for age <	2
Catchability independent of ages for ages >=	7
Survivor estimates shrunk towards the mean F	5 ages / 5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

[1] *The first year of tuning was erroneously listed as 1982 in the initial stock annex. It has been corrected following the 2011 WGNSSK meeting.*

The SAM model

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1:10)
Tuning indices	BTS-Isis 1985-assessment year 1-9 SNS 1982-assessment year 1-4 NL-beam trawl index 1997-assessment year 2-9
Plus group	10
First tuning survey year	1982
Catchability independent of ages for ages >=	7
Prior weighting	Not applied

D Short-term Projection

Because the assessment on which the advice is based is currently a fully deterministic XSA, the short term projection can be done in FLR using FLSTF. Weight-at-age in the stock and weight-at-age in the catch are taken to be the mean of the last 3 years. The exploitation pattern is taken to be the mean value of the last three years, scaled to the last years F. Population numbers at ages 2 and older are XSA survivor estimates, unless there is consistent indication from the most recent recruitment surveys of a stronger or weaker year class. Numbers at age 1 and recruitment (age 0) are taken from the long-term geometric mean.

Management options are given for three different assumptions on the F values in the "intermediate" year; (A) F in the "intermediate" year is assumed to be equal to the

average estimate for F of the last three assessment years scaled to the last years F; (B) F2009 is 0.9 times the average estimate for F of the last three assessment years scaled to the last years F; and (C) F in the "intermediate" year is set such that the landings in the intermediate year equal the TAC of that year. ACOM in 2009 has decided to use option (A)

E Medium-Term Projections

Generally, no medium-term projections are done for this stock.

F Long-Term Projections

Generally, no long- term projections are done for this stock.

G Biological Reference Points

The current reference points were established by the WGNSSK in 1998. The current reference points are **Blim= Bloss=** 25 000 t and **Bpa** is set at 35 000 t using the default multiplier of 1.4. **Fpa** was proposed to be set at 0.4 which is the 5th percentile of **Floss** and gave a 50% probability that SSB is around **Bpa** in the medium term. Equilibrium analysis suggests that F of 0.4 is consistent with an SSB of around 35 000 t. Given that the assessment results in terms of historic biomass estimates did not change substantially following the updates in assessment methodology in WKFLAT2010, the estimates of these reference points are still valid.

	Type	Value	Technical basis
Precautionary approach	Blim	25,000 t	Bloss
	Bpa	35,000 t	Bpa1.4 *Blim
	Flim	Not defined	
	Fpa	0.40	Fpa = 0.4 implies Beq >Bpa and P(SSBMT < Bpa) < 10%.
Targets	Fmgt	0.2	EU management plan

(unchanged since 1998, target added in 2008)

H Other Issues

None identified

I References

Aarts, G., and Poos, J.J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES J. Mar. Sci. 66: 763–771.

Horwood, J.W., and Millner, R.S. 1998. Cold induced abnormal catches of Sole. J.Mar.Biol.Ass.U.K. 78: 345-347.

ICES. 1965. Report of the working group on sole. Cooperative research report 55, International Council for the Exploration of the Sea, Copenhagen, Denmark.

ICES. 1979. Report of the North Sea flatfish working group. Demersal fish committee. ICES CM 1979/G:10

ICES. 2009 Report of the Working Group on Beam Trawl Surveys (WGBEAM). ICES CM 2009/LRC:04

Kraak, S.B.M., Pastoors, M.A., Rijnsdorp, A.D. 2002. Effecten van discarding en high-grading op de toestandsbeoordeling van schol: een quick-scan. CVO rapport ; 02.019 p. 8.

Mollet, F.M., Kraak, S.B.M., and Rijnsdorp, A.D. 2007. Fisheries-induced evolutionary changes in maturation reaction norms in North Sea sole Solea solea. Mar. Ecol. Prog. Ser. 351: 189-199.

Poos, J.J., Bogaards, J.A., Quirijns, F.J., Gillis, D.M., and Rijnsdorp, A.D. 2010. Individual quotas, fishing effort allocation, and over-quota discarding in mixed fisheries. ICES J. Mar. Sci. 67: 0000.

Quirijns, F.J., Poos, J.J., and Rijnsdorp, A.D. 2008. Standardizing commercial CPUE data in monitoring stock dynamics: Accounting for targeting behaviour in mixed fisheries. Fish. Res. 89: 1-8.

Rijnsdorp, A.D., Daan, N., and Dekker, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES J. Mar. Sci. 63: 556-566.

Keeken, O.A. van, Dickey-Collas, M., Kraak, S.B.M., Poos, J.J., Pastoors, M.A. 2003. The use of simulations of discarding to investigate the potential impact of bias, due to growth, on the stock assessment of North Sea plaice (Pleuronectes platessa) ICES CM 2003/X:17

de Veen, J.F. 1967. On the phenomenon of soles (Solea solea L.) swimming at the surface. J. Cons. int. Explor. Mer 31(2): 207-236.

ICES. 2008. Report of the working group on the assessment of demersal stocks in the North Sea and Skagerrak - combined spring and autumn (WGNSSK) ICES CM 2008\ACOM:09. WORKING DOCUMENT 1

Wheeler, A. 1969. The fishes of the British Isles and North-west Europe. MacMillan, London, UK.

WKFLAT 2010

ICES. 2009 Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND) ICES CM 2009/ACOM:32, WORKING DOCUMENT 14.

Annex 04 Recommendations

The following table summarises the main recommendations arising from the WGNSSK and identifies suggested responsibilities for action.

Recommendation	For follow up by:
The IBTS working group would like to change the allocation of rectangles to countries in the IBTS Q3 survey. This leads to the situation that vessels fish in areas they have never fished before. The vessel effects and the potential bias introduced by changing the allocation are not known until more data analyses are carried out. Further changes in relation to the survey gear and the survey design are discussed by the IBTS working group. WGNSS recommends to implement the reallocation of the ICES statistical rectangles in parallel with other planned changes (if possible) and after an analysis of the effects of such a reallocation. In general, every effort has be undertaken to ensure that planned changes do not lead to a break in the time series	IBTS-WG
Surveys should cover the main distribution area of stocks and should give information over a sufficient range of age/length groups. In addition, the distribution of species can change over time (e.g., the North Sea fish assemblage moves towards deeper water) what needs to be reflected in the survey design. With the emergence of DLS stocks, survey information is used for more and more stocks as basis for advice. However, detailed analyses whether a certain survey is suitable to provide information for a given stock are scarce. WGNSSK recommends a workshop to test whether the survey coverage is (still) sufficient to use it as basis for assessments and advice.	WKIDP, new workshop
Under the landing obligation a break in the time series for catch data can be expected. Fish discarded before will be landed. This is especially a problem for assessments where no time series of discard estimates is available so far. Next to changes in the catch composition also changes in the selectivity patterns can be expected what leads to problems especially with forecast assumptions in the first years after the implementation of the landing obligation. Methods to deal with this situation need to be explored	WGMG
The current rules for category 3 stocks treating survey information as point estimates can lead to substantial changes in advice from year to year despite the TAC constraint of +/- 20%. However, an appropriate signal to noise ratio needs to be ensured as basis for advice. Smoothing of time series or similar methods should be considered. Same issues arise when checking the need for an update of advice for biennial stocks. Agreed guidelines on how to determine whether the perception of the stock has changed given the noise in time series would avoid subjective interpretations. In general, the absence of biomass or Fproxy targets for category 3 stocks can make the approach less precautionary than for category 2 (e.g., turbot in IV: decrease in TAC with category 2, but increase with category 3, ple-eche: same as for turbot). This also needs further investigation.	WKLIFE, ACOM leadership

WGNSSK recommends the development of tools for the estimation of uncertainty and bias in catch at age data (age distribution, discard rates). Next to uncertainty estimated for each métier, it is needed to come up with an overall uncertainty estimate on stock level. The regional data bases seem to be an appropriate data source for such kind of analyses. Permission to use the data needs to be granted by national correspondents.	PGDATA, WGCATCH, PGCCDBS
The need to take into account the uncertainty and bias around survey indices is a common problem for working groups. Uncertainty around indices could be automatically produced by DATRAS and included as standard output together with the survey index point estimates. Next to this the production of indices for category 3 DLS stocks would make the assessment of these stocks more efficient and ensures a common approach. Bias due to survey design, changes in vessel characteristic, survey gears is more difficult to address and needs investigation by survey working groups.	DATRAS, WGISDAA, WKIDP, Survey working groups
It is observed that models like SAM or TSA sometimes estimate landings to be considerably different to what is officially reported even for recent years. Especially the estimation of less landings compared to what was officially reported seems to be counterintuitive. An exploration of the applicability of limiting the deviation (and direction) from officially reported landings and its impact on assessments is recommended	WGMG
The internal audit is an additional burden for assessment working groups that can hardly be fulfilled especially not during the meetings. Although the move from reviews to audits removes some of the workload, careful checking needs a considerable amount of time. Given the general high workload (also when back at home in the institutes) and the low number of assessors per stock in some working groups, this time is hardly available. At the same time audits are most important to avoid the loss of credibility due to errors in the assessments and reports. Therefore, alternative ways should be explored by ACOM to strengthen the audit process (e.g., professional auditors as part of the ICES secretariat, external auditors).	ACOM
The saithe and haddock assessment include area VIa in addition to area IV and IIIa. Therefore, it would be beneficial to explore whether it is possible to combine west of Scotland (WoS) and North Sea (NS) survey catches into a combined index. There appears to be some overlap in the surveys and this will be very useful for estimating the relative catchability of one survey compared to the other. An issue to consider is whether untrawlable areas are affecting catchabilities differently in WS and NS. Haddock do not appear to be bottom-dependent and swim upwards when they see trawl coming. WGNSSK suggests to develop a combined survey for the Northern Shelf, specifically run some comparability tests on the area of overlap.	IBTS-WG

Annex 5 Benchmark Planning and Data Problems by Stock

Part A

Benchmarks planning WGNSSK

A.1.1 Latest benchmark results

The ICES Benchmark Meeting on Northern Haddock Stocks (WKHAD) convened at two meetings in early 2014 in Aberdeen and Copenhagen. There were two principal issues under discussion. Firstly, WKHAD considered whether or not the haddock stocks in Division VIa (West of Scotland) and Subarea IV (North Sea, including Division IIIaW Skagerrak) could be considered as a single functional unit for assessment purposes. Existing analyses on genetic and non-genetic markers of differentiation (including otolith micro-chemistry) were reviewed, along with survey and landings distribution maps, extant assessment results for both areas, hydrodynamic models of likely larval and juvenile transport, the location of spawning and juvenile areas, and survey-derived length distributions. WKHAD concluded that there is biological justification for combining the North Sea, Skagerrak and West of Scotland areas into a single assessment unit (Northern Shelf) because the split at 4°W does not seem biologically relevant. There would appear to be enough connectivity at the early life stages to consider these areas as part of an interrelated unit that should be combined in the stock assessment. However, the relatively low exchange of fishable-sized adult haddock between the regions could lead to locally different rates of fishing mortality and hence supports spatial allocation of harvest across the areas.

Secondly, WKHAD considered the data configuration, length of time-series, and model that should be used to conduct the annual Northern Shelf haddock assessment. WKHAD concluded that the assessment should commence in 1972 (to include as much data as possible whilst avoiding obvious problems with very early discard and bycatch estimates); that it should use natural mortality estimates from the latest SMS run; that it should be tuned by the North Sea IBTS Q1 and Q3 surveys only; and that maturity should be assumed to be knife-edged at age 3 until improved estimates of reproductive potential can be generated. In its evaluation of possible assessment models, WKHAD focussed on TSA, SAM and SURBAR, and concluded that the TSA model should be used for the final assessment, for the following reasons:

1. TSA is able to model landings and discards+bycatch separately, which SAM is not currently able to do. The two catch components have very different age compositions and errors structures, and separate modelling is likely to produce more robust results.

2. The recruitment pattern of Northern Shelf haddock is unusual, with occasional, very large year-classes. SAM assumes a lognormal distribution for recruitment, but even that will tend to underestimate very large year-classes. TSA allows the variance on the estimates of large year-classes to be inflated, although this is a rather *ad hoc* fix as both the year-classes and the variance multiplier need to be specified by the assessor.

3. The developer of TSA and the Northern Shelf haddock assessor are both based at the same institute. Problems arising with the use of the TSA model are therefore likely to be addressed more quickly than would be the case with SAM, if only due to delays while awaiting responses to emails, and this practicality was viewed as another compelling reason to use TSA.

Hence, WKHAD recommend that TSA be used as the principal stock assessment method for Northern Shelf haddock, with *inter alia* SAM and SURBAR used as exploratory research models.

For short-term forecasts, WKHAD determined that weights-at-age should derived using linear cohort-based models. A survey-based procedure for splitting the Northern Shelf catch advice into the three extant management units was proposed, although this requires ACOM ratification. WKHAD also applied the previously-used methodology to generate new proposed biomass reference points for Northern Shelf haddock.

A.1.2 Planning future benchmarks

Planning table [used for preparing the ACOM proposal of upcoming benchmarks]

Stock	Assessment status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
cod-347d	Accepted SAM model	Inter-benchmark in Feb 2011	2015	No	Future proposals for internal use	Investigate model configurations and input data
had-34	Accepted TSA model but continued exploratory assessments with SAM and SURBAR	2014	No	No		May need an interbenchmark to check whether benchmark decisions are still appropiate and rules are needed to split TAC between IV, VIa and IIIa
nep-34	OK	NA	No	No		
nep-5	Data-limited.	NA	No	No		TV surveys under developement
nep-6	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	no	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)

nep-7	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-8	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-9	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	No	No		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-10	No assessment		No	No		
nep-32	No reliable assessment can be presented for this stock due to lack of data and an UWTV survey	2013	No	2016		Exploration of all available data, incl new Norw electronic logbooks
nep-33	No reliable assessment can be presented for this stock due to lack of data and an UWTV survey	No benchmark ever on this stock, mainly due to lack of data	no	No		More data should be made available for this stock before a new benchmark
nep-IIIa	OK	No benchmark ever on this stock, 2009 WKNEPH - only benchmarked the UWTV survey process.	no	2016		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nop-34	OK	2012	No	2016		Assessment method, Reference levels in ecosystem / multi-species context, commercial fishyer tuning time series, average recruitment used in forecast for forecast year.
ple-eche	Assessment only accepted for trends	2010	2015	No	Unresolved stock identity, Futher work are planned to create a discard time series (From France, UK and Belgium fisheries) to be used in the assessment	Inconsistencies between survey trends and commercial fleets are still observed and should be adressed in a future Benchmark

ple-SD20 (Skagerrak)	Assessment not accepted	New stock boundary suggested in 2012 (WKPESTO)	2015	no		stock identity, discards data, management plan
ple-nsea	OK	2009, Inter-benchmark procedure in 2013	IBP do deal with inclusion/exclusion of the SNS index in the assessment?	No	-	Changes in catchability for indices of young ages (1-3) may need to be addressed again in a future benchmark. Potentially split th e SNS index now that the two BTS indices (Isis and Tridens) have been combined.
sai-3a46	Accepted FLXSA assessment but exploratory assessments with SAM.	2011		2016 (full benchmark)	Suggested to be fully benchmarked together with NEA saithe	stock identity, discards data, revised CPUE indices, investigation of research surveys (whether they are adequate for use as tuning indices), investigate the lack of 3-year olds in the Q3 survey (fish not appearing until age 4). Full benchmark will look into the models.
sol-eche	OK	2009	no	no	no	no
sol-nsea	OK	2010	2015	no		A revised CPUE index for the stock was presented at WGNSSK 2012. This index will be recalculated and requires a benchmark procedure to be implemented in the assessment. A reliable time series of discards should be created and included in the assessment.
tur-nsea	In development	2012	2014-5 IBP	no	Ongoing work on the assessment may lead to major changes, in which case a benchmark or IBP would be required.	See issue list below.
whg-47d	Update deviating from benchmark	2009, 2013	no	no		Change in catcability of young fish in IBTS surveys – requires application of different but extant method.
whg-kask	No	No	No	2016	No	

Pol-nsea	no	no	no	no	no	
mur-347d	quantitative advice for data-limited stocks	No	2015	no	no	No assessment available
bll-nsea	Data-limited	No/WGNEW	no		?	
dab-nsea	Data-limited	No/WGNEW	no	2016	no	
Fle.nsea	Data-limited	No/WGNEW	no	no	?	
Lem-nsea	Data-limited	No/WGNEW	no	no	no	Currently no stock coordinator available!
Wit-nsea	Data-limited	No/WGNEW	2015	no	no	
Tur-kask	Data-limited	No/WGNEW	No (maybe IBP)	no	no	IBP maybe needed to check current stock definition

A.1.3 Issue lists for stocks with upcoming benchmarks

2015 Benchmarks

Stock	**Cod in IIIaW, IV and VIId**	
Stock coordinator	Name: José De Oliveira	Email: jose.deoliveira@cefas.co.uk
Stock assessor	Name: José De Oliveira	Email: jose.deoliveira@cefas.co.uk
Data contact	Name: José De Oliveira	Email: jose.deoliveira@cefas.co.uk

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified[1]	Alternative tuning indices	Development of alternative tuning indices from commercial fleets and/or fisheries-science partnerships	National data sources	Clara Ulrich and others
Tuning series	Apparent changes in IBTS Q1 and Q3 catchability; discrepancies between stock trends implied by fishery dependent and independent sources, and by different surveys.	Appropriate standardisation of indices, using statistical methods	Datras database	Anders Nielsen, Casper Willestofte Berg, José De Oliveira, Jonathan Gillson
Discards	Improved discard estimation	Discard rates from Scottish CCTV vessels	Scottish CCTV observations	CCTV expert (e.g. Rosanne Dinsdale, Aberdeen)

[1] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Parameters	Evaluation of maturity: in recent years, North Sea cod has shown changes in maturity with fish maturing at a younger age and smaller size. Inclusion of sensitivity tests for different time series of M based on different assumptions in the diet selection model of SMS. Weight at age : catch information is still used for weight at age in stock.	Following WKROUND in 2009, further investigations needed on issues linked to earlier maturity, for example relating the quality of reproductive output of young first-time spawners to recruitment success. For M, SMS runs using different assumptions in the diet selection sub-model. Weight at age : IBTS Q1 weight might be used at least for some younger ages	Maturity and weight data from surveys (IBTS Q1); information on survival rates of eggs and larvae from fish maturing at a younger age and smaller size. For M: SMS key run ready to test different assumptions.	Maturity: external experts. For M: Morten Vinther, Alex Kempf. For weight at age : Casper Willestofte Berg
Assessment method	Open to a range of assessment methods that would be appropriate for this stock (SAM and others)	Development of alternative models, and model configurations; forthcoming WCSAM in Boston (July 2013) may be informative because NS cod is one of the datasets being used to test assessment methods.	Data that could support different model structure, e.g. if discards/landings are modelled separately – already available	Anders Nielsen, José De Oliveira and others experts
Biological Reference Points	Reference points will need to be re-evaluated on the basis of new assessments	Definition of suitable reference points following the determination of the most appropriate stock assessment method.	Stock assessment outputs.	None.
Other	Genetic work may indicate the need to reconsider stock identification and/or account for a spatial dimension in modelling	Further development of genetic studies	Samples collected and analysed as part of scientific research. Methods and data available to separate catches from different stock components.	Peter Wright, Jakob Hemmer Hansen and others

Stock	**Plaice VIId**	
Stock coordinator	Name: Marie Savina Rolland	Email: Marie.Savina.Rolland@ifremer.fr
Stock assessor	Name: Marie Savina Rolland , Youen Vermard,	Email:Marie.Savina.Rolland@ifremer.fr, youen.vermard@ifremer.fr
Data contact	Name: Marie Savina Rolland	Email: Marie.Savina.Rolland@ifremer.fr

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified[2]	Alternative tuning indices.	Development of alternative tuning indices from commercial fleets.	National data sources	
Tuning series	Inconsistencies between survey trends and commercial fleets are still observed.	Assess the impact of the first quarter removals (due to the migration patterns observed between Eastern Channel and adjacent areas) may have an impact in the observed conflicting trends. Look at spatial distribution of the catches from commercial fleets	National data sources	
Catch at age data	Trends in the residuals from late 90' have to be investigated	Evaluate the sampling design (any changes?) and address sampling uncertainty. Assess the impact of migrations patterns?		

[2] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Discards	Discards are not included in the assessment yet.	Include discard information in the stock assessment models trialed (e.g., FLXSA, SAM). Test Aart and Poos model to reconstruct a discard time series	Data on discards; international and national data sources	Jan Jaap Poos and other expert
Biological Parameters	Investigate growth and maturity changes.	Growth and maturity curve fitting.	DATRAS; survey data	
Assessment method	Investigate a range of assessment methods that could be appropriate for this stock (SCA and others).	Development of alternative models, and model configurations. Verification of model uncertainty by comparing uncertainty in parameter estimates with uncertainty in input data.	DATRAS, national data sources, commercial tuning fleet data	Jan Jaap Poos and other expert
Biological Reference Points	Revision of reference points will be needed if there are any large changes resulting from revision of indices.	Generation of new reference points after the final assessment.	Stock assessment outputs	None
Other	Unresolved stock identity	Investigate the impact of migration patterns on the assessment	No new tagging data will be available by that time. Need for other method to assess migration pattern between Eastern Channel, Western Channel and North Sea. Other assessment method might also be investigated together with the other plaice stocks	

Stock	**Red Mullet IIIa, IV, VIId**	
Stock coordinator	Name: Vermard Youen	Email: youen.vermard@ifremer.fr
Stock assessor	Name: Youen Vermard	Email:youen.vermard@ifremer.fr
Data contact	Name: Youen Vermard	Email: youen.vermard@ifremer.fr

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified[3]	This stock has never been assessed	need to develop tuning indices from surveys, commercial fleets, create catch at age data time series, inform biological parameters and define the appropriate assessment method.	National data sources	
Tuning series	This stock has never been assessed	Define appropriate tunning series	National data sources	
Catch at age data	This stock has never been assessed	Create catch at age time series		
Discards	This stock has never been assessed	Discards are not suspected to be a problem for that stock. It however needs to be investigated	Data on discards; international and national data sources	
Biological Parameters	This stock has never been assessed	Inform the biological parameters	DATRAS; survey data	
Assessment method	This stock has never been assessed	Define the appropriate assessment methode		
Biological Reference Points	Revision of reference points will be needed	Generation of new reference points after the final assessment.	Stock assessment outputs	None
Other				

[3] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Stock	**Plaice in Skagerrak**	
Stock coordinator	Name: Clara Ulrich	Email: clu@aqua.dtu.dk
Stock assessor	Name: Clara Ulrich	Email: clu@aqua.dtu.dk
Data contact	Name: Clara Ulrich	Email: clu@aqua.dtu.dk

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified[4]	Stock definition is poorly defined, uncertain level of mixing with the North Sea	Some work is ongoing at DTU Aqua on collecting/analysing new dataon genetics, tagging studies and otolith microstructure	New information hopefully available by 2014	DTU Aqua participants to EFF project (Clara Ulrich, Jacob Hemmer-Hansen, Karin Hussy, Jesper Boje, Henrik Degel) plus relevant experts on plaice ecology in IMARES, SLU Aqua and TI..
Tuning series	This stock is linked to the North Sea and time series must be considered over the the combined area	Define appropriate tunning series . Use IIBTS for the entire area IV-IIIa	National data sources/DATRAS	Clara Ulrich, Aukje Coers, David Miller
Catch at age data	Separation of catches coming from North Sea stock vs. Skagerrak stock,	if a baseline can be established from otoliths and genetics		DTU Aqua participants to EFF project
Discards	The time series of discards was common to Skagerrak and Kattegat	Historical discards estimates must be splitted by area	InterCatch, historic assessment reports and data	Clara Ulrich, Henrik Degel
Biological Parameters	There is uncertainty on growth and otolith reading	Need some work in collaboration with the plaice 21-23 benchmark on age reading and growth estimation	DATRAS; survey data	Plaice age readers from DTU Aqua and SLU Aqua
Assessment method	This stock cannot be assessed alone but together with the North Sea plaice	Define the appropriate assessment methode		David Miller, Aukje Coers, Clara Ulrich. Linkages with 7d assessment

[4] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Biological Reference Points	Revision of reference points will be needed	Generation of new reference points after the final assessment.	Stock assessment outputs	David Miller, Aukje Coers, Clara Ulrich. Linkages with 7d assessment

Stock	**Sole in IV**	
Stock coordinator	Name: David Miller	Email: david.miller@wur.nl
Stock assessor	Name: Tessa van der Hammen	Email: tessa.vanderhammen@wur.nl
Data contact	Name: David Miller	Email: david.miller@wur.nl

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified	Alternative LPUE tuning indices Belgium BTS data should be included	Development of alternative tuning indices from commercial fleets Raise Belgium BTS data	National data sources Belgium BTS data	IMARES expertise on LPUE indices WGBEAM
Discards not included in the catch time series	Discards not currently accounted for and moving to landings obligation will cause a discontinuity in the catch time series	Discard raising (national and international) and reconstruction of past discards.. Inclusion of discards in the assessment model	National data sources	Discard experts
Assessment method	Lack of uncertainty estimates in XSA. Other models can better handle incomplete discard estimates and provide estimates of uncertainty	Alternative (statistical) models should be explored (eg SAM, AAP).	-	Stock assessment experts (SAM - Anders Nielsen)
Reference points	Reference points need to be recalculated if discards are to be included or if a new model is accepted	Reference point analyses	-	Stock assessment/management experts

Stock	**Turbot in IV**	
Stock coordinator	Name: David Miller	Email: david.miller@wur.nl
Stock assessor	Name: David Miller	Email: david.miller@wur.nl
Data contact	Name: David Miller	Email: david.miller@wur.nl

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Assessment method	Explore the inclusion of total catch in the objective function of the assessment model.	Add total catch to the objective function.	-	Stock assessment experts (Jan Jaap Poos, D. Miller)
Assessment method	Improve estimation of Weights at age in time periods with no measurements. The assessment currently assumes mean values of all the data available for all years. A new method using time varying growth parameters will be applied.	Work already done. External review required.	-	Stock assessment experts (Jan Jaap Poos, D. Miller)
Assessment method	No plusgroup used in the assessment. This is likely to become problematic as F decreases (at current high F levels the absence of a plusgroup has not had a significant impact on model results).	Add plusgroup.	-	Stock assessment experts (Jan Jaap Poos, D. Miller)
Assessment method	Explore time-series state-space models such as SAM or TSA, which can also account for missing data but are not reliant on ad hoc decisions about the number of knots.	Run alternative models to validate the choice of assessment model.	-	Stock assessment experts (Jan Jaap Poos, D. Miller)
Reference points	Calculate Blim and Fmsy (ensuring that the probability of SSB < Blim is <5% in the long term)	Reference point analyses.	-	Stock assessment/management experts

Stock	**Witch IIIa, IV and VIId**	
Stock coordinator	Name: Francesca Vitale	Email: francesca.vitale@slu.se
Stock assessor	Name: Max Cardinale	Email: massimiliano.cardinale@slu.se
Data contact	Name: Francesca Vitale	Email: francesca.vitale@slu.se

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified[5]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	IBTS Q1 and Q3, BTS Q1 and Q3	The series are available and need just to be updated	DATRAS	None

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified[5]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Discards	Partially available on Intercatch only for Sweden, Netherland and Denmark in 2013	MS to submit discards information for the rest of the time series	Estimation of discards by country and by area	None
Biological Parameters survey	MO, WAA, NM	The series are available and need to be updated. Ongoing maturity studies.	SLU AQUA will collate and update the biological data	None
Biological Parameters catch	Available on Intercatch only for Denmark in 2013 for IIIa	MS to submit landings information (number at age and weight at age) for the rest of the time series	SLU AQUA will collate and compile the biological data	None
Assessment method	SAM			

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified[5]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Biological Reference Points	MSY library	It will be fitted after the SAM assessment is ready	SAM final assessment model	Einar might be a very good addition to the team here

2016 Benchmarks

Stock	**Nop-34**	
Benchmark	Year: 2016	
Stock coordinator	Name: J. Rasmus Nielsen	Email: rn@aqua.dtu.dk
Stock assessor	Name: J. Rasmus Nielsen	Email: rn@aqua.dtu.dk
Data contact	Name: J. Rasmus Nielsen, Espen Jonssen	Email: rn@aqua.dtu.dk

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or	Additional M - predator relations			
	Prey relations			
	Ecosystem drivers			

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
quantified[6]	*Other ecosystem parameters that may need to be explored?*	Reference levels in ecosystem / multi-species context, The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. This also implies need for information on prey switching dynamics of North Sea fish predators which also are foraging on Norway pout.	Multi-species assessment data, SMS; Data time series on abundances on spatial and seasonal explicit scale for all relevant prey species as well as their suitability for the different predators; data time series for all relevant predator abundances, and data on switching between prey species according to abundances and suitability.	SMS-model expertise

[6] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand.If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Tuning series	Are commercial fishery tuning time series relevant to use after 2006?	Commercial fishery tuning time series: Given the seasonal variability in the fishery, the year to year closures, and the introduction of new species selective devices of different kind in the Danish and Norwegian fishery is it then relevant to include commercial fishery tuning time series after 2006? Or keep it as status quo where only survey tuning time series is used	Danish and Norwegian fleet specific catch and effort data time series for at least the last 30 years with high spatial and seasonal resolution, and also fleet specific data time series on introduction of selective devices and the use of those in Norwegian and Danish fishery. Data on specification of the selective devices also needed.	
Discards				
Biological Parameters				
Assessment method	Potential alternative or better seasonal based assessment method	Evaluation of potential other or new relevant seasonal assessment methods, e.g. stochastic models which better can estimate the uncertainty in the assessment	Standard assessment data; existing data	SAM model expertise
Forecast	Average recruitment used in forecast for forecast year.	Sensitivity and certainty in the forecast according to use long term average recruitment in the forecast compared to use of the 25 percentile of the geometric mean recruitment as used today	Standard assessment and forecast data.	SMS model expertise

Stock	**Nephrops in FU 32**	
Stock coordinator	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no
Stock assessor	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no
Data contact	Name: Guldborg Søvik	Email: guldborg.soevik@imr.no

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
New data to be considered	Current stock definition is based on spatial distribution. The level of larval exchange with Skagerrak is unknown.	Work is ongoing at IMR on collecting/analysing new genetic data from Kattegat, Skagerrak and the Norwegian Deep, as part of a Scandinavian Interreg project	New information will be available by end of 2014/beginning of 2015	Relevant Nephrops experts. The benchmark should be arranged together with the planned benchmark for FU 3 and 4
New analyses to be considered	At WKNEPH 2013 it was suggested that the Nephrops data in the Norwegian annual shrimp survey should be analysed in order to determine if they can be used to provide a fishery independent biomass index	Analyse annual Nephrops catches from shrimp survey	Nephrops data from Norwegian shrimp survey exist back to 1997	Time series experts
Biological Parameters	No biological data exist for this stock	Collection of biological data from stock component along the Norwegian coast	Collection of data from the Norwegian recreational fishery was initiated in 2012. It is expected that by 2016 data on sex ratio, length frequency distribution and life cycle will be available	relevant Nephrops experts
Biological Parameters	No biological data exist for this stock	Collection of biological data from stock component along the western part of the Norwegian Deep	Investigate possibilities for obtaining biological data from the Danish at-sea-sampling-programme	relevant Nephrops experts
Fishery patterns	How much does spatial and temporal variation in the fishery influence stock biomass indices (LPUE)?	The Danish fishery (1990s until present) has gone through large changes. Spatial and temporal patterns in the fishery need to be explored.	Annual Danish VMS data exist	relevant Nephrops experts

Stock	**WHG-kask.....**	
Stock coordinator	Name: Henrik Svedäng	Email: henrik.svedang@slu.se
Stock assessor	Name: Henrik Svedäng	Email: henrik.svedang@slu.se
Data contact	Name: Henrik Svedäng	Email: henrik.svedang@slu.se

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**ICES/External expertise needed at benchmark type of expertise / EG's, names**
(New) data to be Considered and/or quantified[7]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	Inconsistencies in survey indices	Age reading improvements, stock identification	Age reading intercalibrations. Genetic and/ or otolith chemistry studies	SIMWG/ geneticists / otolith chemistry researchers

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	ICES/External expertise needed at benchmark type of expertise / EG's, names
(New) data to be Considered and/or quantified[7]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Discards				
Biological Parameters	Maturity ogive	Maturity studies	Sampling during the IBTS-Q1, BITS-Q1	Within ICES
Assessment method				
Biological Reference Points				

Stock	**Saithe in IIIa, IV and VI**	
Stock coordinator	Name: Jennifer Devine	Email: jennifer.devine@imr.no
Stock assessor	Name: Jennifer Devine, Alexander Kempf	Email: jennifer.devine@imr.no; alexander.kempf@ti.bund.de

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**ICES/External expertise needed at benchmark type of expertise / EG's, names**
(New) data to be Considered and/or quantified[7]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		

Data contact	Name: Jennifer Devine	Email: jennifer.devine@imr.no

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be Considered and/or quantified[8]	Alternative tuning indices. Investigate stock structure using all/any available data (link with NEA saithe data).	Development of alternative tuning indices from commercial fleets.	National data sources	
Tuning series	Evaluate change in design of NORACU.. Estimate sampling variance for the survey indices. Investigate discrepancies in trends in IBTS Q3 and NORACU.	Re-evaluation/recalculation of the Norwegian indices including sampling error.	National data sources	

[8] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand. If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
Catch at age data	Determine if low number of Norwegian commercial samples is creating bias in catch-at-age data. Call for investigation of German and French CPUE series and whether standardized indices are possible. Review of data raising procedures for National data: issues in InterCatch (with data submissions) has been found for multiple countries. Update/revise Norwegian InterCatch data.	Evaluate the sampling design (any changes?) and address sampling uncertainty. Update of Norwegian InterCatch data; investigation of other country's InterCatch data	InterCatch, National data sources	
Discards	Discarding and discard bans are being implemented in the Skaggerak and North Sea. Investigate whether discards should be included in the assessment.	Include discard information in the stock assessment models trialed (e.g., FLXSA, SAM).	Data on discards; international and national data sources	
Biological Parameters	Investigate growth and maturity changes. Lack of 3 year olds in survey data	Growth and maturity curve fitting.	DATRAS; survey data	None
Assessment method	Investigate a range of assessment methods that could be appropriate for this stock (SAM and others).	Development of alternative models, and model configurations. Verification of model uncertainty by comparing uncertainty in parameter estimates with uncertainty in input data.	DATRAS, national data sources, commercial tuning fleet data	Anders Nielsen and other experts
Biological Reference Points	Revision of reference points will be needed if there are any large changes resulting from revision of indices.	Generation of new reference points after the final assessment.	Stock assessment outputs	
Other				

Stock	**Dab nsea**	
Benchmark	Year:2016	
Stock coordinator	Name: Holger Haslob	Email:holger.has-lob@ti.bund.de
Stock assessor	Name:	Email:
Data contact	Name:	Email:

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified[9]	Additional M - predator relations	Not at the moment		
	Prey relations	Not at the moment		
	Ecosystem drivers	Not at the moment		
	Other ecosystem parameters that may need to be explored?	Not at the moment		
Tuning series	Survey indices (e.g. IBTS; BTS; DYFS)	Create suitable survey index; e.g. combined beam trawl survey index	DATRAS	

[9] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand.If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Discards	Discard rates for dab are extremely high and estimate of total catch remains uncertain.	Compile available discard data.	InterCatch (2013); National data sources for previous years.	
Biological Parameters	Not all countries collect biological information for dab.	Compile all available data.	Commercial sampling; survey data; DATRAS	
Assessment method	Survey trend based assessment so far.	Appropriate assessment method has to be evaluated.		
Biological Reference Points	Implementation of new reference points after final assessment.			

Stock	Nep IIIa	
Stock coordinator	Name: Mats Ulmestrand	Email: mats.ulmestrand
Stock assessor	Name: Jordan P. Feekings	Email: jpfe@dtu.aqua.dk
Data contact	Name:	Email:

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be considered and/or quantified[10]	Redefine area of all subareas using up to date information.	Compile available data sources from all available years.	DK & SW VMS data, SW logbook data from <12m vessels and creel vessels, sediment maps etc. Data are available.	
	Create UWTV reference footage.	Review selection of UWTV footage and establish consensus counts	UWTV survey footage. Data are available	
Tuning series	Standardize Swedish lpue.		Logbook data are available.	

[10] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand.If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark type of expertise / proposed names
(New) data to be considered and/or quantified[10]	Redefine area of all subareas using up to date information.	Compile available data sources from all available years.	DK & SW VMS data, SW logbook data from <12m vessels and creel vessels, sediment maps etc. Data are available.	
	Create UWTV reference footage.	Review selection of UWTV footage and establish consensus counts	UWTV survey footage. Data are available	
Discards	Effects of changing the MLS Effects of a landing obligation	Bio-economic analysis of changing the MLS for Nephrops.	VMS, landings, discards, stock estimates, price data, biological data (e.g. size and sex distribution, female and male maturity).	
Biological Parameters	Growth parameter update Length-weight update			
Assessment method	The UWTV survey method is not possible for creel areas. Possible inclusion of a length based assessment model to compliment the UWTV survey.	Develop and finalize a length based model for Nephrops.	Catch data. Data are available for trawled and creeled areas.	Anders Nielsen, DTU Aqua

Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be considered and/or quantified[10]	Redefine area of all subareas using up to date information.	Compile available data sources from all available years.	DK & SW VMS data, SW logbook data from <12m vessels and creel vessels, sediment maps etc. Data are available.	
	Create UWTV reference footage.	Review selection of UWTV footage and establish consensus counts	UWTV survey footage. Data are available	
Biological Reference Points		Model work should provide these reference points.	Proxies for Fmsy exist from LCA. Btrigger estimate requires a longer UWTV time series.	

PART B

Stock Data Problems Relevant to Data Collection –WGNSSK

Stock	Data Problem	How to be addressed in	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
Ple-nsea, sol-nsea	An increasing number of beam trawlers (in the Dutch fleet) are using 'Pulse trawl' gear. There is no recognised gear code for this gear and catches etc. are still registered as TBB, grouping them with the traditional twin beam trawl fleet.	It is felt that this gear is likely to have different selectivity (for discards and landings) as well as different catch per unit effort as the traditional beam trawl gears. This has implication for the assessment of sole and plaice. In the first case, for the raising of discards and landings data. In the second case for the determination of the CPUE index used in the sole assessment. It is necessary to create a separate gear code / gear type category for pulse trawls. This would allow for improved raising of data and prevent a discontinuity in the CPUE index used for sole.	RCM-NS&EA, RBD-SG
Saithe in Subarea IV, VI and Division IIIa	No index for older year-classes in scientific surveys, assessment heavily dependent on commercial CPUE	Increase cover of NORACU (below 200 m) and establish an identical acoustic survey in IBTS Q1 to cover spawning aggregations.	ACOM (Norway)
Saithe in Subarea IV, VI and Division IIIa	Only a short recruitment index time series	The number of recruits is difficult to determine before they have been targeted by the fishery. Establish a recruitment survey .	ACOM (Norway)
Saithe in Subarea IV, VI and Division IIIa	Age sampling from commercial fleets	Possible cluster sampling due to few vessels in the reference fleet (Norway), needs review / redesign	ACOM (Norway); PGCCDBS

Stock	Data Problem	How to be addressed in	By who
Saithe in Subarea IV, VI and Division IIIa	No discard data used in assessment	Quality control of available data sources, including Norwegian reference fleet data	ACOM (Norway); ACOM (Fance); ACOM (UK-Scotland); ACOM (Germany); PGCCDBS
Saithe in Subarea IV, VI and Division IIIa	Norwegian tuning indices must be revisited.	Re-evaluation/recalculation of the Norwegian indices	ACOM (Norway)
Plaice in IIIa	limited survey coverage where the fisheries are	The Western Skagerrak represents by far the huge majority of the catches but there is limited survey coverage there. Progresses have been achieved in 2014 (new hauls by IBTS and BTS), needs to be sustained in the future.	IBTSWG; WGBEAM; DTU Aqua
Plaice in IIIa	Small plaice stocks cannot be easily assessed because of potentially large migrations in and out the large area IV	Most knowledge about stocks connectivity is based on old and limited tagging experiments. New tagging studies would be necessary to improve the understanding of migratory patterns	Some work is ongoing by DTU Aqua
Turbot in in IIIa,	Small turbot stocks cannot be easily assessed because of potentially large migrations in and out the large areas IV and the Baltic	Most knowledge about stocks connectivity is based on old and limited tagging experiments. New tagging studies would be necessary to improve the understanding of migratory patterns	
Plaice in VIId	Discard time series too short to be included in the assessment	Sampling levels have increased in the recent years and more work needs to be done to raise the samples to the population and get reliable estimates of the discards levels	PGCCDBS; ACOM (France); ACOM (UK); ACOM (Belgium)

Stock	Data Problem	How to be addressed in	By who
Sol-eche	*The French Young Fish survey as conducted now is probably not providing the correct recruitment estimates as it only covers part of VIId*	The UK component of the YFS index is not available since 2007, resulting in the unavailability of the combined YFS-index. This combined index has been estimating the incoming year class strength very consistently, hereby providing reliable estimates to the forecasts. Although results of using the YFS indices separately (FR-YFS for 1987-present and UK-YFS for 1987-2006) did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. The Working Group suggests that the assessment could benefit if the French Young Fish survey could be extended to include some of the sampling points from the former UK Young Fish survey along the English coast. The extended French survey could then mimic therefore the earlier available combined Young Fish survey which was an excellent estimator of the incoming recruitment	ACOM (France); SCICOM
Haddock in IV and IIIa	Stock structure	There is increasing evidence that the IV-IIIa and VIa haddock stocks should be assessed as one joint Northern Shelf haddock stock. A preliminary attempt was made at this during WGNSSK 2011, but a more complete data collation and analysis job is required, along with consideration of what this would entail for advice.	ACOM (UK - Scotkand);
Nep 7-10, 34	Lack of Scottish effort data	Anomalies in effort extractions from different Marine Scotland databases require further investigation to be resolved. Ability to provide an LPUE series for FU 10 (no UWTV survey) would improve basis for advice.	ACOM (UK - Scotkand); RCM-NS&EA

Stock	Data Problem	How to be addressed in	By who
Nop34	Missing Norwegian CPUE data by vessel category for 2008, 2010 and 2011 should be made available. Missing Norwegian data time series of samplings should be made available in Intercatch. Some detailed information on distribution of different life stages according to precise indications on spawning sites and spawning periods which will demand self sampling by the fishermen in their quarter 1 and quarter 2 fishery covering all fishing areas and the whole season.	Norway should provide these data in advance of the May2012 assessment	ACOM (Norway)
Nep 32	*Deficient Norwegian catch sampling*	The coast guard sampling of Norwegian and Danish commercial catches is satisfactory in some years, but not in others. The main problems with these data are that catches are often measured by total length (whole cm) and sample weight is missing. As total length data have lower resolution compared with carapace length data, the two cannot be combined without losing accuracy. The coast guard is aware of these problems and strives to improve the data	ACOM (Norway)

Stock	Data Problem	How to be addressed in	By who
Nep 32 & IIIa	*Scarce Norwegian log book data*	The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks compulsory for all vessels ≥ 15 m. As a large portion of the Norwegian fleet landing *Nephrops* in FU 3 and 32 consists of vessels < 15 m, the logbook data will continue to be limited. In 2013 compulsory electronic logbooks for vessels ≥ 12 m were introduced in FU 3. A growing part of the Norwegian *Nephrops* landings come from the trap fishery, but this part of the fleet is not required to fill in logbooks, probably because of the small size of the vessels. Logbooks from traps would provide data from the eastern (less exploited) part of FU 32. Log books should be introduced for vessels < 15 m, including trap fishers.	ACOM (Norway)
Pollack in Subarea IV and Division IIIa	General lack of biological data needed for better understanding of growth and maturity.	In routine surveys, such as the quarter 1 and quarter 3 IBTS in Subarea IV and Division IIIa, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity WGNEW recommended that otoliths and maturity information should be collected during these surveys for a few years. WGNSSK also recommends that biological data from commercial catches should be processed.	IBTSWG; RCM-NS&EA
Whiting in Division IIIa	General lack of stock identity and area specific age readings	Studies on whiting stock identity and connectivity in western Baltic, Division IIIa and Division IV should be encouraged In the routine surveys, IBTS quarter 1 and quarter 3 in Division IIIa, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity it is recommendable that otoliths and maturity information should be collected during these surveys.	National research services and IBTSWG
Cod in subdivision IIIaW, subarea IV, and division VIId	Perceived catchability problems in IBTS Q1 and Q3 indices, continued improvements in catch data	Appropriate standardisation of IBTS Q1 and Q3 surveys, consideration of additional indices (e.g. from commercial fleets or fisheries-science partnerships, if available) that could be used for tuning, continued improvements in catch data.	Anders Nielsen / Casper Willestofte Berg, and José De Oliveira / Jonathan Gillson for standardisation of IBTS indices, Clara Ulrich and others for alternative tuning indices, Scottish work on improvements in discard estimation

Annex 06 Audit reports

Audits were carried out during and after the working group for all WGNSSK stocks (Table 1). Only for grey gurnard (WGNEW stock) no audit was carried out.

In general, the ICES guidelines for audits in working groups (March 2014) were followed. This also implied that no audit report was necessary anymore and issues were directly discussed between the auditors and the stock assessor. The stock assessor implemented the agreed changes directly into the report. Never the less some auditors carried out an in depth audit and filled out the old "review" template from last year. These templates are given additionally below. Such an in depth audit was for example carried out for the haddock assessment. This assessment has been completely changed during the benchmark in 2014.

The audits focused on the consistency between steps from the Intercatch output to the advice. Further it was checked whether the assessments and forecasts were carried out in accordance to the stock annex. It was evaluated whether:

The methods used are those prescribed,

- The data used are those prescribed and that they are properly updated, and
- The methods have been implemented reasonably – that is technically correct while proper checks have been made for indications that the methodology may no longer be fit for purpose.

Table 1: Status of audits for each stock

Fish Stock	Stock coordinator	Status
cod-347d	Jose de Olveira (jose.deoliveira@cefas.co.uk)	Completed
had-346a	Coby Needle (C.Needle@MARLAB.AC.UK)	Completed
nep-5	Ewen Bell (ewen.bell@cefas.co.uk)	Completed
nep-6	Ewen Bell (ewen.bell@cefas.co.uk)	Completed
nep-7	Carlos Mesquita (C.Mesquita@MARLAB.AC.UK)	Completed
nep-8	Carlos Mesquita (C.Mesquita@MARLAB.AC.UK)	Completed
nep-9	Carlos Mesquita (C.Mesquita@MARLAB.AC.UK)	Completed
nep-10	Carlos Mesquita (C.Mesquita@MARLAB.AC.UK)	Completed
nep-32	Guldborg Søvik (guldborg.soevik@imr.no)	Completed
nep-33	Mats Ulmestrand (mats.ulmestrand@slu.se)	Completed
nep-34	Carlos Mesquita (C.Mesquita@MARLAB.AC.UK)	Completed
nep-iiia	Mats Ulmestrand (mats.ulmestrand@slu.se)	Completed
nop-34	Rasmus Nielsen (rn@aqua.dtu.dk)	Completed
ple-eche	Youen Vermard (Youen.Vermard@ifremer.fr); Marie Savina Rolland (marie.savina.rolland@ifremer.fr)	Completed
ple-skag	Clara Ullrich (clu@aqua.dtu.dk)	Completed
ple-nsea	David Miller (david.miller@wur.nl)	Completed
sai-3a46	Jennifer Devine (jennifer.devine@imr.no)	Completed
sol-eche	Willy VanHee (willy.vanhee@ilvo.vlaanderen.be)	Completed
sol-nsea	David Miller (david.miller@wur.nl)	Completed
whg-47d	Elisa Barreto (barretoe@marlab.ac.uk)	Completed
whg-kask	Henrik Svedang (henrik.svedang@slu.se)	Completed
bll-nsea	Kelle Moreau (kelle.moreau@ilvo.vlaanderen.be)	Completed
dab-nsea	Holger Haslob (holger.haslob@ti.bund.de)	Completed
fle-nsea	Holger Haslob (holger.haslob@ti.bund.de) ; David Miller (david.miller@wur.nl)	Completed
lem-nsea	Lisa Readdy (Lisa.Readdy@cefas.co.uk) ; William Lart (William.Lart@seafish.co.uk)	Completed
wit-nsea	Francesca Vitale (francesca.vitale@slu.se)	Completed
Tur-nsea	David Miller (david.miller@wur.nl)	Completed
Tur-kask	Clara Ullrich (clu@aqua.dtu.dk)	Completed
Mur-347d	Youen Vermard (Youen.Vermard@ifremer.fr)	Completed

Audit of Haddock in ICES Subarea IV and Division IIIaW and VIa (North Sea, Skagerrak and West of Scotland)

Date: 20/05/2014

Reviewer: J. Rasmus Nielsen

For single stock summary sheet advice:

Assessment type: Update from Benchmark in early 2014 (ICES WKHAD 2014)

Assessment: Analytical

Forecast: Presented

Assessment model: Age based TSA (Fryer 2002), presented along with SAM and SURBAR exploratory runs. The assessment is tuned using the North Sea IBTS Q1 and Q3 surveys, i.e. 2 demersal trawl survey indices and no commercial CPUE indices.

Data issues:

Concering tuning time series: For the 2014 IBTS Q1 survey less hauls were conducted in the northern part of the North Sea than usual. An increase in the uncertainty around the survey index for 2014 can be expected because of the lower number of hauls.

Maturity-at-age data assumed fixed over time and knife-edged at age 3. After the benchmarking maturity is knife-edged at age 3. Values for natural mortality are varying as used from the SMS multi-species assessment.

Discards (observations available since 1972) and industrial by-catch (IBC) are included in the assessment. Data series originate from the main fleets (covering around 90% of the landings). The new discard collation method used from 2009 onwards has not changed the perception of discard rates for haddock. It should be mentioned how discard data from 1973-1977 is provided.

Specific information on changes in the Scottish fleet during 2011-2013 was not provided to WGNSSK in 2014. Recent changes in fishing power, fishing pattern and exploitation pattern can be expected from a) a number of Scottish vessels have been taking up opportunities for oil support work during recent years, b) because of limited cod and whiting quota vessels have tended to concentrate on the haddock fishery, c) reactions to measures related to the Scottish Conservation Credits Scheme, d) reactions to cod avoidance under real-time closures, and e) reactions in relation to participation in fully documented fishery (FDF) among other in relation to discard patterns. It is difficult to reach firm conclusions on the effects of these recent changes on haddock mortality. It is recognized that there is a tendency towards targeting smaller fish.

1) **Consistency:** There is good consistency in the outcome of the 3 assessment methods. Last year's assessment was accepted. There has been made an extensive benchmarking of the assessment in first part of the year 2014 which has changed the assessment: i) Assessment now produced for the combined Northern Shelf stock, ii) Assessment model is now TSA, presented along with SAM and SURBAR exploratory runs, iii) Maturity is now knife-edged at age 3, iv) Time varying natural mortality estimates from SMS runs are used, v) The assessment is tuned using only two survey fleets (IBTS Q1 and IBTS Q3) now, and vi) The assessment now starts in 1972. No historical plots of comparison of the assessment output with previous years assessment was available to the Audit

(I am aware there has been a benchmark in between). However, the retrospective plots are presented which shows consistency.

2) **Stock status**: Haddock in Subarea IV (North Sea), Division IIIaW (Skagerrak) and Division VIa (West of Scotland) (referred to here as *the Northern Shelf*) were previously assessed as two separate stocks: Subarea IV and Division IIIaW (North Sea and Skagerrak), and Division VIa (West of Scotland). WKHAD (ICES-WKHAD 2014) concluded that there was strong evidence that the stocks were not biologically distinct and should therefore be assessed as a single stock. The Northern Shelf catch advice has been split between the existing management units (Subarea IV, Division IIIaW and Division VIa) according to survey-based indications of current distribution. F is below Fpa and SSB is above MSY-Btrigger, and the stock is viewed as being at full reproductive capacity with most recent estimates of SSB>MSY $B_{trigger.}$

3) **Man. Plan.**:

Subarea IV and Division IIIa

In 2008 the EU and Norway agreed a revised management plan for this stock, which states that every effort will be made to maintain a minimum level of SSB greater than 100 000 t (B_{lim}). Furthermore, fishing was restricted on the basis of a TAC consistent with a fishing mortality rate of no more than 0.30 for appropriate age groups, along with a limitation on interannual TAC variability of ±15%. Following a minor revision in 2008, interannual quota flexibility ("banking and borrowing") of up to ±10% is permitted. The stipulations of the management plan have been adhered to by the EU and Norway since its implementation in January 2007.

Following the agreed North Sea management plan implies fishing at the target rate of 0.3, which results in a TAC (human consumption landings) reduction of 11% and human consumption landings of no more than 34 087 t in 2015. If rates of discards and industrial bycatch do not change from the average of the last 3 years (2011–2013), this implies catches of no more than 51 280 t.

Following the ICES MSY approach implies fishing mortality to be increased to 0.35, resulting in a TAC (Human Consumption landings) in 2015 of no more than 39 563 t (Subarea IV), 927 t (Division IIIa) and 9 791 t (Division VIa). If rates of discards and industrial bycatch do not change from the average of the last 3 years (2011–2013), this implies catches of no more than 59 545 t (Northern Shelf). This is expected to lead to an SSB of 124 442 t in 2016.

Division VIa

An EU management plan proposal for Division VIa (see Annex 6.3.8) was evaluated by ICES and is considered to be precautionary. The aim of this plan is to keep the SSB above 30 000 tonnes with a fishing mortality of no more than 0.3. The main elements in the plan are a 25% constraint on TAC change between years and lower fishing mortality rates whenever the SSB is lower than 30 000 t. This proposal for a management plan has not been formally agreed.

The application of the North Sea management plan to Division VIa implies a TAC (human consumption landings) increase of 112% and human consumption landings of no more than 8 436 t in 2015.

General comments

The assessment report and advice is well written, fully documented and well ordered. It is easy to follow and interpret.

Technical comments

There were no major errors found but a few points to note:

- Concering tuning time series, section 13.2.5: For the 2014 IBTS Q1 survey less hauls were conducted in the northern part of the North Sea than usual. An increase in the uncertainty around the survey index for 2014 can be expected because of the lower number of hauls. Maybe you can also mention that already in section 13.2.5?
- It should be mentioned how discard data from 1973-1977 is provided (is this by modelling?).
- There has been made an extensive benchmarking of the assessment in first part of the year 2014 which has changed the assessment. No historical plots of comparison of the assessment output with previous years assessment was available to the audit (I am aware there has been a benchmark in between). However, the retrospective plots are presented which shows consistency. .
- Table and Figure references in the text should be made in bold (Figure, Table).
- Table 13.2.1: Landings in tonnes and not (000 t)?
- Table 13.2.10: The abbreviation IBC should be spelled out in the table text (Industrial By-Catch).
- In section 13.2 there is referred to Table 1. This is Table 13.2.12. Please adjust the reference to this table.
- Figure 13.3.11: x-axis is year.
- Figure 13.3.25: In the figure text there is indicated F(2-4), however, this is for recruitment, R. Please, correct the figure text.
- Section 13.4: Mis-spelling of Skagerak
- Section 13.6: Table 13.6.2 is mentioned before Table 13.6.1 (detail).
- Table 13.3.5 (Assessment Stock Summary Table) and Table 13.6.2 (Forecast Output) should be checked with respect to numbers for 2014: Why so big differences in SSB and Yield? Maybe elaborate on this in the text?

In general: Comments from reviewers/auditors on last years assessment and how these have been addressed is not included in the text. This is maybe not relevant/ necessary given the benchmark assessment in early 2014.

Technical comments – advice sheet

- There are small differences in the catch for 2013 between Table 13.2.1, Table 13.3.5 and Advice sheet catch by fleet.
- Please, be clear about and consistent in the description of inclusion of discard from 1973-1977 both in the assessment and the advice sheet (see also comment above).
- Historical plots not included yet.

Conclusions

The assessment has been performed correctly.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

YES

InterCatch has been used.

- Is the assessment according to the stock annex description?

YES

- Is general ecosystem information provided and is it used in the individual stock sections?

4) **YES**

- If a management plan has been agreed, has the plan been evaluated?

YES

For update assessments

- Have the data been used as specified in the stock annex?

YES

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

YES

- Is there any **major** reason to deviate from the standard procedure for this stock?

NO

- Does the update assessment give a valid basis for advice?

YES

Audit of Striped red mullet in Subarea IV (North Sea) and Division VIId (Eastern English Shannel) and IIIa (Skagerrak–Kattegat)

Date: 21/05/2014

Reviewer: J. Rasmus Nielsen

For single stock summary sheet advice:

Assessment type: Update

Assessment: Trends / Not presented

Forecast: Not presented

Assessment model: None

Data issues:

Concering catch and survey time series: Different survey and catch time series have been evaluated with respect to abundance, biomass and age/length composition. Age and length composition data is only available to a limited extent for some periods and areas for the landings (catch) and survey time series.

Striped red mullet have two stock components (two units with a western unit and a northern unit), the adults have a more offshore distribution in high saline waters, and the juvenile have a more coastal distribution in low saline waters. Even though the survey time series is considered to cover the different stock components and life stages well, then this could in future evaluations be analysed further. Here there can be made additional size and age distribution analyses of the different survey data time series – as well of the landings data time series. A comparative study of the size and age compositions in the different survey and commercial fishery data time series in relation to their geographical coverage - and potential differences herein - will indicate how well the different time series cover the different stock components and life stages. This should naturally be done under consideration of different gear selectivity and potential targeting in the different data time series.

The main commercial fishery for striped red mullet is a French targeted fishery, however, the species is also caught as by-catch in certain other fisheries.

Further age and length composition data from the different time series with higher temporal and spatial coverage will be made available for the benchmark in 2015.

Are there any indications or reports of discards of striped red mullet? In the advice sheet it is stated that all catches are assumed to be landed.

Are there any indications or reports of changes in fishing patterns in the target and by-catch fisheries fishing striped red mullet?

Are data up-loaded in InterCatch?

1) **Consistency:** There is consistency between last years evaluations and this years evaluations. New data (landings and survey data) available for this stock do not change the perception of the stock.

2) **Stock status**: There is very low biomass and abundance indices in the last years, and the commercial landings have shown a drastic decrease in the last years.

3) **Man. Plan.**: There is no management plan and catch projections for this stock. The advice is based on a biomass index used as indicator of (relative) stock size. The methods applied to derive quantitative advice for data-limited stocks are expected to evolve as they are further developed and validated. The harvest control rules are expected to stabilize stock size, but they may not be suitable if the stock size is low and/or overfished. It should be considered that there are directed (targeted) fisheries for striped red mullet in the management of the stock.

The advice in 2014 is similar to the adcice in 2013 that catches should be no more than 460 tonnes. This is a drastic reduction compared to the 2012 advice of maximum catches of 1700 tonnes..

General comments

The assessment report and advice is well written, fully documented and well ordered. It is easy to follow and interpret.

Concerning ecosystem aspects: Maybe there could be mention of the ecological role of striped red mullet with respect to whether it is a predator (and in given case preying on which species) or a prey species (and in given case food for which species). If no information and knowledge is available on this aspect it could be explicitly stated under the ecosystem aspects section.

Technical comments

There were no major errors found but a few points to note:

- In the advice sheet it is stated that all catches are assumed to be landed. This should maybe also be stated in the assessment text (in relation to discard considerations)?
- Are data uploaded in InterCatch?
- Section 17.3.2: Wrong Figure reference to Figure 17.2.2.2
- Section 17.4.1: Correct Figure number for Fig. 17.1.4.1 (Fig. 17.4.1); Fig. should be with capital F in the text.
- Highligth Table and Figure with bold in general in the text.
- Figure 17.4.1.1: Relative biomass in which unit (y-axis)?
- Figure 17.4.1.4: Indicate “per age group” in figure text.

In general: Comments from reviewers/auditors on last years evaluation and how these have been addressed is not included in the text (or potentially important statements from ICES WKLIFE).

Technical comments – advice sheet

- Table 6.3.13.1: Check that the left column with years is correct, and which years the advice is actually given for.
- In the advice sheet it should be indicated that there are very low biomass and abundance indices in the last years, and that the commercial landings have shown a drastic decrease in the last years.

- Also it should be mentioned that management of the stock should consider that there is a directed (targeted) fishery for the stock.

Conclusions

The evaluation / assessment has been performed correctly.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

YES

Has InterCatch been used?

- Is the assessment according to the stock annex description?

There is no stock annex available yet.

- Is general ecosystem information provided and is it used in the individual stock sections?

YES

Concerning ecosystem aspects: Maybe mention the ecological role of striped red mullet with respect to whether it is a predator (and in given case preying on which species) or prey species (and in given case food for which species). If no information and knowledge is available on this it could be explicitly stated.

- If a management plan has been agreed, has the plan been evaluated?

No

For update assessments

- Have the data been used as specified in the stock annex?

There is no stock annex available yet.

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

There is no stock annex available yet.

- Is there any **major** reason to deviate from the standard procedure for this stock?

NO

- Does the update assessment give a valid basis for advice?

YES

Audit of Turbot in Subarea IV

Date: 30/05/2014

Reviewer: Coby L. Needle

For single stock summary sheet advice:

Assessment type: Update

Assessment: Analytical

Forecast: Presented

Assessment model: Bespoke age-structured model, using splines to describe smooth trends in mortality and abundance. The main advantage is to allow data gaps to be filled. Model still in development to a certain extent. It could be argued that, as this is a model in progress, the report text does not explain it sufficiently, or give a reference to where such an explanation could be found (I believe Aarts and Poos was the paper cited in the past). This makes it difficult to provide an informed review. Methodology is not usually specified in this way, but only because the models used are generally well-known either in WGNSSK (e.g. XSA, SAM, SURBAR) or in other WGs (e.g. TSA), and this is not the case here.

Data issues:

Tuning time series: Assessment is tuned by two survey series and one commercial LPUE series. All series are quite noisy and the internal consistency is generally relatively poor.

Weights-at-age: There is a long gap in measured weights-at-age. The conclusion reached by IBPNEW was to assume fixed weights-at-age throughout the time series, but there is also an acknowledgement that this may lead to bias in SSB estimates. Many other assessments use length data converted to weights, rather than direct weight measurements, and it might be fruitful to consider whether this could be done here also.

Maturity-at-age: The report mentions that a maturity ogive has been fitted to recent data, but neither here nor in the Stock Annex is it clarified what these data are. It would be useful to have a note specifying this.

Natural mortality: Similarly, there are no reasons given for the assumption of M=0.2 across all years and ages.

Discards are not included in the assessment as they are assumed to be negligible.

Consistency:

The retrospective plots highlight a potential problem with retrospective noise and/or bias in estimates of F, with the hypothesis that this is due to insufficient knots in the fitted splines. It is difficult to comment on this as it is not stated what these knots are, but in any case it is possibly a weak point in the assessment if perceptions of stock dynamics are driven by an arbitrary decision on the number of knots. On the other hand, there appear to be no retrospective problems with SSB estimation.

Stock status

After a peak in the early 2000s, estimates of mean F are now significantly lower. Recruitment has fluctuated throughout the time series and would now appear to be at or near the long-term mean. SSB is increasing slowly from the historical minimum, which occurred at around the same time as the historical maximum in F.

Management Plan:

There appears to be no management plan as such, and the advice is based on the MSY approach (using $F_{0.1}$ as a proxy for F_{msy}). The report notes that turbot is fished under a combined quota covering both turbot and brill, and recommends that separate species quotas would be beneficial to sustainable management.

General comments

The assessment report is well written, and is easy to follow and interpret. There remains the issue of the assessment model and its implementation – there does not seem to be enough information given in either the assessment report or the Stock Annex to determine whether the assessment has been done as specified. An external reviewer would find it difficult to know whether the result could be used as the basis for advice or not. This is unfortunate because the assessment team have shown a great deal of innovation and initiative in coming up with solutions to the problems of assessing a stock for which data are missing completely for long periods of time, and for which those data that do exist are quite noisy.

Technical comments

There were no major errors found but a few minor points to note:

- Capitalise "Subarea" throughout.
- It's not clear why the incorporation of total landings yield directly in the assessment would be beneficial (Section 18.2.1) – would that not just be including the landings data twice (or three times, if we consider the commercial LPUA tuning series)?
- Can the table of the use and acceptance of InterCatch be removed from Section 18.2.1? It takes up a lot of space and doesn't say very much.
- 3rd paragraph of Section 18.2.1 – I was wondering what the threshold would be for the "very few" Danish fish to be considered to be "not enough to to be used in the raising of international landings"? I'm not suggesting that all such data has to be used, but it might be helpful to know if the cut-off point was applied under a consistent basis.
- Figure 18.2.6 – are these really Z estimates, or F estimates? I find it hard to see how they could represent Z, as they are landings only and can therefore only indicate F – there may be millions of turbot taken by seals every year, and the Z they exert would not show in these catch curves at all.
- The text states that all the correlations are positive in Figure 18.2.8. This isn't the case, though, as there are many negative correlations. Perhaps the text is referring to the R^2 values, which of course are all positive.
- In Section 18.3.2, there is a comment that "selectivity at these ages is less well estimated." There would need to be variance estimates or confidence limits about the fitted selectivity estimates to support this statement.
- Time-series state-space models such as SAM or TSA can also account for missing data, and are not reliant on *ad hoc* decisions about the number of knots. It

might be helpful to see (next year) exploratory runs using these models (or similar).

- There needs to be an explanation in the text of the reason for the sharp step in estimated F (Section 18.4.2).
- In Section 18.6, the text states that the "forecast was conducted in ADMB". Is this essentially a continuation of the assessment model, or is it something different? As for the assessment model, there needs to be a short note (or at least a reference) in either the assessment report or the Stock Annex.
- Figure 18.2.3 – are these landings for turbot only?
- Figure 18.2.4 – how are these data standardised?
- Figure 18.3.1 – if confidence intervals are available, they would really help with understanding these figures.
- Figure 18.4.2 – are these confidence intervals 95%?
- Seeveral of the Tables are missing units.

Technical comments – advice sheet

- None.

Conclusions

The text reports the application of very innovative solutions to problems of poor data availability. However, there is not really enough information in the assessment report or the Stock Annex to decide whether or not the assessment has been performed correctly.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

Yes

InterCatch has been used.

- Is the assessment according to the stock annex description?

Uncertain/yes after the stock annex has been improved

- Is general ecosystem information provided and is it used in the individual stock sections?

Yes

- If a management plan has been agreed, has the plan been evaluated?

n/a

For update assessments

- Have the data been used as specified in the stock annex?

Yes

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

Uncertain/ yes after the stock annex has been improved

- Is there any **major** reason to deviate from the standard procedure for this stock?

No

- Does the update assessment give a valid basis for advice?

Uncertain/ yes after issues were discussed with the stock coordinator

Audit of Sole in ICES Subarea IV (North Sea)

Date: 23/05/2014

Reviewer: Henrik Svedäng

For single stock summary sheet advice:

Assessment type: Update from Benchmark in 2010 (ICES WKFLAT)

Assessment: Analytical

Forecast: Presented

Assessment model: Age-based analytical assessment (XSA). Commercial catches (international landings, age frequencies from catch sampling), two survey indices (BTS-ISIS Q3, SNS Q3), one commercial index (NL TBB, all year). Natural mortality is assumed constant. Maturity at age is assumed to be knife edged (at age 3). A recruit survey (DFS Q3) is used for estimating recruitment.

Data issues:

Natural mortality in the period 1957–2013 has been assumed constant over all ages at 0.1, although concerns have been raised for increased mortality rates in years with low winter temperatures.

The change in applied raising proocedures since the introduction of InterCatch needs to be investigated. At the present, more weight is given to the small sampled metiers in the total age composition, compared to the procedure applied to the historical time series before the use of InterCatch. This may have contributed to an increase in the SOP discrepancy.

Discards information is incomplete but are estimated in the order of 20% (in weight) in 2011-2013.

No exploratory analyses was carried out and the update following the benchmark procedures exactly was adopted as the basis for the advise.

1) **Consistency:** The assessment is consistent; the results are similar between years. The retrospective pattern is low.
2) **Stock status**: Fishing mortality was estimated at 0.23 in 2013 which is well below F_{pa} (=0.4) and close to F_{msy} (0.22). The SSB in 2014 was estimated at about 47 000t which is well above both B_{lim} and B_{pa}. The present SSB is dominated by the average year classes 2009 and 2010. Year classes 2011 and 2012 appear to be weak. 0-group surveys indicate that year class 2013 may be above average.
3) **Management plan:** The long term management plan for plaice and sole in the North Sea first objective to bring both sole and plaice stocks within safe biological limits has been achieved and the sole stock is above Bpa since 2012. The overall objective of the CFP of all fish stocks at Fmsy has yet to be fulfilled, albeit recent estimates are very close to Fmsy. The ICES advice for sole in 2015 is based on exploitation at Fmsy.

Due to measures resulting from the flatfish management plan, actions taken to reduce bycatch and disturbing the sea bottom and economic incentives (reduce fuel costs), overall, effort in beam fishery has reduced in the past 15 years by 65%. The significant

reduction of effort in the fleet must have contributed to reduce the impact of this fishery on the marine ecosystem. However, as mentioned under 10.1.2. Fisheries, beam trawl methods using pulse stimulation instead of tickler chains have developed fast in recent years. Also other alternatives for the beam itself, such as a fly wings have been introduced. The catch composition with these "new gears" is different from the traditional beam trawl. However, in the logbooks fishing operations using the new gear cannot be distinguished from traditional beam trawling. Such significant changes in fishing technology are likely to represent efficiency, hence partly undo gains in effort reductions. This issue has not been raised neither by WGNSSK nor STECF.

General comments

The assessment report and advice is well written, fully documented and well ordered. It is easy to follow and interpret.

Technical comments

There were no major errors found but a few points to note:

- Figure 10.3.4. Sole in SubArea IV. Plots A,B are placed at the bottom, whereas the left and right Bottom plots are placed on the top.
- Figure 10.3.4. c & d is refered to on p. 542. but does not exist (probably referring to Figure 10.3.4. bottom panels (that are placed on the top).
- The numbering of figures and tables in different sections don't comply. For instance, tables and figures in section 10.3 are called as 10.4.x etc.
- There is no reference to Figure 10.8.1 in the text.
- Thre is no reference to Table 10.8.4
- The text needs to be edited.

Conclusions

The assessment has been performed correctly. The methods, results and conclusion are consistently presented.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

YES

InterCatch has been used.

- Is the assessment according to the stock annex description?

YES

- Is general ecosystem information provided and is it used in the individual stock sections?

YES

- If a management plan has been agreed, has the plan been evaluated?

YES

For update assessments

- Have the data been used as specified in the stock annex?

YES

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

YES

- Is there any **major** reason to deviate from the standard procedure for this stock?

NO

- Does the update assessment give a valid basis for advice?

YES

Audit of Nephrops in Subarea IV: Noup (FU10)

Date: 25/05/2014

Reviewer: Arved Staby

General

For single stock summary sheet advice:

Assessment type: Data limited approach for *Nephrops* stocks (SALY)

Assessment: None. (advice from 2012 is biennial and valid for 2013 and 2014).

Forecast: None.

Assessment model: Densities from 2007 UWTV survey, mean weight (from FU 9), and spatial extent of nephrops grounds (based on BGS maps). Discards 7.9% (no survival)

Data issues: UWTV surveys irregular, no landings or discard sampling

Consistency: -

Stock status: unknown

Man. Plan.: None.

General comments

The Noup FU was benchmarked at WKNEPH in 2013. No assessment was done for this stock in 2014, which is very small and rarely fished by the nephrops fleets. The benchmark concluded that advice should be provided for Nephrops in FU10 on the basis of the data limited approach. This was done in 2012 to provide biennial advice. No new advice was provided or analyses done at WGNSSK 2014.

Technical comments

Figure 4.8.1: Include effort and LPUE in figure text

Figure 4.8.2: Include figure labels for 2006 and 2007

Catch advice table under Management Considerations: units of weights taken from FU 9 and mentioned beneath the catch advice table should be in g. (not in mm).

Table: 4.8.2: the unit of landings (t) is missing

Conclusions

The required work towards answering the TORs for this stock has been done.

The report is clear and understandable.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? **YES.**
- Is the assessment according to the stock annex description? **N/A.**

- Is general ecosystem information provided and is it used in the individual stock sections. **Yes, mainly concerning potential bycatch of whitefish.**
- If a management plan has been agreed, has the plan been evaluated? **N/A.**

For update assessments

N/A for this FU. No assessment, and biennial advice from last year.

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Nephrops in Subarea IV: Norwegian Deep (FU32)

Date: 26/05/2014

Reviewer: Arved Staby

General

For single stock summary sheet advice:

Assessment type:	Data limited approach for *Nephrops* stocks
Assessment:	Trends in fishery LPUE (Danish trawlers), and mean sizes in landings, density estimates from neighboring FU/ combined with mean size from Danish landings.
Forecast:	None.
Assessment model:	None.
Data issues:	Benchmark in 2013.Catches from the Norwegian shrimp trawl survey (back to 1997) may be explored in order to establish a time series index of biomass.
Consistency:	Concerns over effort data because of possible changes in selectivity or gear efficiency leading to technological creep.
Stock status:	unknown
Man. Plan.:	N/A

General comments

The Norwegian Deeps FU was benchmarked at WKNEPH in 2013. No assessment is possible for this stock, but potential data sources on abundance were identified. Biennial advice is provided for this FU in 2015 and 2016. Mean size in 2013 decreased, possibly as a result of the contraction of the fishing area with only small nephrops. WG concludes that the available data give a non-conclusive perception of the stock status.

Some general remarks: mention is made of biomass estimates in 'Status of the stock' – these can be elaborated on somewhat more, e.g. why is density data from Fladen used in combination with mean weight from Danish catches, and why is not any Norwegian data used. Perhaps the Norwegian survey data can also be used to assess spatial differences in length. Such information may be useful when arguing the point that the Danish fishery in 2013 fished a smaller area with possibly smaller nephrops.

Technical comments

Text:

Length composition: check reference to mean sizes in FU3 (fig 3.2.2.2)

Length composition: Figure 4.9.4 is said to include data from 2012, but 2012 is not shown in the figure.

Two advice tables are presented in the section Management considerations with different numbers and information.

Tables

Table s 4.9.1 and 4.9.2 need to be inserted in the report. The text for the corresponding tables needs to be updated to include 2013.

Figures:

Figure 4.9.4 does not have length frequency distributions as suggested in the text.

Conclusions

The required work towards answering the TORs for this stock has been done.

The report is clear, referring to the annex for more details. The annex provides good background information. A map showing the entire size of FU32 (showing Norwegian and Danish fishing activity and suitable sediment) would be useful in future reports. Mean weights of discards from the Danish fishery would be useful in future assessments.

Some minor changes/elaborations are required, as noted above.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes.**
- Is the assessment according to the stock annex description? **N/A**
- Is general ecosystem information provided and is it used in the individual stock sections. **No, refers to stock annex (which contains suitable information)**
- If a management plan has been agreed, has the plan been evaluated? **N/A**

For update assessments

N/A for this FU. Biennial advice was provided in 2012. No new analyses were conducted since the benchmark in 2013.

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Nephrops in Subarea IV: Off Horns Reef (FU33)

Date: 26/05/2014

Reviewer: Arved Staby

General

For single stock summary sheet advice:

Assessment type: Trends in fishery LPUE

Assessment: None.

Forecast: None.

Assessment model: None.

Data issues: No stock annex.

Consistency: -

Stock status: unknown

Man. Plan.: N/A

General comments

There is currently no stock annex for this stock. This should be prepared.

There are no ecosystem considerations in the report section.

Technical comments

Text:

Length composition: - check reference to Figure 4.10.2

Figures:

Figure 4.10.1 this figure is not updated with data from 2012 and 2013. Table text should include LPUE

Figure 4.10.2 this figure is mentioned in the text but is not in the report (length distributions of Danish catches)

Tables:

Table 4.10.2 The text does not state that the data is from Danish vessels

Conclusions

The required work towards answering the TORs for this stock has been done.

The report is clear, but lacks information about ecosystem considerations.

Some minor changes/elaborations are required, as noted above.

A stock annex should be produced for this FU.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? **Yes.**

- Is the assessment according to the stock annex description? **No stock annex exists for this FU.**
- Is general ecosystem information provided and is it used in the individual stock sections. **No.**
- If a management plan has been agreed, has the plan been evaluated? **N/A**

For update assessments

N/A for this FU. No assessment, and biennial advice from last year.

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Audit of Nephrops in Subarea IV: Devil's Hole (FU34)

Date: 26/05/2014

Reviewer: Arved Staby

General

For single stock summary sheet advice:

Assessment type:	Data limited approach for *Nephrops* stocks
Assessment:	Advice from 2012 was biennial and valid for 2013 and 2014. However, 600t landings in 2014 imply a harvest ratio > 8 %, while a precationary harvet ratio < 8 % implies landings of 380 t based on recent landings average (2011-2013).
Forecast:	not presented
Assessment model:	2012 UWTV survey data density, mean weight (average 2007-2010), discard percentage (average 2007-2011), and VMS based spatial extent
Data issues:	Benchmark for Devil's Hole in 2013 (WKNEPH2013). Data described in Stock Annex for FU 34. Areal extent of suitable *Nephrops* habitat was determined using VMS data (2007-2011) and the resulting union of annual polygons.
Consistency:	UWTV survey data collected annually since 2009
Stock status:	data poor / unknown
Man. Plan.:	harvest ratio (landings) to fall within 8-16% of absolute biomass based on latest density estimates.

General comments

In 2012 biennial advice was provided for this stock, but the advice for 2014 was changed to be more precautionary: UWTV survey was not done in 2013, but the densities show a downward trend, and while effort has decreased substantially the LPUE stayed more or less stable. Mean sizes of males and females for the last two years have not been collected – attempts should be made to gather size data from catches and landings. It is not clear from the text under management considerations why the aim is to have a harvest ratio below 8% (while other North Sea stocks have harvest ratios between 8-16%).

Technical comments

Text :

Under 'Research vessel data' it says that UWTV has been collected since 2009, but 2013 there was no survey. This should be mentioned.

Advice table: the unit of the mean weights should be g (not mm).

Tables

Table 4.11.1 figure text does not correspond with years presented in the table.

Table 4.11.1 data for 2013 is missing

Table 4.11.2 data for 2013 is missing

Figure:

There is no reference to figure 4.11.1

Conclusions

The required work towards answering the TORs for this stock has been done.

The report is clear and understandable. Some minor changes/elaborations are required, as noted above.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice? **YES**
- Is the assessment according to the stock annex description? **YES**
- Is general ecosystem information provided and is it used in the individual stock sections. **YES (mainly related to habitat).**
- If a management plan has been agreed, has the plan been evaluated? **N/A**

For update assessments

N/A – biennial advice from last year

- Have the data been used as specified in the stock annex?
- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?
- Is there any **major** reason to deviate from the standard procedure for this stock?

- Does the update assessment give a valid basis for advice? If not, suggested what other basis should be sought for the advice?

Internal audit WGNSSK: Nephrops FU 7, 8 &9

Data

Availability, are the data described in the stock annex available?

Yes they are this year as opposed to last years.

New data series used?

No

Consistency, are data consistent with last year's data, (survey data, catch at age, mean weights, discard rates, etc.)?

No change in input was detected.

Model/methods

Are the models/methods used the same as described in the stock annex?

Yes …

A comparison of scripts (the wrappers) gave a nice overview of the few differences and small fixes needed (missing data etc.)

Have the models/methods been applied as specified in the stock annex?

Yes …

It was not possible given the time available actual check the source scripts if they actually are doing what they are supposed to. The stock annex could be developed into more detailed one at a later stage.

Results

Consistency with last year's assessment

Yes

Development in F and SSB as expected

Yes

Summary: The use of R-scripts for the whole process is a definite improvement from last year. A word of advice: The "wrapper" scripts should keep all year specific (like year range) input in top of the code with an appropriate and detailed comment describing what it is doing/coming from. Finding F2013<-15.6 towards the end of the wrapper script is one example. But overall: Good work.

Internal audit WGNSSK: Norway pout in IIIa and IV

Data

Availability, are the data described in the stock annex available?

Yes. All input identical to last year with 1 year of new data added.

New data series used?

None

Consistency, are data consistent with last year's data, (survey data, catch at age, mean weights, discard rates, etc.)?

Only to a certain degree. Poor coverage of the surveys gives consistency plots with poor performance

Model/methods

Are the models/methods used the same as described in the stock annex?

The assessment software have been kept constant since 1995. Choice of input have been kept constant since last benchmark.

Have the models/methods been applied as specified in the stock annex?

Yes

Results

Consistency with last year's assessment

See text below.

Development in F and SSB as expected

The assessment is for all practical purposes updated twice a year and this has an improvement on the predictive value compared to a solution with only one assessment with forecast per year. The current assessment indicates that the average F in 2013 was 0.4 after landings of 82 thousand tonnes. The May 2013 forecast for the remainder of 2013 suggested a stock twice that size. An uptake in line with the May 2013 forecast would have been a disaster and it seems price/capacity have effectively limited the fishing to rational levels. The stock may also to a degree be safeguarded by the targeted fishing only occurring in parts of the distribution area. The performance of catch predictions is poor.

Elaboration: The assumption of a high and constant natural mortality is for all practical purposes letting the catch at age/quarter matrix be the source of perceived dynamics for this stock. The surveys used in tuning this assessment is only partly covering the distribution of the stock and the erratic behavior of the residuals will be linked to the underlying sampling errors and unknown variation in natural mortality.

Knut Korsbrekke

Plaice in Division VIId (Eastern Channel) ple-eche

Assessment type: Update assessment**,** Category 2.

Assessment: Trend based (decided by WKFLAT 2010)

Forecast: Short-term forecast using FLSTF with average F for last three years.

Assessment model: Exploratory XSA model run. 3 surveys (UK Beam Trawl, French Ground Fish, International Young Fish Survey) and 1 commercial fleet (Belgian Beam Trawl Fleet) used for tuning.

Data issues:

Although, discard data are available since 2002 for this stock they were not used for the assessment in this year. It was concluded that the coverage of discard sampling was too low before 2008, and the improved time series since then is too short to be used.

Considerable inconsistencies between surveys and commercial tuning indices were observed.

Spawning migrations of plaice from neighbouring areas into VIId is taken into account by a 65% removal of catches from quarter 1. The amount of removal is based on results from tagging studies. It could be shown, that the assessment was improved by this procedure. However, uncertainty on the removed quantity remains as this might vary from year to year.

1) **Consistency**:
    - Same settings as for the last year assessment were used for the exploratory XSA.
    - Short term forecast: Instead of F_{max}, this year $F_{0.1}$ was used as F_{MSY} proxy, following the ICES DLS guidelines.
2) **Stock status**: Trends only. Reference points not valid for advice. F decreased for the last decade, but increased slightly in this year assessment (F_{2013}=0.374 compared to F_{2012}=0.356). SSB shows in general an increasing trend since 2003. In 2013, the estimated SSB_{2013}=6055t is lower compared to the previous year SSB_{2012}=6649t.
3) **Management Plan**: No explicit management objectives for this stock. TACs have been set for ICES Divisions VIId and VIIe together.

General comments

This assessment is an exploratory XSA which provides trends for F and SSB. Further, a short-term forecast is presented. The conclusions and results are presented appropriately.

Following the ICES DLS approach for category 2 stocks $F_{0.1}$ was taken as F_{MSY} proxy for the short term forecast this year. Compared to the last year assessment this led to a considerable reduction in the advised landings. It is stated that this substantial reduction is solely due to the lower F_{MSY} proxy (in 2013 $F_{MSY}=F_{max}$=0.23). However, additionally different scenarios were tested applying different F_{MSY} proxies (F_{MSY} derived from eqsim; F_{max}).

The problems which were reported already in the last year review were not addressed in the updated assessment (e.g. poor recruitment estimates, no discards included, inconsistency between tuning fleets). However, it is stated that these issues will be addressed when this stock will be benchmarked in 2015.

Technical comments

All results are presented properly in figures and tables. There were no major errors found but a few points to note:

- Minor comments and suggestions were inserted in the draft report by track changes.
- Section 6.1.2.: please check last paragraph in this section. From figure 6.1.2.1 it seems more that age group 1 is not caught at all.
- Table 6.2.1.1.: please check the numbers for unallocated landings in 2012 and 2013.

Conclusions

The RG agrees with the WG conclusions for this stock.

Saithe in Subareas IV (North Sea), VI West of Scotland), and Division IIIa (Skagerrak) sai – 3a46

Assessment type: Update assessment

Assessment: Analytical, XSA

Forecast: Short-term forecast presented

Assessment model:

XSA presented along with an alternative SAM model run. Both models are based on the same input data. The assessment is tuned using two fishery independent survey indices: the North Sea IBTS Q3 survey and the NORACU acoustic survey; and three commercial CPUE indices from the French demersal trawl, German bottom trawl and Norwegian bottom trawl fleets. Maturity ogive and natural mortality (0.2) kept constant. The XSA model was used as final assessment and results were used for the short term forecast.

Data issues:

Discards were estimated with 12% for the European fleet but were not used in the assessment.

The problem of poor estimates of recruitment could not be solved for this year's assessment and is still a serious concern. The NORACU acoustic survey is not necessarily designed to target saithe, but is more an opportunistic approach on top of the IBTS Q1 and the herring acoustic survey which might not be an adequate method. Further, the design of the NORACU was changed since 2009. It is stated in the report that there is still ongoing work to improve the consistency of this survey time series and that a thorough review of this index will be done during the planned inter benchmark in 2015.

A southward shift of all three commercial tuning fleets was observed since 2009 which could have had an impact on the used tuning indices. However, it seems that the fleets returned to their original fishing grounds.

1) **Consistency**:

   In former assessments the geometric mean of the recruitment time series (1988 to current assessment year) was used to estimate the recruitment input for the short term forecast. A change-point analysis indicated that the geometric mean of the period 2005-2013 was significantly different than the mean 1988-2004. Therefore, the WG agreed to use the new period indicated by this analysis.

2) **Stock status**: The SSB of 186, 306t is lower than B_{pa} (200,000t) and lower than $B_{trigger}$ (200,000t).,F_{2013}(0.301) is lower than F_{pa} (0.40) and lower than F_{lim}(0.60). SSB and F have declined in recent years. F equals F_{MSY} in this assessment.

3) **Man. Plan**: Plan agreed in 2008 to maintain SSB above B_{lim} (106,000 t) EU and Norway agreement which includes a 15% rule on TAC and F should be no more than 0.3. The EU–Norway management plan was reconsidered in February 2013, but no modification was implemented. It was previously evaluated by ICES (ICES, 2012a) and considered to be consistent with the precautionary approach in the short term (< 4 years).

General comments

The section presents the results from two assessments: XSA and an alternative SAM model run. XSA results for SSB and recruitment are lower compared to the SAM. However, the XSA results are within the 95% confidence interval produced by the SAM model. The XSA was used for the final model and a short term forecast.

F equals the target F of 0.3.

The problem of poor estimates of recruitment could not be solved for this year's assessment and is still a serious concern.

Technical comments

The section is well written and all results are presented properly in figures and tables. There were no major errors found but a few points to note:

- Concerning comment on discards in section 11.1.2: It is stated that discards in the off shore fishery are minimal. For the EU fleets discards were estimated with 12% (9400t) which seems to be a rather considerable amount than minimal.
- Section 11.1.3: advice for 2015 is described, should be the last advice for 2014.
- Section 11.2.3: please insert reference for the management plan
- Section 11.3.1: please include brief description on how discards were raised
- Section 11.3.2: Please state why discard estimates were not used in the assessment?
- Section 11.3.5: It should be specified since when the distribution of the commercial fishing fleets shifted back to the original fishing grounds.
- Section 11.3.5: Is the methodology and especially the changes to that described somewhere? Would be helpful to provide a reference.
- Section 11.4.2: check for descriptions of NORASS in the text.
- Section 11.4.6: check reference for section 11.4.5
- Section 11.7: results of the change-point analyses should be included into the report (stock annex)
- Figure 11.4.3: please check figure caption. Only two survey indices are shown since the NORASS was excluded from assessment in 2013!?
- Figure 11.4.4: it is not clear if the x-axis extends to 2013.
- Table 11.3.1: the total reported landings (area IV and IIIa) for the years 2005 and 2007 differ from the sum of the reported values.
- Table 11.3.1: the total ICES estimate for 2012 differs from the sum of the two tables.
- Table 11.7.2: Why are two different values for MSY occur in the table?
- Table 11.7.2: What is the reason to split the landings using average of the time period 1993 – 1998?

Conclusions

The assessment has been performed correctly.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

YES

- Is the assessment according to the stock annex description?

YES

- Is general ecosystem information provided and is it used in the individual stock sections?

Yes

- If a management plan has been agreed, has the plan been evaluated?

YES

For update assessments

- Have the data been used as specified in the stock annex?

YES

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

YES

- Is there any **major** reason to deviate from the standard procedure for this stock?

NO

- Does the update assessment give a valid basis for advice?

YES

Annex 07 Joint WGNSSK and WGMIXFISH data call

DCF national correspondents

Els Torreele, Marie-Bénédicte Peyrat, Jørgen Dalskov, Christoph Stransky, Kees Verbogt, Mathew Elliott, Frank O'Brien, Anna Hasslow

ICES ACOM members

Els Torreele, Alain Biseau, Morten Vinther, Christopher Zimmermann, Floor Quirijns, Carl O'Brien, Maurice Clarke, Max Cardinale, Harald Gjøsæter

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

General Secretary
Anne Christine Brusendorff

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark

Telephone: (45) 33 38 67 00
Telefax: (45) 33 93 42 15
E-mail: info@ices.dk
www.ices.dk

Our Ref: L.27/NH/ACB/HKN 3 February 2014

Subject: Data call: Landings, discards, biological sample and effort data from 2013 in support of ICES work for the advice of the stocks in the North Sea (IV), Skagerrak and Kattegat (IIIa) and Eastern Channel (VIId).

Dear reader,

Please find enclosed a document describing the rationale, scope and technical details of this data call.
The data will be used as a basis for ICES advice to fisheries management regarding North Sea and Skagerrak fisheries, specifically in the analysis to be conducted at the ICES Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH) and Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) and the Working Group on Assessment of New MoU Species (WGNEW). A data call for the Celtic Seas Ecoregion will be issued soon, covering megrim and anglerfish stocks from the North Sea region as well.
The data requested will be analysed and used only for scientific evaluation of the stock status and advice. For countries which are also EU members this data call is under the DCF regulation ((EC) No 199/2008).
In case of questions please contact the ICES Secretariat (Henrikkn@ices.dk) for clarification.

Sincerely,

Anne Christine Brusendorff

General Secretary

CC:

Paul Dolder (ICES WGMIXFISH Chair), Alexander Kempf (ICES WGNSSK Chair), Jan Jaap Poos (ICES WGNEW Chair), Amélie Knap (European Commission/ DG-MARE), Bas Drukker (European Commission/ DG-MARE)

Excellence in marine science since 1902

Annex 8 Working Documents

Estimation of Missing Data using InterCatch for North Sea Whiting (wg-47d) 2013

Liz Clarke, Marine Scotland Science, Aberdeen

11/06/2014

Summary

This paper describes the InterCatch raising procedure in R for stock whg-47d and year 2013. For this stock and year, the Scottish discard weights, numbers-at-age, mean weights-at-age etc, were erroneously allocated to the wrong fleets, resulting in the wrong discard rates etc for those fleets, though the total discards for the Scottish fleets were correct. However, when the error was corrected, the discard estimates etc were virtually unchanged. Here we explain that this happened because all the fleets were concerned were used in the estimation of all missing discards, and the weighting factor in this discard estimation was landed weight.

InterCatch Algorithms

The "allocation algorithms" for discard weights, catch numbers-at-age and weights-at-age are given in the InterCatch manual (InterCatch User Manual Doc1-11.pdf) and are reproduced below.

Discard weight

From the InterCatch manual (p 79):

"When the user presses 'Ok (Calculate and continue to Discard Groups page)', the total weighted landing-discard ratio for all the selected ratios is calculated. Then this ratio is multiplied with the raised discard's related landing weight, to calculate the raised discard weight. This is done for each of the raised discard strata in the group."

This procedure can be expressed by the equation below (expressed in the notation used in the InterCatch manual):

$$DiscardWeight_{cell} = LandedWeight_{cell} * \sum_{i=1}^{n} \frac{DiscardWeight_i}{LandedWeight_i} * \frac{WeightingFactor_i}{\sum_{j=1}^{n} WeightingFactor_j} \quad ,$$

When landed weight is chosen as the weighting factor, this becomes

$$DiscardWeight_{cell} = LandedWeight_{cell} * \sum_{i=1}^{n} \frac{DiscardWeight_i}{LandedWeight_i} * \frac{LandedWeight_i}{\sum_{j=1}^{n} LandedWeight_j} \quad ,$$

$$= LandedWeight_{cell} * \frac{\sum_{i=1}^{n} DiscardWeight_i}{\sum_{j=1}^{n} LandedWeight_j} \quad , \qquad (1)$$

Thus, when landed weight is chosen as the weighting factor (the default), the individual discard rates of the cells included in the allocations are not used, instead an overall discard rate for the allocated cells is calculated. Therefore the discard weights for two cells both included in the calculation can be swapped over or altered without affecting the overall result as long as the total discard weight is the same. Similarly, if the discard

weights are swapped between cells but only one of those cells is used in the estimation, the estimates will also be wrong.

Landed or discard numbers-at-age and mean weights-at-age

For completeness we also present the estimation equations for Landed or discard numbers-at-age and mean weights-at-age. From the InterCatch manual (p98-99), the estimation equations are:

$$Number_{a,s} = CatchWeight_{unsampled} * \sum_{i=1}^{n} \frac{Number_{a,s,i}}{CatchWeight_i} * \frac{WeightingFactor_i}{\sum_{j=1}^{n} WeightingFactor_j} \quad , \quad (2)$$

$$a = [age_{first} .. age_{last}] \ \vee \ a = [length_{first} .. length_{last}] \quad ,$$

$$s = (female, male, unspecified) \ ,$$

$$n = number\ of\ allocated\ sampled\ catches$$

$$MeanWeight_{a,s} = \sum_{i=1}^{n} MeanWeight_{a,s,i} * \frac{WeightingFactor_i}{\sum_{j=1}^{n} WeightingFactor_{a,s,j}} \quad , \quad (3)$$

Here CatchWeight means LandedWeight when landings are being considered and DiscardWeight when discards are being considered. The mean weights at age and number at age have the same weighting factor unless the 'Mean weight weighted by numbers at age or length' algorithm is chosen.

Again from the manual, p98, when the 'Mean weight weighted by numbers at age or length' algorithm is chosen, we have:

$$Number_{a,s} = CatchWeight_{unsampled} * \frac{\sum_{j=1}^{n} Number_{a,s,i}}{\sum_{j=1}^{n} CatchWeight_j} \quad , \quad (4)$$

and

$$MeanWeight_{a,s} = \sum_{i=1}^{n} MeanWeight_{a,s,i} * \frac{Number_{a,s,i}}{\sum_{j=1}^{n} Number_{a,s,j}} \quad , \quad (5)$$

$$= \frac{\sum_{j=1}^{n} (MeanWeight_{a,s,i} * Number_{a,s,i})}{\sum_{j=1}^{n} Number_{a,s,j}}$$

From these equations, it can be seen that as long as all landed or discard information (weights, numbers, etc) are for a cell are kept together, the information can be swapped between cells without affecting the estimation. Of course, if mean weights-at-age are swapped without swapping the corresponding numbers-at-age (or other weighting factors), then the estimates will be wrong. Similarly, if information is swapped between cells but only one of those cells is used in the estimation, the estimates will also be wrong.

Implementation in R

The InterCatch estimation algorithms expressed by equations (1), (4) and (5) have been implemented in R and tested using a simple test case.

The output from InterCatch contains everything required to reproduce the InterCatch estimation procedures in files: CatchAndSampleDataTables.txt, DiscardAllocations.txt and

AllocationsAndCatchData.txt.

The first of these files contains the input and output catch data for each cell, whilst the others contain the groups of sampled data and weighting used in each stage of the estimation. Extraction of the groups of sampled data used is not particularly easy from latter two files, but for the numbers-at-age and weights-at-age, these are also presented in

AllocationOverviewForPivot_Discards_By_Fleet_.txt in a more tractable form.

Another InterCatch output file, Validationfile.txt, is also extremely useful as this allows one to check at a glance if (at least some) discards have been raised, and whether all unsampled cells have been allocated numbers and weights.

There might be slight differences in InterCatch estimates and those calculated in R due to the fact that the InterCatch output is rounded to 2 d.p.

In the test case, data were input into InterCatch (for year 1111 to avoid confusion) and all sampled data were grouped to estimate all unsampled cells. The InterCatch output data were then used as input to the estimation procedure in R. To avoid compounding differences, the discard weights estimated by InterCatch (rather than those estimated in R) were used in the reproduction of the numbers and weights-at-age calculations.

Complete agreement was found between InterCatch and R for discard weights and mean weights-at-age, and agreement of 0.0004% was found for total discard numbers-at-age. It is thought these small differences in numbers-at-age are due to the rounding of the data used as input to R.

Case study: whg-47d 2013

For whg-47d 2013, the fleet codes for Scottish discards had been mis-allocated prior to input. The discard weights, and corresponding numbers-at-age, weights-at-age etc had been correctly calculated, so the total discard weights and numbers-at-age were correct.

When the error was corrected, the total weights, numbers-at-age and weights-at-age output from InterCatch scarcely changed. This is because the discard weights, numbers-at-age and weights-at-age for the sampled discards were consistently used to estimate for all missing and unsampled discards. This means that an average discard rate, and average numbers-at-age per kg, and average weights-at-age are allocated to all cells with missing data. This is a robust method which is particularly appropriate when there are lots of cells comprising a mixture of fleets accounting for a small percentage of the overall catch.

The weighting factors, and the groupings for the discard numbers and weights-at-age, have been confirmed by studying the InterCatch Allocation files described above. It is harder to confirm the discard weight groupings and there has not been time to do so here. Instead, the same allocations as used for the numbers and weights-at-age have been used and found to be approximately correct. However, the comparison of discard rates show that I have not used exactly the same cells in the for the discard weight estimation as has been used in InterCatch. The discards weights calculated by InterCatch were used in the calculation of numbers and weights-at-age to avoid compounding the effect of differences between discard weights.

The landings were not affected by the error and so have not been reproduced here.

Tables 1-3 compares the total discard weight, numbers-at-age and weights-at-age as calculated by InterCatch and R, for the two runs WGNSSK (with incorrect fleets) and

ADG (with correct fleets). They show a very close agreement between R and Inter-Catch, and between the two versions in R. We have therefore confirmed that the Inter-Catch raising for these two sets of data should result in the same N-at-age etc, in the case when all sampled fleets are used for all unsampled fleets and landed weight is chosen as the weighting for the discard estimation, as is the case for whg-47d.

Table 1: Total discard weight and mean discard rate used for cells with missing discard information.

	WGNSSK FROM IC	WGNSSK IN R	ADG FROM IC	ADG IN R	% DIFF
Discard weight	5904984	5890887	5904984	5890887	-2.4%
Discard rate	0.2822213	0.2785537	0.2822214	0.2785537	

Table 2: Total discard numbers at age for area IV

AGE	WGNSSK FROM IC	WGNSSK IN R	ADG FROM IC	ADG IN R
0	3635518.38	3635560.7	3635520.55	3635562.2
1	11827221.51	11827367.6	11827225.76	11827369.4
2	6580071.72	6580154.0	6580073.35	6580154.2
3	7550748.17	7550841.8	7550750.03	7550842.1
4	1946696.47	1946715.8	1946695.51	1946714.5
5	380594.51	380598.1	380595.94	380599.4
6	104019.90	104020.9	104019.92	104020.9
7	13506.18	13506.3	13506.18	13506.3
8	9108.01	9108.2	9108.02	9108.2

Table 3 Discard mean weights at age in area IV

	0	1	2	3	4	5	6	7	8
WGNSSK from IC	33.35	61.84	168.29	205.09	274.02	329.86	206.25	341.99	508.16
WGNSSK in R	33.35	61.84	168.29	205.09	274.02	329.86	206.25	341.99	508.16
ADG from IC	33.46	61.83	165.35	205.00	274.21	329.77	206.25	341.99	508.16
ADG in R	33.46	61.83	165.35	205.00	274.21	329.77	206.25	341.99	508.16