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0 Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met at ICES Headquarters in Copenhagen, Denmark, during 24-30 April – 2013. There were 23 participants from 8 countries. The main terms of reference for the Working Group were: to produce a first draft of the advice on the fish stocks and fisheries under considerations, to update, quality check and report relevant data for the working group, to produce an overview of the sampling activities on a national basis to update the description of major regulatory changes and comment on the potential effects of such changes and to update and audit the assessment of the stocks.

0.1 Working procedures

As a new procedure, the WGNSSK reviewed the advice sheets produced by WGNEW for a number of North Sea flatfish stocks, which did not prove to be an easy process as the knowledge transfer between groups is difficult to achieve.

The progresses initiated in late 2011 on the quality of the data collection process were pursued in 2013. Notably, a number of improvements were brought to the InterCatch data raising process, 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 data call, and the deadline for early data delivery were largely hold.

In 2013, North Sea whiting and a couple of Nephrops stocks were benchmarked, and the agreed setup were used by WGNSSK.

0.2 State of the Stocks

The overall perception of the demersal stocks in the North Sea is that fishing mortality has been declining significantly for most stocks, leading to progressive improvements of abundance for a number of stocks, and even an outburst of North Sea plaice. However, recruitment remains poor for most stocks, and there are also still some stocks that have low or decreasing abundance. The summary of stock status is as follows :

- Nephrops: abundance is globally decreasing in the North Sea and Skagerrak and is now at or below the MSYBtrigger for a number of FU stocks, although harvest levels are considered sustainable in many 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 very 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 well below the long-term average F (0.6)
- Cod in Subarea IV and Divisions IIIa and VIId: There has been a gradual improvement in the status of the stock over the last few years. SSB has increased from the historical low in 2006, and is now in the vicinity of Blim. Fishing mortality declined from 2000 and is now estimated to be around 0.4, between Fpa and the FMSY proxy. Recruitment since 2000 has been poor.

- Haddock in area IV and IIIa: Fishing mortality has been below Fpa and around the FMSY proxy and SSB has been above 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 about average, recent recruitment has been poor.
- Whiting in IV and VIId: SSB has been below average since 2002, while fishing mortality has been declining over the whole time series. Recruitment has been well below average since 2003.
- Saithe in IIIa, IV and VI: SSB increased above Bpa in 1997, but has declined since 2005. The latest SSB estimate is close to Bpa. Fishing mortality has fluctuated around FMSY since 1997. Recruitment has been below average since 2006 and shows a declining trend in recent 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 2013. Recruitment has been around the long-term average from 2007 onwards. In recent years, fishing mortality has been estimated below FMSY.
- Sole in IV : SSB has fluctuated around the precautionary reference points for the last decade and is estimated to be well above Bpa in 2013. Fishing mortality has shown a declining trend since 1995 and is estimated to be close to Fmsy in 2012.
- Plaice in VIId : Fishing mortality has declined since the mid-1990s and is presently among the lowest in the time-series. Spawning-stock biomass declined from the 1990s to a record low (2003–2008) and has subsequently increased.
- Sole in VIId : The spawning-stock biomass has fluctuated 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
- Striped red mullet in Subarea IV and Divisions VIId and IIIa.: The stock is mainly fished in the eastern English Channel (Division VIId) and southern North Sea. Biomass estimates from Division VIId show high variability and indicate a considerable decrease in the last three years. Abundance in the North Sea has also been low in recent years. The landings follow a similar pattern over this period and have reduced since 2009.

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 Clara Ulrich, Denmark, will meet at ICES Headquarters, 24–30 April 2013 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 2014 on plaice in Skagerrak and haddock in the North Sea

c) Compare FMSY and biomass reference points from single species and multispecies stock assessments and comment on differences observed.

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 11 May and 21 September 2012 (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
gug-347d	Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)				Biennial 2nd year
had-34	Haddock in Subarea IV (North Sea) and Division IIIa	UK(Scotland)	UK(Scotland)	UK(England)	Update
mut-347d	Striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)				Biennial 2nd year
nep-5	*Nephrops* in Division IVbc (Botney Gut - Silver Pit, FU 5)	UK(England)	UK(England)	Denmark	re-examine
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	re-examine
nep-32	*Nephrops* in Division IVa (Norwegian Deeps, FU 32)	Norway	Norway	Denmark	re-examine

nep-33	*Nephrops* in Division IVb (Off Horn Reef, FU 33)	Denmark	Denmark	Sweden	re-examine
nep-34	*Nephrops* in Division IVb (Devil's Hole, FU 34)	Denmark	Denmark	Sweden	re-examine
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	re-examine
ple-skag	Plaice in Subdivision 20 (Skagerrak)	Denmark	Denmark	Sweden	re-examine
ple-nsea	Plaice Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Update
pol-nsea	Pollack in Subarea IV and Division IIIa				Biennial 2nd year
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	Biennial 2nd year
bll-nsea	Brill in Subarea IV and Divisions IIIa and VIId,e	Kelle (NL)			Update – WGNEW*
dab-nsea	Dab in Subarea IV and Division IIIa	Kay (DE)			Update – WGNEW*
fle-nsea	Flounder in Division IIIa and Subarea IV				Update – WGNEW*
lem-nsea	Lemon sole in Subarea IV and Divisions IIIa and VIId	United Kingdom			Update – WGNEW*
wit-nsea	Witch in Subarea IV, Division IIIa and VIId	Sweden			Update – WGNEW*
Tur-nsea	Turbot in Subarea IV	The Netherlands	The Netherlands		Update
Tur-kask	Turbot in Division IIIa				Update WGNEW*

* Finalise advice based on draft prepared by 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, WGHMM, WGEF and WGHANSA.

The working group should focus on:

For all stocks:

a) If no stock annex is available this should be prepared prior to the meeting, based on the previous year advice basis or on the data limited advice basis proposed as the basis for advice this year.

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

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

d) 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.

e) Consider target categories for stocks in the medium term as proposed and revise as needed

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

g) 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;

h) Prepare planning for benchmarks next year, and put forward proposals for benchmarks of integrated ecosystem, multi or single species for 2015

i) Draft the required elements of the Popular Advice for each stock.

j) 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 14 October and will report on reopened advice before 29 October.

For <u>update</u> advice stocks:

k) 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.

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

   i) 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.

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

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

iv) 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.

m) On basis of the outcomes of WKMSYREF calculate Fmsy for stocks where the information exists but the calculations have not been done yet, resolve inconsistencies between Fmsy and MSY $B_{trigger}$/Blim and if possible, fill in the Precautionary Approach reference points where they are missing

For <u>re-examine</u> advice stocks

n) Consider the advice for 2013 and review data and/or method to ascertain if there is reason to update advice for 2014.
   i) Where an update is required, revert to an update procedure

   ii) Where no advice update is required, produce a brief report of the work carried out regarding the stock, indicating why the advice is not updated. A one page, 'same advice as last year' should be drafted.

For stocks with <u>multiyear</u> advice or <u>biennial</u> 2nd year advice

o) 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 <u>update</u> procedure.

The ToRs specific to the individual stocks are dealt with within the relevant stock sections. Compared to previous years report, this report a new sections dealing with the review of the North Sea stocks assessed by WGNEW (section 18)

Below is an overview of the more generic aspects.

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.

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 2013, the procedure for data submission was largely the same as in 2012, with almost an identical data call (only the Crangon species was added to the species list upon request from WGCRAN). An official data call was issued by ICES, with a deadline for data delivery by 22th March. No major issues occurred at that stage, and only few data were delayed compared to this data.

However, not all North Sea demersal stocks assessed have been covered by the data call, as this was initially focused on the only stocks included in mixed-fisheries projections. It has been decided that all North Sea demersal stocks (including some belonging to other WGs than WGNSSK) should be covered by the data call in 2014.

1.2.2 Data raising and allocation to unsampled strata

The major changes in 2013 dealt 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

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. 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, 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, the raising priorities we implemented last year.

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. 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.

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 :

InterCatch template section for stock assessment Expert Groups' reports

Acceptance test of InterCatch

All stock coordinators should make sure that catch data are imported into InterCatch and use InterCatch, following the Generic Terms of Reference. InterCatch is the standardised documentation system for stock assessment expert groups and a part of the ICES Quality Assurance Program. Therefore it is suggested that stock coordinators request national data submitters to import catch data into InterCatch over the internet in the InterCatch format to ease the stock coordinators work. If stock coordinators have not used, tested and compared the output from InterCatch with the so far used system, it is suggested that it is done in 2011. Stock coordinators should verify that InterCatch fulfils the needs of their stocks and gives the expected output. Hereby the stock coordinator can also approve InterCatch as the system, which can be use in the future.

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 have 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.
Whg-47d	Only tool	Used	comparison done in 2012 was small and acceptable	
Cod-3a47d	Only tool	used	comparison done in 2012 was small and acceptable	
had-3a4	Only tool	Used	comparison done in 2012 was small and acceptable	
NOP34	Partly used	Norwegian data is missing		
Sai-3a46	Only tool	Used		
Ple-7d	Only tool	Used		
Sol-7d	Only tool	Used		
Ple-3a	Only tool	Used		
whg-3a	Only tool	Used		
Ple-nsea	In parallel with another tool	Some discrepancies in some discards data provided in InterCatch. InterCatch used for landings	significant and not acceptable (for discards)	
Sol-nsea	Only tool	Used	Comparison not made	
NEP 5	Only tool	Used		
NEP 6	Only tool	Used		
NEP 7	Only tool	Used		

NEP 8	Only tool	Used
NEP 9	Only tool	Used
NEP 10	Only tool	Used
NEP iiia	In parallel with another tool	Used
NEP 32	Only tool	Used
NEP 33	Only tool	Used
NEP 34	Only tool	Used
Pollack		No age data collected
Grey gurnard		No age data collected
Stripped red mullet		No age data collected

1.3 Internal auditing

This year, 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 review is another heavy task pending on group members, and it was not possible to accomplish it during the 7-days meeting itself. WGNSSK operates with seldom more than one scientist per stock (sometimes one scientist for more than one stock), and there was simply not enough time to have assessments finalized in time in order to carry their subsequent review 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 requires that at least one additional day is given to the WG meeting, to avoid delaying too long the completion of the full process and final report.

1.4 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 2013 in order to integrate mixed-fisheries advice for the North Sea into single stock advice.

It is therefore referred to ICES WGMIXFISH 2013 report for any further description of mixed-fisheries context.

1.5 Generic ToR on indicators (ToR d)

Regarding Generic ToR d) for assessment working groups

ToR d): ”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 candi-

date 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.

Therefore, WGNSSK considers that this overall approach is important to explore further for data limited stocks but not so much for the accepted analytical assessments

1.6 Multispecies advice and multi species reference points

WGNSSK has discussed the progresses achieved under various initiatives such as ICES WGSAM (2011, 2012), ICES WKMTRADE (2012) and EU project MYFISH. WGNSSK supports also the development of the first multi-species advice sheet for the North Sea in 2013.

1.6.1 Summary of discussions

WGNSSK discussed the issue of differences between single species and multi species reference points Main conclusions were:

1) It is too early for final answers to this TOR. First simulations were carried out during ICES WGSAM in 2012 and in the EU FP7 project MYFISH but there are doubts on some of the results. More work will be carried out inside MYFISH during 2013 and 2014. It should be waited until final results are available. Preliminary results are presented in the following section to get an idea on important trade-offs between species in the North Sea food web and to get a general idea on possible multi species reference points and how they compare to single species ones.

2) A multispecies benchmark as in the Baltic may be needed where the North Sea SMS model and keyrun settings are reviewed by external experts. A

North Sea regional benchmark is envisaged for 2015 providing the opportunity for such a benchmark exercise.

3) 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).

1.6.2 Preliminary results from ICES WGSAM and MYFISH

During ICES WGSAM and in the EU project MYFISH simulations were carried out with the stochastic multi species assessment model SMS to deal mainly with following questions (for details see ICES WGSAM 2012):

1. Where are important trade-offs between species?
2. Will fishing top predatory species (cod and saithe) at current single species estimate of FMSY allow prey stocks above precautionary biomass reference points?
3. For which fishing mortalities is close-to-maximum average yield obtained for each of the modelled species when species interactions are included in a model?
4. How different are these F values compared with single species F_{msy} estimates?

The main results are summarized below:

Question1 - Where are important trade-offs between species:

Yield of virtually all species are strongly affected by the target F on cod and saithe and the effect of changes in predation on yield is as large or larger than the effect of target F for all species (Figure 1.5.1; diagonal = direct effect on the stock itself, off-diagonal = indirect effects via predation interactions). Thereby indirect predation effects seem to be important complicating the situation additionally. An increase in F on cod will give a smaller cod stock and less predation on its prey species. For whiting and haddock higher cod F leads to an increase in SSB (decrease in direct predation effect), while SSB of herring, sandeel, Norway pout and sprat will decrease (top row of Figure 1.5.1). This decrease in SSB for the typically prey species is due to that the gain in whiting and haddock SSB induces more predation on the prey species than the predation from a larger cod stock (second order effect). The effects of an increase in saithe F are similar to the effects of an increased cod F. All species have at least two strong off-diagonal interactions, and whiting and sandeel yield are strongly

affected by F on three other species (saithe, cod and sandeel or saithe, cod and haddock, respectively). Norway pout and sprat are the only two species where F does not significantly affect yield of other species. Whiting and haddock fishing mortalities are the second least important for other species with only two interactions each. There are also both direct and indirect predation effects of fishing on prey species. An increase in F on sandeel leads to a smaller sandeel biomass which induces a higher cannibalism for cod and whiting via the functional feeding response leading to a decrease in SSB for those species. This lower biomass predates less on haddock which therefore increases with increasing F on sandeel, although sandeel is the main (fish) prey for haddock. The effects of an increase in F on sandeel for the other prey species herring, Norway pout and sprat seems limited. Herring and Norway pout show a slight increase in SSB, probably because the decrease in cod and whiting biomass more than compensate the higher predation due to the reduction of sandeel.

Question 2 - Will fishing top predatory species (cod and saithe) at current single species estimate of FMSY allow prey stocks above precautionary biomass reference points:

Combinations of target F's where cod and saithe are fished at even moderately low F's result in cascading effects through the model as cod and saithe biomass increases resulting in increased natural mortality of haddock and whiting and subsequent lower biomass and yield of these species (Figures 1.5.1 and 1.5.2). Their prey (herring, sandeel, Norway pout and sprat) are then released of predation and increase substantially. Increasing the fishing pressure on cod and saithe leads to the reverse situation as cod and saithe biomass is decreased, haddock and whiting biomass increases and yield of herring, sandeel, Norway pout and sprat decrease. Because of these large effects of predation on haddock and whiting, it might be not possible to maintain their stocks above B_{lim} when reducing fishing pressure on cod and saithe to their single species F_{MSY}.

Single species F_{MSY} is currently 0.2 for cod and 0.3 for saithe (see table 1.5.1). The question whether these Fmsy values lead to unprecautionary biomasses for their prey species could not be answered fully as both F_{MSY} are defined unconditional of SSB while the SMS scenarios used in the WGSAM and MYFISH analysis just applied Fmsy for biomass above B_{pa}. Below B_{pa} a linear decrease of fishing mortality towards zero at Blim was assumed. In addition, only a subset of possible F combinations could be tested so far. The lower range of F in the SMS simulations is 0.4 for the two predator species. Under these constraints a low F-value (F<=0.25) maintain haddock SSB above Bpa (140 kt), but median whiting SSB is below 80 kt, and thereby considerably below 250kt that could be used as proxy for Bpa (see table 1.5.1; no official value defined) for combinations of F in the range 0.3-0.6. Due to time constraints, lower values of whiting F was not evaluated, however, it seems unlikely that such values will provide a SSB three times higher than for whiting F=0.3.

In conclusion, fishing cod and saithe at F=0.4 and therefore at higher F than the single species F_{MSY} resulted in scenario SSB above B_{pa} for all species, except for whiting where SSB is considerably below a possible B_{pa} proxy. However, whiting has previously had a rather large stock size concurrently with high stock sizes of cod and saithe. The main difference between the scenario situation and the state of the stocks in the 1980'ies is the assumption that the present high stock size of grey gurnard is maintained in the scenarios. Grey gurnard was responsible for more than half of the high M2 on 0-group whiting in the most present years whereas the M2 in the period before 1985 was quite low.

Question 3 - For which fishing mortalities is close-to-maximum average yield obtained for each of the modelled species when species interactions are included in a model:

The results from the previous section indicate that stock size of the predators, cod and saithe, should be lower than the species-specific Bmsy to obtain an overall system MSY. Given a fixed F at 0.5 for cod and 0.45 for saithe, a rule based approach was tried to identify fishing mortalities close to maximum sustainable yield. The rule is simply a stepwise exclusion of the scenario F combination that provides the lowest yield relative to the estimated maximum yield for the particular species. The stepwise elimination of F combinations is outlined below:

a) Exclude the F combination that provides the lowest species yield relative to the maximum yield calculated in any scenario.

b) Recalculate median yield and identify the present maximum yield for all remaining F combinations.

c) Repeat a), until all species have just one F combination (one F value) left.

Using this method the F_{MSY} values are estimated to

- • Cod 0.50 (realized average F = 0.45)
- • Whiting 0.60 (realized average F = 0.12)
- • Haddock 0.40 (realized average F = 0.15)
- • Saithe 0.45 (realized average F = 0.40)
- • Herring 0.55 (realized average F = 0.40)
- • Sandeel 0.55 (realized average F = 0.48)
- • Norway pout 0.60 (realized average F = 0.22)
- • Sprat 0.55 (realized average F = 0.43)

However, the F combination leading to maximum yield for each of the species in the model must not be precautionary. Estimates of Fmsy, MSY and B_{MSY} leading to yield close to maximum average yield per species are presented in table 1.5.2. The B_{msy} values represent the mean value for the time period 2016–2070, which means that SSB in individual years might be below Bpa or Blim although the average is above these reference points. More work is needed to provide improved performance statistics. Average SSB for cod, saithe, herring, sandeel and sprat are above Bpa, while SSB for haddock and Norway pout are between B_{lim} and B_{pa}. Whiting SSB is below Blim (200k as proxy for Blim chosen; see table 1.5.1). If whiting target F is fixed at 0.3 (lowest value tested, other combinations need to be included in future analyses), and the same exclusion rules are applied, the resulting Fmsy candidates are similar to the first set of FMSY (see above), except for haddock, where Fmsy is now estimated to be 0.05 lower (0.35, table 1.5.3). SSB for whiting is increased to 150000 t which is still below a potential Blim proxy.

It has to be mentioned that in the scenarios tested F_{MSY} values were conditional of a SSB above B_{pa}. For SSB lower than B_{lim} F is 0 and there is a linear reduction of F for SSB between B_{lim} and B_{pa}. Therefore, a HCR was tested instead of a simple equilibrium prediction with fixed F and F_{MSY} is therefore not realized for all stocks. The realized average F values are considerably lower than target F for whiting, haddock and Norway pout. The discrepancy between target F and realized F is showing that SSB was considerably lower than B_{pa} for some species in most scenario years. The discrepancy between target and realized F may also indicate that the currently used SSB trigger values, or the type of HCR, are not appropriate. Further work is needed to come up with precautionary reference points and HCRs in a multi species framework. Preliminary results show that it may be difficult to keep all stocks above B_{pa} (so far used as $B_{trigger}$ in the MSY approach). For whiting it seems to be already problematic to keep the stock above possible B_{lim} proxies.

Question 4 - How different are these F values compared with single species F_{msy} estimates:

The F_{msy} values resulting in yield close to maximum average yield for each species in a multi species context (see table 1.5.2 and 1.53) are higher than single species ones (see table 1.5.1). The model simulations show that the predators cod and saithe should be fished at higher F to lower the predation pressure on their prey and in case of cod also to lower cannibalism. According to SMS results even herring, a typical prey species, should be fished at considerably higher F values than single species models suggest (0.55 multi species vs. 0.24-0.3 single species). However, the realized

F is only 0.4 showing that fishing mortality had to be reduced quite often during the forecast period because the stock falls below B_{pa}. This highlights that it depends on the constraints and acceptable risk level what F_{msy} is appropriate.

To optimize for close-to-maximum average yield for each of the modeled species is only one of many possible objectives. WKM-TRADE (2012) suggested the following scenarios to be investigated:

1) Precautionary scenarios
2) Maximize the proportion of single species MSY on average across species within precautionary scenarios
3) "Extreme" scenarios which maximize each species in turn within precautionary scenarios
4) North Sea: Consider the impact of the recovery of cod within precautionary scenarios
5) In addition to these, WGSAM decided to consider
6) Combinations providing 'close-to-MSY' for all species
7) Maximize the sum of weight of landings
8) Maximize the sum of value of landings

Preliminary results for some of these scenarios are available in the ICES WGSAM (2012) report. Results confirm that the exact combination of species target F depends on the exact definition of the objectives, constraints and the weighting factors (e.g. price per kg) actually used for calculating these objectives.

1.7 Special requests

Seven EU-Norway requests dealing with North Sea demersal stocks have been issued in spring 2013. Progresses on these requests have been reviewed and discussed 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.

1.8 References

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.

Table 1.5.1 Reference points for the North Sea fish stocks as applied in the SMS analysis. Reference points in brackets are 'guesstimates', as the (single species) reference point does not exists or seems inappropriate in a multispecies context.

Stock	Blim	Bpa	MSY Btrigger (BESCAPEMENT)	mean F ages	Fpa	FMSY
Cod	70 kt	150 kt	150 kt	2-4	0.65	0.19
Whiting	(200 kt)	(250 kt)	(250 kt)	2-6	(0.5)	
Haddock	100 kt	140 kt	140 kt	2-4	0.70	0.25–0.48
Saithe	106 kt	200 kt	200 kt	3-6	0.40 (0.45)	0.30
Herring*	800 kt	1000 kt	1300 kt	2-6	(0.35)	0.24-0.30
Sandeel	430 kt	600 kt	600 kt	1-2	(0.5)	
Norway pout	90 kt	150 kt	150 kt	1-2	(0.4)	
Sprat	(110 kt Bloss)	(150 kt)	(150 kt)		(0.5)	
Sole	25 kt	35 kt	35 kt	2-6	0.40	0.22
Plaice	160 kt	230 kt	230 kt	2-6	0.60	0.25

*revised Oct 2012.

Table 1.5.2: Estimates of yield (landings) and SSB for Fmsy candidates, with fixed target F=0.5 for cod and fixed target F=0.45 for saithe.

	FMSY	Lower trigger biomass ('1000 tonnes)	Higher trigger biomass ('1000 tonnes)	MSY ('1000 tonnes)	BMSY ('1000 tonnes)
Cod	0.50	150	70	91	168
Whiting	0.60	200	250	12	148
Haddock	0.40	100	140	22	120
Saithe	0.45	106	200	132	207
Herring	0.55	800	1000	561	1302
Sandeel	0.55	787	1098	622	867
Norway pout	0.60	263	440	84	132
Sprat	0.55	157	213	151	220

Table 1.5.3: Estimates of yield and SSB for Fmsy with fixed target F=0.5 for cod, fixed target F=0.45 for saithe and fixed target F for whiting at 0.30.

	FMSY (F for biomass above trigger point)	Lower trigger biomass ('1000 tonnes)	Higher trigger biomass ('1000 tonnes)	Mean realized F	MSY ('1000 tonnes)	BMSY ('1000 tonnes)
Cod	0.50	150	70	0.45	91	168
Whiting	0.30	200	250	0.07	8	150
Haddock	0.35	100	140	0.14	22	128
Saithe	0.45	106	200	0.40	132	207
Herring	0.55	800	1000	0.40	561	1303
Sandeel*	0.55	787	1098	0.48	616	859
Norway pout*	0.60	263	440	0.22	82	130
Sprat*	0.55	157	213	0.43	151	221

*Trigger biomass refers to total-stock biomass.

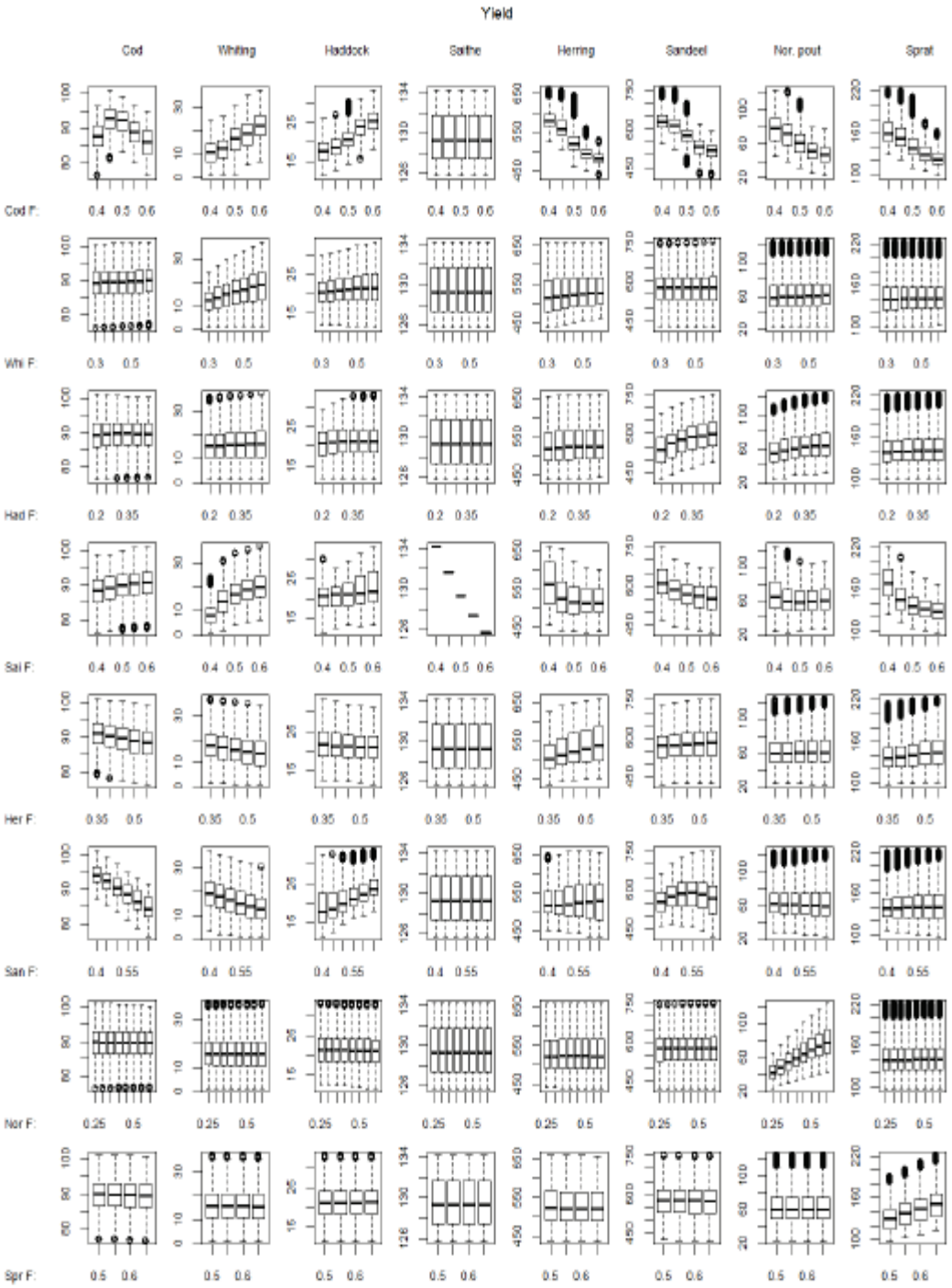


Figure 1.5.1. Yield of (from left to right) cod, whiting, haddock, saithe, herring, sandeel, Norway pout and sprat as a function of (top to bottom) target F on cod, whiting, haddock, saithe, herring, sandeel, Norway pout and sprat. Note that the F-values on the X-axis is the target F for SSB above the specified MSY B trigger biomass. For SSB below the trigger value, the F realized might be considerably lower.

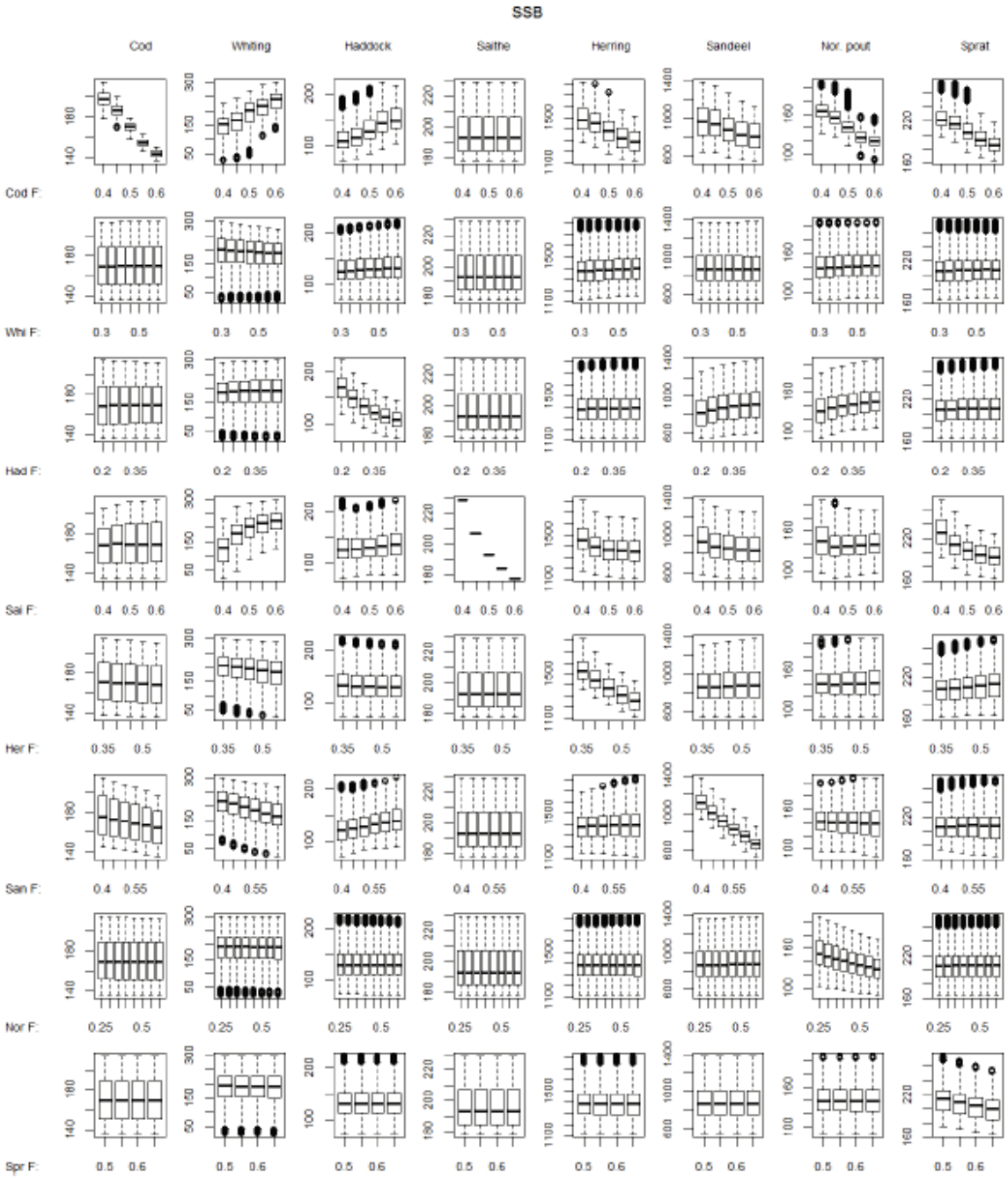


Figure 1.5.2. SSB of (from left to right) cod, whiting, haddock, saithe, herring, sandeel, Norway pout and sprat as a function of (top to bottom) target F on cod, whiting, haddock, saithe, herring, sandeel, Norway pout and sprat.

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, or *Nephrops* with a bycatch of roundfish and flatfish. A fishery directed at saithe exists along the shelf edge. Landings used by the WG for each North Sea stock are summarised in Table 2.1.1.

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 and Norway pout including IIIa, for whiting including VIId, and for saithe including IIIa and VI. 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 (see also section 01). The single-stock assessments and advice presented in this report are however not (yet) produced by the multispecies assessment model, but average values of natural mortalities estimated by this multispecies assessments for cod, haddock, and whiting are incorporated in the assessments of these species.

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 2013), 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 main trends are summarised below:

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 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, see WGMIXFISH 2013 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 (2013) produces a number of synthetic figures describing main trends, between 2003 and 2012, of effort and catches and landings by fleet and stock.

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. These management frames can be summarised as such.

2.2.1 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.

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.

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 (−40% between 2003 and 2012, -16% between 2008 and 2012). 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 (−14%, −45%, and −48%, respectively, between 2004 and 2012). Gill and trammel nets fisheries have remained stable (ICES, 2013b). Effort in large mesh size beam trawl (>=120 mm, BT1) has increased significantly in 2012 after a decade of continuous decline. Nominal effort reported by Norway has been increased since 2011 due to the generalization of electronic logbooks. (ICES WGMIXFISH 2013)

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)

2.2.2 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 dif-

ferent 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.

2.2.3 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, and summarised here..

2.2.3.1 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.

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

2.2.3.2 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.

2.2.3.3 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 with-

in 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

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.

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 cod, haddock, whiting and some *Nephrops* FUs in the North Sea, to raise landings to catch (see also section 01). In 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.. 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 discards ban 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.

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 2013 is that many North Sea stocks of roundfish and flatfish species are now recovering after long periods of low SSB and high fishing mortality. 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). Spawning stock biomass is also increasing, and many stocks are now within safe biological limits, and exploited around Fmsy levels. However, an important aspect is that recruitment still remains poor compared to historical average. Reduced recruitment 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 which is unfavourable to recruitment. This indicates that recovery 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.

On the opposite, the overall abundance of Nephrops stocks seem decreasing, both for stocks with estimated high or low harvest rates.

Each year, ICES WGMIXFISH summarises the main points from WGNSSK of status and advice for the main stocks in its report, and this section is copied below also (ICES WGMIXFISH 2013):

2.4.2.2 Cod in IIIa – IV – VIId

Trends

There has been a gradual improvement in the status of the stock over the last few years. SSB has increased from the historical low in 2006, and is now in the vicinity of Blim. Fishing mortality declined from 2000 and is now estimated to be around 0.4, between Fpa and the FMSY proxy. Recruitment since 2000 has been poor.

Advice

ICES advises on the basis of the EU–Norway management plan that landings in 2014 should be no more than 28 809 tonnes. If discards rates do not change from those in 2012, this implies catches of no more than 37 496 tonnes.

The EU–Norway agreement management plan as updated in December 2008 aims to be consistent with the precautionary approach and is intended to provide for sustainable fisheries and high yield leading to a target fishing mortality of 0.4. The EU has adopted a long-term plan for this stock with the same aims (Council Regulation (EC) 1342/2008; Annex 6.4.3). In addition to the EU–Norway agreement, the EU plan also includes effort restrictions, reducing kW-days available to community vessels in the main metiers 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}.

In 2013, there has been no reduction in effort ceilings compared to the preceding year.

2.4.2.3 Haddock in IIIa – IV

Trends

Fishing mortality has been below Fpa and around FMSY and SSB has been above 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 about average, recent recruitment has been poor.

Advice

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.

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 (Blim). 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 (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.

2.4.2.4 Plaice in IV

Trends

The stock is well within precautionary limits, has increased in the past ten years, and has reached a record-high level in 2013. Recruitment has been around the long-term average from 2007 onwards. In recent years, fishing mortality has been estimated below FMSY.

Advice

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.

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).

2.4.2.5 Sole in IV

Trends

SSB has fluctuated around the precautionary reference points for the last decade and is estimated to be well above Bpa in 2013. Fishing mortality has shown a declining trend since 1995 and is estimated to be close to Fmsy in 2012.

Advice

ICES advises on the basis of stage one 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.

Both the North Sea plaice and sole stocks have 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).

2.4.2.6 Saithe in IIIa – IV – VI

Trends

SSB increased above Bpa in 1997, but has declined since 2005. The latest SSB estimate is close to Bpa. Fishing mortality has fluctuated around FMSY since 1997. Recruitment has been below average since 2006 and shows a declining trend in recent years.

Advice

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.

2.4.2.7 Whiting in IV – VIId

Trends

SSB has been below average since 2002, while fishing mortality has been declining over the whole time series. Recruitment has been well below average since 2003.

Advice

ICES advises on the basis of precautionary considerations that total catches should be no more than 36 992 tonnes. If rates of discards and industrial bycatch do not change from the average of the last 3 years (2010-2012), this implies human consumption landings of no more than 24 389 tonnes (18 514 tonnes in the North Sea and 5875 tonnes in Division VIId). Management for Division VIId should be separated from the rest of Subarea VII.

2.4.2.8 Plaice in VIId

Trends

Fishing mortality has declined since the mid-1990s and is presently among the lowest in the time-series. Spawning-stock biomass declined from the 1990s to a record low (2003–2008) and has subsequently increased.

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.

There is currently no management plan for this stock.

2.4.2.9 Sole in VIId

Trends

The spawning-stock biomass has fluctuated without trend and is above MSY $B_{trigger}$ since 2002. Fishing mortality has always been above FMSY, and has been above F_{pa} since 2005. Recruitment has been fluctuating without trend.

Advice

ICES advises on the basis of the transition to the MSY approach that catches in 2014 should be no more than 3251 tonnes. All catches are assumed to be landed.

There is currently no management plan for this stock

2.4.2.10 *Nephrops* in Botney Gut (FU 5)

Trends

The state of this stock is unknown. Landings per unit effort (lpue) fluctuate without trend.

A new scheme has been developed for *Nephrops* stocks without accepted analytical assessments. This uses the known area of *Nephrops* habitat and the range of densities observed on this (or neighboring) grounds to indicate if historical landings are likely to represent sustainable harvest rates or not.

Advice

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 1000 tonnes.

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

There is currently no management plan for this Functional Unit. In the absence of a full analytical assessment, ICES bases advice for *Nephrops* on habitat extent and population characteristics.

2.4.2.11 *Nephrops* in Farn Deeps (FU 6)

Trends

The UWTV survey indicates that the stock status has declined since 2005 and has been fluctuating near MSY $B_{trigger}$ since 2007. Changes in survey methodology in 2007 make exact comparisons with the preceding series difficult, but the general trend is considered reliable.

Advice

ICES advises on the basis of the MSY transition that landings in 2014 should be no more than 1173 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 1329 tonnes. Note that this figure includes discards expected to survive the discarding process – assumed to be 15% 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.

There is currently no management plan for this Functional Unit.

2.4.2.12 *Nephrops* Fladen Ground (FU 7)

Trends

The stock has declined from the highest observed value in 2008 and is now just below the MSY $B_{trigger}$. The harvest rate has fluctuated in recent years, and fell to approximately 4% in 2012 which is below F_{MSY}.

Advice

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.

There is currently no management plan for this Functional Unit.

2.4.2.13 *Nephrops* in Firth of Forth (FU 8)

Trends

The stock remains above MSY $B_{trigger}$ but has declined since 2008. The harvest rate remains above F_{MSY}.

Advice

ICES advises on the basis of the transition to the MSY approach that landings in 2013 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.

There is currently no management plan for this Functional Unit.

2.4.2.14 *Nephrops* in Moray Firth (FU 9)

Trends

The stock is declining but remains just above MSY $B_{trigger.}$ The harvest rate was above F_{MSY} in 2011 and decreased in 2012, although it is still above Fmsy.

Advice

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.

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

There is currently no management plan for this Functional Unit

2.4.2.15 *Nephrops* in Noup (FU 10)

Trends

The state of the stock is not fully known. Based on guideline evaluation the stock appears to be exploited close to 10% harvest rate on the basis of preliminary TV density estimates of 0.2m2.

Advice

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.

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

Additional management considerations

There is currently no management plan for this Functional Unit. The In the absence of a full analytical assessment, ICES bases advice for *Nephrops* on habitat extent and population characteristics.

2.4.2.16 *Nephrops* in Norwegian Deep (FU 32)

Trends

The state of the stock is unknown but lpue is fluctuating without trend indicating a stable stock status and suggest that current and past levels of exploitation are sustainable. A slight increase in mean size in the catches in 2007 and 2010 could indicate a reduced exploitation pressure.

Advice

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 800 tonnes.

For the stock in this functional unit (FU), management is implemented at the functional unit level.

There is currently no management plan for this Functional Unit. In the absence of a full analytical assessment, ICES bases advice for *Nephrops* on habitat extent and population characteristics. The density in FU 32 is most likely found in the range 0.05-0.1 animals m^{-1}, where 0.1 animals m^{-1} is the minimum density observed in the neighbouring Fladen Ground.

2.4.2.17 *Nephrops* off Horn's Reef (FU 33)

Trends

The state of this stock is unknown. Lpue has been increasing up to 2008, probably reflecting increase in gear efficiency (technological creep) in the last years. The mean sizes in 2005 catches and the increased lpue's in the subsequent years could indicate a high recruitment in 2005. The development in 2009 then suggests that the contribution of the 2005 recruitment to the stock now has faded.

Following WKLIFE guidelines a new scheme has been developed for *Nephrops* stocks without accepted analytical assessments. This uses the known area of *Nephrops* habitat and the range of densities observed on this (or other) grounds to indicate if historical landings are likely represent sustainable harvest rates or not. Historical maximum landings appear to be sustainable and robust to uncertainty in the estimated stock

Advice

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 1100 tonnes

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

There is currently no management plan for this Functional Unit. In the absence of a full analytical assessment, ICES bases advice for *Nephrops* on habitat extent and population characteristics. *Nephrops* density on this ground is unknown, but the neighbouring Fladen ground has typical densities 0.1-0.3 per m^2 so these values are useful proxies.

2.4.2.18 *Nephrops* in Devil's Hole (FU 34)

Trends

The state of the stock is not fully known. Based on guideline evaluation the stock appears to be to be exploited close to 10% harvest rate.

Advice

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.

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

There is currently no management plan for this Functional Unit. In the absence of a full analytical assessment, ICES bases advice for *Nephrops* on habitat extent and population characteristics. The discard rate and mean weight was taken from FU7. The 2012 survey shows that density is low to moderate on this ground at 0.3 burrows per metre squared.

2.4.2.19 Stocks in the Skagerrak and Kattegat (Division IIIa)

Nephrops in IIIa is now assessed using the Underwater TV survey methodology. Survey coverage has increased sufficiently to allow this method to be considered appropriate for these stocks.

The assessment of Plaice in IIIa remains problematic but significant changes were achieved in 2012 after the closer investigation of the stock structure and connectivity of plaice populations between the Eastern North Sea and the Baltic Sea

The available data for Whiting in IIIa were examined and a preliminary survey-based assessment explored, but the data are not considered reliable enough for an independent assessment.

In addition, recent trends in European effort and landings can also be found in the STECF-11-13 report "Evaluation of Fishing Effort Regimes Regarding Annexes IIA, IIB and IIC of TAC & Quota Regulations, Celtic Sea and Bay of Biscay" (2011).

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. Following good recruitments in 2008 and 2009 the stock in 2011 was well above $B_{pa.}$ but the 2010 year class is estimated to be the lowest on record, so the prognosis for a fishery in 2011 is poor.

The table below indicates the amount of demersal bycatch in the Danish industrial fisheries In the North Sea and Skagerrak by type of fishery in 2012

EART	Art	norway p.	sandeel	sprat	Grand Total
Argentine	ARG	52			52
Atlantic Cod	TOR		1	0	1
Atlantic Herring	SIL	1920	158	8594	10673
Atlantic Horse mackerel	HMK		5	2	7
Atlantic Mackerel	MAK	1	51	246	298
Blue Whiting	BLH	59			59
Common Dab	ISG			147	147
Common Prawn	ARJ	4			4
Cuttlefish	BSP	0	8	17	26
European Anchovy	ANS			27	27
European Flounder	SKR			0	0
European Hake	KLM	55		0	55
European Pilchard	PIL			6	6
European Plaice	RSP			3	3
Freshwater Bream	BRA		3		3
Great Silver Smelt	GUK	31			31
Greater Weever	FJS			0	0
Grey Gurnard	KNH		43	144	187
Haddock	KUL	11		0	11
Hag	SLI	16			16
Invertebrates	INV	2			2
Long-Rough Dab	HSG	141		45	186
Marine Crabs	KRA			3	3
North Deepwater Prawn	DVR	91			91
Norway Lobster	DVH	6			6
Norway Pout	SPE	22288		0	22288
Sandeel	TBS		51206	93	51299
Sculpin	ULK			0	0
Silvery Pout	SVT	7			7
Sprat	BRS	2	53	67319	67374
Tub Gurnard	KNR			19	19
Whiting	HVL	737	20	355	1112
Witch Flounder	SKI	4			4
Grand Total		25428	51549	77021	153997

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

The WGFTFB provides every year fishery development information specific to the various assessment Expert Groups, based on annual questionnaires to a number of

FTFB members(ICES 2012, WGFTB). The information specific to WGNSSK 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).

3 *Nephrops* in Subareas IIIa and IV

3.1 General comments relating to all *Nephrops* stocks

3.1.1 Introduction

Nephrops stocks have previously been identified by WGNEPH on the basis of 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 from out with the previously defined FUs in Subarea IV. This has led to the introduction of a new FU (FU 34) covering the Devil's Hole and data are collated for this area for the first time in this report. Additional catches of *Nephrops* are also taken from smaller, isolated pockets of mud distributed throughout the ICES divisions (eg 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 1.3.4.

The presentation of data and text relating to the Division IIIa FUs can be found as follows: Skagerrak (FU3) in Section 3.2.2; Kattegat (FU4) in Section 3.2.3; Division IIIa overall in Section 3.2.3. The presentation of data and assessments for the Division IV FUs can be found as follows: Botney Gut – Silver Pit (FU 5) in Section 3.3.1; Farn Deeps (FU 6) in Section 3.3.2; Fladen (FU 7) in Section 3.3.3; Firth of Forth (FU 8) in Section 3.3.4; Moray Firth (FU 9) in Section 3.3.5; Noup (FU 10) in Section 3.3.6; Norwegian Deeps (FU 32) in Section 3.3.7; Off Horn Reef (FU 33) in Section 3.3.8; Devil's Hole in Section 3.3.9; Other areas of Subarea IV in Section 3.3.10.

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

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 FSPR reference points have been identified as proxies for SSBMSY and FMSY respectively. These reference points […] could be used to

inform risk assessment approaches applied to category 6 and 7 stocks. These reference points 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."

The working group chose a different approach this year 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 General comments relating to all *Nephrops* stocks

3.2.1 Introduction

Nephrops stocks have previously been identified by WGNEPH on the basis of 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 from outwith the previously defined FUs in Subarea IV. This has led to the introduction of a new FU (FU 34) covering the Devil's Hole and data are collated for this area for the first time in this report. 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 1.3.4.

The presentation of data and text relating to the Division IIIa FUs can be found as follows: Skagerrak (FU3) in Section 3.2.2; Kattegat (FU4) in Section 3.2.3; Division IIIa overall in Section 3.2.3. The presentation of data and assessments for the Division IV FUs can be found as follows: Botney Gut – Silver Pit (FU 5) in Section 3.3.1; Farn Deeps (FU 6) in Section 3.3.2; Fladen (FU 7) in Section 3.3.3; Firth of Forth (FU 8) in Section 3.3.4; Moray Firth (FU 9) in Section 3.3.5; Noup (FU 10) in Section 3.3.6; Nor-

wegian Deeps (FU 32) in Section 3.3.7; Off Horn Reef (FU 33) in Section 3.3.8; Devil's Hole in Section 3.3.9; Other areas of Subarea IV in Section 3.3.10.

Overall landings for Divisions IIIa and IV reported to the WG are summarised by Functional Unit in Table 3.1.2 and Figure 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. Neprhops 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 2012. ICES concluded that:

'The *Nephrops* stock in Div. IIIa was assessed with UWTV survey for the second year and the time series of UWTV estimates is still insufficient to draw conclusions regarding stock trajectory.

The 2011 Harvest Ratio was estimated to be relatively low (5.0% from TV 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.'

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area IIIa was decreased from 6000 tonnes in 2012 to 5200 t in 2013. 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 70% of the catch (in number) in IIIa consists of undersized individuals (Figure 3.2.1.1). It is expected that ongoing experimental work on improved selectivity of the gear eventually will reduce the amounts of discards. The European Union and Norway have agreed that a discard ban should be implemented in the Skagerrak (Division IIIa N). The discard ban will be applicable to 15 species and apply in the Unions waters from the 1st January 2014. New technical measures have also been agreed upon and have been implemented since the 1st February 2013. ICES have also been requested to investigate the effect of decreasing the minimum landing size for *Nephrops*.

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 in Kattegat 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 140mm square-mesh panel 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 60 % and 36 % by weight of the landings in 2012, 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 2012 accounted for 35% 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 2012, 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%), however, no landings were recorded in 2012.

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 period. Landings declined in 2011 but have increased in 2012 (Figure 3.2.2.4).

Length compositions

For the Skagerrak, size distributions of both the landings and discards are available from both Denmark and Sweden for 1991-2012. 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 1990-2012, and from Denmark for 1992-2012. 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 2012. 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 17 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 is 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 the 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, effort and research vessel data – FU3

Effort data for the Swedish fleet are available from logbooks for 1978-2012 (Figure 3.2.2.1 and Table 3.2.2.2). In recent years the twin trawlers have shifted to targeting both fish and *Nephrops*, which resulted in a decreasing trend in LPUE from 1998 to 2005 for this gear (Table 3.2.2.2). In the most recent years LPUEs have increased for both gear types. 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 grid single trawl (targeting only *Nephrops*).

Danish effort figures 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 1994-97, effort did increase again in the next five years followed by a decrease to a relatively low level in 2007 to 2012. 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 (GLM to standardise LPUE regarding vessel size, Figures 3.2.2.3).

Note, that the trends in the resulting LPUE are very similar. However, this may merely reflect that vessels catching *Nephrops* in this area are very similar with respect to e.g. size and HP.

Catch, effort and research vessel data – FU4

Swedish total effort, converted to single trawl effort, has been relatively stable over the period 1978-90. An increase is noted in 1993 and 1994, followed by a decrease to 1996, and a stabilisation at intermediate levels in recent years (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 (GLM to standardise LPUE regarding vessel size, (Figure 3.2.2.6).

Notice, that the trends in the resulting LPUE (relative indices) are very similar which may reflect that vessels catching *Nephrops* in this area are very similar with respect to e.g. size and HP.

3.3.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

There was no review of this stock in 2011.

3.3.3.1 TV survey in IIIa

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). In 2011, the TV survey was further expanded to cover density information from the main fishing grounds in IIIA (subarea 1-6). Figure 3.2.3.4 presents the distribution of stations with valid density estimates from both the Danish and Swedish survey 2012. Similar survey design have 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 areas estimates for each subarea are defined in table 3.2.3.1. Burrow counting and identification follows the standard protocols defined by SGNEPS.

Abundance indices from UWTV surveys

The number of valid stations conducted in the TV surveys 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 2012 Assessment.

The assessment of the state of the *Nephrops* stock in IIIa is based on UWTV survey from 2012 and patterns in fluctuations of total combined LPUE by Denmark and Sweden during the period 1990-2012 and the patterns in fluctuations of discards in the fisheries as estimated from the catch samples for the same period.

Combined relative effort declined slightly over the period 1990 to 2012 (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 sig-

nificantly 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 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 Division IIIa. Owing to the way *Nephrops* are assessed, it is not possible to estimate FMSY directly and hence proxies for FMSY are determined. WGNSSK (2010) developed a framework for proposing Fmsy 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 FMSY are F0.1, F35%SpR and Fmax. 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 FMSY 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 FMSY proxies (ICES, 2010a). These proxies may be modified following further data exploration and analysis. The combined sex FMSY 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 FMSY 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	> F_{max}	$F_{35\%SPR}$	F_{max}	F_{max}
	F_{max} - $F_{0.1}$	$F_{0.1}$	$F_{35\%SPR}$	F_{max}
	< $F_{0.1}$	$F_{0.1}$	$F_{0.1}$	$F_{35\%SPR}$
	Unknown	$F_{0.1}$	$F_{35\%SPR}$	$F_{35\%SPR}$
Stock size estimates	Variable	$F_{0.1}$	$F_{0.1}$	F35%
	Stable	$F_{0.1}$	$F_{35\%SPR}$	F_{max}
Knowledge of biological parameters	Poor	$F_{0.1}$	$F_{0.1}$	$F_{35\%SPR}$
	Good	$F_{35\%SPR}$	$F_{35\%SPR}$	F_{max}
Fishery history	Stable spatially and temporally	$F_{35\%SPR}$	$F_{35\%SPR}$	F_{max}
	Sporadic	$F_{0.1}$	$F_{0.1}$	$F_{35\%SPR}$
	Developing	$F_{0.1}$	$F_{35\%SPR}$	$F_{35\%SPR}$

The estimated bias corrected burrow density in Division IIIa is medium (0.3-0.8/m2), the observed harvest ratio is higher than F_{max} and historically the fishery is stable both spatially and temporally. This means that F_{max} 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.

As burrow density is <0.3 (0.257) and the harvest rate is higher than F_{max} >7.9 (0.823) the decision making framework (ICES 2010a) suggests to use $F_{35\%SpR}$ as a Proxy for F_{MSY}. For 2014 this corresponds to a TAC of 5423 tons.

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

	Male	Female	Combined
F_{max}	6.8 %	10.0 %	7.9 %
$F_{0.1}$	4.9 %	7.6 %	5.6 %
$F_{35\%SpR}$	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	Harvest rate %	Landings 2014 (tonnes)
	2.0	1 033
	4.0	2 066
	5.0	2 607
$F_{0.1}$	5.6	2 892
F_{max}	7.9	4 080
F2012 (UWTV)	8.0	4 251
$F_{35\%SpR}$	10.5	5 423

A summary of the results from the TV survey 2012 is presented in Table 3.2.3.1. The estimated bias corrected abundance index was 0.257 resulting in a total biomass of 97 thousand tons (2526 million individuals). Total removals (landings + dead discards) were estimated to 8007 tons resulting in a harvest rate of 8.23%.

Conclusions drawn from the indicator analyses

The combined logbook recorded effort has decreased 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 2012 was conducted in all 6 defined subareas in IIIa. Correction factor of 1.1 for estimated bias was used. A total weighted mean density was estimated based on density estimate from each sub-area weighted with area size of 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 vessel size and engine. 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, 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.

3.3.6 Status of the Stock

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

The 2012 Harvest Ratio was estimated to be relatively low (8.0% from TV 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 TV- 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 recent six 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.

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 should be implemented in the Skagerrak (Division IIIa N). The discard ban will be applicable to 15 species and apply in the Unions waters from the 1st January 2014.

3.4 *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 2010 EC TAC for *Nephrops* in ICES Subarea IIa and IV was 24688 tonnes in EC waters (plus 1200 tonnes in Norwegian waters). For 2011, this was been reduced to 23454 tonnes in EC waters and 1200 tonnes in Norwegian waters. In 2012, there has been a further reduction to 21929 tonnes in EC waters, but no change to the allowance for 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 2010 are just under 21,000 tonnes which is around 3,500 tonnes lower than in 2009. All nations have reported lower landings in 2010. In particular, the reported UK landings have declined by over 3,000 tonnes between 2009 and 2010. Minor updates have been made to landings in previous years. Quota uptake by UK vessels (who have a share of around 90 % of the TAC) was just over 80 % in 2010.

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) has been designated. The trends observed in the 2010 Fishers' North Sea stock survey for *Nephrops* are discussed in the Quality of Assessment sections for each FU.

3.4.1 Botney Gut (FU5)

3.4.1.1 The fishery in 2009 and 2010.

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 2010 and 2011, the UK and Netherlands continued to dominate the fishery taking ~80% of the landings from this area. Germany continued to take around 14% in both years whilst Denmark's and Belgium share remained small. The size of the UK fleet prosecuting this fishery has declined sharply from seven vessels in 2009 to three in 2010 and just one in 2011. *Nephrops* in FU5 are caught by trawling. There is no creeling in the area.

3.4.1.2 Data Available

Landings

Landings by country for FU 5, including Belgium, Denmark, Netherlands, Germany and UK are available since 1991 (Table 3.3.1.1). Landings consistently exceeded 1000t between 1997 and 2005 peaking at over 1400t in 2001. Landings dropped substantially in 2009 but have returned to over 1000t in 2011. 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. Danish landings have been at very low levels in recent years. 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 and this will be available for next year's assessment. 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 composition in the Dutch landings are available from 2003 to 2011 (Figure 3.3.1.1. Both mean sizes of males and females show an increasing trend over time (Table 3.3.1.2), 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 number measured are 10318 individuals a year, while in 2010 and 2011 the sampling measurements drop to around 3500 individuals. Sampling intensity in 2011 was particularly low in the third quarter which is the main period of the fishery.

3.4.1.3 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).

3.4.1.4 Commercial catch-effort data and research vessel surveys

Effort and LPUE Figures are available for Belgian *Nephrops* specialist trawlers (1985-2005), the Dutch fleet (all vessels catching *Nephrops* for the period 2000-2011), Danish bottom trawlers with mesh size > 70 mm (1996-2011) and English vessels using *Nephrops* gears 2000-2011, Table 3.3.1.3 and Figure 3.3.1.2.

The effort of the Belgian *Nephrops* fleet has shown an almost continuous decrease since the initial high in the early 1990s. In 2005, effort was at the lowest level in the time series No data are available since 2006.

The effort of the Dutch fleet (all trips recording catches of *Nephrops*) peaked in 2001 and was in general decline since then, however it has stabilised over the last 3 years.

Danish effort has been negligible since 2007.

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.

Effort by English vessels targeting *Nephrops* in FU5 has been very variable and appears to go in phases of high and low activity. Effort in the last two years has been decreasing from the maximum in 2008 and was entirely composed of one vessel's activity in 2011. 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 3.3.1.3) and is considerably higher than observed in FU6. Twin-rigged vessels generally have higher LPUE than single rigged vessels, particularly in 2010. (Figure 3.3.1.3)

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

In autumn 2010 and spring 2012 initial TV *Nephrops* surveys were undertaken at FU5 (Botney Gut Silver Pit grounds). The 2011 autumn survey was unable to take place due to adverse weather so it was conducted in the spring of 2012 instead. Initially 42 stations were selected around a randomized fixed grid delimited by the combination of VMS data and BGS sediment maps (Figure 3.3.1.4). In order to ensure VMS data represented *Nephrops* fishing activity, UK VMS data were screened to only include vessels fishing with *Nephrops* gear at towing speeds of less than 4 knots. At these stations 10 minutes of clear video were recorded and 7 minutes were recounted following the same counting protocol employed on the FU 6 survey which in turn complies with the general protocol defined by SGNEPS. Further details on this survey can be found in the report of SGNEPS (2010). The 2012 survey increased the number of sta-

tions and included grounds in the Dutch sector that had previously not been sampled. Poor underwater visibility means that the survey results are subject to a high degree of uncertainty. Due to the complex shape of the *Nephrops* ground, it is not anticipated that a geostatistical method for determining abundance can be followed. A preliminary analysis of the spatial distribution of the counts shows the centre of abundance to be at the eastern end of the ground (Figure 3.3.1.5), compared to the VMS data which shows more fishing activity at the north western end of the ground. Comparison with FU6 of the statistical distribution of burrow counts (Figure 3.3.1.6) shows that FU5 is characterized by a large proportion of low density *Nephrops* stations with a smaller number of high locations, unlike FU6 which shows a much less skewed distribution of burrow densities.

Intercatch

FU5 data were put onto Intercatch for all nationalities. Quarterly landings by metier were available for all countries and quarterly length compositions were entered for the Netherlands.

3.4.1.6 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 and the mean weight from the Dutch landings sampling programme. The 2012 survey shows that density is relatively high on this ground at 0.7 burrows per metre squared. 10 year average landings of 1000 at this density equates to a harvest rate of around 3.8%, 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. Maximum landings of 1400t carries an appreciably higher risk of exceeding any MSY proxies.

	FU 5: Botney Gut			1,850	Area (km2)	25.6	mean weight (g)		25%	percentage discards
		Assumed Density								
Basis	**landings**	**0.05**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**
0.5 * Average	500	26.4%	13.2%	6.6%	4.4%	3.3%	2.6%	2.2%	1.9%	1.6%
average	1000	52.8%	26.4%	13.2%	8.8%	6.6%	5.3%	4.4%	3.8%	3.3%
maximum	1400	73.9%	37.0%	18.5%	12.3%	9.2%	7.4%	6.2%	5.3%	4.6%
									Latest TV survey * preliminary	

3.4.1.7 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.

3.4.2 Farn Deeps (FU6)

3.4.2.1 Fishery in 2010 & 2011

Since the beginning of the time-series, the UK fleet has accounted for virtually all landings from the Farn Deeps (Table 3.3.2.1). In 2011, total landings were 2,070 tonnes, an increase on the low 2010 value but still below the 10 year average. (Figure 3.3.2.1). 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 2011 decreased from the 2010 level but has 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 moves towards multi-rig fishing gears which generally have a higher fishing power. The proportion of landings by twin riggers rose steadily until 2008 after which the proportion has been fairly stable (Figure 3.3.2.2). Historically the fishery is 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 number of vessels in the fishery has been decreasing since the peak in 2006 and 2007 and was at the same level in 2011 as in the late 1990s .

The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2011 fishery comprised the end of the 2010-2011 fishery and the start of the 2011-2012 fishery. Directed effort by English vessels in 2010 was more skewed that normal with higher levels in the first quarter and relatively little in the fourth, but 2011 effort was more even between these major quarters. (Figure 3.3.2.6).

3.4.2.2 ICES Advice in 2011

The last assessment of *Nephrops* in FU6 was in 2011.

The basis for advice in 2011 was the "Transition to an **MSY approach** with caution at low stock size". This corresponded to landings of less than 1 300 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.

3.4.2.3 Assessment

Review of the 2010 assessment

The values of Btrigger throughout the document are not consistent:

> *Page 49, second paragraph: "WGNSSK suggests the bias adjusted TV abundance as observed in 2007… should become a proxy for Btrigger (Btrigger = 879 million)."*
>
> *Page 47, Final Assessment, 1st paragraph: 802 million*
>
> *Tables 3.3.2.4 and 3.3.2.5: 801 million*
>
> *-802 million is likely a rounding issue but it is unclear where 879 million came from.*

Adding the value of MSY Btrigger to the figure description for Figure 3.3.2.8 would be helpful.

The inconsistencies in the Btrigger value have been resolved.

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 hence the use of a fixed discard ogive on the catch length distributions since 2002. Discard survival is set to zero for this FU in contrast to the 25% used in many other FUs. This is due to the practice of catch sorting and tailing whilst steaming back to port when the vessel passes over ground not suitable for *Nephrops* habitation.

There is a clear change in length frequencies around 2007 with much lower contributions from the smaller (discarded) size classes. 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. This, in combination with the higher proportion of females in the catches indicates another season where large mature females were foraging for food on the surface at a time when they would have been expected to be brooding eggs within their burrows. For males there is a more unimodal form although this has broadened in 2010 and 2011 (Figure 3.3.2.7)

Effort and LPUE

Directed effort fell from a very high level in the mid 1990s and had been fluctuating upwards again since 1999. In 2008 there was a decrease in directed effort following the decline in the stock and has only increased by a small amount since then.

Between 1998 and 2006, overall directed LPUE had fluctuated around 33kg per hour but fell in 2007 and was only 17kg per hour in 2010 (Table 3.3.2.2 & Figure 3.3.2.1). 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 3.3.2.5) 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. *Nephrops* directed

gears all show a similar LPUE in 2011 compared to 2010 whilst unspecified otter trawls appear to have increased their LPUE.

Males generally predominate in 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 and 2010, Figure ????).

Directed effort is generally highest in the 1st and 4th quarter of the year in this fishery (Figure 3.3.2.6) with landings correspondingly highest in these quarters. Effort in 2010 was particularly skewed with a relatively high level of effort in the first quarter and very little in the fourth quarter, a more normal pattern was resumed in 2011. The reduced number of larger vessels in the 2008 fishery may have a disproportional negative impact on CPUE measures in that the larger vessels are likely to have a higher efficiency. Female LPUE in the fourth quarters of 2000, 2006, 2009 and 2011 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. A time series of indices is given in Figure 3.3.2.8 and table 3.3.2.5. 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 3.3.2.9 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.

Whilst analysing the 2011 survey, the processes used for the surveys between 2007 and 2010 were checked and amendments made to the width of visible track. Some of these changes were minor, but the 2010 value was increased from 71.25cm to 81.5cm (+14%). The effect of this is to decrease the total abundance estimate for 2010 from 892 million to 753 million (-18.5%). The 2007 value, used as the reference point increased from 876 million to 881 million.

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. There were a few technical hitches with extracting the data due to the nature of *Nephrops* weights (very low weight at lengths were occasionally rounded down to zero thus causing internal divide by zero errors). ICES staff worked through the weekend to rectify this problem and Intercatch proved to be a useful tool for the aggregation of *Nephrops* data for this FU.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex.

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 factors were estimated for each FU and for FU6 the bias correction factor is 1.2 meaning that the TV estimate is likely to overestimate absolute abundance of *Nephrops* by 20%. Estimates of mean burrow density and the resulting bias-corrected abundance estimates (with confidence estimates) are given in Table 3.3.2.4.

A revision of the burrow counts and assumed width of visible screen resulted in changes to the most recent abundances (i.e. since 2007, where the abundance is determined using geostatistics). The value for 2007 was increased slightly from 879 to 890 whilst the 2010 value was decreased significantly from 892 to 753, a 16% reduction.

Final Assessment

The estimated abundance in 2011 was 892 million individuals (95% confidence interval of ±17 million), just below the 2007 estimate used as MSY $B_{trigger}$ (890 million). The estimated harvest rate for 2011 was 11.4 %, above the MSY proxy level of 8.4%. The stock therefore remains in a vulnerable state. The dominance of large females in the landings again for the 2009-2010 fishery suggests that they had not successfully mated and therefore there remains the potential for poor recruitment for 2011 and 2012 (recruits to the fishery are estimated to be ~ 2-3 years old)

3.4.2.4 Historical stock trends.

The time series of TV surveys is (10 consecutive years) and 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. The abundance approximately halved from 2006 to 2009 but has been climbing since then.

Estimates of historical harvest ratio (the proportion of the stock which is removed) range from 6.4% to 25.5% (Table 3.3.2.5). 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 10 years.

3.4.2.5 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% which is well above the F_{max} level for males. The stock has shown signs of stress and decreasing abundance concurrent with this observed harvest rate.

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 have been recalculated in 2011 using a length cohort analysis model (SCA, see ICES, WKNep 2009) on the combined length frequencies for 2008-2010. The model fit to the data (Figure 3.3.2.10) is reasonable but not ideal as the model under-predicts the numbers of large females observed. This is because the model assumes reduced availability of mature females to the fishery and the 2010 length frequency has an abnormally large number of mature females in the landings. This phenomena is expected to be short lived and the fact that the model has not fitted well to the anomaly means that the parameters are probably robust. The previous estimates of F_{msy} proxies had been made using 2005-2007 data and the new values are only slightly different (but lower, reflecting the lower productivity of the stock).

		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%

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%).

WGNSSK suggests the bias adjusted TV abundance 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 $B_{trigger}$ ($B_{trigger}$ = 890 million).

Short term forecasts.

Catch and landing predictions for 2013 are given in the text table below. This assumes that the bias corrected survey index made in October 2011 is relevant to the stock status for 2013. Discard rates and mean weight in the landings are the mean of 2008-2010 as used in the reference point calculations.

	Harvest ratio	Bias corrected survey index	Retained number	Landings
	2%	870	17	331
	4%		35	663
	6%		52	994
Male F0.1	6.38%		55	1056
Combined F0.1	7%		63	1194
Fmsy=Male F35%SpR	8%		70	1325
Fmsy transition	9%		76	1450
Male Fmax	9.47%		82	1569
F35% combined	11.46%		100	1899
Combined Fmax	12.08%		105	2002
Female F0.1	12.68%		110	2101
Fcurrent	*13.90%*		121	2302
Female F35%SpR	18.74%		163	3104
Female Fmax	20.02%		174	3317

$F_{0.1(T)}$: 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.

3.4.2.6 BRPs

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

3.4.2.7 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 2011 survey results are similar to the 2007 reference year. The spine of high density on the western edge of the ground remains a regular feature but perhaps not as pronounced as usual. The main features of the survey series is now a steady decline from 2005 to 2009 and a small increase in 2010 and 2011.

The revision of the abundance estimates has also resulted in revisions to the harvest rate (removals in numbers divided by the TV abundance, figure 3.3.2.10). The harvest rate fluctuates considerably and the 2010 level has been revised upwards from 8.3% to 9.9% which is above the Fmsy proxy of 8% (F35% male).

The most recent North Sea Stock Survey was carried out in mid 2011. 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 not followed the increasing trend of other Functional Units. There is also agreement with the Stock Survey that 2011 saw an increase in abundance compared to 2010. Overall participation in the survey dropped for *Nephrops* with 74 respondents in 2011 compared to 86 in 2010.

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.

3.4.2.8 Status of stock

The TV survey indicates the stock to have improved and is just below the level of MSY $B_{trigger}$. There are no indications of strong recruitments coming into the stock.

3.4.2.9 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.

3.4.3 Fladen Ground (FU7)

3.4.3.1 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 3.5.1). This region is characterised by an extensive area of mud and muddy sand and hydrographic conditions include a large scale seasonal gyre developing 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 Functional Unit these substrates are distributed more or less continuously over a very large area (approx. 30000km2). The distribution is slightly more patchy towards the SW of the ground and sediments are more patchy and coarse towards the North. Figure 3.3.3.5 shows the distribution of sediment in the area. Numerous fish species occur in in the same area as *Nephrops* and towards the north the preponderance of demersal fish increases. In the softest areas of mud, Pandalus borealis is also found.

3.4.3.2 The Fishery in 2010 and 2011

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels, with Denmark the only other nation taking a significant amount of landings (Table 3.3.3.1).

No major changes were reported in the Scottish fishery in 2010. In 2011 over 100 vessels participated at various times through the year in the fishery which takes a mixed catch consisting of haddock, whiting, cod, anglerfish and megrim as well as *Nephrops*. The majority of these vessels (80%) fish out of Fraserburgh. A number of vessels have installed freezer capabilities enabling longer trip to be carried out. However, a number of vessels have left the Scottish fleet and are now registered in England to avoid the ban on multiple-rig (>2) trawling and a number of larger vessels spent time fish-

ing inshore grounds. During 2011, industry reported lower catch rates and several moved to other fisheries. The generally poorer fishing was a feature throughout much of the year and the spring 'tie up'period extended longer than usual and the summer fishery was especially poor. Scarcity of prawns led to an increase in price. Other developments that may have mitigated effort increases (due to new vessels) to some extent, are the number of larger boats taking up oil guard vessel duties. Further general information on the fishery can be found in the Stock Annex.

3.4.3.3 ICES advice in 2011

The ICES conclusions in 2011 in relation to State of the Stock were as follows:

The stock remains at a high level, well above MSY $B_{trigger}$. The harvest rate has been increasing but is still below F_{MSY}.

The ICES advice for 2011 (Single-stock exploitation boundaries) was as follows:

MSY approach

ICES advises on the basis of the MSY approach that landings in 2012 should be no more than 14 100 t.

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

3.4.3.4 Management

TAC management is at the ICES Subarea level as described at the beginning of Section 3.3. Most *Nephrops* vessels operate TR2 gear (100mm mesh) and are subject to the effort regulations of the cod recovery plan. In Scotland the Conservation Credits scheme is in operation, various technical measures apply to *Nephrops* vessels

3.4.3.5 Assessment

Review of the 2011 assessment

The review group concluded that the assessment has been performed correctly

The RG's comments mainly consisted of a list of editorial comments, requests for greater clarity in presentation and highlighting of missing material in the Stock Annex. Some of these are dealt with in the remainder of the text.

Approach in 2012

The assessment in 2012 is based on a combination of examining trends in fishery indicators and underwater TV using an extensive data series for the Fladen Ground FU 7. 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 2010 developed the process defined by the benchmark WG. 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.

3.4.3.6 Data available

Commercial catch and effort data

Landings from this fishery are predominantly reported from Scotland, with small contributions from Denmark and others, and are presented in Table 3.3.3.1 and Figure 3.3.3.1. Total international landings (as reported to the WG) in 2011 were 7885 tonnes (over 5000 tonnes lower than the 2010 total), consisting mostly of Scottish landings and only 64 tonnes landed by Denmark. 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 Ground. 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. For next year it is hoped the data series can be extended back in time and provide quarterly data – this will enable the standarad presentations to be included once more.

Trends in Scottish effort and LPUE are shown in Figure 3.3.3.1 and Table 3.3.3.2. Effort has shown a gradual decline over the time period. Some of this is recently attributable to the EU effort management regime although *Nephrops* vessels have generally been allocated exemptions. LPUE has risen since 2000 but in the most recent year has dropped back slightly. Danish LPUE data are presented in Table 3.3.3.3. These show an increase in the mid-2000s, with a decline in 2011, similar to that observed in Scotland.

Males consistently make the largest contribution to the landings, although the sex ratio does seem to vary and in 2011 males were particularly evident. 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* (Figure 3.3.3.2). This is confirmed by the information on quarterly landings as shown in Figure **. In 2011, landings were much lower in the 2nd and 3rd quarters of the year, periods when females would be expected to be more available for capture.

Discarding of undersized and unwanted *Nephrops* occurs in this fishery, and quarterly discard sampling has been conducted on the Scottish *Nephrops* trawler fleet since 2000. Discarding rates average around 10 % by number in this FU. In the last few-years discard rates have dropped below the long term average and in 2011 no discards were recorded in the observer tris 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 2011 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2012 WG and output length compositions obtained in formats suitable for running assessment

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are shown in Section 2.2.4.XX. Although assessments based on detailed catch data analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

Figure 3.3.3.3 shows a series of annual length frequency distributions for the period 2000 to 2011. 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 and examination of the tails of the distributions above 35 mm shows no evidence of reductions in relative numbers of larger animals. In 2011 there was a noticeable shift in the length distribution and an increase in mean size, particularly for males.

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 3.3.3.1 and Table 3.3.3.4. This parameter might be expected to reduce in size if over-exploitation 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 although there has been an increase in the last 4 years which may be associated with lower recruitments. Similar sizes were observed in the early 2000s when recruitment also appears to have been at a lower level. The mean size in < 35 mm component of the landing appears to be generally lower in 2007-10 when compared to 2003-2006. This appears to be due to increased retention of small individuals (resulting in a lower discard rate) rather than a change in the size composition of the catches. In 2011, this landing mean size increased again but discarding stopped, this may also signal a period of reduced recruitment but could possibly reflect the increasing use of more selective gears – quantitative information on trends in gear changes are not, unfortunately, 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 are shown in Figure 3.3.3.4 and Table 3.3.3.5 and these show no systematic changes over the time series. The variability in mean size is greater than in other areas. In 2011 mean size increased but remains within the previously observed range.

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 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*.

The numbers of valid stations used in the final analysis in each year are shown in Table 3.3.3.6. On average, about 64 stations have been considered valid each year. Data are raised to a stock area of 28153 km^2 based on the stratification (by sediment type).

General analysis methods for underwater TV survey data are similar for each of the Scottish surveys, and are described in more detail in the Stock Annex.

Previous RGs 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 bias corrected estimated abundance is likely to be slightly underestimated by the UWTV survey.

3.4.3.7 Data analyses

Exploratory analyses of survey data

Table 3.3.3.7 shows the basic analysis for the three most recent TV 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, the latter predominate. Most of the variance in the survey is associated with this coarse sediment which surrounds the main centres of abundance.

Figure 3.3.3.5 shows the distribution of stations in recent TV surveys (2005-2010), 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 but in 2007, high densities were also widely recorded in the coarser sediment of the ground. Table 3.3.3.6 and Figure 3.3.3.6 show the time series 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 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 TV survey is likely to overestimate *Nephrops* abundance by 35 %.

Final assessment

The underwater TV survey is again presented as the best available information on the Fladen Ground *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 2011 TV survey data presented at this meeting shows that the abundance has reduced further from the high values observed in 2007 and 2008 but remains above the biomass trigger.

Historical Stock trends

The TV survey estimates of abundance for *Nephrops* in the Fladen suggest that the population has fluctuated over the 20 year period of the surveys. In the 12 year period up to 2008 the population showed a generally increasing trend The recent decrease follows the two highest estimates in 2007 and 2008 and takes the population down to a size around that observed on two previous occasions (in the early and late

1990s). The bias adjusted abundance estimates from 2003-2010 are shown in Table 3.3.3.8. The current stock size is estimated to be 3382 million individuals.

Table 3.3.3.7 also shows the estimated harvest ratios over this period. 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 3.3.3.8 also shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

3.4.3.8 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.

3.4.3.9 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 analysis was updated last year 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 Section 2.

WGNSSK 2011		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
$F_{0.1}$	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
F_{max}	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
$F_{35\%SpR}$	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 stock annex for previously estimated values used at WGNSSK 2010). 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 (bias adjusted lowest observed UWTV abundance) is calculated as 2767 million individuals.

3.4.3.10Short-term forecasts

A landings prediction for 2013 was made for the Fladen Ground (FU7) using the approach agreed at the Benchmark Workshop and outlined in the introductory section of the 2010 WGNSSK report (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 2012 (assumed equal to the 2011 value) . The landings prediction for 2013 at the F_{msy} proxy harvest ratio is 10115 tonnes. There is no transition stage as the current harvest ratio is actually below that equivalent to F_{msy}.

The inputs to the landings forecast were as follows:

Mean weight in landings (09-11) = 30.25 g

Dead discard rate (by number) = 4 % (average 09-11)

Survey bias = 1.35.

F_{sq} = average (F_{2009} - F_{2011})= 8.5 %. The average harvest ratio of the last three years is taken as the best estimate of F_{2011} as the harvest ratio has fluctuated in the last three years.

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	3382	162	4911
	8.0%	3382	260	7857
F_{2012}	8.5%	3382	275	8315
	10.0%	3382	325	9821
$F_{msy}=F_{0.1(T)}$	10.3%	3382	334	10115
$F_{35\%SPR(T)}$	12.4%	3382	404	12209
	15.0%	3382	487	14732
$F_{max\ (T)}$	18.5%	3382	599	18122
	20.0%	3382	649	19643

Discard Percetage 4%; mean wt of retained 30.25g

$F_{0.1(T)}$: 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.

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

3.4.3.11 Biological Reference points

Biological reference points have not been defined for this stock.

3.4.3.12 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 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 Ground 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 bias adjusted 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.

3.4.3.13 Status of the stock

The perception of the state of the stock has changed somewhat since the assessment in 2011. The 2011 TV survey data presented at this meeting shows that the abundance has dropped although it is still within the range of fluctuation observed during the time series of surveys and is 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 2011 (removals/TV abundance) is lower than $F_{0.1}$.

3.4.3.14 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 the 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.

3.4.4 Firth of Forth (FU 8)

3.4.4.1 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 3.3.3.1). 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 915km2, 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 3.3.4.4 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.

3.4.4.1.1 The Fishery in 2010 and 2011

The *Nephrops* fishery in the Firth of Forth is dominated by UK (Scotland) vessels with low landings reported by other UK nations (Table 3.3.4.1). There has been a decline in the number of local Scottish vessels regularly fishing this FU. A further 3 boats left this fleet in 2011 leaving around 27 vessels although this varies seasonally as vessels move around the UK in response to varying catch rates. Days at sea regulations affect opportunities for diversification. In 2011 there were very few visiting vessels apart from some NE vessels fishing in the summer months. These left after catches consisted mainly of smaller *Nephrops.* 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 no squid fishery in 2011. There is also a small amount of landings by creel vessels in this area (< 1 % of the total), 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.

3.4.4.2 Advice in 2011

The ICES conclusions in 2011 in relation to State of the Stock were as follows:

The stock remains at a high level, well above MSY $B_{trigger}$. The harvest rate remains slightly above F_{MSY}.

The ICES advice in 2011 (for 2012) (Single-stock exploitation boundaries) was as follows:

MSY approach

ICES advises on the basis of the transition to the MSY approach that landings in 2012 should be no more than 1700 t.

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

3.4.4.3 Management

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

3.4.4.4 Assessment

Review of the 2011 assessment

The review group concluded that the assessment has been performed correctly

The RG's comments mainly consisted of a list of editorial comments, requests for greater clarity in presentation and highlighting of missing material in the Stock Annex. Some of these are dealt with in the remainder of the text

Approach in 2012

The assessment in 2012 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 3.3.4.1 and Figure 3.3.4.1,. Most of the landings are made by trawlers with creels accounting for about 4.7%. Reported landings rose very slightly between 2010 and 2011 after a significant drop in 2010. The value for 2009 of over 2,600 tonnes was the highest in the available time series whilst the 2010 and 2011 landings are just under the long term average (1906 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. For next year it is hoped the data series can be extended back in time and also provide quarterly data – this will enable the standard presentations to be included once more.

Trends in Scottish effort and LPUE are shown in Figure 3.3.4.1 and Table 3.3.4.2 . Effort has shown a gradual decline over the time period. Some of this is recently attributable to the EU effort management regime although *Nephrops* vessels have generally been allocated exemptions. LPUE rose in the early 2000s but since 2006 it has stabilised.

Males consistently make the largest contribution to the landings (Figure 3.3.4.2), although the sex ratio does vary and in 2011 more females in the catches moved the ratio closer to 1:1. 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 3.3.4.2.

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. 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 25 and 55 % of the catch by number (long term average 40 %). In the last five years, discard rates appear to have dropped to well below this value (30 % on average by number) and in 2011 were just below 20%. 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 2011 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2012 WG and output length compositions obtained in formats suitable for running assessment

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are shown in Table 2.2.XX. Although assessments based on detailed catch data analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 3.3.4.3 shows a series of annual length frequency distributions for the period 2000 to 2011. 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.

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 3.3.4.1 and Table 3.3.4.3. This parameter might be expected to reduce in size if over-exploitation 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 3.3.4.1) also shows no particular trend although it has been rising very slightly in the last 3 years

Mean weight in the landings is shown in Figure 3.3.3.4 and Table 3.3.3.5 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 3.3.4.4. On average, about 40 stations have been considered valid each year. In 2011, there were 45 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 3.3.4.5 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 3.3.4.4 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 3.3.4.4 and Figure 3.3.4.5 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 biases were highlighted including those due to edge effects, species burrow mis-identification and burrow occupancy. The cumulative

bias correction factor estimated for FU 8 was 1.18 meaning that the TV survey is likely to overestimate *Nephrops* abundance by 18 %.

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 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 2011 is 24 % lower than the 2010 abundance and is similar to that recorded in 2002. The TV survey information, taken together with information showing stable mean sizes, suggest that the stock does not show signs of overexploitation. The calculated harvest ratio in 2010 (dead removals/TV abundance) is above F_{max}.

The mean size of individuals < 35 mm in the catch show no trend in recent years.

3.4.4.5 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 bias adjusted abundance estimates form 2003-2010 (the period over which the survey estimates have been revised) is shown in Table 3.3.4.5. The stock is currently estimated to consist of 533 million individuals.

Table 3.3.4.6 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 2011 is 22 % which above the estimated value at F_{max} (16.3 %).

In addition to the discard rate, Table 3.3.4.6 also shows the dead discard rate (av 08-10 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).

3.4.4.6 Recruitment estimates

Survey recruitment estimates are not available for this stock.

3.4.4.7 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 analysis has been updated this year using 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.

WGNSSK 2011		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
	M	0.14	0.06	7.7	40.8	62.3	49.9
F0.1	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
	M	0.25	0.11	12.7	25.3	46.8	34.4
Fmax	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
	M	0.17	0.07	9.4	34.6	56.6	43.9
F35%SpR	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. (See stock annex for previously calculated values used at WGNSSK 2010).

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.

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

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

3.4.4.8 Short-term forecasts

A landings prediction for 2013 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 2009 using the input parameters agreed at WKNEPH (ICES 2009). The landings prediction for 2013 at the F_{msy} proxy harvest ratio is 1324 tonnes. The F_{msy} transition stage harvest ratio results in a landings option of 1393 tonnes.

The inputs to the landings forecast were as follows:

Mean weight in landings (09-11) = 19.6 g

Dead discard rate (by number, average 09-11) = 22.3 %

Survey bias = 1.18

F_{sq} = average harvest ratio of 2009-2011 = 22.2 %

F_{msy} transition (17.5 %) is calculated from 0.6 x Fmsy + 0.4 x F_{2010} where F_{2010}=18.4 %

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	533	21	407
$F_{0.1\,(T)}$	9.4%	533	39	761
	10.0%	533	41	813
$F_{35\%SPR(T)}$	12.7%	533	53	1033
	15.0%	533	62	1220
F_{msy}	16.3%	533	67	1324
F_{msy} transition	17.1%	533	71	1393
	20.0%	533	83	1626
F_{2012}	22.2%	533	92	1802

$F_{0.1(T)}$: 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.

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

3.4.4.9 Biological Reference points

Biological reference points have not been defined for this stock.

3.4.4.10 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 increased abundance in 2010, but this covers the Firth of Forth and parts of the Devil's Hole in addition to the Moray Firth.

3.4.4.11 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 2011 is 24 % lower than the 2010 abundance and is similar to that recorded in 2002. The TV survey information, taken together with information showing stable

mean sizes, suggests that the stock does not show signs of overexploitation. The calculated harvest ratio in 2010 (dead removals/TV abundance) is above F_{max}.

3.4.4.12 Management considerations

The WG, ACOM and STECF have repeatedly advised that management should be at a smaller scale than the ICES Division level. 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 uses 80mm mesh. Larger square mesh panels 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_{max} and therefore it would be unwise to allow effort to increase in this FU.

3.4.5 Moray Firth (FU 9)

3.4.5.1 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 3.3.3.1). 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 2195km2, 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 3.3.5.4 shows the distribution of sediment in the area. It is thought that most larvae are produced locally although some drift from the Fladen Ground 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).

3.4.5.2 The Fishery in 2009 and 2010

The Moray Firth *Nephrops* fishery is essentially a Scottish fishery with only occasional landings made by vessels from elsewhere in the UK (Table 3.3.5.1). The general situation in 2010 and 2011 is similar to previous years with the vessels targeting this fishery typically conducting day trips from the nearby ports along the Moray Firth coast. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from

the Fladen or in times of poor weather. In 2011, shortages of *Nephrops* at the Fladen Ground led to periodic visits by larger vessels (5-6) fishing mainly the outer areas of the Firth. Further general information on the fishery can be found in the Stock Annex.

3.4.5.3 Advice in 2010

The ICES conclusions in 2011 in relation to State of the Stock were as follows:

The stock remains above MSY $B_{trigger}$. The harvest rate has declined since 2006 and is now at F_{MSY}.

The ICES advice for 2011 was as follows:

ICES advises on the basis of the MSY approach that landings in 2012 should be no more than 1100 t.

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

3.4.5.4 Management

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

3.4.5.5 Assessment

Review of the 2011 assessment

The review group concluded that the assessment has been performed correctly

The RG's comments mainly consisted of a list of editorial comments, requests for greater clarity in presentation and highlighting of missing material in the Stock Annex. Some of these are dealt with in the remainder of the text.

Approach in 2012

The assessment in 2012 is based on a combination of examining trends in fishery indicators and underwater TV 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 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 intersessional 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 3.3.5.1. Total landings (as reported to the WG) in 2011 rose to just under 1,400 tonnes, (34% higher than 2010). Landings in recent year are more reliable due to the introduction of 'buyers and sellers' legislation). The long term landings trends are shown in Figure 3.3.5.1.

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 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. For next year it is hoped the data series can be extended back in time and also provide quarterly data – this will enable the standard presentations to be included once more.

Trends in Scottish effort and LPUE are shown in Figure 3.3.5.1 and Table 3.3.5.2. Effort has shown a gradual decline over the time period. 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 3.3.5.2), although in 2011, the proportion of females is higher than in the recent past. This 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 of between 8 and 33 % of the catch by number in recent years with 3 of the lowest values occurring in the last four years. In 2011 the observed rate by number was 13.9%. Discards rates were consistently 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 2011 were successfully uploaded into Intercatch. National data co-ordinators for other countries also uploaded data to Intercatch ahead of the 2012 WG and output length compositions obtained in formats suitable for running assessment

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are shown in Table 2.2.XX. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions may provide an indication of exploitation effects.

Figure 3.3.5.3 shows a series of annual length frequency distributions for the period 2000 to 2008. 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). 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 3.3.5.1 and Table 3.3.5.3. This parameter might be expected to reduce in size if over-exploitation were taking place but over the last 15 years has in fact been quite stable.

Mean weight in the landings is shown in Figure 3.3.3.4 and Table 3.3.3.5 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 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*.

The numbers of valid stations used in the final analysis in each year are shown in Table 3.3.5.4. On average, 39 stations have been considered valid each year – 37 stations were sampled in 2011. Abundance data 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, and are described in the Stock Annex.

Data analyses

Exploratory analyses of survey data

Table 3.3.5.5 shows the basic analysis for the three most recent TV surveys conducted in FU 9. 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 3.3.5.4 shows the distribution of stations in TV surveys, 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 3.3.5.4 and Figure 3.3.5.5 show the time series of estimated abundance for the TV 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 %.

Final assessment

The underwater TV 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 has not changed substantially since the assessment in 2009. There has been a slow decline in abundance in the last few years although the error bars overlap considerably so these decline may not be significant.. The TV survey suggests that the population is relatively stable, but at a lower level than that evident from 2003-2005.

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

3.4.5.6 Historical Stock trends

The TV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased between 1997 and 2005 but has fallen to a fairly stable lower level since then. The bias adjusted abundance estimates from 2003-2011 are shown in Table 3.3.5.6. The stock is currently estimated to consist of 372 million individuals.

Table 3.3.5.6 also shows the estimated harvest ratios over this period. These range from 7-20 % 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 2011 is about 19 % and since last year has risen above the F_{msy} proxy value of 11.8 %.

In addition to the discard rate, Table 3.3.5.6 also shows the dead discard rate (av 09-11 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).

3.4.5.7 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.

3.4.5.8 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 analysis has been updated this year using 2008-10 catch-at-length data, to account for the apparent changes in the discard pattern. 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)		HR (%)	SPR (%)		
		M	F		M	F	T
	M	0.13	0.07	7.16	42.35	61.48	49.89
$F_{0.1}$	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
	M	0.26	0.13	12.31	25.80	45.16	33.42
F_{max}	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
	M	0.17	0.09	9.11	34.69	54.48	42.48
$F_{35\%SpR}$	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 (bias adjusted lowest observed UWTV abundance) is calculated as 262 million individuals.

3.4.5.9 Short-term forecasts

A landings prediction for 2013 was made for the Moray Firth (FU9) 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 status quo harvest ratio. The landings prediction for 2013 at the F_{msy} proxy harvest ratio is 937 tonnes. The inputs to the landings forecast were as follows:

Mean weight in landings (09-11) = 24.01 g

Dead discard rate (by number, average 09-11) = 11 %

Survey bias = 1.21

F_{sq} = Average (F_{2009} F_{2011}) (average since values fluctuating) = 13.9 %

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	372	17	397
$F_{0.1\,(T)}$	7.8%	372	26	623
	10.0%	372	33	795
F_{msy}	11.8%	372	39	937
F_{2011}	13.9%	372	46	1105
$F_{max\,(T)}$	14.9%	372	49	1186
	15.0%	372	50	1192
	20.0%	372	66	1590

Discard Percentage 11%; mean wt of retained 24.01g

$F_{0.1(MT)}$: 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 male SPR equal to 35% of the unfished level.

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

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

3.4.5.10 Biological Reference points

Biological reference points have not been defined for this stock.

3.4.5.11 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 1998. Confidence intervals around the abundance estimates are greater during years when abundance estimates have been slightly higher.

The Fishers' North Sea stock survey does not include specific information for the Moray Firth. The time series of perceived abundance for area 3 which includes the Moray Firth (but also Firth of Forth and Devil's Hole) shows an increase up to 2011.

3.4.5.12 Status of the stock

The evidence from the TV survey suggests that the population is stable, but at a lower level than that evident from 2003-2005. There is no evidence from the mean size information to suggest overexploitation of the FU. Harvest ratios (removals/TV abundance) for 2011 was above F_{msy}..

3.4.5.13 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 $F_{35\%SpR}$ and although the abundance (as estimated by the TV survey) does not appear to have been adversely affected by this, it would be unwise to allow effort to increase in this FU.

3.4.6 Noup (FU 10)

3.4.6.1 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.

3.4.6.2 The Fishery in 2010 and 2011

The Noup supports a relatively small fishery with only 3-4 boats fishing regularly. The landings data as reported to the WG are shown in Table 3.3.6.1. No specific information is available for 2010 and 2011. Further general information on the fishery can be found in the Stock Annex.

3.4.6.3 Advice in 2011

The advice provided in 2010 was biennial and valid for 2011 and 2012.

The ICES conclusions in 2010 in relation to State of the Stock were as follows:

The state of the stock is unknown.

The ICES advice for 2012 (Single-stock exploitation boundaries) was as follows:

The 2010 advice for this *Nephrops* stock was biennial and valid for 2011 and 2012 (see ICES, 2010) and indicated there is no basis for advice. Based on the 2012 advisory framework in these circumstances, ICES advises on the basis of precautionary considerations that catches should be reduced.

To protect the stock in this Functional Unit, 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 3.3.6.1 and Figure 3.3.6.1, together with a breakdown by gear type. Total landings (as reported to the WG) in 2011 were 69 tonnes, an increase on the previous year but still low compared to the earlier periods of the time series. *Nephrops* are almost exclu-

sively landed by 'non-*Nephrops*'. This supports the anecdotal information received from the fishing industry that this Functional Unit 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 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. For next year it is hoped the data series can be extended back in time and also provide quarterly data – this will enable the standard presentations to be included once more.

Trends in Scottish effort and LPUE are shown in Figure 3.3.6.1 and Table 3.3.6.2. Effort has declined over the time period and is more marked than on other *Nephrops* grounds owing to the higher preponderance of trawlers targeting demersal fish in the area – demersal vessels having been more directly impacted by effort reductions. LPUE in the last 3 years has been relatively low but interpretation of this index id difficult since the vessels are mainly 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 3.3.6.1 and Table 3.3.6.3 Size composition has been generally stable and in the last couple of years the size of the landed component has increased slightly.

Natural mortality, maturity at age and other biological parameters

No data available.

Research vessel data

An underwater TV survey of this FU has been conducted sporadically (1994, 1999, 2006 and 2007). A density distribution map of these surveys is shown in Figure 3.3.6.2 and results shown in Table 3.3.6.4.

Data analyses

No assessment has been presented in 2012.

3.4.6.4 Historical stock trends

Recent landings for this FU have been low (around 50 tonnes) which represents < 1% of the total landings from the North Sea.

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

3.4.6.5 Recruitment estimates

There are no recruitment estimates for this FU.

3.4.6.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

3.4.6.7 Status of the stock

The current state of the stock is unknown.

3.4.6.8 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.

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 the functional unit 34 – Devil's Hole (see text table below). The discard rate and mean weight was taken from FU9. The 2007 survey shows that density is low on this ground (around 0.2) burrows per metre squared. 10 year average landings of 150 tonnes at this density equates to a harvest rate of around 8.5%, which is below any proxy for Fmsy used on other grounds. Maximum landings of 500t carries an appreciably higher risk of exceeding any MSY proxies.

FU 10: NOUP — 409 Area (km2) — 24 mean weight (g) — 11% 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	75	17.0%	8.5%	4.2%	2.8%	2.1%	1.7%	1.4%	1.2%	1.1%
Average	150	33.9%	17.0%	8.5%	5.7%	4.2%	3.4%	2.8%	2.4%	2.1%
Maximum	500		56.5%	28.3%	18.8%	14.1%	11.3%	9.4%	8.1%	7.1%

Most recent density estimate (2007)

3.4.7 Norwegian Deep (FU 32)

3.4.7.1 General

3.4.7.1.1 Ecosystem aspects.

See stock annex (section A.3).

3.4.7.1.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2).

3.4.7.1.3 Advice in 2010

In 2010 ICES noted for this stock that:

- "International landings from the Norwegian Deep increased from less than 20 t in the mid-1980s to 1,190 t in 2001, the highest figure so far (...). Since

then landings have declined and total landings in 2009 amounted to only 477 t, due to a reduction of Danish landings. This is the lowest figure since 1994."

- "Perceptions of this stock (FU 32) are based on Danish LPUE data. The trend in these LPUE figures does not indicate any decline in stock abundance."
- "Recent trends in overall size distribution in the catches also indicate that the *Nephrops* stock in FU 32 is not over-exploited."
- "However, the effect of technological creep on the effective effort of the fishery is not known."

The WG concludes that the level of exploitation on this stock is sustainable. No TAC was suggested for 2011 or 2012, but the WG advised that catches should remain at the present level. It was noted that historic average annual landings have been app. 1000 t (2002-2007), while recent average landings were 575 t (2008-2009). The WG considered that the stock should be monitored more closely.

3.4.7.1.4 Management

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. 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.

3.4.7.2 Assessment

3.4.7.2.1 Data available

Catch

Landings data for the 2013 assessment (all fleets in 2011) have been uploaded using InterCatch.

Dutch landings from FU 32 were incorporated in 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 1,190 t in 2001, the highest figure so far (Table 3.3.7.1, Figure 3.3.7.1). Since then landings have declined due to a reduction of Danish landings, and total landings in 2011 amounted to only 392 t. This is the lowest figure since 1994. The decreased Danish landings are probably mainly explained by a reduction in the number of vessels and increased fuel prices. Danish vessels used to take 80-90 % of the total landings, but in 2009-2010 this decreased to 69 % due to smaller Danish landings in relation to the Norwegian ones. Norwegian landings have decreased since 2008 and were reduced by more than 40 % from 2010 to 2011. This resulted in Danish landings in 2011 again comprising around 80 % of the total.

Length composition

The average size of *Nephrops* as recorded from Danish landings (120 mm mesh size) showed a decreasing trend for both males and females in the period 2000-2006, but increased again in 2007, and then, in 2010, either remained on this level (males) or increased further (females) (Figure 3.3.7.1). Average sizes in catches of both sexes (landings and discards) showed similar trends. There were no sex specific Danish size

data for 2008, 2009 or 2011. Due to changes in the Danish at-sea-sampling programme in 2011 (stock annex, section B.1), the catch sampling in 2011 was very limited and is expected to be equally low in 2012. Norwegian data (from coast guard inspections of (mainly) Danish and Norwegian trawlers) on mean length in catches per sex were added to Figure 3.3.7.1 this year and fill out gaps in the Danish time series. The two female time series (catches) overlap well, while the Norwegian male time series (catches) overlap with the Danish male time series of landings.

The increased mean size in the catches observed in recent years (Figure 3.3.7.1) may indicate lower recruitment, but this is rather uncertain due to lack of small individuals (120 mm mesh size) in the samples and a biased sampling programme. Increased mean sizes in landings and catches may also imply a lower exploitation pressure in recent years.

The size distributions in the Danish catches (120 mm mesh size) from 2002 to 2010 did not show any conspicuous changes (Figure 3.3.7.2). Size data of catches (120 mm mesh size) from Norwegian coast guard inspections of (mainly) Danish and Norwegian trawlers are available for 2005 to 2011, but with very limited 2005- and 2009-data and no data from 2010 (Figure 3.3.7.3). The size distributions are fairly similar from year to year. The sharp increase from 39 to 40 mm length in the distributions from 2006, 2008 and 2011 can be explained by the slight difference in methods of measuring MLS (total vs. carapace length, see stock annex section B.1). Danish and Norwegian length distributions in catches have been compared for 2006-2007 (only years with data from both countries) (Figure 3.3.7.4). The length distributions from 2007 are very similar, but the 2006-distributions show some discrepancies.

Since 2003 the Danish at-sea-sampling programme has provided data for discard estimates. However, the samples have not covered all quarters. Discard estimates are included in the Danish catches presented in Figure 3.3.7.1. Discards have decreased recently compared to the years 2003-2006. There were no discards data for 2008 or 2011.

Natural mortality, maturity at age and other biological parameters

No data available.

Catch, effort and research vessel data

Effort and LPUE figures for the period 1989-2011 are available from Danish logbooks (Table 3.3.7.2, Figure 3.3.7.1). Available logbook data from Norwegian *Nephrops* trawlers cover only a small proportion of the landings (15-40%) in 2001-2005 and are lacking for 2006-2011. The working group considers them unsuitable for any LPUE analysis. In the beginning of the 1990s vessel size increased in the Danish fleet fishing in the Norwegian Deep. This increase and more directed fisheries for *Nephrops* in areas with hitherto low exploitation levels are probably partly responsible for the observed increase in the Danish LPUEs in those years (Table 3.3.7.2, Figure 3.3.7.1). Since 1994 the Danish LPUEs have fluctuated around 200 kg day^{-1}. Some of the fluctuations may be caused by fishing vessels locally switching between roundfish and *Nephrops* due to changes in management regulations in the Norwegian zone. The Danish effort increased from 2004 to 2006, but showed a strong decline in 2007 and

has since continued decreasing. This decline corresponds to large declines in landings.

It has not been possible to incorporate 'technological creeping' in the evaluation of the effort data. However, use of twin trawls has been widespread for many years. Figure 3.3.7.1 shows the GLM standardised LPUE (regarding vessel size) from the Danish logbook data. Note that the trends in the non-standardised and the standardised LPUE values (relative indices) are very similar. However, this may merely reflect that vessels catching *Nephrops* in this area are very similar with respect to e.g. size and HP.

An estimated guidance of the *Nephrops* biomass was applied to FU 32 this year. By using UWTV-survey information from the neighbouring functional unit (FU 7 Fladen Ground) on mean density of *Nephrops* (minimum value of 0.1 animals/m^2) together with an even lower value of 0.05 animals/m^2 as densities seem to be low in FU 32, as well as the mean weight of *Nephrops* in the Norwegian catch samples in 2011 (68 g), minimum/maximum ranges of total biomass were calculated. The area of the *Nephrops* ground in FU 32 was estimated using information on the geographic distribution of the Norwegian and Danish fisheries, as well as suitable sediment (stock annex, Figures A2-2, A2-3, and A3-1). A more conservative area estimate was also applied, using the area of the Danish grounds (based on VMS data). The biomass estimates imply very low harvest ratios in FU 32 (≤ 2 %), even in former years with high landings (1000-1200 t) (Tables 3.3.7.3, 3.3.7.4).

3.4.7.2.2 Data analysis

Review of last year's assessment

The last assessment of this stock was in 2010. The Review Group (RG) noted:

"The group outlined an appropriate management strategy considering the data poor nature of the fishery. They also outlined the caveats and their hesitations of using the data as they are and required data to improve the assessment and ensure the fishery is harvesting sustainably. An improvement to the management of this FU would be to manage at the FU level as opposed to the Subarea level."

Exploratory analysis of catch data

There was no age based analysis carried out

Exploratory analysis of survey data

The only survey data for this stock are catches of *Nephrops* during the annual Norwegian shrimp trawl survey. These catches are too small and variable to be useful for exploratory analysis (see stock annex, section B.3).

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.

3.4.7.2.3 Historic stock trends

The slight increase in mean size in catches and landings from 2006 to 2010 in females and from 2005 to 2007 in males could indicate both a slight decrease in recruitment and/or a lower exploitation pressure in recent years which coincides well with the

decreasing landings in the same time period. The Danish LPUE decreased from 2005 to 2006, increased in 2007, decreased from 2008 to 2010, and then increased again in 2011. The overall picture is that of a stable LPUE fluctuating around a mean of 200 kg/day. The working group notes that the highest landings from this stock (in 1999-2006) did not cause a decrease in LPUE. Thus the stock seems to be stable and shows no sign of overexploitation.

3.4.7.2.4 Recruitment estimates

There are no recruitment estimates for this stock.

3.4.7.2.5 Forecasts

There were no forecasts for this stock.

3.4.7.2.6 Biological reference points

No reference points are defined for this stock.

3.4.7.2.7 Quality of assessment

The data available for this stock remains limited.

3.4.7.2.8 Status of stock

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. Historic average annual landings have been app. 1000 t (2002-2007), while recent average landings are 490 t (2008-2011). The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 2 %), even in the years of maximum landings.

3.4.7.2.9 Management considerations

For 2006-2008 the agreed catch for EU vessels was 1300 t, while this decreased to 1200 t in 2009-2012. The working group notes, however, that there is no TAC for the Norwegian vessels fishing in FU 32.

The WG considers that the stock should be monitored more closely. The newly implemented changes in the Danish at-sea-sampling programme with observer trips being randomly drawn from all Danish fishing trips (stock annex, section B.1), result in a very low chance of selecting the few fishing trips in FU 32. The working group recommends that a satisfactory number of observer trips, as in previous years, should be allocated to FU 32 irrespective of the new at-sea-sampling programme.

The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks compulsory for all vessels > 15 m length. This will provide consistent data for part of the fleet, but as a large portion of the Norwegian fleet landing *Nephrops* in FU 32 consists of vessels < 15 m, the logbook data will continue to be limited.

The coast guard sampling of Norwegian commercial catches from this area has been 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 their data.

3.4.8 Off Horns Reef (FU 33)

3.4.8.1 Data available

Catch

The landings from FU 33 were marginal for many years. However, from 1993 to 2004, Danish landings increased considerably, from 159 to 1,097 t. In this period Denmark dominated this fishery. The other countries reporting landings from the area are Belgium, Netherlands, Germany and the UK. In 2007 total landings increased to above 1400 t. Since 2004 Danish landings have gradually decreased, and was almost 400t in 2011. During the same period landings from Netherlands increased. In 2011 total landings from this FU amounted to almost 1200 t (Table 3.3.8.1), of which the Netherlands accounted for around 400 t. The other countries contributed with around 400 t.

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 are shown in Figure 3.3.8.2. Notice, that except for 2005 they are rather similar. Figure 3.4.5.3 gives the development of the mean size of the catches and landings by sex. The drop in mean CL in 2005 reflect increased numbers around 30 mm CL in the catch and could indicate a large recruitment that year, see also Fig. 3.3.8.1

In the period 2001-2005, and in 2009-2011 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, effort and research vessel data

Table 3.3.8.1 and Figure 3.3.8.1 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. After 2004 the Danish effort decreases markedly and is below 1000 days in 2008-2011. Dutch effort data are available from 2005-2011 and was around 1500 days in recent 6 years. The Danish LPUEs show an increasing trend during the whole period until a high record in 2011 of more than 600 kg/day. This increase in LPUE could reflect increase in gear efficiency (technological creep). Lpue decreased in 2009 and 2010. LPUEs from Netherland increased from 200 kg/day in 2006 to around 300 kg/day in 2007-2009 and fall to around 200 kg/day in 2010 and 2011.

3.4.8.1.1 Data analysis

Reviews of the 2011 assessment (FU33)

No review was done on this FU during 2011.

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

3.4.8.1.2 Historic stock trends

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

When the Danish effort decreased after the high in 2004, the LPUE increased markedly until 2008, shows a decreasing trend in 2009 and 2010 and a high record in 2011. However, the increase in previous years also could reflect technological creep. This year new data from Netherlands was available for recent six years and show a more stable effort. LPUE is increasing for both countries in 2011.

The size distribution in the 2011 catches is similar to those in 2001-04. The generally smaller individuals in the 2005 catches could reflect a high recruitment that year. The decrease in mean size could indicate either high recruitment or a decline in stock reflected by fewer large individuals.

Recruitment estimates: There are no recruitment estimates, but fluctuations in discards may reflect corresponding fluctuations in recruitment.

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 Netherlands LPUE data and trends in size composition in Danish catches. As stated above, comparing the size distribution in the 2005 catches with those in the 2001-2004 catches as well as the 2009 catches could indicate a high recruitment in 2005.

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 monitored closely.

3.4.9 Devil's Hole (FU 34)

ICES has previously highlighted that the quantity of 'Other' (non-functional unit) landings has been steadily increasing (see Table 3.1.2) and reached the highest on record in 2009 (amounting to 2300 tonnes or just under 10 % of the total North Sea landings). On further investigation, it was apparent that approximately half of these 'Other' landings were being taken in an area known as the Devil's Hole, to the south of the Fladen. SGNEPS (2010) recommended that given the level of landings coming from the area, it should be designated as a functional unit: FU 34

3.4.9.1 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 3.3.9.1 and suggests that there is one large, and several smaller areas of muddy sand (10 – 50 % silt and clay).

3.4.9.2 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 2011, a number of Fladen vessels moved into the area from time to time.

Advice in 2011

ICES did not provide advice for this FU in 2011.

3.4.9.3 Management

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

3.4.9.4 Assessment

Data are presented which in future may form the basis for an assessment.

3.4.9.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 2009 -2011 are presented in Table 3.3.9.1 and a longer time series of Scottish landings is also included in this table and shown in Figure 3.3.9.2. Scottish landings declined from over 1300 tonnes in 2009 to 430 tonnes in 2011, although they still made up a very significant proportion of the total international landings from this functional unit last year. Current landings are comparable to those made in the early 2000s.

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. For next year it is hoped the data series can be extended back in time and also provide quarterly data – this will enable the standard presentations to be included once more.

Trends in Scottish effort and LPUE are shown in Figure 3.3.9.3 and Table 3.3.9.2. Effort has declined over the time period partly as a result of reductions 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 to 2009 but has dropped back slightly in the last couple of years but remaining relatively high compared with the rest of the time series.

Length compositions

Levels of both market and discard sampling are low and in 2011 there were no samples taken. Sampled data are only available from the Scottish fleet. Mean sizes in the catch and landings or 2009 and 2010 are shown Table 3.3.9.3. 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 8 years. The survey has been conducted using the same towed sledge as that used to survey the other functional units around Scotland (e.g. Fladen). 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.

3.4.9.6 Data analyses

A density distribution map of these surveys is shown in Figure 3.3.9.4 with the size of the symbol reflecting the *Nephrops* burrow density. Table 3.3.9.4 and Figure 3.3.9.5 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 method described in this report (and used for FUs 6-9) requires a bias-corrected estimate of absolute abundance. The first step in obtaining this estimate is to be able to raise the density estimates to an absolute abundance 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 also investigated. Figure 3.3.9.6 shows the BGS map overlaid with VMS data from Scottish *Nephrops* vessels from 2006-2009. It is clear 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.

Fished area estimates were obtained from the VMS data using a number of different approaches:

1) thin plate regression spline (TPS) model
2) alpha convex hull
3) cells containing on average > 2 pings/year

Methods 1) and 2) are described in detail in ICES (2010) (the SGNEPS report) where they are applied to data from the North and South Minch. The parameter values used for the Devil's Hole were identical to those used previously, but without full investigation of the appropriateness of the values. The third method entails discretising the area into cells approximately 1 km^2, calculating the frequency of VMS pings within each cell and then excluding cells which have < 2 pings per year. The total area is then divided into ten sub-areas and the fished area within each polygon calculated.

Figure 3.3.9.7 shows the estimated fished area for the three methods using the 2009 VMS data (all years for method 3). The TPS model excludes many of the low density outlying areas, but due to the choice of discretisation scheme, the fished area within the trenches appears to be broader. The alpha-convex hull method appears to give a more realistic picture of the fished area, but this method is highly dependent on the choice of alpha, with lower values giving finer scale variation in the shapes. Method 3 averages over years and hence does not include areas which are not fished consistently throughout the time series (in the northeast of the region). Methods 2 and 3 give relatively similar pictures of the fished area.

A comparison of the estimated areas is given in the text table below.

AREA ESTIMATES (KM^2)

	TPS model (>50 pings grid sq)	α hull (α=0.01)	Average > 2 pings/year
2006	336.3	666.8	
2007	1390.7	1149.3	
2008	1379.8	1296.1	1061.8
2009	1211.8	1145.0	

From this preliminary analysis, it appears that the stock distribution of *Nephrops* at the Devil's Hole has an area of around 1100 km^2. Raising the average densities to this area would result in an abundance estimate of ~ 350 million individuals, at the lower end of abundance estimates for N Sea functional units (with UWTV surveys). Further exploration of these methods with potentially more appropriate parameter estimates will be carried out in future. In addition, appropriate bias-correction factors also need to be derived to account for edge-effects, burrow misidentification, etc.

3.4.9.7 Historical stock trends

Scottish landings from this area have risen substantially over the last ten years but fell by over 40 % in 2010 and 2011. Estimates of mean density in the stock have declined from 2009 to 2011, but remain significantly 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.

3.4.9.8 Recruitment estimates

There are no recruitment estimates for this FU.

3.4.9.9 MSY considerations

There is currently insufficient catch-at-length data to conduct a combined length cohort analysis, and therefore Fmsy proxy harvest rates have not been calculated for this functional unit. Sampling was not possible in 2012 so no additional analysis was performed in 2012.

3.4.9.10 Short-term Forecasts

No short-term forecasts are presented for this FU.

3.4.9.11 Status of the stock

The current state of the stock is unknown.

3.4.9.12 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.

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 the functional unit 34 – Devil's Hole (see text table below). The discard rate and mean weight was taken from FU7. The 2012 survey shows that density is low to moderate on this ground at 0.3 burrows per metre squared. 10 year average landings of 600 at this density equates to a harvest rate of around 6.3%, which is well below any proxy for Fmsy used on other grounds. There is uncertainty in the TV estimate, but the table below shows that even if the density were over-estimated by 50%, the harvest rate would still be below 10% at the level of average landings. Maximum landings of 1200t carries an appreciably higher risk of exceeding any MSY proxies.

FU34 : Devil's Hole 1,100 Area (km2) 30 mean weight (g) 4% 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	300	18.9%	9.5%	4.7%	3.2%	2.4%	1.9%	1.6%	1.4%	1.2%
Average	600	37.8%	18.9%	9.5%	6.3%	4.7%	3.8%	3.2%	2.7%	2.4%
Maximum	1200	75.6%	37.8%	18.9%	12.6%	9.5%	7.6%	6.3%	5.4%	4.7%

Latest TV survey * preliminary

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	IIIa	
4	Kattegat	IIIa	
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 , 1991-2008.

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				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	2924	1304	862	2063	4223	1404	1519	196				560	15055
1992	1893	1012	612	1473	3363	1757	1591	188				401	12290
1993	2288	924	721	3030	3493	2369	1808	376	339	160		434	15942
1994	1981	893	503	3683	4569	1850	1538	495	755	137		703	17107
1995	2429	998	869	2569	6440	1763	1297	280	489	164		844	18142
1996	2695	1285	679	2483	5217	1688	1451	344	952	77		808	17679
1997	2612	1594	1149	2189	6171	2194	1446	316	760	276		662	19369
1998	3248	1808	1111	2177	5136	2145	1032	254	836	350		694	18791
1999	3194	1755	1244	2391	6521	2205	1008	279	1119	724		988	21428
2000	2894	1816	1121	2178	5569	1785	1541	275	1084	597		900	19760
2001	2282	1774	1443	2574	5541	1528	1403	177	1190	791		1268	19971
2002	2977	1471	1231	1954	7247	1340	1118	401	1170	861		1383	21153
2003	2126	1641	1144	2245	6294	1126	1079	337	1089	929		1390	19400
2004	2312	1653	1070	2153	8729	1658	1335	228	922	1268		1224	22552
2005	2546	1488	1099	3094	10685	1990	1605	165	1089	1050		1120	25931
2006	2392	1280	974	4903	10791	2458	1803	133	1028	1288		1249	28299
2007	2771	1741	1294	2966	11910	2652	1842	155	755	1467		1637	29190
2008	2851	2025	963	1218	12240	2450	1514	173	675	1444		1673	27226
2009	3004	1842	728	2703	13327	2662	1067	89	477	1163		2367	29429
2010	2938	2185	959	1443	12825	1871	1032	38	407	806	757	709***	25970
2011	2511	1475	1053	2070	7558	1888	1391	69	395	1191	433	1166****	20034

* Provisional

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

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

******IV only**

Table 3.2.1.1 Nephrops in Division IIIa. Total landings per country (tonnes)

Year	Denmark	Norway	Sweden	Germany	Total
1991	2824	185	1219		4228
1992	2052	104	749		2905
1993	2250	103	859		3212
1994	2049	62	763		2874
1995	2419	90	918		3427
1996	2844	102	1034		3980
1997	2959	117	1130		4206
1998	3541	184	1319	12	5056
1999	3486	214	1243	6	4949
2000	3325	181	1197	7	4710
2001	2880	138	1037	1	4056
2002	3293	116	1032	7	4448
2003	2757	99	898	13	3767
2004	2955	95	903	12	3965
2005	2901	83	1048	2	4034
2006	2432	91	1143	6	3672
2007	2887	145	1467	13	4512
2008	3174	158	1509	19	4860
2009	3372	128	1331	15	4846
2010	3721	124	1249	29	5123
2011	2937	87	945	17	3986

.

Table 3.2.1.2. - Division IIIa: Total *Nephrops* landings (tonnes) by Functional Unit, 1991-2011.

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

Table 3.2.1.3. - Division IIIa: Total *Nephrops* landings (tonnes) by country, 1991-2011.

Year	Denmark	Norway	Sweden	Germany	Total
1991	2824	185	1219		4228
1992	2052	104	749		2905
1993	2250	103	859		3212
1994	2049	62	763		2874
1995	2419	90	918		3427
1996	2844	102	1034		3980
1997	2959	117	1130		4206
1998	3541	184	1319	12	5056
1999	3486	214	1243	6	4949
2000	3325	181	1197	7	4710
2001	2880	138	1037	1	4056
2002	3293	116	1032	7	4448
2003	2757	99	898	13	3767
2004	2955	95	903	12	3965
2005	2901	83	1048	2	4034
2006	2432	91	1143	6	3672
2007	2887	145	1467	13	4512
2008	3174	158	1509	19	4860
2009	3372	128	1331	15	4846
2010	3721	124	1249	29	5123
2011	2937	87	945	17	3986

Table 3.2.2.1. *Nephrops* in Skagerrak (FU 3): Landings (tonnes) by country, 1991-2011.

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

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, 1991-2011. (*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
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

Table 3.2.2.3. *Nephrops* Skagerrak (FU 3): Logbook recorded effort (days fishing) 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, 1991-2011.

Year	Logbook data		Estimated total effort
	Effort	LPUE	
1991	17136	73	22158
1992	12183	70	16239
1993	11073	105	14068
1994	10655	110	11958
1995	10494	132	11935
1996	11885	138	12793
1997	11791	140	12075
1998	12501	155	13038
1999	13686	139	14787
2000	14802	120	15663
2001	14244	100	13976
2002	16386	123	16750
2003	10645	121	11802
2004	11987	122	12996
2005	10682	144	12003
2006	9638	141	10737
2007	7598	212	7877
2008	7785	216	8058
2009	8394	236	8535
2010	8475	221	8949
2011	8685	196	9160

Table 3.2.2.4. - Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991-2011.

Year	Catches					
	Undersized		**Full sized**		**All**	
	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

Table 3.2.2.5. *Nephrops* Kattegat (FU 4): Landings (tonnes) by country, 1991-2011.

Year	Denmark	Sweden		Sub-total	Germany	Total
		Trawl	Creel			
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

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, 1991-2011 (*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

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	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

Table 3.2.2.7. *Nephrops* Kattegat (FU 4): Logbook recorded effort (days fishing) 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, 1991-2011.

Year	Logbook data		Estimated total effort
	Effort	LPUE	
1991	13494	69	17175
1992	12126	65	13627
1993	8815	75	10195
1994	9403	77	9802
1995	9039	91	9357
1996	9872	96	11209
1997	10028	112	11348
1998	10388	122	12144
1999	11434	109	13019
2000	12845	100	14448
2001	13017	93	15870
2002	11571	88	13772
2003	11768	103	13015
2004	11122	115	11669
2005	9286	127	9286
2006	8080	113	7998
2007	7165	162	7588
2008	7911	170	8428
2009	8323	167	8159
2010	9319	181	9722
2011	7502	137	8102

Table 3.2.2.8. ***Nephrops*** **Kattegat (FU 4): Mean sizes (mm CL) of male and female** ***Nephrops*** **in discards, landings and catches, 1991-2011. Since 2005 based on combined Danish and Swedish data.**

Year	**Catches**					
	Discards		**Landings**		**All**	
	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

Table 3.2.3.1. Summary output of the TV-survey in IIIa from 2011.

Subarea	area ($km^{2)}$	Number of stations	Mean density	Bias correction	95%Confidens interval	Population numbers (mill.)	Population estimates (tons)
1	3079	52	0.410	0.369	0.047	1135	43132
2	1982	50	0.277	0.249	0.046	494	18771
3	2462	10	0.419	0.377	0.080	928	35253
4	676	5	0.423	0.381	0.141	258	9788
5	670	5	0.465	0.418	0.149	280	10645
6	973	24	0.551	0.496	0.062	482	18322
Total	9842	146		0.363		3577	135911
Mean weight (2009-2011)			38.0g		Harvest rate	0.0505	
Removals (landings +dead discard*)			7305tons				

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

Table 3.3.1. Nominal landings (tonnes) of *Nephrops* in Sub-area IV, 1984 – 2010, as officially reported to ICES.

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

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011 *
Belgium	238	350	252	283	284	229	213	180	214	205	200	265	115	471
Denmark	1440	1963	1747	1935	2154	2128	2244	2339	2024	1408	1078	875	604	457
Faeroe Islands	1	1	0	-	-	-	-	-	-	-	-	-	-	
France	0	0	0	-	-	-	-	-	-	-	-	-	+	
Germany	58	104	79	140	125	50	50	109	288	602	266	410	373	353
Netherlands	695	662	572	851	966	940	918	1019	982	1147	737	882	701	631
Norway	93	144	147	115	130	100	93	132	96	99	143	139	123	69
Sweden	3	4	37	26	14	1	1	3	1	5	26	2	1	1
UK (Eng + Wales + NI)	2094	2431	2210	2691	1964	2295	2241	3236	4937	3295	1679	3437	-	
UK (Scotland)	8980	10715	9834	9681	11045	10094	12912	10565	16165	17930	17960	18587	-	
UK	-	-	-	-	-	-	-		-	-	-	-	18914	14041
Total	13602	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20832	16023

* Landings data for 2011 are preliminary.

Table3.3.1.1 *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

* provisional na = not available

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

Table 3.3.1.2. *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	40.5

Table 3.3.1.3 *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	566	74	7.7									
1992	525	74.5	7									
1993	672	58.3	11.5									
1994	453	35.5	12.7									
1995	559	32.5	17.2									
1996	245	30.1	8.1				34	132	261			
1997	399	31.8	12.5				24	59	412			
1998	309	28.6	10.8				78	174	447			
1999	322	31.8	10.1				44	107	408			
2000	174	21.8	8	402	7936	50.7	76	247	306	43	1416	30.5
2001	195	21.5	9.1	553	9797	56.5	78	283	275	73	2349	31.2
2002	144	15.8	9.1	617	8999	68.6	47	200	237	7	360	20.4
2003	118	6.2	19.3	661	9043	73.1	33	132	247.3	21	509	42.2
2004	106	5.7	18.8	646	8676	74.5	36	149	241.9	14	249	57.8
2005	69	2.9	23.9	654	7950	82.3	87	297	290.9	59	1193	49.4
2006	no data	no data	no data	444	6784	65.4	24	66	365.6	171	3320	51.4
2007	no data	no data	no data	464	6859	67.6	3	13	253.6	176	2494	70.5
2008	no data	no data	no data	268	4976	53.9	29	41	777	239	3787	63.1
2009	no data	no data	no data	288	5909	48.7	3	9	323.9	139	2337	59.6
2010	no data	no data	no data	354	5735	61.7	5	14	365.5	135	1576	86
2011	no data	no data	no data	480	5811	82.6	18	13	1362.3	75	980	77

* 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 3.3.2.1 ***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

* provisional na = not available

** Other countries includes Ne, Be and Dk

Table 3.3.1.2: *Nephrops* in FU 6: Landings and effort by English vessels targeting *Nephrops*.

Year	Landings (tonnes)	Effort (000 hrs)	LPUE (Kg per hr)
1994	2449	91	26.9
1995	1790	60	29.8
1996	1830	55	33.3
1997	1580	46	34.3
1998	1124	30	37.6
1999	1294	40	32.3
2000	1070	30	35.1
2001	1100	39	28.1
2002	1054	33	31.7
2003	1376	45	30.5
2004	1209	37	32.7
2005	1586	44	36.3
2006	1945	55	35.3
2007	1093	51	21.4
2008	644	38	17.1
2009	1193	42	28.2
2010	794	45	17.8
2011	968	38	25.5
	* provisional		

Table 3.3.2.3 ***Nephrops*** **in FU 6: Mean sizes in catches and landings by sex.**

Year	**Catches**		**Landings**	
	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	27.3	26.8	31.1	31.3
2001	26.3	26.4	30.6	31.3
2002	28.4	26.8	31.2	29.8
2003	29.3	27.2	31.9	30.6
2004	30.4	28.0	32.5	30.9
2005	29.9	29.4	32.2	32.2
2006	29.0	30.3	31.4	32.4
2007	31.2	30.5	33.1	32.5
2008	31.1	30.3	33.5	32.7
2009	30.5	31.0	32.1	33.2
2010	31.2	31.4	32.8	33.1
2011	32.0	31.6	33.7	33.6
* provisional na = not available				

Table 3.3.2.4 *Nephrops* **in FU 6: Results of the UWTV survey.**

Year	Stations	Season	Mean density burrows/m² (not bias-corrected)	Bias-corrected Abundance millions	95% confidence interval millions	Method
1997	87	Autumn	0.55	1500	125	Box
1998	91	Autumn	0.39	1090	89	Box
1999	-	Autumn	No survey			Box
2000	-	Autumn	No survey			Box
2001	180	Autumn	0.67	1685	67	Box
2002	37	Autumn	0.39	1048	112	Box
2003	958	Autumn	0.39	1085	90	Box
2004	76	Autumn	0.51	1377	101	Box
2005	105	Autumn	0.59	1657	148	Box
2006	105	Autumn*	0.44	1244	114	Box
2007	105	Autumn*	0.33	890	23	Geostatistics
2008	95	Autumn*	0.37	949	39	Geostatistics
2009	76	Autumn*	0.26	683	38	Geostatistics
2010	95	Autumn*	0.30	753	21	Geostatistics
2011	97	Autumn*	0.33	870	17	Geostatistics

Table 3.3.2.5 ***Nephrops*** **in FU 6: Historical harvest rate determination.**

Year	Bias corrected TV abundance index	Landings (t)	Discard rate	Mean Weight (g)	N removed	Observed Harvest Rate
2001	*1685*	2574	66.60%	20.67	374	*22.2%*
2002	*1048*	1953	46.10%	20.00	182	*17.3%*
2003	*1085*	2245	42.10%	21.89	177	*16.3%*
2004	*1377*	2152	41.70%	23.14	160	*11.6%*
2005	*1657*	3094	34.50%	23.58	200	*12.1%*
2006	*1244*	4858	31.30%	22.53	317	*25.5%*
2007	890	2966	25.00%	24.95	158	17.8%
2008	949	1213	24.90%	26.63	61	6.4%
2009	683	2711	29.30%	24.45	155	22.7%
2010	753	1443	23.00%	25.18	74	9.9%
2011	870	2072	22.60%	27.05	99	11.4%

Table 3.3.3.1 *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

		UK Scotland			Other	
Year	Denmark	*Nephrops* trawl	Other trawl	Sub-total	countries **	Total
1981	0	304	69	373	0	373
1982	0	382	40	422	0	422
1983	0	548	145	693	0	693
1984	0	549	97	646	0	646
1985	7	1016	125	1141	0	1148
1986	50	1398	95	1493	0	1543
1987	323	1024	349	1373	0	1696
1988	81	1306	186	1492	0	1573
1989	165	1719	415	2134	0	2299
1990	236	1703	598	2301	3	2540
1991	424	3024	769	3793	6	4223
1992	359	1794	1179	2973	31	3363
1993	224	2033	1233	3266	3	3493
1994	390	1817	2356	4173	6	4569
1995	439	3569	2428	5997	4	6440
1996	286	2338	2592	4930	1	5217
1997	235	2713	3221	5934	2	6171
1998	173	2291	2672	4963	0	5136
1999	96	2860	3549	6409	16	6521
2000	103	2915	2546	5461	5	5569
2001	64	3539	1936	5475	2	5541
2002	173	4513	2546	7059	15	7247
2003	82	4175	2033	6208	4	6294
2004	136	7274	1319	8593	0	8729
2005	321	8849	1514	10363	1	10685
2006	283	9396	1101	10497	11	10791
2007	119	11055	733	11788	3	11910
2008	133	11432	667	12099	8	12240
2009	130	12696	491	13187	10	13327
2010	124	12410	279	12689	12	12825
2011*	64	***7494		7494	<0.5	7558

* provisional na = not available

** Other countries includes Belgium, Norway and UK England

*** 4 main trawl gears combined in 2011; other gears <0.5 tonnes

Table 3.3.3.2 *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, 2000-2011.

Year	Landings	Effort	LPUE
2000	5127	35.4	144.8
2001	5169	28.6	180.7
2002	6230	28.6	217.8
2003	5900	22	268.2
2004	8405	21.6	389.1
2005	10223	23.6	433.2
2006	10348	22.8	453.9
2007	11736	21.6	543.3
2008	12069	22.9	5270
2009	13173	21.2	621.4
2010	12665	21	603.1
2011	7494	15.3	489.8

Table 3.3.3.3 *Nephrops*, Fladen (FU 7): Logbook recorded effort (days fishing) 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, 1991-2011.

	Logbook data	
Year	Effort	LPUE
1991	3115	116
1992	2289	130
1993	820	130
1994	1209	251
1995	841	343
1996	568	254
1997	395	349
1998	268	165
1999	197	251
2000	292	170
2001	213	181
2002	335	368
2003	194	308
2004	290	461
2005	607	482
2006	576	450
2007	274	426
2008	241	512
2009	282	512
2010	212	556
2011	117	609

Table 3.3.3.4 *Nephrops*, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1993-2011.

	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	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	38.4
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
2002	30.6	30	31.3	30.7	39.5	38.3
2003	30.9	29.8	31.2	30.1	40	38.1
2004	30.8	29.9	31.1	30.2	40.1	38.7
2005	30.9	30	31.2	30.1	40.1	38.2
2006	30.1	29.5	30.8	30	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	30.5	29	39.8	38.4
2011	31.7	29.6	31.7	29.6	41.2	38.6
* provisional, na = not available						

Table 3.3.3.5 ***Nephrops*, FUs 7-9 and 34. Mean weight (g) in the landings.**

Year	Fladen	Firth of Forth	Moray Firth
1990	31.59	20.29	20.05
1991	26.5	20.03	18.53
1992	29.61	20.96	23.49
1993	25.38	24.3	23.42
1994	23.72	19.51	22.25
1995	27.51	19.55	20.59
1996	29.82	20.81	21.4
1997	32.08	18.87	20.43
1998	31.37	18.23	20.47
1999	30.55	20.05	21.79
2000	36.35	21.83	25.44
2001	25.1	21.22	24.18
2002	27.93	19.62	27.68
2003	30.15	22.31	23.32
2004	30.98	22.45	27.57
2005	29.05	22.33	23.84
2006	29.25	21.43	22.34
2007	26.63	20.97	23.04
2008	28.18	17.23	25.29
2009	28.2	19.41	23.46
2010	26.38	19.76	26.94
2011	36.17	19.75	21.63
*Mean (08-10)	27.59	18.8	25.23

*** values used in forecast based on LCA year range**

Table 3.3.3.6. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2011 TV surveys (not bias-adjusted).**

Year	Stations	Abundance millions	Mean density burrows/m^2	95% confidence interval millions
1992	69	4942	0.17	508
1993	74	6007	0.21	768
1994	59	8329	0.3	1099
1995	61	6733	0.24	1209
1996	No survey			
1997	56	3736	0.13	689
1998	60	5181	0.18	968
1999	62	5597	0.2	876
2000	68	4898	0.17	663
2001	50	6725	0.23	1310
2002	54	8217	0.29	1022
2003	55	7488	0.27	1452
2004	52	7729	0.27	1391
2005	72	5839	0.21	894
2006	69	6564	0.23	836
2007	82	9473	0.34	986
2008	74	9936	0.35	1375
2009	59	7367	0.26	1042
2010	67	7052	0.25	959
2011	73	4566	0.16	587

Table 3.3.3.7. ***Nephrops*****, Fladen Ground (FU 7):Summary of TV results for most recent 3 years (2009-2011) 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 (km^2)	Number of Stations	Mean burrow density (no./m^2)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
>80	3248	10	0.622	0.013	2020	14039	0.052
55<80	4967	13	0.318	0.039	1582	74914	0.276
40<55	4304	18	0.394	0.049	1697	50394	0.186
<40	15634	18	0.132	0.01	2067	132204	0.487
Total	28153	59			7366	271551	1
2010 TV survey							
>80	3248	8	0.48	0.013	1559	17558	0.076
55<80	4967	13	0.378	0.041	1880	78487	0.341
40<55	4304	13	0.258	0.022	1112	31196	0.136
<40	15634	33	0.16	0.014	2501	102861	0.447
Total	28153	67			7052	230102	1
2011 TV survey							
>80	3248	11	0.265	0.002	862	1848	0.021
55<80	4967	16	0.234	0.011	1164	17020	0.198
40<55	4304	11	0.201	0.015	865	24765	0.288
<40	15634	35	0.107	0.006	1675	42499	0.493
Total	28153	73			4566	86132	1

Table 3.3.3.8 *Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2011.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	5547	6294	0.1	0.08	0.04
2004	5725	8729	0.11	0.08	0.05
2005	4325	10685	0.11	0.09	0.09
2006	4862	10791	0.13	0.1	0.08
2007	7017	11910	0.11	0.08	0.07
2008	7360	12240	0.04	0.03	0.06
2009	5457	13327	0.1	0.07	0.09
2010	5224	12825	0.06	0.05	0.1
2011	3382	7558	0	0	0.062

Table 3.3.4.1 *Nephrops*, Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	UK Scotland				UK	
	Nephrops trawl	Other trawl	Creel	Sub-total	(E, W & NI)	Total **
1981	945	61	0	1006	0	1006
1982	1138	57	0	1195	0	1195
1983	1681	43	0	1724	0	1724
1984	2078	56	0	2134	0	2134
1985	1908	61	0	1969	0	1969
1986	2204	59	0	2263	0	2263
1987	1582	92	0	1674	0	1674
1988	2455	73	0	2528	0	2528
1989	1833	52	0	1885	1	1886
1990	1901	28	0	1929	1	1930
1991	1359	45	0	1404	0	1404
1992	1714	43	0	1757	0	1757
1993	2349	18	0	2367	2	2369
1994	1827	17	0	1844	6	1850
1995	1708	53	0	1761	2	1763
1996	1621	66	1	1688	0	1688
1997	2137	55	0	2192	2	2194
1998	2105	38	0	2143	2	2145
1999	2192	9	1	2202	3	2205
2000	1775	9	0	1784	1	1785
2001	1484	35	0	1519	9	1528
2002	1302	31	1	1334	6	1340
2003	1115	8	0	1123	3	1126
2004	1651	4	0	1655	3	1658
2005	1973	0	6	1979	11	1990
2006	2437	4	12	2453	5	2458
2007	2628	9	8	2645	7	2652
2008	2435	3	7	2445	5	2450
2009	2626	1	26	2653	9	2662
2010	1848	3	12	1862	9	1871
2011*	***1794		89	1883	5	1888

* provisional na = not available

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

*** 4 trawl gears in 2011;also includes 5 t other gears

Table 3.3.4.2 *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, 2000-2011.

Year	Landings	Effort	LPUE
2000	1778	10.5	169.3
2001	1494	11.5	129.9
2002	1314	10.4	126.3
2003	1118	8.3	134.7
2004	1651	9.5	173.8
2005	1972	7.7	256.1
2006	2406	6.2	388.1
2007	2627	6.4	410.5
2008	2435	6.4	380.5
2009	2628	5.9	445.4
2010	1847	5.1	362.2
2011	1789	4.6	388.9

Table 3.3.4.3 *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, 1981-2011.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31	39.7	38.7
1982	na	na	30.4	30.1	40	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
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	30.3	29.5	39	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	27.4	29.8	28.8	38.6	38.6
1997	27.2	27	29.2	28.7	38.8	38.2
1998	27.7	26.4	29	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27	30.6	29.2	38	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
2004	28.6	27.8	30.7	30	38.4	37.6
2005	27.6	26.9	30.3	30	38.7	38.2
2006	27.3	27	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
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011*	28.6	27.5	30	28.3	38.8	38.2

* provisional na = not available

Table 3.3.4.4. *Nephrops*, Firth of Forth (FU 8): Results of the 1993-2011 TV surveys.

Year	Stations	Mean Density burrows/m²	Abundance millions	95% conf interval millions
1993	37	0.72	655	167
1994	30	0.58	529	92
1995	no survey			
1996	27	0.48	443	104
1997	no survey			
1998	32	0.38	345	95
1999	49	0.6	546	92
2000	53	0.57	523	83
2001	46	0.54	494	93
2002	41	0.66	600	140
2003	36	0.99	905	163
2004	37	0.81	743	166
2005	54	0.92	838	169
2006	43	1.07	976	148
2007	49	0.9	816	156
2008	38	1.14	1040	350
2009	45	0.94	864	168
2010	39	0.88	804	173
2011	45	0.69	629	103

Table 3.3.4.5. ***Nephrops*****, Firth of Forth (FU 8):Summary of TV results for most recent 3 years (2009-2011) 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	Area (km^2)	Number of Stations	Mean burrow density ($no./m^2$)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
M & SM	171	9	1.178	0.657	201	2123	0.284
MS(west)	139	9	0.842	0.628	117	1346	0.18
MS(mid)	211	13	1.318	0.348	278	1189	0.159
MS(east)	395	14	0.679	0.215	268	2397	0.32
Total	915	45			864	7055	1
2010 TV survey							
M & SM	170	7	1.074	0.48	183	1992	0.266
MS(west)	139	7	0.587	0.252	82	694	0.093
MS(mid)	211	12	0.868	0.538	183	1988	0.266
MS(east)	395	13	0.903	0.234	357	2806	0.375
Total	915	39			805	7480	1
2011 TV survey							
M & SM	170	7	0.376	0.074	64	307	0.116
MS(west)	139	9	0.507	0.127	70	272	0.103
MS(mid)	211	10	0.77	0.075	162	332	0.125
MS(east)	395	19	0.843	0.212	333	1740	0.656
Total	915	45			629	2651	1

Table 3.3.4.6 ***Nephrops*****, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2011.**

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	767	1126	0.54	0.47	0.123
2004	630	1658	0.35	0.29	0.164
2005	710	1990	0.42	0.35	0.194
2006	827	2458	0.55	0.48	0.267
2007	692	2652	0.25	0.2	0.229
2008	881	2450	0.29	0.24	0.211
2009	732	2662	0.34	0.28	0.26
2010	682	1871	0.3	0.24	0.184
2011	533	1888	0.19	0.15	0.221

Table 3.3.5.1 *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	UK Scotland				UK England	Total **
	Nephrops trawl	Other trawl	Creel	Sub-total		
1981	1298	118	0	1416	0	1416
1982	1034	86	0	1120	0	1120
1983	850	90	0	940	0	940
1984	960	210	0	1170	0	1170
1985	1908	173	0	2081	0	2081
1986	1933	210	0	2143	0	2143
1987	1723	268	0	1991	0	1991
1988	1638	321	0	1959	0	1959
1989	2101	475	0	2576	0	2576
1990	1698	340	0	2038	0	2038
1991	1285	234	0	1519	0	1519
1992	1285	306	0	1591	0	1591
1993	1505	303	0	1808	0	1808
1994	1178	360	0	1538	0	1538
1995	967	330	0	1297	0	1297
1996	1084	364	1	1449	2	1451
1997	1102	343	0	1445	1	1446
1998	739	289	4	1032	0	1032
1999	813	193	2	1008	0	1008
2000	1344	194	3	1541	0	1541
2001	1188	213	2	1403	0	1403
2002	884	232	2	1118	0	1118
2003	874	194	11	1079	0	1079
2004	1223	103	9	1335	0	1335
2005	1526	64	12	1602	3	1605
2006	1718	73	11	1802	1	1803
2007	1816	17	7	1840	2	1842
2008	1443	67	4	1514	0	1514
2009	1042	22	2	1066	1	1067
2010	999	24	10	1032	0	1032
2011*	***1381		9	1390	1	1391

* Provisional

** No landings by non UK countries from this FU

*** 4 trawl gears in 2011; includes 5 t from other mobile gears

Table 3.3.5.2 *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, 2000-2011.

Year	Landings	Effort	LPUE
2000	1508	7.9	190.9
2001	1360	7.2	188.9
2002	1050	7.5	140
2003	1024	5.9	173.6
2004	1287	6.2	207.6
2005	1563	4.8	325.6
2006	1770	4.6	384.8
2007	1824	4.8	380
2008	1503	4.3	349.5
2009	1059	3.5	302.6
2010	1017	3.6	282.5
2011	1376	3.9	352.8

Table 3.3.5.3 *Nephrops*, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1991-2011.

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	40	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	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	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	30.5	38.3	38
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31	39.4	37.5
1995	25.8	25	29.9	29.3	39.1	38
1996	29.3	28.4	30.6	29.7	38.5	38
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	29.2	30.9	30.2	39.5	37.9
2002	27.2	27	31.2	30.9	41	38.7
2003	29.3	29.2	30.3	30.1	39.8	38
2004	29.3	28.4	31.3	30.8	39	39.2
2005	30	28.7	31	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	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	38.9
2011*	28.6	28.4	29.4	29	39.5	38.4

* provisional na = not available

Table 3.3.5.4 *Nephrops*, Moray Firth (FU 9): Results of the 1993-2011 TV surveys.

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.19	418	94
1994	29	0.39	850	213
1995	no survey			
1996	27	0.26	563	109
1997	34	0.14	317	66
1998	31	0.18	391	115
1999	52	0.22	484	105
2000	44	0.21	467	118
2001	45	0.19	417	135
2002	31	0.29	630	146
2003	32	0.4	883	380
2004	42	0.35	757	225
2005	42	0.48	1052	239
2006	50	0.25	539	150
2007	40	0.29	642	189
2008	45	0.26	579	183
2009	50	0.23	502	169
2010	43	0.22	491	140
2011	37	0.205	451	194

Table 3.3.5.5 ***Nephrops*, Moray Firth (FU 9):Summary of TV results for most recent 3 years (2009-2011) 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	Area (km^2)	Number of Stations	Mean burrow density ($no./m^2$)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
M & SM	169	8	0.46	0.13	78	459	0.064
MS(west)	682	15	0.24	0.14	164	4206	0.59
MS(mid)	698	15	0.19	0.04	135	1145	0.161
MS(east)	646	12	0.19	0.04	125	1315	0.185
Total	2195	50			502	7125	1
2010 TV survey							
M & SM	169	5	0.26	0.05	44	285	0.058
MS(west)	682	13	0.2	0.08	135	2765	0.568
MS(mid)	698	13	0.22	0.03	150	940	0.193
MS(east)	646	12	0.25	0.03	162	882	0.181
Total	2195	43			491	4872	1
2011 TV survey							
M & SM	169	2	0.105	0	18	6	0.001
MS(west)	682	8	0.39	0.151	266	8794	0.933
MS(mid)	698	12	0.097	0.004	68	176	0.019
MS(east)	646	15	0.154	0.016	99	453	0.048
Total	2195	37			451	9429	1.001

Table 3.3.5.6 *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 2003-2011.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	730	1079	0.14	0.11	0.07
2004	626	1335	0.33	0.27	0.11
2005	869	1605	0.15	0.12	0.09
2006	445	1803	0.13	0.1	0.2
2007	531	1842	0.08	0.06	0.16
2008	481	1514	0.11	0.09	0.14
2009	415	1067	0.08	0.06	0.12
2010	406	1032	0.2	0.16	0.11
2011	372	1391	0.14	0.11	0.19

Table 3.3.6.1 *Nephrops*, Noup (FU 10), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	Nephrops Trawl	Other trawl	Creel	Sub Total	Other UK	Total
1997	184	130	0	314	0	314
1998	183	71	0	254	0	254
1999	211	68	0	279	0	279
2000	196	79	0	275	0	275
2001	88	88	0	176	0	176
2002	244	157	0	401	0	401
2003	258	79	0	337	0	337
2004	174	53	0	227	0	227
2005	81	84	0	165	0	165
2006	44	89	0	133	0	133
2007	47	108	0	155	0	155
2008	75	98	0	173	0	173
2009	24	65	0	89	0	89
2010	4	34	0	38	0	38
2011	69		0	69	0	69

Table 3.3.6.2 *Nephrops*, Noup (FU 10): 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	270	1.6	169
2001	155	1.4	111
2002	331	2	166
2003	322	1.4	230
2004	217	0.9	241
2005	165	0.7	236
2006	132	0.6	220
2007	150	0.6	250
2008	172	0.7	246
2009	89	0.9	99
2010	39	0.8	49
2011	69	0.8	86

Table 3.3.6.3 *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997-2011. 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	40.2	38.8
2005	31	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

Table 3.3.6.4 *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006 & 2007 TV surveys. No surveys since then

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	millions
1994	10	0.63	250	90
1995	no survey			
1996	no survey			
1997	no survey			
1998	no survey			
1999	10	0.30	120	42
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	0.18	73.7	47.1
2007	9	0.15	60	25

Table 3.3.7.1 *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993-2010.

Year	Denmark	Norway			Sweden	UK	Netherlands	Total
		Trawl	Creel	Sub-total				
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	68	11	79	1	14		1090
2004	835	72	8	80	1	6		922
2005	979	89	13	102	2	6		1089
2006	939	62	19	81	1	7	5	1033
2007	652	77	20	97	5	1		755
2008	505	112	30	142	24	4		675
2009	331	107	31	138	2	6		477
2010	282	82	41	123	1	1		407
2011*	322	29	40	69	1	3		395
* provisional								

Table 3.3.7.2 *Nephrops* Norwegian Deep (FU 32): Danish effort (days) and LPUE, 1993-2010

Year	Effort	LPUE
1993	1317	121
1994	2126	208
1995	1792	198
1996	3139	235
1997	3189	218
1998	2707	214
1999	3710	226
2000	3986	192
2001	5372	166
2002	4968	188
2003	5273	177
2004	3488	216
2005	3919	234
2006	4796	196
2007	2878	226
2008	2301	220
2009	1694	195
2010	1522	185
2011	1398	231

Table 3.3.8.1 ***Nephrops*** **in FU 33. (Off Horns Reef) Landings (tonnes) by country, 1993-2010.**

	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

* provisional na = not available

** Totals for 1993-94 exclusive of landings by the Netherlands

Table 3.3.8.1 ***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, 1993-2010.**

	Logbook data		Estimated total effort
	Effort	LPUE	
1993	975	170	971
1994	739	165	761
1995	724	194	816
1996	370	157	469
1997	925	161	1078
1998	1442	208	1593
1999	2323	252	2679
2000	2286	209	2570
2001	2868	191	3454
2002	3294	207	3714
2003	3640	212	3921
2004	4306	234	4660
2005	2524	285	2776
2006	2062	308	2288
2007	1609	337	1818
2008	755	448	805
2009	543	444	515
2010	432	343	525
2011	613	607	644

* provisional na = not available

Table 3.3.9.1. *Nephrops*, Devil's Hole (FU 34). Nominal landings (tonnes) of *Nephrops* as reported to the WG for 2011. Scottish data only 1991 to 2008

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-total				
1991	83							
1992	106							
1993	44							
1994	129							
1995	132							
1996	128							
1997	99							
1998	88							
1999	202							
2000	185							
2001	270							
2002	343							
2003	674							
2004	489							
2005	379							
2006	448							
2007	715							
2008	937							
2009	1297	8	0	1305	0	0	0	1305
2010	712	18	0	730	25	1	1	757
2011*	423	0	0	423	10			433
* provisional								

Table 3.3.9.2 *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, 2000-2011.

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

Table 3.3.9.3. *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, 2009-2010. Samples not available in 2011

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
2009	31.6	31	31.7	31.1	41.3	40.6
2010*	32.2	29.9	32.2	29.9	39.6	39.4
* provisional						

Table 3.3.9.4. ***Nephrops*, Devil's Hole (FU 34). Results of the 2003, 2005 and 2009-11 surveys.**

Year	Stations	Mean density	95% confidence interval
		burrows/m²	millions
2003	20	0.13	0.03
2004	no survey		
2005	29	0.12	0.05
2006	no survey		
2007	no survey		
2008	no survey		
2009	14	0.36	0.17
2010	20	0.32	0.11
2011	15	0.26	0.13

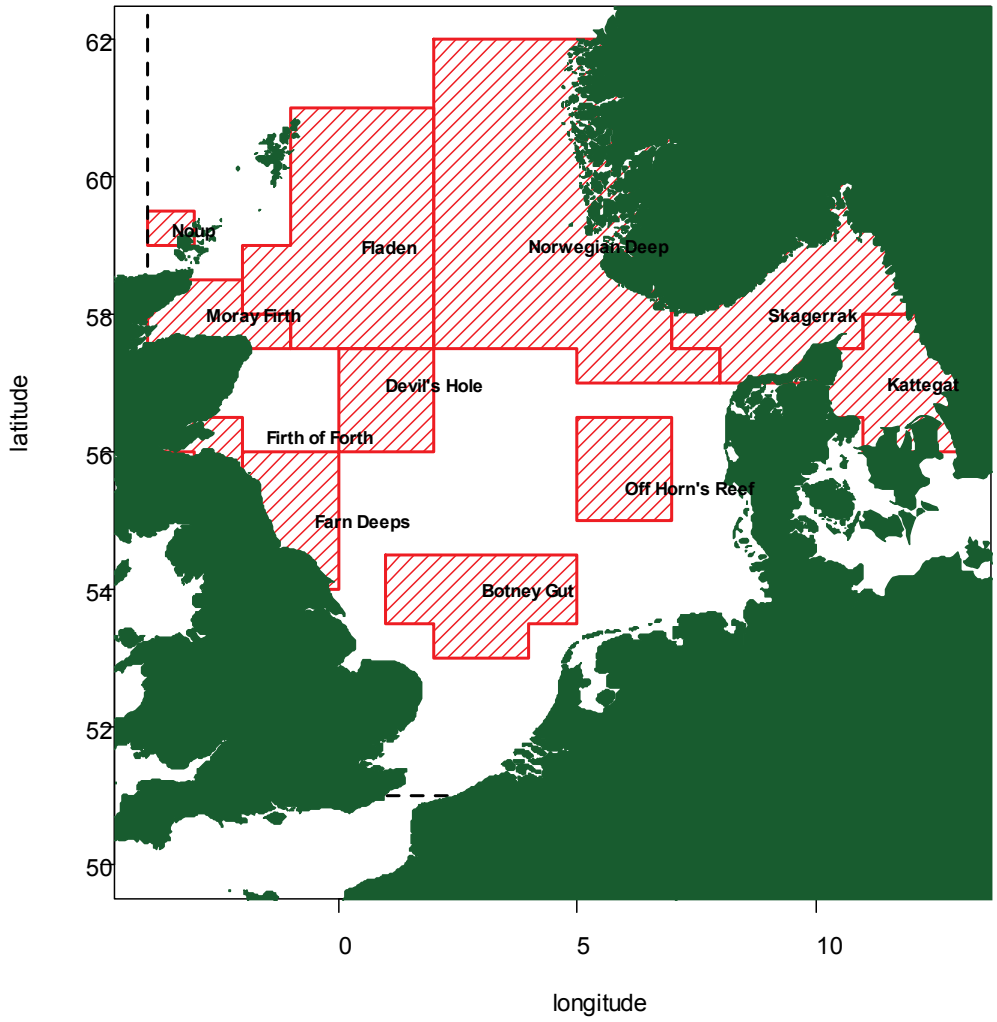


Figure 3.1.1. Nephrops Functional Units in the North Sea and Skagerrak/Kattegat region.

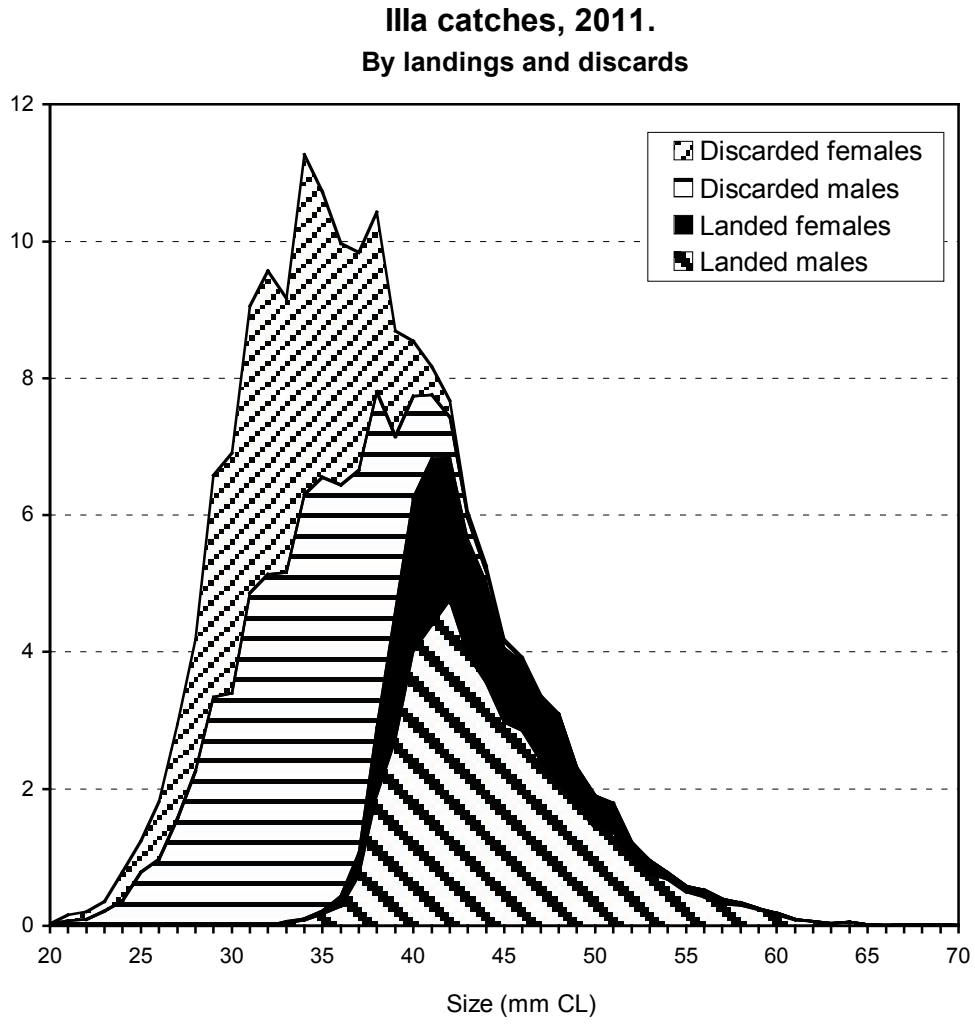


Figure 3.2.1.1. - Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of Nephrops catches, split by catch fraction (landings and discards) and sex. Data for Den-mark and Sweden combined for 2011.

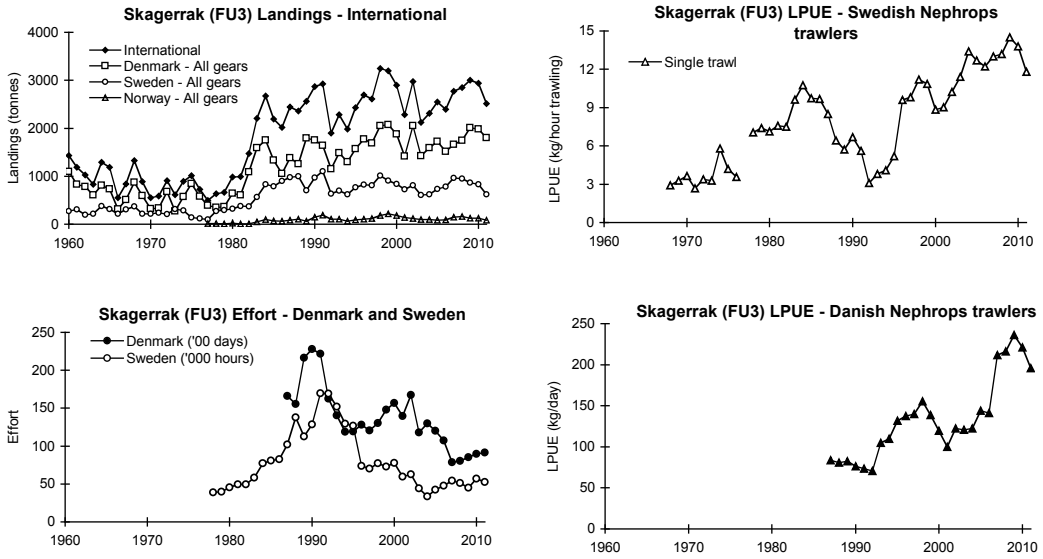


Figure 3.2.2.1. Nephrops Skagerrak (FU 3): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.

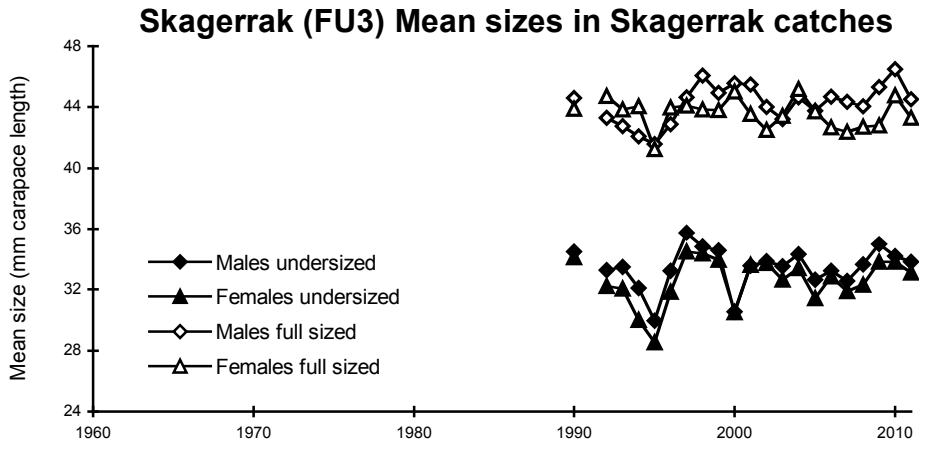


Figure 3.2.2.2 Nephrops in FU 3. Mean sizes in the catches.

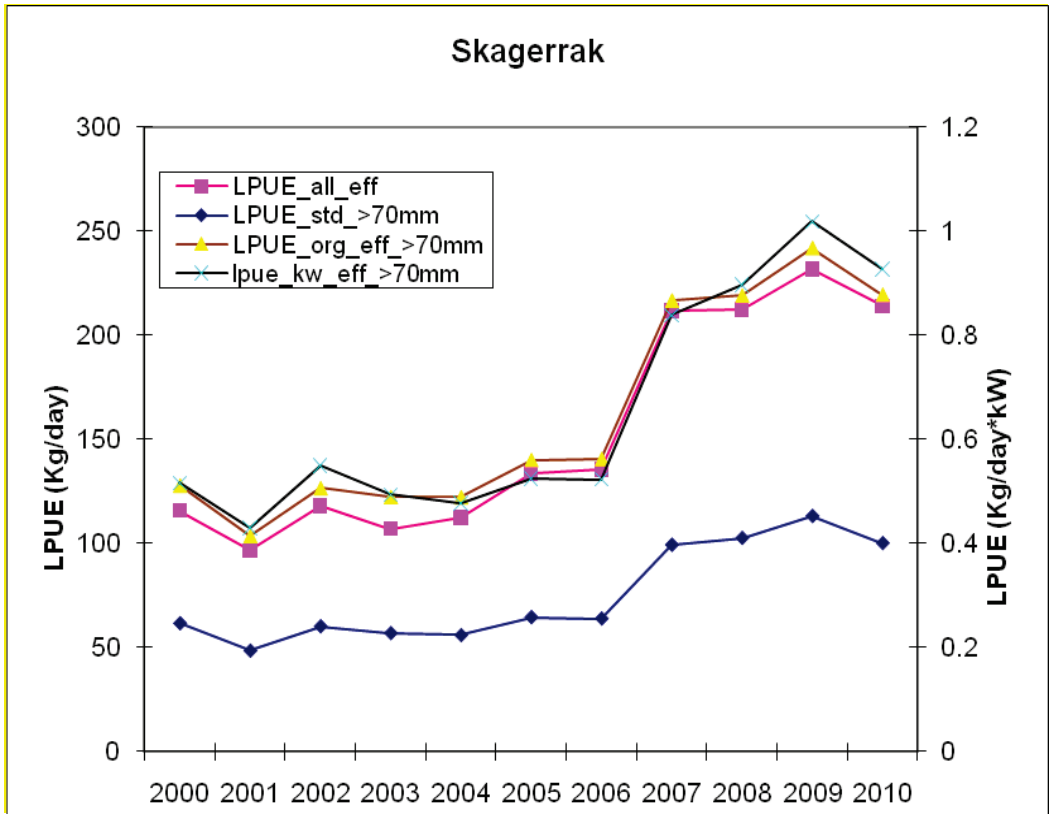


Figure 3.2.2.3 Nephrops in FU 3. LPUE trends.

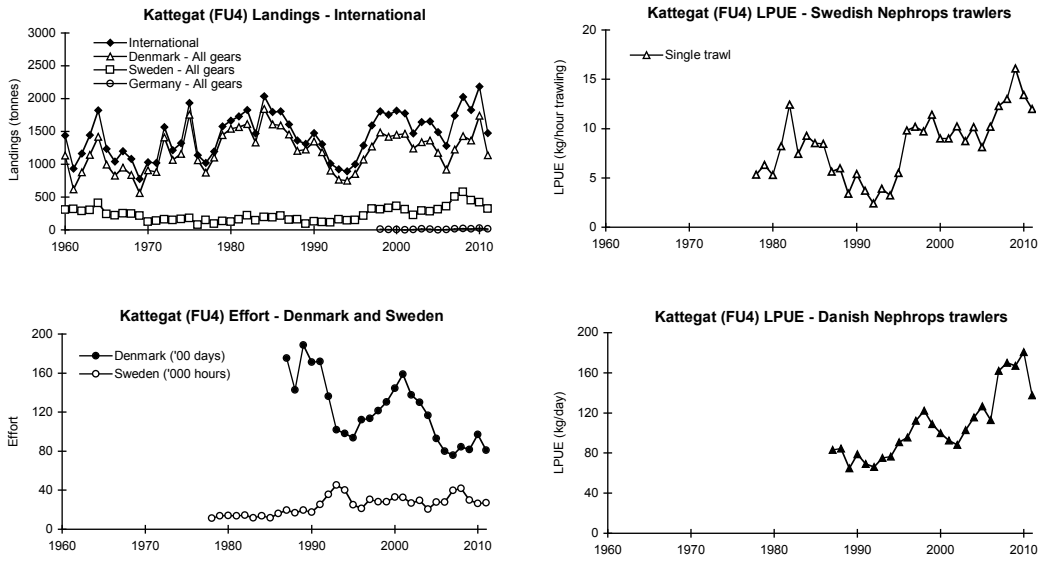


Figure 3.2.2.4. Nephrops Kattegat (FU 4): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.

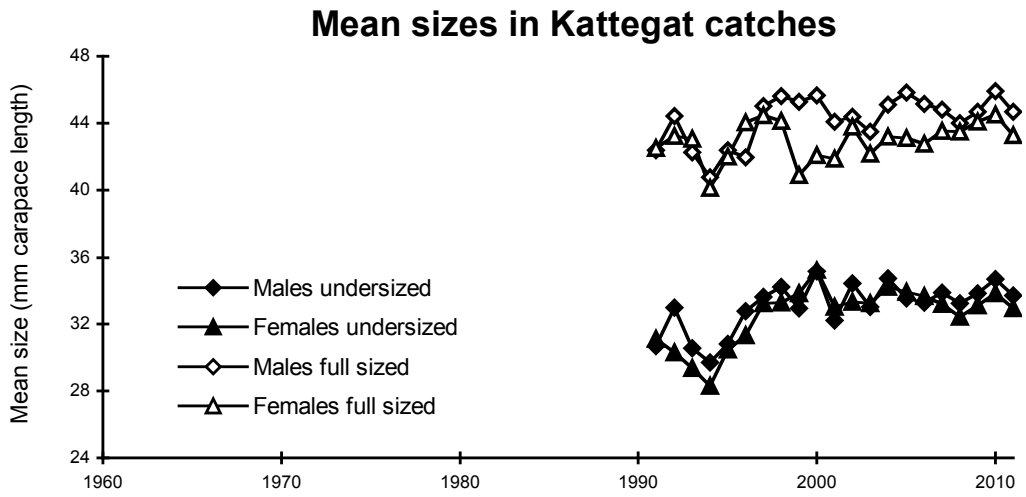


Figure 3.2.2.5 Nephrops in FU 4. Mean sizes in the catches.

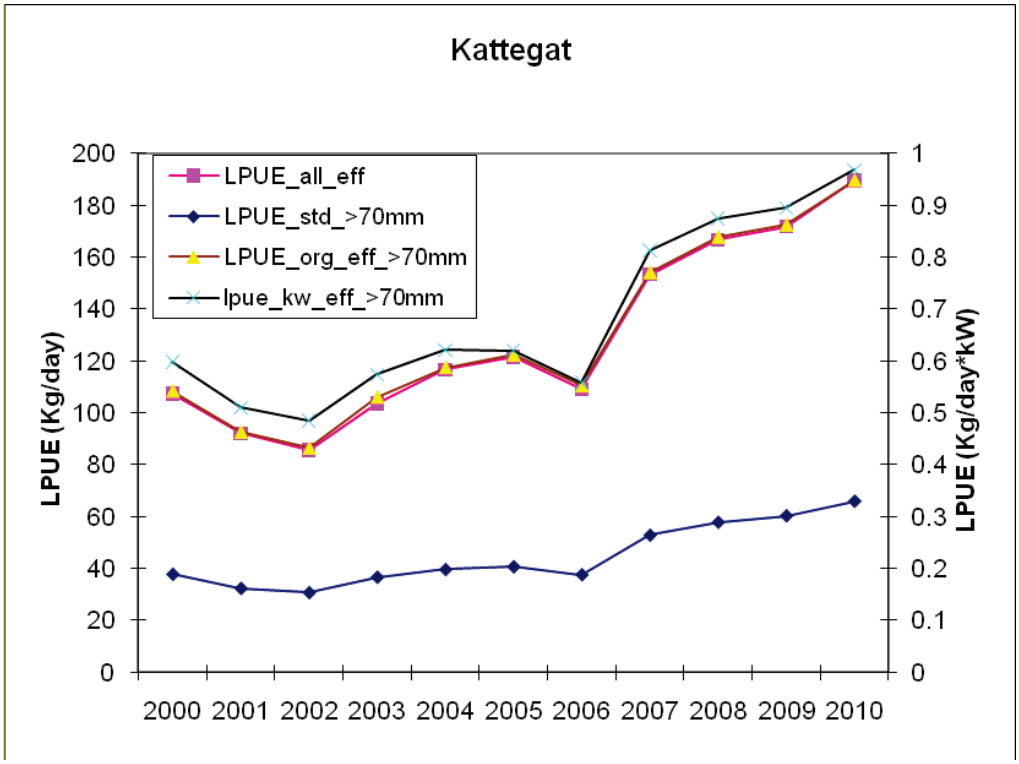


Figure 3.2.2.6 Nephrops in FU 4. LPUE trends.

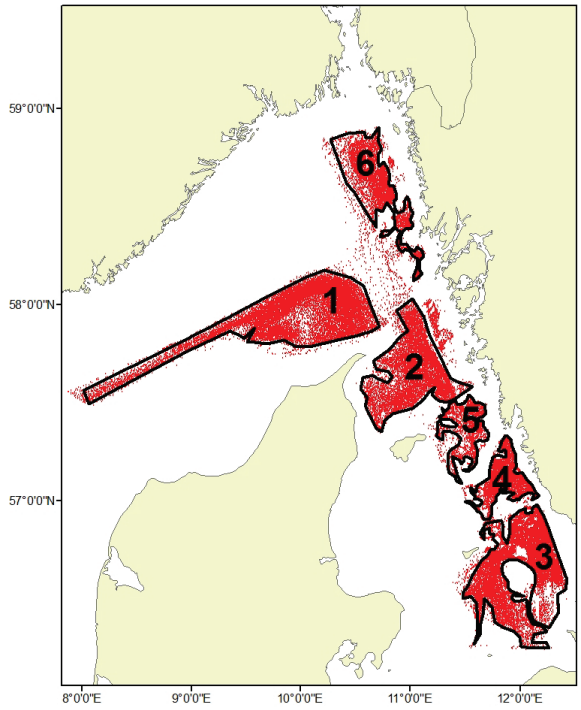


Figure 3.2.3.2. The defined sub areas of the Nephrops stock in IIIa.

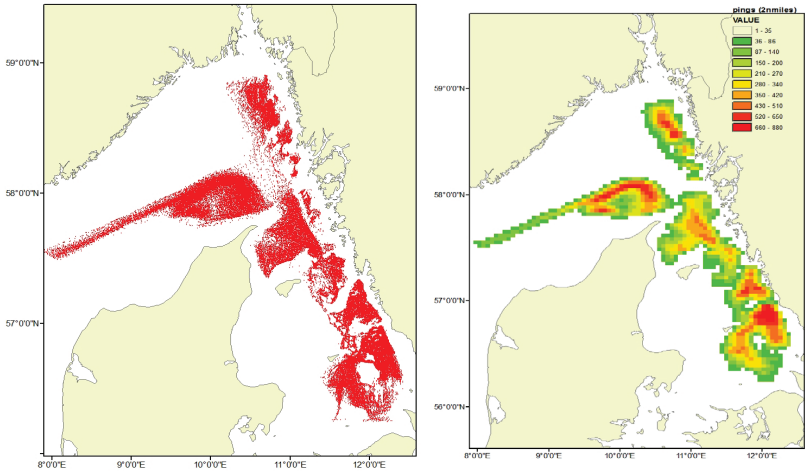


Figure 3.2.3.3. The spatial distribution of the Danish and Swedish Nephrops fishery in 2010. Left map shows vms pings and the right map shows density of vms pings.

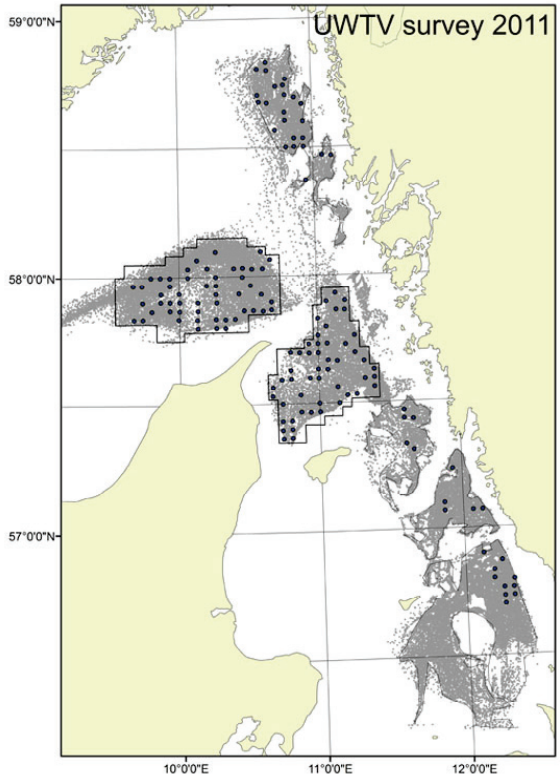


Figure 3.2.3.4. Stations of the Danish and Swedish TV-survey in 2011.

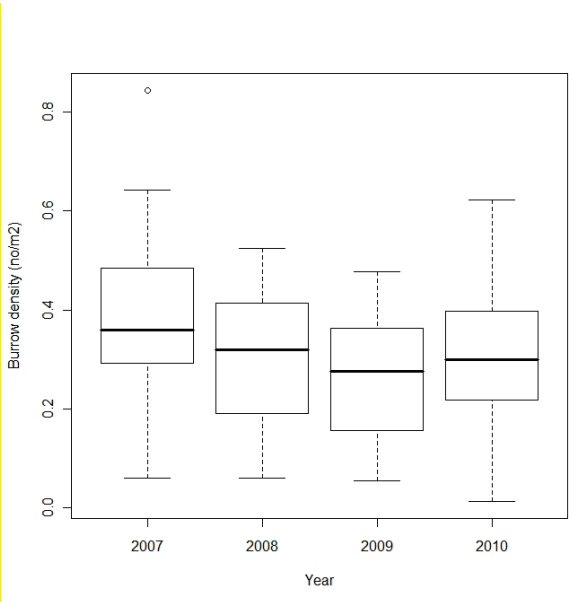


Figure 3.2.3.5. Boxplot of the density (no. of burrows/m2) bias corrected for sub-area 2 from 2007 to 2010.

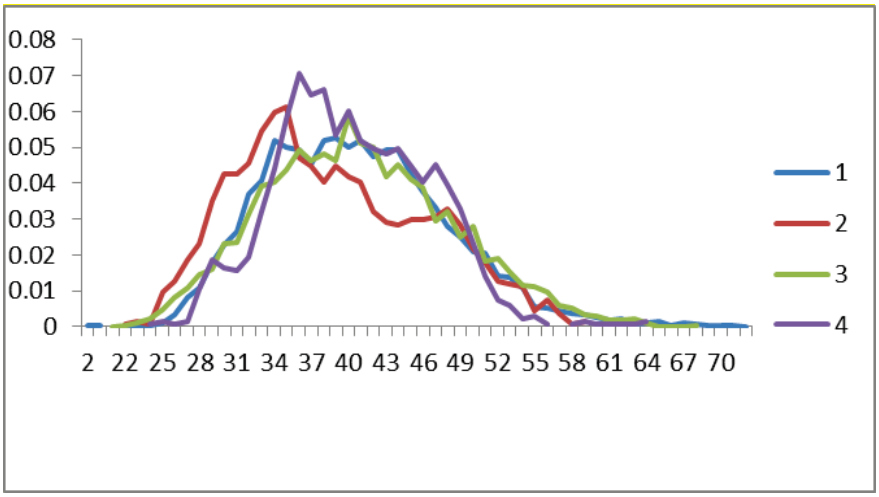


Figure 3.2.3.6. Length distributions of the Danish sea-samples in 2010 by subarea(1-4). No information exist for subarea 5 and 6.

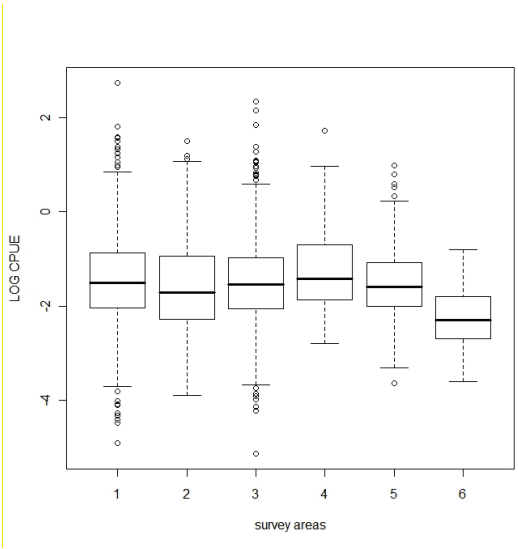


Figure 3.2.3.7. Boxplot of the catch rate (kilo Nephrops/kilowatt days) for the Danish fleet in 2010 by subarea.

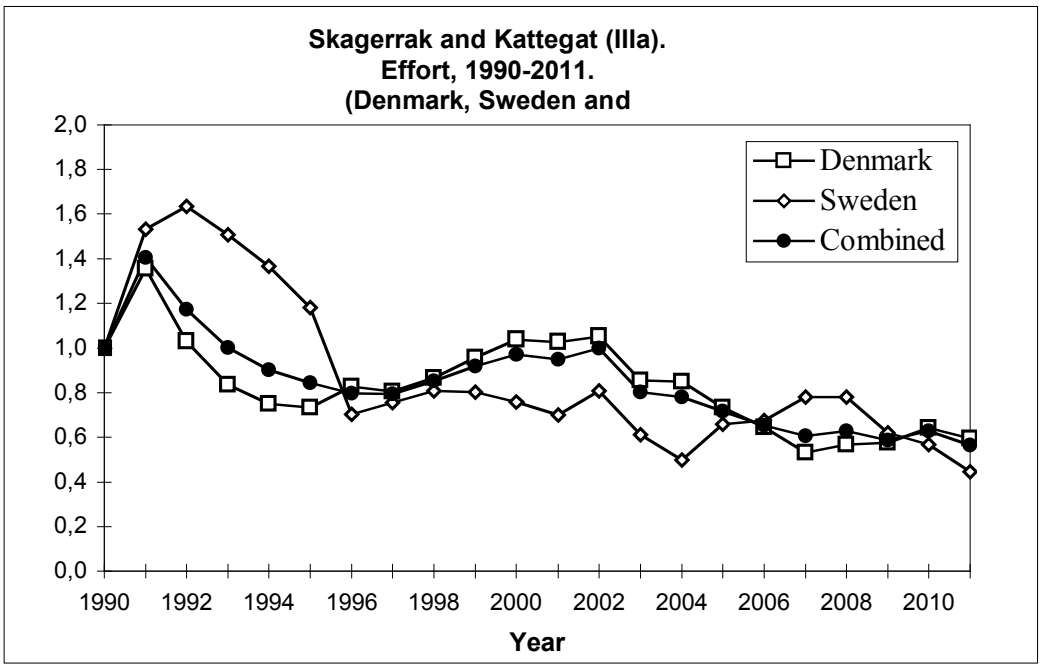


Figure 3.2.4.1 Nephrops in Area IIIa. Combined Effort for FU 3&4

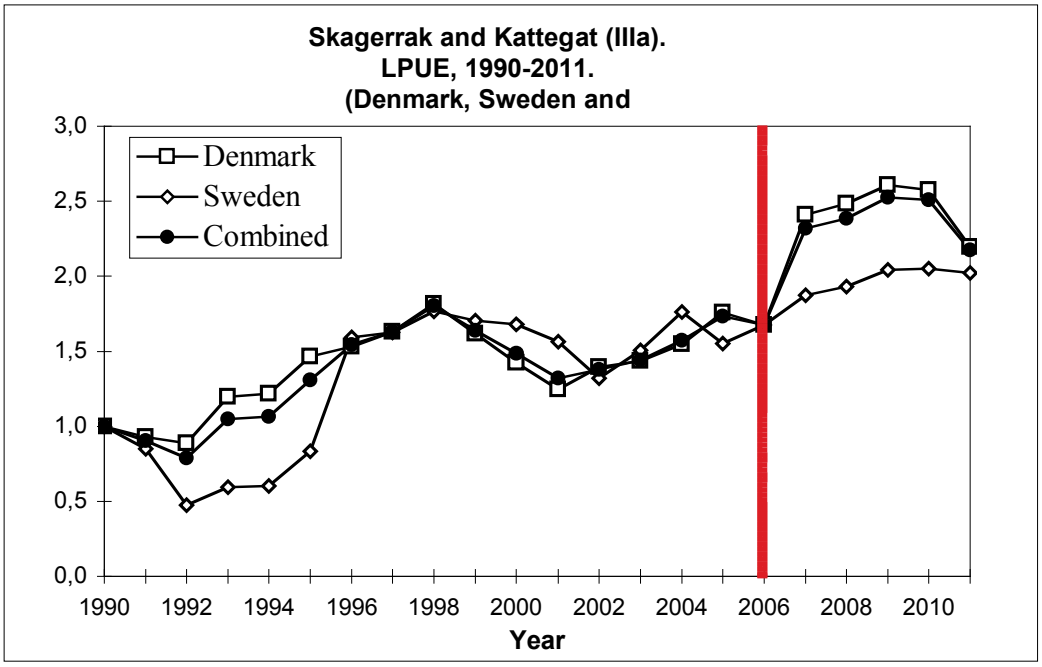


Figure 3.2.4.2 Nephrops in Area IIIa. Combined LPUE for FU 3&4. Red dotted line shows the year before the shift in Danish management system.

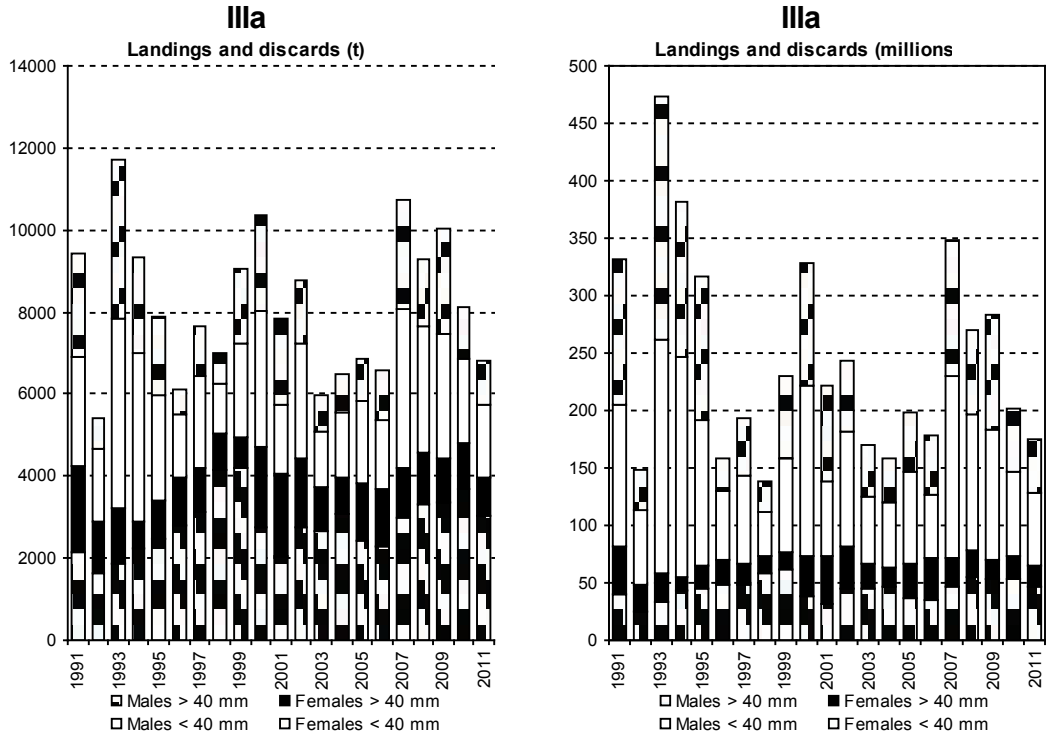


Figure 3.2.4.3 ***Nephrops*** **in IIIa FUs 3&4. Catch by sex and size category in numbers and biomass.**

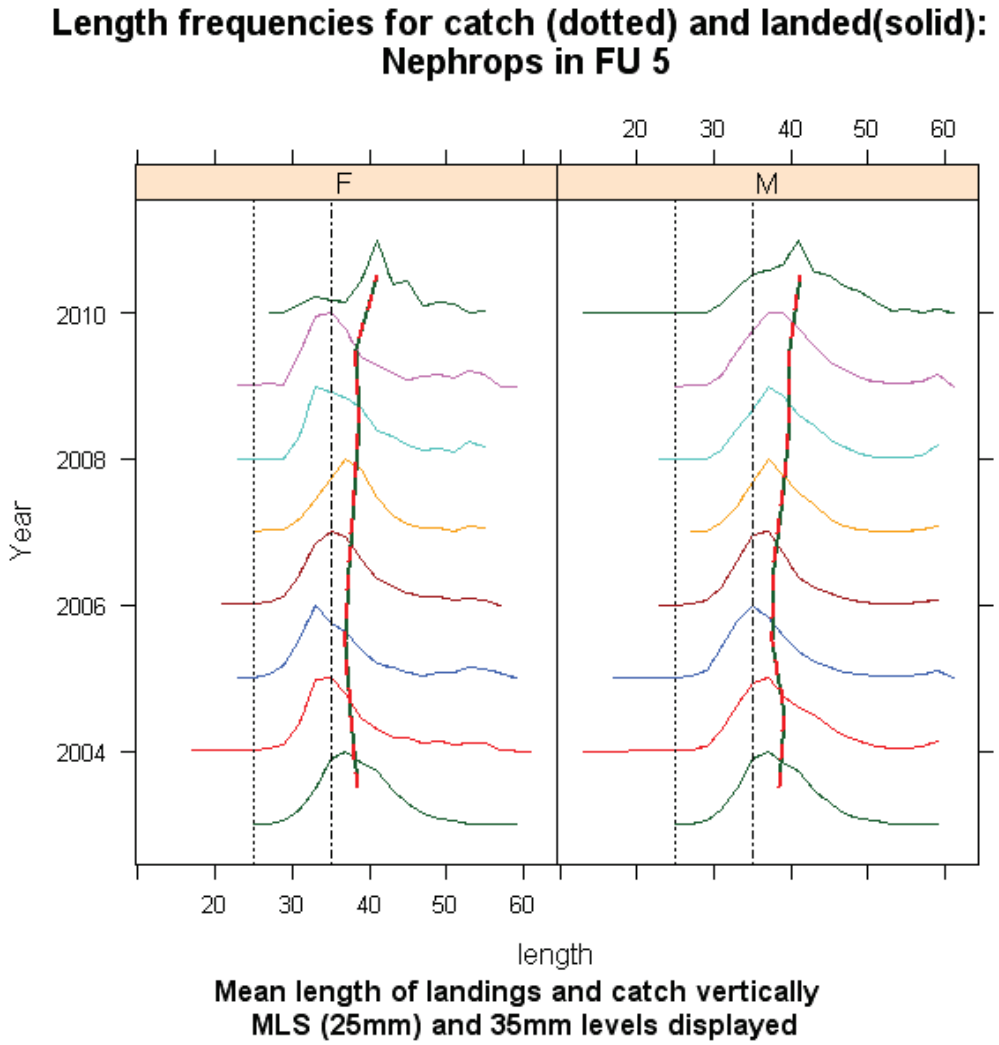


Figure 3.3.1.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2003 to 2011. For 2003 the length distribution is given by sex combined.

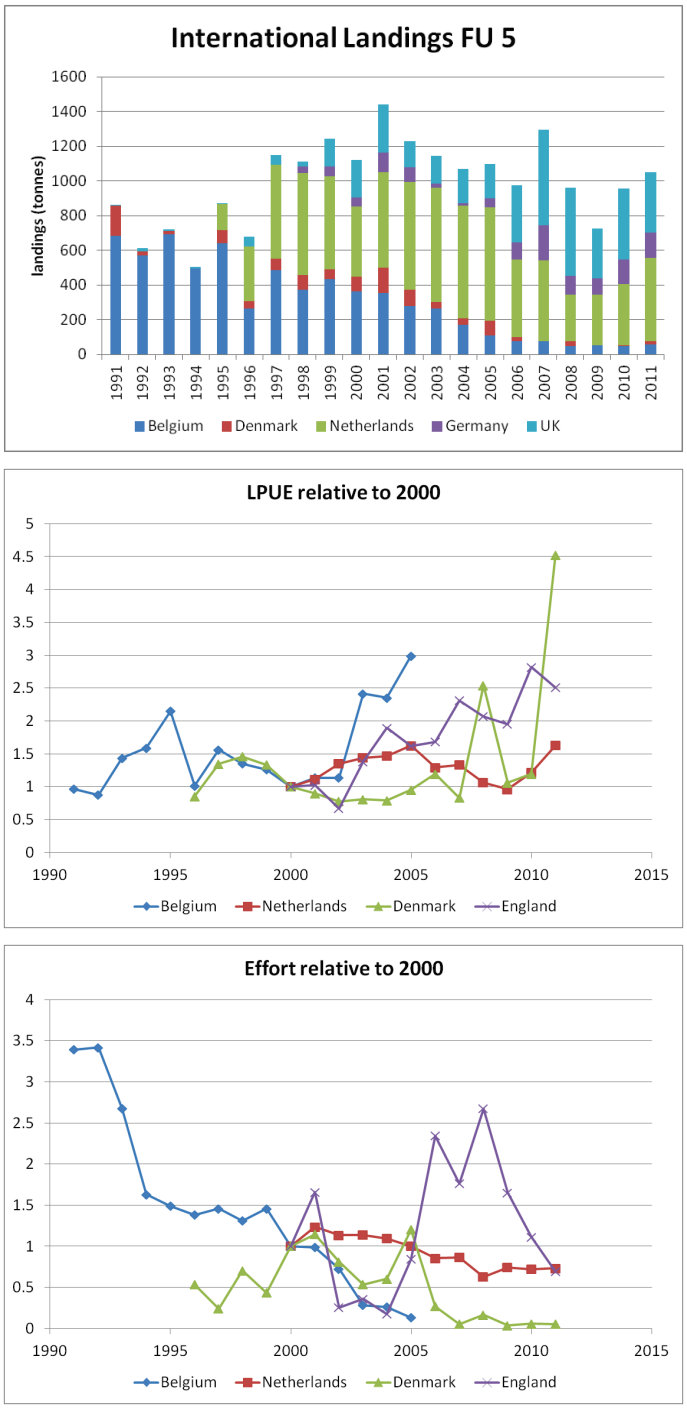


Figure 3.3.1.2 - FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUEs.

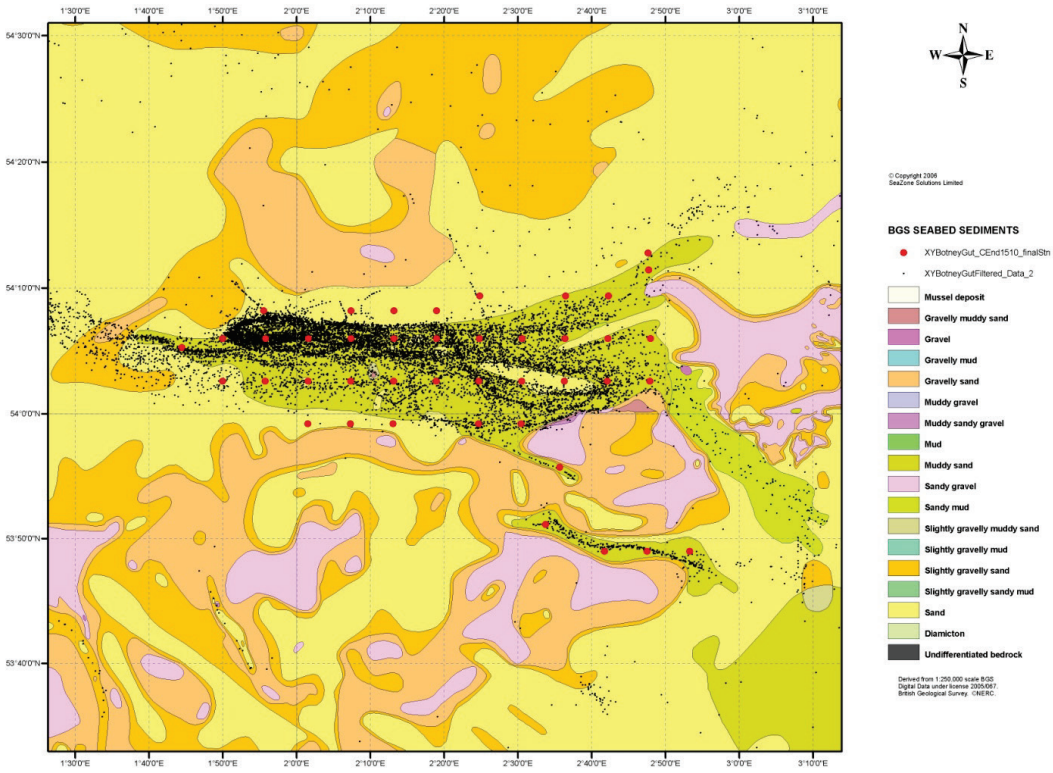


Figure 3.3.1.3 - FU5 Botney Gut/Silver Pit. Map showing BGS sediment data, fishing vessel activity from satellite data and the 42 survey station locations.

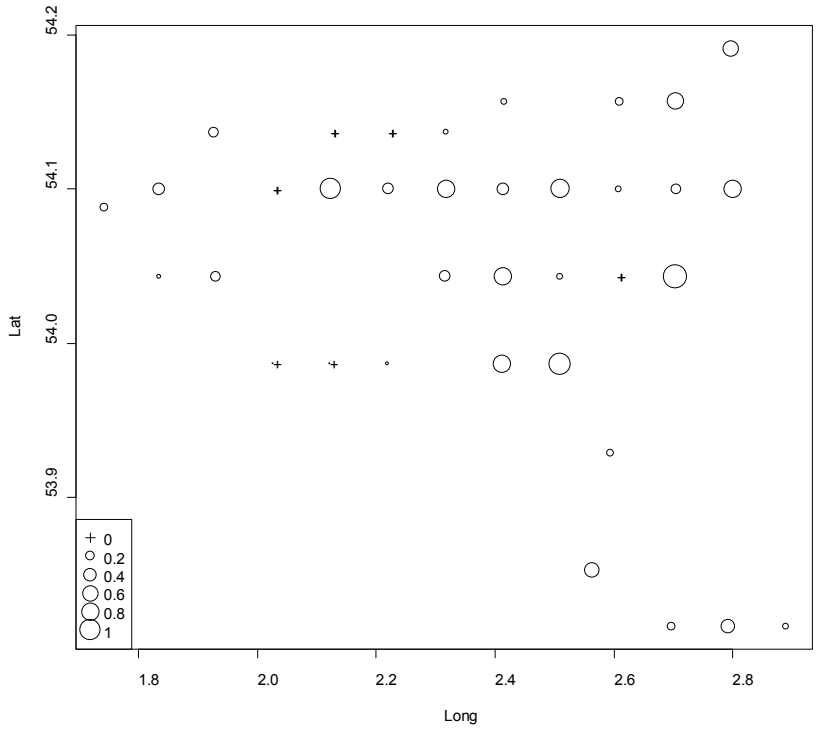


Figure 3.3.1.5. Preliminary UWTV survey results for FU5.

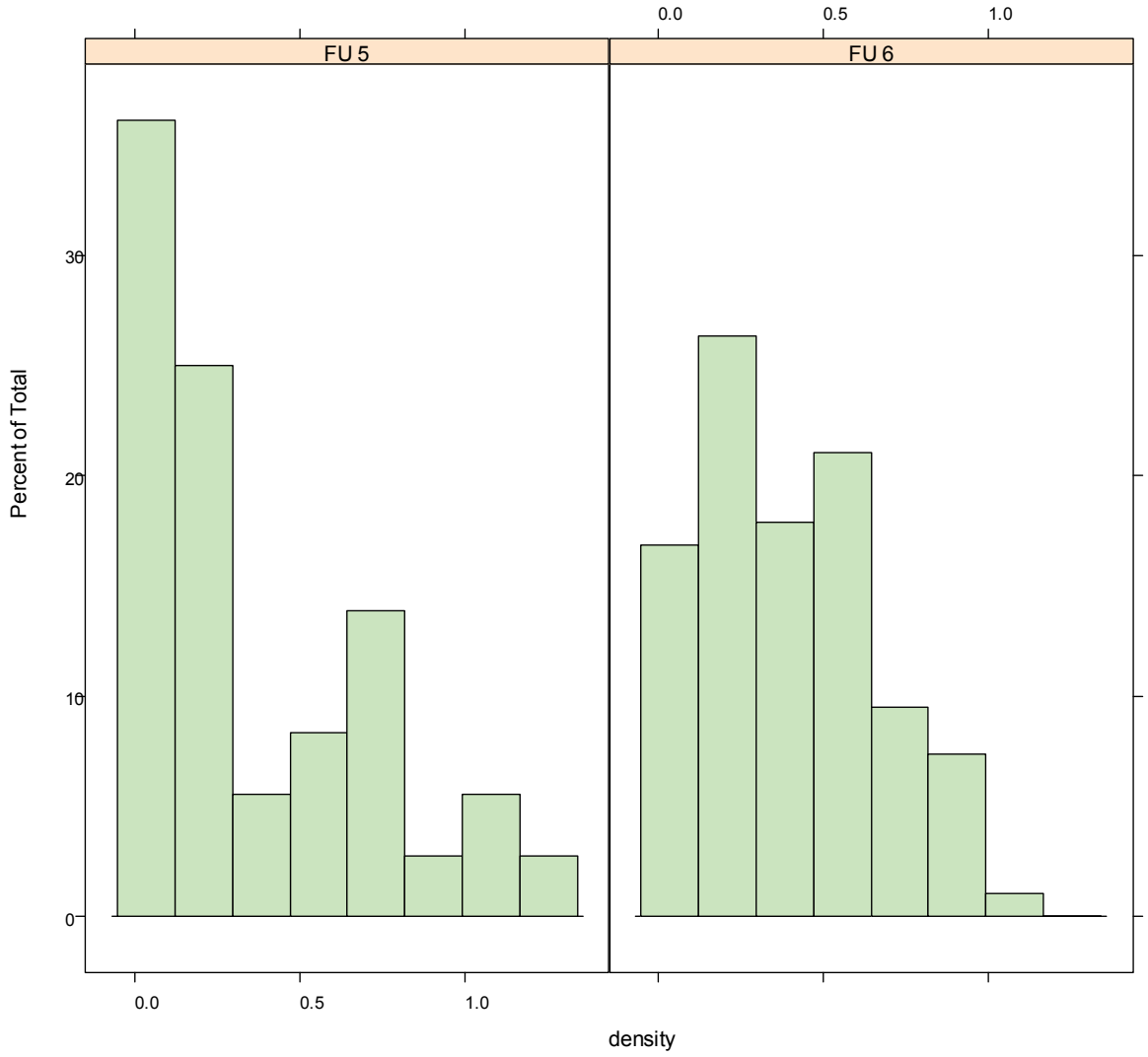


Figure 3.3.1.6. Comparison of burrow density composition between functional units 5 and 6

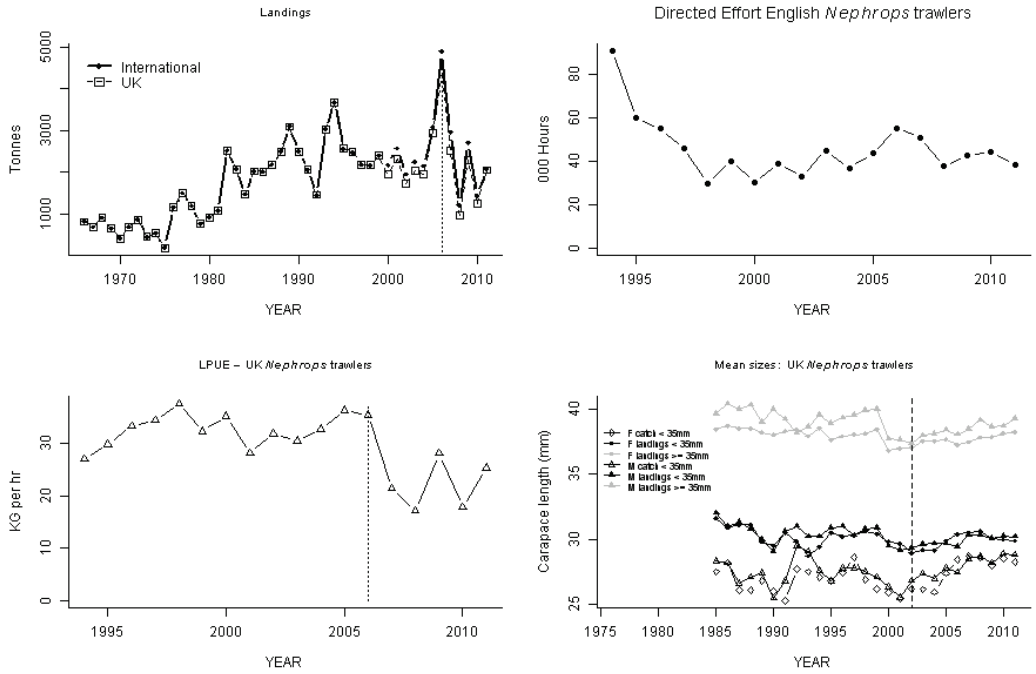


Figure 3.3.2.1 ***Nephrops*** **in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.**

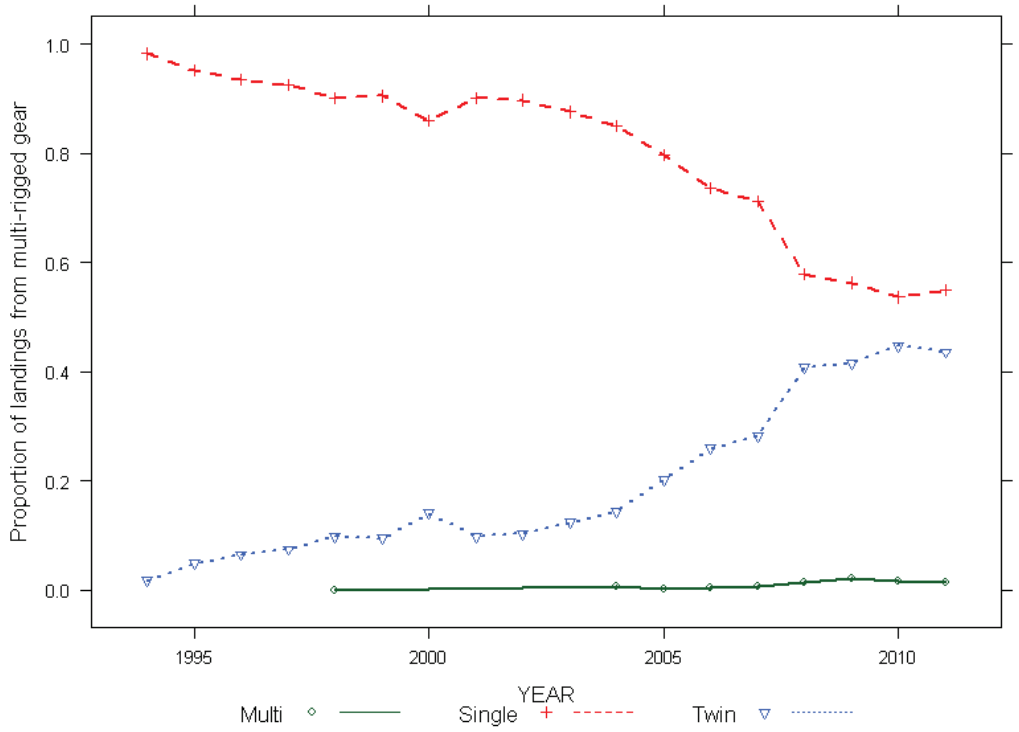


Figure 3.3.2.2 ***Nephrops*** **in FU6. Proportion of landings from different gear types.**

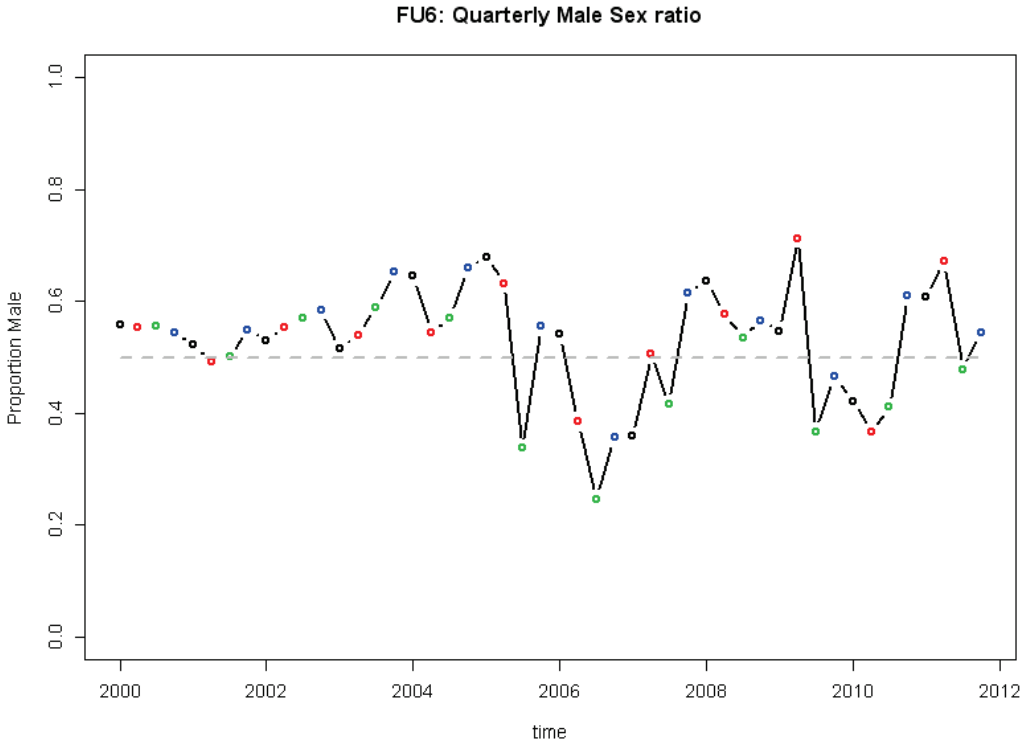


Figure 3.3.2.4 ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

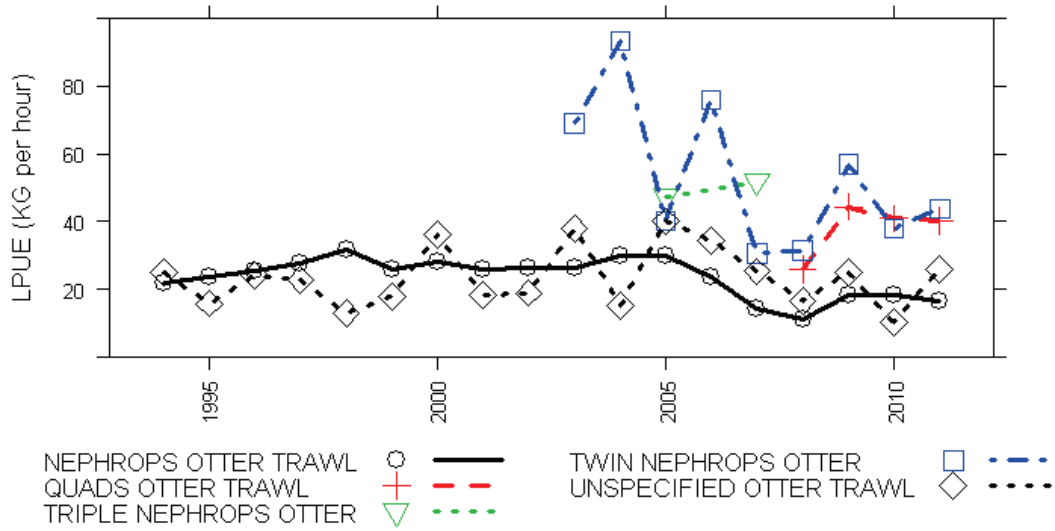


Figure 3.3.2.5 ***Nephrops*** **in FU6: LPUE for directed English trawlers by gear type.**

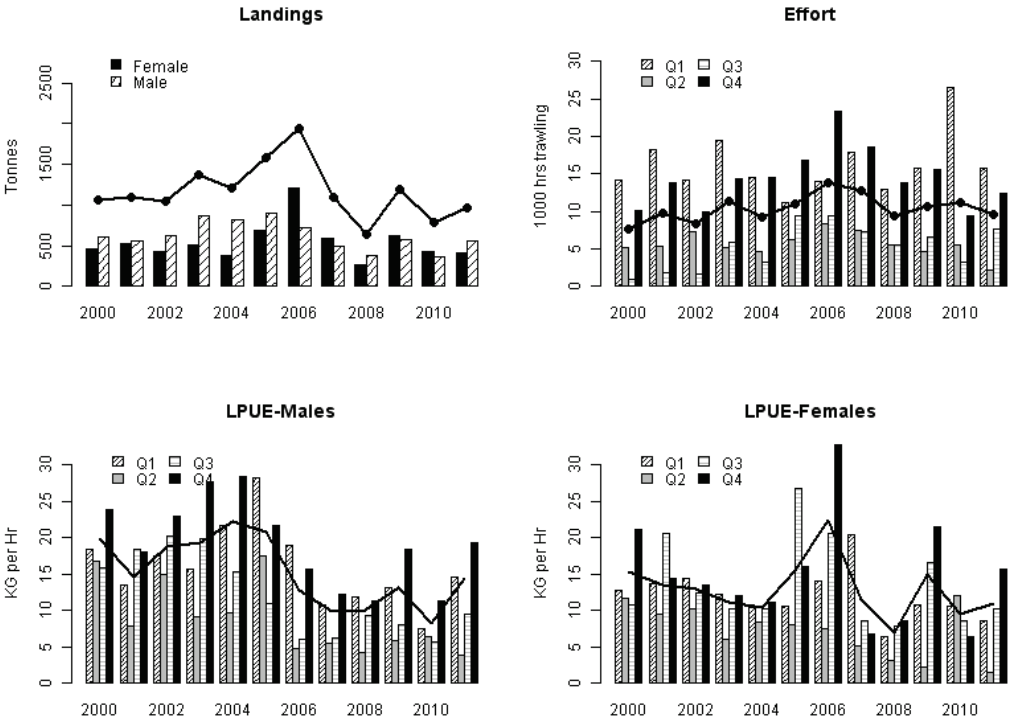


Figure 3.3.2.6 ***Nephrops*** **in FU6: LPUE by sex and quarter.**

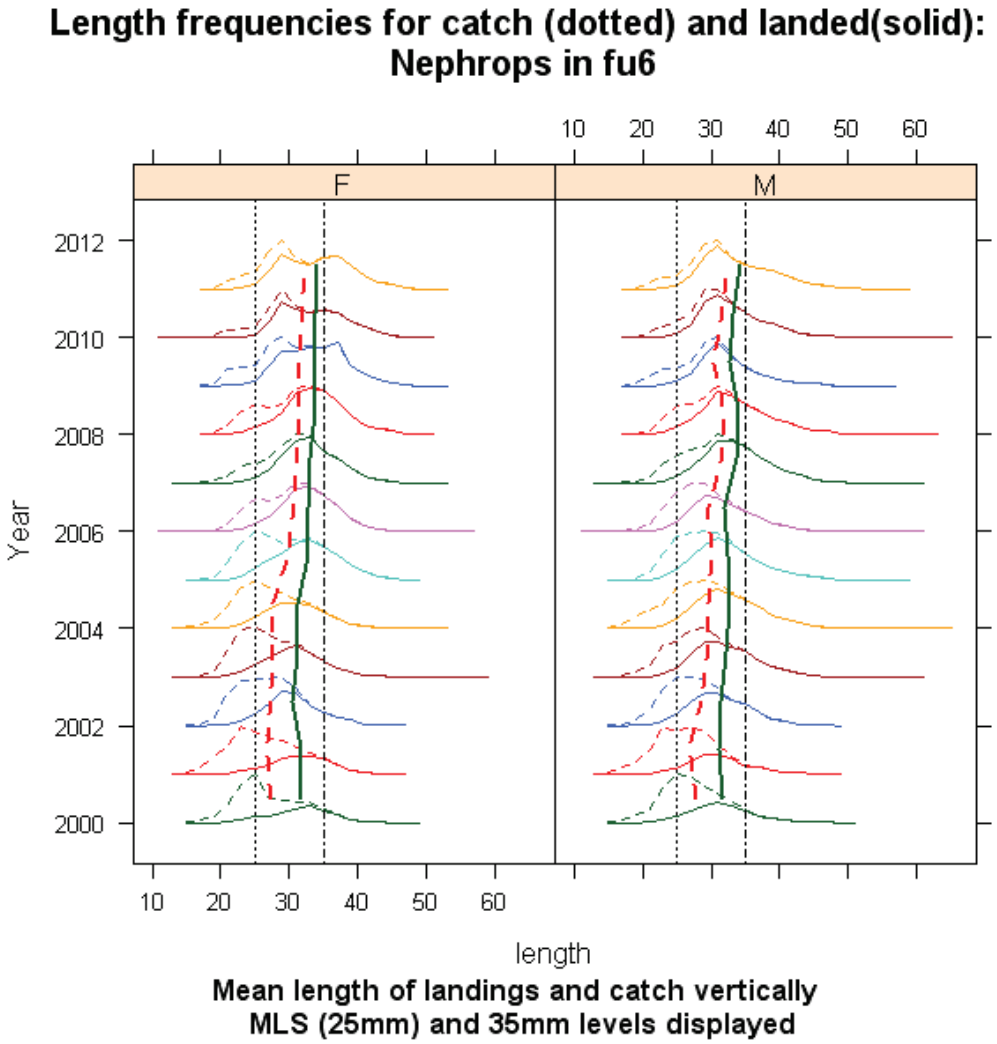


Figure 3.3.2.7 ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

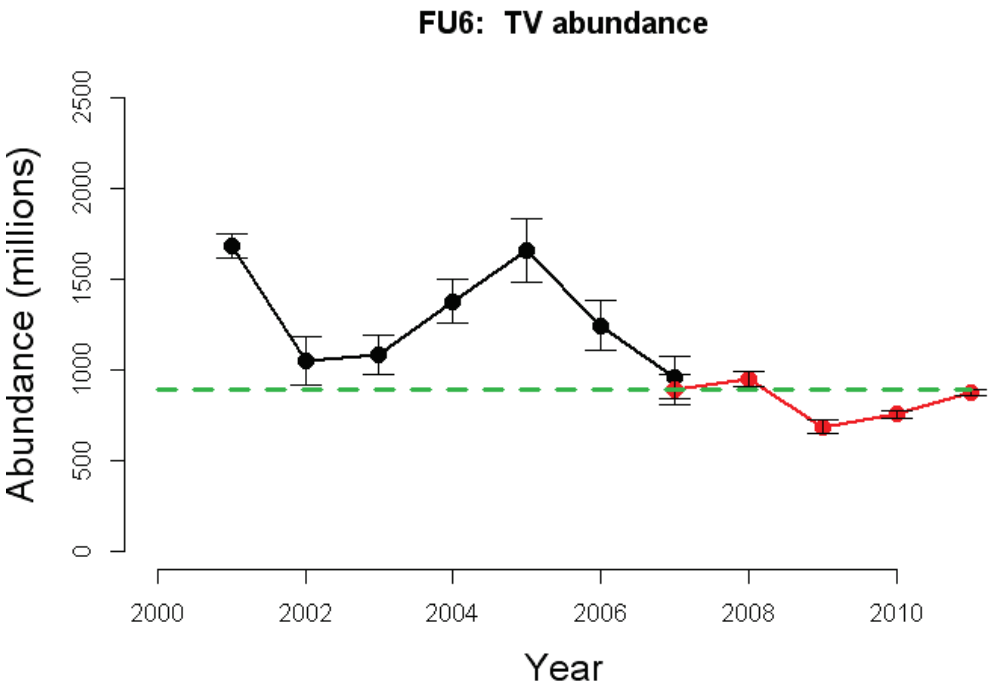


Figure 3.3.2.8 ***Nephrops*** **in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the Geostatsistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.**

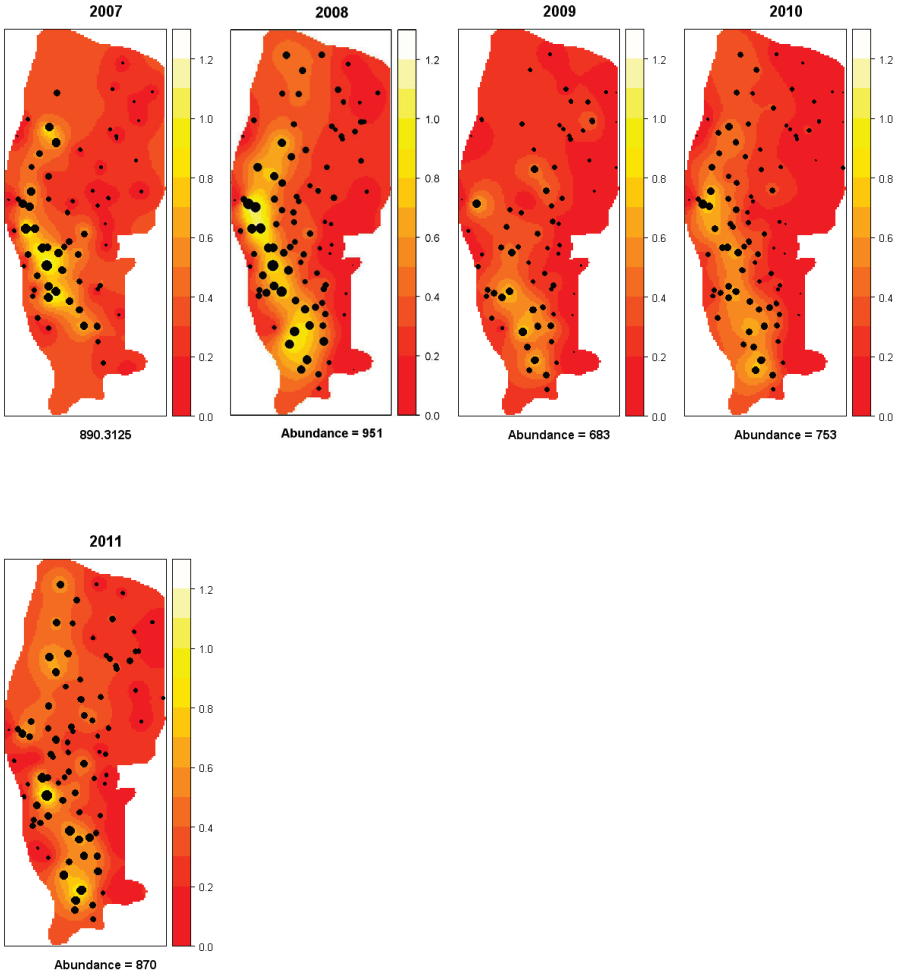


Figure 3.3.2.9 ***Nephrops*** **in FU6: Results of the UWTV survey.**

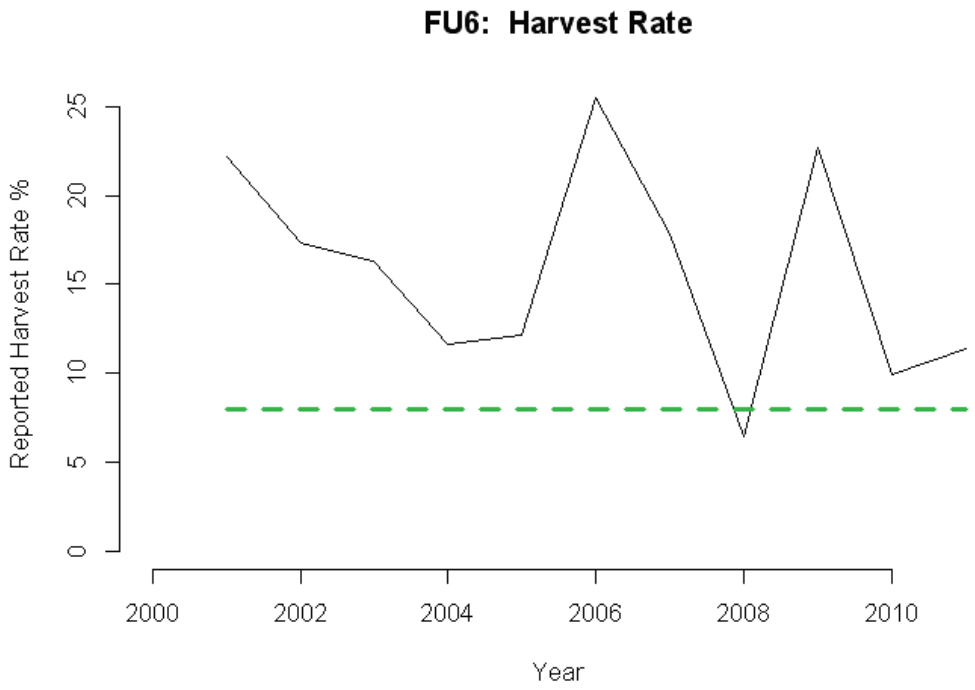


Figure 3.3.2.10 ***Nephrops*** **in FU6: Observed harvest ratio (removals divided by abundance estimate).**

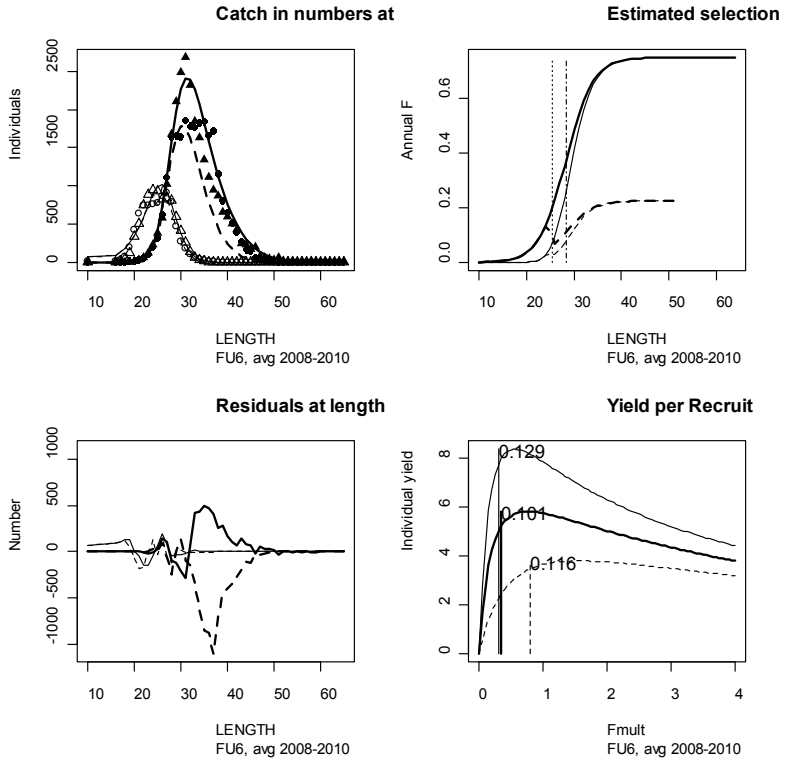


Figure 3.3.2.10 ***Nephrops*** **in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards 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.**

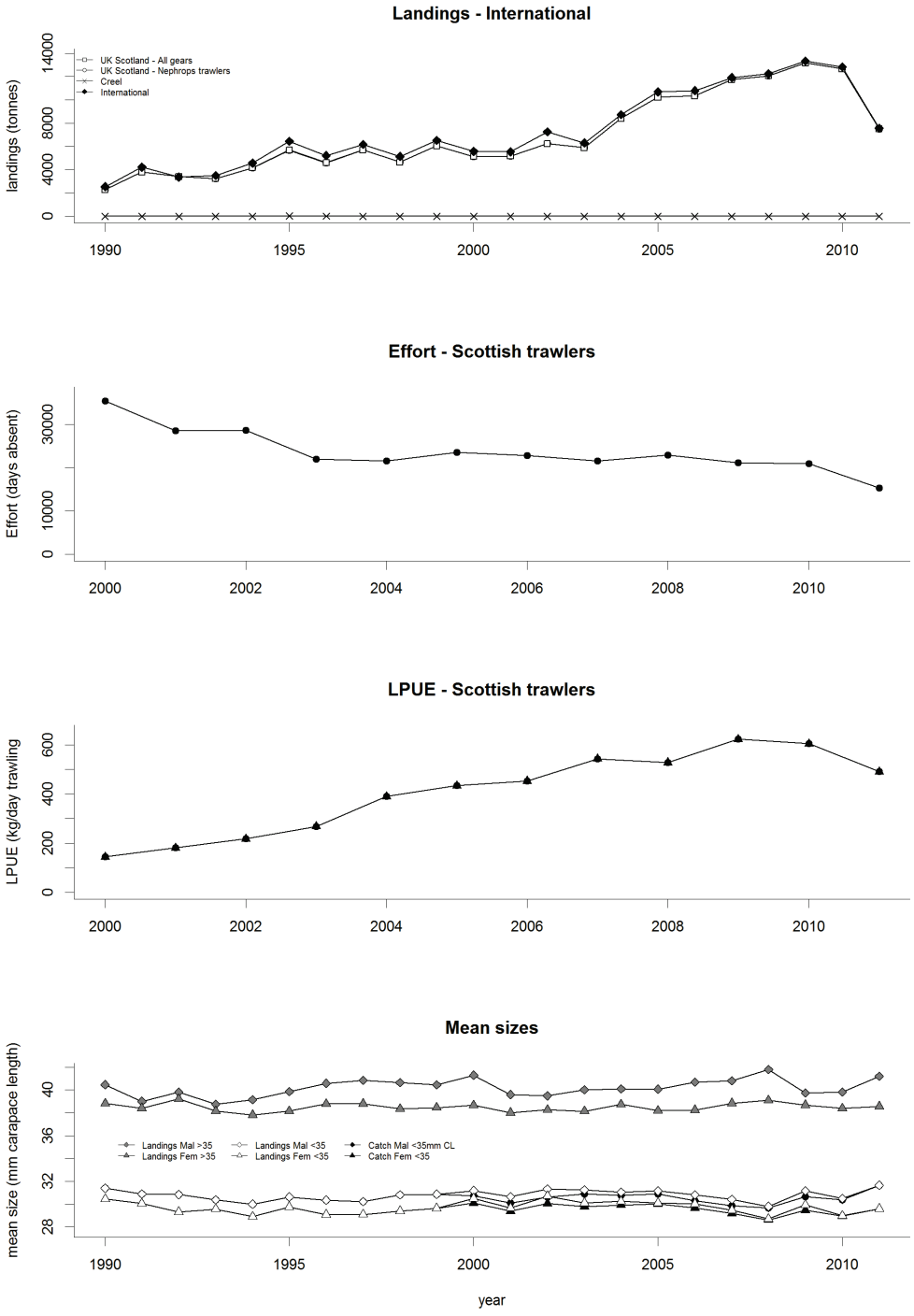


Figure 3.3.3.1 *Nephrops*, **Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2012**

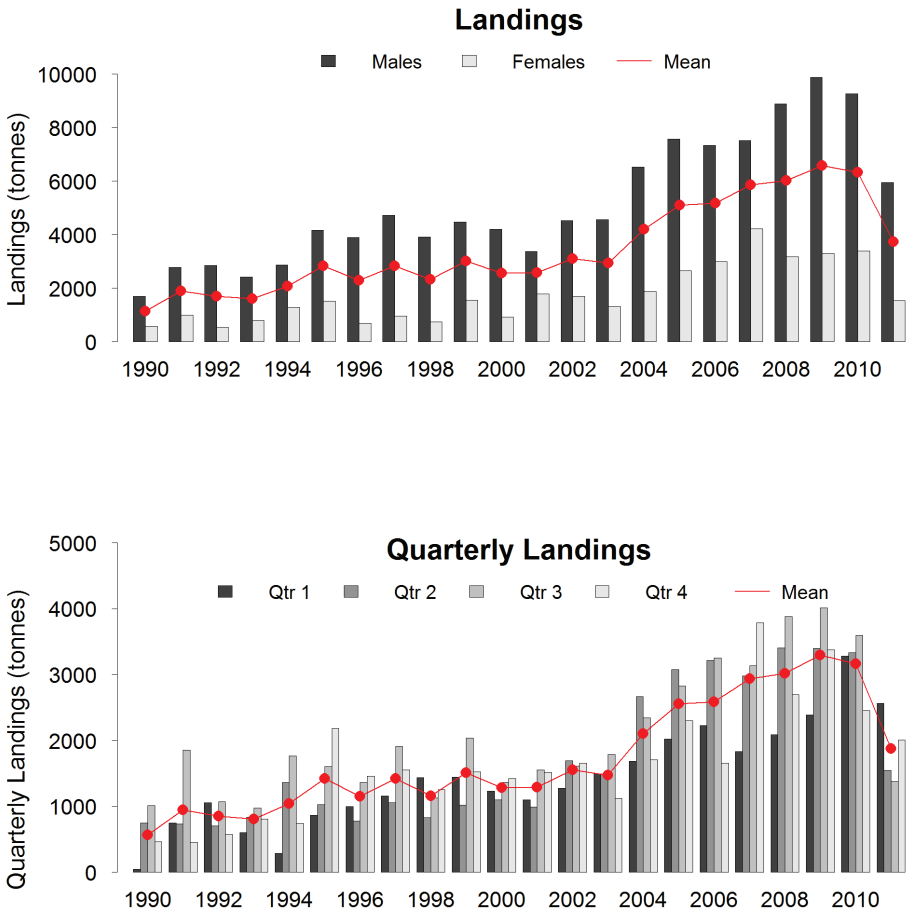


Figure 3.3.3.2 ***Nephrops*****, Fladen (FU 7), Landings by sex and effort by quarter from Scottish trawlers.**

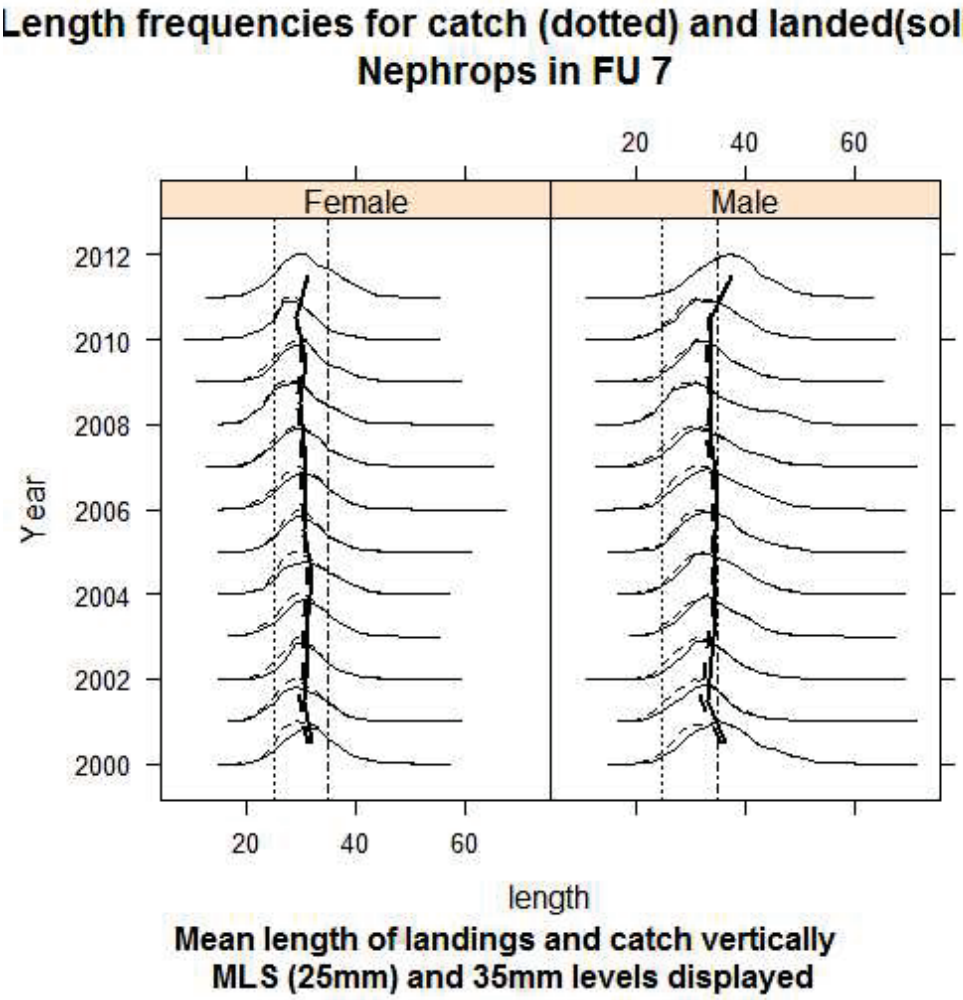


Figure 3.3.3.3. *Nephrops* **Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

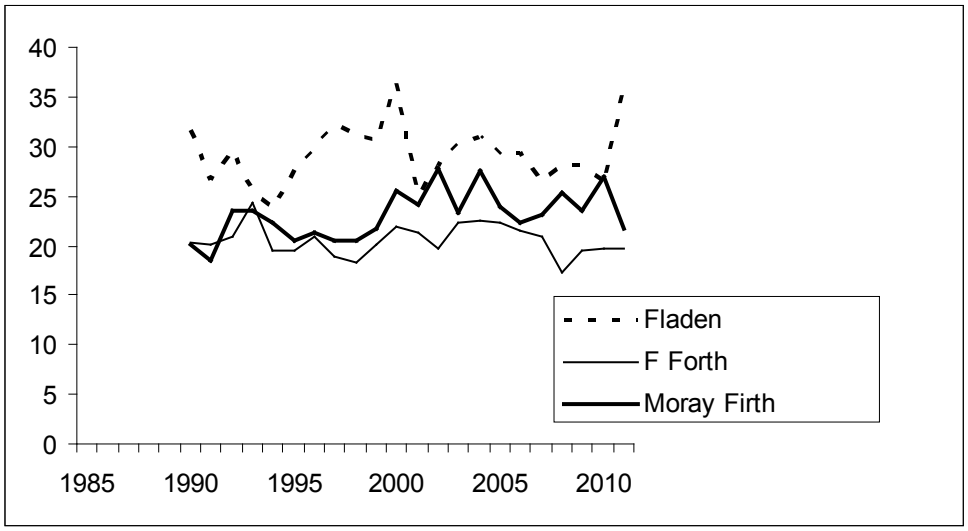


Figure 3.3.3.4 ***Nephrops*****, (FUs 7-9), individual mean weight in the landings from 1990-2011 (from Scottish market sampling data).**

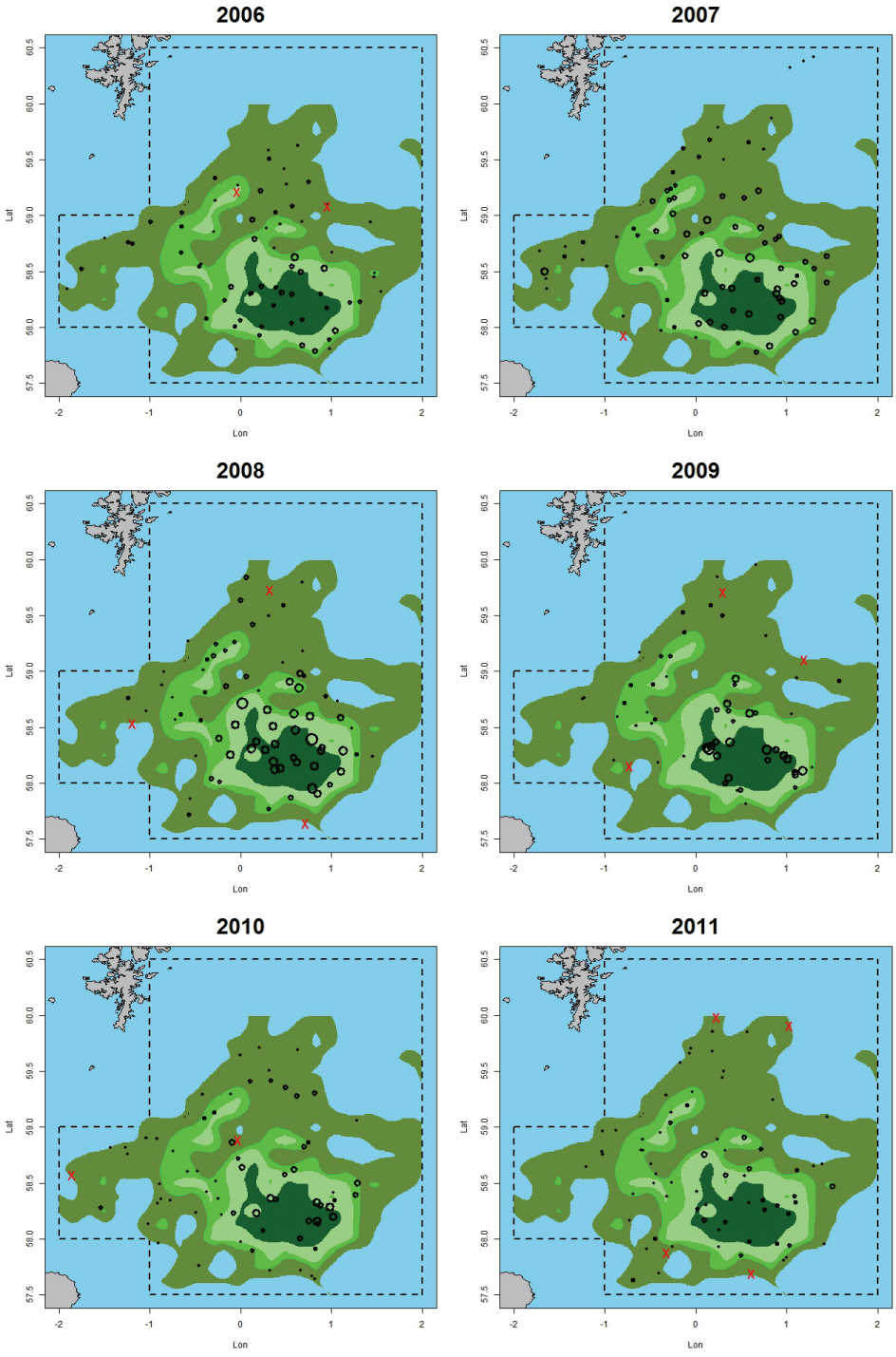


Figure 3.3.3.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

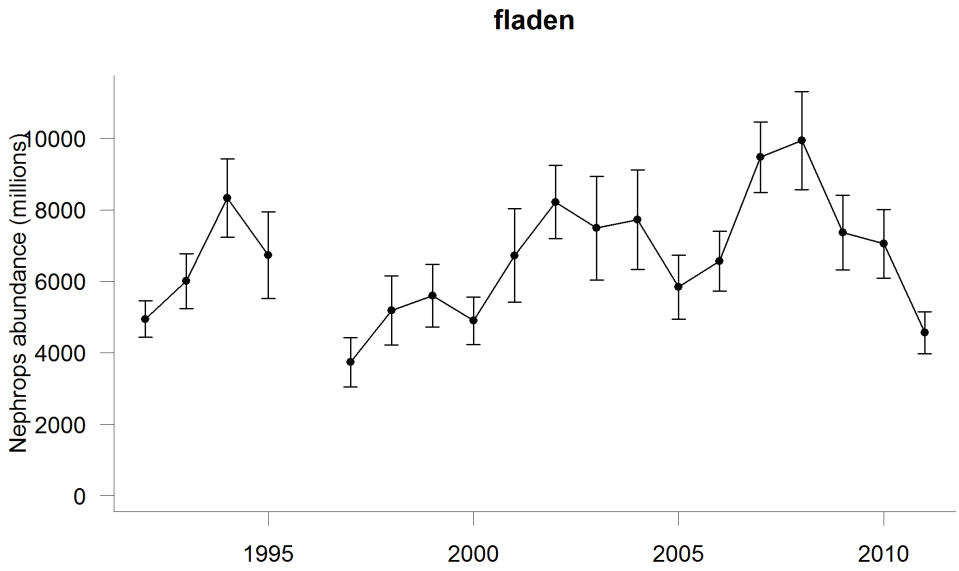


Figure 3.3.3.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates (not bias adjusted), with 95% confidence intervals, 1992 – 2011.**

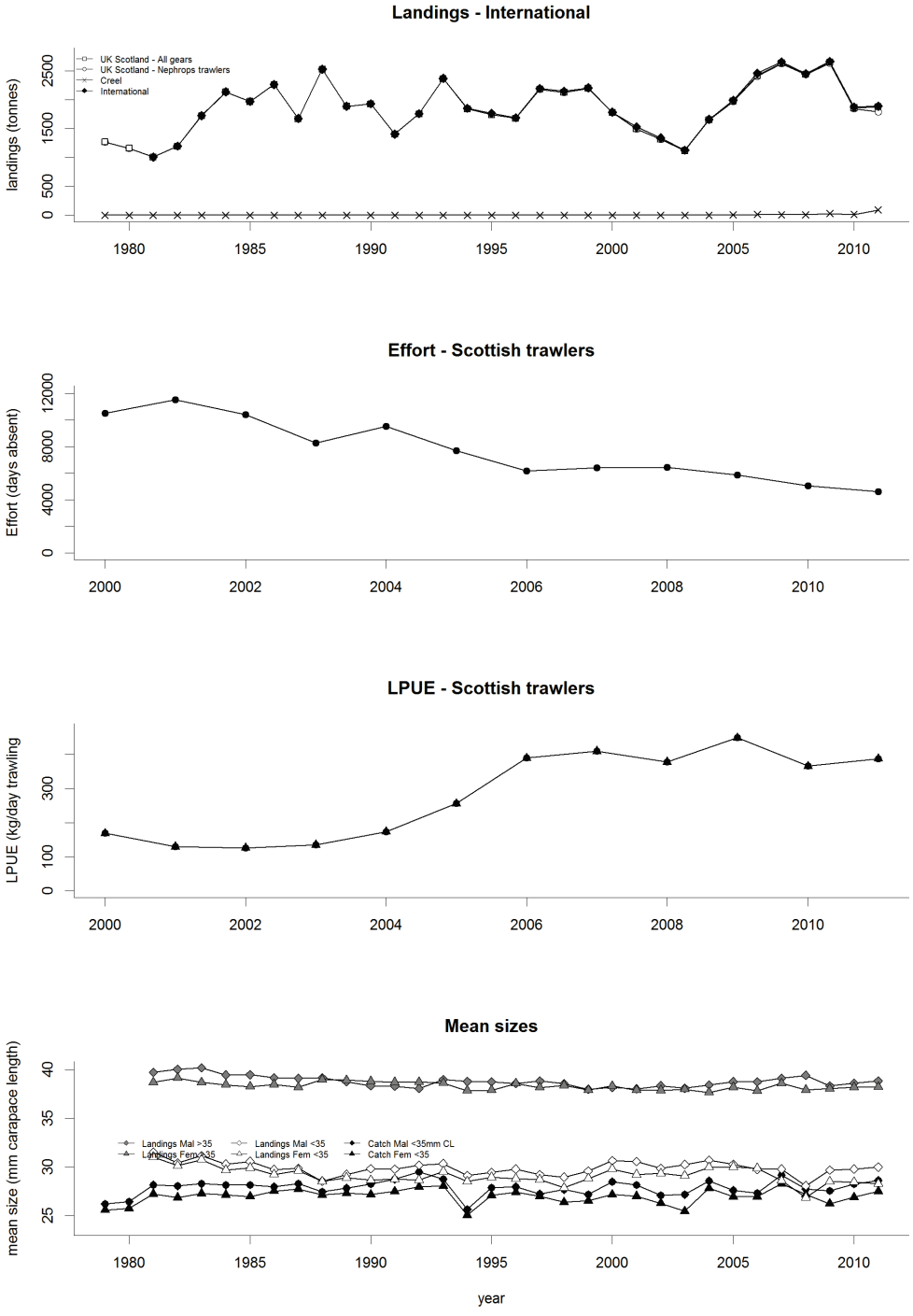


Figure 3.3.4.1 ***Nephrops*****, Firth of Forth (FU 8),), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2012**

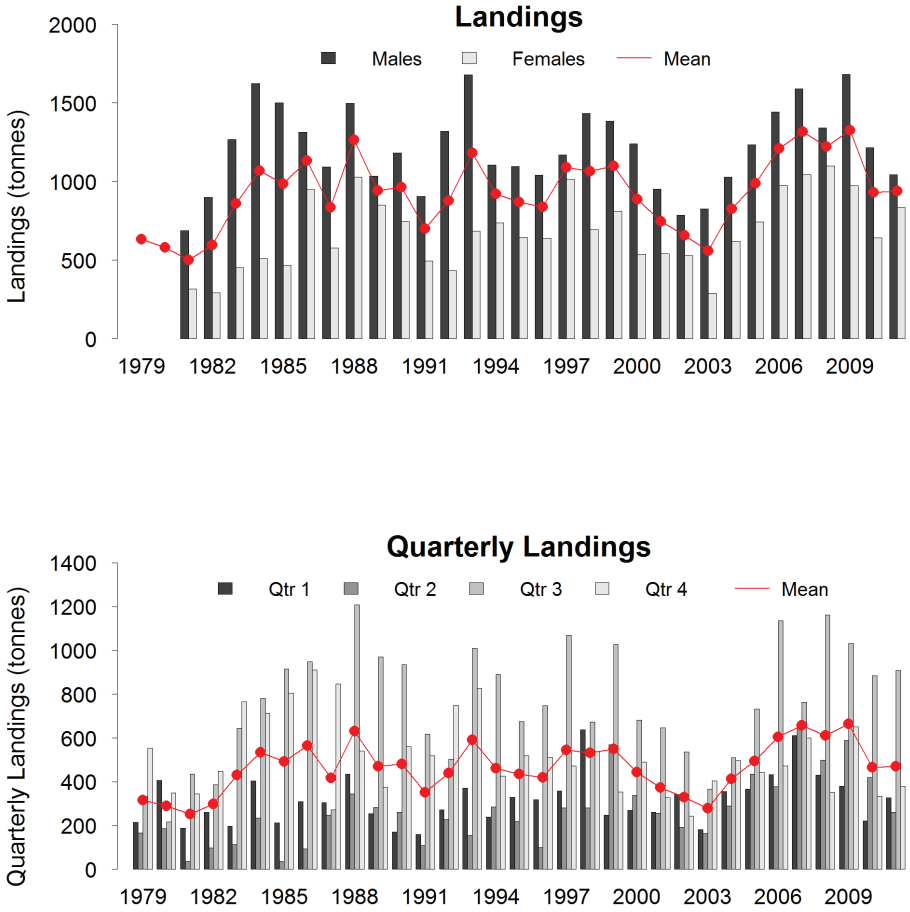


Figure 3.3.4.2 ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

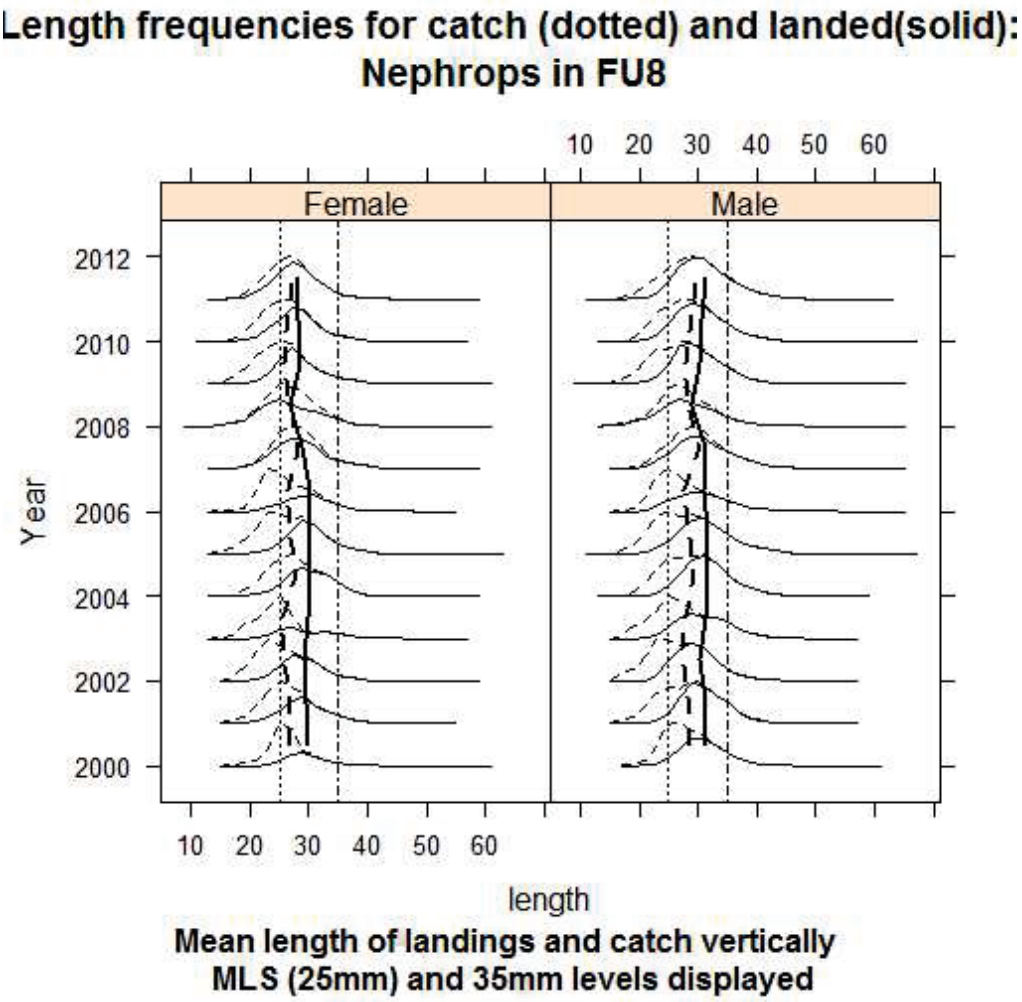


Figure 3.3.4.3 *Nephrops* **Firth of Forth (FU 8)Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

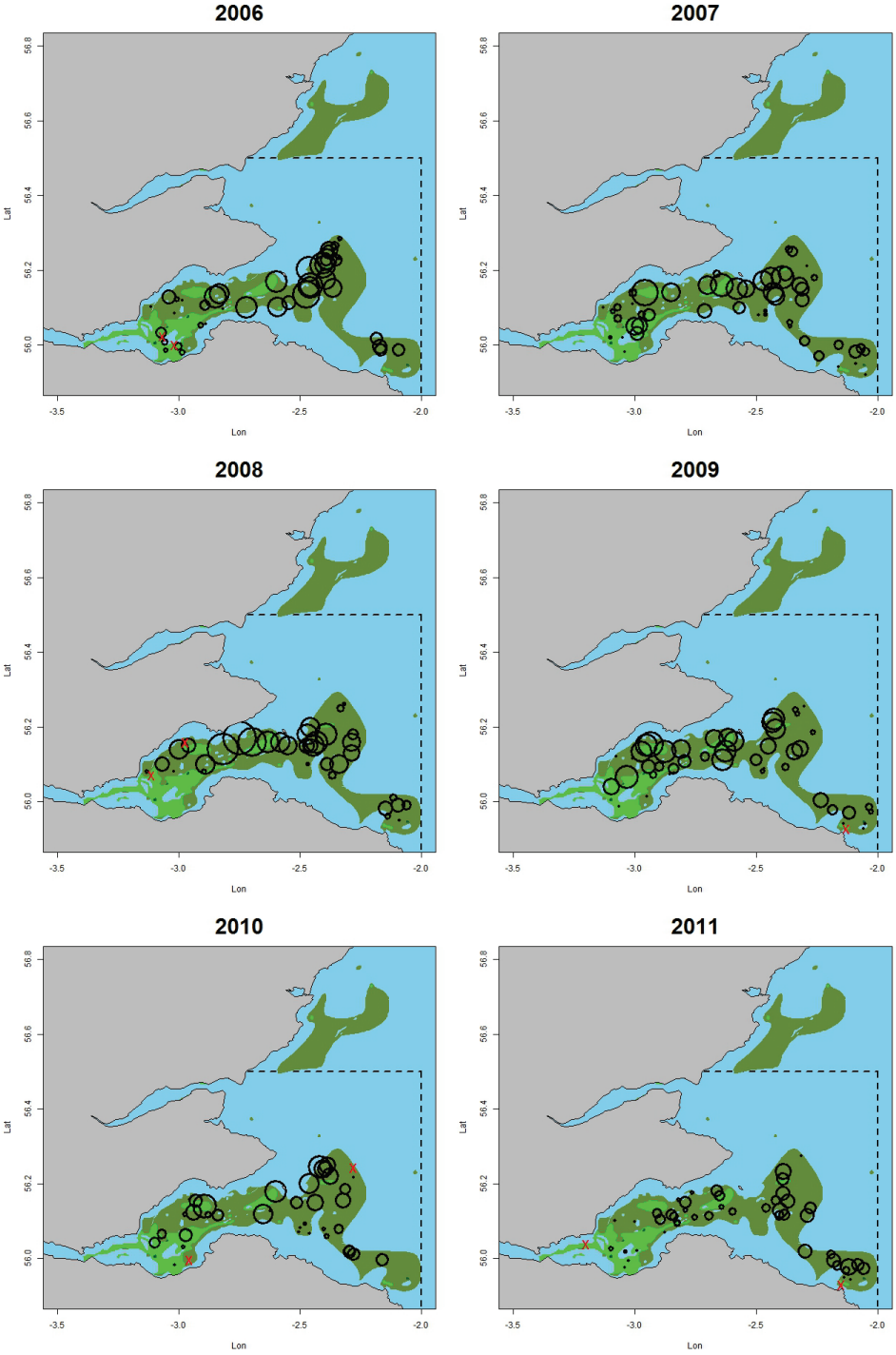


Figure 3.3.4.4 ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

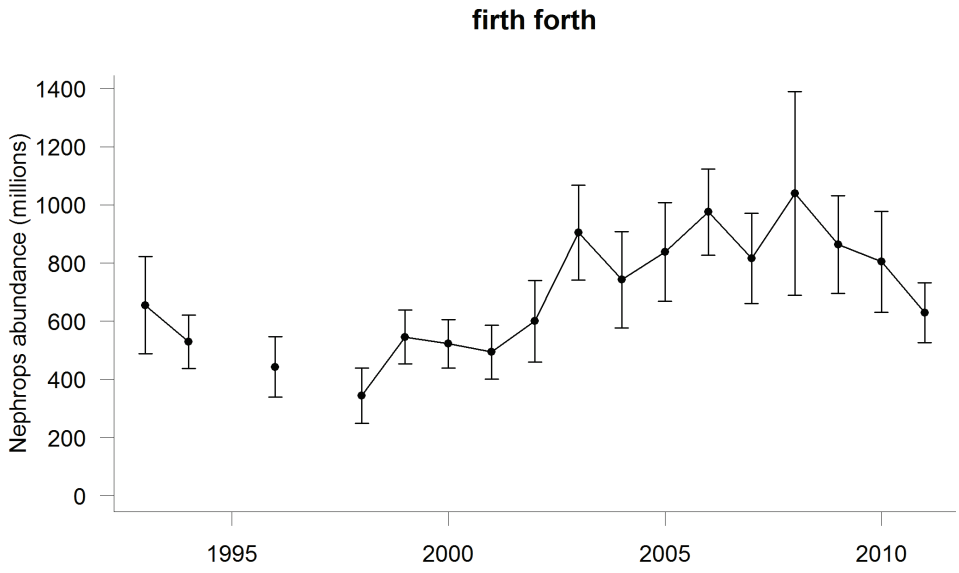


Figure 3.3.4.5 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates, with 95% confidence intervals, 1995 – 2011.**

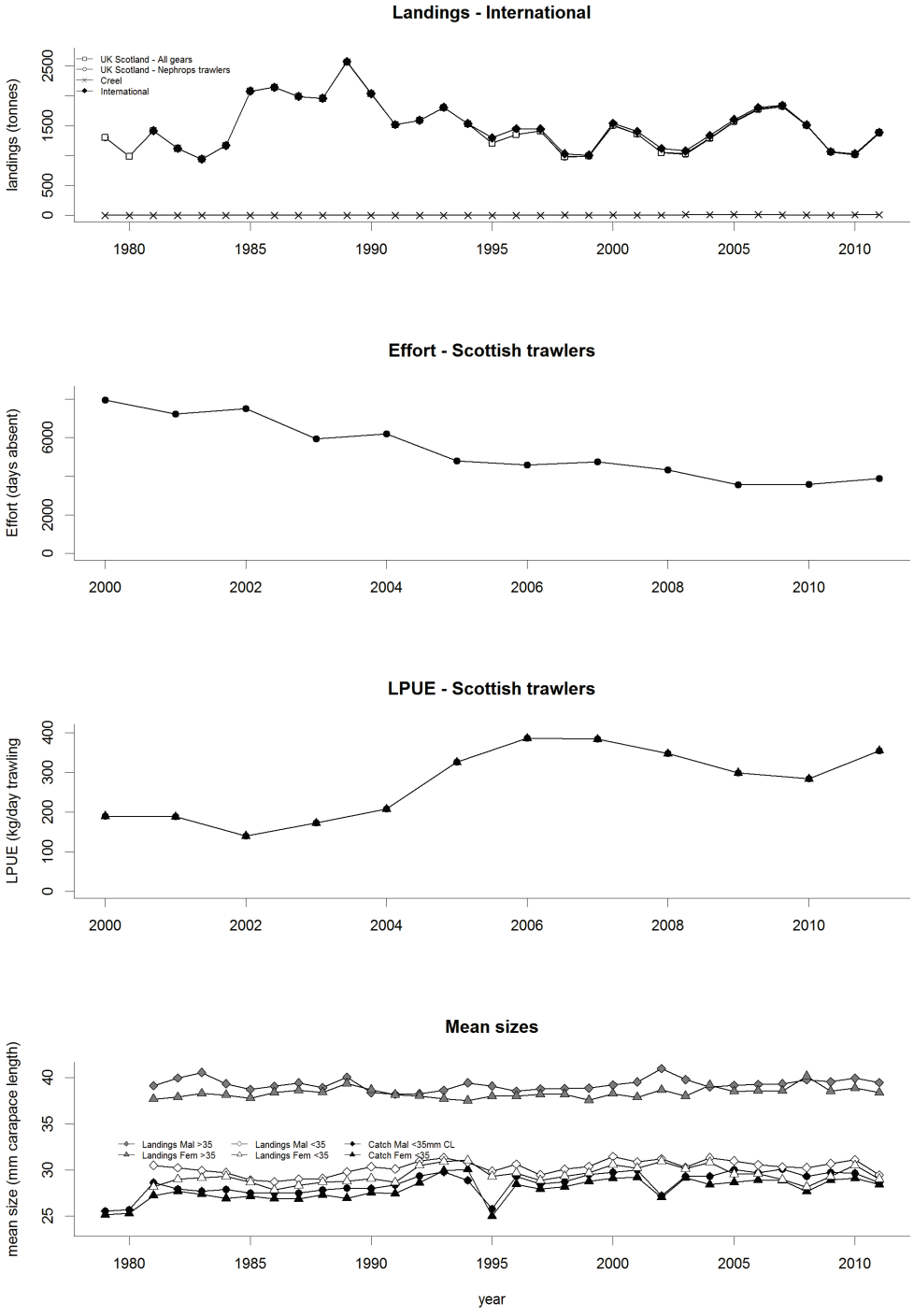


Figure 3.3.5.1 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes.**

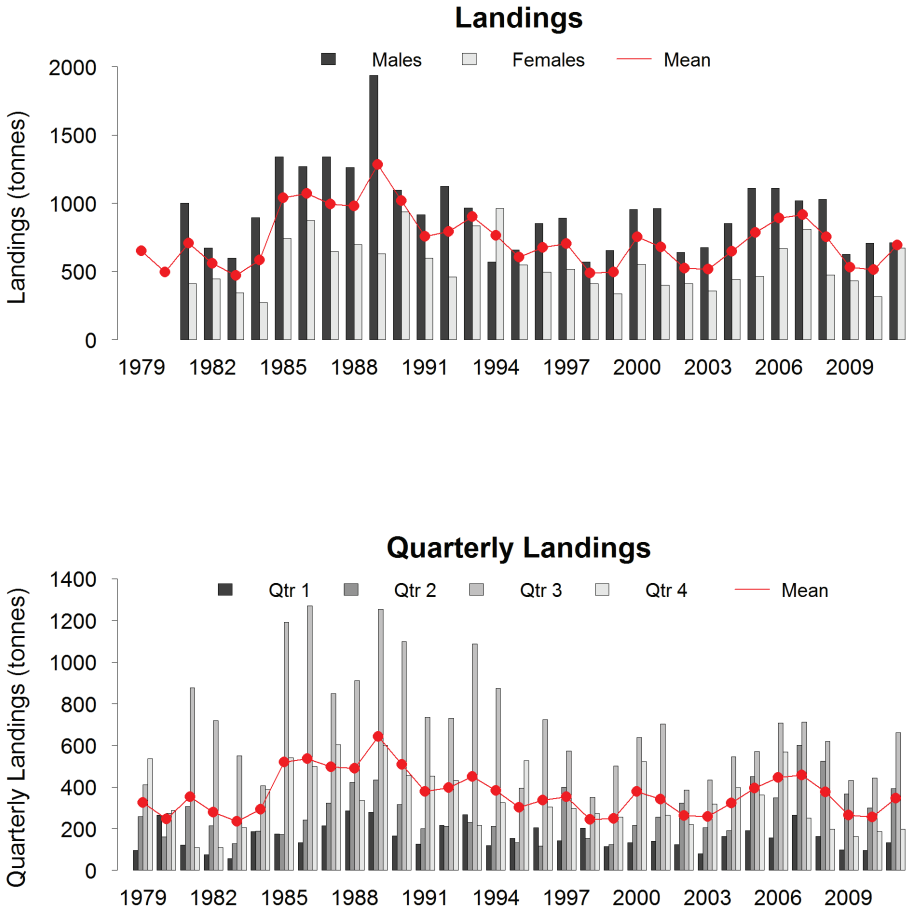


Figure 3.3.5.2 ***Nephrops*****, Moray Firth (FU 9), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

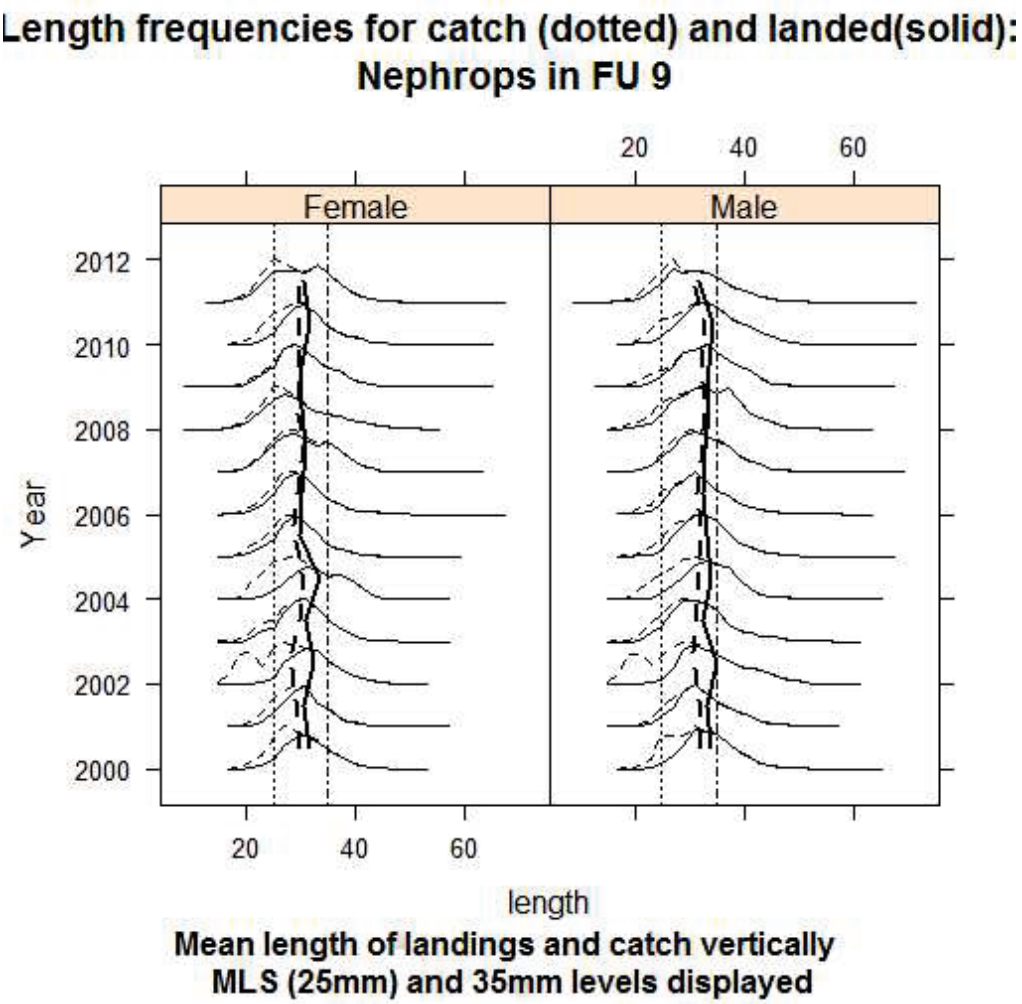


Figure 3.3.5.3 *Nephrops* **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

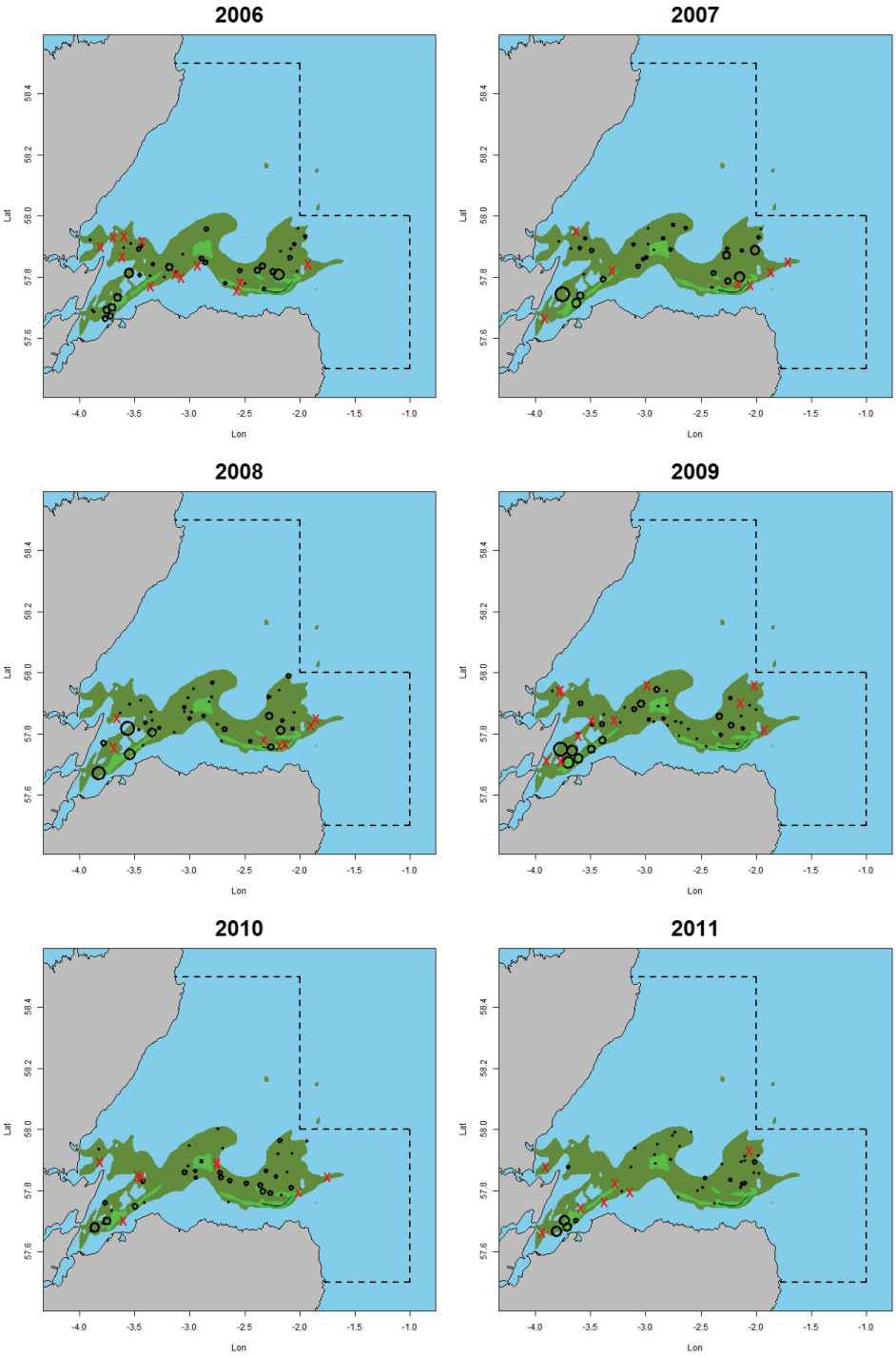


Figure 3.3.5.4 ***Nephrops*****, Moray Firth (FU 9). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

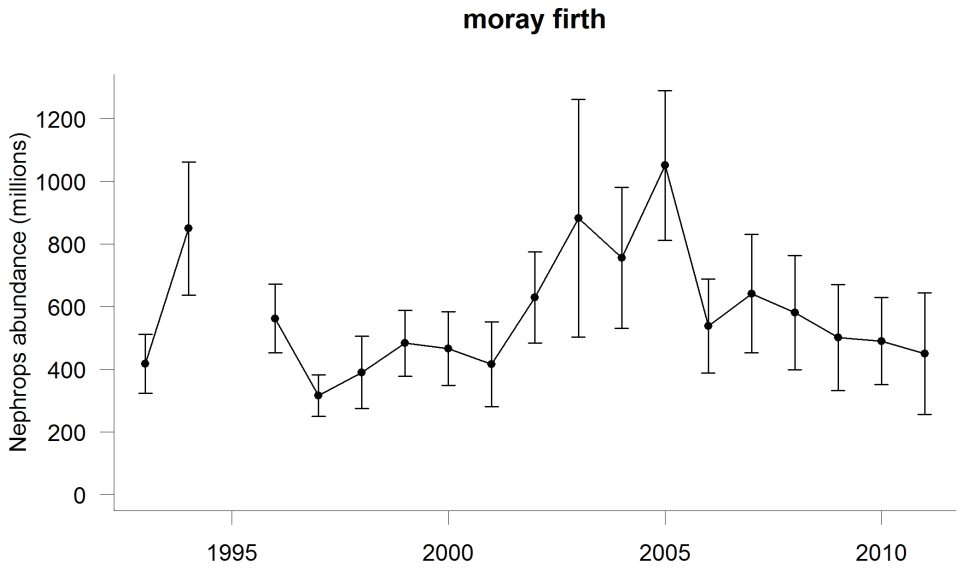


Figure 3.3.5.5 ***Nephrops*****, Moray Firth (FU 9), Time series of TV survey abundance estimates, with 95% confidence intervals, 1993 – 2011.**

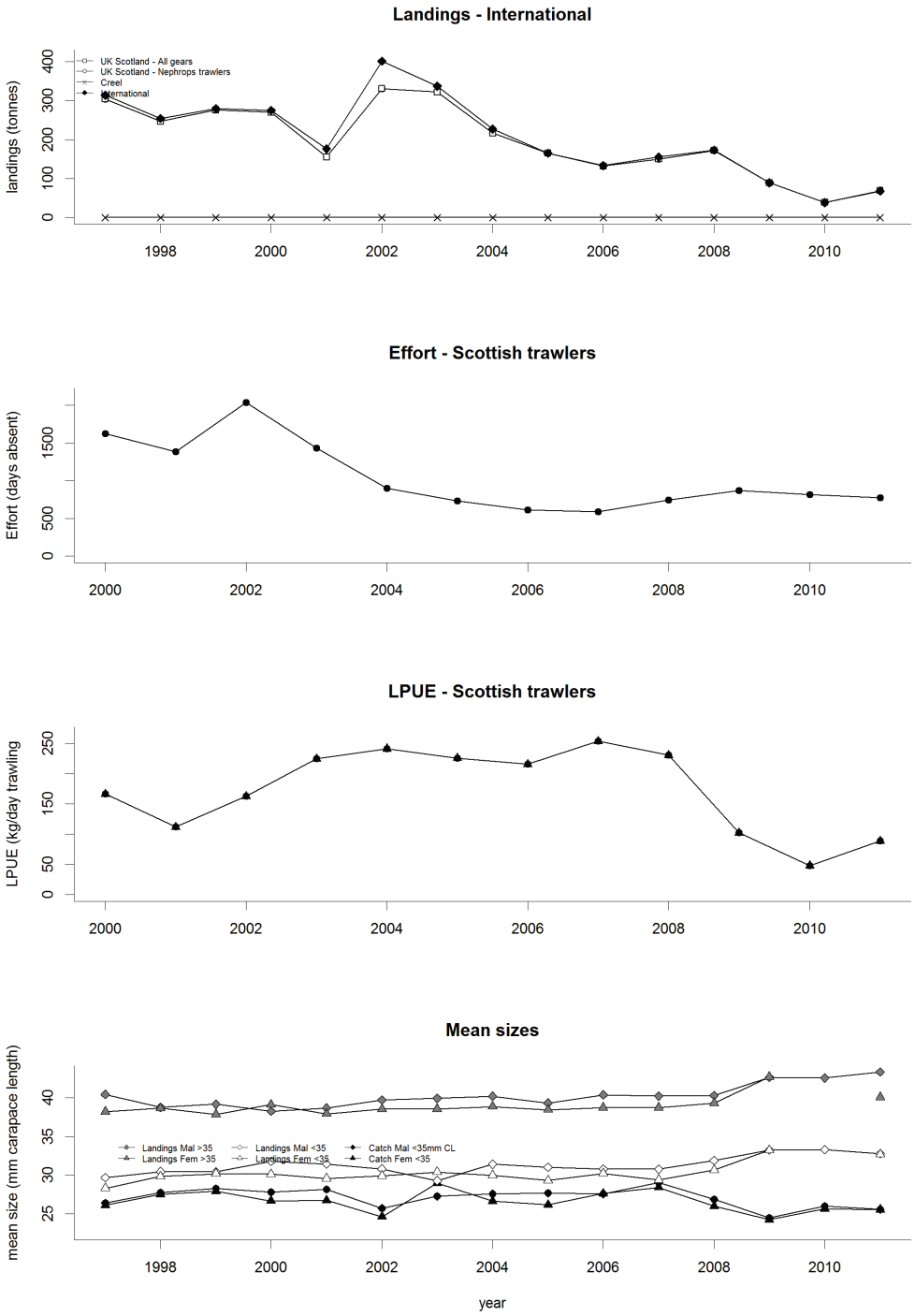


Figure 3.3.6.1 *Nephrops*, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010).

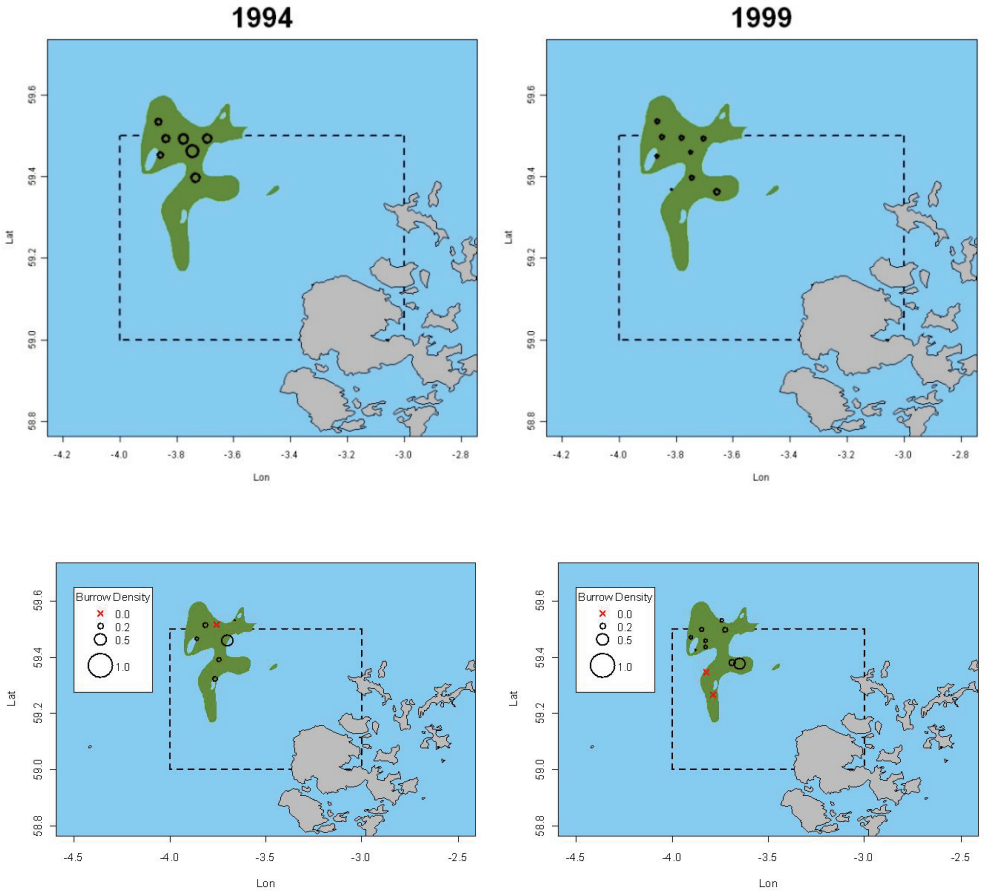


Figure 3.3.6.2 ***Nephrops*****, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

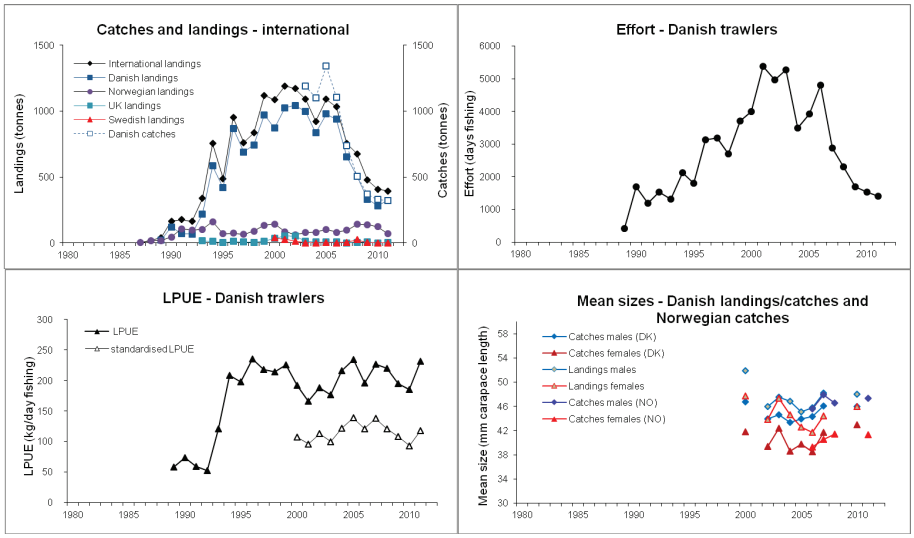


Figure 3.3.7.1, *Nephrops* in FU 32 (Norwegian Deep): Landings, effort, LPUE and mean size.

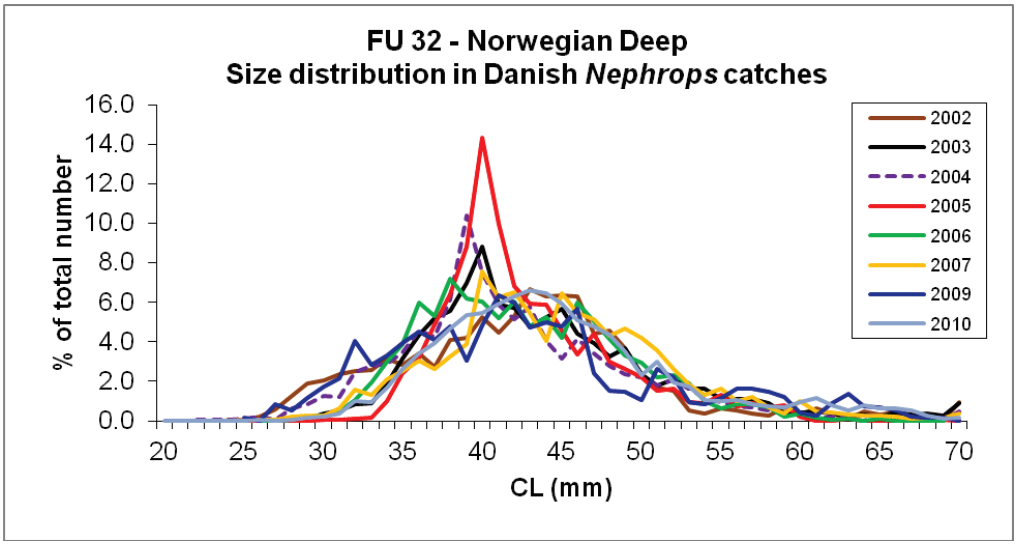


Figure 3.3.7.2, Nephrops in FU 32 (Norwegian Deep): Size distribution in Danish catches.

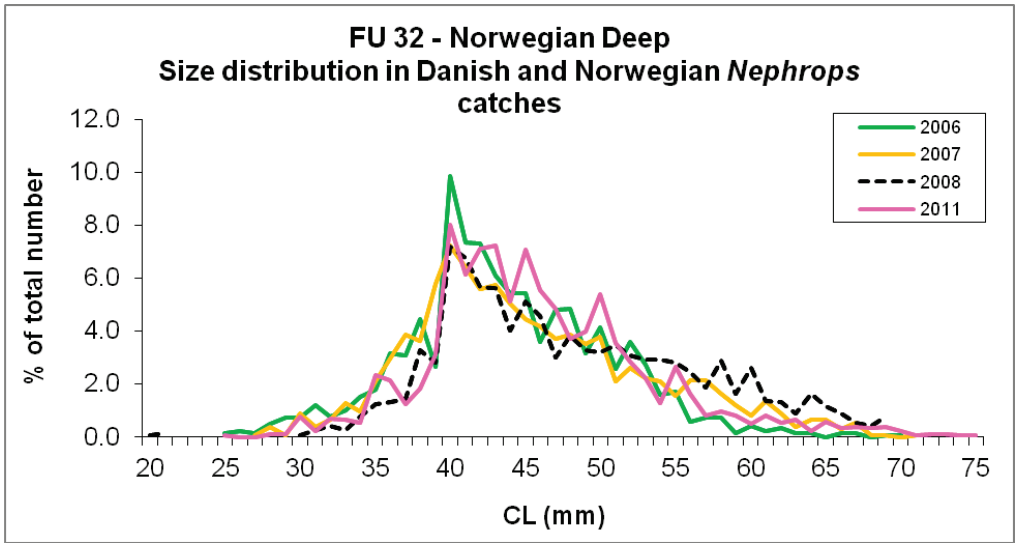


Figure 3.3.7.3, Nephrops in FU 32 (Norwegian Deep): Size distribution of Danish and Norwegian catches. Data from the Norwegian coast guard.

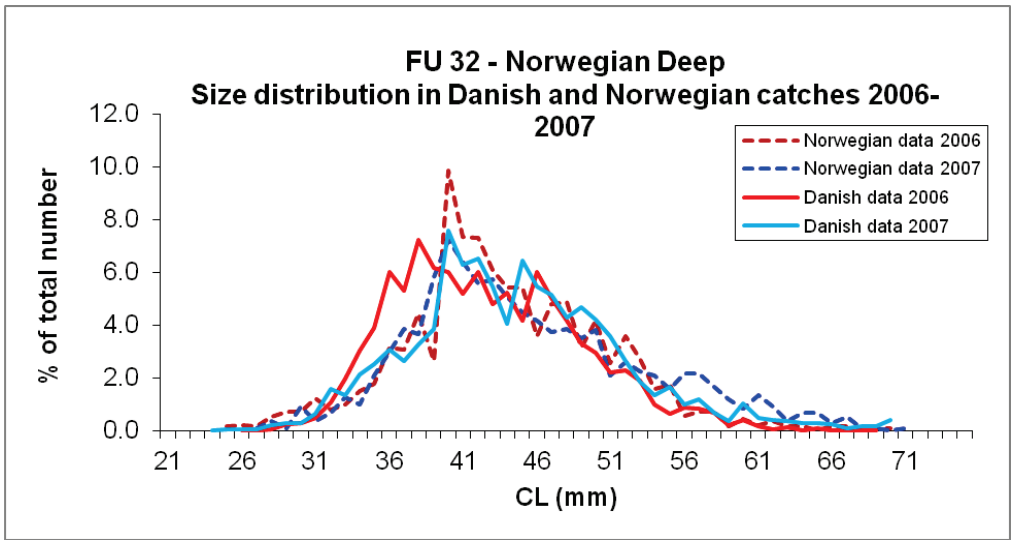


Figure 3.3.7.4, Nephrops in FU 32 (Norwegian Deep): Comparison of size distribution in catches (2006-2007) from Danish and Norwegian data sources.

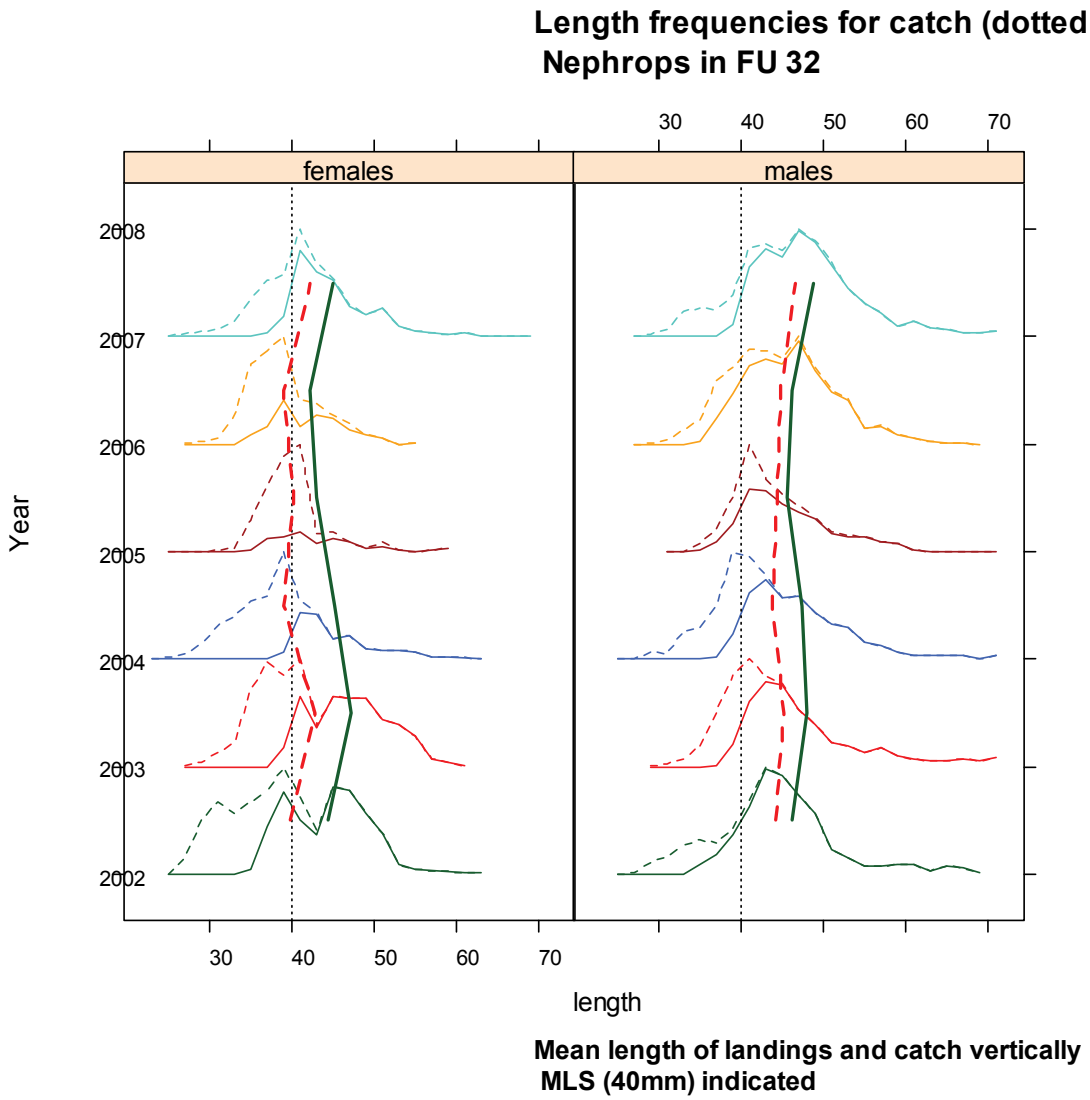


Figure 3.3.7.5, *Nephrops* in FU 32 (Norwegian Deep): Evolution of size composition in landings and discards.

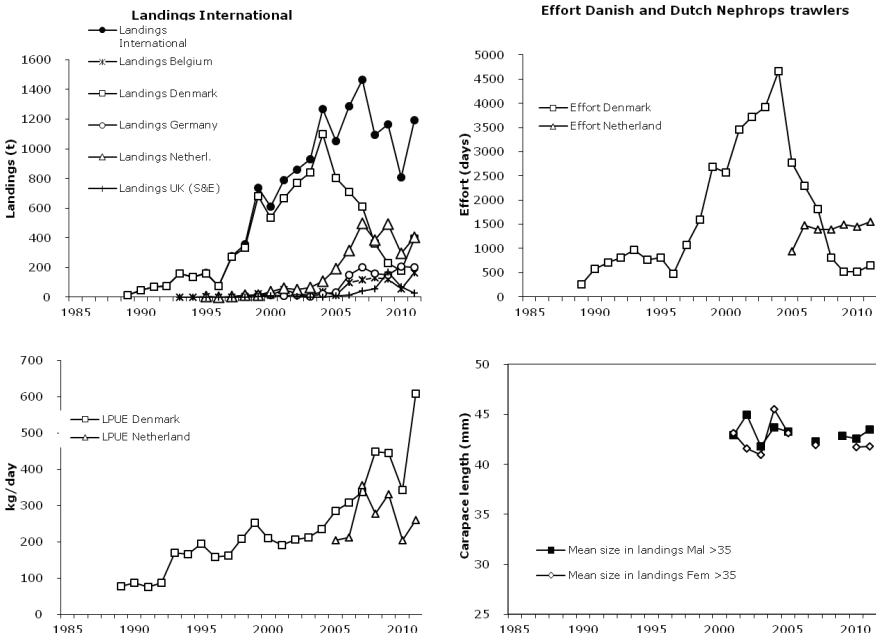


Figure 3.3.8.1 *Nephrops* in FU 33 (Off Horns Reef): Landings, effort and mean size.

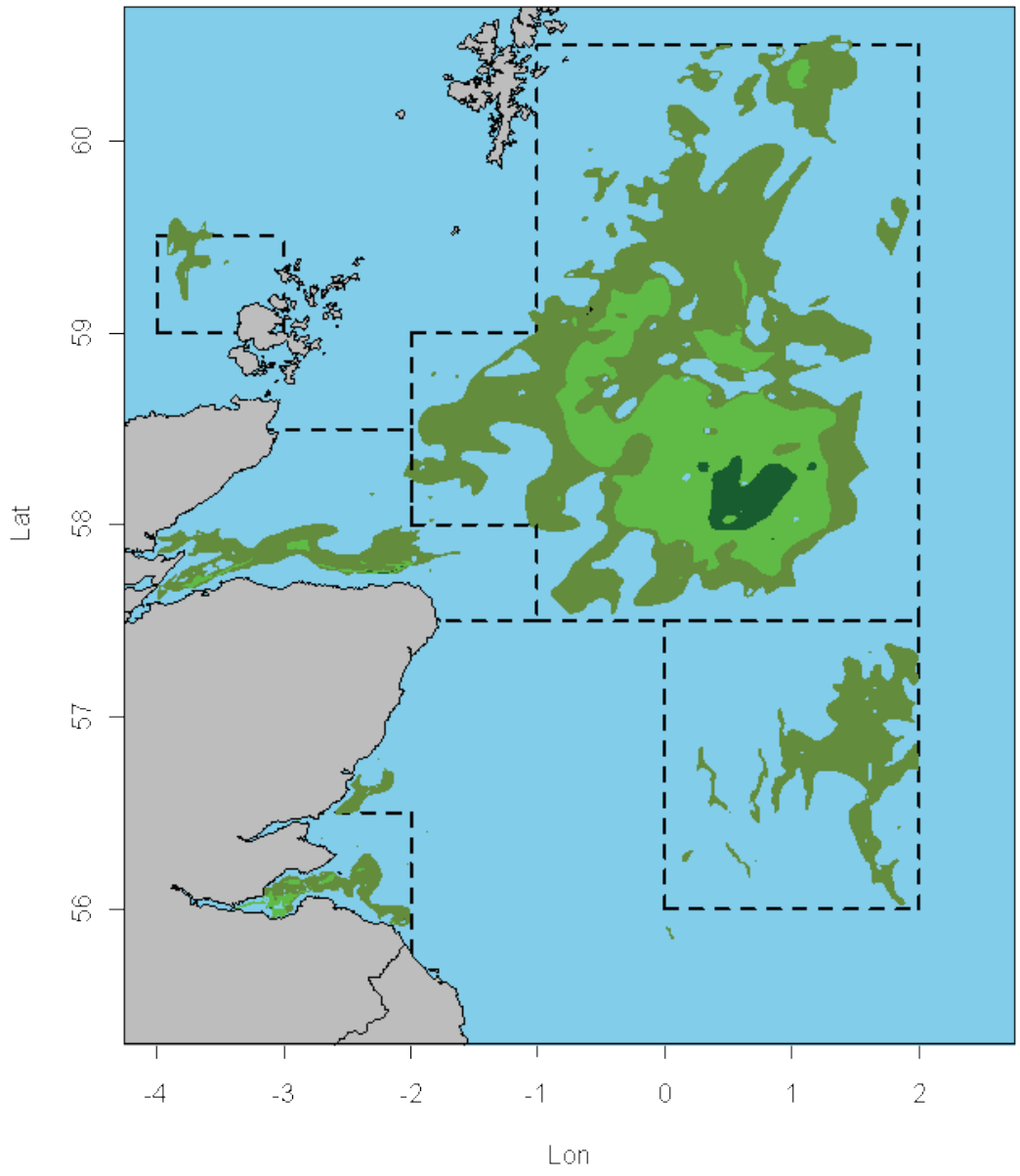


Figure 3.3.9.1. ***Nephrops*****, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for** ***Nephrops*** **in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**

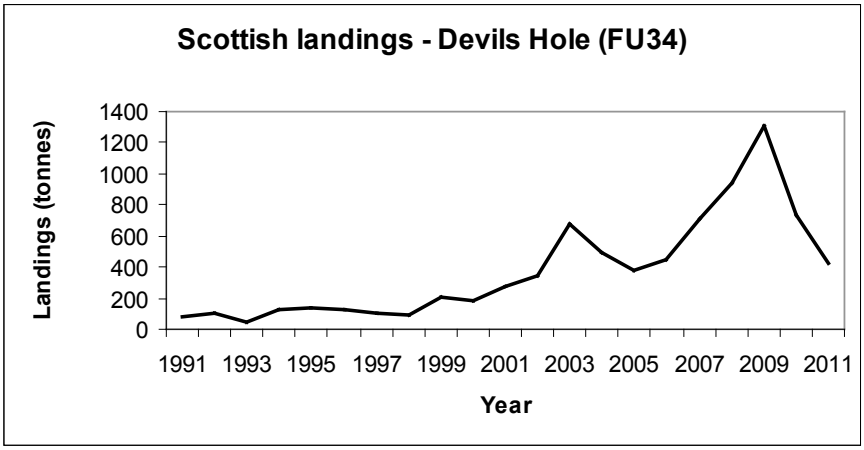
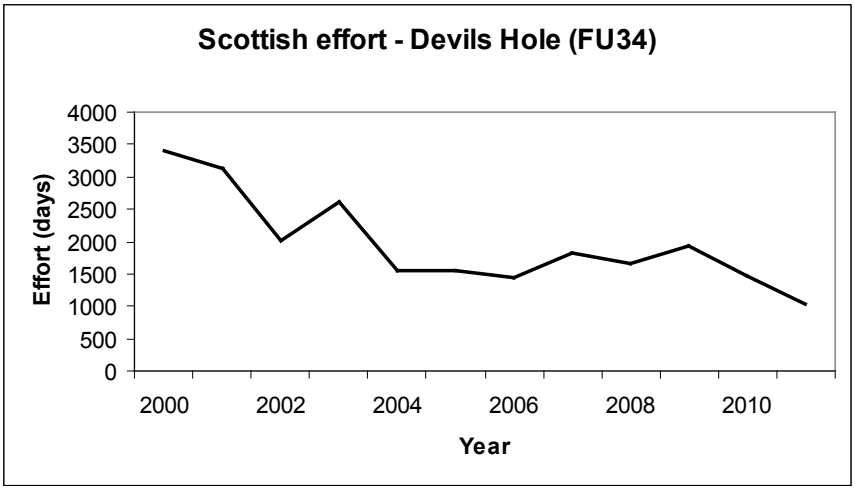


Figure 3.3.9.2. *Nephrops*, **Devil's Hole (FU 34). Scottish landings from 1991 to 2011.**



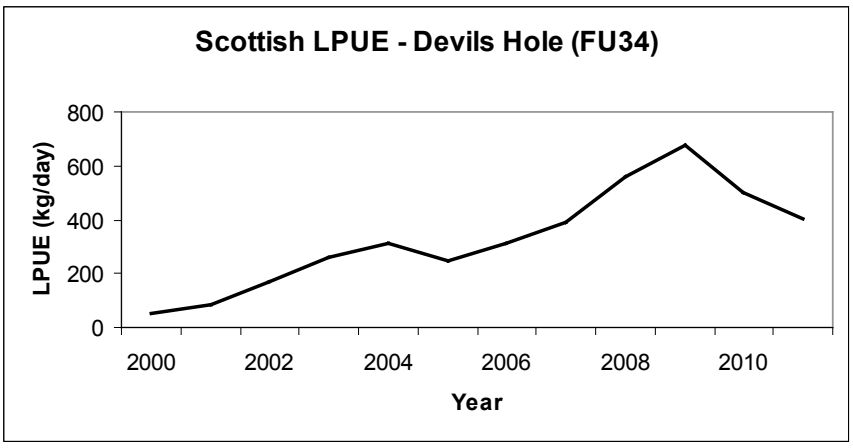


Figure 3.3.9.3. *Nephrops*, **Devil's Hole (FU 34). Effort (days) and LPUE (kg/day by Scottish trawlers.**

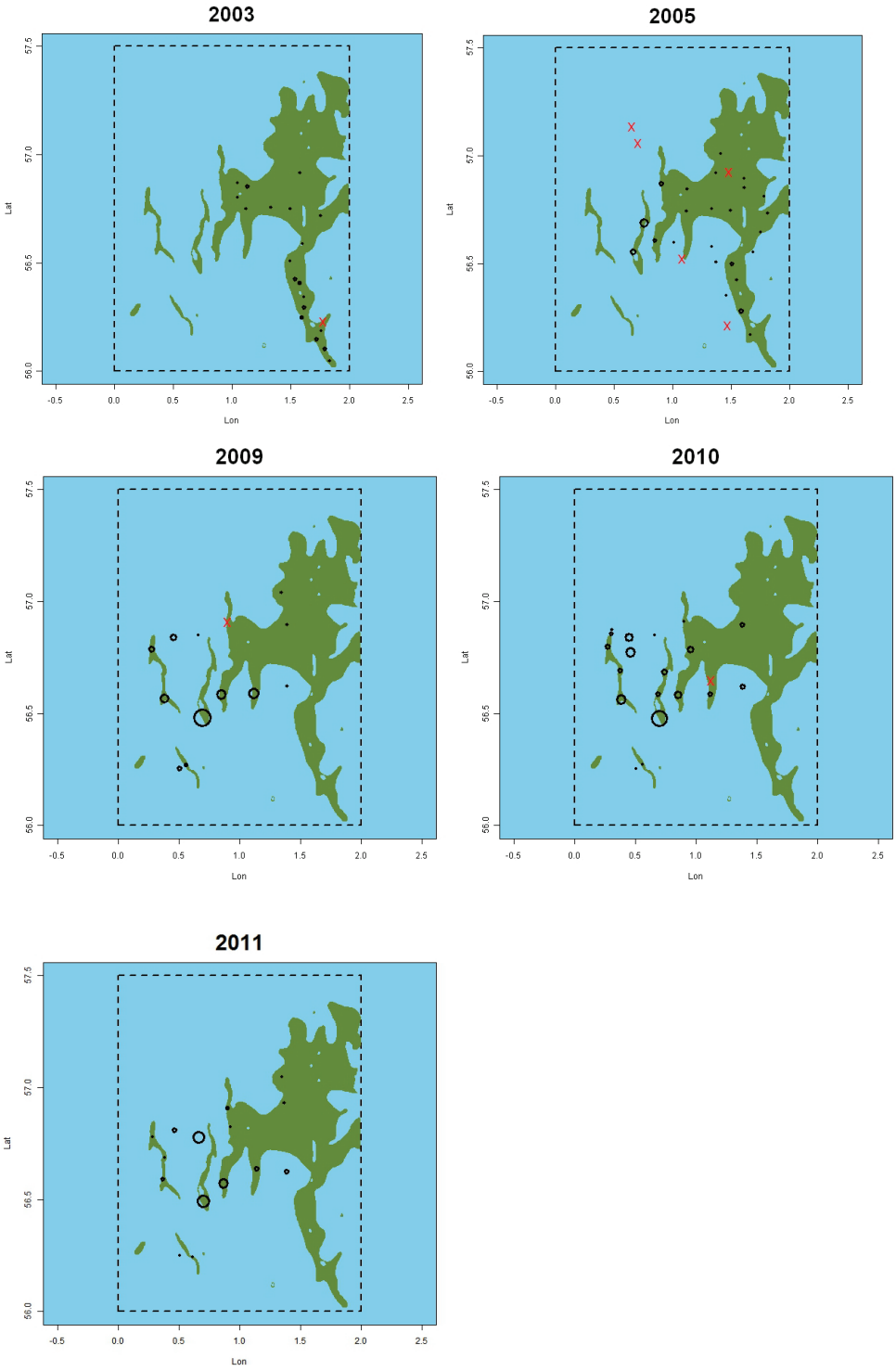


Figure 3.3.9.4. *Nephrops*, Devil's Hole (FU 34). TV survey distribution and relative density (2003, 2005, 2009-2011). Olive areas indicate areas of suitable sediment for *Nephrops*. 2009 - 2011 survey station locations generated from VMS data. Density proportional to circle radius.

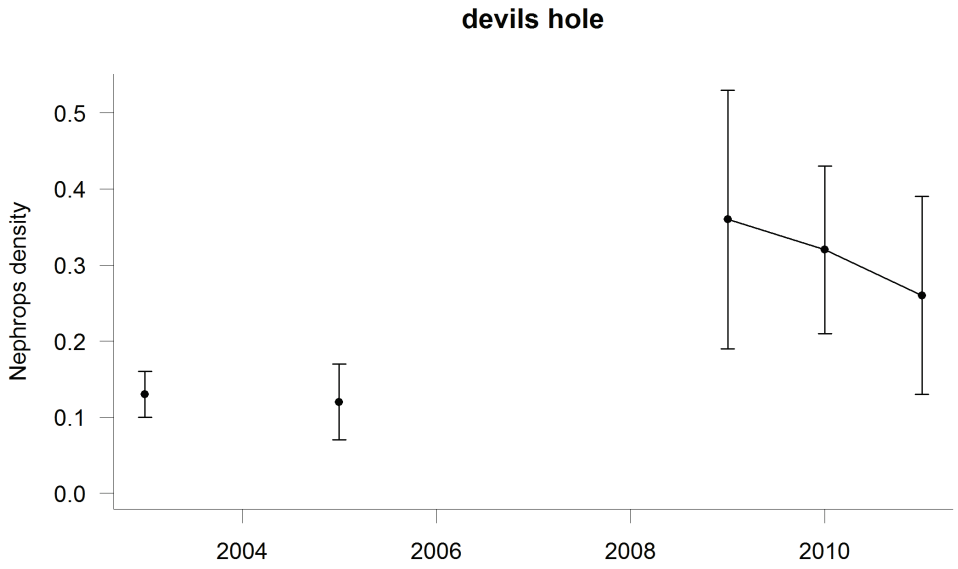


Figure 3.3.9.5. ***Nephrops*, Devil's Hole (FU 34). Time series of TV survey density estimates, with 95 % confidence intervals, 2003, 2005, 2009-11.**

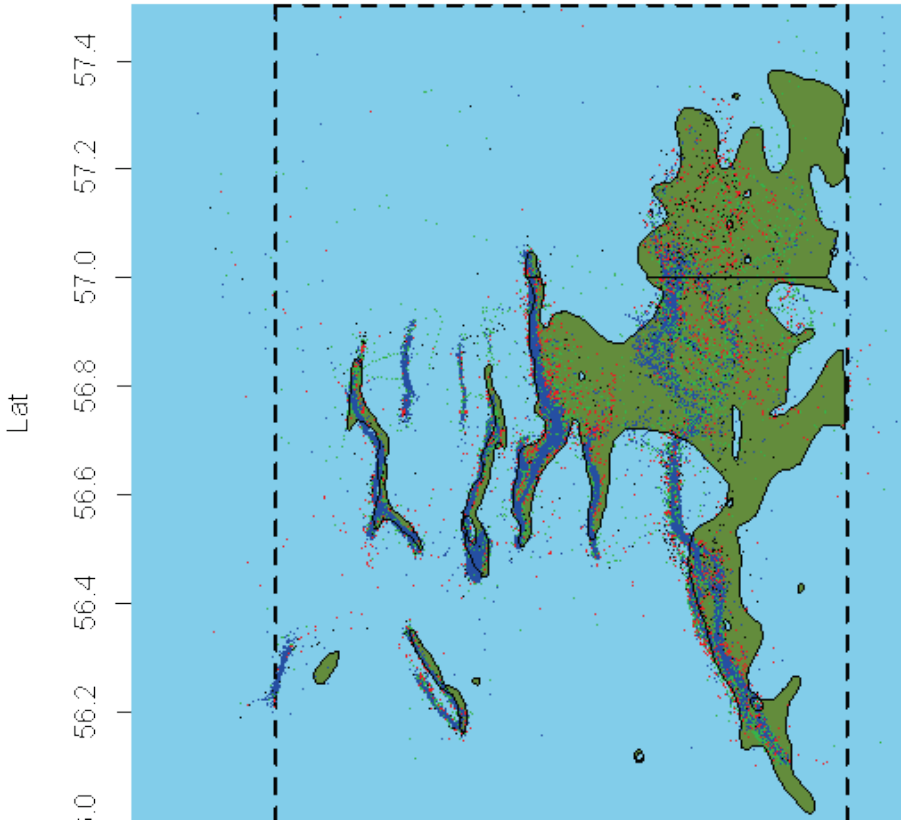
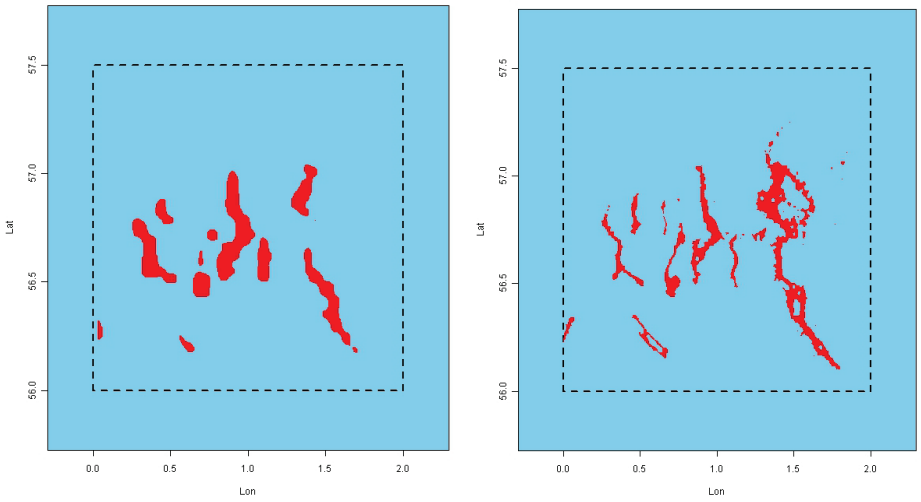


Figure 3.3.9.6. ***Nephrops*, Devil's Hole (FU 34). Comparison of BGS muddy sediment and VMS data from Scottish *Nephrops* trawlers (2006-2009).**

a) **b)**



c)

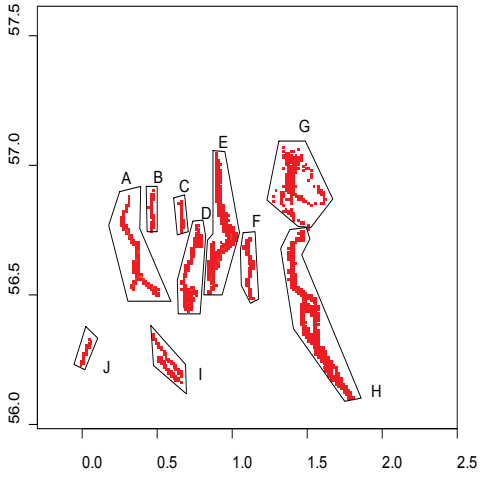


Figure 3.3.9.7. ***Nephrops*, Devil's Hole (FU 34). Estimated fished area by a) thin plate regression spline method (2009 data), b) alpha convex hull (2009 data) and c) cells containing on average > 2 pings/year.**

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 2011 EC TAC for *Nephrops* in ICES Subarea IIa and IV was 23454 tonnes in EC waters (plus 1200 tonnes in Norwegian waters). For 2012, this was reduced to 21929 tonnes in EC waters and 1200 tonnes in Norwegian waters. In 2013, there has been a further reduction to 21929 tonnes in EC waters, but no change to the allowance for 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 2012 are around 13,500 tonnes, representing a decline of 11,500 tonnes from the peak observed in 2009. The decline has been almost entirely from within the UK.. Minor updates have been made to landings in previous years. Quota uptake by UK vessels (who have a share of around 90 % of the TAC) was just over 80 % in 2010.

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.

4.2.1 Review of the 2012 assessment

" The RG agrees with the WG conclusions of uncertainty regarding the status of this stock. Under the new approach for data poor stocks FU 5 (Botney Gut) is defined as Category 6 (data limited stocks) and the recommended advice is Advice Draft C. On the bases of precautionary considerations – catches should be reduced."

4.3 Botney Gut (FU5)

4.3.1 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 2011 and 2012, the UK and Netherlands continued to dominate the fishery taking ~80% of the landings from this area. Germany continued to take around 14% in both years whilst landings from Belgium doubled in 2012. There was no reported fishery by Danish vessels in 2012 for the first time since 1994.

It was erroneously reported in the 2012 WG report that *"the size of the UK fleet prosecuting this fishery had declined sharply from seven vessels in 2009 to three in 2010 and just one in 2011"*. This was the number of vessels towing specific Nephrops gears using the mesh range 70-99mm, and excluded any trips in which the gear was recorded as simply "trawl". In fact the size English fleet targeting *Nephrops* in FU5 has fluctuated between 11 and 28 since 2000, and was 14 and 11 vessels in 2011 and 2012 respectively. *Nephrops* in FU5 are caught by trawling, there is no creeling in the area.

4.3.2 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 since increased sharply and were >1200t in 2012. 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 doubled the landings between 2011 and 2012. Danish landings have been at very low levels in recent years and were zero in 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 assessment 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 composition in the Dutch landings are available from 2003 to 2012 (Figure 4.3.1. 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 number measured are >10000 individuals a year, while between 2010 and 2012 the sampling measurements drop 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.

4.3.3 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).

4.3.4 Commercial catch-effort data and research vessel surveys

Effort and LPUE Figures are available for Belgian *Nephrops* specialist trawlers (1985-2005), the Dutch fleet (all vessels catching *Nephrops* for the period 2000-2012), Danish bottom trawlers with mesh size > 70 mm (1996-2011) and English vessels using *Nephrops* gears 2000-2012, Table 4.3.3 and Figure 4.3.2.

The effort of the Belgian *Nephrops* fleet has shown an almost continuous decrease since the initial high in the early 1990s. In 2005, effort was at the lowest level in the time series. No data are available since 2006.

The effort of the Dutch fleet (all trips recording catches of *Nephrops*) peaked in 2001 and was in general decline since then, however it has stabilised over the last 4 years.

Danish effort has been negligible since 2007 and there was no activity at all by Danish vessels in 2012.

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.

Effort by English vessels targeting *Nephrops* (targeting being classed as trips where *Nephrops* comprise >=25% of landings by biomass) in FU5 is variable, ranging from 11-37 and appears to go through cycles of high and low activity. 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 ves-

sels 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)

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

There were no new surveys in this FU since the last assessment in 2012. In autumn 2010 and spring 2012 initial TV *Nephrops* surveys were undertaken at FU5 (Botney Gut Silver Pit grounds). The 2011 autumn survey was unable to take place due to adverse weather so it was conducted in the spring of 2012 instead. Initially 42 stations were selected around a randomized fixed grid delimited by the combination of VMS data and BGS sediment maps (Figure 4.3.4). In order to ensure VMS data represented *Nephrops* fishing activity, UK VMS data were screened to only include vessels fishing with *Nephrops* gear at towing speeds of less than 4 knots. At these stations 10 minutes of clear video were recorded and 7 minutes were recounted following the same counting protocol employed on the FU 6 survey which in turn complies with the general protocol defined by SGNEPS. Further details on this survey can be found in the report of SGNEPS (2010). The 2012 survey increased the number of stations and included grounds in the Dutch sector that had previously not been sampled. Poor underwater visibility means that the survey results are subject to a high degree of uncertainty. Due to the complex shape of the *Nephrops* ground, it is not anticipated that a geostatistical method for determining abundance can be followed. A preliminary analysis of the spatial distribution of the counts shows the centre of abundance to be at the eastern end of the ground (Figure 4.3.5), compared to the VMS data which shows more fishing activity at the north western end of the ground. Comparison with FU6 of the statistical distribution of burrow counts (Figure 4.3.6) shows that FU5 is characterized by a large proportion of low density *Nephrops* stations with a smaller number of high locations, unlike FU6 which shows a much less skewed distribution of burrow densities.

Intercatch

FU5 data were available from Intercatch for all nationalities for 2011 and 2012. Quarterly landings by metier were available for all countries fishing the functional unit and quarterly length compositions for the landing component (by the OTB-CRU-70-99 component) were entered for the Netherlands. The number of samples going into the length frequencies was low and therefore the annual length frequencies were constructed by pooling quarterly length frequencies, weighted by the tonnage per quarter.

4.3.6 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 and the mean weight from the Dutch landings sampling programme. The 2012 survey shows that density is relatively high on this ground at 0.7 burrows per metre squared. 10 year average

landings of 1090 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	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	

4.3.7 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.

4.4 Farn Deeps (FU6)

4.4.1 Fishery in 2011 & 2012

Since 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 2070t in 2011 to 2460t in 2012, which is just below the 10 year average (2530t) but significantly higher than the 5 year average (1980t). (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 2012 was almost identical to from the 2011 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 moves towards multi-rig fishing gears which generally have a higher fishing power. The proportion of landings by twin riggers rose steadily until 2008 after which the proportion has been fairly stable (Figure 4.4.2). Historically the fishery is 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 number of vessels in the fishery has been decreasing since the peak in 2006 and 2007 and was at the same level in 2011 as in the late 1990s .

The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2012 data comprise the end of the 2011-2012 fishery and the start of the 2012-2013 fishery. Quarterly patterns of directed effort by English vessels were very similar in both 2011and 2012 and conformed to the long term pattern. (Figure 4.4.6).

4.4.2 ICES Advice in 2012

The last assessment of *Nephrops* in FU6 was in 2012.

The basis for advice in 2012 was the "Transition to an **MSY approach** with caution at low stock size". This corresponded to landings of less than 1 400 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.

4.4.3 Assessment

Review of the 2012 assessment

" The assessment has been performed correctly. The RG agrees with the WG that management of this stock at the functional unit level as opposed to the sub-area level would be an improvement."

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 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. 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 appears to be becoming 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, and the mean annual increment of the second mode is only around 2mm and therefore year class strength is unlikely to be the cause of this feature. The higher proportion of females in the catches during 2012 (figure 4.4.4) indicates another sea-

son where large mature females were foraging for food on the surface at a time when they would have been expected to be brooding eggs within their burrows. For males there is a more unimodal form which has broadened since 2010 (Figure 4.4.7).

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.

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 4.4.5) 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. *Nephrops* directed gears all show a similar LPUE in 2011 compared to 2010 whilst unspecified otter trawls appear to have increased their LPUE.

Males generally predominate in 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 and 2010, Figure ????).

Directed effort is generally highest in the 1st and 4th quarter of the year in this fishery (Figure 3.3.2.6) with landings correspondingly highest in these quarters. Effort in 2010 was particularly skewed with a relatively high level of effort in the first quarter and very little in the fourth quarter, a more normal pattern was resumed in 2011. The reduced number of larger vessels in the 2008 fishery may have a disproportional negative impact on CPUE measures in that the larger vessels are likely to have a higher efficiency. Female LPUE in the fourth quarters of 2000, 2006, 2009 and 2011 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. A time series of indices is given in Figure 4.4.8 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 4.4.9 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.

Whilst analysing the 2011 survey, the processes used for the surveys between 2007 and 2010 were checked and amendments made to the width of visible track. Some of these changes were minor, but the 2010 value was increased from 71.25cm to 81.5cm (+14%). The effect of this is to decrease the total abundance estimate for 2010 from 892 million to 753 million (-18.5%). The 2007 value, used as the reference point increased from 876 million to 881 million.

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. Length distributions for landings and discards were raised on a quarterly basis, fleet specific LDs were generated for TR1 (3.7%) and TR2 (94%) gears whilst all other metiers were allocated pooled LDs from all available gears.

Natural mortality, maturity at age and other biological parameters

Biological parameter values are included in the Stock Annex which was updated at the 2013 benchmark. The principle change was to the female maturity parameters which have shown an increase in length for 50% maturity over the past 5 years from

~25mm to ~32mm. Changes in biological parameters requires that the MSY reference points need to be re-determined and this is described later.

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 factors were estimated for each FU and for FU6 the bias correction factor is 1.2 meaning that the TV estimate is likely to overestimate absolute abundance of *Nephrops* by 20%. Estimates of mean burrow density and the resulting bias-corrected abundance estimates (with confidence estimates) are given in Table 3.3.2.4.

Further revisions to burrow counting have resulted in some changes in the historical estimates of TV abundance, the differences are described below.

	WGNSSK 2012	WGNSSK 2013	Difference
2007	890	858	*-3.6%*
2008	951	987	*3.8%*
2009	683	682	*-0.1%*
2010	753	785	*4.2%*
2011	870	878	*0.9%*

Final Assessment

The estimated abundance in 2012 was 758 million individuals (95% confidence interval of ±13 million), significantly below the 2007 estimate used as MSY $B_{trigger}$ (858 million). The estimated harvest rate for 2012 was 16.2%, nearly double the MSY proxy level of 8.1%.

The stock therefore remains in a vulnerable state. The dominance of large females in the landings again for the 2011-2012 fishery suggests that they had not successfully mated and therefore there remains the potential for poor recruitment for 2011 and 2012 (recruits to the fishery are estimated to be ~ 2-3 years old)

4.4.4 Historical stock trends.

The time series of TV surveys is 12 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 6.4% 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.

4.4.5 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 have been 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 3.3.2.10) 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 bias adjusted TV abundance 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 2014 are given in the text table below. This assumes that the bias corrected survey index made in October 2012 is relevant to the stock status for 2014. Discard rates and mean weight in the landings are the mean of 2010-2012 as used in the reference point calculations.

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. The TAC for an MSY compliant land-all policy will therefore be less than the sum of catch components under the current management arrangements.

	Harvest ratio	Retained number	Landings	Dead Discards	Surviving Discards	TAC for land-all policy
	2%	12	307	35	6	342
	4%	24	615	70	12	685
	6%	36	922	104	18	1026
Male F0.1	7.1%	43	1093	124	22	1217
Transition	7.6%	46	1173	133	23	1306
Male F35%	8.1%	49	1248	141	25	1389
Comb F0.1	8.7%	52	1334	151	27	1485
Comb F35%	11.1%	67	1712	194	34	1906
Male Fmax	11.6%	70	1782	202	36	1984
Fcurrent	12.3%	74	1894	215	38	2109
Female F0.1	14.0%	84	2154	244	43	2398
Female F35%	15.2%	*91*	*2334*	264	47	2598
Comb Fmax	15.3%	92	2351	266	47	2617
Female Fmax	21.6%	130	3319	376	66	3695

$F_{0.1(T)}$: 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.

4.4.6 BRPs

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

4.4.7 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 2012 survey results is similar to 2008 but 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 mid 2011. 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 not followed the increasing trend of other Functional Units. There is also agreement with the Stock Survey that 2011 saw an increase in abundance compared to 2010. Overall participation in the survey dropped for *Nephrops* with 74 respondents in 2011 compared to 86 in 2010.

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.

4.4.8 Status of stock

The TV survey indicates the stock to have improved and is just below the level of MSY $B_{trigger}$. There are no indications of strong recruitments coming into the stock.

4.4.9 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.

4.5 Fladen Ground (FU7)

4.5.1 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. 30000km2). Figure 3.3.3.5 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.

4.5.2 The Fishery in 2012

The *Nephrops* fishery at Fladen is the largest in the North Sea and is mainly prosecuted by UK (Scotland) vessels (4292 tonnes), with Denmark taking 75 tonnes and England only two tonnes (Table 4.5.1).

In 2012, 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. Fishing was extremely poor around March 2012 and as a result 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. Vessels returned to Fladen throughout summer but catches remained considerably lower than previous years and fishing only improved in the last quarter. Prices for *Nephrops* fell sharply in 2012 (by up to 25%) because of a decreased demand from Italy and Spain, and reports suggest that large quantities of frozen *Nephrops* remained unsold. Oil guard vessel duties are still attractive, and provide a guaranteed income when fishing is poor. Other vessels are switching between TR1 and TR2 in order to land more whitefish.

4.5.3 ICES advice in 2012

The last assessment of *Nephrops* in FU7 was in 2012.

The basis for advice in 2012 was the **MSY approach** which advised that landings in 2013 should be no more than 10 000 t .

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

4.5.4 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 3.4.2)

4.5.5 Assessment

Review of the 2012 assessment

General comments from the review group;

"The drop in abundance along with the increase in mean length of smaller individuals (possible lower recruitment) could be early warning signs for this stock.

For the past few years this stock has been characterized in the assessment of being at a high level of abundance, well above the MSY Btrigger. It is no longer "well" above the MSY Btrigger, at least relative to previous abundance estimates and is rapidly approaching this MSY Btrigger (decline of more than 50% since 2008). Better refined management at the FU level would help protect this stock.."

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

Approach in 2013

The assessment in 201The assessment of *Nephrops* in 2013 is based on examining trends in the UWTV survey data (1992-2012)) and utilisingan extensive series of 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 2013 followed the process of 2012, 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 TVUWTV 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 ICES, WGNSSK, 2010.

4.5.6 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 2012 were 4369 tonnes (over 3000 tonnes lower than the 2011 total), consisting mostly of Scottish landings and only 75 tonnes landed by Denmark.

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 Ground. 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 2012 and only annual summaries are available.

Trends in Scottish effort and LPUE are shown in Figure 4.5.1 and Table 4.5.2. Note that Figure 4.5.1 shows landings, effort and LPUE for Scottish *Nephrops* trawlers only (TR2 vessels), whilst Table 4.5.2 shows landings, effort and LPUE for TR1 and TR2 vessels. Effort has been relatively stable from 2002 to 2010 but fell in 2011 and 2012 because of poor fishing and the fleet relocating to the west coast of Scotland. LPUE has gradually increased since 2000 to a peak of approximately 620 kg/day in 2009. It has gradually fallen since then and was 360 kg/day in 2012. The decrease in LPUE may be explained through the lower abundance of *Nephrops*, and also the possibility of lower recruitment (indicated by the increase in mean length of smaller individauls). Danish LPUE data are presented in Table 4.5.3. Effort has decreased over the time series (1991-2012) whilst LPUE has gradually increased to a high of 681kg/day in 2012. At the moment there is no suitable explanation as to why the Scottish LPUE has fallen in recent years whilst the Danish LPUE has increased, but we can speculate that this may be due to the differences in the spatial distribution of the fishery. .

Males consistently make the largest contribution to the landings and this was the same in 2012 (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, 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 (2000-2012) is approximately 10% by number in this FU. In the last few years discard rates have dropped below the long term average and in 2011 and 2012 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 of25 % survival is assumed for this FU in order to calculate removals (landings + dead discards) from the population.

Intercatch

Scottish data for 2012 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2013 WG and output length compositions were obtained in formats suitable for running the assessment.

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 2012. 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 although for males in 2011 and 2012 there has been a noticieable shift in the length distribution and an increase in the mean size.

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 4.5.1 and Table 4.5.4. 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 although there has been an increase in the last four years which may be associated with lower recruitments. In 2011 and 2012, the landing 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. 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 (1990-2012) 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 and 2012 the mean weight increased and 2012 is the highest value in the time series for Fladen, with a mean weight of 36.91g.

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*.

Table 4.5.6. On average, approximately 64 stations have been considered valid each year (70 stations in 2012). 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 bias corrected estimated abundance is likely to be slightly underestimated by the UWTV survey.

4.5.7 Data analyses

Exploratory analyses of survey data

Table 4.5.7 shows the basic analysis (bias adjusted) for the three most recent UWTV surveys conducted in FU 7. The table includes estimates of abundance and variabil-

ity 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 this coarse sediment which surrounds the main centres of abundance.

Figure 4.5.5 shows the distribution of stations in recent UWTV surveys (2005-2012), 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 but in 2007, high densities were also widely recorded in the coarser sediment 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 TV survey is likely to overestimate *Nephrops* abundance by 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 surveyand it therefore only provides information on abundance over the area of the survey.

The 2012 UWTV survey data shows that the abundance has continued to reduce from the high value observed in 2008 and has now fallen below 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 to a peak of 7360 million individuals in 2008. Since 2008 the abundance has fallen and the bias adjusted abundance in 2012 is estimated to be 2748 million individuals (Table 4.5.8).

Table 4.5.8 shows the estimated harvest ratios from 2003-2012. These range between 4 and10% 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 also shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

4.5.8 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.

4.5.9 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 the WGNSSK 2010 report.

WGNSSK 2011		Fbar(20-40 mm) M	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
	M	0.14	0.09	9.5	40.3	47.6	43.3
$F_{0.1}$	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
	M	0.28	0.18	16.2	23.6	30.8	26.5
F_{max}	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
	M	0.18	0.11	11.4	34.5	41.9	37.6
$F_{35\%SpR}$	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

$F_{0.1(T)}$: 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.

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 stock annex for previously estimated values used at WGNSSK 2010). 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 (bias adjusted lowest observed UWTV abundance) is calculated as 2767 million individuals.

4.5.10 Short-term forecasts

A landings prediction for 2014 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 2012. The landings prediction for 2014 at the F_{msy} proxy harvest ratio is 9227 tonnes. The UWTV abundance has fallen below the Btrigger and so the harvest rate is reduced (bias adjusted UWTV 2012 abundance/Msy B trigger * Fmsy) to 10% with predicted landings of 8959 tonnes.

There is no transition stage as the current harvest ratio is actually below that equiv

The inputs to the landings forecast were as follows:

Mean weight in landings (2010-2012) = 33.15 g

Dead discard rate (by number) = 1.7% (average 2010-2012)

Survey bias = 1.35.

F_{2012} = the F_{msy} proxy harvest ratio 10.3%.

Basis	Harvest rate	**Landings (tonnes)**
	5.0%	**4479**
	7.5%	**6719**
F2010-2012	6.9%	**6181**
Fmsy (Btrig*)	10.0%	**8959**
Fmsy=F0.1(T)	10.3%	**9227**
	12.5%	**11198**
	15.0%	**13438**
	17.5%	**15678**
	20.0%	**17917**

* B trigger rule applies under MSY approach

$F_{0.1(T)}$: 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.

4.5.10.1 Biological Reference points

4.5.11 Biological Reference points

Biological reference points have not been defined for this stock.

4.5.12 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 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 approximately 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 bias adjusted absolute abundance estimate for this ground is therefore likely to be underestimated by the current methodology.

There appears to be some inconsistencies between the Fishers' North Sea stock survey in 2011 and 2012. In 2011, the survey suggests that moderate or higher amounts of recruits were apparent in Area 1 (within which the Fladen FU largely lies) and that perceived abundance of *Nephrops* increases up to 2011. The 2012 results appear to show that perceived abundance has fallen since 2009 and dipped further in 2012. Results in 2012 were based on six responses for Area 1, of which four people thought there were less or much less *Nephrops*.

Status of the stock

The 2012 UWTV survey data presented at this meeting shows that abundance has continued to drop and is now below 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 2012 (removals/UWTV abundance) was 4.7% and is considerable lower than F0.1.

4.5.13 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.

4.6 Firth of Forth (FU 8)

4.6.1 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 3.3.3.1). 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 915km^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.

4.6.2 The Fishery in 2011 and 2012

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 2011 around 27 vessels worked regularly in the Firth while this increased to 30 in 2012. Most vessels are under 12m in length with about 10 in the 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 2011 there were very few visiting vessels apart from some NE vessels fishing in the summer months. In 2012 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*. 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. 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 (these have increased to just over 124 tonnes in 2012) 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.

4.6.3 Advice in 2012

The ICES conclusions in 2012 in relation to State of the Stock were as follows:

The stock remains above MSY $B_{trigger}$ but has declined over the last 3 years. The harvest rate remains above F_{MSY}.

The ICES advice in 2012 (for 2013) (Single-stock exploitation boundaries) was as follows:

MSY approach

ICES advises on the basis of the transition to the MSY approach that landings in 2013 should be no more than 1400 t.

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

The review group concluded that "the assessment has been performed correctly with the available data.

The current estimate of stock abundance is above MSY $B_{trigger}$ but the harvest rate is above Fmsy and ICES Fmsy framework dictates that the recommended F should be the current Fmsy proxy (Fmax= 16.3%).

The RG agrees again this years with WG conclusion that "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_{max} and therefore it would be unwise to allow effort to increase in this FU."

The RG's comments mainly consisted of a list of editorial comments, requests for greater clarity in presentation and highlighting of missing material in the Stock A

Approach in 2013

The assessment in 2013 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) and 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 fewer than 6%. Reported landings rose by over 200 tonnes between 2011 and 2012 after a significant drop in 2010. The value for 2009 of over 2,600 tonnes was the highest in the available time series whilst the 2012 landings (2091 tonnes) are above the long term average (2091 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. 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 (2003 -2012 average 35 %). In the last five years, discard rates appear to have dropped to below this value (28 % on average by number) and may be explained by the use of more selective fishing gear and the retention of *Nephrops*.

This appears to be due to increased rate

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 2012 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2013 WG and output length compositions obtained in formats suitable for running assessments.

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 2012. 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. In males there is some evidence of an increase.

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 been rising very slightly in the last three years

Mean weight in the landings is shown in Figure 4.6.4 and Table 4.6.5 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 2012, there were 66 valid stations – the highest in 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, 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 UWTV 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 UWTV 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 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 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 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 2012 is close to the 2011 abundance and is similar to that recorded in 2002. The UWTV 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 2012 (dead removals/TV abundance) is well above F_{max}.

The mean size of individuals < 35 mm in the catch show no strong trend in recent years.

4.6.6 Historical Stock trends

The UWTV 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 2003-2010 (the period over which the survey estimates have been revised) is shown in Table 4.6.5. The stock is currently estimated to consist of 522 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 2012 is 25% which above the estimated value at F_{max} (16.3%).

In addition to the discard rate, Table 4.6.6 also shows the dead discard rate (average 2010-2012 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.

4.6.8 MSY considerations

A number of potential F_{msy} proxies are obtained from the per-recruit analysis for *Nephrops*. 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.

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

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 (bias adjusted lowest observed UWTV abundance) is calculated as 292 million individuals.

4.6.9 Short-term forecasts

A landings prediction for 2014 was made for the Firth of Forth (FU8) using the approach agreed at the Benchmark Workshop and outlined in the *Nephrops* introductory section. The table below shows landings predictions at various harvest ratios, including a selection of those equivalent to the per-recruit reference points discussed. The landings prediction for 2014 at the F_{msy} proxy harvest ratio is 1381 tonnes. The F_{msy} transition stage harvest ratio results in a landings option of 1417 tonnes. The table also shows predicted discard weights (both discards expected to die and those surviving). A column is also included to show expected landings under a land all policy.

The inputs to the landings forecast were as follows:

Survey abundance (2012) = 522

Mean weight in landings (2010-12) = 20.39 g

Mean weight in discards (2010-12) = 9.7g

2010-12) = 20.4 % Survey bias = 1.18

Harvest ratio $F_{(2010\text{-}2012)}$ = 21.7 %

F_{msy} transition (16.7 %) is calculated from 0.8 x Fmsy + 0.2 x F_{2010} where F_{2010}=18.4 %

		Implied fishery				
	Harvest rate	Retained number	Landings (tonnes)	Dead discards (tonnes)	Surviving discards (tonnes)	TAC for land all policy
	5.0%	21	424	51	17	*461*
$F_{0.1\ (T)}$	9.4%	39	793	96	32	*864*
	10.0%	42	848	103	34	*923*
$F_{35\%SPR(T)}$	12.7%	53	1077	131	44	*1173*
	15.0%	62	1272	154	51	*1384*
F_{msy}	16.3%	68	1381	168	56	*1503*
F_{msy} transition	16.7%	69	1417	172	57	*1542*
	20.0%	83	1696	206	69	*1846*
	21.7%	90	1840	223	74	*2003*

$F_{0.1(T)}$: 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.

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 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.

4.6.11 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 2012 is about the same abundance and is similar to that recorded in 2002. The UWTV 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 2012 (dead removals/UWTV abundance) is above F_{max}.

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.

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_{max} and therefore it would be unwise to allow effort to increase in this FU.

4.7 Moray Firth (FU 9)

4.7.1 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 3.3.3.1). 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).

4.7.2 The Fishery in 2012

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). The general situation in 2012 is similar to previous years with the vessels targeting this fishery typically conducting day trips from the nearby ports along the Moray Firth coast. Occasionally larger vessels fish the outer Moray Firth grounds on their way to/from the Fladen or in times of poor weather. In 2011 and 2012, shortages of *Nephrops* at the Fladen led to periodic visits by larger vessels who mainly fished the outer areas of the Firth. In 2012, these larger vessels moved into the inner Moray Firth and this caused friction with the local fleet. Local fishermen sent a petition to the Scottish Government with the aim of preventing larger vessels from fishing within 12 miles of the shore. Further general information on the fishery can be found in the Stock Annex.

4.7.3 Advice in 2012

The ICES advice for 2013 was as follows:

"ICES advises on the basis of the MSY approach that landings in 2013 should be no more than 950 t.

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

4.7.4 Management

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

4.7.5 Assessment

Review of the 2012 assessment

"The review group agrees with the conclusions of the working group and the updated assessment was consistent with previous years. We also agree with the WG that management of this stock at the functional unit level as opposed to the sub-area level would be an improvement. However, the RG would like to point out that not all signs are positive for this stock. There has been a decrease in survey density and mean size, as well as increased landings and the harvest ratio is well above the Fmsy proxy harvest ratio."

Approach in 2013

The assessment in 2013 is based on a combination of examining trends in fishery indicators and UWTV using an extensive data series for the Moray Firth (FU9). 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 2013 followed the process of 2012, 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 2012 for Scotland were 860 tonnes (530 tonnes lower than 2011) and England landed under one tonne (958kg). 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 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 4.7.1 and Table 4.7.2. Effort has shown a gradual decline over the time period (2000-2012). 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 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 6 and 33% of the catch by number. In 2012 the observed rate by number was approximately 10%. 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 2012 were successfully uploaded into Intercatch. National data coordinators for other countries also uploaded data to Intercatch ahead of the 2013 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 2012. 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). 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 4.7.4 and Table 4.7.5 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) 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, 37 stations were sampled in 2011 and 44 in 2012. 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 FU9 (2010-2012). 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 (2007-2012), 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 %.

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 2007 (from 531 million to 299 million individuals in 2012). The abundance is still above the biomass trigger of 262 million individuals.

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

4.7.6 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. The abundance estimates from 2003-2012 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 2003-2012. 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 2012 is approximately 14% and is still above the F_{msy} proxy value of 11.8%, although it has fallen from 19% in 2011.

In addition to the discard rate, Table 4.7.6 also shows the dead discard rate (average 2010-2012 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).

4.7.7 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.

4.7.8 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)		HR (%)	SPR (%)		
		M	F		M	F	T
	M	0.13	0.07	7.16	42.35	61.48	49.89
$F_{0.1}$	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
	M	0.26	0.13	12.31	25.80	45.16	33.42
F_{max}	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
	M	0.17	0.09	9.11	34.69	54.48	42.48
$F_{35\%SpR}$	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

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

$F_{0.1(T)}$: 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.

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.

4.7.9 Short-term forecasts

A landings prediction for 2014 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 (2010-2012). The landings prediction for 2014 at the F_{msy} proxy harvest ratio is 739 tonnes. The inputs to the landings forecast were as follows:

Mean weight in landings (2010-2012) = 24.29 g

Dead discard rate (by number, average 2010-2012) = 12.3 %

Survey bias = 1.21

$F_{(2010-2012)}$ = Average F2010-2012= 14.6 %

Basis	Harvest rate	**Landings (tonnes)**
	5.0%	**313**
	7.5%	**470**
	10.0%	**627**
F_{msy}	11.8%	**739**
	12.5%	**783**
$F_{2010-2012}$	14.6%	**915**
	15.0%	**940**
	20.0%	**1253**

Biological Reference points

Biological reference points have not been defined for this stock.

4.7.10 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.

nnual 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 Firth of Forth. Area 3 covers 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.

4.7.11 Status of the stock

The evidence from the UWTV survey suggests that the population has continued to decrease since 2007. There is no evidence from the mean size information to suggest overexploitation of the FU. Harvest ratios (removals/UWTV abundance) for 2012 was lower than 2011 but still above F_{msy}.

4.7.12 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 $F_{35\%SpR}$ and because the abundance (as estimated by the UWTV survey) appears to have declined in recent years, it would be unwise to allow effort to increase in this FU.

4.8 Noup (FU 10)

4.8.1 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.

4.8.2 The Fishery in 2011 and 2012

The Noup currently supports a relatively small fishery. In 2011, five vessels fished this area regularly and this fell to only two vessels in 2012. Landings have decreased steadily since 2002 and in 2012 only 13 tonnes of *Nephrops* was landed (Table 4.8.1). Further general information on the fishery can be found in the Stock Annex.

4.8.3 Advice in 2012

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

"Based on the ICES approach for data-limited stocks, ICES advises that catches should be no more than 50 tonnes. This is the first year that ICES is providing quantitative advice for data-limited stocks (see Quality considerations)."

"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 2012 were only 13 tonnes, a decrease of 55 tonnes from the previous year and the lowest landing reported in the time series (1997-2012). *Nephrops* are almost exclusively landed by 'non-*Nephrops*' vessels. This supports the anecdotal information received from the fishing industry that this Functional Unit 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 increased in 2011 but fell again in 2012. Interpretation of this index is difficult since the vessels are not targeting *Nephrops*

Length compositions

4.8.1 and Table 4.8.3

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 2013.

4.8.4 Historical stock trends

Recent landings for this FU have been low, approximately 68 tonnes in 2011 and only 13 tonnes in 2012.

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

4.8.5 Recruitment estimates

There are no recruitment estimates for this FU.

4.8.6 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.8.7 Status of the stock

The current state of the stock is unknown.

4.8.8 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.

Following the procedure outlined for the data limited approach, 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*/m^2), from the most recent UWTV survey (2007)), was used together with the mean weight and discard percentage taken from FU 9 (Moray Firth). The advice in 2012 was for maximum landings of 50 tonnes, which would equate to a harvest ratio of approximately 5.3% which is below any proxy for Fmsy used on other grounds in the North Sea and is therefore seen as precautionary.

	FU10 : Noup					Area (km2)	mean weight (g)		percentage discards
						409	24		12.30%
		Density (Nephrops per m^2)							
Basis	**landings**	**0.06**	**0.08**	**0.11**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**
0.5 * Average	70	13.60%	10.20%	7.40%	6.80%	5.80%	5.10%	4.50%	4.10%
Average	140	27.10%	20.30%	14.80%	13.60%	11.60%	10.20%	9.00%	8.10%
Maximum	400	77.40%	58.10%	42.20%	38.70%	33.20%	29.00%	25.80%	23.20%
Recent average	40	7.70%	5.80%	4.20%	3.90%	3.30%	2.90%	2.60%	2.30%
2012 advice	50	9.70%	7.30%	5.30%	4.80%	4.10%	3.60%	3.20%	2.90%

Bias corrected 2007 density = 0.11

4.9 Norwegian Deep (FU 32)

4.9.1 General

4.9.1.1 Ecosystem aspects.

See stock annex (section A.3).

4.9.1.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2).

4.9.2 Advice in 2012

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."

4.9.3 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. 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.

4.9.4 Assessment

4.9.4.1 Data available

Landings data for the 2014 assessment (all fleets in 2012) 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 2012 amounted to only 310 t, the lowest figure since 1994. 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 70-75 %. Norwegian landings have decreased since 2009 and were reduced by around 40 % from 2010 to 2011-2012.

Since 2003, the Danish at-sea-sampling programme has provided discard estimates (Figure 4.9.1). Discards are low due to the 120 mm mesh size and have decreased recently compared to the years 2003-2006. There are no Norwegian discard data (see stock annex, section B.1).

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. The average sizes in the catches have shown similar trends. The Norwegian time series of mean size in catches also shows an increasing trend from 2006 until present for females, while for male, the mean size is fluctuating without trend. This could be due to limited Norwegian catch sampling in 2012. The increased mean size in the catches observed in recent years (Figure 4.9.1) may indicate lower recruitment, or larger individuals in the population. The mean sizes in the discards is more informative than mean sizes in catches when considering recruitment, and will be presented at the 2014 WG meeting.

The length frequency distributions in the Danish catches do not show any clear changes from year to year (Figure 4.9.2) as would have been expected considering the increased mean size in the catches. However, the 2012 distribution does have a relatively larger number of individuals in the size range 45-54 mm compared with former years. There are in general 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 either (Figure 4.9.3). Danish and Norwegian length 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 1989-2012 are available from Danish logbooks (Table 4.9.2, Figure 4.9.1). 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). Since 1994, the Danish LPUE has fluctuated around 200 kg day^{-1}. Some of the fluctuations may be caused by fishing vessels locally switching between roundfish and *Nephrops* due to changes in management regulations in the Norwegian zone. The Danish effort increased from 2004 to 2006, but showed a strong decline in 2007 and has since continued decreasing. This decline corresponds to a large decline in landings. It has not been possible to incorporate 'technological creeping' in the evaluation of the effort data. However, the use of twin trawls has been widespread for many years. Trends in the non-standardised and the GLM standardised LPUE values (relative indices) are very similar (Figure 4.9.1). However, this may merely reflect that vessels catching *Nephrops* in this area are very similar with respect to e.g. size and HP.

The Danish LPUEs may be a candidate for an indicator of stock size, and can potentially be used to determine when an assessment update is required. The WG suggests that an LPUE index outside the currently observed range of LPUE values of 160-240 kg/day in the years 1994-2012 should trigger an assessment update of the *Nephrops* stock in FU 32. This corresponds to approximately a 20 % increase/decrease from the current mean LPUE of 207 kg/day

The information on *Nephrops* in Norwegian logbooks is deficient. Logbook catches from FU 32 constitute 17 to 59 % of trawl landings in 2000-2012. The 2013 benchmark (WKNEPH 2013) analysed the Norwegian LPUE figures from bottom and shrimp trawls. The data from bottom trawls prior to 2010 are considered unsuitable for LPUE analyses. This is mainly because one particular vessel, with 70-100 % of the logbook catches in 2003-2008, has strange recordings of haul duration in 2005-2007 resulting in very high mean LPUE values in the same time period, which cannot reflect the state of the stock (WKNEPH 2013). The data from shrimp trawls prior to 2010 are also considered unsuitable for LPUE analyses. This is due to lack of data in some years and concerns that varying *Nephrops* catch rates in shrimp trawls may reflect more the choice of shrimp grounds than the state of the *Nephrops* stock. From 2011 onwards, trawl haul positions are given in logbooks, such that the spatial distribution of vessels fishing with shrimp and bottom trawls can be compared and the overlap between shrimp and *Nephrops* grounds elucidated. 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) will be 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 analysis 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). The distribution of the stock appears not to have changed much since 2006.

4.9.4.2 Data analysis

Review of last year's assessment

The last assessment of this stock was in 2012. The Review Group (RG) noted:

"All indicators suggest that there has been little change in recent years in mean size or LPUE implying that the level of exploitation is sustainable. Based on the estimated guidance approach of using input estimates from adjacent areas, the harvest rates in FU 32 are very low at < 2 % even when landings were in the order of 1000 to 1200 t. (...) The RG agrees with the WG conclusion that the level of exploitation is sustainable based on very limited data. (…) On the bases of precautionary considerations – catches should be reduced."

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.

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.

4.9.4.3 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 Danish LPUE has been fluctuating without trend around a mean of 207 kg/day since 1994. The WG notes that the highest landings from this stock in 1999-2006 did not cause a decrease in LPUE.

4.9.4.4 Recruitment estimates

There are no recruitment estimates for this stock.

4.9.4.5 Forecasts

There were no forecasts for this stock.

4.9.4.6 Biological reference points

No reference points are defined for this stock.

4.9.4.7 Quality of assessment

The data available for this stock remains limited.

4.9.4.8 Status of stock

The perceptions of this stock (FU 32) are based on Danish landings and effort data. The overall trend in the 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. The trends in mean size in landings and catches, and overall size distribution in the catches also indicate that the *Nephrops* stock in FU 32 is not overexploited. The WG concludes that the stock seems to be stable and that the level of exploitation is sustainable. The average annual landings over the last ten years are 715 t (2003-2012), while the short-term average landings are 453 t (2008-2012). The biomass estimates indicate that harvest ratios for this stock have always been very low (≤ 1 %), even in years where landings were highest.

4.9.4.9 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. 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 2012. Possibilities for obtaining biological data from the at-sea-sampling programme should be explored. 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. As total length data have lower resolution compared with carapace length data, the two cannot be combined without losing accuracy.

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 0.1 animals/m²), from the neighbouring functional unit (FU 7 Fladen Ground), was used together with the mean discard percentage in Danish catches in 2003-2012 (17 %) and mean weight of *Nephrops* in the Danish catches in 2012 (69 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 landings in 2014 and 2015 should be no more than 800 t.

	FU 32: Norwegian Deep	55 500	Area (km2)	69	mean weight (g)	17 % discards			
		Density							
	landings	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.5 * Average	355	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	715	0.4%	0.2%	0.1%	0.1%	0.1%	0.0%	**0.0%**	**0.0%**	0.0%
Maximum	1200	0.7%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
			min. Fladen density							

	FU 32: Norwegian Deep			55,500	Area (km2)	69	mean weight (g)		17%	discards
						Density				
	landings	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
0.5 * Average	355	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Average	715	0.4%	0.2%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Maximum	1200	0.7%	0.4%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%
			min. Fladen density							

4.10 Off Horns Reef (FU 33)

4.10.1 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. The other countries reporting landings from the area are Belgium, Netherlands, Germany and the UK. In 2007, total landings increased to above 1400 t. Since 2004, Danish landings have gradually decreased to almost 400t in 2012. On the contrary, Dutch landings increased during the same period. Total landings in 2012 from this FU amounted to almost 1100 t (Table 4.10.1 and Fig. 4.8.1), of which the Netherlands accounted for approximately 400 t. The other countries contributed with around 300 t.

Length compositions

Length (CL) distributions of the Danish catches 2001 to 2005 and 2009 to 2012 are shown in Figure 4.10.2. Notice, that except for 2005 and 2011 they are rather similar. Figure 4.10.3 shows the development of the mean size of *Nephrops* <35 mm by sex. The drop in the mean CL in the catches in 2005 and 2011 reflects an increase in num-

bers at around 30 mm CL and could indicate a large recruitment in these years, see also Fig. 4.10.1

In the period 2001-2005, and in 2009-2011 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, effort and research vessel 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 decreases markedly and was below 1000 days in 2008-2012. Dutch effort data are available from 2005-2012 and has been around 1500 days in the most recent 7 years. The Danish LPUEs show an increasing trend during the whole period (except 2010) and in 2012 were the highest on record (~700 kg/day). This increase in LPUE could reflect an increase in gear efficiency (technological creep) or in fishers ability to exploit the stock. LPUEs from the Netherlands increased from 200 kg/day in 2006 to around 300 kg/day in 2007-2009 and have since fallen to around 200 kg/day.

4.10.2 Data analysis

Reviews of the 2012 assessment (FU33)

"The RG agrees with the general conclusions of the WG. Under the new approach for data poor stocks FU 33 (Off Horn Reef) is defined as Category 6 (data limited stocks) and the recommended advice is Advice Draft C. On the basis of precautionary considerations – catches should be reduced".

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

4.10.2.1 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. This year, new data from the Netherlands was available for the last eight years and shows a more stable effort. LPUE has slightly increased for Denmark and slightly decreased for Netherlands in 2012.

The size distribution in the 2012 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.

Recruitment estimates: There are no recruitment estimates, but fluctuations in discards may reflect corresponding fluctuations in recruitment.

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.

4.11 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.

4.11.1 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).

4.11.2 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.

Advice in 2012

Advice provided in 2012 was biennial for 2013 and 2014.

"This is the first year ICES gives advice for this functional unit separately. Based on the ICES approach for data-limited stocks, ICES advises that landings should be no more than 600 tonnes. This is the first year ICES is providing quantitative advice for data-limited stocks (see Quality considerations). "

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

4.11.3 Management

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

4.11.4 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.

4.11.5 Data available

Commercial catch and effort data

Overall landings from this fishery for 1991-2012 are presented in Table 4.11.1 and a time series of landings (2000-2012) 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 but increased slightly in 2012 to 597 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 to 2009 before falling again. The decrease may partly be explained as a result of reductions 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 to 2009 but has dropped back slightly in the last couple of years.

Length compositions

Levels of both market and discard sampling are low and in 2012 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

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.

4.11.6 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 abso-

lute 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 benchmark earlier this year (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 outside 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.

4.11.7 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.

4.11.8 Recruitment estimates

There are no recruitment estimates for this FU.

4.11.9 MSY considerations

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

4.11.10 Short-term Forecasts

No short-term forecasts are presented for this FU.

4.11.11 Status of the stock

The current state of the stock is unknown.

4.11.12 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.

Following the procedure outlined for the data limited approach, 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*/m²), from the most recent UWTV survey (2012), was used together with the mean weight (average 2007-2010) and discard percentage (average 2007-2011). The 2012 survey shows that density is low at 0.13 *Nephrops*/m². The advice for last year was based on the recent average landings and recommended landings of no more than 600 tonnes which equates to a harvest ratio of 9.5% which is within the range of harvest ratios observed for other North Sea functional units (8-16%).

FU34 : Devil's Hole		1,753	Area (km2)	31.76	mean weight (g)	12.9%	percentage discards	

		Density (Nephrops per m2)					
Basis	**landings**	**0.1**	**0.13**	**0.15**	**0.2**	**0.25**	**0.3**
s0.5 * Average	300	6.2%	4.8%	4.1%	3.1%	2.5%	2.1%
Average	675	13.9%	10.7%	9.3%	7.0%	5.6%	4.6%
Maximum	1305	26.9%	20.7%	17.9%	13.5%	10.8%	9.0%
Recent average	600	12.4%	9.5%	8.2%	6.2%	4.9%	4.1%

Most recent absolute density estimate = 0.13

Table 4.2.1. Nominal landings (tonnes) of *Nephrops* in Sub-area IV, 1984 – 2010, 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	367
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	370
Netherlands	662	572	851	966	940	918	1019	982	1147	737	882	701	1012	1023
Norway	144	147	115	130	100	93	132	96	99	143	139	123	70	76
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

* Landings data for 2011 are preliminary.

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

* 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	40.5

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	566	74	7.7									
1992	525	74.5	7									
1993	672	58.3	11.5									
1994	453	35.5	12.7									
1995	559	32.5	17.2									
1996	245	30.1	8.1				34	132	261			
1997	399	31.8	12.5				24	59	412			
1998	309	28.6	10.8				78	174	447			
1999	322	31.8	10.1				44	107	408			
2000	174	21.8	8	402	7936	50.7	76	247	306	43	1416	30.5
2001	195	21.5	9.1	553	9797	56.5	78	283	275	73	2349	31.2
2002	144	15.8	9.1	617	8999	68.6	47	200	237	7	360	20.4
2003	118	6.2	19.3	661	9043	73.1	33	132	247.3	21	509	42.2
2004	106	5.7	18.8	646	8676	74.5	36	149	241.9	14	249	57.8
2005	69	2.9	23.9	654	7950	82.3	87	297	290.9	59	1193	49.4
2006	no data	no data	no data	444	6784	65.4	24	66	365.6	171	3320	51.4
2007	no data	no data	no data	464	6859	67.6	3	13	253.6	176	2494	70.5
2008	no data	no data	no data	268	4976	53.9	29	41	777	239	3787	63.1
2009	no data	no data	no data	288	5909	48.7	3	9	323.9	139	2337	59.6
2010	no data	no data	no data	354	5735	61.7	5	14	365.5	135	1576	86
2011	no data	no data	no data	480	5811	82.6	18	13	1362.3	75	980	77
2012	no data	no data	no data				no data	no data	no data	81	971	83

* 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

* 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	1209	36.954	32.7
2005	1586	43.704	36.3
2006	1945	55.062	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	1039	39.218	26.5
	* provisional		

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

Year	Catches		Landings	
	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
* provisional na = not available				

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

Year	Stations	Season	Mean density burrows/m²	Absolute Abundance millions	95% confidence interval millions	Method
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	958	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

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	374	*22.2%*
2002	*1048*	1953	46.10%	20.00	9.50	182	*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	317	*25.5%*
2007	858	2966	25.00%	24.95	10.89	158	18.5%
2008	987	1213	24.90%	26.63	10.97	61	6.2%
2009	682	2711	29.30%	24.45	10.54	155	22.7%
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	123	16.2%

Table 4.4.6 *Nephrops* in FU 6: Revisions to UWTV indices.

	WGNSSK 2012	WGNSSK 2013	Difference
2007	890	858	*-3.6%*
2008	951	987	*3.8%*
2009	683	682	*-0.1%*
2010	753	785	*4.2%*
2011	870	878	*0.9%*

Table 4.5.1 *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

		UK Scotland			Other	
Year	Denmark	*Nephrops* trawl	Other trawl	Sub-total	countries **	Total
1981	0	304	69	373	0	373
1982	0	382	40	422	0	422
1983	0	548	145	693	0	693
1984	0	549	97	646	0	646
1985	7	1016	125	1141	0	1148
1986	50	1398	95	1493	0	1543
1987	323	1024	349	1373	0	1696
1988	81	1306	186	1492	0	1573
1989	165	1719	415	2134	0	2299
1990	236	1703	598	2301	3	2540
1991	424	3024	769	3793	6	4223
1992	359	1794	1179	2973	31	3363
1993	224	2033	1233	3266	3	3493
1994	390	1817	2356	4173	6	4569
1995	439	3569	2428	5997	4	6440
1996	286	2338	2592	4930	1	5217
1997	235	2713	3221	5934	2	6171
1998	173	2291	2672	4963	0	5136
1999	96	2860	3549	6409	16	6521
2000	103	2915	2546	5461	5	5569
2001	64	3539	1936	5475	2	5541
2002	173	4513	2546	7059	15	7247
2003	82	4175	2033	6208	4	6294
2004	136	7274	1319	8593	0	8729
2005	321	8849	1514	10363	1	10685
2006	283	9396	1101	10497	11	10791
2007	119	11055	733	11788	3	11910
2008	133	11432	667	12099	8	12240
2009	130	12696	491	13187	10	13327
2010	124	12410	279	12689	12	12825
2011*	64	***7494		7494	<0.5	7558

* provisional na = not available
** Other countries includes Belgium, Norway and UK England
*** 4 main trawl gears combined in 2011; other gears <0.5 tonnes

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, 2000-2011.

Year	Landings	Effort	LPUE
2000	5127	35.4	144.8
2001	5169	28.6	180.7
2002	6230	28.6	217.8
2003	5900	22	268.2
2004	8405	21.6	389.1
2005	10223	23.6	433.2
2006	10348	22.8	453.9
2007	11736	21.6	543.3
2008	12069	22.9	5270
2009	13173	21.2	621.4
2010	12665	21	603.1
2011	7494	15.3	489.8

Table 4.5.3 *Nephrops*, Fladen (FU 7): Logbook recorded effort (days fishing) 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, 1991-2011.

	Logbook data	
Year	Effort	LPUE
1991	3115	116
1992	2289	130
1993	820	130
1994	1209	251
1995	841	343
1996	568	254
1997	395	349
1998	268	165
1999	197	251
2000	292	170
2001	213	181
2002	335	368
2003	194	308
2004	290	461
2005	607	482
2006	576	450
2007	274	426
2008	241	512
2009	282	512
2010	212	556
2011	117	609

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, 1993-2011.

	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	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	38.4
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
2002	30.6	30	31.3	30.7	39.5	38.3
2003	30.9	29.8	31.2	30.1	40	38.1
2004	30.8	29.9	31.1	30.2	40.1	38.7
2005	30.9	30	31.2	30.1	40.1	38.2
2006	30.1	29.5	30.8	30	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	30.5	29	39.8	38.4
2011	31.7	29.6	31.7	29.6	41.2	38.6

* provisional, na = not available

Table 4.5.5 *Nephrops*, FUs 7-9 and 34. Mean weight (g) in the landings.

Year	Fladen	Firth of Forth	Moray Firth
1990	31.59	20.29	20.05
1991	26.5	20.03	18.53
1992	29.61	20.96	23.49
1993	25.38	24.3	23.42
1994	23.72	19.51	22.25
1995	27.51	19.55	20.59
1996	29.82	20.81	21.4
1997	32.08	18.87	20.43
1998	31.37	18.23	20.47
1999	30.55	20.05	21.79
2000	36.35	21.83	25.44
2001	25.1	21.22	24.18
2002	27.93	19.62	27.68
2003	30.15	22.31	23.32
2004	30.98	22.45	27.57
2005	29.05	22.33	23.84
2006	29.25	21.43	22.34
2007	26.63	20.97	23.04
2008	28.18	17.23	25.29
2009	28.2	19.41	23.46
2010	26.38	19.76	26.94
2011	36.17	19.75	21.63
*Mean (08-10)	27.59	18.8	25.23

*** values used in forecast based on LCA year range**

Table 4.5.6. *Nephrops*, Fladen (FU 7): Results of the 1992-2011 TV surveys (not bias-adjusted).

Year	Stations	Abundance millions	Mean density burrows/m²	95% confidence interval millions
1992	69	4942	0.17	508
1993	74	6007	0.21	768
1994	59	8329	0.3	1099
1995	61	6733	0.24	1209
1996	No survey			
1997	56	3736	0.13	689
1998	60	5181	0.18	968
1999	62	5597	0.2	876
2000	68	4898	0.17	663
2001	50	6725	0.23	1310
2002	54	8217	0.29	1022
2003	55	7488	0.27	1452
2004	52	7729	0.27	1391
2005	72	5839	0.21	894
2006	69	6564	0.23	836
2007	82	9473	0.34	986
2008	74	9936	0.35	1375
2009	59	7367	0.26	1042
2010	67	7052	0.25	959
2011	73	4566	0.16	587

Table 4.5.7. *Nephrops*, Fladen Ground (FU 7):Summary of TV results for most recent 3 years (2009-2011) 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 (km^2)	Number of Stations	Mean burrow density ($no./m^2$)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
>80	3248	10	0.622	0.013	2020	14039	0.052
55<80	4967	13	0.318	0.039	1582	74914	0.276
40<55	4304	18	0.394	0.049	1697	50394	0.186
<40	15634	18	0.132	0.01	2067	132204	0.487
Total	28153	59			7366	271551	1
2010 TV survey							
>80	3248	8	0.48	0.013	1559	17558	0.076
55<80	4967	13	0.378	0.041	1880	78487	0.341
40<55	4304	13	0.258	0.022	1112	31196	0.136
<40	15634	33	0.16	0.014	2501	102861	0.447
Total	28153	67			7052	230102	1
2011 TV survey							
>80	3248	11	0.265	0.002	862	1848	0.021
55<80	4967	16	0.234	0.011	1164	17020	0.198
40<55	4304	11	0.201	0.015	865	24765	0.288
<40	15634	35	0.107	0.006	1675	42499	0.493
Total	28153	73			4566	86132	1

Table4.5.8 *Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2011.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	5547	6294	0.1	0.08	0.04
2004	5725	8729	0.11	0.08	0.05
2005	4325	10685	0.11	0.09	0.09
2006	4862	10791	0.13	0.1	0.08
2007	7017	11910	0.11	0.08	0.07
2008	7360	12240	0.04	0.03	0.06
2009	5457	13327	0.1	0.07	0.09
2010	5224	12825	0.06	0.05	0.1
2011	3382	7558	0	0	0.062

Table 4.6.1 *Nephrops*, Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	UK Scotland				UK	
	Nephrops trawl	Other trawl	Creel	Sub-total	(E, W & NI)	Total **
1981	945	61	0	1006	0	1006
1982	1138	57	0	1195	0	1195
1983	1681	43	0	1724	0	1724
1984	2078	56	0	2134	0	2134
1985	1908	61	0	1969	0	1969
1986	2204	59	0	2263	0	2263
1987	1582	92	0	1674	0	1674
1988	2455	73	0	2528	0	2528
1989	1833	52	0	1885	1	1886
1990	1901	28	0	1929	1	1930
1991	1359	45	0	1404	0	1404
1992	1714	43	0	1757	0	1757
1993	2349	18	0	2367	2	2369
1994	1827	17	0	1844	6	1850
1995	1708	53	0	1761	2	1763
1996	1621	66	1	1688	0	1688
1997	2137	55	0	2192	2	2194
1998	2105	38	0	2143	2	2145
1999	2192	9	1	2202	3	2205
2000	1775	9	0	1784	1	1785
2001	1484	35	0	1519	9	1528
2002	1302	31	1	1334	6	1340
2003	1115	8	0	1123	3	1126
2004	1651	4	0	1655	3	1658
2005	1973	0	6	1979	11	1990
2006	2437	4	12	2453	5	2458
2007	2628	9	8	2645	7	2652
2008	2435	3	7	2445	5	2450
2009	2626	1	26	2653	9	2662
2010	1848	3	12	1862	9	1871
2011*	***1794		89	1883	5	1888

* provisional na = not available

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

*** 4 trawl gears in 2011;also includes 5 t other gears

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, 2000-2011.

Year	Landings	Effort	LPUE
2000	1778	10.5	169.3
2001	1494	11.5	129.9
2002	1314	10.4	126.3
2003	1118	8.3	134.7
2004	1651	9.5	173.8
2005	1972	7.7	256.1
2006	2406	6.2	388.1
2007	2627	6.4	410.5
2008	2435	6.4	380.5
2009	2628	5.9	445.4
2010	1847	5.1	362.2
2011	1789	4.6	388.9

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, 1981-2011.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31	39.7	38.7
1982	na	na	30.4	30.1	40	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
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	30.3	29.5	39	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	27.4	29.8	28.8	38.6	38.6
1997	27.2	27	29.2	28.7	38.8	38.2
1998	27.7	26.4	29	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27	30.6	29.2	38	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
2004	28.6	27.8	30.7	30	38.4	37.6
2005	27.6	26.9	30.3	30	38.7	38.2
2006	27.3	27	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
2010	28.3	26.9	29.8	28.4	38.6	38.2
2011*	28.6	27.5	30	28.3	38.8	38.2

* provisional na = not available

Table4.6.4. *Nephrops*, Firth of Forth (FU 8): Results of the 1993-2011 TV surveys.

Year	Stations	Mean Density burrows/m²	Abundance millions	95% conf interval millions
1993	37	0.72	655	167
1994	30	0.58	529	92
1995		no survey		
1996	27	0.48	443	104
1997		no survey		
1998	32	0.38	345	95
1999	49	0.6	546	92
2000	53	0.57	523	83
2001	46	0.54	494	93
2002	41	0.66	600	140
2003	36	0.99	905	163
2004	37	0.81	743	166
2005	54	0.92	838	169
2006	43	1.07	976	148
2007	49	0.9	816	156
2008	38	1.14	1040	350
2009	45	0.94	864	168
2010	39	0.88	804	173
2011	45	0.69	629	103

Table 4.6.5. *Nephrops*, Firth of Forth (FU 8):Summary of TV results for most recent 3 years (2009-2011) 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	Area (km²)	Number of Stations	Mean burrow density (no./m²)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
M & SM	171	9	1.178	0.657	201	2123	0.284
MS(west)	139	9	0.842	0.628	117	1346	0.18
MS(mid)	211	13	1.318	0.348	278	1189	0.159
MS(east)	395	14	0.679	0.215	268	2397	0.32
Total	915	45			864	7055	1
2010 TV survey							
M & SM	170	7	1.074	0.48	183	1992	0.266
MS(west)	139	7	0.587	0.252	82	694	0.093
MS(mid)	211	12	0.868	0.538	183	1988	0.266
MS(east)	395	13	0.903	0.234	357	2806	0.375
Total	915	39			805	7480	1
2011 TV survey							
M & SM	170	7	0.376	0.074	64	307	0.116
MS(west)	139	9	0.507	0.127	70	272	0.103
MS(mid)	211	10	0.77	0.075	162	332	0.125
MS(east)	395	19	0.843	0.212	333	1740	0.656
Total	915	45			629	2651	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 2003-2011.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	767	1126	0.54	0.47	0.123
2004	630	1658	0.35	0.29	0.164
2005	710	1990	0.42	0.35	0.194
2006	827	2458	0.55	0.48	0.267
2007	692	2652	0.25	0.2	0.229
2008	881	2450	0.29	0.24	0.211
2009	732	2662	0.34	0.28	0.26
2010	682	1871	0.3	0.24	0.184
2011	533	1888	0.19	0.15	0.221

Table4.7.1 *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	UK Scotland				UK England	Total **
	Nephrops trawl	Other trawl	Creel	Sub-total		
1981	1298	118	0	1416	0	1416
1982	1034	86	0	1120	0	1120
1983	850	90	0	940	0	940
1984	960	210	0	1170	0	1170
1985	1908	173	0	2081	0	2081
1986	1933	210	0	2143	0	2143
1987	1723	268	0	1991	0	1991
1988	1638	321	0	1959	0	1959
1989	2101	475	0	2576	0	2576
1990	1698	340	0	2038	0	2038
1991	1285	234	0	1519	0	1519
1992	1285	306	0	1591	0	1591
1993	1505	303	0	1808	0	1808
1994	1178	360	0	1538	0	1538
1995	967	330	0	1297	0	1297
1996	1084	364	1	1449	2	1451
1997	1102	343	0	1445	1	1446
1998	739	289	4	1032	0	1032
1999	813	193	2	1008	0	1008
2000	1344	194	3	1541	0	1541
2001	1188	213	2	1403	0	1403
2002	884	232	2	1118	0	1118
2003	874	194	11	1079	0	1079
2004	1223	103	9	1335	0	1335
2005	1526	64	12	1602	3	1605
2006	1718	73	11	1802	1	1803
2007	1816	17	7	1840	2	1842
2008	1443	67	4	1514	0	1514
2009	1042	22	2	1066	1	1067
2010	999	24	10	1032	0	1032
2011*	***1381		9	1390	1	1391

* Provisional

** No landings by non UK countries from this FU

*** 4 trawl gears in 2011; includes 5 t from other mobile gears

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, 2000-2011.

Year	Landings	Effort	LPUE
2000	1508	7.9	190.9
2001	1360	7.2	188.9
2002	1050	7.5	140
2003	1024	5.9	173.6
2004	1287	6.2	207.6
2005	1563	4.8	325.6
2006	1770	4.6	384.8
2007	1824	4.8	380
2008	1503	4.3	349.5
2009	1059	3.5	302.6
2010	1017	3.6	282.5
2011	1376	3.9	352.8

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, 1991-2011.

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	40	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	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	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	30.5	38.3	38
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31	39.4	37.5
1995	25.8	25	29.9	29.3	39.1	38
1996	29.3	28.4	30.6	29.7	38.5	38
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	29.2	30.9	30.2	39.5	37.9
2002	27.2	27	31.2	30.9	41	38.7
2003	29.3	29.2	30.3	30.1	39.8	38
2004	29.3	28.4	31.3	30.8	39	39.2
2005	30	28.7	31	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	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	38.9
2011*	28.6	28.4	29.4	29	39.5	38.4

* provisional na = not available

Table 4.7.4 *Nephrops*, Moray Firth (FU 9): Results of the 1993-2011 TV surveys.

Year	Stations	Mean density burrows/m²	Abundance millions	95% confidence interval millions
1993	31	0.19	418	94
1994	29	0.39	850	213
1995	no survey			
1996	27	0.26	563	109
1997	34	0.14	317	66
1998	31	0.18	391	115
1999	52	0.22	484	105
2000	44	0.21	467	118
2001	45	0.19	417	135
2002	31	0.29	630	146
2003	32	0.4	883	380
2004	42	0.35	757	225
2005	42	0.48	1052	239
2006	50	0.25	539	150
2007	40	0.29	642	189
2008	45	0.26	579	183
2009	50	0.23	502	169
2010	43	0.22	491	140
2011	37	0.205	451	194

Table 4.7.5 *Nephrops*, Moray Firth (FU 9):Summary of TV results for most recent 3 years (2009-2011) 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	Area (km²)	Number of Stations	Mean burrow density (no./m²)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2009 TV survey							
M & SM	169	8	0.46	0.13	78	459	0.064
MS(west)	682	15	0.24	0.14	164	4206	0.59
MS(mid)	698	15	0.19	0.04	135	1145	0.161
MS(east)	646	12	0.19	0.04	125	1315	0.185
Total	2195	50			502	7125	1
2010 TV survey							
M & SM	169	5	0.26	0.05	44	285	0.058
MS(west)	682	13	0.2	0.08	135	2765	0.568
MS(mid)	698	13	0.22	0.03	150	940	0.193
MS(east)	646	12	0.25	0.03	162	882	0.181
Total	2195	43			491	4872	1
2011 TV survey							
M & SM	169	2	0.105	0	18	6	0.001
MS(west)	682	8	0.39	0.151	266	8794	0.933
MS(mid)	698	12	0.097	0.004	68	176	0.019
MS(east)	646	15	0.154	0.016	99	453	0.048
Total	2195	37			451	9429	1.001

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 2003-2011.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	730	1079	0.14	0.11	0.07
2004	626	1335	0.33	0.27	0.11
2005	869	1605	0.15	0.12	0.09
2006	445	1803	0.13	0.1	0.2
2007	531	1842	0.08	0.06	0.16
2008	481	1514	0.11	0.09	0.14
2009	415	1067	0.08	0.06	0.12
2010	406	1032	0.2	0.16	0.11
2011	372	1391	0.14	0.11	0.19

Table 4.8.1 *Nephrops*, Noup (FU 10), Nominal Landings (tonnes) of *Nephrops*, 1981-2011, as reported to the WG.

Year	Nephrops Trawl	Other trawl	Creel	Sub Total	Other UK	Total
1997	184	130	0	314	0	314
1998	183	71	0	254	0	254
1999	211	68	0	279	0	279
2000	196	79	0	275	0	275
2001	88	88	0	176	0	176
2002	244	157	0	401	0	401
2003	258	79	0	337	0	337
2004	174	53	0	227	0	227
2005	81	84	0	165	0	165
2006	44	89	0	133	0	133
2007	47	108	0	155	0	155
2008	75	98	0	173	0	173
2009	24	65	0	89	0	89
2010	4	34	0	38	0	38
2011	69		0	69	0	69

Table 4.8.2 *Nephrops*, Noup (FU 10): 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	270	1.6	169
2001	155	1.4	111
2002	331	2	166
2003	322	1.4	230
2004	217	0.9	241
2005	165	0.7	236
2006	132	0.6	220
2007	150	0.6	250
2008	172	0.7	246
2009	89	0.9	99
2010	39	0.8	49
2011	69	0.8	86

Table 4.8.3 *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997-2011. 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	40.2	38.8
2005	31	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

Table4.8.4 *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006 & 2007 TV surveys. No surveys since then

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	millions
1994	10	0.63	250	90
1995	no survey			
1996	no survey			
1997	no survey			
1998	no survey			
1999	10	0.30	120	42
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	0.18	73.7	47.1
2007	9	0.15	60	25

Table 4.9.1 *Nephrops* Norwegian Deep (FU 32): Landings (tonnes) by country, 1993-2010.

Year	Denmark	Norway			Sweden	UK	Netherlands	Total
		Trawl	Creel	Sub-total				
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	68	11	79	1	14		1090
2004	835	72	8	80	1	6		922
2005	979	89	13	102	2	6		1089
2006	939	62	19	81	1	7	5	1033
2007	652	77	20	97	5	1		755
2008	505	112	30	142	24	4		675
2009	331	107	31	138	2	6		477
2010	282	82	41	123	1	1		407
2011*	322	29	40	69	1	3		395
* provisional								

Table 4.9.2 *Nephrops* Norwegian Deep (FU 32): Danish effort (days) and LPUE, 1993-2010

Year	Effort	LPUE
1993	1317	121
1994	2126	208
1995	1792	198
1996	3139	235
1997	3189	218
1998	2707	214
1999	3710	226
2000	3986	192
2001	5372	166
2002	4968	188
2003	5273	177
2004	3488	216
2005	3919	234
2006	4796	196
2007	2878	226
2008	2301	220
2009	1694	195
2010	1522	185
2011	1398	231

Table 4.10.1 ***Nephrops*** **in FU 33. (Off Horns Reef) Landings (tonnes) by country, 1993-2010.**

	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

* 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, 1993-2010.**

	Logbook data		Estimated
	Effort	LPUE	total effort
1993	975	170	971
1994	739	165	761
1995	724	194	816
1996	370	157	469
1997	925	161	1078
1998	1442	208	1593
1999	2323	252	2679
2000	2286	209	2570
2001	2868	191	3454
2002	3294	207	3714
2003	3640	212	3921
2004	4306	234	4660
2005	2524	285	2776
2006	2062	308	2288
2007	1609	337	1818
2008	755	448	805
2009	543	444	515
2010	432	343	525
2011	613	607	644

* provisional na = not available

Table 4.11.1. *Nephrops*, Devil's Hole (FU 34). Nominal landings (tonnes) of *Nephrops* as reported to the WG for 2011. Scottish data only 1991 to 2008

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total
	Nephrops trawl	Other trawl	Creel	Sub-total				
1991	83							
1992	106							
1993	44							
1994	129							
1995	132							
1996	128							
1997	99							
1998	88							
1999	202							
2000	185							
2001	270							
2002	343							
2003	674							
2004	489							
2005	379							
2006	448							
2007	715							
2008	937							
2009	1297	8	0	1305	0	0	0	1305
2010	712	18	0	730	25	1	1	757
2011*	423	0	0	423	10			433
* provisional								

Table4.11.2 *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, 2000-2011.

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

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, 2009-2010. Samples not available in 2011

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
2009	31.6	31	31.7	31.1	41.3	40.6
2010*	32.2	29.9	32.2	29.9	39.6	39.4
* provisional						

Table4.11.4. *Nephrops*, Devil's Hole (FU 34). Results of the 2003, 2005 and 2009-11 surveys.

Year	Stations	Mean density	95% confidence interval
		burrows/m²	millions
2003	20	0.13	0.03
2004	no survey		
2005	29	0.12	0.05
2006	no survey		
2007	no survey		
2008	no survey		
2009	14	0.36	0.17
2010	20	0.32	0.11
2011	15	0.26	0.13

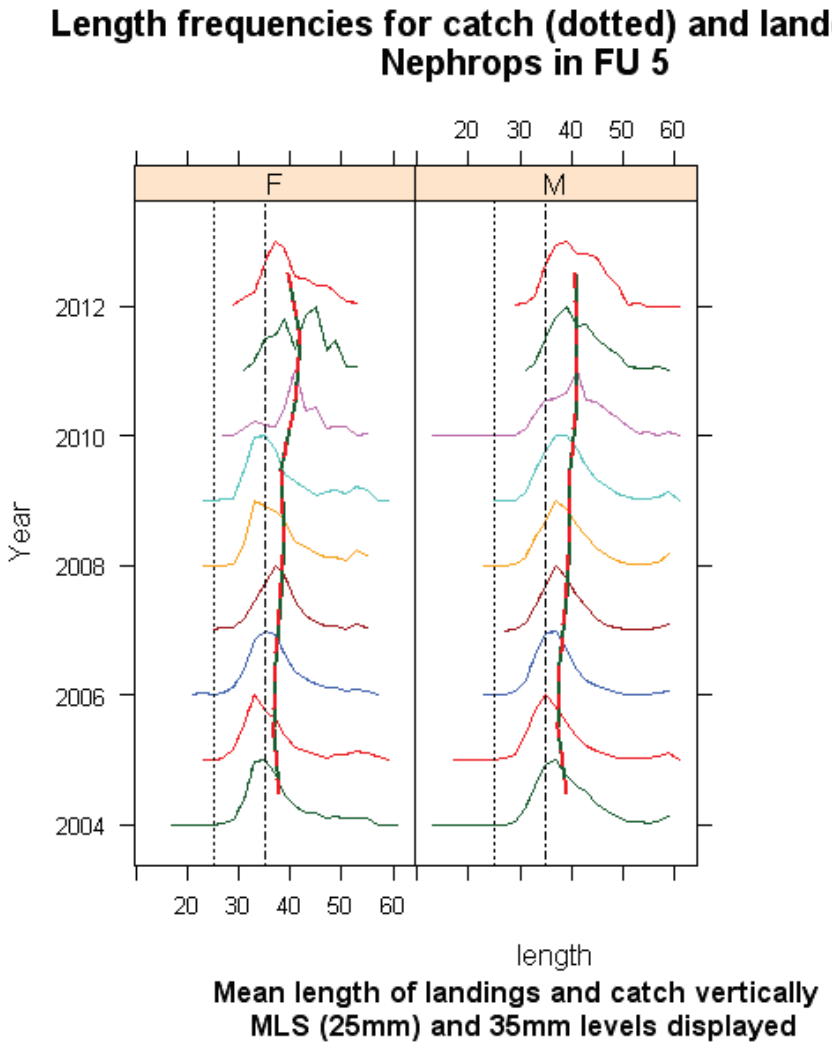
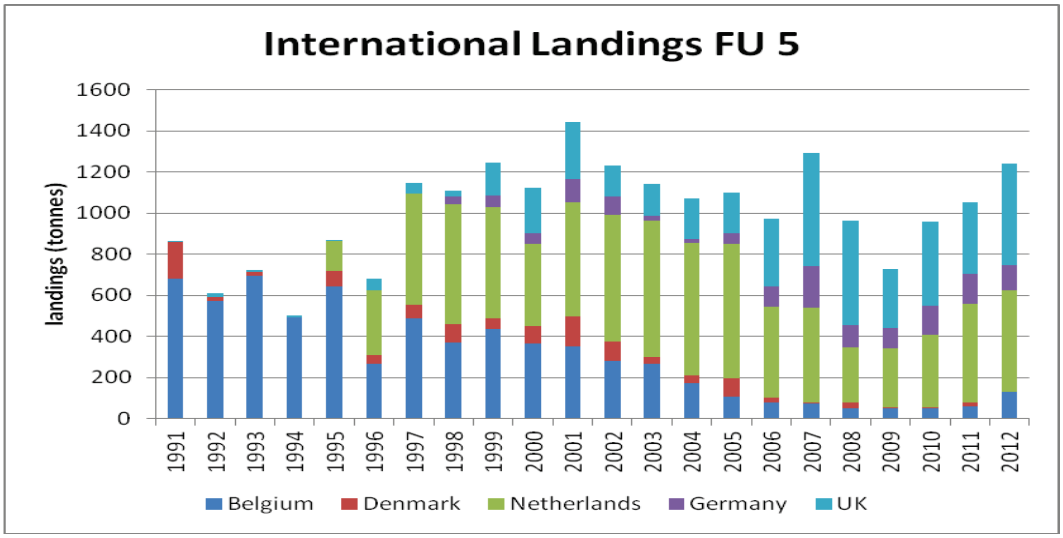
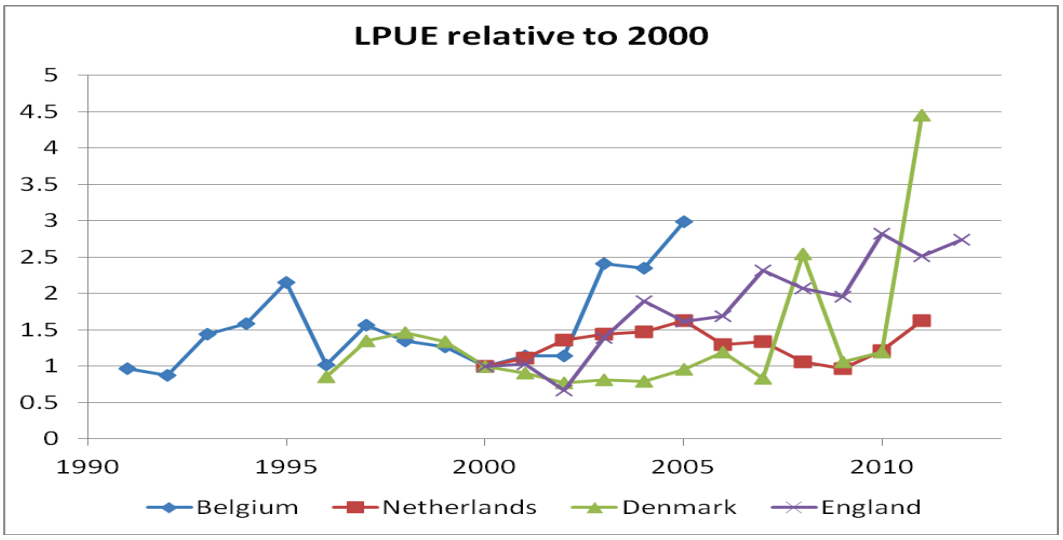


Figure 4.3.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2003 to 2011. For 2003 the length distribution is given by sex combined.





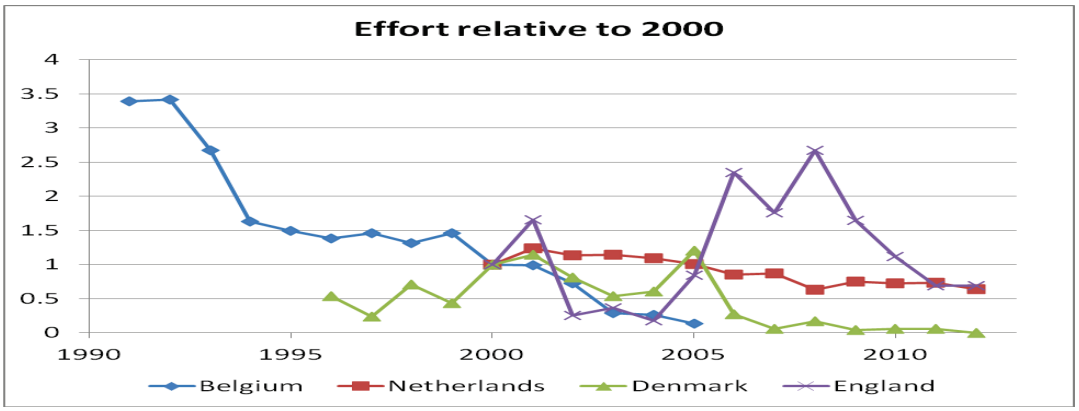


Figure 4.3.2 - FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUEs.

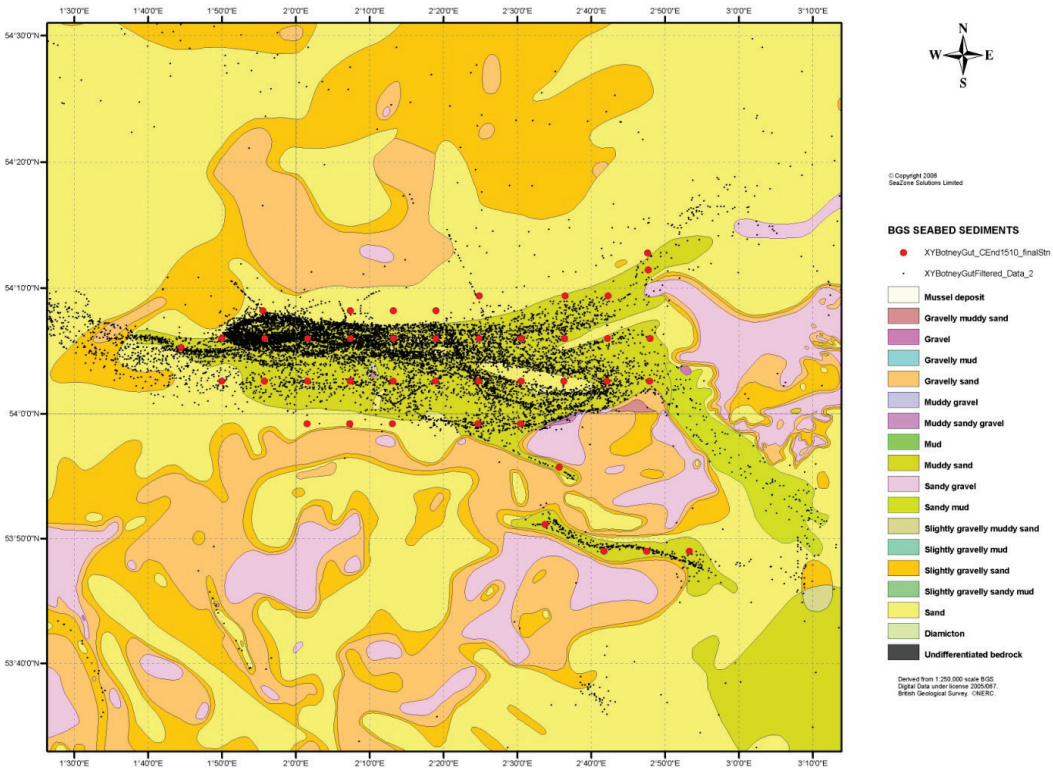


Figure 4.3.3 - FU5 Botney Gut/Silver Pit. Map showing BGS sediment data, fishing vessel activity from satellite data and the 42 survey station locations.

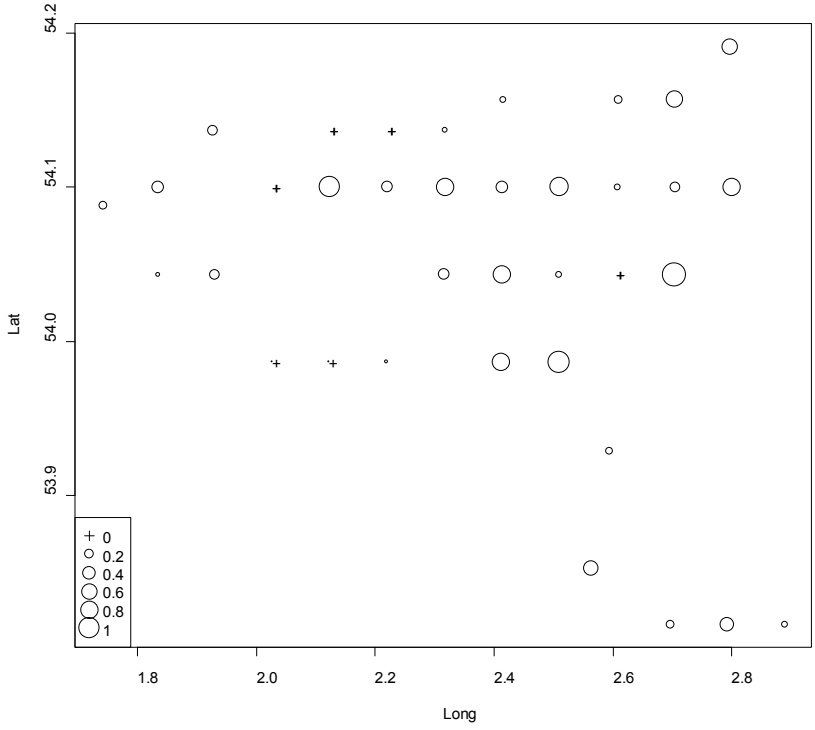


Figure 4.3.5. Preliminary UWTV survey results for FU5.

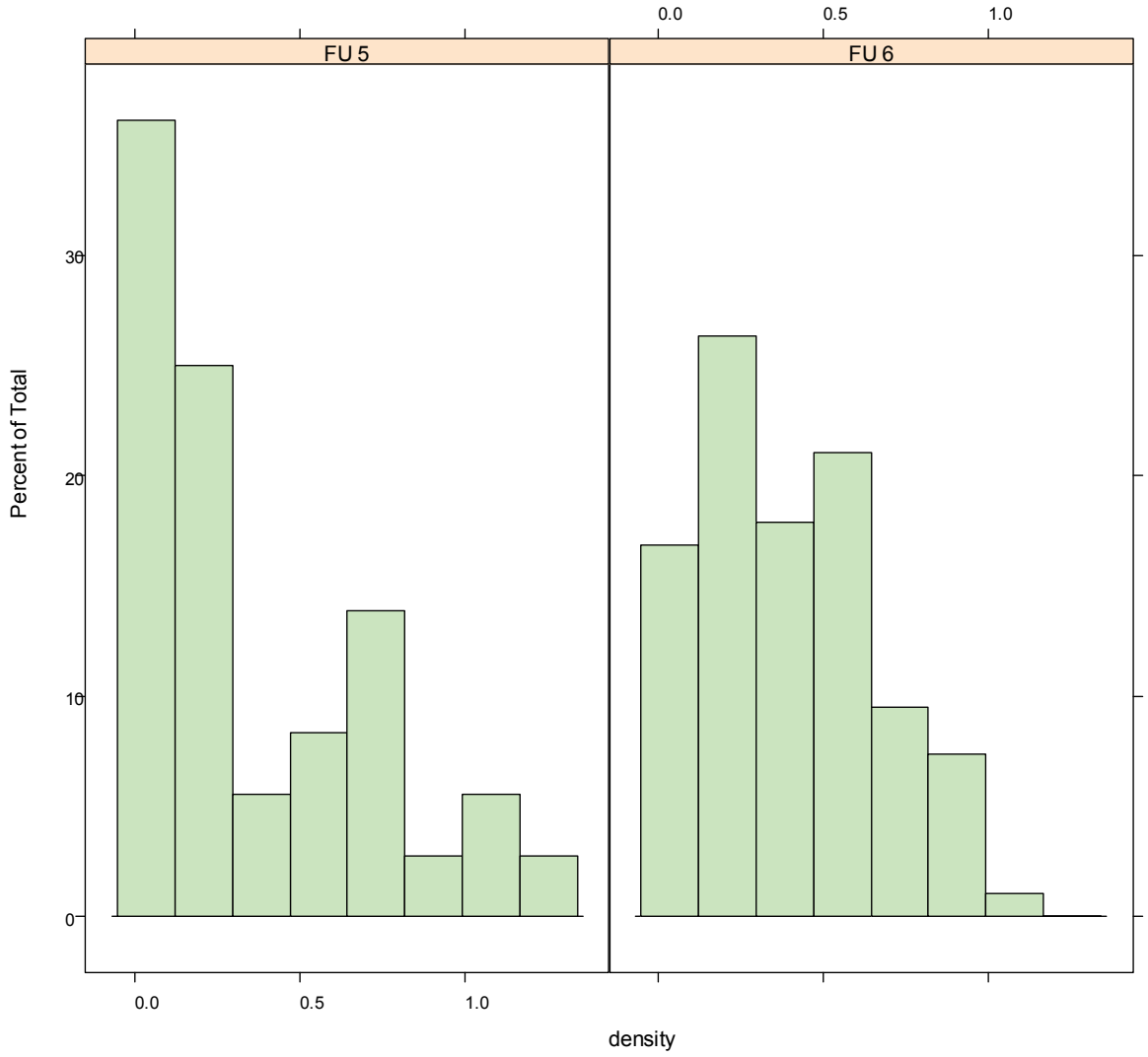


Figure 4.3.6. Comparison of burrow density composition between functional units 5 and 6

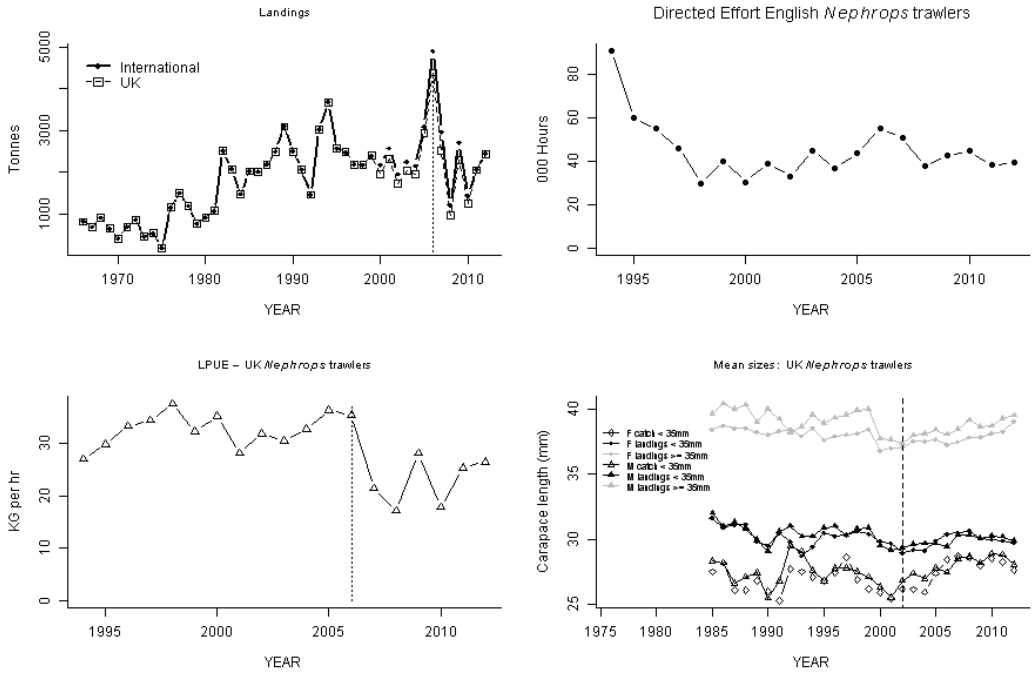


Figure 4.4.1 ***Nephrops*** **in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.**

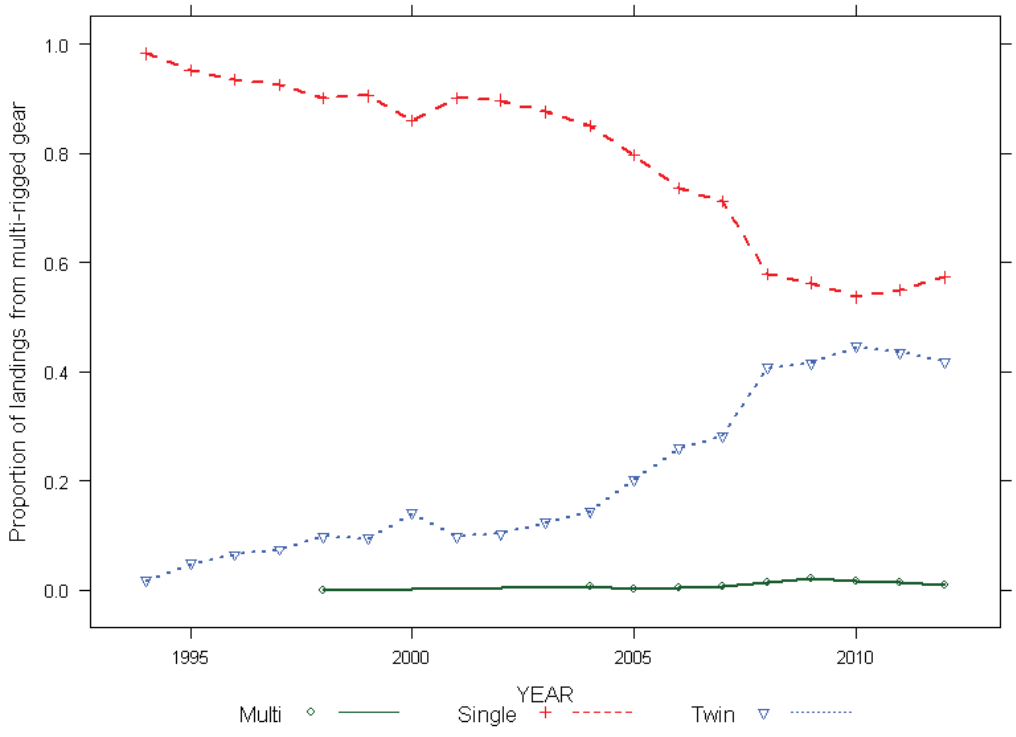


Figure 4.4.2 ***Nephrops*** **in FU6. Proportion of landings from different gear types.**

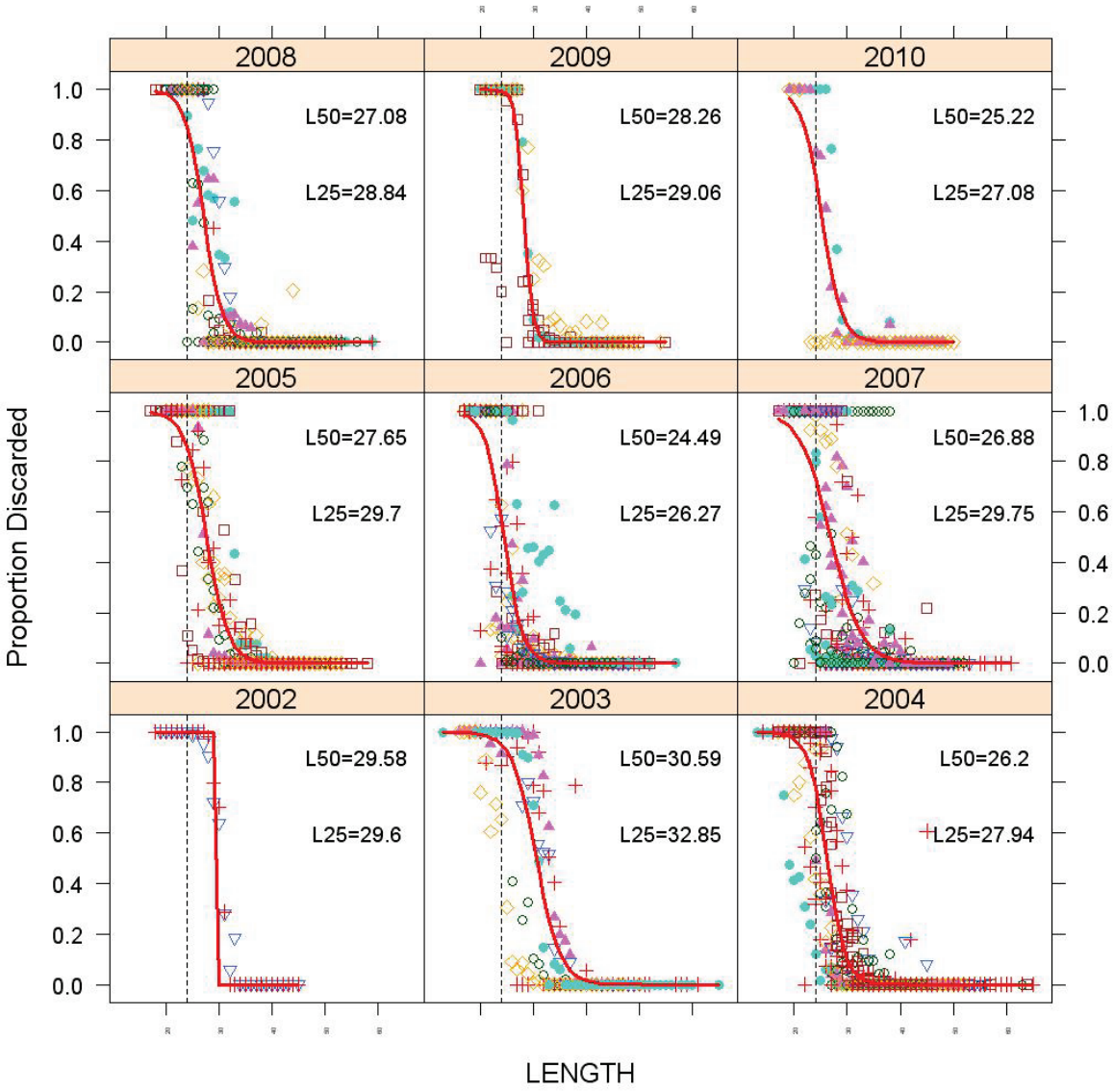


Figure 4.4.3 *Nephrops* **in FU6, annual discard ogives. The different point shapes represent different sampling trips within any year.**

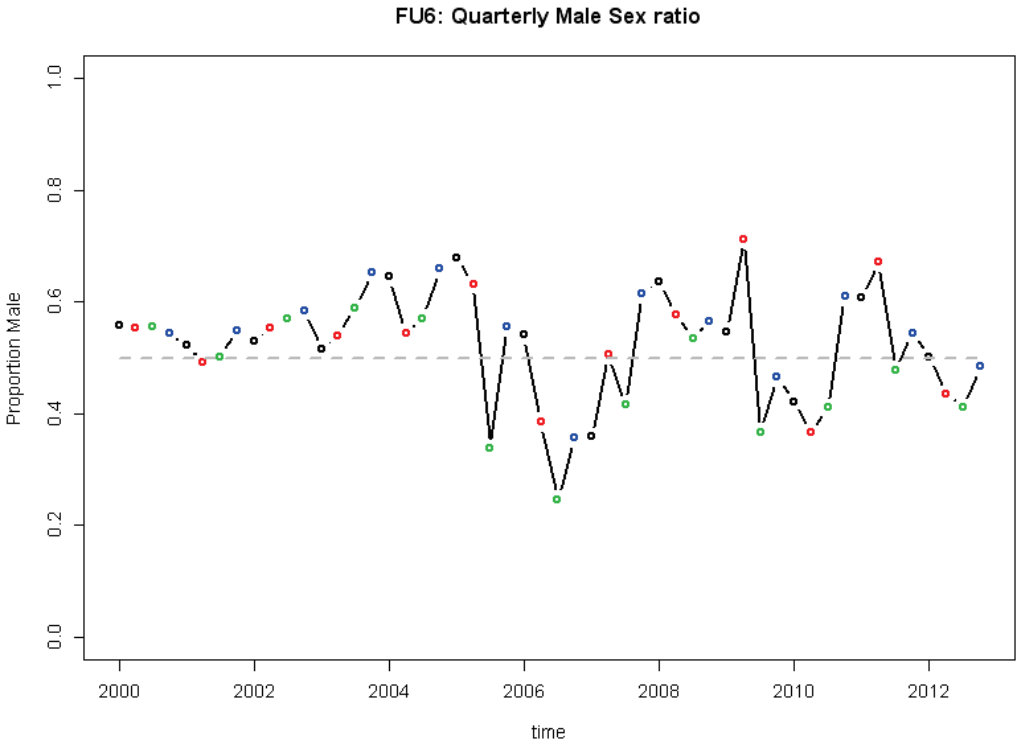


Figure 4.4.4 ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

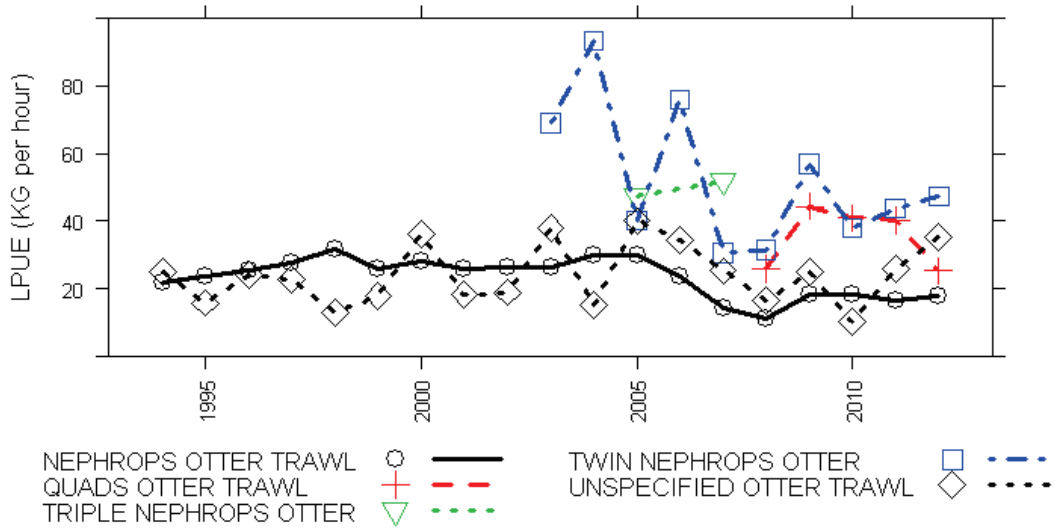


Figure 4.4.5 ***Nephrops*** **in FU6: LPUE for directed English trawlers by gear type.**

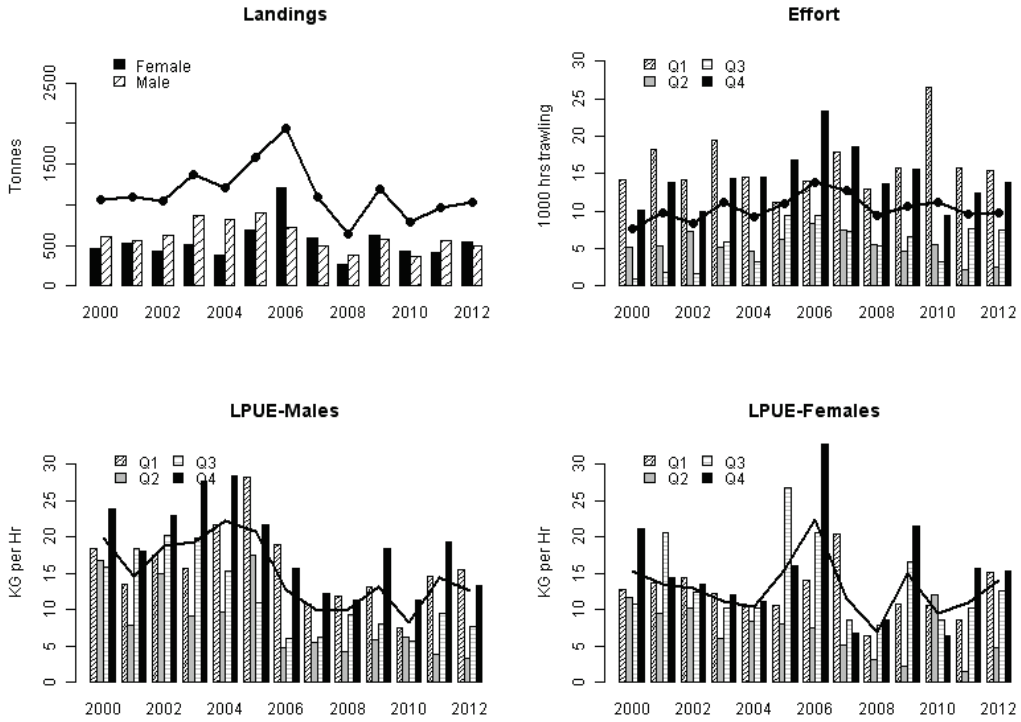


Figure 4.4.6 *Nephrops* in FU6: LPUE by sex and quarter.

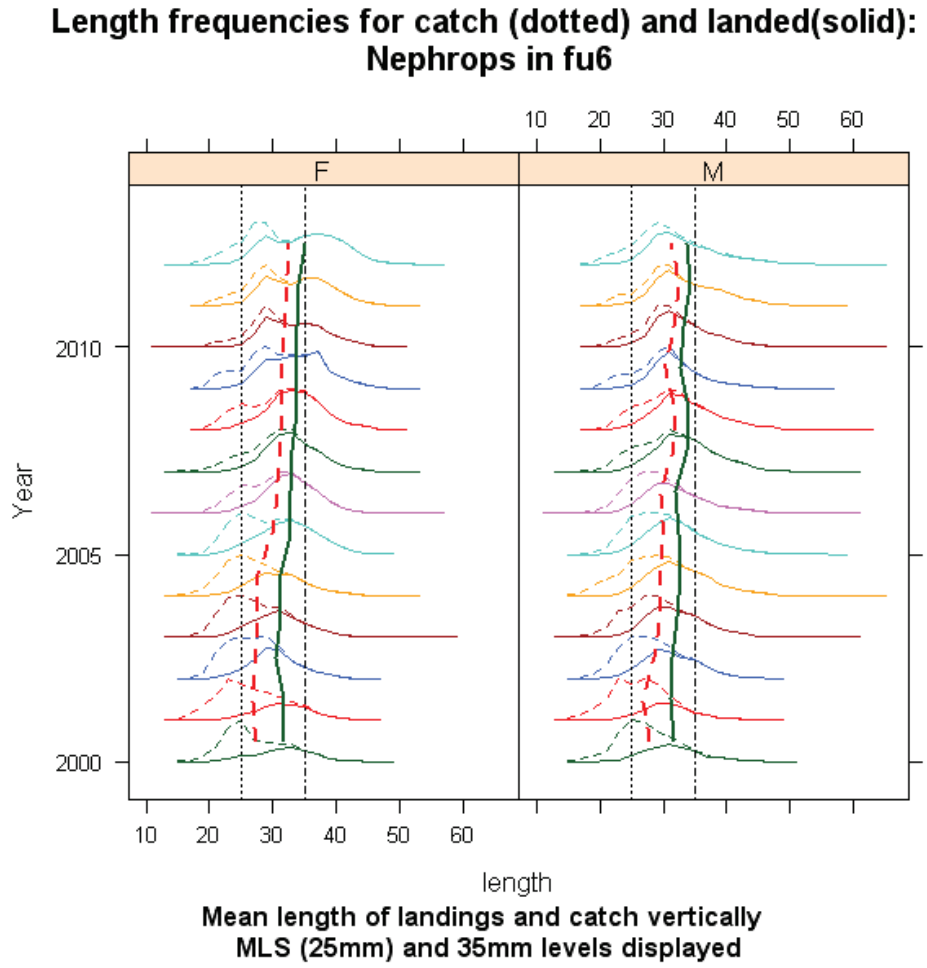


Figure 4.4.7 ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

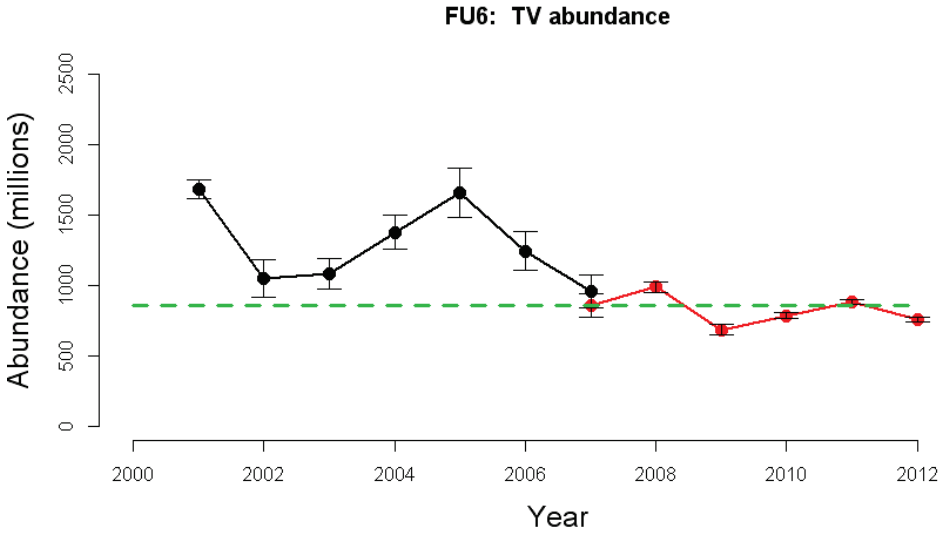


Figure 4.4.8 ***Nephrops*** **in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the Geostatsistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due to the spatial distribution of stations was biased.**

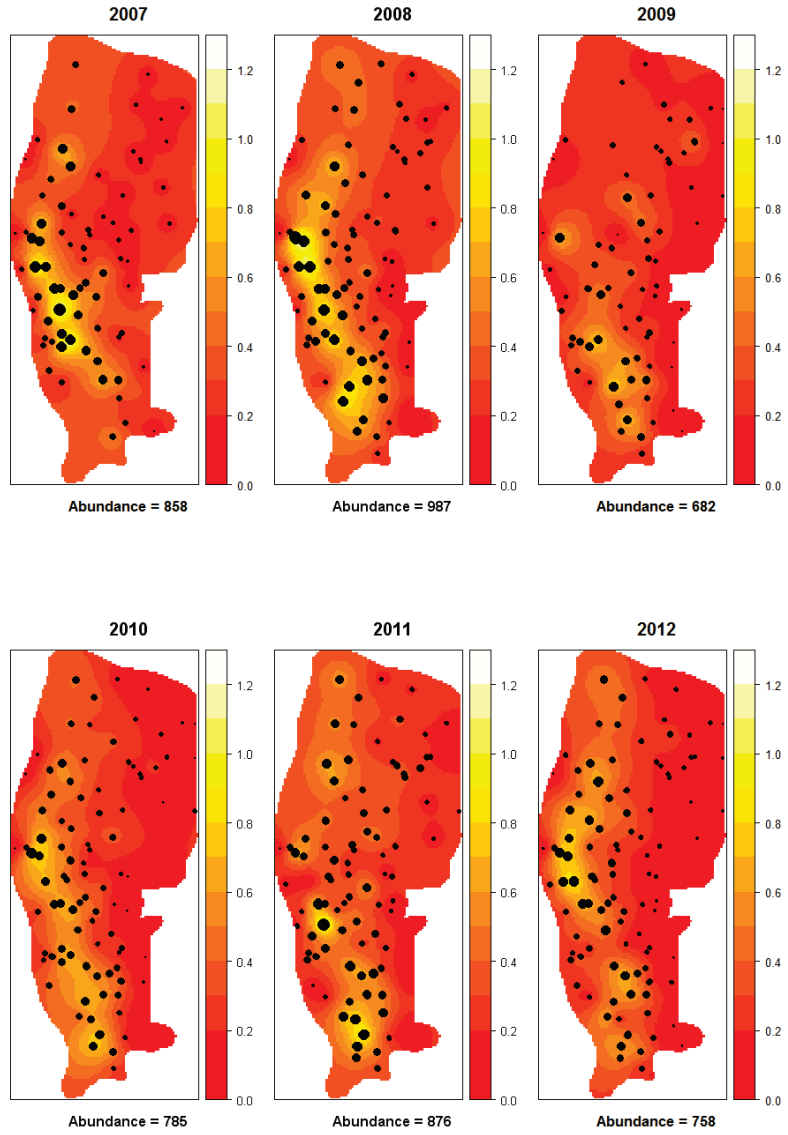


Figure 4.4.9 *Nephrops* in FU6: Results of the UWTV survey.

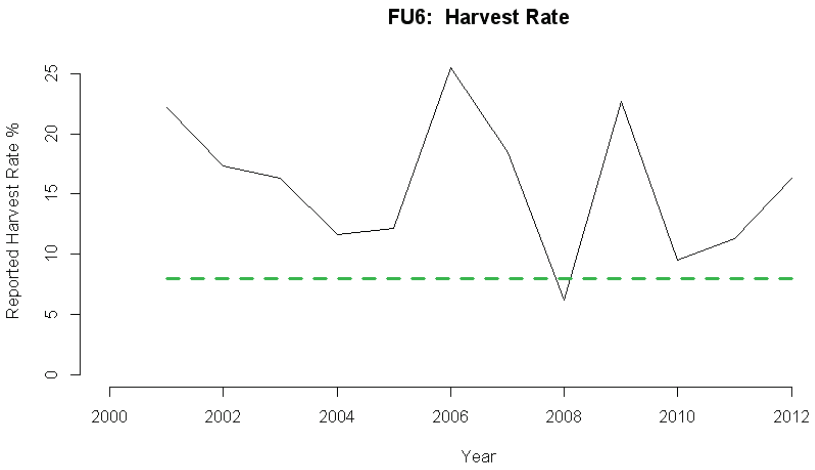


Figure 4.4.10 *Nephrops* in FU6: Observed harvest ratio (removals divided by abundance estimate).

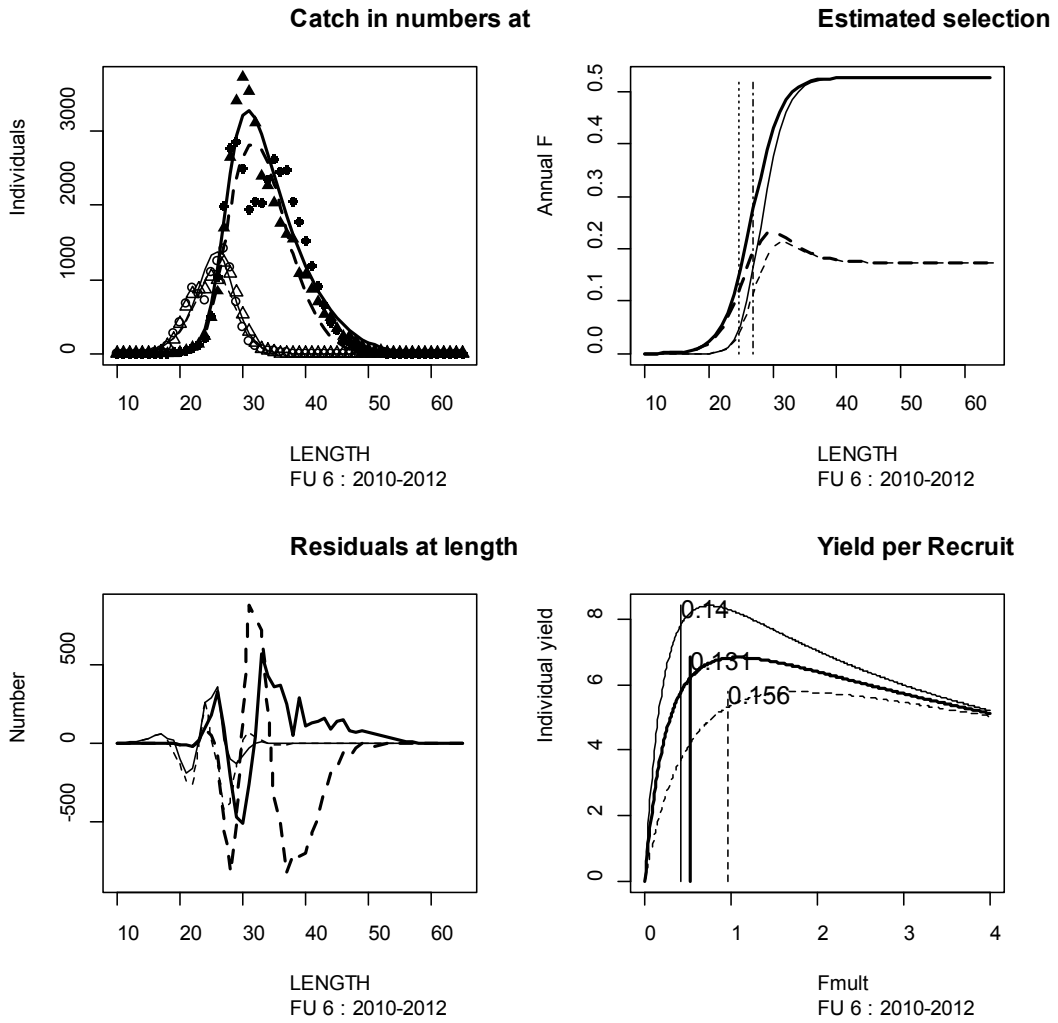


Figure 4.4.11 ***Nephrops*** **in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards 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.**

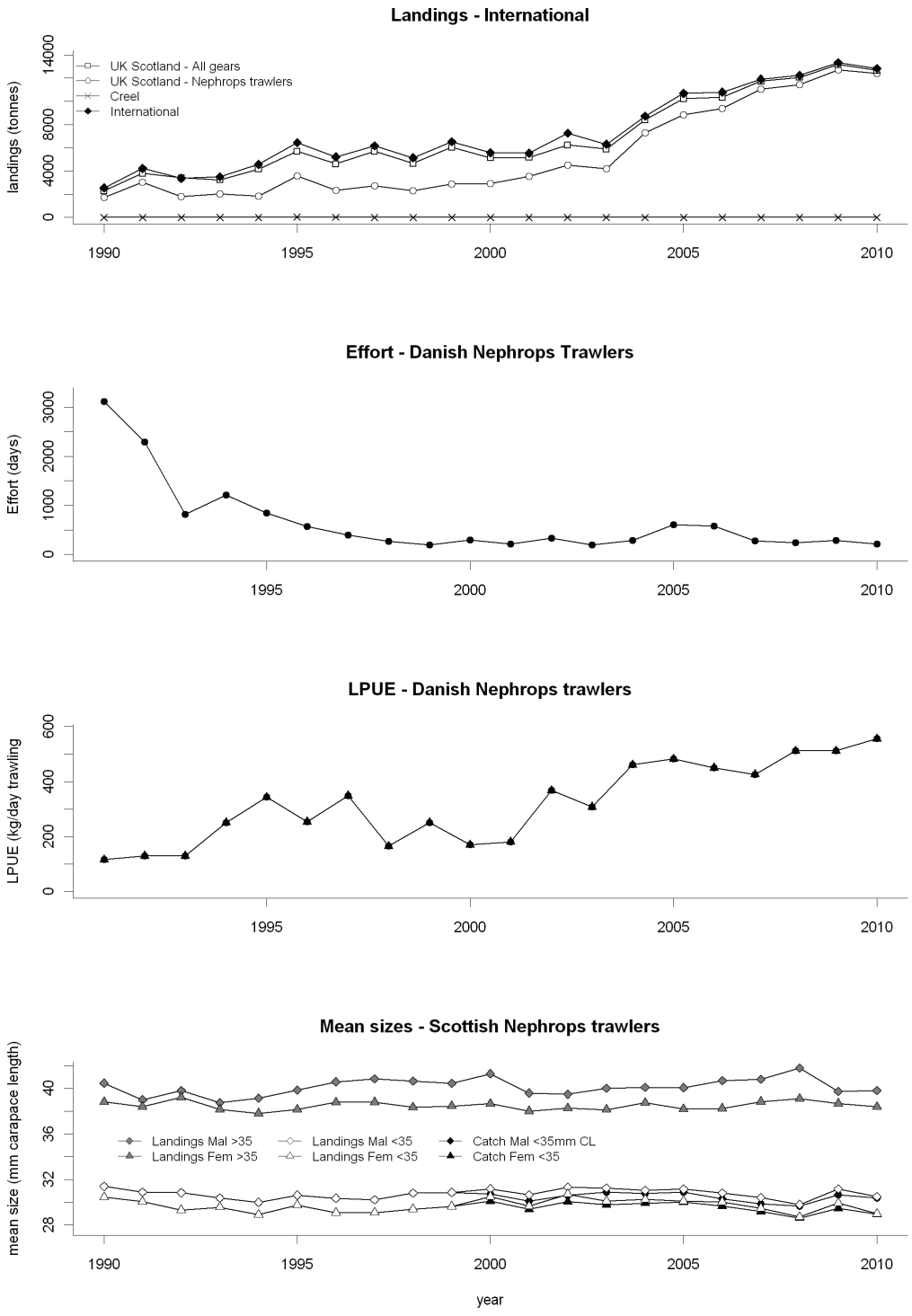


Figure 4.4.12 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.**

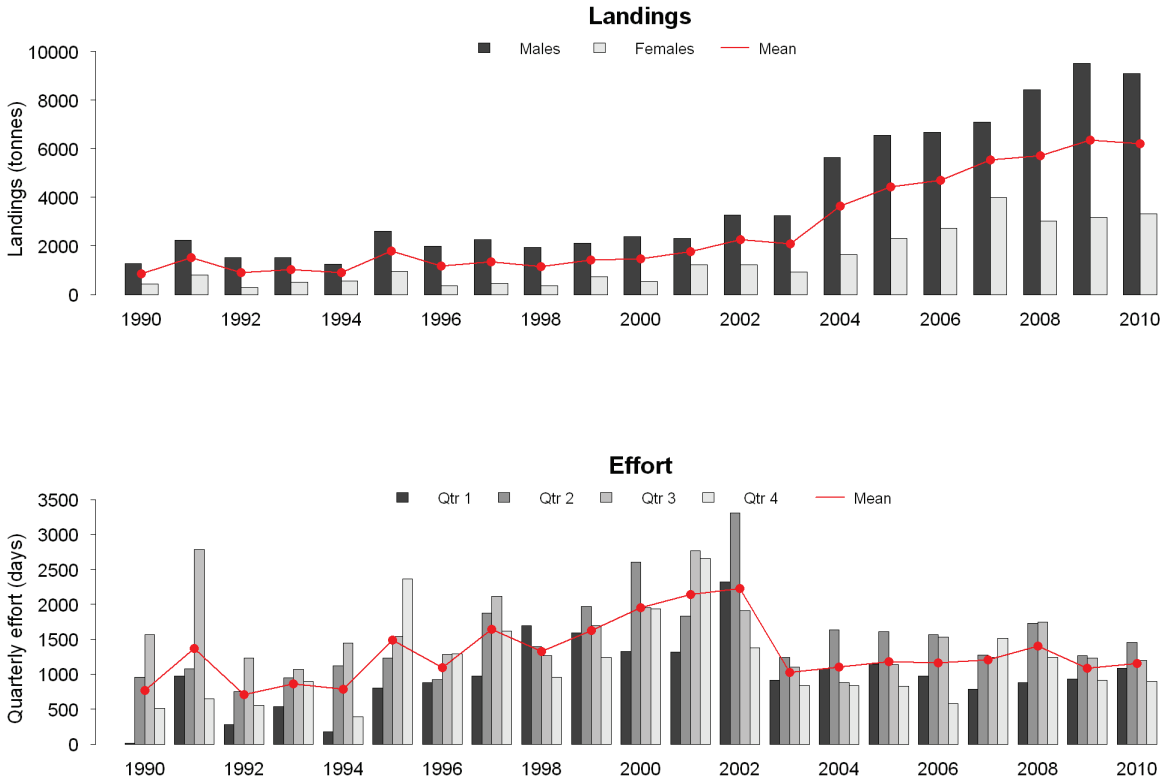


Figure 4.4.12.1 ***Nephrops*****, Fladen (FU 7), Landings by sex and effort by quarter from Scottish** ***Nephrops*** **trawlers.**

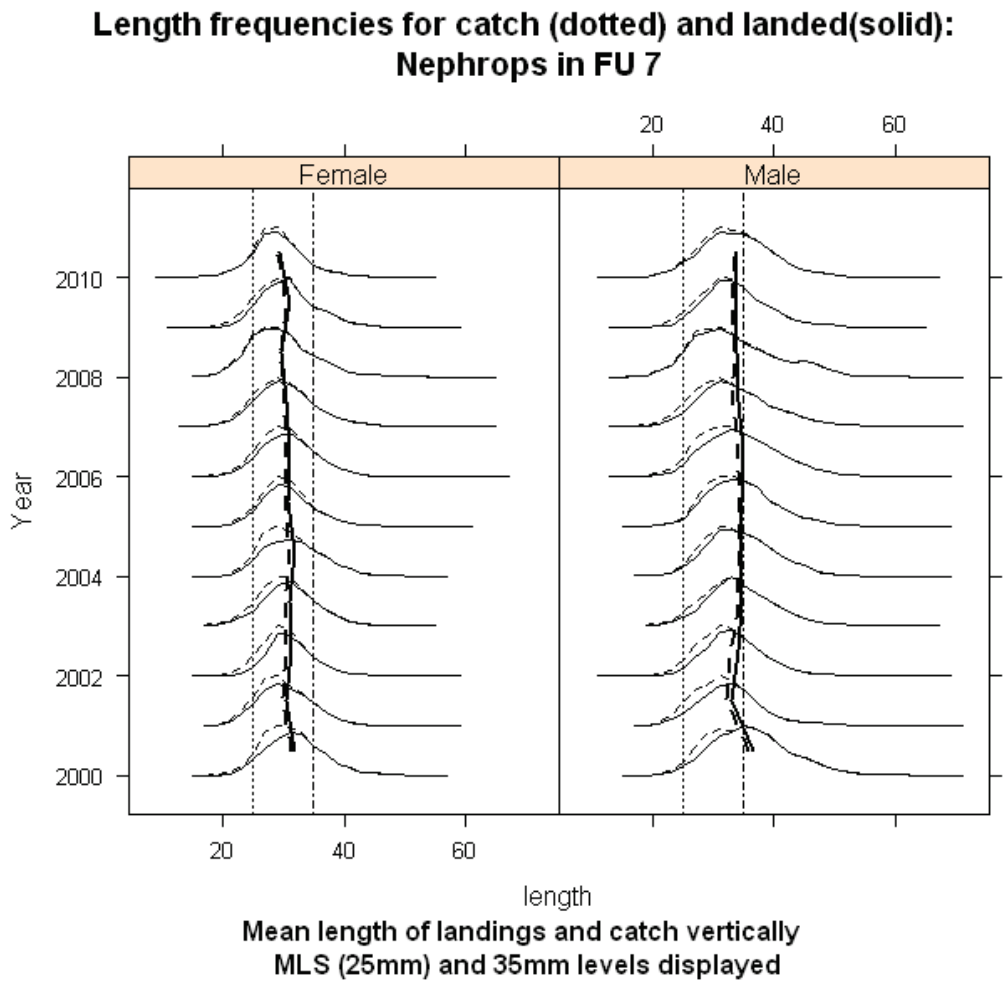


Figure4.4.12.2 *Nephrops* Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2009 (top). Mean sizes of catch and landings are displayed vertically.

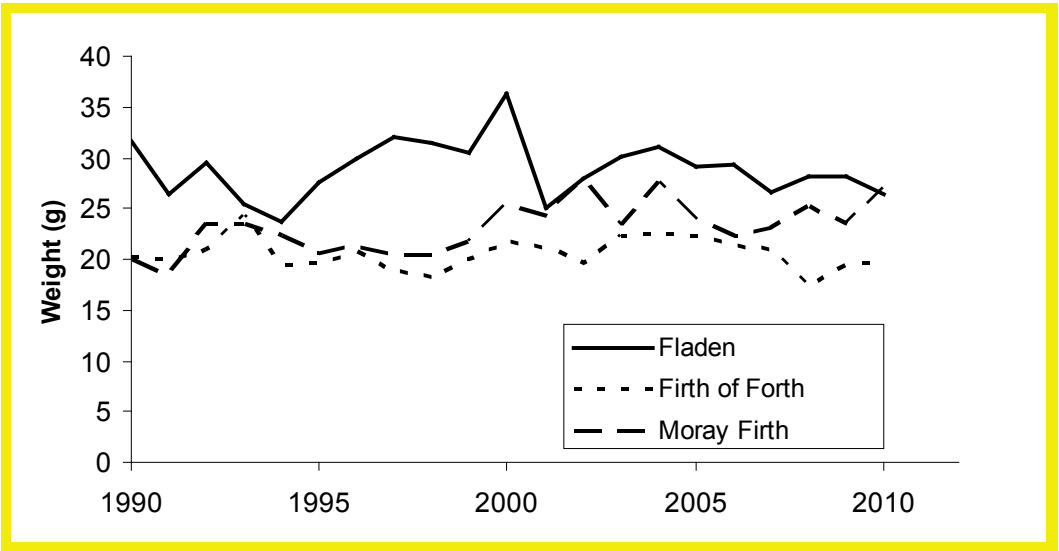


Figure 4.4.12.3 *Nephrops*, (FUs 7-9), individual mean weight in the landings from 1990-2010 (from Scottish market sampling data).

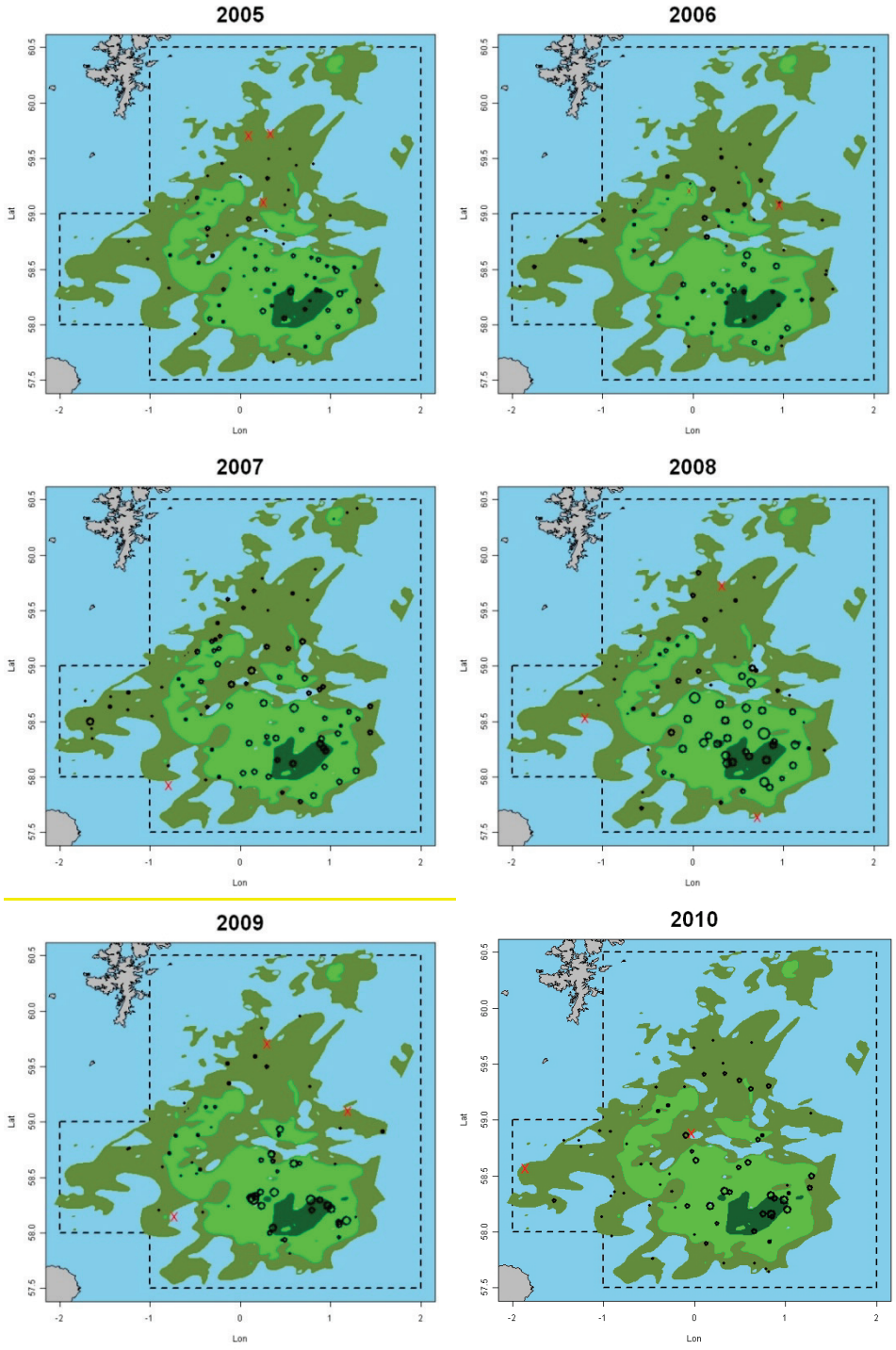


Figure 4.4.12.4Nephrops, Fladen (FU 7). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for Nephrops. Density proportional to circle radius. Red crosses represent zero observations.

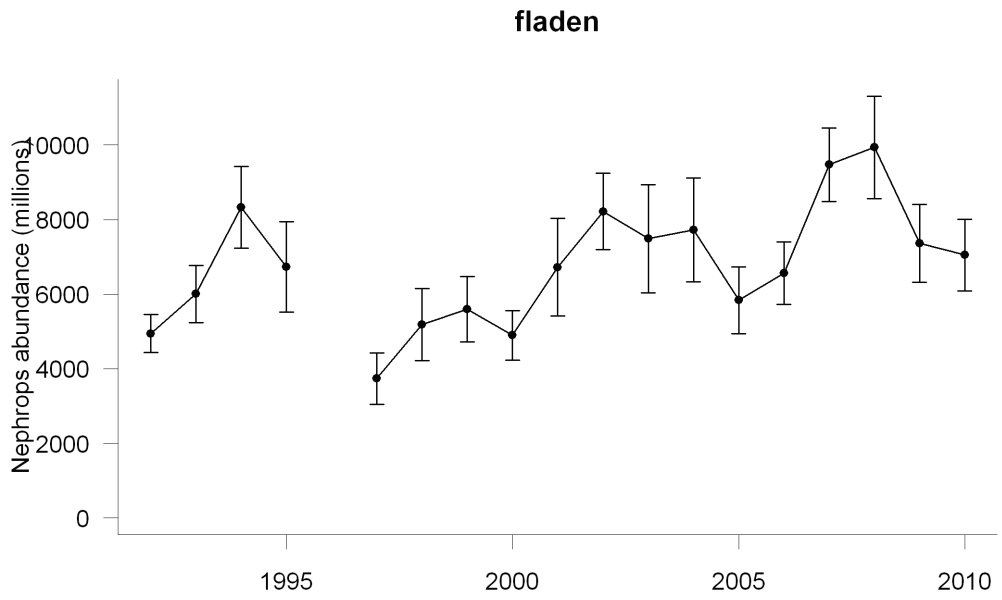


Figure 4.4.12.5 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates (not bias adjusted), with 95% confidence intervals, 1992 – 2010.**

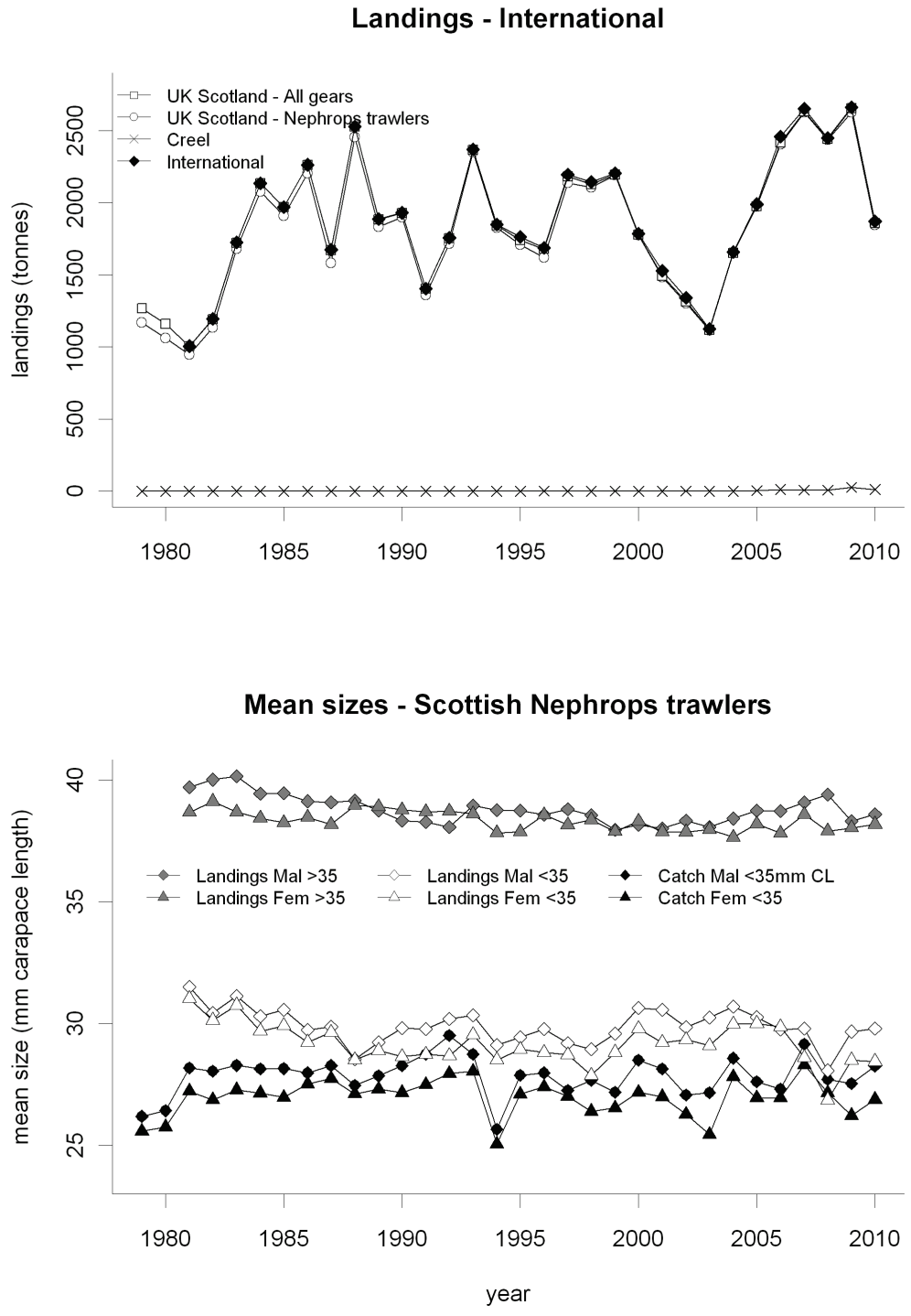


Figure 4.4.13 ***Nephrops*****, Firth of Forth (FU 8), Long term landings and mean sizes.**

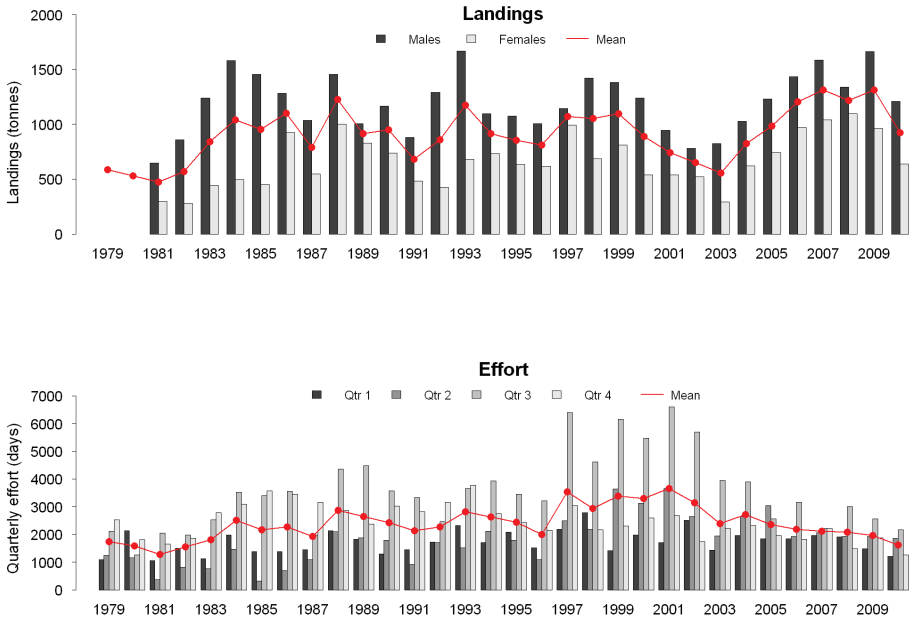


Figure 4.4.13.1 *Nephrops*, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

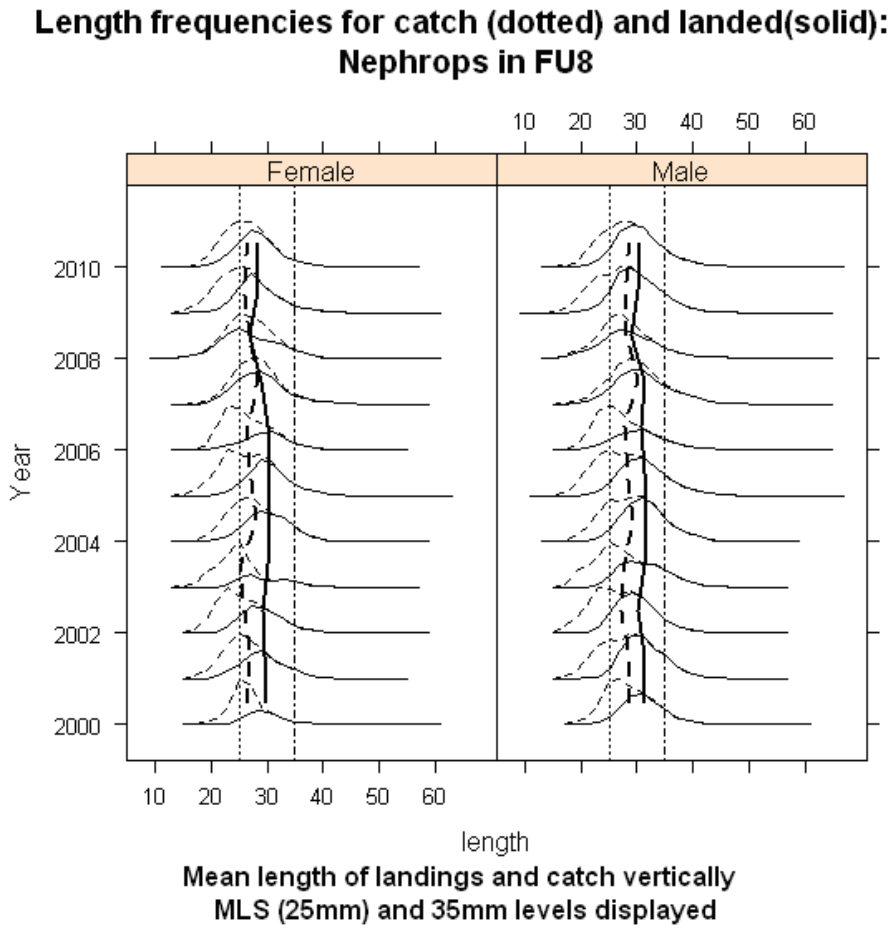


Figure 4.4.1.32 *Nephrops* **Firth of Forth (FU 8)Length composition of catch of males (right) and females left from 2000 (bottom) to 2010 (top). Mean sizes of catch and landings are displayed vertically.**

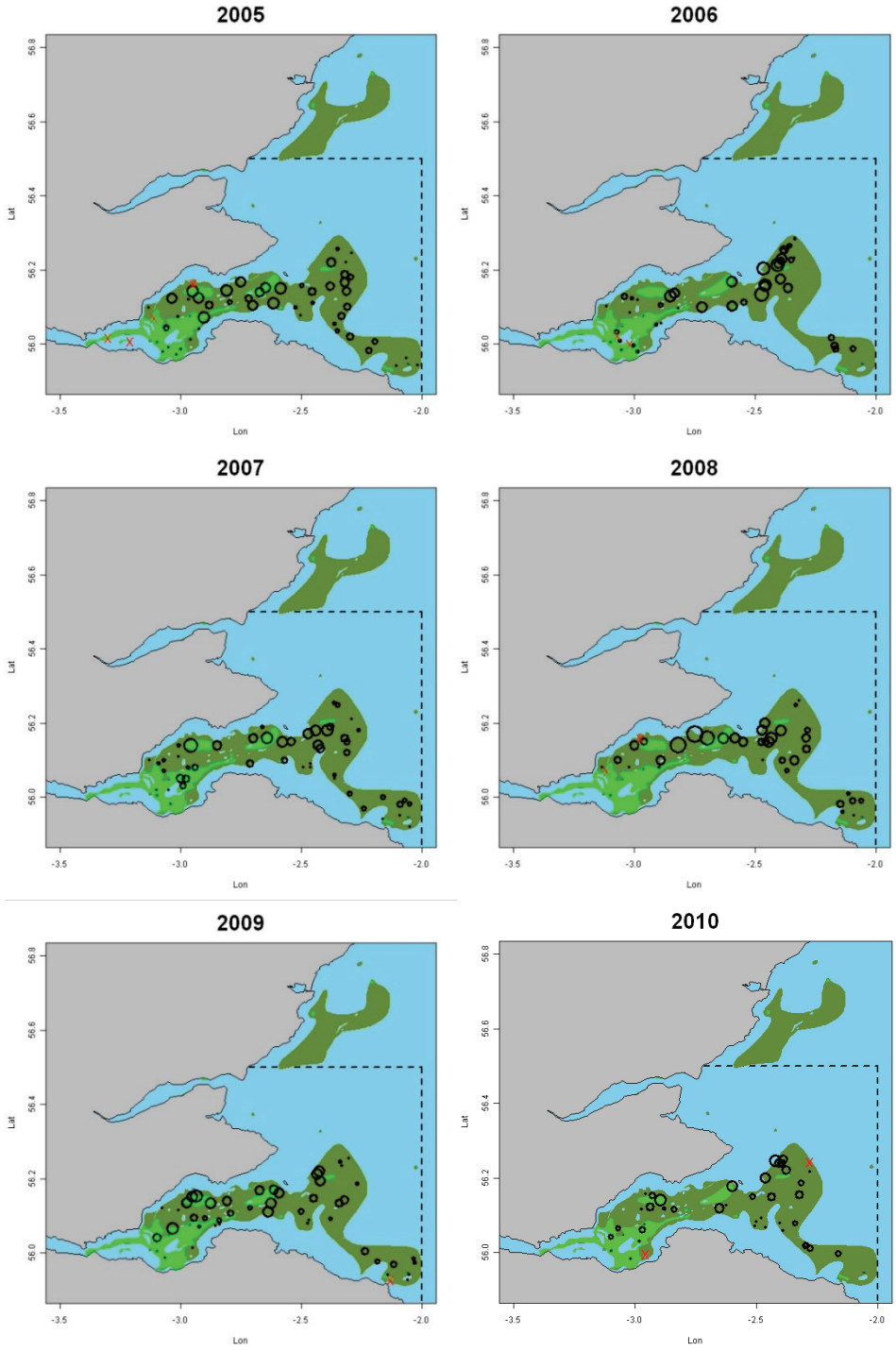


Figure 4.4.13.3 ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

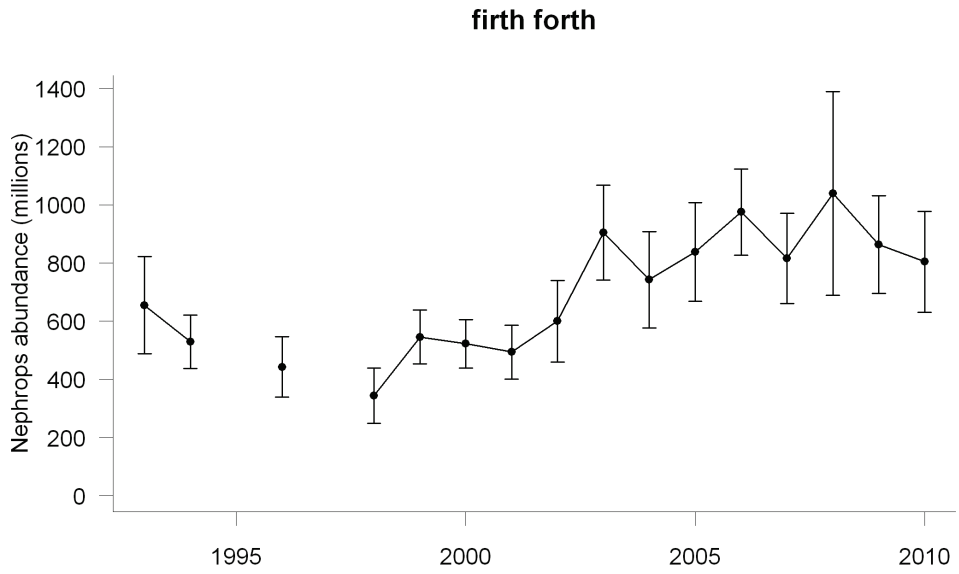


Figure 4.4.13.4 ***Nephrops*****, Firth of Forth (FU 8), Time series of TV survey abundance estimates, with 95% confidence intervals, 1995 – 2010.**

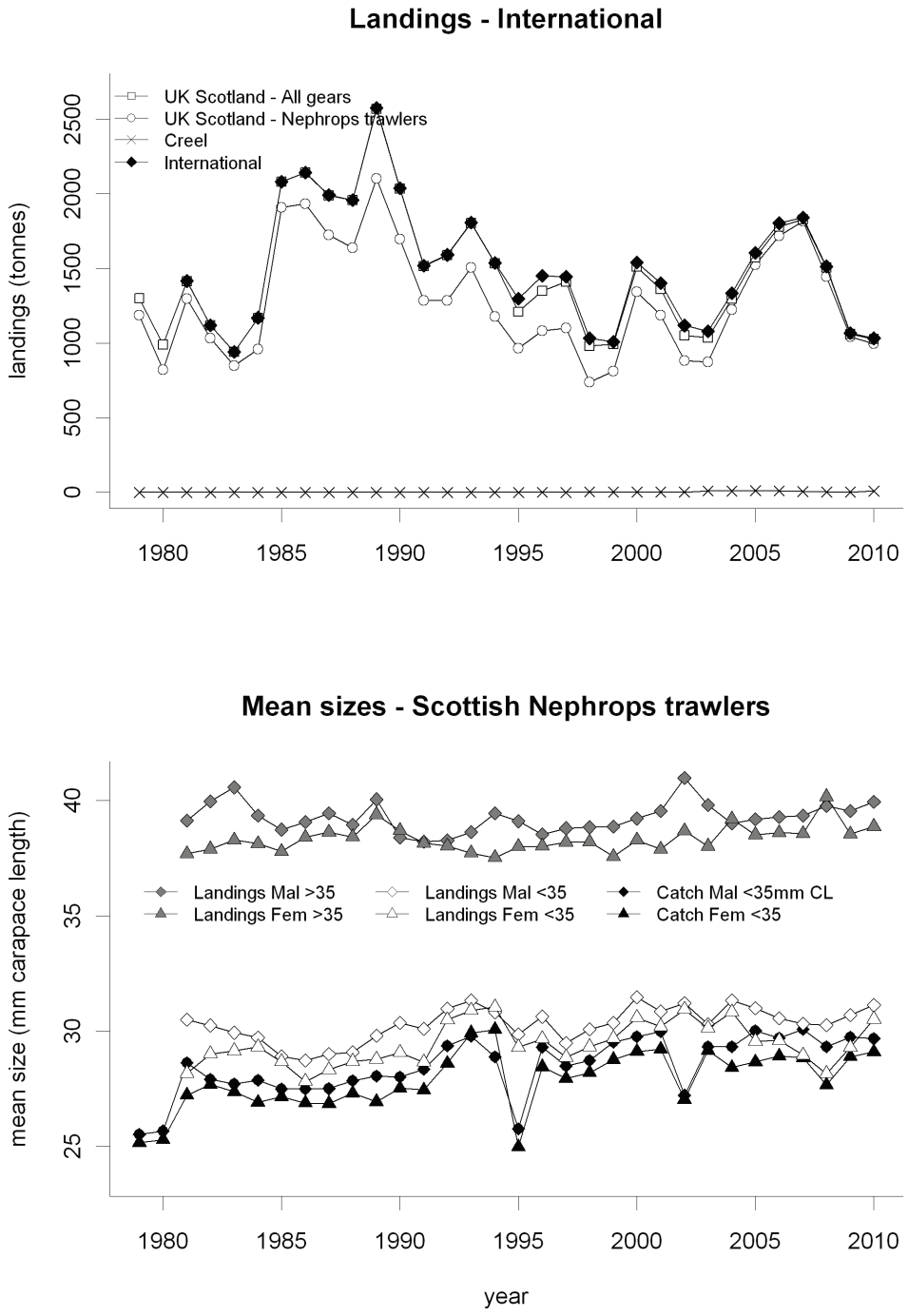


Figure4.4.14 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes.**

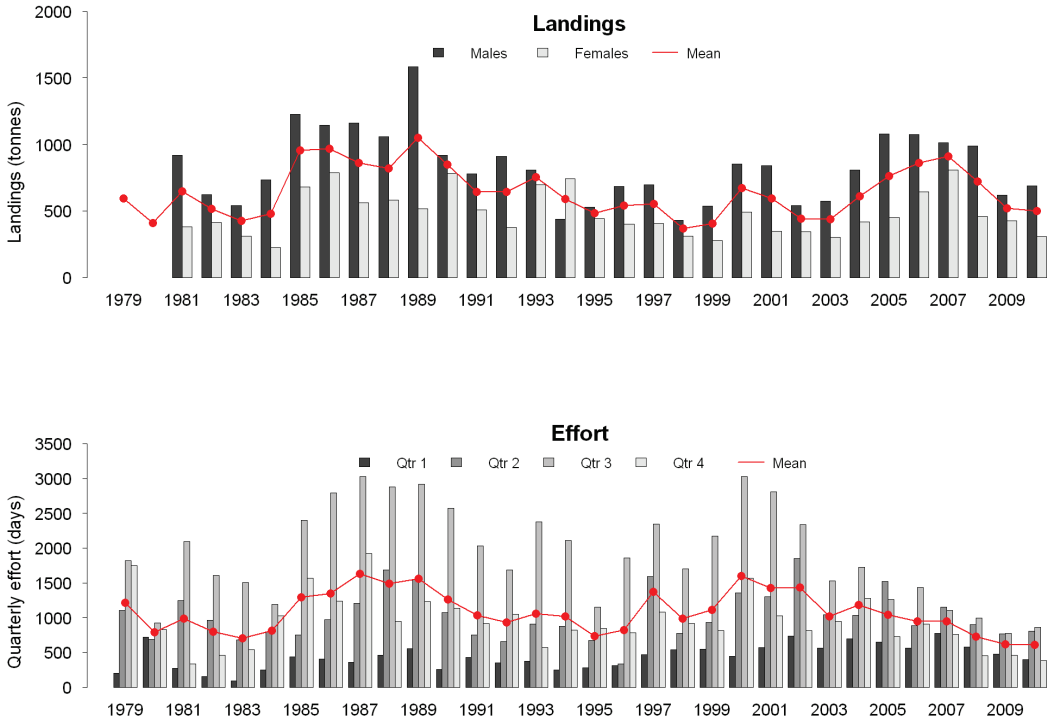


Figure 4.4.14.1 *Nephrops*, Moray Firth (FU 9), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

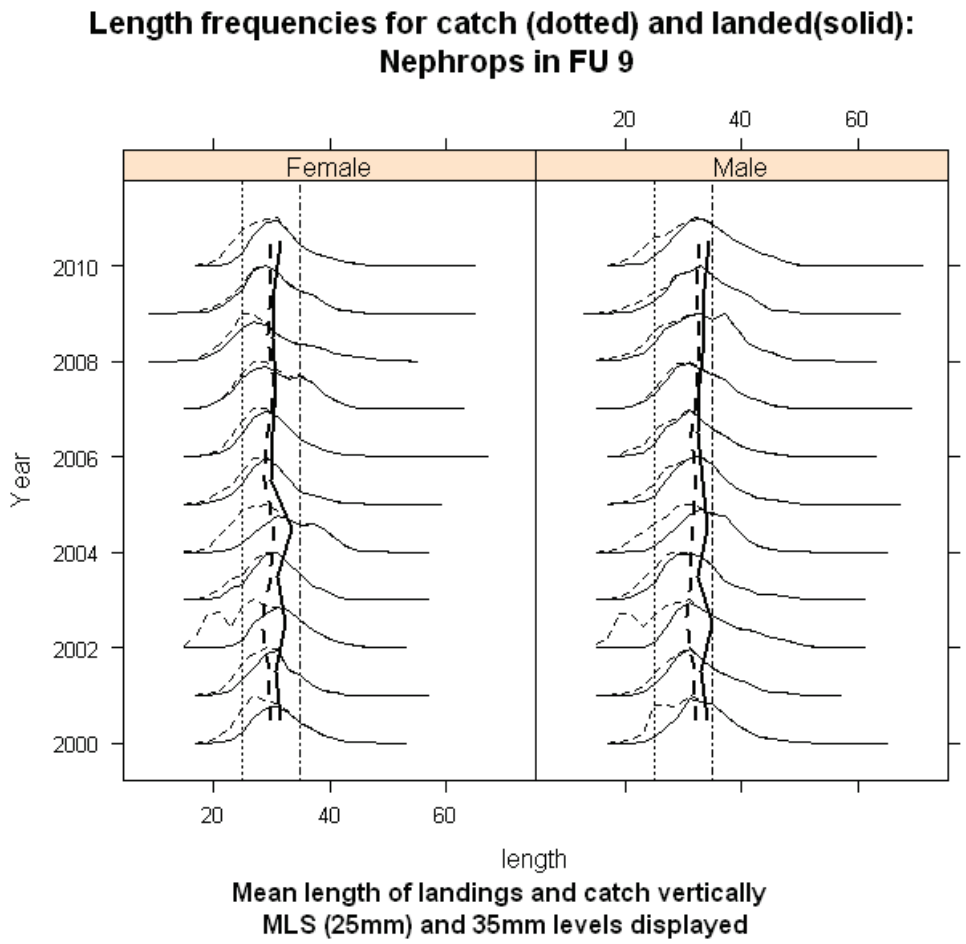


Figure 4.4.14.2 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2010 (top). Mean sizes of catch and landings are displayed vertically.**

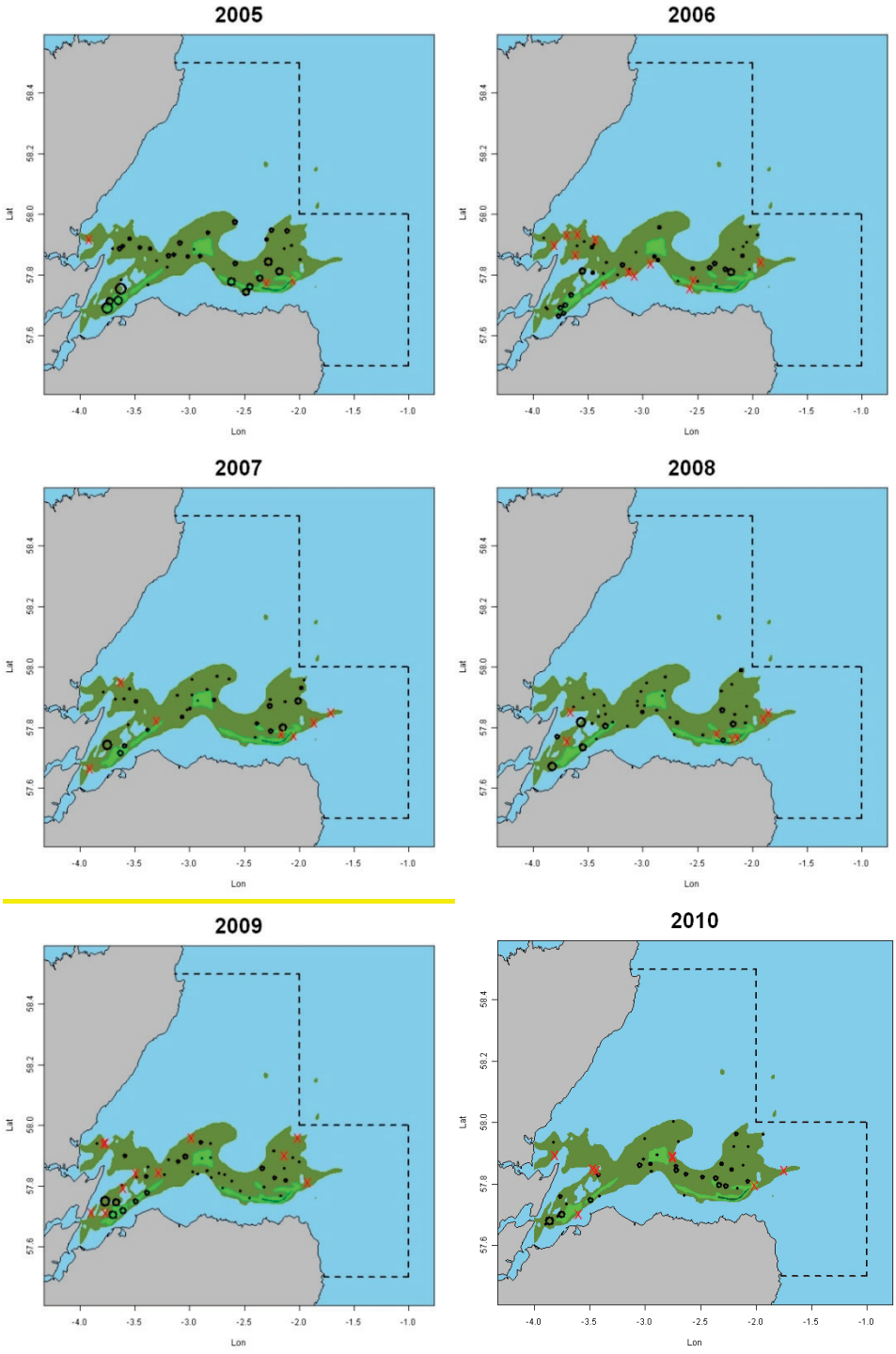


Figure4.4.14.3 ***Nephrops*****, Moray Firth (FU 9). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

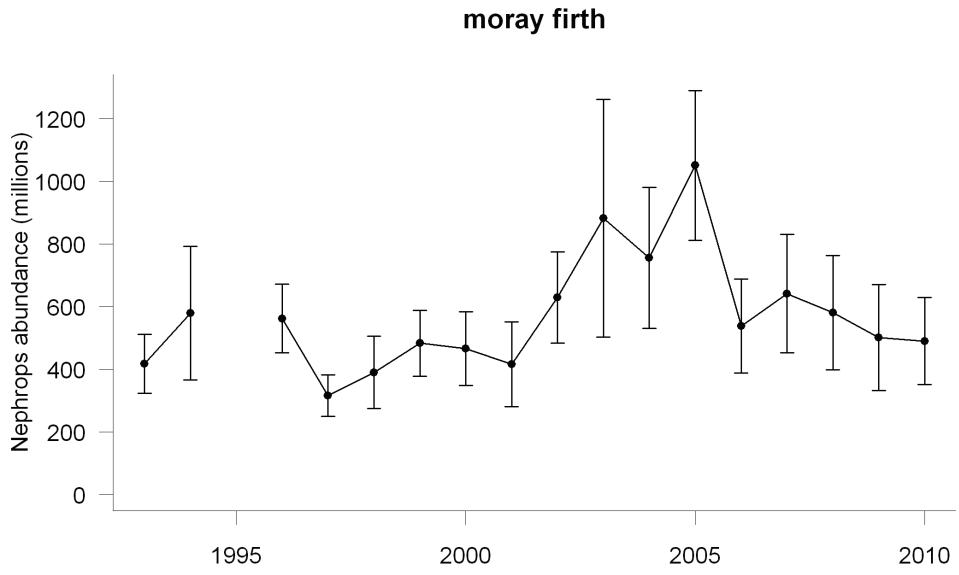


Figure 4.4.14.4 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates, with 95% confidence intervals, 1993 – 2010.

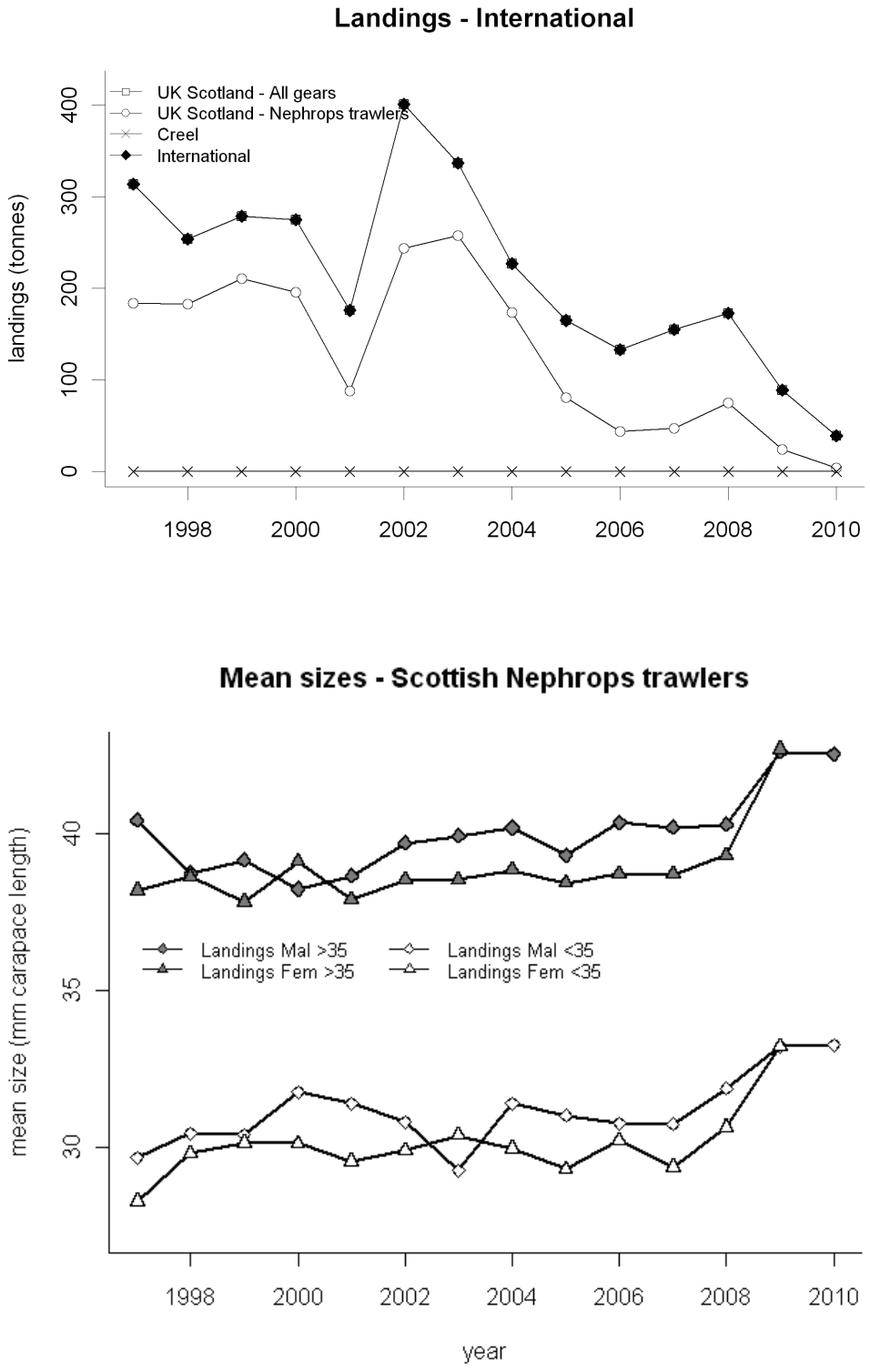


Figure 4.4.15 ***Nephrops*****, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010).**

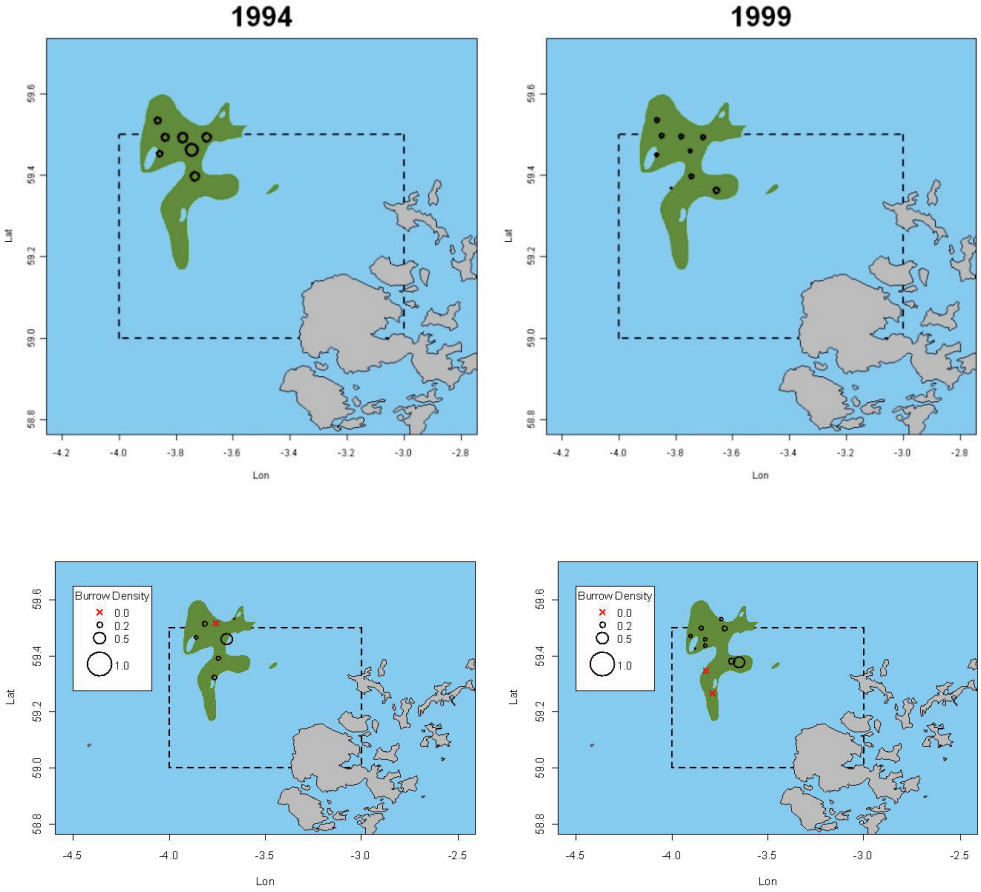


Figure 4.4.15.1 ***Nephrops*****, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

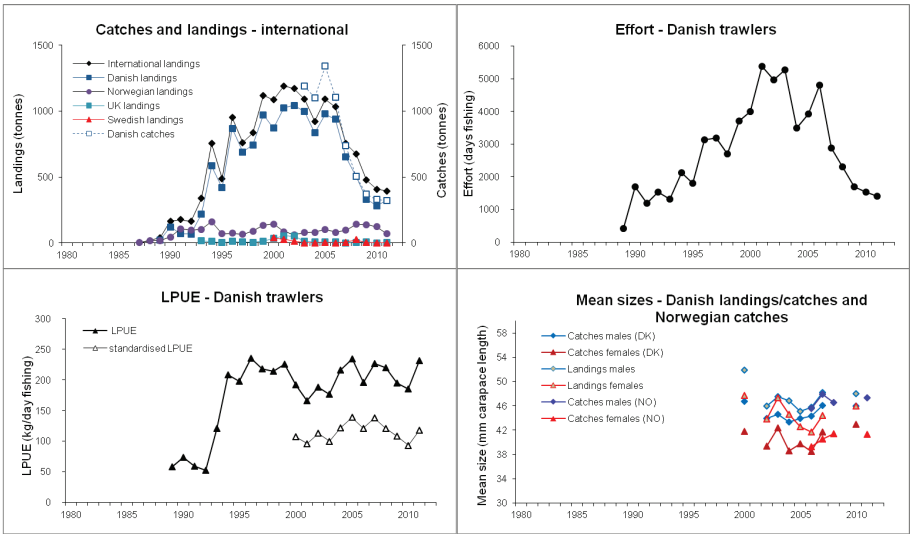


Figure 4.4.15.2 ***Nephrops*** **in FU 32 (Norwegian Deep): Landings, effort, LPUE and mean size.**

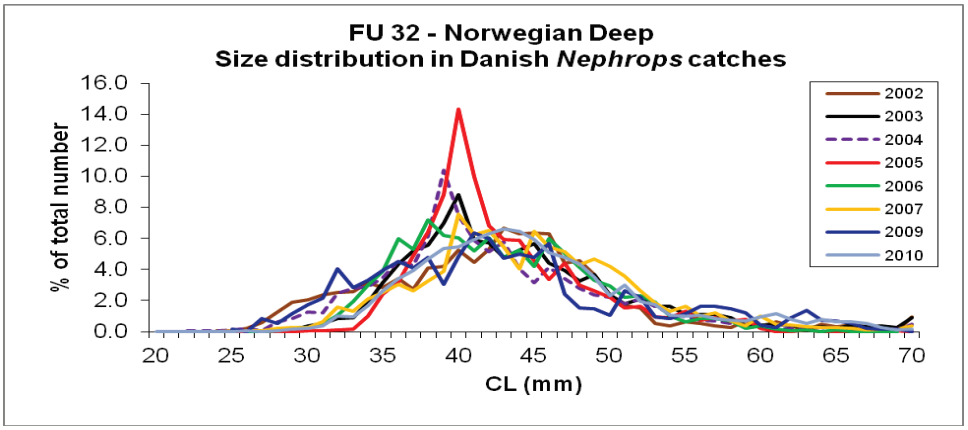


Figure 4.4.15.3 Nephrops in FU 32 (Norwegian Deep): Size distribution in Danish catches.

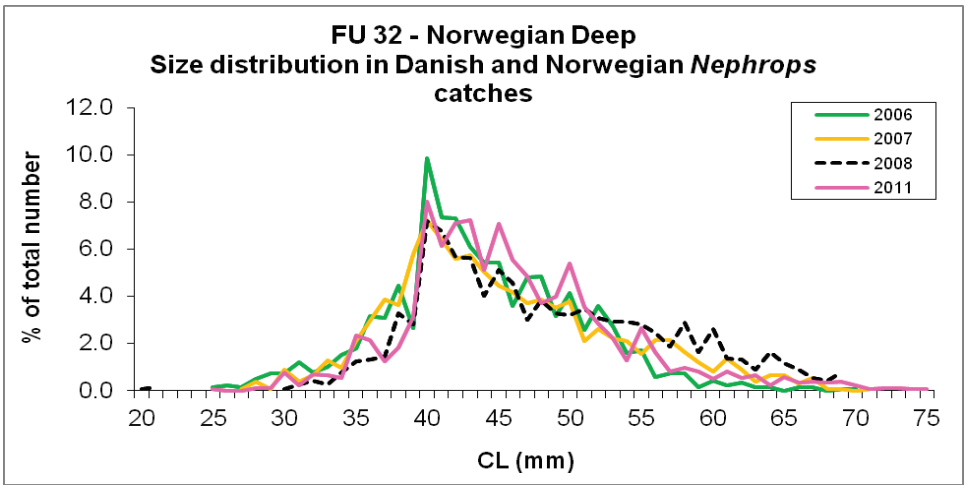


Figure 4.4.15.4, Nephrops in FU 32 (Norwegian Deep): Size distribution of Danish and Norwegian catches. Data from the Norwegian coast guard.

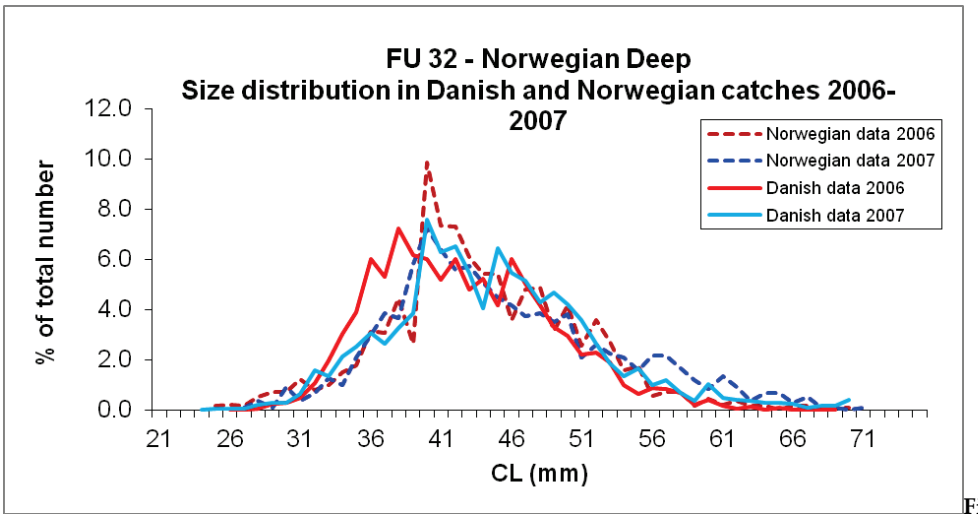


Figure 4.4.15.5, Nephrops in FU 32 (Norwegian Deep): Comparison of size distribution in catches (2006-2007) from Danish and Norwegian data sources.

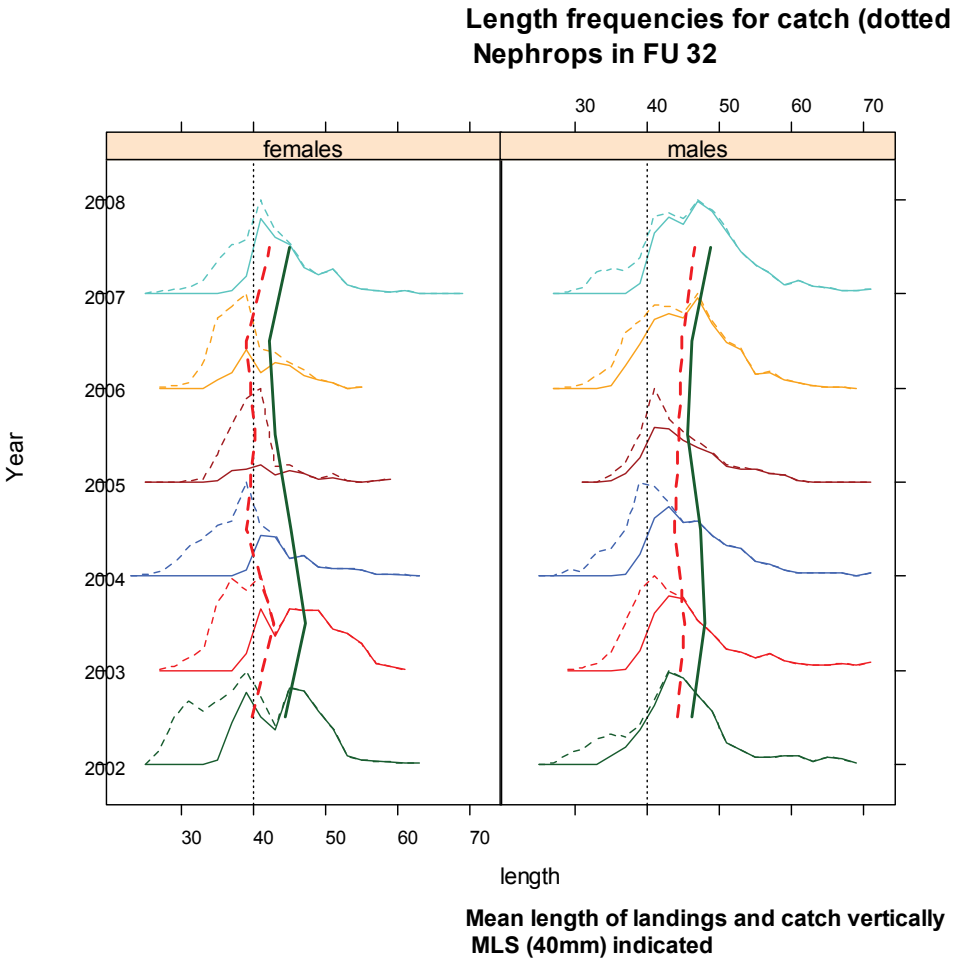


Figure4.4.15.6 *Nephrops* in FU 32 (Norwegian Deep): Evolution of size composition in landings and discards.

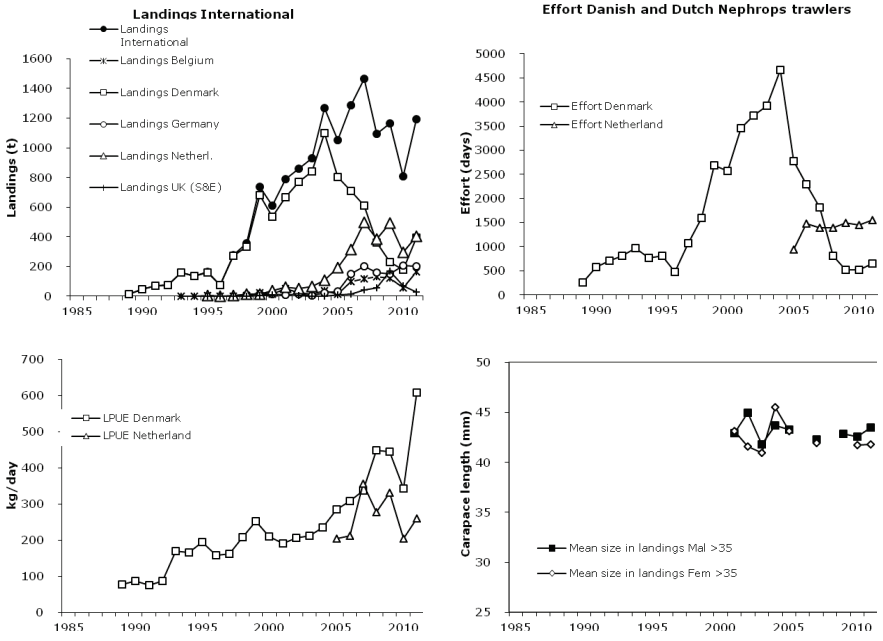


Figure 4.4.16 *Nephrops* in FU 33 (Off Horns Reef): Landings, effort and mean size.

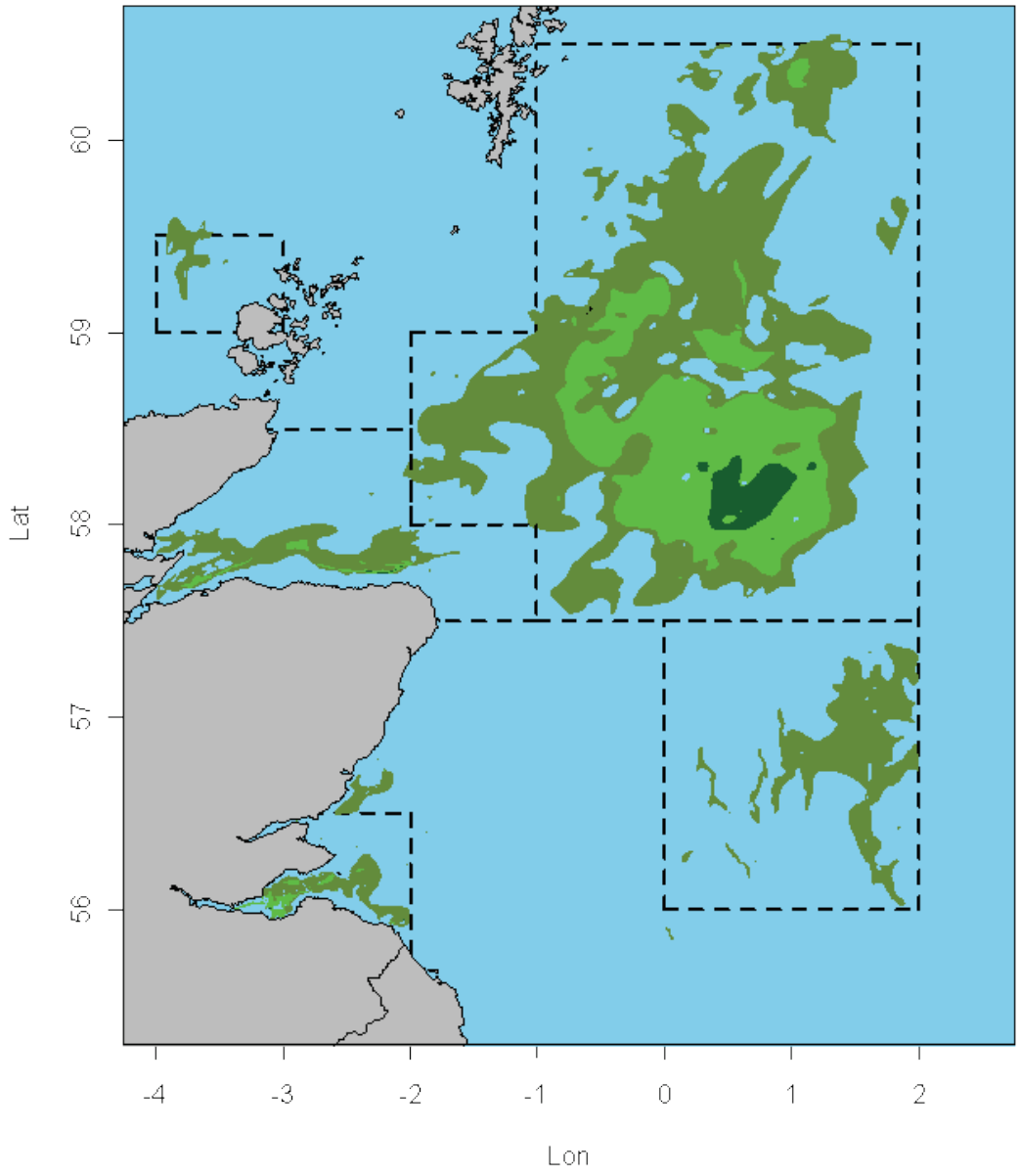


Figure 4.4.17. ***Nephrops*****, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for** ***Nephrops*** **in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**

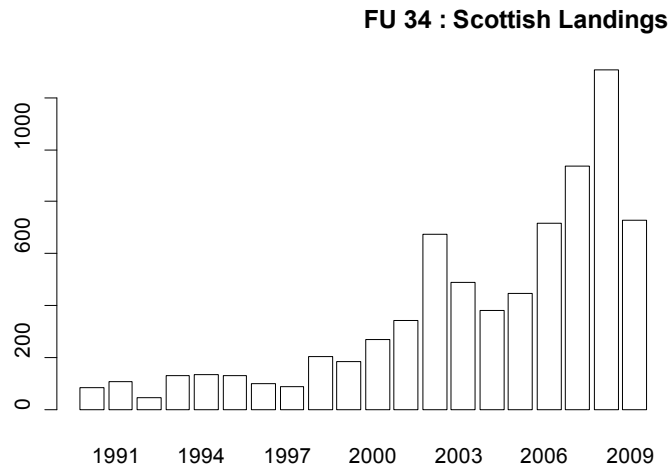


Figure 4.4.17.1. Nephrops, Devil's Hole (FU 34). Scottish landings from 1991 to 2010.

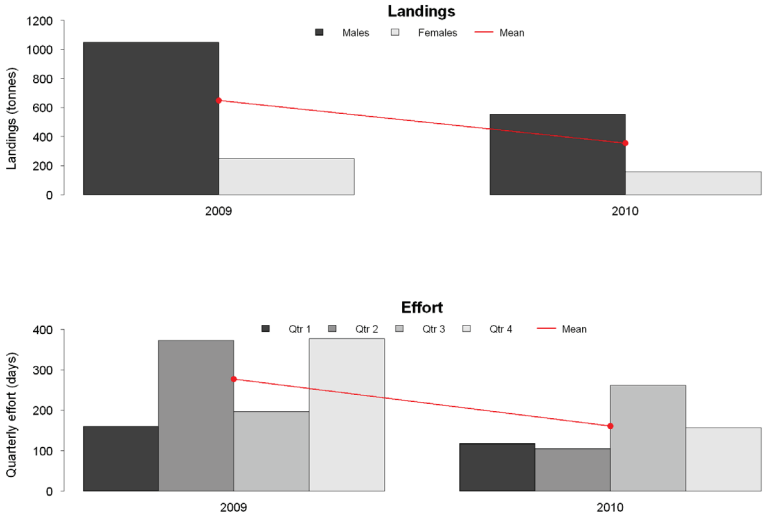


Figure 4.4.17.2. *Nephrops*, Devil's Hole (FU 34). Landings by sex and effort by quarter from Scottish *Nephrops* trawlers.

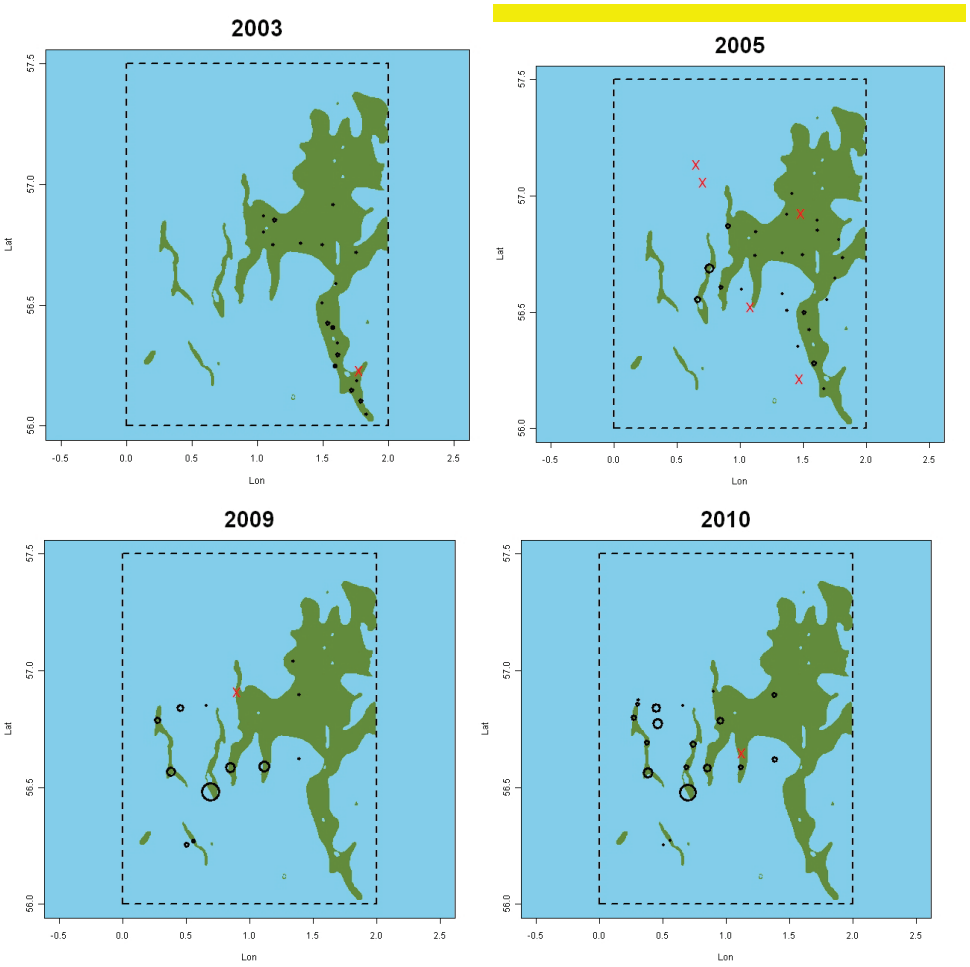


Figure 4.4.17.3. Nephrops, Devil's Hole (FU 34). TV survey distribution and relative density (2003, 2005, 2009-2010). Olive areas indicate areas of suitable sediment for Nephrops. 2009 and 2010 survey station locations generated from VMS data. Density proportional to circle radius.

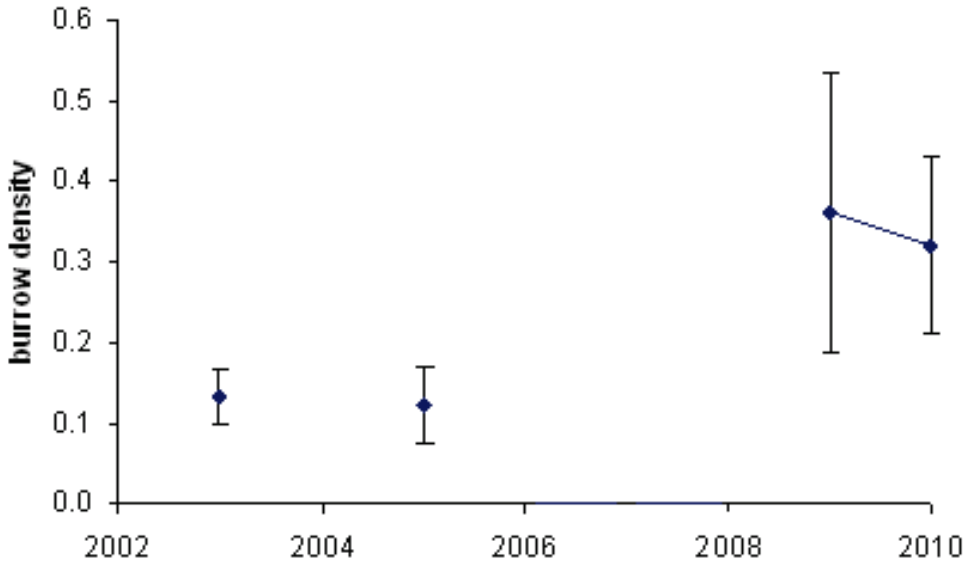


Figure 4.4.17.4. Nephrops, Devil's Hole (FU 34). Time series of TV survey density estimates, with 95 % confidence intervals, 2003, 2005, 2009-10.

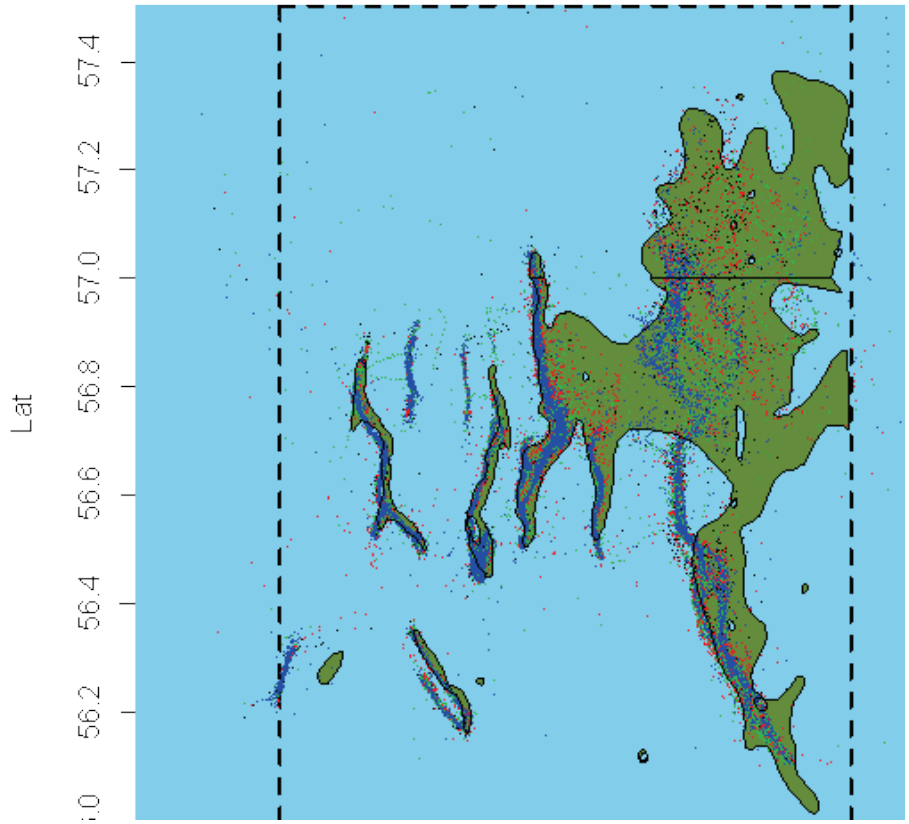


Figure 4.4.17.5. Nephrops, Devil's Hole (FU 34). Comparison of BGS muddy sediment and VMS data from Scottish Nephrops trawlers (2006-2009).

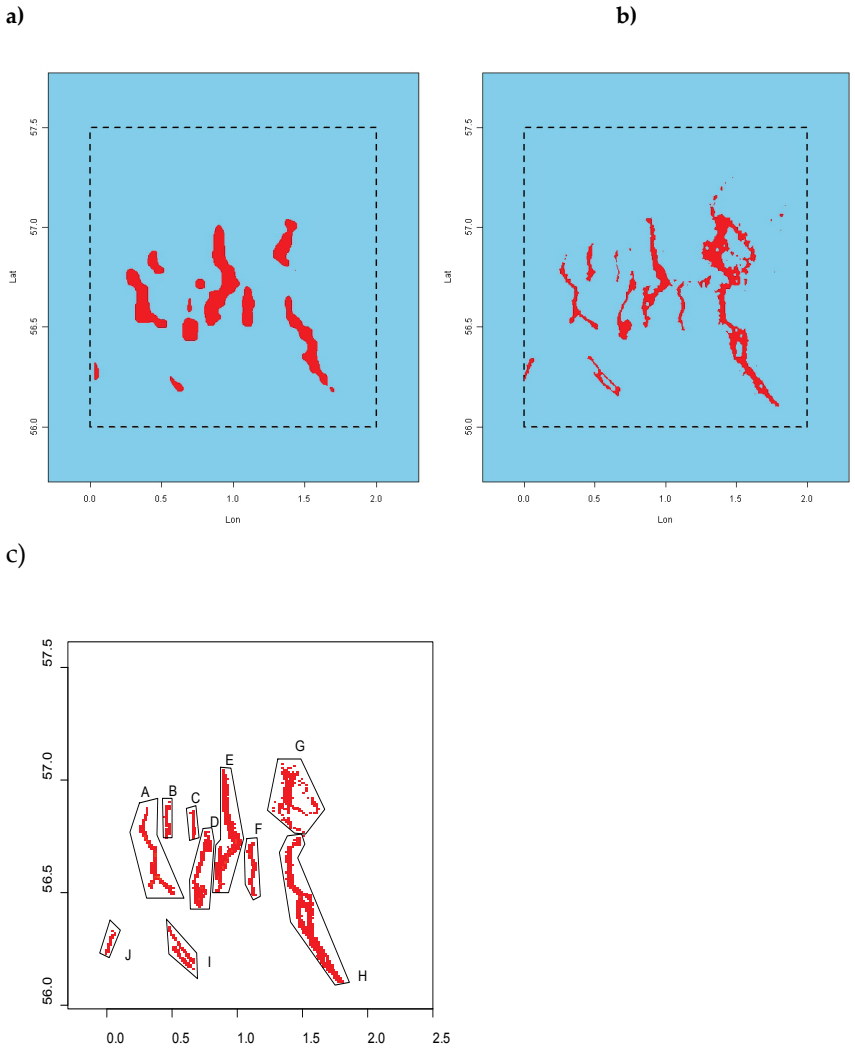


Figure 4.4.17.6. Nephrops, Devil's Hole (FU 34). Estimated fished area by a) thin plate regression spline method (2009 data), b) alpha convex hull (2009 data) and c) cells containing on average > 2 pings/year.

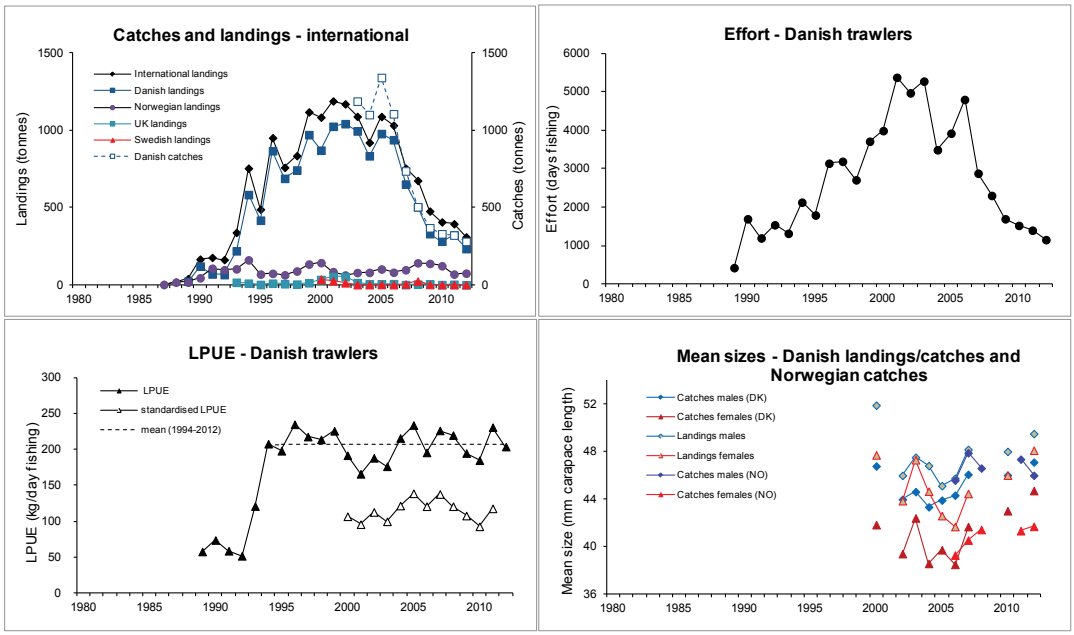


Figure 4.4.18, Nephrops in FU 32 (Norwegian Deep): Landings, Danish effort and LPUE, and mean size in catches and landings (Danish (DK) and Norwegian (NO) data).

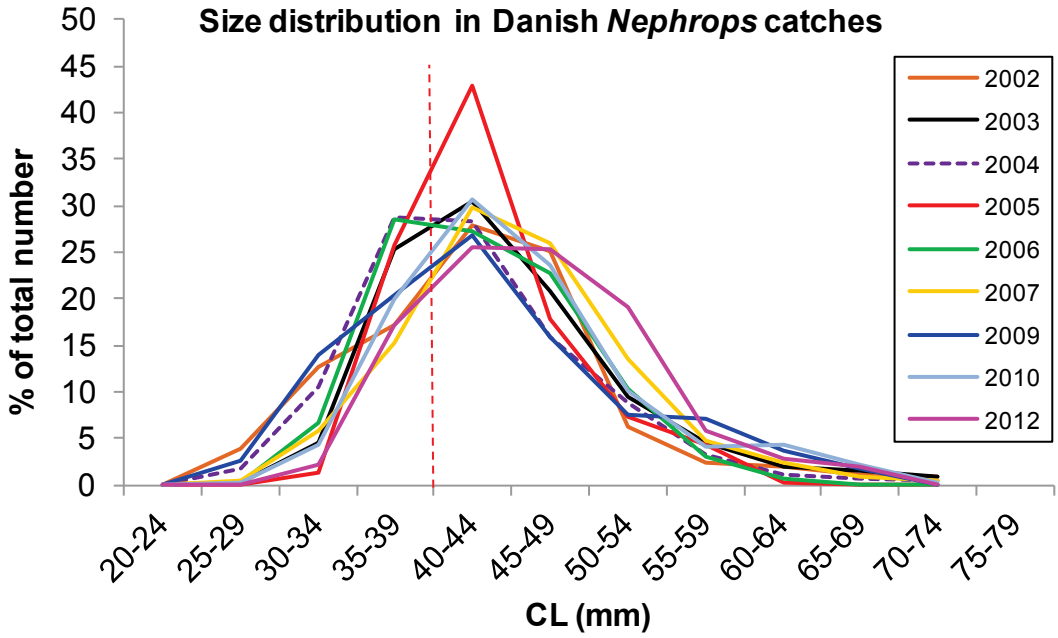


Figure 4.4.18.1, Nephrops in FU 32 (Norwegian Deep): Size distribution in Danish catches. Vertical line indicates MLS (40 mm CL). Data from the Danish at-sea-sampling programme.

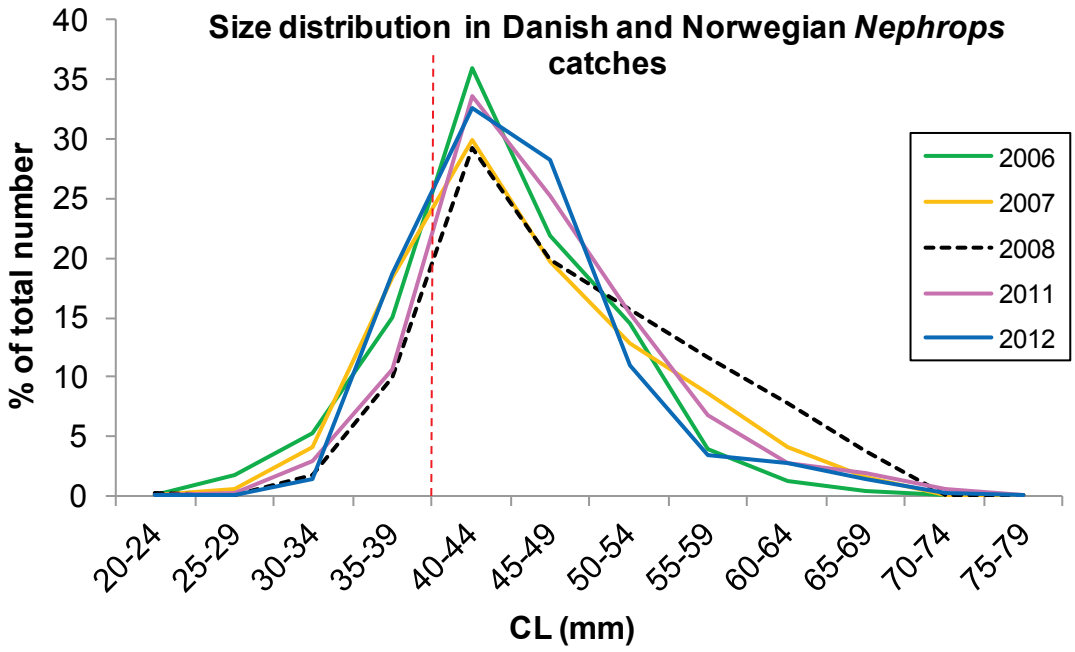


Figure 4.4.18.2 Nephrops in FU 32 (Norwegian Deep): Size distribution of Danish and Norwegian catches. Vertical line indicates MLS (40 mm CL). Data from the Norwegian coast guard.

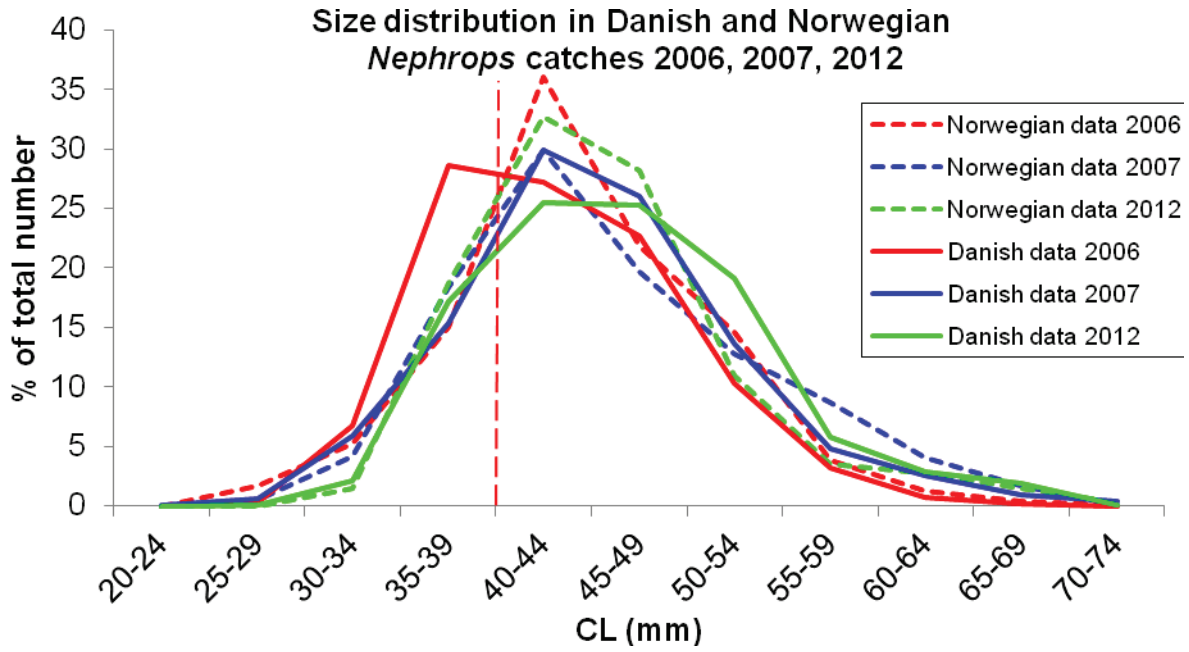


Figure 4.4.18.3, Nephrops in FU 32 (Norwegian Deep): Comparison of size distribution in catches (2006, 2007, 2012) from Danish and Norwegian data sources. Vertical line indicates MLS (40 mm CL).

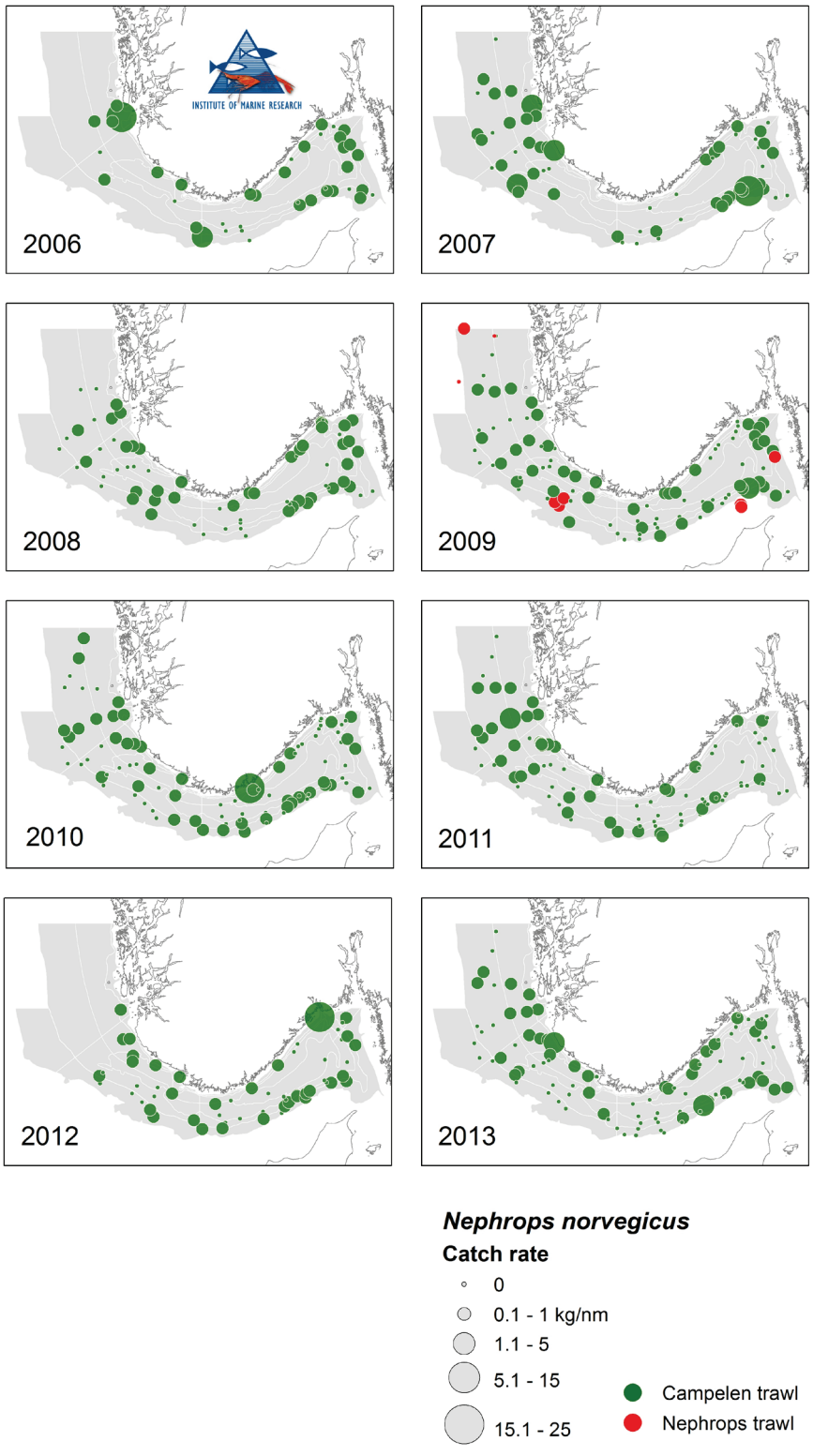


Figure 4.4.18.4, *Nephrops* in FU 32 (Norwegian Deep): Catches of *Nephrops* (kg/nm trawled) from the Norwegian annual shrimp survey (using a Campelen 1800/35 bottom trawl with cod end mesh size 22 mm with 6 mm lining net), in January-February 2006-2013.

5 Norway Pout in ICES Subarea IV and Division IIIa (May 2013)

Introduction: Update and inter-benchmark assessment

The May 2013 assessment of Norway pout in the North Sea and Skagerrak is an up-date assessment from the May and September 2012 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 2013, and includes new information from second half year 2012 and 1st quarter 2013.

Furthermore, a within year short term prognosis (Forecast) up to 1st January 2014 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; 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.

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). Spawn-ing 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 (vary-ing 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). 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, mini¬¬mum 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 to-wards Norway pout as one of the target species together with Blue Whiting in the Norwegian fishery.

Landings have been 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 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. Trends in yield are shown in Table 5.3.5 and Figures 5.3.1-3.

By-catch of herring, saithe, cod, had¬dock, 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. Exis¬ting tech-nical measures such as the closed Norway pout box, minimum mesh size in the fish-ery, 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 2012 the advice on North Sea Norway pout was updated with the addition of the 3rd quarter 2012 English and Scottish groundfish surveys.

Based on the estimates of SSB in September 2012, ICES classified the stock to show full reproductive capacity (SSB>Bpa=MSY Bescapement). Based on the real time management and confirmation of recruitment estimates through consecutive surveys, the in year ICES advice was to open fishery in 2008-2010 and second half 2011 and 2012. The in year (September) ICES advice according to the escapement management strategy was in 2008, 2009, 2010, 2011 and 2012 148 kt, 157 kt, 434 kt, 6 kt, and 101 kt, respectively, while the TAC in 2008 was 115 kt, 116 kt (only EU Part) in 2009, 162 kt in 2010, 6 kt in 2011, and 101 kt in 2012. Due to the weak 2010 and 2011 year classes ICES advised closure of the fishery in first half year 2011 and 2012, and only a small TAC of 6 kt in 2011 based on the September 2011 in year advice. ICES advised in September 2012 re-opening of the fishery based on the strong 2012 recruitment.

Fishing mortality has generally been lower than the natural mortality for this stock and has decreased in recent years well 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 2013 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 2012 - on the basis of precautionary limits and MSY limits - that in order to maintain the spawning stock biomass above Bpa= MSY Bescapement by 1st January 2014 the directed Norway pout fishery should be maximum 101 kt in 2012 and 458 kt in 2013 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 0.30), and under the long term fixed fishing mortality or fishing effort strategy (TAE) a TAC on 58 000 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 2012

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 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.

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, and 101 kt for 2012, however, the TACs were not taken during this period except for the small TAC in 2011. This is probably due to high fishing (fuel) costs in this period but also because of management with bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch), and late opening of the fishery by the end of quarter 3 in 2012. Fishery was closed in first half year 2011 and 2012.

In managing this fishery by-catches of other species have been taken into account. Existing technical measures such as the closed Norway pout box, mini¬¬mum 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 yet been decided on. Based on new joint EU–Norway requests (ICES, 2012b), long term management strategies have been evaluated again in September 2012 and April 2013 for the stock to be avail-

able for the September 2012 and May 2013 ICES advice, respectively (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 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 2008, 2009 and 2011, while the landings were moderate in 2010 and 2012 where the TAC was not reached. 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, 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.

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, and second half 2012.

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 de-

scribed 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, but not Norwegian data.

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 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 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 multispecies 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 re-vised 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 Tables 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 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 2013 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 5.1.7-5.1.9, 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 si¬ze 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 2008-2012 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 2010-12 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 2010-12 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 2007-2013.

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 2013 IBTS and the 3rd quarter 2012 IBTS research surveys have been

included in this assessment (as well as the 3rd quarter 2012 EGFS and SGFS research survey information which also were included in the September 2012 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.

5.2.6.2 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 2007-2012 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 2012 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 last year's assessment

The general and technical review comments on the Norway pout 2011 assessment were the following:

General comments:

This is a detailed assessment report that was easy to follow despite the unique aspects of monitoring and managing this stock.

In the stock annex Norway pout is considered a one time spawner. Natural mortality of 1.6 is used and the number of age groups in the catch are usually few. Is there a possibility that the stock could be much larger or smaller? Predation is what counts, it is variable, and can be type II feeding function (i.e higher M at lower stock size). This looks really like capelin assessment and some of them (Barents Sea) are complicated multispecies models still having one survey (acoustic measurement) where q=1 can be assumed.

Reply: Actually, the constant natural mortality of 0.4 per quarter over years have been changed in the May 2012 assessment and onwards according to the benchmark assessment spring 2012 (ICES, 2012c). The spawning stock biomass in 2011 was around 375 kt which is a historical maximum since the early 1980'ies (1983-84) besides the biomasses around 350 in 1996 and 2010 based on the strong 1996, 2009 and 2012 year classes. Assessments and stock levels previous to 1983 are uncertain due to uncertainty on species catch compositions in the industrial fishery catches previous to this period. Recent strong year classes (2010-2012) are on the same level as previous strong year classes (e.g. 1994, 1996 and 199 year classes), however, the frequency of strong year classes seems to have declined (at least in the period 2000-2005). Accordingly, it is difficult to answer whether the stock can obtain higher levels. This should also be seen in context on natural mortality and predation on the stock which will

vary according to other fish species composition in the North Sea ecosystem, i.e. in relation to predator stock biomasses as well as other (alternative) forage fish (prey) stock biomasses to which the predators can potentially switch (sprat, sandeel, etc). We have seen historical low levels of the stock in 2003-2004 due to repeated low recruitment in the period 2000-2004, and it is given the historic development (and recovery) of the stock difficult to imagine lower stock levels, however, this depends more on natural processes than the fishery.

Technical comments

The assessment is not simply an update of the 2011 assessments (May and September). While the assessment model and tuning indices are consistent between years in 2012 parameter settings for natural mortality, maturity at age, and mean weight at age have been changed. More specific details of these changes (presented later in the report) may be useful in the introduction/summary section of the assessment report.

Reply: It has already in the Introduction been mentioned that the population dynamic parameters have been changed in the assessment from May 2012 and onwards, but to meet the reviewer comment the following additional information has been include in the Introduction: "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."

It is indicated in the report that the status of the stock is more determined by natural processes less by the fishery. This species is viewed as an important forage species in the region and one of the important natural processes that should be further explored and possibly quantified is consumption by the main predators of Norway pout.

Reply: It has both in the May 2012(and again in the present May 2013) assessment and in the Stock Annex been stated that: "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. 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. Growth and mean weight-at-age for the abovementioned predators seems independent of the stock size of Norway pout." Consequently, we believe that this reviewer comment is taken into consideration and met.

Conclusions

The RG agrees with the WG conclusions for this stock.

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 2013. 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 2012 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 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 has been low in 2008 and 2009 and moderate in year 2010 and second half 2012, 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 Blim in 2005 which is the lowest level ever recorded. By 1st January 2007 and 2008 the stock was at Bpa (=MSY Bescapement) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1st January 2009, 2010, 2011, 2012 and 2013 has been well 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 2012 was very high, and on this basis the SSB is expected to be well above Bpa (=MSY Bescapement) in 2013 even with a high TAC in 2013 considering growth of the 1-group, high natural mortality, and 20% maturation at age 1 (see forecast).

5.3.3 Comparison with 2012 assessment

The final, accepted May 2013 SXSA assessment run was compared to the Inter-benchmark May 2012 and up-date September 2012 Scenario 2 SXSA assessment with new population dynamic parameters. The results of the comparative run between the September 2012 and the May 2013 assessments are shown in Figure 5.3.5. The retrospective analysis based on the May 2013 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.

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.

Recruitment Estimates

The long-term average recruitment (age 0, 3rd quarter) is 46 billions (arithmetic mean) and 37 billions (geometric mean) for the period 1983-2013 (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 and 2011year classes were weak. The 2008 year class was above long term average, and the 2009 year class was very strong. The two latest recruitment indices show that the 2010 and 2011 year classes to be very low and the 2012 year class to be very strong.

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 2014 using full assessment information for 2012 and 1st quarter 2013, i.e. it is based on the SXSA assessment estimate of stock numbers at age at the start of 2013.

The purpose of the forecast is to calculate the catch of Norway pout in 2013 which would result in SSB at or above Bpa = MSY Bescapement (=150 000 t) 1st of January 2014. 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 2012 have been used (assessment year).

The forecast assumes a 2013 (the forecast year) fishing pattern scaled to the long term (1983-2011) average standardized exploitation pattern (F) (all years included except for the closure periods and standardized with yearly Fbar to F(1,2)=1) and a fishing mortality of 0 for all ages in quarter 1 2013 because of the near to 0 catches here. 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.

Recruitment in the forecast year is assumed to the 25th percentile = 24 732 millions of the SXSA recruitment estimates (GM = 36 741 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 (2012) and based on recent running 5 year averages (i.e. for the 5 last years with covering observations) for the forecast year (2013). 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 2013.

Twenty percent of age 1 is mature and is included in SSB. Therefore, the recruitment in 2012 does influence the SSB in 2013.

The results of the forecasts are presented in Table 5.6.2. It can be seen that if the objective is to maintain the spawning stock biomass above MSY Bescapement = Bpa by 1st of January 2014 With catches up to 457 kt in 2013 the spawning-stock biomass will re-main above a reference level of MSY Bescapement by 1st January 2014 according to the escapement strategy. This is because the SSB is expected to remain high during 2013 due to the very high 2012 recruitment, the growth and 20 % mature as 1-group of this strong 2012 year class, and still considering the high natural mortality of the stock. When combining a fixed F management strategy (F around 0.35 in 2013) with a fixed TAC strategy (a TAC of 50 000 t in 2013) according to the 2007 Long Term Management Strategy evaluation the SSB is expected to be well above Bpa and MSY Bescapement by 1st January 2014. 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. According to the escapement strategy a 457 kt catch in 2013 will result in a spawning stock biomass at MSY Bescapement. With the objective to maintain the spawning stock biomass at or above a reference level of MSY Bescapement by 1st of January 2014 the spring 2013 the ICES advice is that the fishery can catch a TAC up to 457 kt in 2013 in the directed Norway pout fishery. The reason for this advice in 2013 is mainly the very strong 2012 recruitment, growth of the 1-group and still taking into consideration the high natural mortality as well as the short life span of the stock.

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 Bescapement = Bpa. No F-based reference points are advised for this stock.

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 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 Bpa is considered a good proxy for a SSB reference level for MSY Bescapement. Blim is defined as Bloss and is based on the observations of stock developments in SSB (especially in 1986 and 1989) been set to 90 000 t. MSY Bescapement = Bpa has been calculated from

Bpa = Blim e0.3*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 Bescapement = Bpa (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 Bloss be retained as the Blim reference point = 90 kt and Bpa as MSY Bescapement 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 2012c) 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.

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 of the 2012 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 2012, ICES classified the stock at full reproductive capacity with SSB well above Bpa at the start of 2012 (up to 1st July 2012). Also, the most recent estimates of SSB (Q1 2013) show full reproductive capacity of the stock (SSB> MSY Bescapement = Bpa). With catches up to 457 kt in 2013 the spawning-stock biomass is expected to remain above a reference level of MSY Bescapement by 1st January 2014 according to the escapement strategy due to the very strong 2012 recruitment, growth of the 1-group 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

histor-ical 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 where fishing mortality was low in 2008, 2009 and 2011 and moderate in 2010 and 2012.

The 2008 recruitment was above long term average, and the 2009 year class was very strong. 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 2012 was high (same level as 2009) 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 Btrigger = Bpa 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.

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 2013-2014 will be provided for the stock in autumn 2013 (in year September assessment and forecast).

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 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 Bpa is considered a good proxy for a SSB reference level for MSY Bescapement. (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, mini¬¬mum 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 Stock Annex.

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. Sort-

ing grids in combination with square mesh panels have been shown to reduce by-catches 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 Bpa = MSY Bescapement, i.e. away from Blim 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 a initial TAC of up to 50 kt is sustainable when having a within year up-date assessment. The difference be-

tween 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.

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 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 distribu-tion 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.

Future benchmark should promote that a quarterly based SAM assessment model is developed which can be applied for the stock assessment.

Sources (to be put into the general reference list by the secretariat):

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Table 5.2.1 NORWAY POUT IV & IIIa. Nominal landings (tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas IV and IIIa in the period 2000-2012, as officially reported to ICES and EU. By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	3.780	4.235	110	-	18	24	156	-	51	2	118 *
Faroe Islands	-	50	45	-	-	-	-	-	-	-	-
Norway	96	30	41	-	2	-	-	209	711	-	-
Sweden	-	-	-	-	-	-	-	-	10	-	-
Germany	-	-	54	-	-	-	4	-	-	-	-
Total	3.876	4.315	250	0	20	24	160	209	772	2	118

*Preliminary.

Norway pout ICES area IVa

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	68.858	12.223	10.762	941***	39.531	59	32.158	19.226	71.032	4.038	24.829 *
Faroe Islands	3.367	2.199	1.085	24	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	22	18	-	-
Germany	-	-	-	-	15	-	-	-	-	-	-
Norway	23.657	11.357	4.953	311	13.618	4.712	6.650	36.961	64.303	3.189	4.528 *
Sweden	-	-	-	-	-	-	10	-	+	1	3 *
UK(Scotland)	-	-	-	-	-	-	-	-	29	-	6 *
Total	95.882	25.779	16.800	1.092	53.164	4.771	38.818	56.209	135.353	7.228	29.360

*Preliminary.

Norway pout ICES area IVb

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	556	191	473	-	394	-	244	595	229	32	611 *
Faroe Islands	12	125	29	-	-	-	-	-	-	-	-
Germany	-	-	-	-	19	-	-	75	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	2	-	-	82	620	21	59 *
Sweden	-	-	88	-	-	-	-	-	-	-	-
UK (E/W/NI)	+	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	-	-
Total	568	316	590	0	415	0	244	752	849	53	670

*Preliminary.

Norway pout ICES area IVc

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	73.194	16.649	11.345	941***	39.943	83	32.558	19.821	71.312	4.072	25.558
Faroe Islands	3.379	2.374	1.159	24	0	0	0	0	0	0	0
Norway	23.753	11.387	4.994	311	13.622	4.712	6.650	37.252	65.634	3.210	4.587
Sweden	0	0	88	0	0	0	10	0	10	1	3
Netherlands	0	0	0	0	0	0	0	22	18	0	0
Germany	0	0	54	0	34	0	4	75	0	0	0
UK	0	0	0	0	0	0	0	0	0	0	0
Total nominal landings	100.326	30.410	17.640	1.252	53.599	4.795	39.222	57.170	136.974	7.283	30.148
By-catch of other species and other	-20.326	-3.310	-4.140	-	-6.973	-	-3.084	-2.670	-11.019	-759	-3.075
WG estimate of total landings (IV+IIIaN)	80.000	27.100	13.500	-	46.626	-	36.138	54.500	125.955	6.524	27.073
Agreed TAC	198.000	198.000	198.000	0****	95.000	0****	114.616 x	116.279 x	162.950 x	4.500 x	70.683 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 1961-2012 (Data provided by 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

* 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 (t) by quarter of year 1996-2013. (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	11	11	70

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											
	Quarter	1											
0		0											
1		0											
2		0											
3		0											
4+		0											
SOP		0											

In 2007-08: Catch numbers from Norwegian fishery calculated from Norwegian total catch weight divided by mean weight at age from Danish Fishery.
In 2013: Only very low catches in first quarter 2013 (59 t by Denmark and 11 t by Norway). As there has been no samplings
(age distribution and mean weight at age) of Norway pout in Q1 2013, and the catch is very low, then the catch has been set to 0 in the assessment.

Table 5.2.5 NORWAY POUT in IV and IIIaN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1983-2013, 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
Quarter of year	1
Age 0	
1	
2	
3	
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.
In 2013: Only very low catches in first quarter 2013 (59 t by Denmark and 11 t by Norway). As there has been no samplings
(age distribution and mean weight at age) of Norway pout in Q1 2013 and the catch is very low then the catch has been set to 0 in the assessment.

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 1988-2012. 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
51-100	-	-	-	-	51,67
101-150	-	-	-	-	-
151-200	-	-	-	-	-
201-250	-	-	-	-	-
251-300	-	-	-	-	-
301-	79,13	94,78	106,15	96,63	71,96

* 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, 1983-2012.

	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	***	***	***	***	***	***	***	***	***	***	***
2011	***	***	***	***	***	***	***	***	***	***	***
2012	***	***	***	***	***	***	***	***	***	***	***

* 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 2010-11 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

* 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	.	.	.	.	.	.	.	.	.	.	.	.
2008	.	.	.	.	.	.	.	.	.	.	.	.
2009	.	.	.	.	.	.	.	.	.	.	.	.
2010	.	.	.	.	.	.	.	.	.	.	.	.
2011	.	.	.	.	.	.	.	.	.	.	.	.
2012	.	.	.	.	.	.	.	.	.	.	.	.

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/IYFS[1] February (1st Q)			EGFS[2,3] August				SGFS[4] August				IBTS 3rd Quarter[1]			
	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	1,556	22	-	-	-	-	-	-	-	-	-	-	-	-	-
1972	2,578	872	3	-	-	-	-	-	-	-	-	-	-	-	-
1973	4,207	438	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	25,557	391	24	-	-	-	-	-	-	-	-	-	-	-	-
1975	4,573	1,880	4	-	-	-	-	-	-	-	-	-	-	-	-
1976	4,411	371	2	-	-	-	-	-	-	-	-	-	-	-	-
1977	6,093	274	42	-	-	-	-	-	-	-	-	-	-	-	-
1978	1,479	575	47	-	-	-	-	-	-	-	-	-	-	-	-
1979	2,738	316	75	-	-	-	-	-	-	-	-	-	-	-	-
1980	3,277	550	29	-	-	-	-	-	1,928	346	12	-	-	-	-
1981	1,092	377	15	-	-	-	-	-	185	127	9	-	-	-	-
1982	4,537	262	59	6,594	2,609	39	77	8	991	44	22	-	-	-	-
1983	2,258	592	7	6,067	1,558	114	0.4	13	490	91	1	-	-	-	-
1984	4,994	982	75	457	3,605	359	14	2	615	69	8	-	-	-	-
1985	2,342	1,429	73	362	1,201	307	0	5	636	173	5	-	-	-	-
1986	2,070	383	20	285	717	150	80	38	389	54	9	-	-	-	-
1987	3,171	481	61	8	552	122	0.9	7	338	23	1	-	-	-	-
1988	124	722	15	165	102	134	20	14	38	209	4	-	-	-	-
1989	2,013	255	172	1,531	1,274	621	20	2	382	21	14	-	-	-	-
1990	1,295	748	39	2,692	917	158	23	58	206	51	2	-	-	-	-
1991	2,450	712	130	1,509	683	399	6	10	732	42	6	7,301	1,039	189	2
1992	5,071	885	32	2,885	6,193	1,069	157	12	1,715	221	24	2,559	4,318	633	48
1993	2,682	2,644	258	5,699	3,278	1,715	0	2	580	329	20	4,104	1,831	608	53
1994	1,839	374	66	7,764	1,305	112	7	136	387	106	6	3,196	704	102	14
1995	5,940	785	77	7,546	6,174	387	14	37	2,438	234	21	2,860	4,440	597	69
1996	923	2,631	228	3,456	1,332	319	3	127	412	321	8	4,554	763	362	12

1997	9,752	1,474	670	1,045	6,262		376	30	1	2,154	130	32	490	3,447	236	46
1998	1,010	5,336	265	2,573	404		260	0	2,628	938	127	5	2,931	801	748	12
1999	3,527	597	667	6,358	1,930		88	26	3,603	1,784	179	37	7,844	2,367	201	94
2000	7,900	1,495	65	2,005	6,261		141	2	2,094	6,656	207	23	1,643	7,868	282	11
2001	1,305	2,861	235	3,948	1,013		693	5	759	727	710	26	2,088	1,274	862	27
2002	1,793	809	880	9,737	1,784		61	21	2,559	1,192	151	123	1,974	766	64	48
2003	1,239	575	94	379	681		85	5	1,767	779	126	1	1,812	1,063	146	7
2004	895	376	34	564	542		90	7	731	719	175	19	773	647	153	12
2005	690	133	37	6,912	803		67	11	3,073	343	132	18	2,614	439	125	17
2006	3,299	145	27	1,680	2,147		151	18	1,127	1,285	69	9	1,337	1,837	152	15
2007	1,286	778	23	3,329		1,084	339	1	5,003	1,023	395	8	4,143	1,191	447	11
2008	2,345	506	186	1,435	1,371		253	35	3,456	1,263	263	57	3,035	1,643	274	58
2009	5,414	1,618	150	6,401	5,368		428	3	5,835	1,750	202	16	5,898	2,562	254	11
2010	4,663	1,448	137	235	3,977		626	31	1,449	5,101	930	29	834	4,744	833	17
2011	535	2.229	301	1,304	870		1,024	38	1,895	226	935	38	1,797	471	1126	60
2012	995	330	537	5,084	835		181	70	10,067	1,070	159	216	6,476	863	150	110
2013	4,453	536	82													

[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 2005-2013 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

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 2013

Run: May 2013 (Summary from NP513)

The following parameters were used:

```
Year range:                                  1983 - 2013
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):                                   tun2013.xsa
Weighting for rhats:                                  rweigh.xsa
```

Table 5.3.3 Norway pout IV & IIIaN (Skagerrak). easonal 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	*	*	85133.	63316.	*	*	46326.	34663.	*	*	31325.	23434.
1	74086.	51797.	37178.	22780.	45066.	31335.	21498.	11510.	24007.	16005.	11235.	7195.
2	12952.	7702.	4199.	1548.	13329.	7894.	4386.	1585.	5592.	2664.	1685.	488.
3	126.	69.	37.	10.	736.	359.	15.	3.	469.	148.	85.	39.
4+	0.	457.	294.	190.	1.	0.	0.	0.	2.	1.	1.	0.
SSN	2716.				23079.				10865.			
SSB	69785.				443803.				201910.			
TSN	87164.	60024.	126840.	87843.	59132.	39587.	72226.	47762.	30071.	18818.	44329.	31157.
TSB	995603.	843153.	1440130.	1011887.	768281.	591306.	899129.	559334.	374761.	266122.	478638.	342283.

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	62620.	46856.	*	*	16625.	12433.	*	*	49509.	36404.
1	16948.	12339.	9007.	5714.	30241.	20304.	14262.	9265.	9107.	6600.	4856.	3475.
2	2797.	1014.	615.	215.	2727.	1516.	977.	521.	5072.	2858.	1874.	1063.
3	187.	63.	38.	20.	113.	63.	41.	26.	161.	88.	56.	36.
4+	25.	14.	9.	6.	16.	10.	6.	4.	15.	10.	6.	4.
SSN	6399.				8905.				7070.			
SSB	109337.				128054.				150500.			
TSN	19957.	13429.	72290.	52811.	33098.	21893.	31912.	22249.	14356.	9555.	56302.	40983.
TSB	231362.	177316.	502541.	433718.	345793.	285256.	464584.	328574.	216072.	155585.	397797.	349951.

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	53226.	39690.	*	*	47655.	35641.	*	*	92438.	68533.
1	24519.	16845.	12018.	7546.	25500.	17489.	11547.	7800.	25810.	18014.	12930.	8360.
2	2054.	1351.	805.	326.	4141.	2323.	1102.	594.	4815.	2161.	1131.	588.
3	387.	244.	152.	94.	144.	77.	34.	17.	307.	123.	64.	23.
4+	26.	17.	11.	7.	55.	27.	18.	11.	15.	5.	3.	2.
SSN	7370.				9440.				10299.			
SSB	112404.				158264.				179950.			
TSN	26986.	18457.	66212.	47663.	29840.	19916.	60356.	44064.	30947.	20303.	106566.	77507.
TSB	288942.	249064.	554703.	445312.	341864.	273317.	525429.	433609.	365784.	276623.	742067.	645094.

Year	1992				1993				1994			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	39803.	29023.	*	*	28560.	21287.	*	*	116994.	86983.
1	48266.	33039.	23405.	14523.	20892.	13952.	9736.	6293.	14912.	9450.	6749.	4160.
2	5349.	2728.	1606.	767.	8459.	5152.	3099.	1348.	3801.	2087.	1178.	452.
3	245.	63.	25.	15.	300.	181.	70.	30.	547.	307.	174.	55.
4+	2.	0.	0.	0.	8.	5.	3.	2.	19.	12.	8.	5.
SSN	15249.				12945.				7349.			
SSB	230506.				261517.				144785.			
TSN	53861.	35830.	64839.	44328.	29658.	19291.	41469.	28961.	19278.	11856.	125103.	91655.
TSB	578017.	467826.	810051.	568766.	411936.	305582.	485837.	340702.	252152.	181612.	694300.	647172.

Year	1995				1996				1997			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	36827.	26951.	*	*	88614.	65680.	*	*	24316.	18101.
1	61420.	42505.	30157.	20364.	18703.	13532.	9641.	6312.	46969.	34564.	25777.	16615.
2	2120.	1238.	627.	386.	12341.	7720.	5062.	2603.	4160.	2549.	1618.	790.
3	196.	122.	53.	32.	213.	126.	51.	3.	1488.	895.	481.	226.
4+	39.	25.	16.	10.	25.	16.	10.	7.	6.	4.	3.	2.
SSN	14638.				16319.				15048.			
SSB	173549.				352088.				248415.			
TSN	63774.	43889.	67680.	47743.	31281.	21394.	103378.	74605.	52623.	38011.	52194.	35733.
TSB	615771.	548484.	929482.	688086.	486747.	362575.	800987.	656178.	586591.	523459.	835274.	568660.

Year	1998				1999				2000			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	34541.	25765.	*	*	84613.	63278.	*	*	28330.	21135.
1	13248.	9687.	7066.	4932.	18986.	14031.	10224.	6527.	46374.	34135.	25300.	17747.
2	10770.	6724.	4298.	2636.	3231.	2082.	1229.	554.	4385.	2817.	1737.	957.
3	364.	197.	112.	71.	1608.	977.	555.	329.	244.	155.	61.	23.
4+	119.	70.	26.	16.	46.	29.	18.	12.	201.	130.	84.	54.
SSN	13902.				8682.				14105.			
SSB	314298.				181818.				214125.			
TSN	24500.	16677.	46043.	33420.	23870.	17119.	96639.	70700.	51204.	37236.	55510.	39916.
TSB	409681.	298092.	493452.	387444.	318516.	270895.	676484.	584110.	548015.	495034.	818924.	610106.

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	*	*	25978.	19411.	*	*	17669.	12927.	*	*	7892.	5899.
1	15554.	11448.	8451.	6219.	14206.	10210.	7336.	4952.	9422.	6999.	5182.	3712.
2	9286.	5592.	3584.	2404.	4422.	2872.	1925.	1070.	3297.	2169.	1429.	868.
3	447.	260.	87.	55.	1266.	802.	513.	311.	439.	265.	151.	85.
4+	45.	29.	18.	12.	42.	27.	18.	11.	187.	120.	77.	50.
SSN	12888.				8572.				5806.			
SSB	280520.				189156.				127376.			
TSN	25331.	17328.	38119.	28101.	19937.	13912.	27460.	19271.	13344.	9554.	14731.	10613.
TSB	392506.	291764.	463777.	371291.	291440.	235967.	361836.	262196.	195212.	158201.	227303.	167793.

Year	2004				2005				2006			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	10041.	7501.	*	*	39520.	29571.	*	*	19277.	14416.
1	4413.	3291.	2459.	1796.	5564.	4163.	3115.	2331.	22127.	16531.	12321.	9107.
2	2730.	1803.	1208.	776.	1258.	852.	576.	390.	1744.	1138.	733.	443.
3	455.	286.	180.	110.	461.	297.	191.	123.	264.	163.	86.	50.
4+	60.	38.	25.	16.	80.	51.	33.	21.	93.	60.	39.	25.
SSN	4128.				2912.				6526.			
SSB	97754.				64377.				99191.			
TSN	7659.	5419.	13913.	10199.	7362.	5363.	43435.	32436.	24228.	17892.	32455.	24040.
TSB	129531.	101020.	160735.	127331.	104434.	88968.	270477.	258436.	258504.	238330.	419609.	334757.

Year	2007				2008				2009			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	31479.	23555.	*	*	60097.	44968.	*	*	80670.	60312.
1	10469.	7816.	5813.	4321.	17625.	13184.	9818.	7203.	32628.	24372.	18206.	13086.
2	5875.	3943.	2648.	1780.	3225.	2175.	1439.	880.	5011.	3392.	2258.	1024.
3	258.	166.	107.	68.	1200.	773.	498.	320.	570.	367.	232.	142.
4+	47.	31.	20.	13.	51.	33.	21.	14.	215.	139.	89.	57.
SSN	8275.				8001.				12322.			
SSB	178705.				163227.				218850.			
TSN	16650.	11956.	40067.	29737.	22101.	16165.	71873.	53386.	38424.	28269.	101455.	74622.
TSB	254080.	202385.	383582.	324496.	290128.	253080.	573253.	503665.	453775.	403363.	882062.	738244.

Year	2010				2011				2012			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	10383.	7769.	*	*	18225.	13637.	*	*	86258.	64544.
1	45119.	33756.	24568.	17416.	5813.	4350.	3254.	2397.	10203.	7634.	5708.	4264.
2	9645.	6529.	3676.	1882.	12413.	8404.	5686.	3793.	1774.	1201.	811.	546.
3	672.	433.	265.	159.	1002.	645.	415.	265.	2518.	1621.	1043.	670.
4+	128.	83.	53.	34.	124.	80.	51.	33.	192.	124.	80.	51.
SSN	19469.				14701.				6524.			
SSB	356396.				367804.				174163.			
TSN	55565.	40801.	38945.	27260.	19352.	13479.	27631.	20124.	14686.	10580.	93900.	70075.
TSB	681256.	594561.	818666.	566492.	409660.	299038.	406607.	308805.	247624.	209615.	582754.	554588.

Year	2013
Season	1
AGE	
0	*
1	48179.
2	2842.
3	218.
4+	457.
SSN	13152.
SSB	192067.
TSN	51695.
TSB	538956.

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	0.327	0.417	0.114	0.063	0.154	0.616
2	0.128	0.212	0.570	0.342	0.132	0.194	0.587	0.750	0.340	0.068	0.766	0.536
3	0.156	0.185	0.766	1.541	0.270	1.584	0.917	0.000	0.654	0.116	0.323	0.000
4+	*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.466	0.000	0.000	0.000
F (1- 2)	0.098	0.127	0.383	0.292	0.102	0.140	0.457	0.584	0.227	0.066	0.460	0.576

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.146	*	*	0.001	0.021	*	*	0.017	0.104
1	0.027	0.025	0.163	0.434	0.107	0.063	0.140	0.305	0.032	0.017	0.044	0.232
2	0.584	0.108	0.616	0.243	0.193	0.049	0.233	0.715	0.180	0.032	0.174	0.581
3	0.607	0.059	0.214	0.000	0.140	0.000	0.010	0.266	0.166	0.000	0.000	0.000
4+	0.157	0.000	0.000	0.000	0.079	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.306	0.067	0.389	0.338	0.150	0.056	0.187	0.510	0.106	0.024	0.109	0.407

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.003	0.151	*	*	0.000	0.033	*	*	0.009	0.060
1	0.085	0.047	0.173	0.303	0.086	0.124	0.101	0.190	0.069	0.041	0.144	0.155
2	0.029	0.126	0.488	0.408	0.185	0.344	0.223	0.264	0.395	0.251	0.257	0.464
3	0.019	0.031	0.038	0.184	0.186	0.354	0.240	0.329	0.451	0.209	0.538	1.668
4+	0.000	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.625	0.000	0.000	0.000
F (1- 2)	0.057	0.087	0.331	0.356	0.136	0.234	0.162	0.227	0.232	0.146	0.201	0.309

Year	1992				1993				1994			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.026	0.039	*	*	0.004	0.066	*	*	0.006	0.058
1	0.088	0.054	0.185	0.246	0.113	0.069	0.145	0.211	0.164	0.046	0.191	0.373
2	0.276	0.138	0.337	0.520	0.104	0.117	0.424	0.487	0.205	0.178	0.536	0.428
3	0.811	0.475	0.051	0.177	0.062	0.481	0.394	0.086	0.134	0.123	0.650	0.000
4+	*	*	*	*	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.182	0.096	0.261	0.383	0.109	0.093	0.284	0.349	0.185	0.112	0.364	0.401

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	0.078	0.053	0.102	0.208	0.033	0.049	0.132	0.126	0.017	0.003	0.148	0.142
2	0.146	0.282	0.094	0.202	0.078	0.032	0.268	0.166	0.099	0.064	0.317	0.371
3	0.036	0.378	0.073	0.124	0.084	0.447	1.486	0.118	0.068	0.177	0.307	0.207
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)	0.112	0.168	0.098	0.205	0.056	0.040	0.200	0.146	0.058	0.034	0.233	0.256

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	0.132	0.012	0.026	0.157	0.107	0.016	0.009	0.064	0.348
2	0.080	0.057	0.098	0.103	0.049	0.135	0.391	0.414	0.052	0.093	0.202	0.359
3	0.172	0.121	0.018	0.259	0.058	0.124	0.080	0.090	0.014	0.468	0.508	0.375
4+	0.087	0.532	0.000	0.000	0.014	0.007	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.052	0.041	0.083	0.117	0.031	0.081	0.274	0.260	0.034	0.051	0.133	0.354

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	0.116	0.054	0.009	0.245	0.041	0.010	0.194	0.476	0.028	0.027	0.107	0.249
3	0.102	0.605	0.016	0.020	0.016	0.008	0.058	0.110	0.063	0.122	0.137	0.590
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.032
F (1- 2)	0.066	0.034	0.013	0.148	0.041	0.025	0.148	0.296	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	0.066	0.000	0.000	0.000	0.000	0.002	0.004	0.012	0.147
2	0.025	0.011	0.052	0.128	0.000	0.000	0.000	0.000	0.037	0.049	0.113	0.147
3	0.025	0.024	0.049	0.019	0.000	0.000	0.001	0.001	0.041	0.197	0.107	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)	0.014	0.006	0.038	0.097	0.000	0.000	0.000	0.000	0.019	0.027	0.063	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	0.031	*	*	0.001	0.000
1	0.002	0.006	0.006	0.003	0.000	0.005	0.020	0.072	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	0.385	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	0.002
1	0.000	0.028	0.054	0.048	0.000	0.000	0.016	0.011	0.000	0.001	0.002	0.115
2	0.000	0.181	0.272	0.235	0.000	0.001	0.015	0.020	0.000	0.002	0.006	0.502
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	0.163	0.142	0.000	0.001	0.015	0.015	0.000	0.002	0.004	0.308

Year	2013
Season	1
AGE	
0	*
1	0.000
2	0.000
3	0.000
4+	0.000
F (1- 2)	0.000

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 1983-2013 (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	*	*	*	11.104
1	10.383	*	9.731	9.132
2	9.261	*	8.794	8.491
3	9.261	*	8.794	8.491

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2013 (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	2.139	*	*	*
2	1.508	*	*	*
3	1.508	*	*	*

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2012 (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	*	*	2.385	*
1	*	*	1.496	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2012 (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	*	*	2.325	*
1	*	*	1.773	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2012 (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	*	*	1.526	*
3	*	*	1.526	*

Table 5.3.5 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2013 (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	*	*	*	1.078
1	1.358	*	3.222	2.109
2	2.171	*	1.695	1.240
3	1.240	*	*	0.765

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2013 (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	1.800	*	*	*
2	1.915	*	*	*
3	1.131	*	*	*

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2012 (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	*	*	1.310	*
1	*	*	2.421	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2012 (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	*	*	1.809	*
1	*	*	2.345	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2012 (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	*	*	1.573	*
3	*	*	0.925	*

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	85133	462487	1440130	457,6	0,900
1984	46326	443803	899129	393,0	1,283
1985	31325	201910	478638	205,1	1,329
1986	62620	109337	502541	174,3	1,100
1987	16625	128054	464584	149,3	0,903
1988	49509	150500	397797	109,3	0,646
1989	53226	112404	554703	166,4	0,831
1990	47655	158264	525429	163,3	0,759
1991	92438	179950	742067	186,6	0,888
1992	39803	230506	810051	296,8	0,922
1993	28560	261517	485837	183,1	0,835
1994	116994	144785	694300	182,0	1,062
1995	36827	173549	929482	236,8	0,583
1996	88614	352088	800987	163,8	0,442
1997	24316	248415	835274	169,7	0,581
1998	34541	314298	493452	57,7	0,293
1999	84613	181818	676484	94,5	0,646
2000	28330	214125	818924	184,4	0,572
2001	25978	280520	463777	65,6	0,261
2002	17669	189156	361836	80,0	0,510
2003	7892	127376	227303	27,1	0,245
2004	10041	97754	160735	13,5	0,155
2005	39520	64377	270477	1,9	0,000
2006	19277	99191	419609	46,6	0,256
2007	31479	178705	383582	5,7	0,022
2008	60097	163227	573253	36,1	0,134
2009	80670	218850	882062	54,5	0,246
2010	10383	356396	818666	126,0	0,409
2011	18225	367804	406607	6,5	0,031
2012	86258	174163	582754	27,0	0,314
2013		192067			
Arit mean	**45.831**	**212.174**	**603.349**		**0,572**
Geomean	**36.741**				

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 2013 (forecast year) observed exploitation pattern and 2013 quarter 2 to quarter 4 fishing pattern scaled to the long term average seasonal exploitation pattern (standardized with the long term Fbar to F(1,2)=1)). Recruitment in the forecast year is assumed to the 25% percentile = 24732 millions (of the long term geometric mean 36741 millions) in the 3rd quarter of the year.

Basis: F (2012) = F (1,2) = 0.314; R (2013) = 25% percentile of long-term recruitment (1983–2011) = 25 billion (3rd quarter); SSB (2013) = 192 (assessment); SSB (2013) (forecast model output) = 189; catches (2012) = 27 kt.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2012	1	0	0	0,000	0,000	0,000	0,29	0
2012	1	1	10203	0,000	0,009	0,027	0,29	0,2
2012	1	2	1774	0,000	0,026	0,036	0,39	1
2012	1	3	2518	0,000	0,043	0,037	0,44	1
2012	2	0	0	0,000	0,000	0,000	0,29	0
2012	2	1	7634	0,001	0,014	0,023	0,29	0
2012	2	2	1201	0,002	0,025	0,041	0,39	0
2012	2	3	1621	0,001	0,038	0,047	0,44	0
2012	3	0	86258	0,000	0,004	0,007	0,29	0
2012	3	1	5708	0,002	0,028	0,029	0,29	0
2012	3	2	811	0,006	0,038	0,040	0,39	0
2012	3	3	1043	0,002	0,051	0,048	0,44	0
2012	4	0	65544	0,002	0,006	0,007	0,29	0
2012	4	1	4264	0,115	0,028	0,039	0,29	0
2012	4	2	546	0,502	0,040	0,050	0,39	0
2012	4	3	670	0,018	0,058	0,059	0,44	0

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	48179	0,000	0,009	0,019	0,29	0,2
2013	1	2	2842	0,000	0,026	0,032	0,39	1
2013	1	3	218	0,000	0,043	0,037	0,44	1
2013	2	0	0	0,000	0,000	0,000	0,29	0
2013	2	1	0	0,070	0,014	0,018	0,29	0
2013	2	2	0	0,148	0,025	0,033	0,39	0
2013	2	3	0	0,148	0,038	0,046	0,44	0
2013	3	0	24732	0,005	0,004	0,007	0,29	0
2013	3	1	0	0,197	0,028	0,026	0,29	0
2013	3	2	0	0,415	0,038	0,036	0,39	0
2013	3	3	0	0,415	0,051	0,049	0,44	0
2013	4	0	0	0,053	0,006	0,008	0,29	0
2013	4	1	0	0,304	0,028	0,031	0,29	0
2013	4	2	0	0,639	0,040	0,039	0,39	0
2013	4	3	0	0,639	0,058	0,057	0,44	0

Table 5.6.2 NORWAY POUT IV and IIIaN (Skagerrak). Results of the short term forecast (May 2013) with different levels of fishing mortality. Shaded scenarios are not considered consistent with the precautionary approach of B(MSY)=Bpa..

Basis: HCR with quarter 1 to 4 2012 (assessment year) and quarter 1 2013 (forecast year) observed exploitation pattern and 2013 quarter 2 to quarter 4 fishing pattern scaled to the long term average seasonal exploitation pattern (standardized with the long term Fbar to F(1,2)=1)). Recruitment in the forecast year is assumed to the 25% percentile = 24732 millions (of the long term geometric mean 36741 millions) in the 3rd quarter of the year.

Basis: F (2012) = F (1,2) = 0.314; R (2013) = 25% percentile of long-term recruitment (1983–2011) = 25 billion (3rd quarter); SSB (2013) = 192 (assessment); SSB (2013) (forecast model output) = 189; catches (2012) = 27 kt.

Rationale	Landings 2013	Basis	F 2013	SSB 2014	%SSB change[1)]
MSY approach	457	MSY $B_{escapement}$	0.77	150	- 21
Precautionary approach	457	B_{pa}	0.77	150	- 21
Zero Catch	0	No fishery	0	448	137
Other options (2007 LTMP MSE)	50	Fixed TAC Strat. (2007 LTMP MSE)	0.12	415	120
	134	Fixed F Strat. (2007 LTMP MSE)	0.35	358	89
	560	B_{lim}	2.71	90	- 52

Weights in '000 tonnes.

[1)] SSB 2014 relative to SSB 2013.

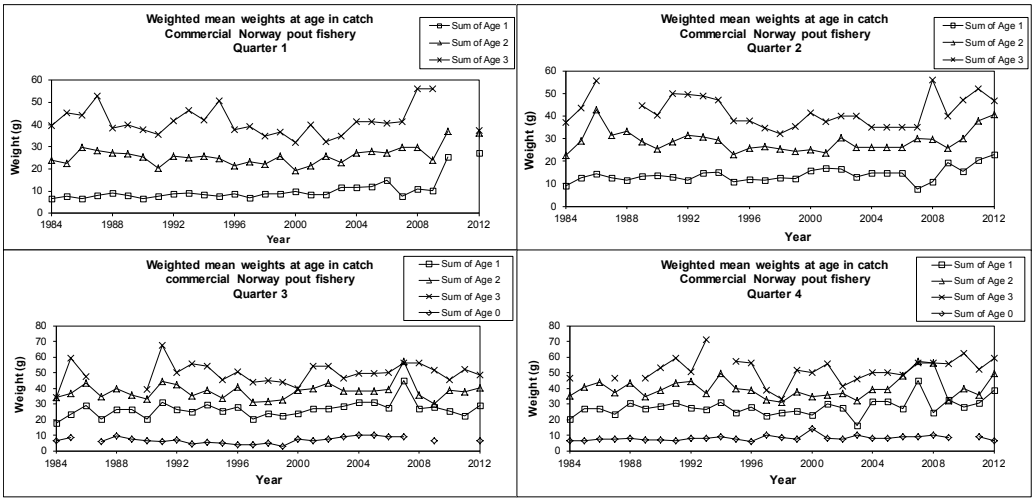


Figure 5.2.1. NORWAY POUT IV and IIIaN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1982-2012.

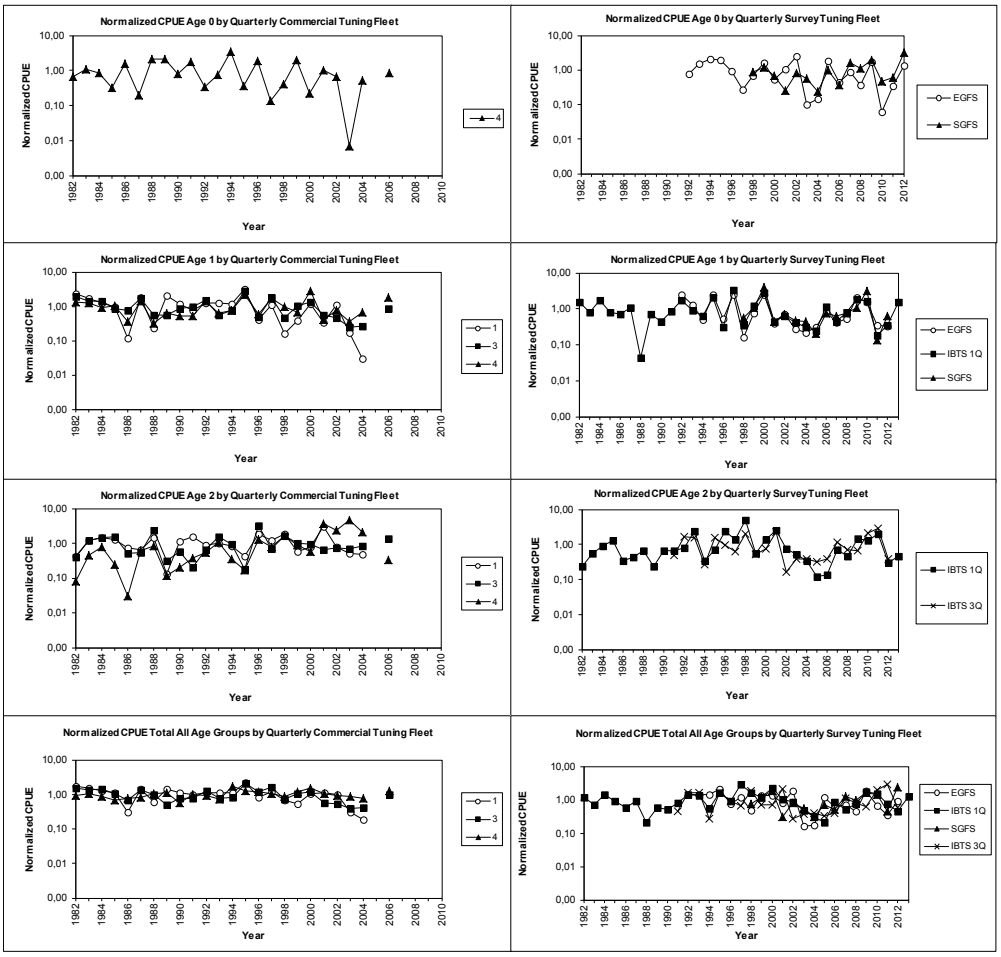


Figure 5.2.2 NORWAY POUT IV and IIIaN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly commercial tuning fleet and survey tuning fleet used in the Norway pout SXSA assessment for each age group and all age groups together.

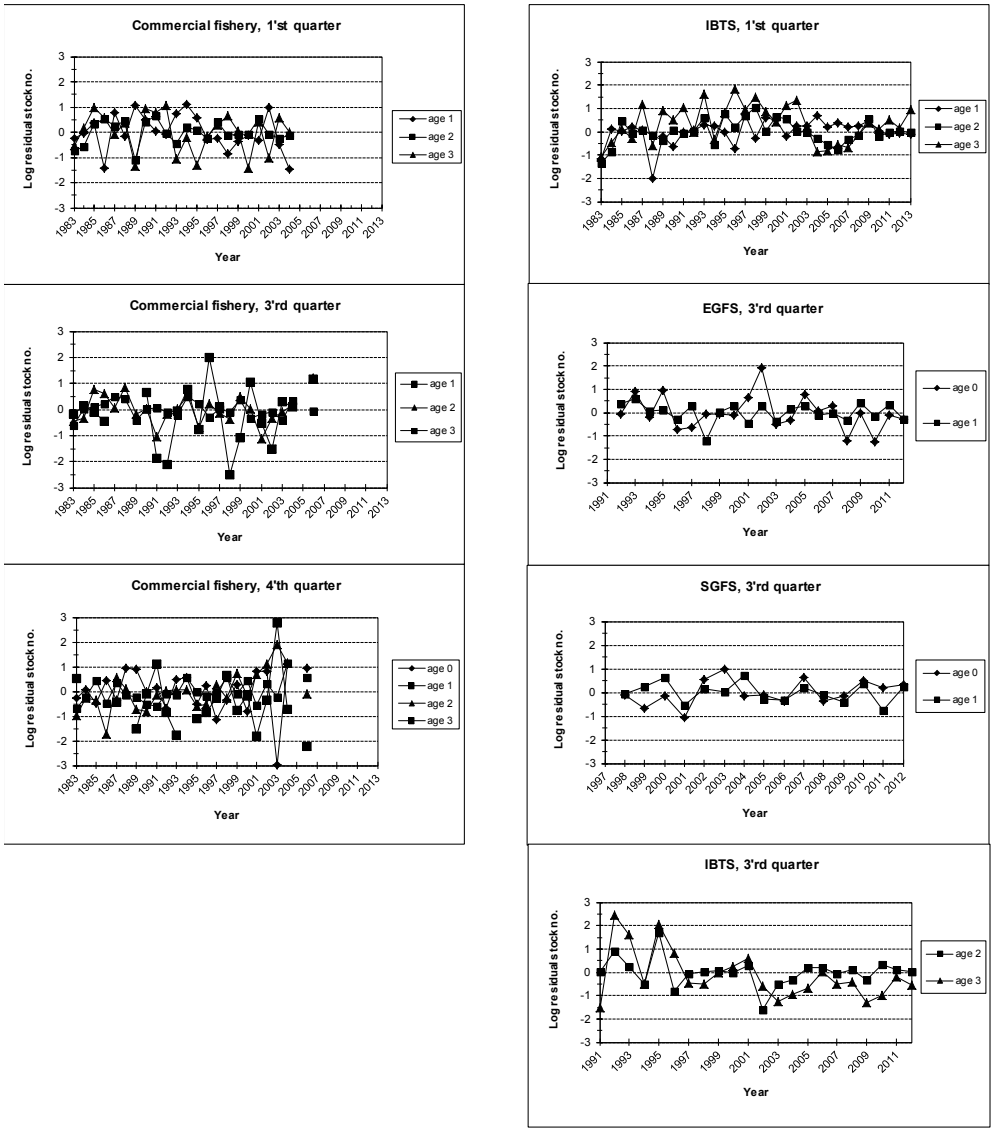


Figure 5.3.1 Norway pout IV & IIIaN (Skagerrak). Log residual stock numbers (log (Nhat/N)) per age group. SXSA divided by fleet and season.

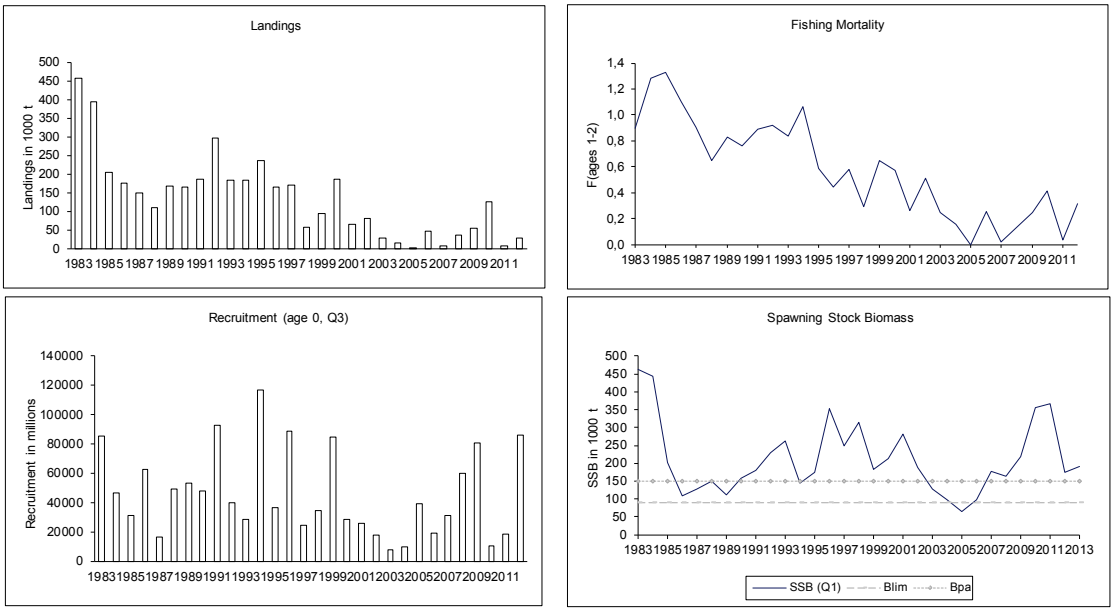


Figure 5.3.2 Norway Pout IV and IIIaN (Skagerrak). Stock Summary Plots. SXSA baseline run May 2013.

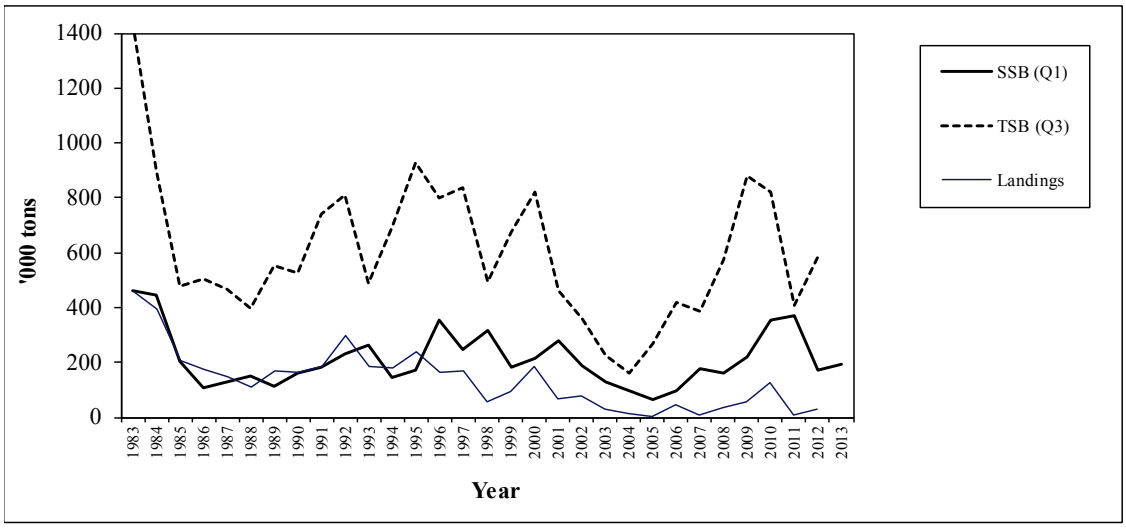


Figure 5.3.3 Norway pout IV & IIIaN (Skagerrak). Trends in yield, SSB and TSB during the period 1983-2013.

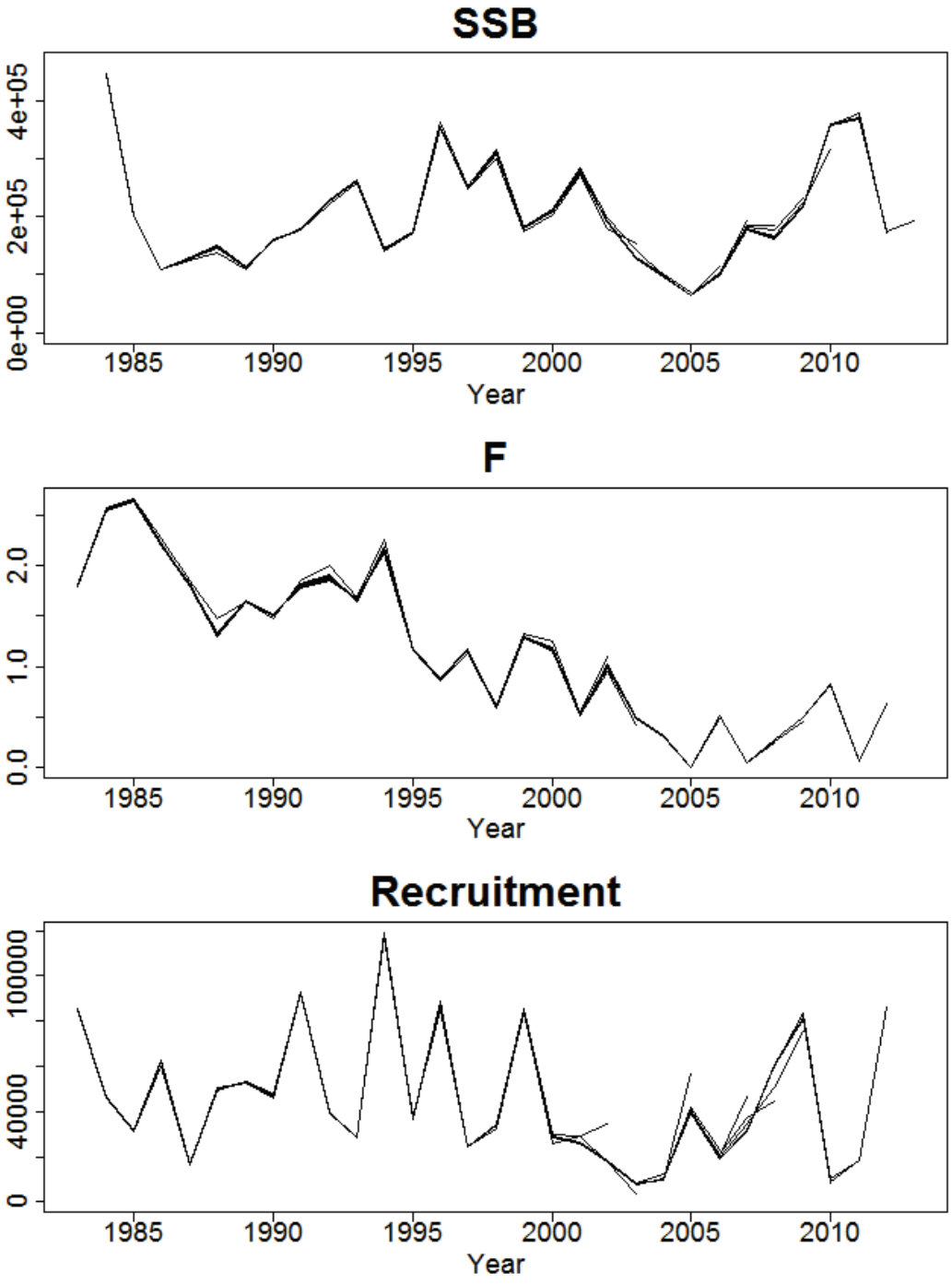


Figure 5.3.4 **Norway pout IV & IIIaN (Skagerrak). Retrospective plots of final SXSA assessment May 2013, with terminal assessment year ranging from 2003-2013.**

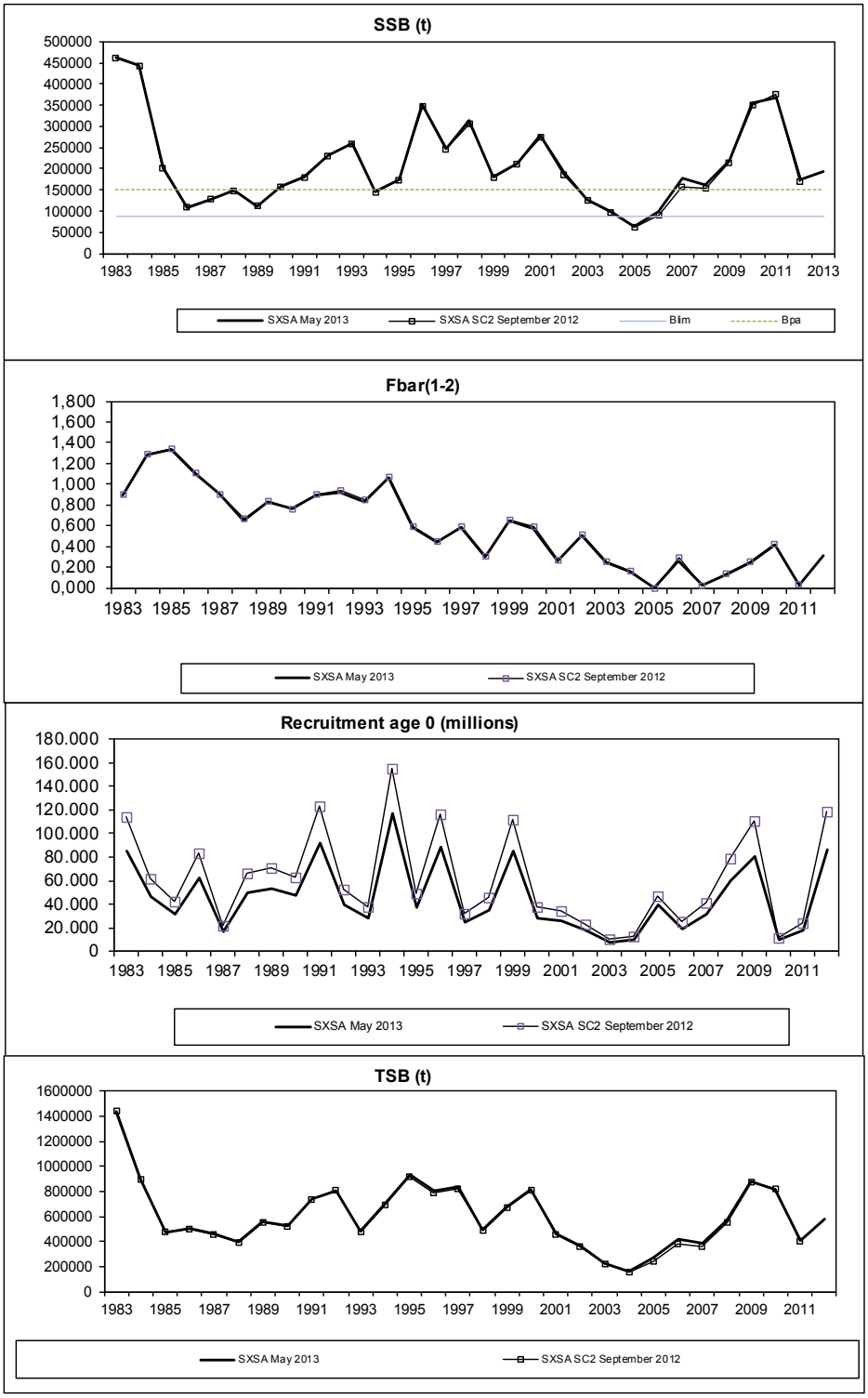


Figure 5.3.5 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2013 SXSA with the September 2012 assessment based on the new benchmark baseline assessment SXSA May 2012 Scenario 2.

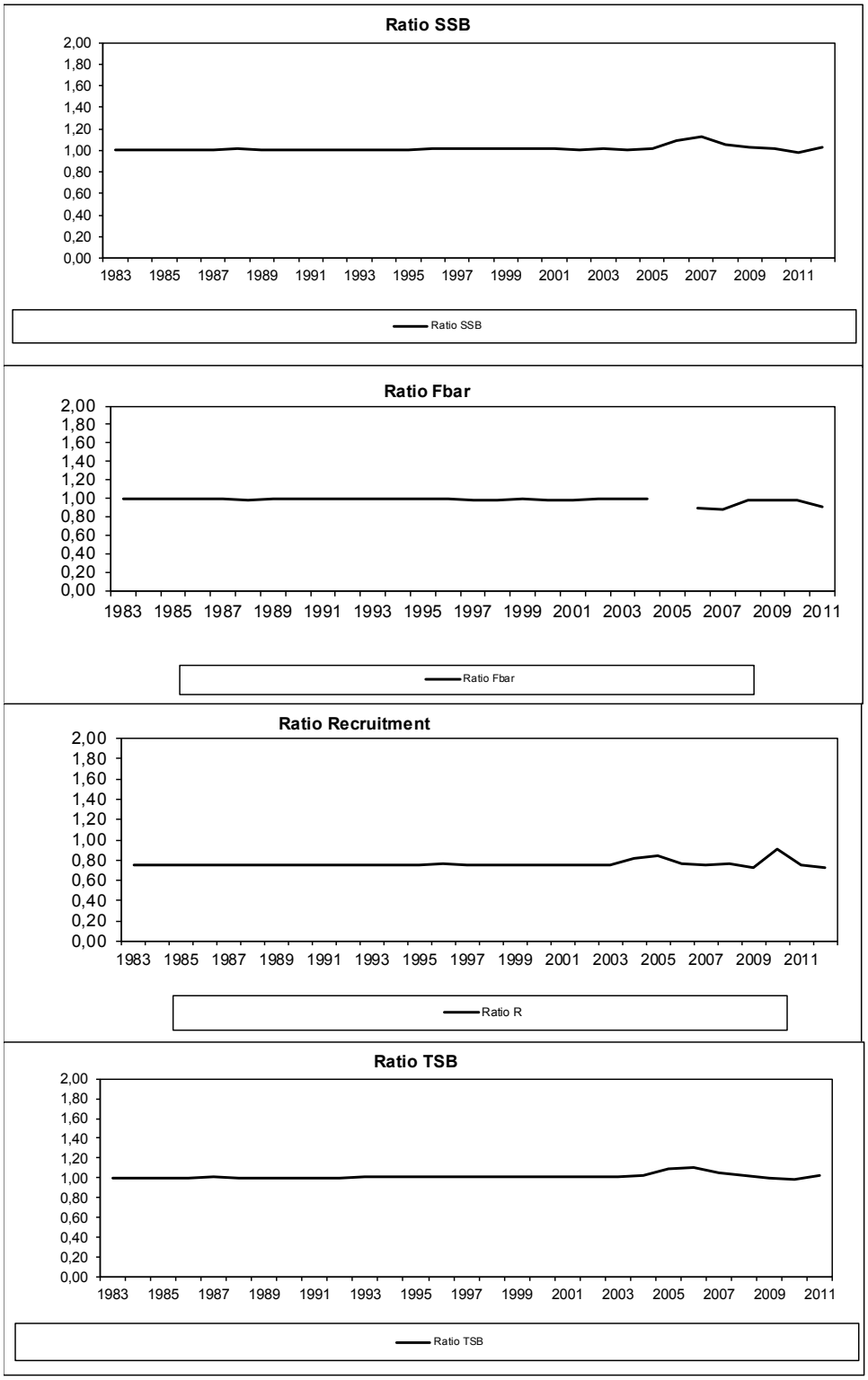


Figure 5.3.6 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2013 SXSA with the September 2012 SXSA based on the new benchmark baseline assessment SXSA May 2012 Scenario 2: Ratios.

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 concerning spawning migration from areas IV and VIIe during the first quarter. However, due to high retrospective patterns appearing in 2012 and hardly reliable Fbar values for the last years, the group investigated the input data and found that catches of age 6 and plus since 2009 were very low and based on very few samples.

Following last year's conclusions, the assessment was then 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 beam trawl 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, where the main fleet segments are the English and Belgian beam trawlers. The Belgian beam trawlers 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. There is only light activity by this fleet between April and September. In 2012, 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 offshore 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. The inshore trawlers and netters are mainly vessels <12 m 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 latter two groups 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 to a value around 30 of the total recently. In 2012, catches were equally distributed among the year (see text table below).

Quarter	Landings	Cum Landings	Cum %
1	1033	1033	29%
2	884	1917	53%
3	760	2677	75%
4	910	3587	100%

However, following the ICES WKFLAT 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 Quarter1 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 1 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.

Belgium beam trawlers are increasingly being equipped with 3D mapping sonar which opens up new areas to fishing (close to wrecks) and very few French vessels have shifted from otter trawl to Danish seine recently (WGFTFB, 2007). These changes are not likely to have modified the fisheries behaviour or affected the data entering into the assessment model.

However the changes in effort distribution of the Belgium Beam Trawler fleet in 2012 with higher effort in the Celtic Sea compared to previous years slightly modified the catch ratios among quarters with lower catches in the first quarter compared to previous years.

6.1.3 ICES advice

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.*

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 100-mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

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. From 1992 to 2002, the landings have remained steady between 5100 t and 6300 t. The 2012 landings of 3587t (2915t attributed to the resident stock and 672t 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 5 years. As usual, France contributed the largest share (55%) of the total VIId landings in 2012 followed by Belgium (29%) and UK (15%) which is nearly unchanged since 2007.

Routine discard monitoring has recently begun following the introduction of the EU data collection regulations.

Discards data for the period 2003-2012 are available from France, Belgium and UK although sampling levels are not high. .

As shown in 2011 report, although the series may appear long enough (2003-2011) , the sampling intensity before 2008 do not allow for using the discards information in the assessment yet.

The time series of discards is currently not long enough to be used in analytical assessment.

Uk, France, Netherland and Belgian have provided data this year under the ICES InterCatch format. And Inter Catch was used to produce the input data.

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 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. Weight for the oldest ages (after 7 years old) overlapped with a 10 plus group. Reducing the plus group to 7 removed this problem due to sampling intensity and based on very few individuals in the

catches. The sampling intensity for this ages that are not frequent in the stock nor in the catches is very low (less than 3% in number after 5 years old).

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 percent and at age four years 96 percent 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

Effort and CPUE data are available from Belgian Beam Trawlers commercial fleets (Figure 6.2.5.1).

The survey series consist of:

UK Beam Trawlers

French Ground Fish Survey

International Young fish survey.

All survey and commercial data available for calibration of the assessment are presented in Tables 6.2.5.1 and Figure 6.2.5.2 and fully described in the Stock Annex. The Belgian beam trawler fleet has been increasing since 1998 due to the absence of restriction on fishing efforts. This effort is decreasing since 2007. However, LPUE has been decreasing for Belgium to its lowest level in 2006 and has slightly increased since then.

6.3 Data analyses

6.3.1 Reviews of last years assessment

The RG last year 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 but will be addressed in the coming years and no later than 2015 where eastern Channel plaice is proposed to be benchmarked.

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 are still observed this year but the timing of the survey can't be changed. These inconsistencies should be addressed during a benchmark and might also be the result of the removals from the first quarter, assumed to be fishes coming in the eastern channel to spawn but period where no survey is conducted.

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. Together with the two surveys covering the entire geographical area of the stock (UK BTS and French GFS). There is a jump in the residuals of the UK BTS in 2000, correlated to the decrease of the SSB that same year and 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. It is important to notice that the three surveys occur in the second half of the year, whereas the period when the most plaice is landed was the first semester. A part of the annual dynamic of the stock seems to be missing in the survey indices.

6.3.5 Final assessment

The settings in the XSA assessment:

Year of assessment:		2012	2013
Assessment model:		XSA	XSA
Assessment software		FLR library	FLR library
Fleets:			
BE Beam Trawlers	Age range	2–5	2–5
UK Beam Trawl Survey	Age range	4–6	4–6
FR Ground Fish Survey	Age range	**2–3**	**2–3**
Intern'l Young Fish Survey	Age range	1	1
Catch/Landings			
Age range:		1–7+	1–7+
Landings data:		1980–2011	1980–2012
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 Recruitment estimates

Considering the truncation of the surveys ages ranges for the XSA agreed during the Benchmark, the recruitment is poorly estimated.

The 2011 year class used for predictions was calculated as the geometric mean recruitment over the period 2000-2010, applying the observed fishing mortality of age 1 in 2012 to get the number of age 2 in 2013.

The 2012 and 2013 year classes were estimated using the average recruitment calculated over the period 2000–2010. The truncation was meant to take into account the relative stability of the recruitment in the recent years at a lower level than at the be-

ginning of the series. The geometric mean was about 12 millions 1-year-old-fish. Year class strength estimates used for short term prognosis are summarized in the text table below.

Year Class	At age in 2011	XSA	GM (99-09)	Accepted estimate
2010	2	8334	**10531**	10531
20011	1	-	**12988**	GM (2000-10)

6.6 Short-term forecasts

The short term prognosis was carried out with FLSTF (FLR package) and following ICES 2012 recommendations. Weight-at-age in the stock and 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. Population number at age 3 and older in 2013 is XSA survivors estimates. Age 1 and 2 are taken from the long term geometric mean (2000-2010).

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 computed as the long term average proportion of catches taken in the area over the total catches (72%).

As landings numbers and XSA survivors in 2013 are computed from the resident population (catches made on fishes from area VIIe and IV are removed), the TAC in VIId and resulting F in intermediate year was also computed to take into account this first quarter removals. The first quarter removal was also estimated as the long term average, and TAC reduced by this average (23%).

TACs for the following 3 years are calculated using $F_{MSY\text{-}proxy}$, assuming that F is at $F_{MSY\text{-}proxy}$ level after 2 years and using the formula provided by ICES 2012:

$$F_{y+1} = (1-\omega)F_{SQ} + \omega F_{MSY-proxy}$$

Where $\omega = \min[\frac{y-Y+1}{n};\ 1]$ ω=0.8

Another management option was tested on the same period. The management option was to set the catches at the level of the average three last years as they've been set the past years.

Input to the short term predictions are presented in Table 6.6.1 and results in Table 6.6.2.1 and 6.6.2.2.

Assuming HCR defined by ICES 2012 implies a catch in 2013 in VIId (including component from IV and VIIe) of 3904t (the agreed TAC is 5342t for both VIId and VIIe) and a catch of 3925t in 2014. It will result in a spawning biomass resident in VIId in 2014 and 2015 of 8392t and 9916t, respectively. $F_{MSY\text{-}proxy}$ is reached by 2015.

Assuming that TAC are fixed at the level of the average of the 3 last years will implies a catch in 2014 of 3904. It will result in a spawning biomass resident in VIId in 2014 and 2015 of 8392t and 9969t, respectively. In 2015 $F_{MSY\text{-}proxy}$ is nearly reached with a Fbar at 0.25.

6.7 Medium-term forecasts

No medium-term forecast is available for this stock.

6.8 Biological reference points

Results from stochastic stock-recruits fits using ADMB CEFAS softwrea for three alternative stock-recruit models were presented in 2012 report. F_{MSY} reference points were selected on the basis of these stochastic age-structured MSY equilibrium analyses. These analyses produced a range of potential estimates given assumptions made on the form of the stock-recruit relationship and considering uncertainty in the estimation of numbers at age and biological (weights at age, maturity and natural mortality) and fishery (selectivity at age) parameters.

Given the large uncertainty around these values. It was decided to choose F_{MSY} estimate based on Beverthon-Holt relationship which gives a value of 0.23. and being in the range of F_{MSY} defined for North Sea Plaice (0.2-0.3)

6.9 Quality of the assessment

The sampling for plaice in VIId are 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 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.

Trends from surveys and commercial fleets are similar before and after 2000. The rescaling of surveys estimates operated in 2000 is consistent with the shift in log q residuals seen for FR GFS and UK BTS, both for plaice and sole in VIId.

6.10 Status of the stock

Fishing mortality and SSB are only given here for trends. F has been decreasing for the last years.

The spawning stock biomass has followed a stepped decline in the last 10 years, following a peak generated by the strong 1996 year class. The SSB staid 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.

6.11 Management considerations

The Spawning Biomass estimated in 2013, corresponding to the spawning biomass resident in VIId is slightly increasing in the recent year. Projections indicate that the SSB will follow the same trend of increase.

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. There exists a directed fishery on plaice occurring in a limited period at the beginning of the year on the spawning grounds. Plaice is mainly taken as by-catch by the demersal fisheries, especially targeting sole.

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 plug group to age 7.

The perception of historical stock trends from UK BTS differs from that of the commercial tuning series. This is interpreted as if the survey would have a full view of the age structure of the stock, whereas the information coming from the commercial series is truncated due to the discarding behaviour. It is also known that plaice undergo spawning and feeding migrations, and one possibility is that the survey fleets are estimating F only in the resident stock, as they are done outside the spawning period, while the commercial fleets operate throughout the year possibly estimating F on an additional migratory component that enters VIId to spawn.

Sources

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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	3839	977	3177	17
2011	3537	1154	2787	21
2012	3587	1033	2915	19

Table 6.2.1.1 - Plaice in VIId. Nominal landings (tonnes) as officially reported to ICES , 1976-2010.

Year	Belgium	Denmark	France	UK(E+W)	Others	Total reported	Un-allocated	Total landings VIId	Quarter1 removal	Total as used by WG (6)	Total landings reported 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	-	3276 (23)	700	+	4830	932	5762	1295	4467	1430	5700
1999	1306	-	3388 (23)	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	1033		2000	460	56	3549	-12	3537	750	2787	1192	4665
2012	955		1962	529	63	3486	-101	3587	672	2915	1339	5092

1 Estimated by the working group from combined Division VIId+e

2 Includes Division VIIe

3 Provisional

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 6.2.2.1. 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

Table 6.2.2.2. Plaice in VIId. Landings in numbers (thousands) by quarter for 2012, not taking into account the first quarter removal.

		1	**2**	**3**	**4**	**5**	**6**	**7+**
Quarter	**1**	0	61	1329	891	292	115	91
	2	0	87	951	765	215	66	46
	3	3	487	819	351	118	56	56
	4	15	403	1109	409	116	45	54

Table 6.2.3.1. Plaice in VIId. Weights in the landings

year	1	2	3	4	5	6	7
1980	0.317	0.320	0.511	0.642	0.806	1.167	1.449
1981	0.235	0.295	0.368	0.457	0.702	0.857	1.054
1982	0.243	0.268	0.350	0.427	0.634	0.788	1.220
1983	0.258	0.287	0.339	0.408	0.526	0.798	1.199
1984	0.216	0.274	0.312	0.373	0.471	0.639	0.873
1985	0.245	0.268	0.290	0.412	0.484	0.550	0.833
1986	0.235	0.318	0.344	0.422	0.568	0.505	0.838
1987	0.253	0.285	0.363	0.481	0.582	0.790	0.979
1988	0.285	0.262	0.314	0.422	0.547	0.642	0.945
1989	0.203	0.271	0.325	0.374	0.478	0.655	1.095
1990	0.213	0.271	0.345	0.400	0.512	0.646	1.114
1991	0.227	0.280	0.314	0.394	0.458	0.561	1.025
1992	0.184	0.280	0.355	0.433	0.514	0.591	0.803
1993	0.218	0.270	0.333	0.428	0.503	0.586	0.858
1994	0.252	0.280	0.299	0.369	0.483	0.597	1.011
1995	0.217	0.269	0.311	0.388	0.482	0.684	0.939
1996	0.231	0.313	0.303	0.414	0.496	0.672	1.128
1997	0.204	0.259	0.306	0.341	0.454	0.592	1.043
1998	0.170	0.260	0.285	0.406	0.535	0.813	1.189
1999	0.207	0.258	0.247	0.322	0.485	0.790	1.153
2000	0.220	0.261	0.278	0.301	0.399	0.613	0.969
2001	0.238	0.279	0.335	0.409	0.494	0.710	1.156
2002	0.249	0.251	0.303	0.368	0.429	0.551	0.829
2003	0.265	0.279	0.282	0.378	0.579	0.670	0.753
2004	0.224	0.251	0.304	0.434	0.509	0.629	0.926
2005	0.219	0.274	0.305	0.375	0.549	0.558	0.849
2006	0.218	0.275	0.332	0.391	0.484	0.638	0.868
2007	0.265	0.316	0.347	0.412	0.510	0.583	0.911
2008	0.262	0.307	0.359	0.434	0.547	0.641	0.940
2009	0.122	0.253	0.307	0.406	0.508	0.639	1.058
2010	0.339	0.307	0.336	0.424	0.466	0.596	0.870
2011	0.256	0.285	0.338	0.446	0.502	0.776	1.263
2012	0.264	0.303	0.341	0.441	0.534	0.733	1.120

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

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

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	

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

BE	CBT								
1981	2012								
1	1	0	1						
2	10								
24,4	217	650	285	35	12	4	4	7	9
29,8	112	615	331	96	31	10	4	2	3
26,4	362	377	666	85	29	11	19	1	1
35,4	70	906	343	241	75	30	17	3	4
33,4	423	649	536	48	110	26	19	3	4
30,8	531	659	321	139	81	30	7	3	4
49,3	1475	946	428	177	52	76	25	15	9
48,9	586	2460	626	122	61	56	22	14	15
43,8	56	1000	1420	501	119	56	37	12	0
38,5	282	1551	935	518	103	22	30	7	9
32,8	452	975	553	561	389	43	22	32	1
30,9	675	595	194	143	157	79	35	33	4
28,2	371	395	132	102	68	37	38	6	12
32,8	322	726	686	138	74	54	45	48	24
31,7	30	341	445	204	46	69	50	14	0
32,6	197	398	261	259	77	23	30	21	28
39,7	0	166	448	293	165	71	22	15	7
23,6	125	520	297	63	22	20	11	10	9
27,6	31	974	657	191	38	13	8	8	8
37	46	213	255	121	24	6	4	6	1
40,2	321	1015	522	363	67	13	6	4	17
41,1	313	785	308	297	77	31	6	3	17
40	309	689	280	74	99	65	15	10	16
39,13	241	767	151	80	27	34	31	7	15
44	227	426	341	123	41	20	21	11	1
56,9	361	509	365	227	44	17	25	22	16
65,1	627	526	349	254	209	52	13	3	25
54,5	565	558	406	158	72	88	7	1	6
49,9	630	630	146	121	68	44	9	1	15
42	674	604	290	113	80	27	11	26	2
41	729	675	187	74	11	2	6	1	4
34.1	76	646	315	119	50	19	17	7	5

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 2013-04-25 09:20:25

CPUE data from indices

Catch data for 33 years. 1980 to 2012. Ages 1 to 7.

   fleet first age last age first year last year alpha beta
1 BE CBT         2        5       1981      2012     0    1
2 UK BTS         4        6       1988      2012   0.5 0.75
3 FR GFS         2        3       1988      2012  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   2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
   year
age  2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
  1 0.054 0.095 0.037 0.059 0.068 0.038 0.034 0.030 0.007 0.035
  2 0.422 0.530 0.401 0.405 0.450 0.407 0.396 0.373 0.224 0.135
  3 1.305 0.751 0.748 0.606 0.608 0.545 0.758 0.621 0.454 0.305
  4 0.921 0.544 0.598 0.665 0.572 0.516 0.628 0.631 0.488 0.534
  5 0.861 0.400 0.494 0.481 0.673 0.397 0.420 0.284 0.426 0.504
  6 0.805 0.871 0.338 0.417 0.437 0.444 0.428 0.369 0.070 0.329
```

7	**0.805**	**0.871**	**0.338**	**0.417**	**0.437**	**0.444**	**0.428**	**0.369**	**0.070**	**0.329**

Table 6.3.5.1. (cont.) Plaice in VIId. XSA diagnostics

```
XSA population number ( NA )

XSA population number ( NA )
      age
year       1     2     3    4    5   6    7
  2003 12959 13174  6331 2160  497 501  621
  2004 11234 11111  7813 1554  778 190  431
  2005  9351  9245  5917 3338  816 472  762
  2006  9322  8153  5599 2535 1660 450  619
  2007 12635  7951  4919 2763 1179 928  458
  2008 10189 10681  4588 2423 1410 544  626
  2009 14893  8877  6431 2406 1308 858  857
  2010 21054 13027  5407 2728 1162 778  946
  2011  9280 18485  8120 2630 1313 792 1492
  2012   532  8334 13363 4667 1461 776  705

 Estimated population abundance at 1st Jan  2013
      age
year   1   2     3       4        5       6     7
2013  1   465  6591 8910 2475 799 505


 Fleet:  BE CBT

 Log catchability residuals.
```

	year								
age	1981	1982	1983	1984	1985	1986	1987	1988	1989
2	-0.083	-0.169	0.425	-1.322	0.370	0.475	0.312	-0.003	-2.039
3	0.372	-0.301	0.133	0.076	-0.035	0.057	-0.403	-0.099	-0.405
4	0.502	0.123	0.381	0.282	0.196	-0.151	-0.292	-0.419	-0.010
5	-0.089	0.172	-0.225	0.042	-0.773	-0.022	-0.371	-0.726	0.342

age	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.293	0.916	1.198	0.391	0.844	-1.760	-0.298	0.000	-0.946
3	0.495	0.892	0.625	-0.088	0.159	0.129	-0.078	-1.486	-0.271
4	-0.034	0.237	-0.015	-0.235	0.773	0.243	0.285	0.596	0.295
5	-0.044	0.299	-0.180	0.138	0.460	0.455	0.554	1.378	0.599

age	1999	2000	2001	2002	2003	2004	2005	2006	2007
2	-1.513	-1.476	0.335	0.247	0.127	0.121	0.070	0.403	0.866
3	0.013	-0.891	0.940	0.493	0.543	0.236	-0.194	-0.278	-0.250
4	0.480	-1.086	0.234	0.519	0.219	-0.209	-0.252	-0.137	-0.443
5	0.745	-0.414	-0.054	0.521	0.301	-0.256	0.060	-0.304	0.102

age	2008	2009	2010	2011	2012
2	0.625	1.002	0.847	0.530	-0.789
3	0.028	-0.007	0.238	-0.108	-0.535
4	-0.008	-0.888	-0.151	-0.593	-0.442
5	-0.497	-0.592	-0.433	-0.888	-0.300

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	-7.3197	-5.8283	-5.4843	-5.4516
S.E_Logq	0.8518	0.4808	0.4238	0.4925

Fleet: UK BTS

Log catchability residuals.

year									
age	1988	1989	1990	1991	1992	1993	1994	1995	1996
4	-0.285	0.260	-0.590	-0.134	0.329	-0.530	0.231	-0.345	-1.410
5	0.459	-0.265	-0.034	-0.292	0.584	0.049	0.297	-0.423	-0.630
6	0.113	0.106	0.045	0.004	0.185	-0.048	-0.037	-0.039	-0.115

year									
age	1997	1998	1999	2000	2001	2002	2003	2004	2005
4	-1.410	-0.303	-0.768	0.364	0.340	0.614	0.118	0.373	0.750
5	-1.018	-0.921	-0.557	0.233	0.699	-0.189	0.774	-0.535	0.646
6	-0.449	-0.055	-0.060	0.060	0.170	0.201	0.038	-0.338	0.214

age	2006	2007	2008	2009	2010	2011	2012
4	-0.072	-0.048	-0.214	0.504	0.826	0.817	0.584
5	-0.182	-0.145	-0.194	0.226	0.196	0.965	0.257
6	-0.095	0.110	0.050	0.278	0.193	0.377	-0.001

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	-6.0957	-5.9152	-5.9152
S.E_Logq	0.6149	0.5256	0.1790

Fleet: FR GFS

Log catchability residuals.

year									
age	1988	1989	1990	1991	1992	1993	1994	1995	1996
2	0.186	-0.485	-1.696	-1.000	-0.672	-0.098	-0.738	-0.718	-1.291
3	0.044	-0.893	-0.421	-0.847	0.170	0.392	-1.363	-0.412	-2.078

year									
age	1997	1998	1999	2000	2001	2002	2003	2004	2005
2	-0.481	-0.189	-0.397	0.940	-0.612	0.026	0.203	0.456	0.816
3	0.359	-0.500	0.271	0.271	-0.284	0.656	-0.014	0.535	1.224

year							
age	2006	2007	2008	2009	2010	2011	2012
2	0.719	0.643	1.113	0.335	0.739	0.629	1.571
3	0.574	0.651	0.301	-0.180	-0.021	0.344	1.222

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	-6.9916	-7.2524
S.E_Logq	0.8068	0.7509

Fleet: IN YFS

Log catchability residuals.

	year								
age	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.199	0.315	0.066	0.038	-0.255	0.574	0.508	0.249	0.652

age	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.441	-0.495	0.472	0.167	-0.275	0.136	0.216	-1.137	0.393

age	2005	2006
1	-0.983	-0.398

```
 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                1
Mean_Logq -9.8463
S.E_Logq   0.4966

 Terminal year survivor and F summaries:

 Age 1 Year class = 2011

source
survivors         N scaledWts
      465         1         1

 Age 2 Year class = 2010

source
       survivors N scaledWts
BE CBT      2994 1     0.330
FR GFS     31717 1     0.377
fshk        2114 1     0.292

 Age 3 Year class = 2009

source
       survivors N scaledWts
BE CBT      6442 2     0.552
FR GFS     23730 2     0.305
fshk        3873 1     0.143

 Age 4 Year class = 2008

source
       survivors N scaledWts
BE CBT      1919 3     0.591
UK BTS      4440 1     0.174
FR GFS      4046 2     0.118
fshk        2278 1     0.117

 Age 5 Year class = 2007

source
       survivors N scaledWts
BE CBT       602 4     0.542
UK BTS      1229 2     0.304
FR GFS       892 2     0.054
fshk         943 1     0.100

 Age 6 Year class = 2006

source
       survivors N scaledWts
BE CBT       314 4     0.248
UK BTS       620 3     0.667
FR GFS       677 2     0.020
fshk         347 1     0.065
```

Table 6.3.5.2. Plaice in VIId. Fishing mortality (F) at age

Plaice in VIId (run: XSAAEDB01/X01) : harvest
2013-04-25 09:20:26 units= f age

year	1	2	3	4	5	6	7
1980	0.003	0.210	0.316	0.535	0.909	0.589	0.589
1981	0.002	0.148	0.814	0.952	0.533	0.770	0.770
1982	0.016	0.184	0.544	0.946	0.801	0.818	0.818
1983	0.007	0.198	0.561	0.965	0.661	0.519	0.519
1984	0.020	0.148	0.677	1.085	0.823	0.911	0.911
1985	0.007	0.384	0.676	1.041	0.376	0.627	0.627
1986	0.017	0.267	0.765	0.849	0.905	1.178	1.178
1987	0.001	0.228	0.574	0.840	0.692	0.662	0.662
1988	0.001	0.244	0.744	0.707	0.620	0.652	0.652
1989	0.076	0.218	0.463	0.811	0.942	0.697	0.697
1990	0.125	0.282	0.784	0.669	0.733	0.740	0.740
1991	0.103	0.626	0.984	0.957	0.549	0.825	0.825
1992	0.085	0.553	0.950	0.760	0.612	0.429	0.429
1993	0.080	0.503	0.548	0.597	0.492	0.464	0.464
1994	0.103	0.506	0.811	0.905	0.918	0.794	0.794
1995	0.150	0.461	0.680	0.747	0.645	0.595	0.595
1996	0.053	0.350	0.600	0.722	0.900	0.763	0.763
1997	0.022	0.226	0.851	1.580	1.689	1.948	1.948
1998	0.048	0.190	0.660	1.025	1.066	1.008	1.008
1999	0.057	0.211	0.771	1.282	0.917	1.228	1.228
2000	0.113	0.734	0.564	0.791	0.655	0.442	0.442
2001	0.189	0.416	0.868	0.550	0.567	0.322	0.322
2002	0.063	0.562	1.014	1.285	1.154	0.520	0.520
2003	0.054	0.422	1.305	0.921	0.861	0.805	0.805
2004	0.095	0.530	0.751	0.544	0.400	0.871	0.871
2005	0.037	0.401	0.748	0.598	0.494	0.338	0.338
2006	0.059	0.405	0.606	0.665	0.481	0.417	0.417
2007	0.068	0.450	0.608	0.572	0.673	0.437	0.437
2008	0.038	0.407	0.545	0.516	0.397	0.444	0.444
2009	0.034	0.396	0.758	0.628	0.420	0.428	0.428
2010	0.030	0.373	0.621	0.631	0.284	0.369	0.369
2011	0.007	0.224	0.454	0.488	0.426	0.070	0.070
2012	0.035	0.135	0.305	0.534	0.504	0.329	0.329

Table 6.3.5.3. Plaice in VIId. Stock number at age

Plaice in VIId (run: XSAAEDB01/X01) : stock.n
2013-04-25 09:20:26 units= NA
age

year	1	2	3	4	5	6	7
1980	18252	12972	4180	921	571	119	312
1981	8548	16464	9516	2758	488	208	462
1982	17551	7719	12842	3815	963	259	334
1983	14025	15628	5814	6745	1341	391	554
1984	18761	12603	11595	3003	2326	626	545
1985	21538	16643	9831	5333	918	924	673
1986	43579	19353	10258	4524	1704	570	371
1987	23753	38786	13407	4318	1752	623	1106
1988	19089	21469	27953	6832	1687	793	1224
1989	11844	17257	15215	12017	3050	821	1035
1990	14641	9931	12558	8667	4830	1076	1143
1991	16594	11696	6779	5190	4018	2101	797
1992	21501	13548	5658	2292	1804	2100	2235
1993	10168	17871	7055	1979	970	885	1638
1994	13374	8497	9779	3690	986	537	1488
1995	19564	10920	4635	3931	1350	356	1380
1996	22617	15236	6233	2124	1685	641	1144
1997	26747	19400	9713	3095	933	620	871
1998	10345	23678	14009	3754	577	156	475
1999	14102	8919	17726	6554	1218	180	328
2000	13633	12055	6533	7417	1645	441	415
2001	16384	11021	5233	3365	3043	773	553
2002	15508	12274	6578	1988	1757	1561	742
2003	12959	13174	6331	2160	497	501	621
2004	11234	11111	7813	1554	778	190	431
2005	9351	9245	5917	3338	816	472	762
2006	9322	8153	5599	2535	1660	450	619
2007	12635	7951	4919	2763	1179	928	458
2008	10189	10681	4588	2423	1410	544	626
2009	14893	8877	6431	2406	1308	858	857
2010	21054	13027	5407	2728	1162	778	946
2011	9280	18485	8120	2630	1313	792	1492
2012	532	8334	13363	4667	1461	776	705

Table 6.3.5.4. Plaice in VIId. Summary table

	recruitment	ssb	catch	landings	tsb	fbar3-6	Y/ssb
1980	18252	3170	2060	2060	10922	0.587	0.65
1981	8548	4027	3706	3706	9453	0.767	0.92
1982	17551	4752	3781	3781	9881	0.777	0.80
1983	14025	5108	3919	3919	9903	0.676	0.77
1984	18761	4491	4010	4010	9178	0.874	0.89
1985	21538	4978	4680	4680	10477	0.680	0.94
1986	43579	5700	5311	5311	15049	0.924	0.93
1987	23753	8475	6502	6502	21708	0.692	0.77
1988	19089	8537	8098	8098	16636	0.681	0.95
1989	11844	9049	6807	6807	14313	0.728	0.75
1990	14641	9480	7031	7031	14686	0.731	0.74
1991	16594	6303	6072	6072	11799	0.829	0.96
1992	21501	5998	4925	4925	11598	0.688	0.82
1993	10168	4665	4143	4143	10694	0.525	0.89
1994	13374	4786	4757	4757	9740	0.857	0.99
1995	19564	4487	3987	3987	9977	0.667	0.89
1996	22617	4068	4191	4191	11860	0.746	1.03
1997	26747	4200	4872	4872	10310	1.517	1.16
1998	10345	4873	4467	4467	11556	0.940	0.92
1999	14102	5375	4951	4951	9561	1.050	0.92
2000	13633	4004	4294	4294	7516	0.613	1.07
2001	16384	4515	4083	4083	8687	0.577	0.90
2002	15508	4374	4256	4256	9004	0.993	0.97
2003	12959	2780	3665	3665	7023	0.973	1.32
2004	11234	2863	3183	3183	7533	0.641	1.11
2005	9351	3287	2722	2722	6554	0.544	0.83
2006	9322	3283	2643	2643	6477	0.542	0.81
2007	12635	3132	2889	2889	6874	0.573	0.92
2008	10189	3175	2763	2763	7699	0.476	0.87
2009	14893	3936	2889	2889	6505	0.558	0.73
2010	21054	3748	3204	3204	7240	0.476	0.85
2011	9280	5831	2787	2787	13102	0.359	0.48
2012	532	5918	2916	2916	9535	0.418	0.49

Table 6.6.1. Plaice in VIId. Input to catch forecast

Age	Stock	Mat	M	F
1	12988	0	0,1	0,03
2	10531	0,15	0,1	0,1
3	13363	0,53	0,1	0,31
4	4667	0,96	0,1	0,53
5	1461	1	0,1	0,50
6	776	1	0,1	0,33
7	705	1	0,1	0,33

Table 6.6.2.1 Plaice in VIId. Management option table following ICES 2012 recomendations

year	2013	2014	2015
landings with Q1 removal	3000	3016	2706
Total landings VIId (including component from IV and VIIe)	3904	3925	3522
Fbar	0,29	0,28	0,23
ssb	7394	8392	9916
Changes in TAC	-	1%	-11%
Changes in SSB	25%	13%	18%

Table 6.6.2.2 Plaice in VIId. Management option table (TAC = average landings for 3 past years)

year	2013	2014	2015
landings with Q1 removal	3000	2958	2979
Total landings VIId (including component from IV and VIIe)	3904	3849	3877
Fbar	0,29	0,27	0,25
ssb	7394	8392	9969
Changes in TAC	-	-1%	1%
Changes in SSB	25%	13%	19%

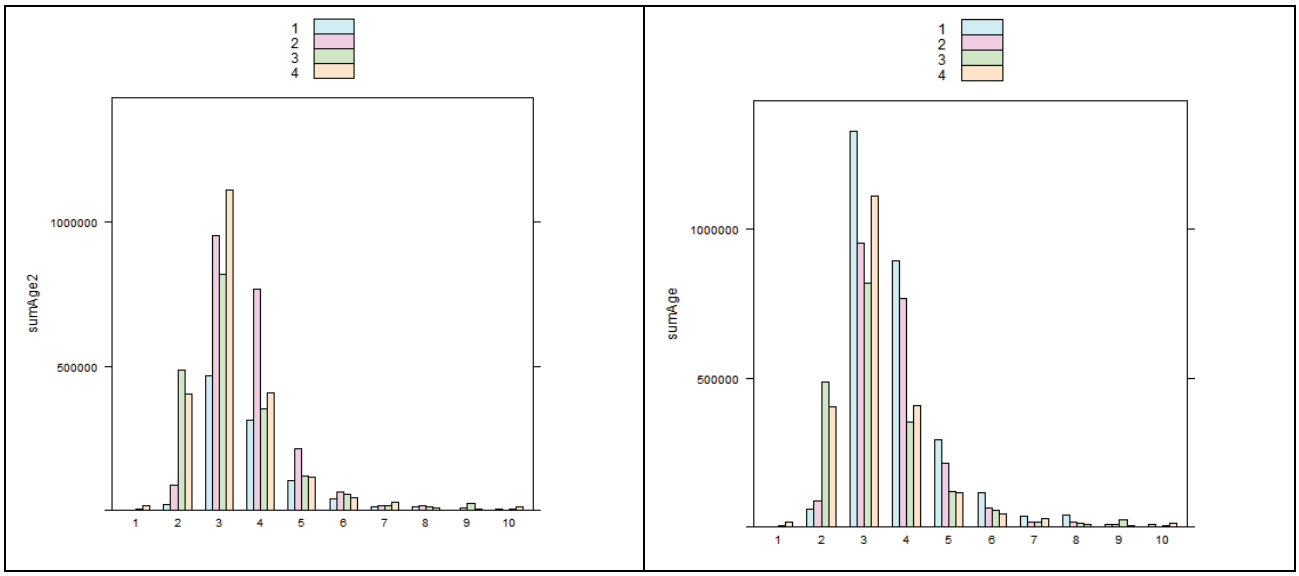


Figure 6.1.2.1. Plaice in VIId. 2012 Age distribution in the landings per quarter, after Q1 removals (left panel) and total landings from VIId (right panel).

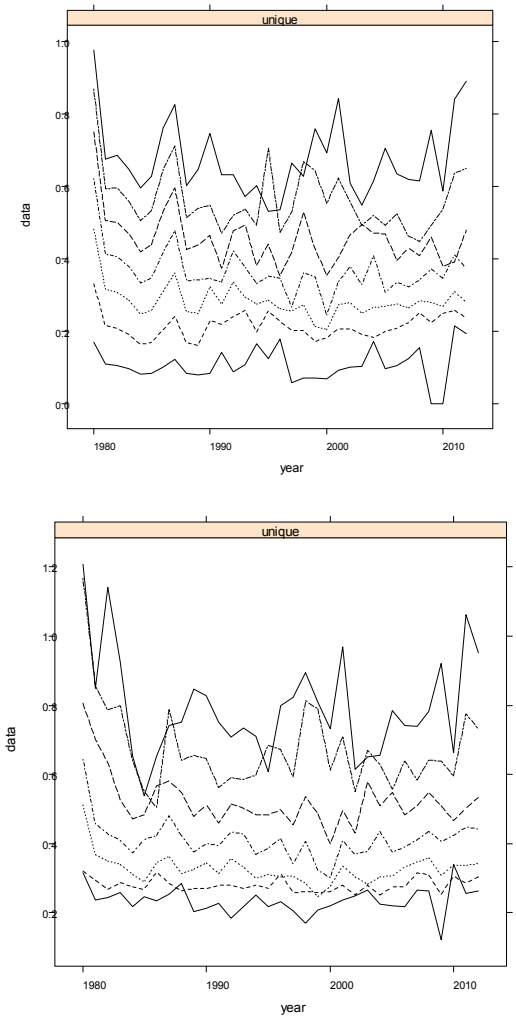


Figure 6.2.3.1. Plaice in VIId. Stock(left panel) and Catch weight (right panel)

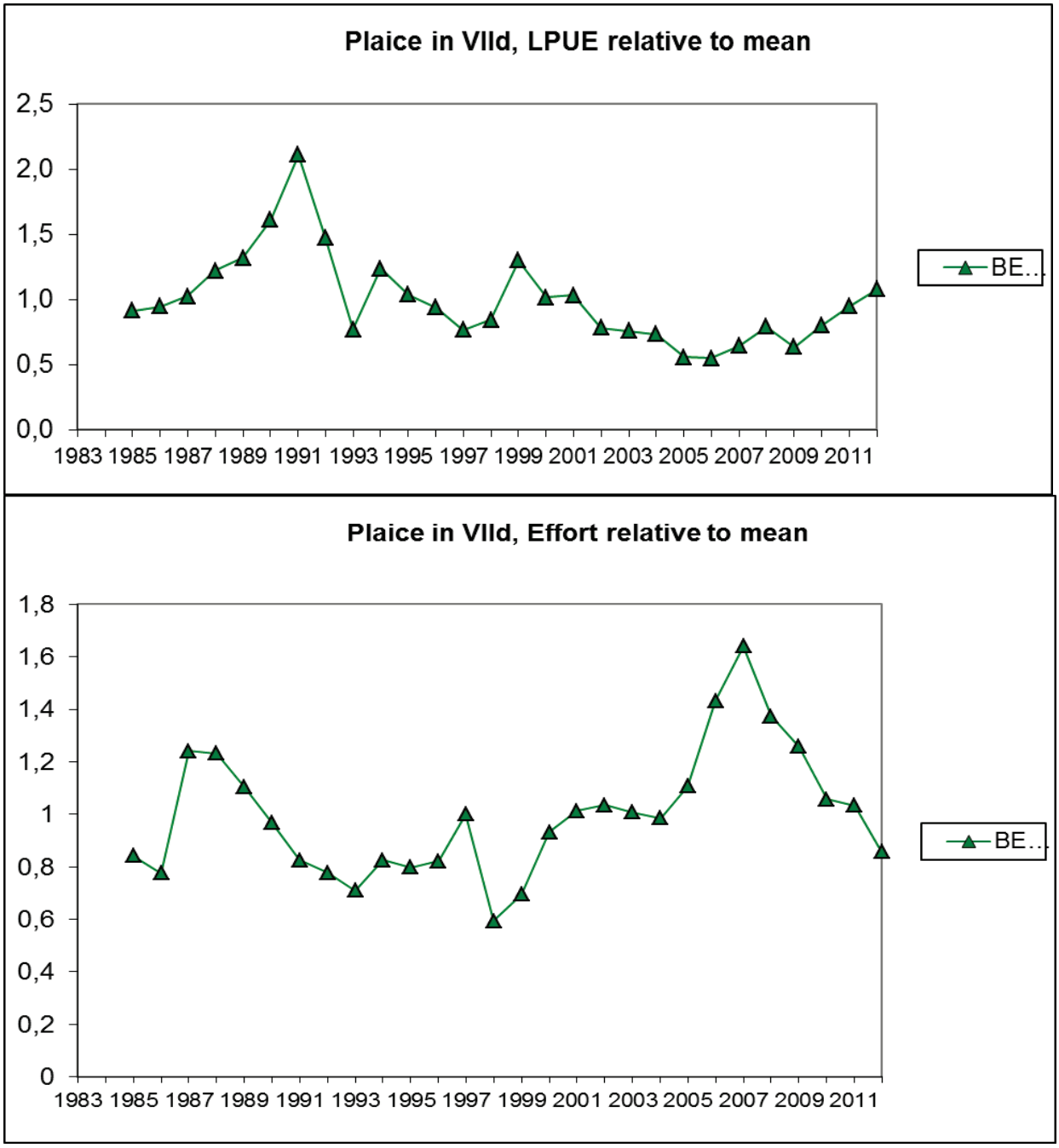


Figure 6.2.5.1 - Plaice in VIId. LPUE and effort

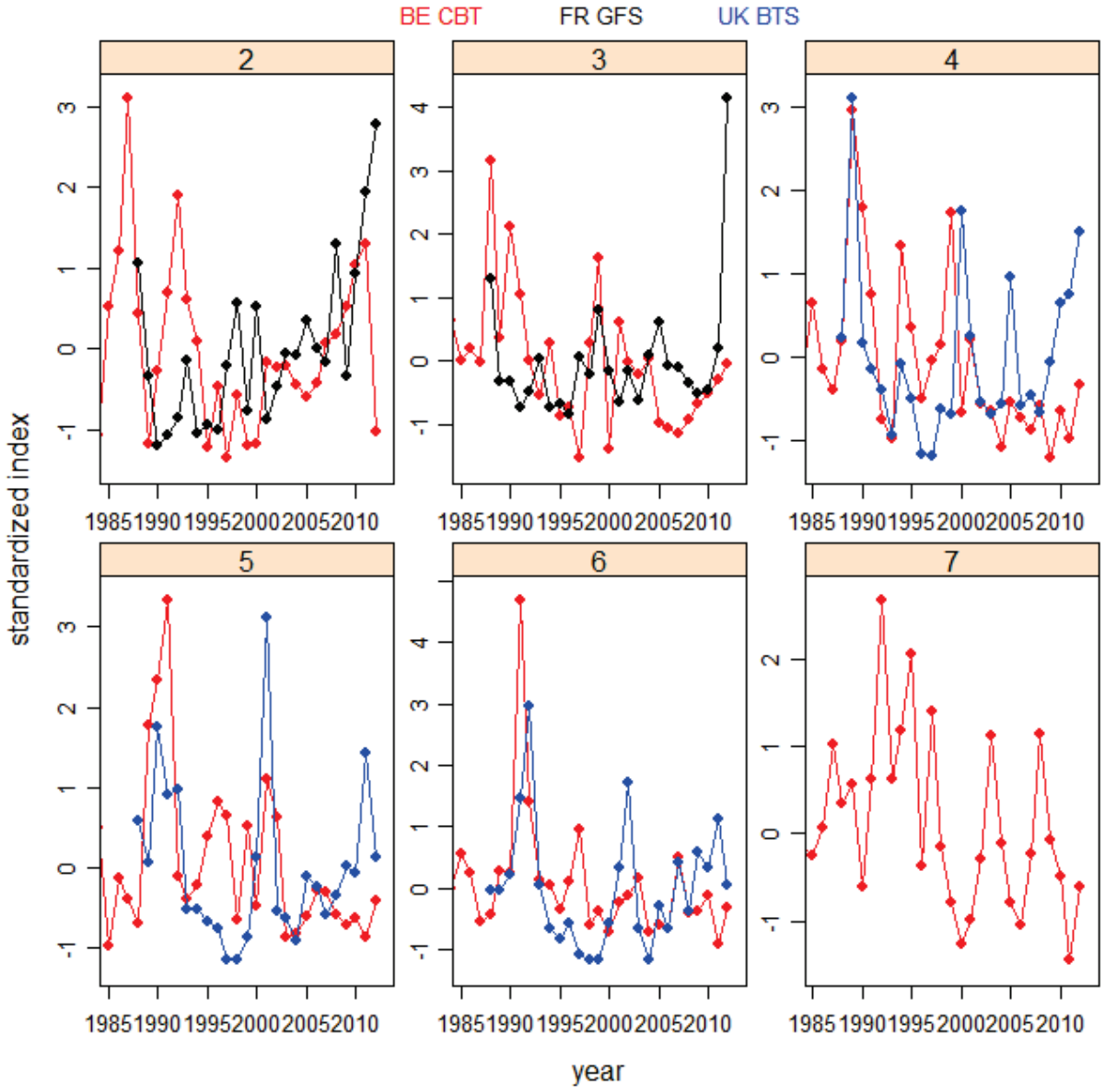


Figure 6.2.5.2. Plaice in VIId. Between survey consistency. Mean standardised indices by surveys for each age

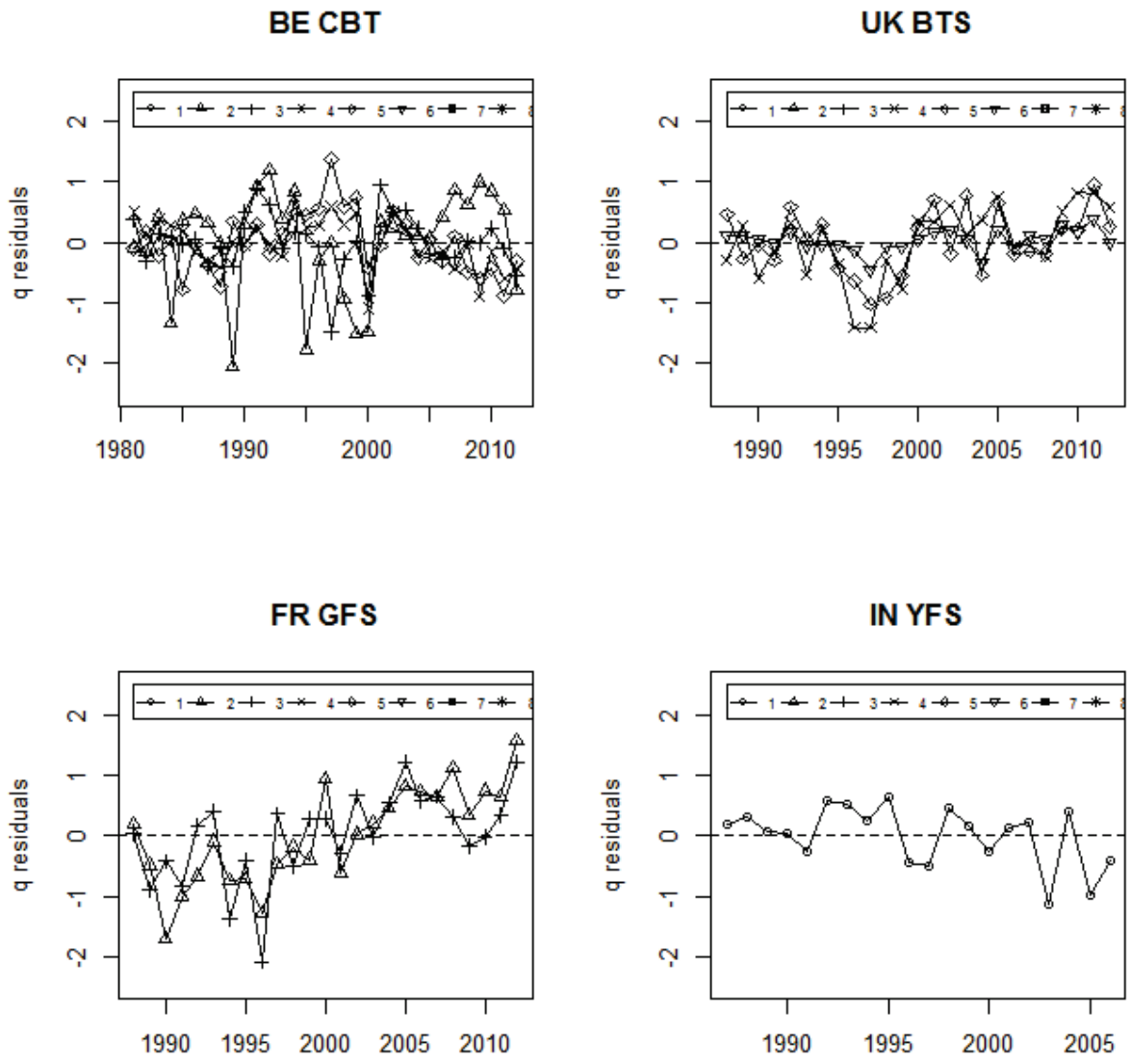


Figure 6.3.2.2. Plaice in VIId. Log q residuals for the single fleet runs (XSA settings and F shrinkage = 1.0)

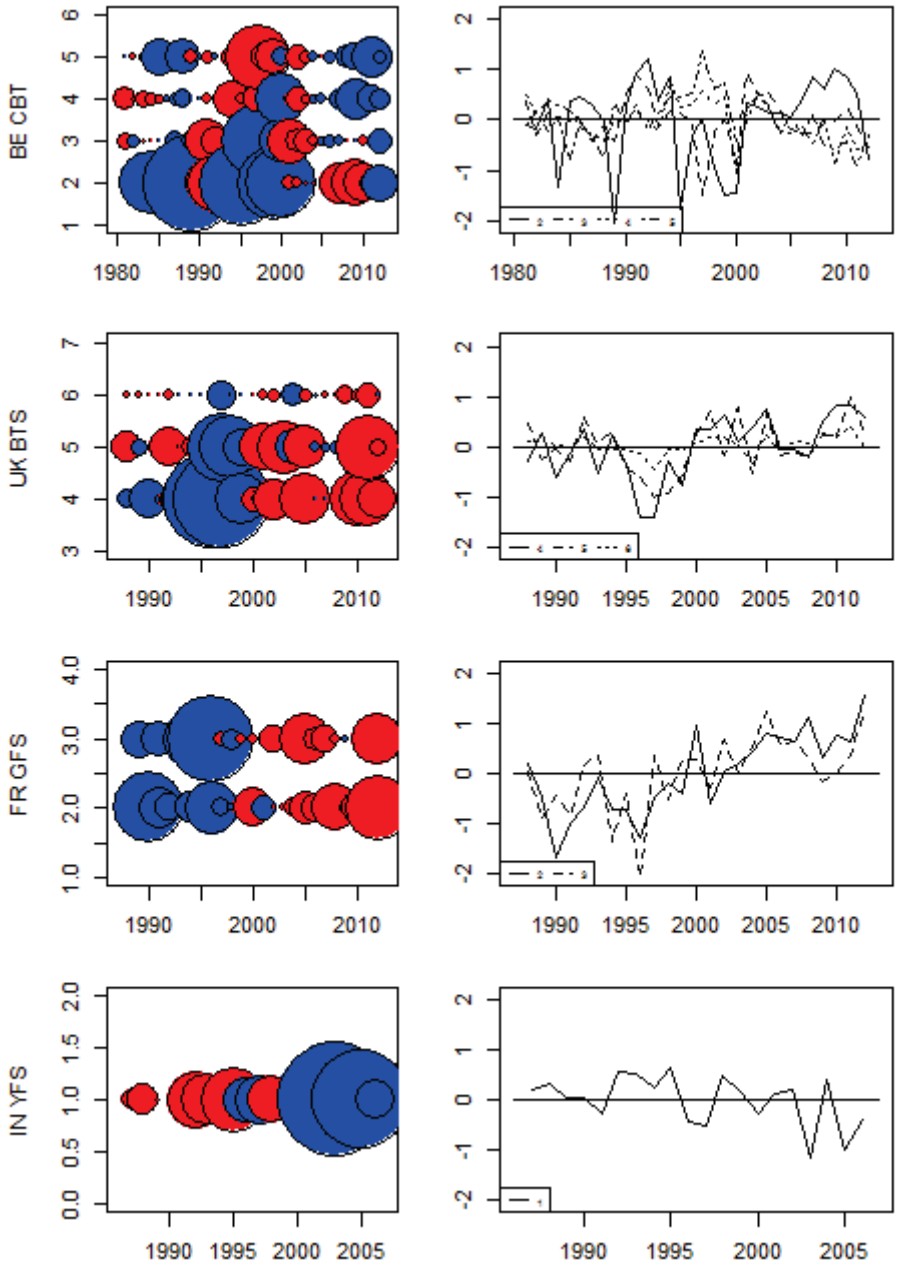


Figure 6.3.2.3. Plaice in VIId. Log q residuals. All fleets combined. Settings as proposed section 6.3.5.

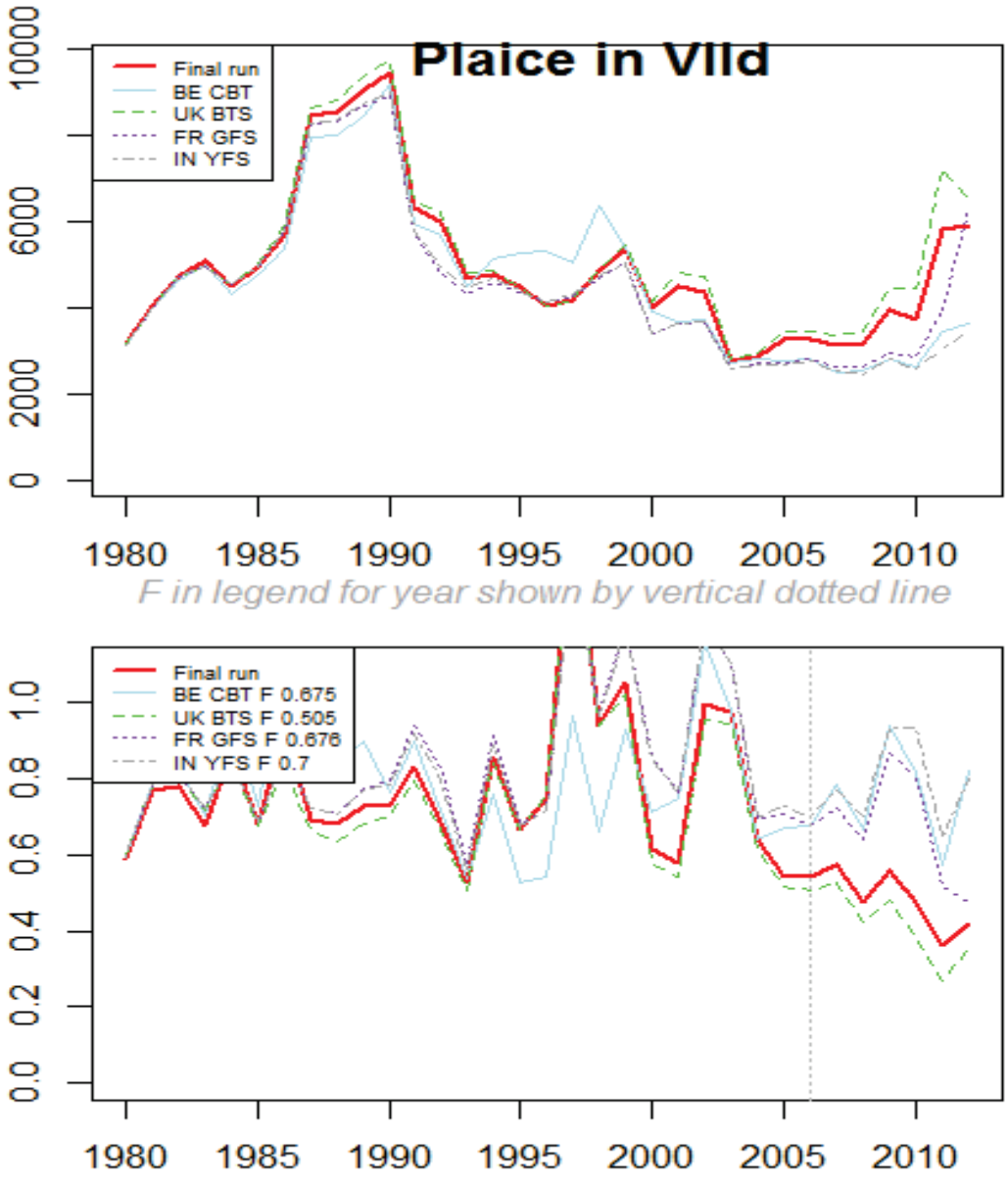


Figure 6.3.4.1. Plaice in VIId. Individual fleet historical performance.

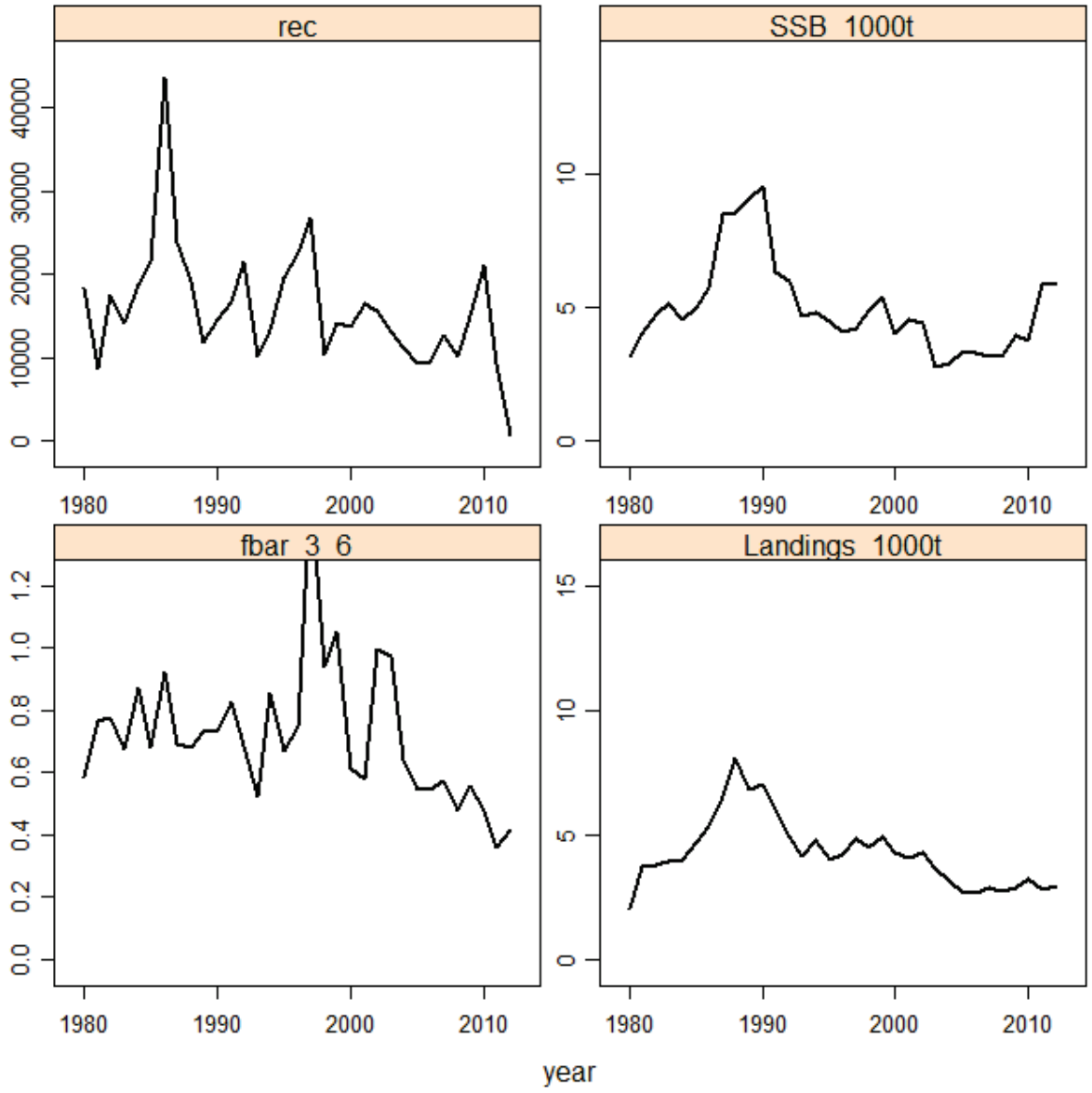


Figure 6.3.5.1. Plaice in VIId. Summary of assessment results

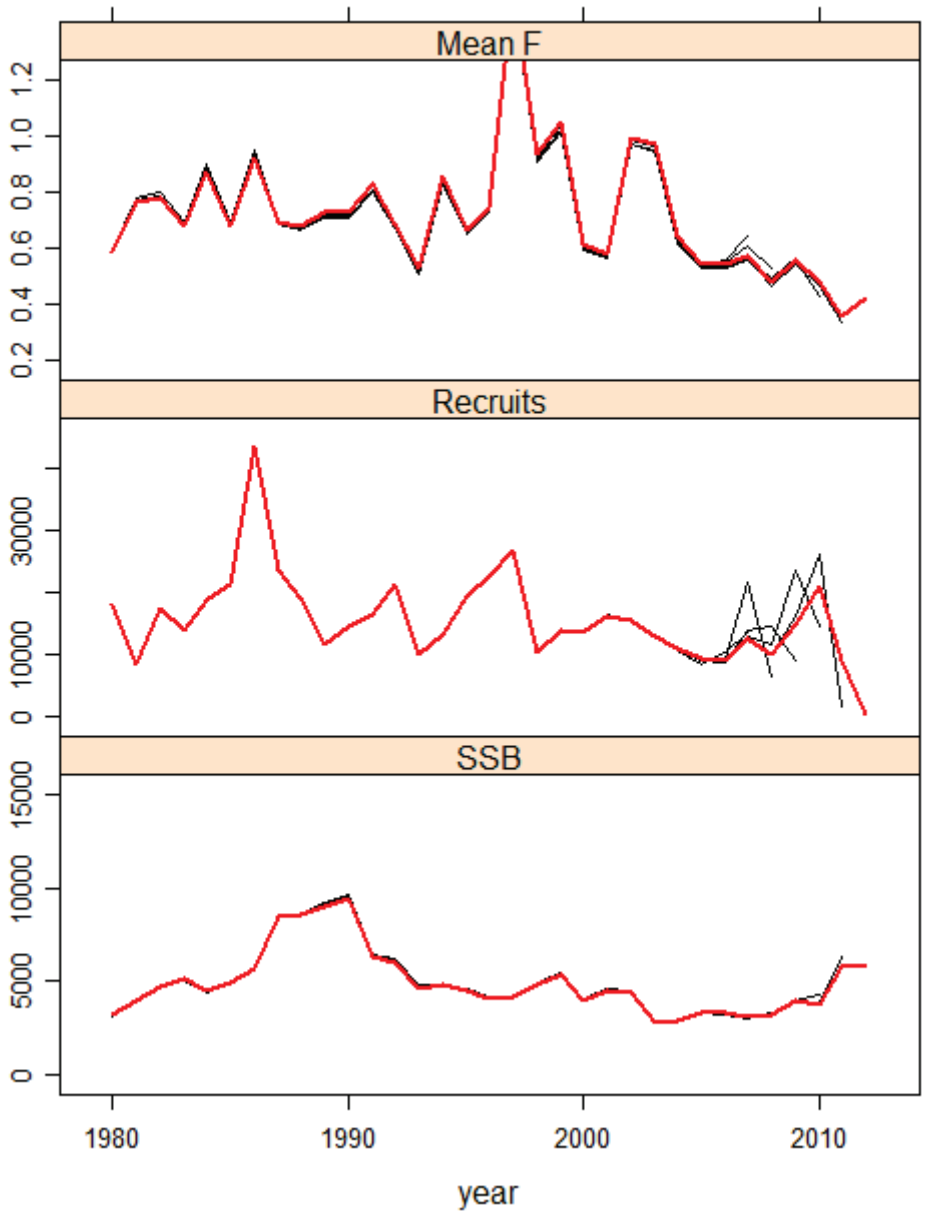


Figure 6.3.5.2. Plaice in VIId. Retrospective patterns for the final run

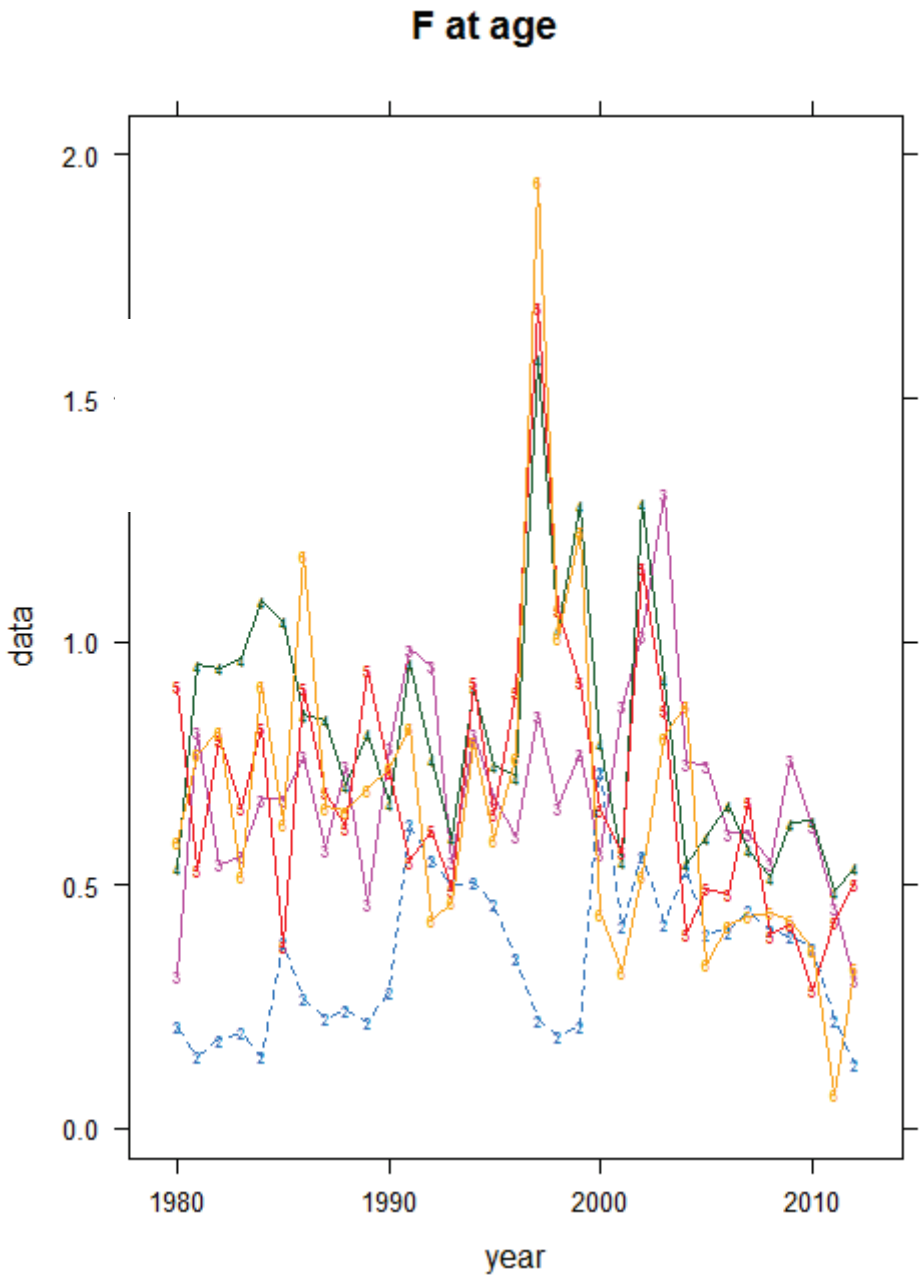


Figure 6.6.1 Plaice in VIId. Exploitation patterns over the last 6 years

7 Plaice in Skagerrak (IIIaN)

Significant changes have been provided to the assessment of this stock in 2012. Before then, ICES 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.

A dedicated workshop was convened in early March 2012 (ICES WKPESTO 2012) to address these issues more specifically, following the recommendations from ICES WKFLAT 2010. WKPESTO provided an overview of the distribution and linkages between the various plaice populations in the North Sea region and adjacent areas, and concluded that the collected information on biology and fishery of plaice in IIIa and adjacent waters suggested for changes in assessment units as well as in management areas. WKPESTO considered plaice in Skagerrak (Division 20) to be closely associated with plaice in the North Sea, and proposed to include this area in the North Sea plaice stock assessment, although it was also recognized that local populations are present in the area and should be monitored. WKPESTO explored also the possibilities for combined or disaggregated assessments of current defined stocks. In particular, WKPESTO considered plaice in Kattegat (Division 21), the Belts (Div. 22) and the Sound (Div 23) as one stock unit and proposed it to be assessed as such.

Last year, WGNSSK 2012 produced both the old setup (combined assessment Skagerrak-Kattegat) and the new setups (Kattegat, 22 and 23 assessment and North Sea-Skagerrak assessment, section 18). In addition, an answer to an EU-Norway request dealing with management options for Skagerrak plaice was also produced (ICES 2012). The new setup was accepted as the basis of the 2012 advice, and the TAC for 2013 was consequently de-coupled between Kattegat and Skagerrak.

In 2013, ICES does not present the combined IIIa assessment, but only the considerations specific to Plaice in Skagerrak. The Plaice Kattegat-SD22-23 assessment is now part of the WGBFAS. As a consequence, this section has been largely rewritten and differs substantially from the previous year's report.

As the methodological approach to this stock is still under ongoing 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 at the latest during the benchmark scheduled for 2015.

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 (2012)[1], although results are presented aggregated for the annex IIa-Area 3b of the North Sea cod area, i.e. including North Sea (IV), Skagerrak (IIIaN) and Eastern Channel (VIId)

In 2012, 20% of the plaice landings in Skagerrak came from Fully Documented Fisheries, 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 could form the basis of an interim management plan[2]. The 2013 ICES advice sheet for Skagerrak plaice has included considerations for this.

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.

7.1.3 Management

There are no explicit management objectives for this stock. However as noted above, EU and Norway are considering options for an interim management plan for plaice in Skagerrak, on the basis of the putative linkages between this stock and North Sea Plaice.

In 2011, The TAC had been decreased by 15% compared to 2010, to 9 938 t (7 950 t in Skagerrak and 1 988 t for Kattegat), following the EC Policy Paper (COM(2010) 241), This corresponded to the level of landings in 2010. (Table 7.1.4).

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[1] http://stecf.jrc.ec.europa.eu/documents/43805/394916/12-11_STECF+12-16+-+Evaluation+of+Fishing+Effort+Regimes+pII_JRC76738.pdf

and http://stecf.jrc.ec.europa.eu/data-reports

[2] http://nsrac.org/reports/meetings-c/skwg/skagerrak-and-kattegat-working-group-16th-april-2013-copenhagen/

In 2012, the TAC was rolled over to the same level as 2011. In 2013, the TAC for Skagerrak was decoupled from the TAC in Kattegat for the first time. The TAC was increased by 15% compared to 2012, on the basis of the increasing stock and TAC in the neighbouring North Sea.

Since 2010 the TAC uptake has been 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 and Kattegat until 2011. Official statistics for Skagerrak are only available for 2012. 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 (96% in 2012).

Previously, misreporting had been considered to potentially occur in the area between the North Sea and the Skagerrak, and notably in the ICES rectangle 43F8 which is shared between both areas and represents a large part of the landings (Figure 7.2.1). However, extensive checks using VMS data (for vessels >15m) and investigation of departure harbour for the vessels <15m showed that no obvious pattern of misreporting could be detected, and that only minor mismatch occurred between VMS and logbooks information (ICES WGNSSK 2011, ICES WKPESTO 2012). In 2012, the fishing pattern moved slightly away from that boundary rectangle towards the more central Skagerrak.

As in previous years, InterCatch was used to raise catch-at-age information. This year, as last year, information was provided by DCF metier as specified in the data call (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 age composition was available summed up to more than 95% of all landings weight. (Figure 7.2.2). There are almost no landings from age 1 plaice, and generally poor tracking of the cohorts (Figure 7.2.3).

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).

However, 2012 discards data were worked out separately for the two areas. InterCatch discards raising in bulk weight was applied separately to the third largest metier (FDF Danish seine), using the discards ratio from the non-FDF seiners (12%). Missing discards data for the other metiers were raised 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 discards age composition was applied to all unsampled strata.

2012 discards were estimated at 1025 tonnes, corresponding to a discards ratio to landings of 13.4 % (=12% ratio of discards to catches). 70% of this discards estimates come from sampled strata, and 30% from the raising to unsampled strata.

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). This is considered as the main cause of the lack of year class signal in the catch-at-age matrix.

7.2.3 Maturity and natural mortality

Not estimated

7.2.4 Catch, effort and research vessel data

In 2013, landings and effort data by gear were computed at the level of the ICES rectangle. 2011 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". 2012 data from Sweden, Denmark and Germany were added in the same format. (Figure 7.2.1).

Additionally, ICES (2012) and Ulrich et al. (2013) considered that the area IIIa should b split in various spatial components with potentially different stock origins (Figure 7.2.4). Since 2010, nearly all catches have been taken in the Western area, 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 7.2.5). Skagerrak landings amount to around 10% of North Sea landings.

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. No improvements have been brought to this yet, but the issue is still being considered.

7.3 Data analyses

7.3.1 Comments from the technical review group 2012

General comments

The recommendation to redefine the stock structure is based on extensive work by the WKPESTO which reviewed all of the available information. This yet to be approved plaice stock represents a divergence from the traditional stock structure where IIIaW is not considered part of the traditional Division IIIa complex. Not having been involved in the discussions, the review group has taken the approach to review the documentation provided for each of the Plaice stock definitions and await the decision on which stock structure is accepted.

Technical comments

The report implies that it is unlikely there will be an independent assessment for IIIaW (Skagerrak) and there is inadequate survey coverage of the area. Commercial CPUE will be used as a proxy for the western Skagerrak and IBTS for the eastern.

Suggestion to using an updated version of the spatially explicit abundance indices of adult aggregations Cardinale *et al*. (2011) as an alternative to the commercial LPUE. This would provide new indices for the Division IIIa sub-populations and possibly eliminate the need for commercial LPUE.

Under the new assessment the IIIaW would be lumped in with the North Sea assessment with increased catches leading to an increase in stock biomass. This is a scaling factor with trends very similar.

Based on the NSRAC rules the West of Skagerrak TAC could increase or be rolled over as it appears to be increasing or stable and the NS is above Btrigger and rising.

Conclusions

The RG agrees with the WG conclusions on the technical aspects of the assessment for this stock. Given the recent stock affinity review and the influence of the North Sea on the Skagerrak, an analytical assessment on a single stock in area IIIa is likely not appropriate. This partitioning represents one feasible option.

7.3.2 Catch-at-age matrix

The Landings-at-age matrix is shown on the figure 7.2.3. The matrix shows clearly a limited ability to track down the cohorts over time in the Skagerrak. Weight at age has been increasing over the decade for the main ages.

7.3.3 Tuning series

Catches trends in fishing patterns by the main gear groups across areas were computed (Figure 7.3.1). 2012 lpue for the main fishery (TR1 in Western Skagerrak, 81% of total landings for the stock in 2012) have remained at the recent high level. Highest CPUE used to be observed at the western entrance but in 2012, these were mainly observed in the Central area.

Trends in IBTS area different between spring and autumn (Figure 7.3.2). 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, there are usually only weak correlations between the IBTS abundance indices in Eastern North Sea (area 7) and the Skagerrak (area 8) (Figure 7.3.3)

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 7.3.4 and Table 7.3.1).

This index is relatively noisy and based on a limited number of hauls, therefore trends have been computed using a non parametric smoother (lowess with span 0.5). This indicates a smoothed recent increase in the Western component (where nearly all catches take place) of 4% per year. Conversely, in the Eastern component the abundance shows a smoothed decreasing trend of 4% also for the recent period.

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 made available to the WG. With regards to plaice, the trends in Skagerrak (areas 8) are comparable to the ones from the Eastern North Sea. Recruitment is also considered "moderate" to "high" in both areas.

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 on that stock has finally led to some major changes for this stock (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) 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 was 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 hypothesed that the increased Western landings 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 an abundance index is available (DLS category 3), 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.

The spatially-disaggregated abundance index presented Figure 7.3.4 is used as the basis of advice. This indicates a smoothed recent increase in the Western component (where nearly all catches take place) of 4% per year, Considering that effort has decreased recently and that lpue of the main fisheries in 2012 have remained around the same high level as in 2011, no additional reductions to reduce exploitation rate are deemed necessary in this area.

Conversely, in the Eastern component the abundance shows a smoothed decreasing trend of 4% also for the recent period, and the component is considered depleted. Catches in the area are very low (under 1% of the 2012 catches), but the actual exploitation rate is uncertain due to the reduced stock status.

On these considerations, ICES advises that catches in Skagerrak could increase by 4% compared to the recent average catch of the last 3 years, corresponding to catches of no more than 9833 t in 2014 (average of landings 2010-2012 with 2012 discards rate of 12% of catches =9454 t, x 1.04=9833 tonnes). In the depleted Eastern Skagerrak, no directed fisheries should occur and bycatch and discards should be minimized.

Alternative options for potential interim management plans

In 2013, EU and Norway are considering options for an interim management plan for plaice in Skagerrak, on the basis of the putative linkages between this stock and North Sea Plaice.

In 2012 ICES considered that a pragmatic harvest control rule indexing changes in Skagerrak TAC to the changes in the North Sea TAC or in the SSB of the combined assessment 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, 2012 and Table 7.12.1). The SSB estimated from the combined assessment raised by 10% between 2011 and 2012 and is well above MSY Btrigger. The West Skagerrak survey index also shows a slightly increasing trend.

An increase in the TAC in Skagerrak indexed to 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).

An increase indexed to 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 assessment benchmark scheduled for early 2015.

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. 23 pp

Ulrich et al., 2013

Table 7.1.1. Plaice in Skagerrak. Landings in tonnes. Working Group estimates 1972-2012, and official statistics since 2012. TAC in thousands tonnes

Year	Denmark		Sweden		Germany		Belgium		Norway		Netherlands		Total	TAC
	ICES estimates	Official statistics	ICES estimates	Official statistics	ICES estimates	Official statistics	ICES estimates	Official statistics	ICES estimates	Official statistics	ICES estimates	Official statistics	ICES estimates	
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	11.2
1993	9 125		287		37		326		79				9 854	11.2
1994	8 783		315		37		325		91				9 551	11.2
1995	8 468		337		48		302		224				9 379	11.2
1996	7 304		260		11				428				8 003	11.2
1997	7 306		244		14				249				7 813	11.2
1998	6 132		208		11				98				6 449	11.2
1999	6 473		233		7				336				7 049	11.2
2000	6 680		230		5				67				6 982	11.2
2001	9 045		125						61				9 231	9.4
2002	6 470		140		3				58				6 671	6.4
2003	4 847		143		8				74		1 584		6 656	10.4
2004	5 717		179						106		1 511		7 513	9.5
2005	4 515		144						116		915		5 690	7.6
2006	6 334		175		14				142		1 190		7 855	7.6
2007	5 467		159		21				100		1 659		7 406	8.5
2008	6 901		219		5				79		403		7 607	9.3
2009	5 617		92		13				60		253		6 035	9.3
2010	7 644		153		10				49		1 332		9 187	9.3
2011	7 744		179		13		185		215		6		8 342	7.9
2012	7 328	7 104	155	155	12	9.3			122	126	10		15 021	7.9
2013														9.142

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

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

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				
	numObs	avg.cpue	sd.cpue	lowess		numObs	avg.cpue	sd.cpue	lowess
1974	4	4038	3097	2599	1974	1	2464	NA	1482
1975	4	2428	3782	2912	1975	1	2909	NA	1742
1976	9	3465	6291	3226	1976	2	1418	1597	2016
1977	5	1816	1108	3541	1977	6	3189	1472	2301
1978	6	3579	4951	3853	1978	2	2584	2837	2598
1979	8	2591	2952	4164	1979	4	2055	1300	2903
1980	8	5050	3699	4475	1980	4	1256	559	3214
1981	12	9085	11638	4791	1981	6	1736	1034	3526
1982	6	10455	11913	5123	1982	6	3023	2225	3839
1983	9	2290	1418	5487	1983	10	3521	2232	4163
1984	11	4652	3579	5837	1984	11	6366	3379	4581
1985	8	5605	5569	6159	1985	9	6781	5089	4994
1986	7	3714	2253	6448	1986	13	3622	2573	5356
1987	12	9700	6122	6706	1987	13	6438	4594	5663
1988	7	10129	9012	6938	1988	9	5591	4021	5921
1989	11	7236	7289	7122	1989	10	10243	7094	6108
1990	9	7516	7001	7231	1990	9	9788	7980	6218
1991	11	5905	3950	7258	1991	8	2692	1713	6245
1992	11	7155	4801	7222	1992	9	10123	6841	6193
1993	10	13403	10930	7127	1993	9	5414	5034	6072
1994	10	8661	6426	6986	1994	11	3704	2982	5883
1995	10	13497	15000	6809	1995	12	7376	2458	5621
1996	10	6574	6168	6623	1996	10	8240	13898	5296
1997	10	4402	3359	6460	1997	12	2886	3327	4965
1998	10	4434	2045	6316	1998	10	6078	4323	4686
1999	11	5234	3562	6167	1999	11	3268	2621	4492
2000	11	7287	4838	6031	2000	9	4300	2713	4346
2001	11	5421	2053	5951	2001	9	2814	1679	4207
2002	11	6135	4249	5991	2002	6	1731	1046	4053
2003	8	3585	2458	6175	2003	9	3167	1422	3867
2004	11	6249	4247	6475	2004	11	2621	1865	3669
2005	15	5579	3203	6894	2005	11	7907	5146	3514
2006	11	8573	11857	7273	2006	11	6028	3939	3411
2007	11	20073	19761	7637	2007	11	5193	4547	3332
2008	10	6787	4058	7999	2008	11	1880	1175	3260
2009	11	4312	3658	8366	2009	10	3224	3409	3186
2010	11	12123	7692	8740	2010	9	1709	915	3105
2011	11	10542	17779	9126	2011	7	1448	812	3015
2012	10	16005	13045	9524	2012	9	1268	901	2917
2013	11	6691	8863	9930	2013	10	6025	4844	2814

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.

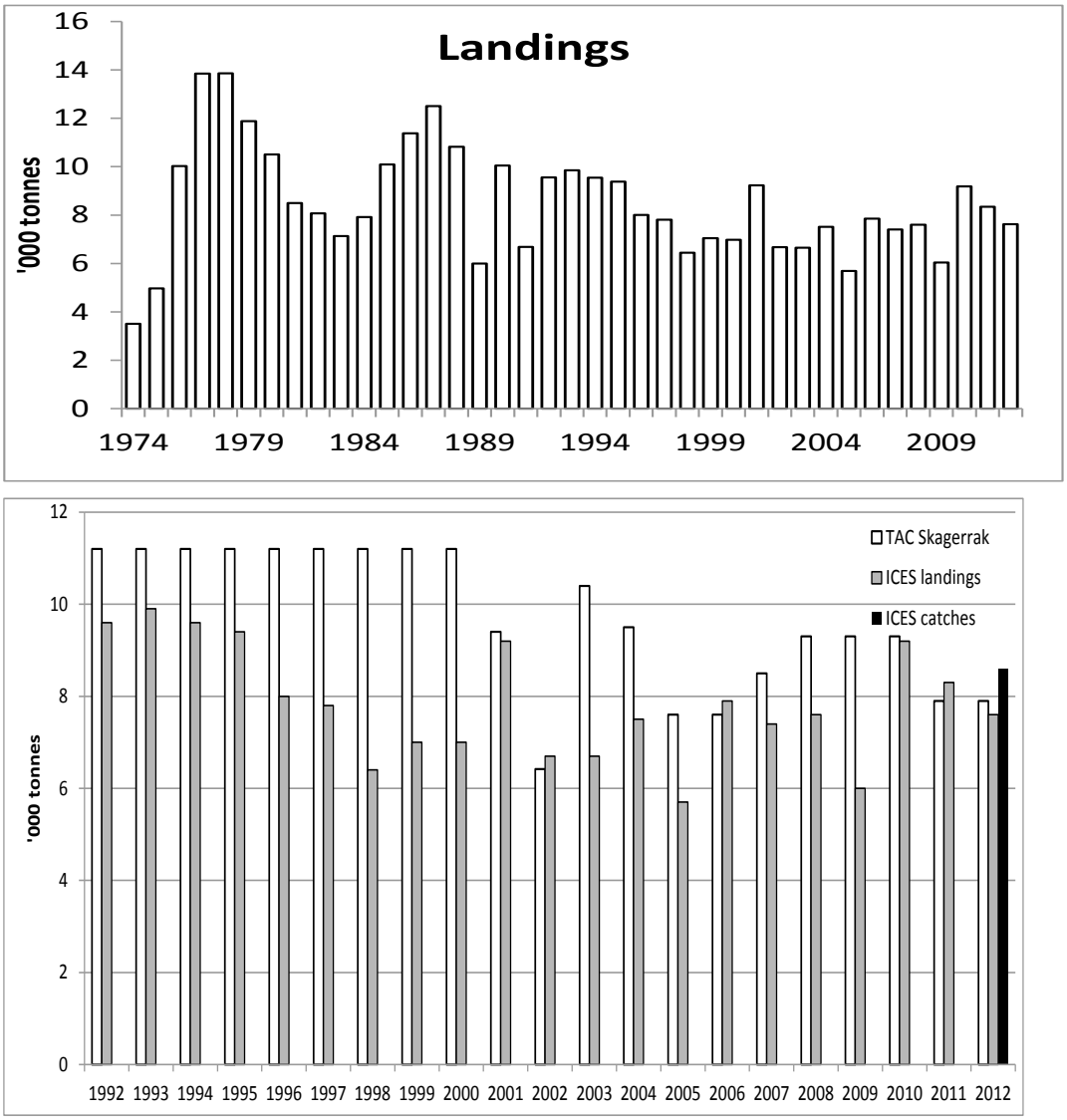


Figure 7.1.1. Plaice Skagerrak. Upper : total landings 1974-2012. Lower : Landings vs. TAC in Skagerrak, 1992-2012. Total catches 2012 added.

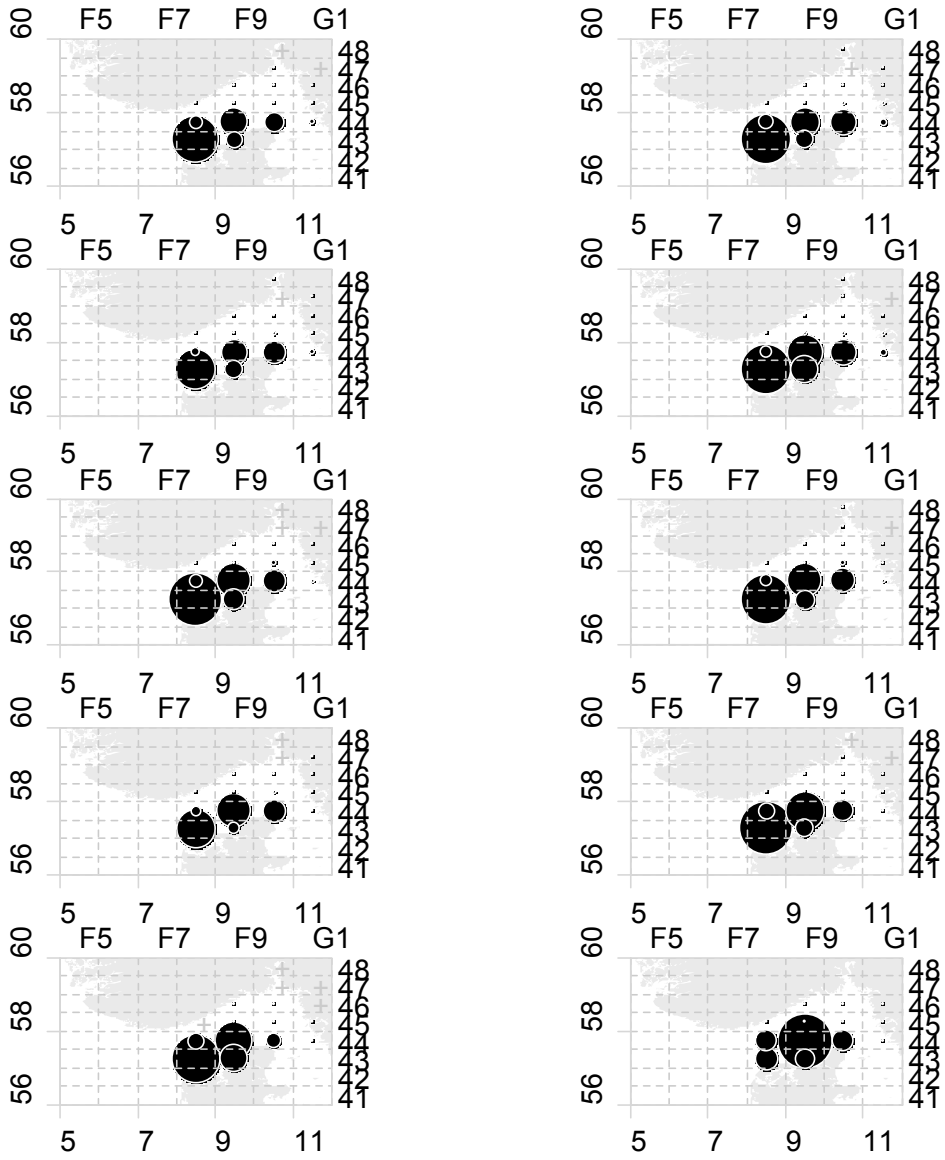


Figure 7.2.1. EU Landings all gears 2003-2012 (from left to right then top to bottom) all gears (STECF data). Bubble max size= 4400 tonnes.

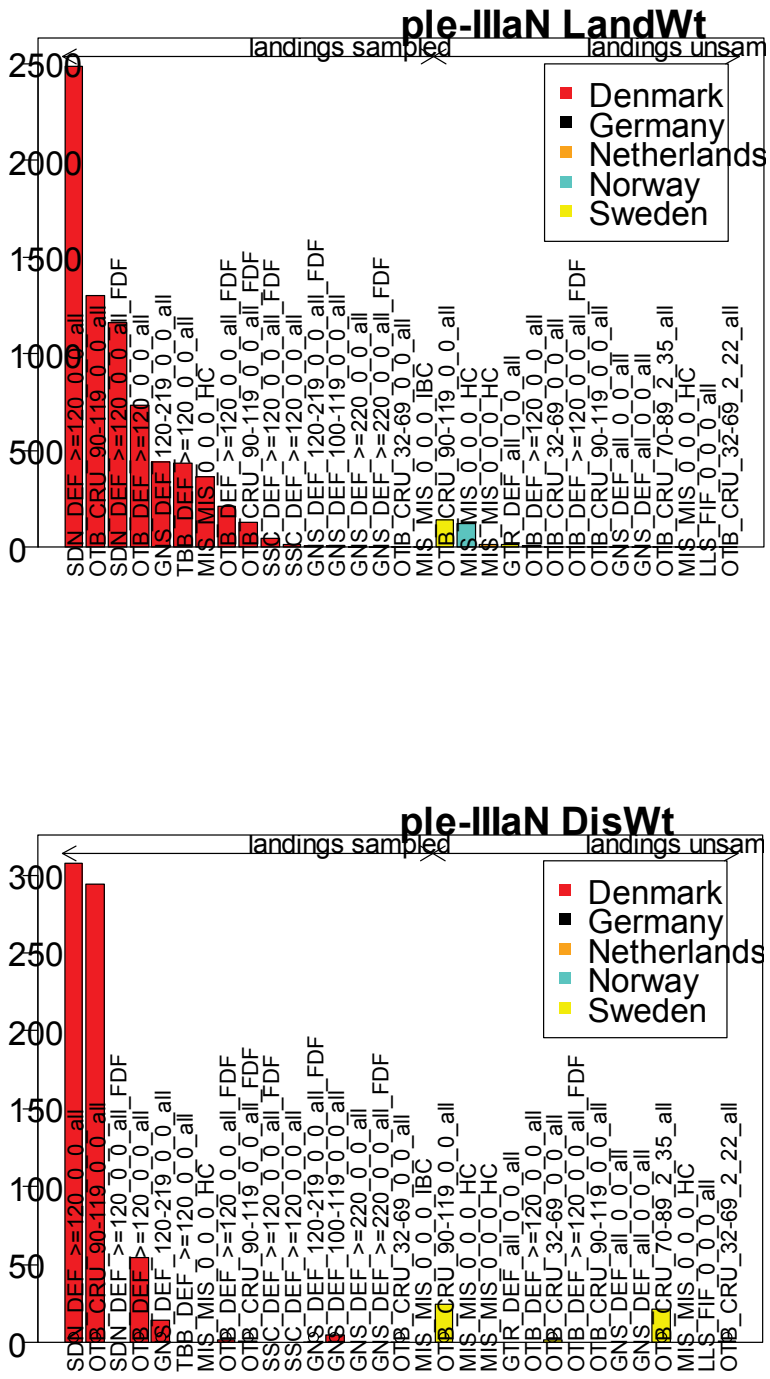


Figure 7.2.2. Landings and discards information as provided to InterCatch before raising.

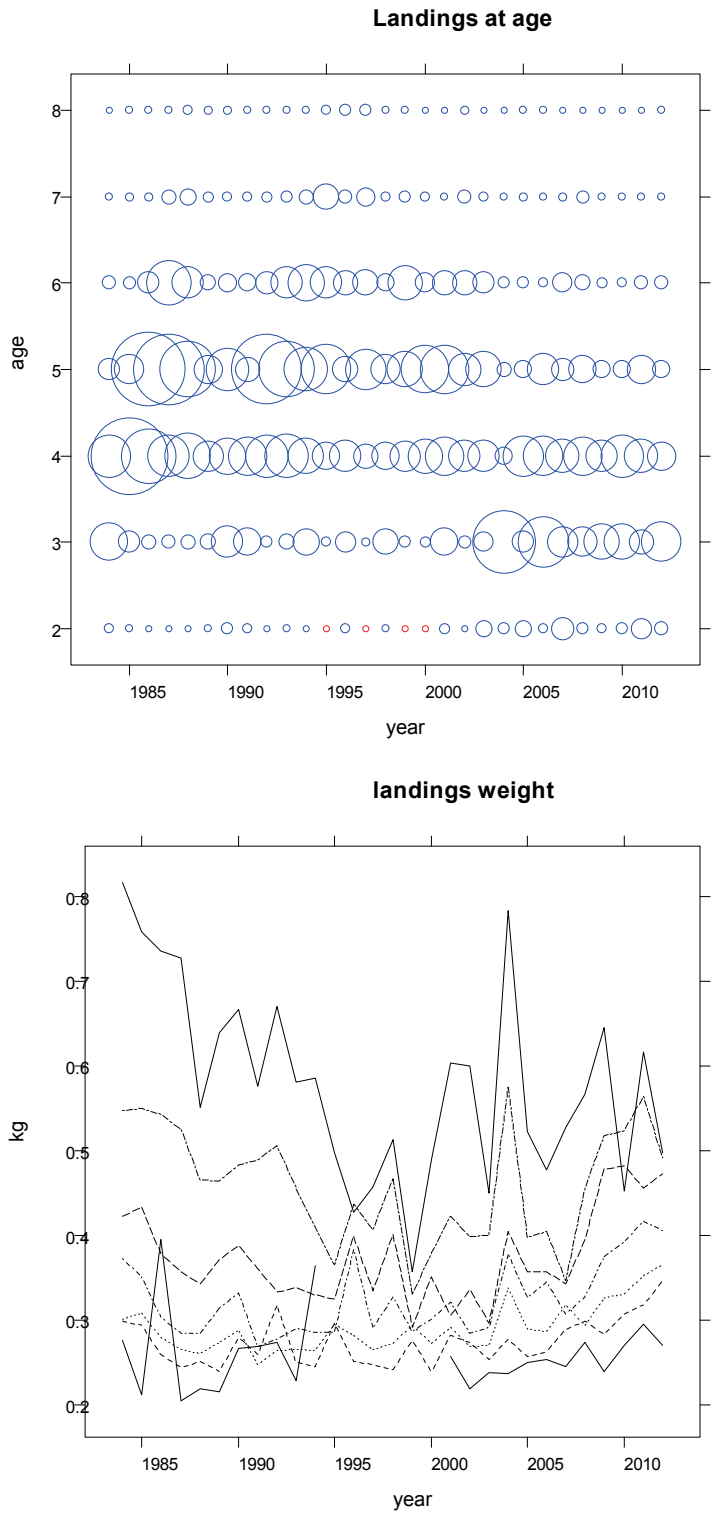


Figure 7.2.3. Landings number and landings weight at age (age 2 to 8) in Skagerrak

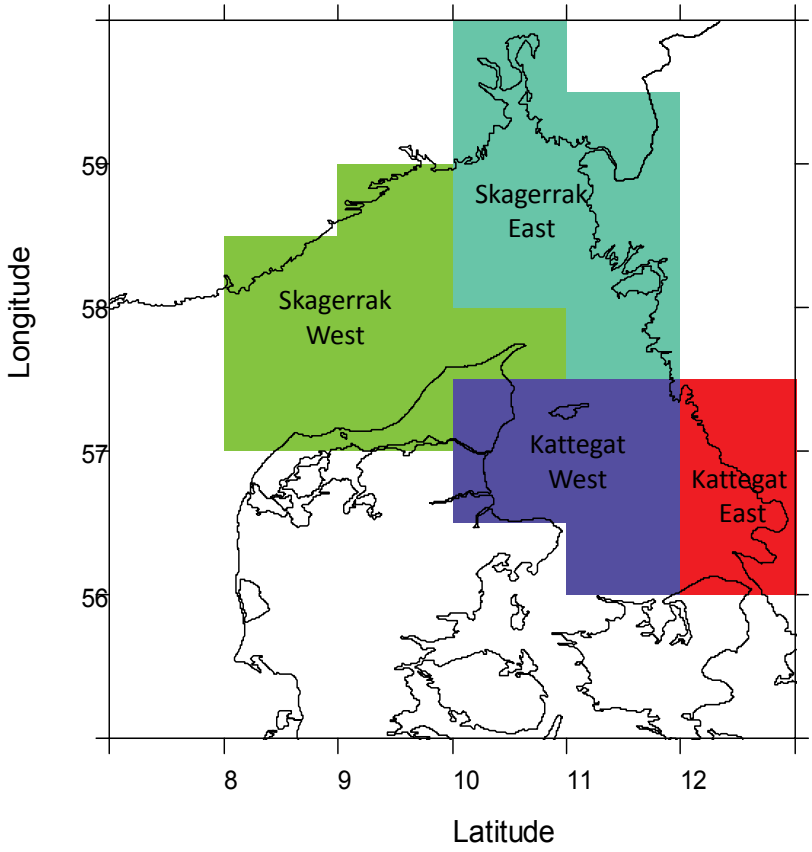


Figure 7.2.4 Areas defined within ICES division IIIa. From ICES WKPESTO 2012.

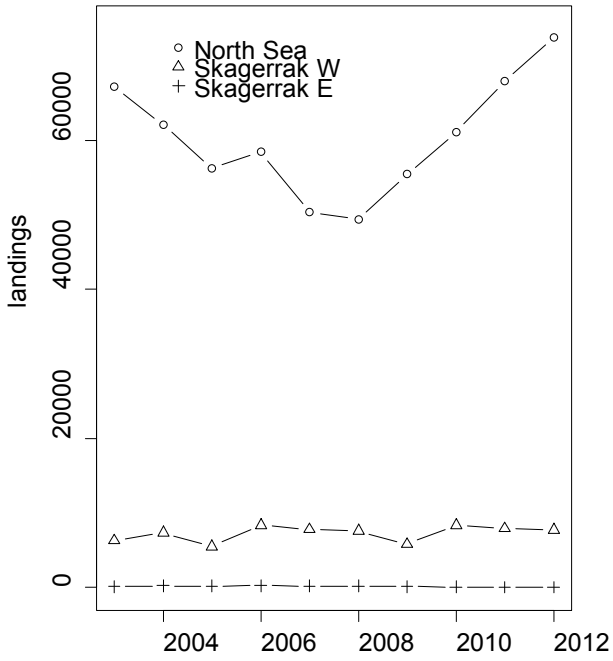


Figure 7.2.5 Landings in Skagerrak areas and compared with the North Sea.

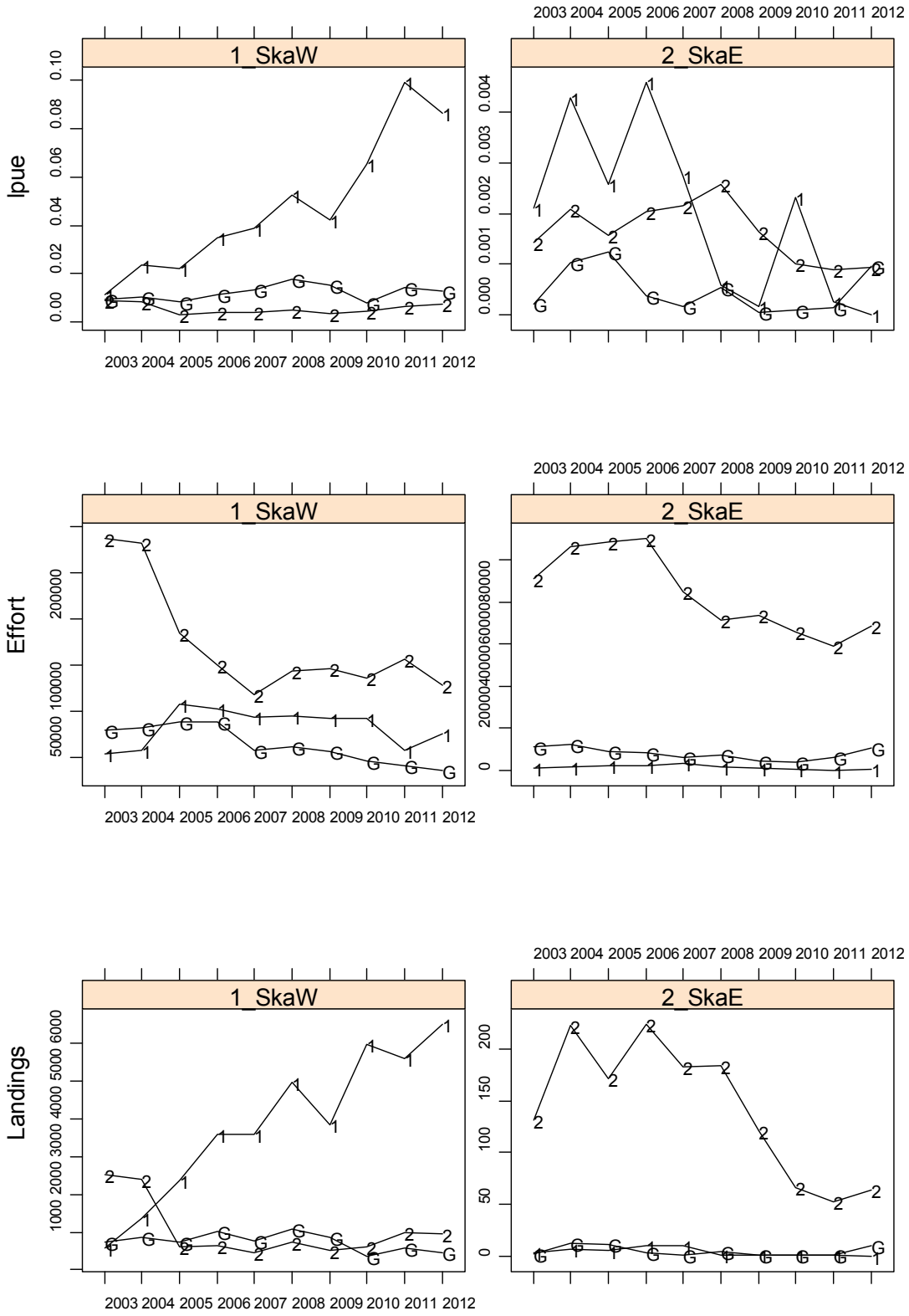


Figure 7.3.1 Trends in Landings, effort and lpue by gear and Skagerrak area. G=Gillnets fishery, 1 = TR1 (otter trawls and seines with >100 mesh size), 2= TR2 (otter trawls and seines with 70-99 mesh size).

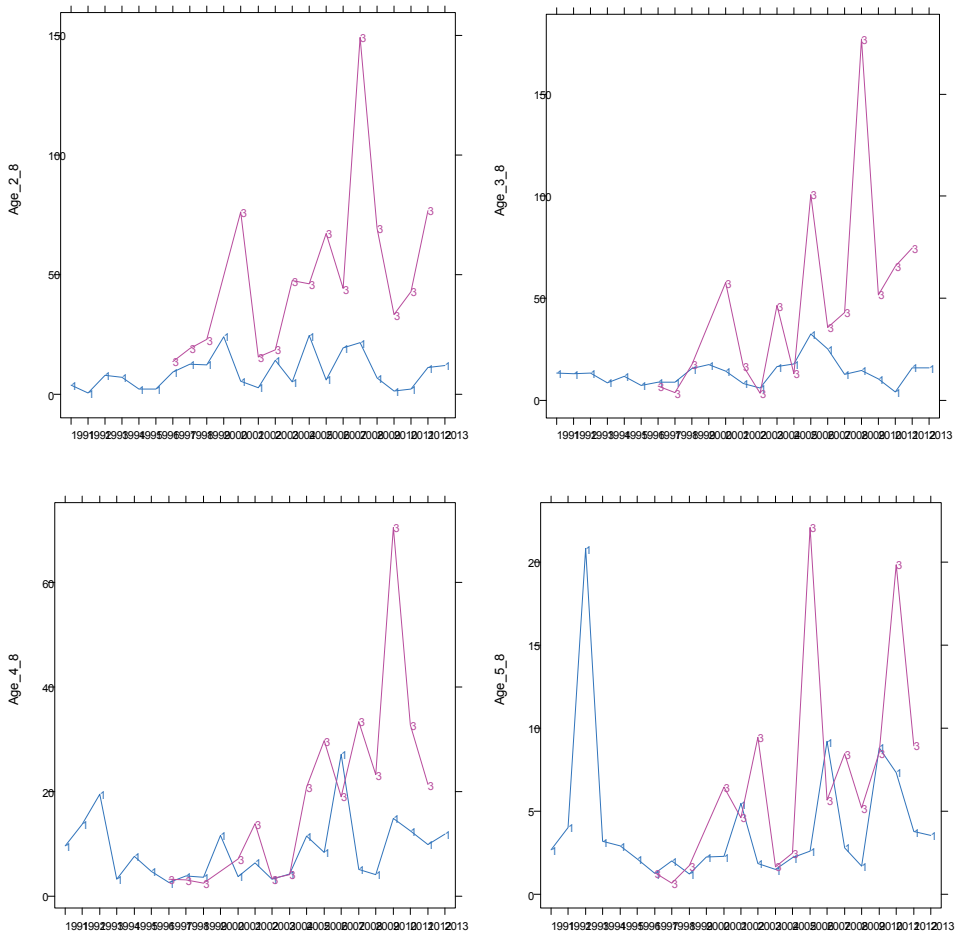


Figure 7.3.2. IBTS index in Skagerrak (area 8) by quarter (1 and 3) and age.

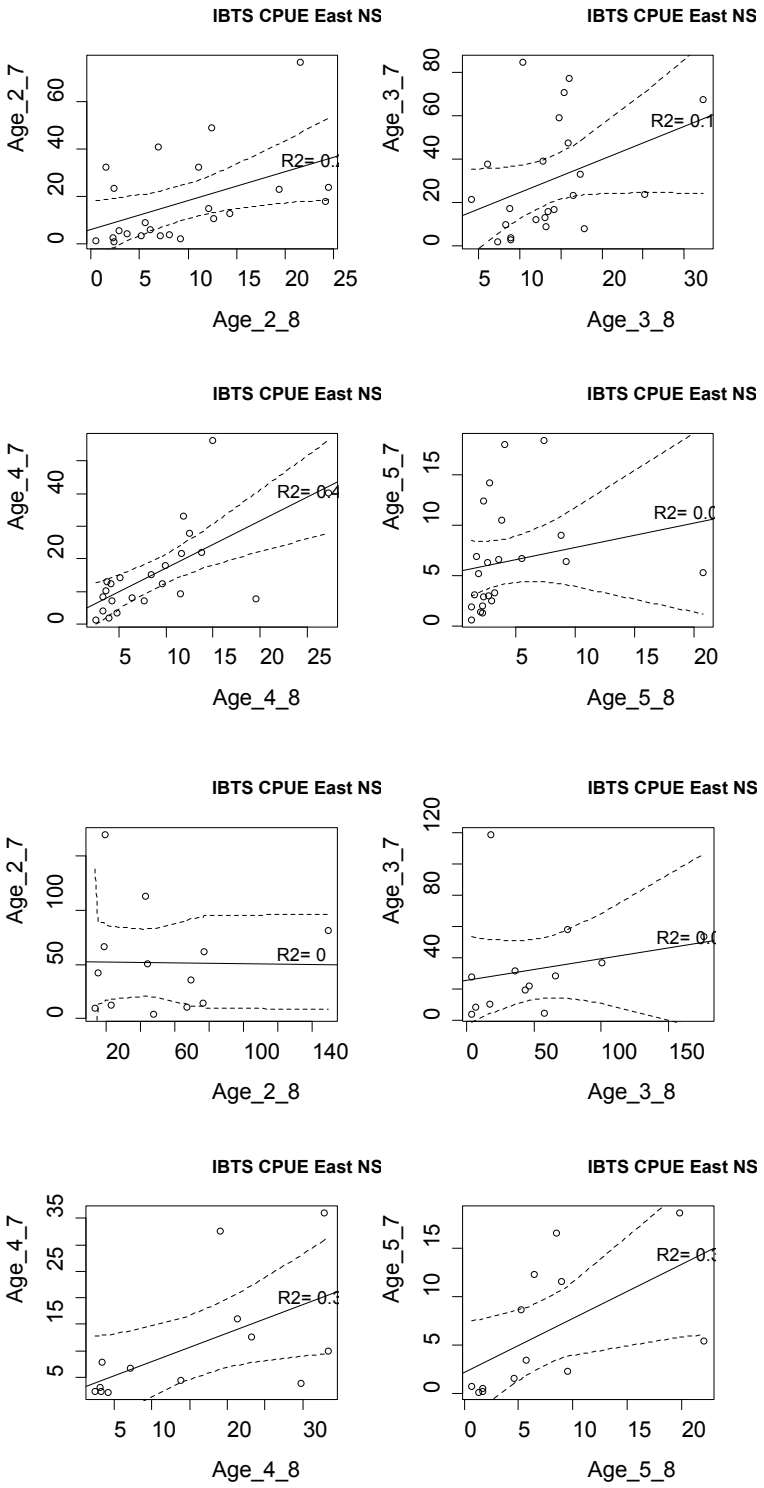


Figure 7.3.3 correlation between IBTS index at age in the Skagerrak (area 8, x-axis) and in the Eastern North Sea (area 7, y-axis). Quarter 1 : 1991-2013. Quarter 3 : 1997-2012.

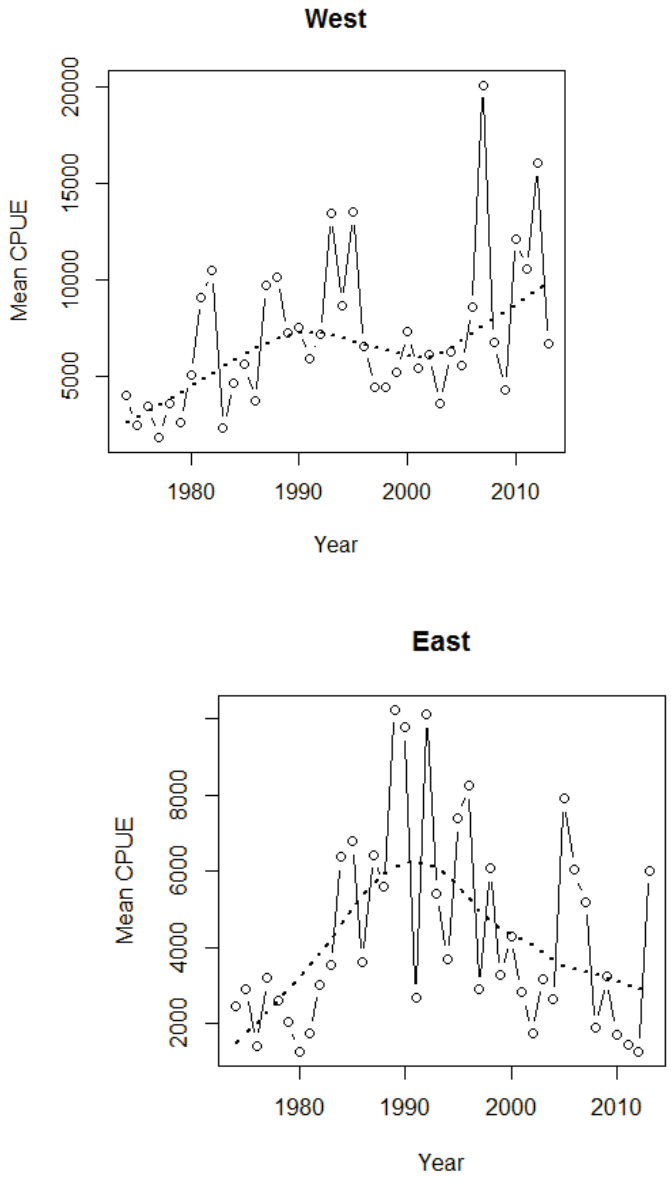


Figure 7. 3.4 Trends in the spawning-stock biomass index (cpue of fish above 25 cm, g/hour) in the local Skagerrak components Eastern and Western (IBTS). The dotted line is a loess smoother (span 0.5).

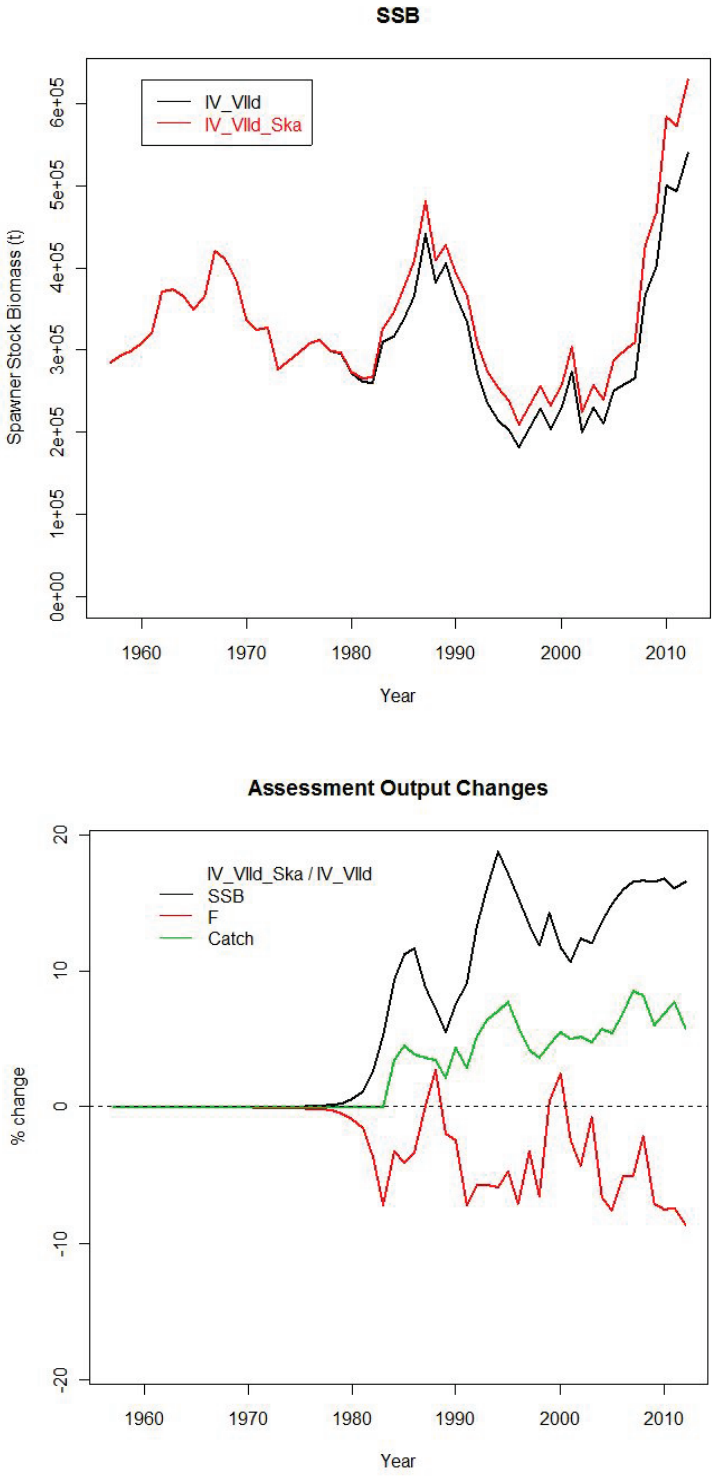


Figure 7.4.1. top : SSB for the North Sea stock, with and without the Skagerrak landings data included in the assessment. Bottom : differences in North Sea plaice assessment with and without the Skagerrak landings included.

8 Plaice in Subarea IV

A Stock Annex is available for North Sea plaice. Therefore only 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 (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 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 Kattegat 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 (). 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.

This year - as in 2012 - part of the catches in the VIId area in the first quarter are included in the North Sea plaice assessment as it is known that North Sea plaice migrates into the area in that season.

8.1.2 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2013. All available information on ecosystem aspects can be found in the Stock Annex.

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. Debate is on-going in the EU about extensions of an additional 42 derogation licenses as well as possible amendments to EU regulations which would permanently legalize the use of pulse gears for the whole fleet. Potential future impact either on the sole 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 2012, section 6.4.7:

ICES advises on the basis of the EU management plan (Council Regulation No. 676/2007) that landings of plaice in Subarea IV in 2013 should be no more than 97 070 t. The implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Single-stock exploitation boundaries

Exploitation boundaries in relation to existing management plans

"Following the EU multiannual plan would imply a TAC of 97 070 t (F=0.27) for Subarea IV in 2013, which is a 15% increase in comparison to 2012, complying to the constraint of 15% TAC change of the plan. This is expected to lead to an SSB of 665 000 t in 2014. ICES has evaluated this management plan and considers it to be precautionary. Both the North Sea plaice and sole stocks have 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)".

Exploitation boundaries in relation to precautionary limits

"The fishing mortality in 2012 should be no more than F_{pa} (0.6) corresponding to landings of less than 189 000 t of plaice in Subarea IV in 2013. This is expected to keep SSB above B_{pa} in 2014."

Advice for mixed fisheries management

In 2012, ICES for the first time presented an advice sheet specifically dedicated to describing several fishing opportunity scenarios based on modeling mixed fisheries in the North Sea (ICES, 2012). This advice was based on the single-stock assessments combined with knowledge on the species composition in catches in North Sea fisheries. Five example scenarios were presented, taking into account the single stock advice for fisheries catching cod, haddock, whiting, saithe, plaice, sole, and Nephrops:

Max 'Maximum': Fishing stops when all stocks considered have been caught up to the ICES single-stock advice. This option causes overfishing of the single-stock advice possibilities of most stocks. For 2013, the least limiting stock would be whiting for fleets representing 96% of the effort in 2011.

Min 'Minimum': Fishing stops when the catch for any one of the stocks considered meets the single-stock advice. This option causes under-utilization of the single-stock advice possibilities of other stocks. For 2013, the limiting stock would be cod for fleets representing 100% of the effort in 2011.

Cod 'Cod management plan': All fleets set their effort corresponding to their cod quota share, regardless of other catches.

Sq_E 'Status quo effort': The effort is set equal to the effort in the most recently recorded year for which landings and discard data are available.

Ef_Mgt 'Effort management': The effort in métiers using gear controlled by the EU effort management regime have their effort adjusted according to this regime (see Table 6.4.25.3).

No specific recommendation for a particular scenario was made, since specific mixed-fisheries management objectives are lacking. Rather, it provides insight in where single stock objectives are in conflict with each other. E.g. a 'minimum' scenario assumes that fleets would stop fishing when their first quota share is exhausted, regardless of the actual importance of this quota share, implying that the TAC for other species in the mixed fisheries are not fully utilized. Similarly a 'maximum' scenario demonstrates the upper bound of potential fleet effort and stock catches, through assumption of all fleets continuing their fishing until all their quotas are exhausted. These scenarios are not presented as plausible options for management, but rather to illustrate a 'bandwidth' of possible implications of different ways of simultaneously implementing all single stock TACs.

For plaice, the results for the different scenarios were rather variable. See the text table below.

Stock	advice WGNSSK	'Max'	'Min'	'Cod'	'Sq_E'	'Ef_Mgt'
Plaice	97.070	121	49	52	94	68

In all but the ' Max' and 'Sq_E' scenario, the landings would have been substantially lower than the TAC as advised by the WGNSSK. Under the ' Max' scenario, the landings would in fact have been substantially larger than the advised TAC based on the single species advice.

Key points highlighted in the 2012 advice sheet

The stock is well within precautionary boundaries. Recruitment has been around long-term average from 2005 onwards.

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.

The change in distribution of juvenile plaice further offshore has resulted in conflicting estimates of abundance between the SNS survey (mainly inshore) and the Tridens and BTS-Isis surveys (offshore). This is a cause for uncertainty in recruitment and has resulted in a persistent underestimation of recruitment, which was then revised upwards in subsequent years as signs of abundance in old age classes became apparent.

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 2010) it was decided that 50% of Q1 landings taken in the eastern channel are actually plaice form the North Sea stock migrating in and out of the area. 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 2012 were estimated by the WG at 73830 t, an increase of 6444 t from the 2011 landings, but 10580 t (13%) less than the 84410 t TAC for 2012. 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 2000–2012, as is described in the stock annex. From Belgium, discards data have been available as well but were only used in the assessment for the first time this year for 2012 data, 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 solely 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. The stock assessment of North Sea plaice used to use three different survey indices as tuning fleets: (1) the Beam Trawl Survey RV Isis (BTS-Isis), (2) the Beam Trawl Survey RV Tridens (BTS-Tridens) and (3) the Sole Net Survey (SNS). In 2008 and 2009, WGNSSK and WKFLAT (the ICES Benchmark and Data Compilation Workshop for Flatfish) respectively addressed concerns about differing signals in the three scientific tuning indices. Based on an observed offshore movement of the younger ages relative to the areas covered by each of the surveys, it was concluded that the trends in the indices of these surveys may no longer independently reflect the trend in abundances of age classes in the whole of the North Sea. As it was considered generally to be better to have indices spanning as much of the distribution as possible rather than having separate indices, which are prone to showing local trends, it was suggested to combine the two separate BTS-indices into one. Through an Inter Benchmark Protocol, in March 2013, the effect of combining the indices, were investigated incorporating data up to 2011 (Miller and Coers 2013). The indices were combined applying a gear efficiency correction as recommended by WGBEAM (ICES 2005). The results showed that the XSA model fit improved using a combined BTS index rather than BTS-ISIS and BTS-Tridens as separate indices. At the same time, the impact on assessment results were limited, allowing for a smooth transition to using the new index in the assessment that forms the basis of management for the North Sea plaice stock. The current assessment was thus conducted using the combined BTS-indices, while maintaining the early part of the BTS-Isis index in the assessment separately (since this survey started 11 years before the BTS-Tridens and so only part of the time series could be combined).

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); (1996-2012)
- Beam Trawl Survey RV Isis (BTS-Isis) for the older part of the time series; (1985-1995)
- Sole Net Survey (SNS); (1982-2012)

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 (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 WKFLAT 2009 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

This year, all countries 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). 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). Table 8.2.12. shows the allocation scheme that was used for applying discard rates from monitored metiers to unmonitored metiers across countries and metiers (by quarter). A similar scheme was used to allocate age-composition information from sampled to unsampled metiers (by quarter).

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

General comments by the review group

The assessment was well done and reasonably easy to follow what is going on. Comments from last year's review (8.3.1) are all valid and most of them related to the problem of discard which is more a management problem than assessment problem. The assessment problem is mostly if M2 from discards is highly variable it affects recruitment estimates. With reduced fishing mortality the abundance of older fish increases and the advice should be less sensitive to precise recruitment estimates.	The issue of estimation of M has not been addressed during the WG. Possibly, estimates from multi-species models could provide a possible way forward. At present, plaice is not included in those models however. Variability of mortality by discarding may be limited since it is likely related to fleet effort which has been relatively stable in recent years. However, large scale changes in spatial distribution of the fleet and introduction of innovative gears (e.g. pulse gears and sum wings) may affect this relationship.
Fishing mortality has been reduced in recent years and is estimate around 0.2. This sudden decrease introduces all kind of uncertainties in the assessment and makes inference and everything more dependent on the assumed value of M.	Indeed the assumption of M may have gained importance in the assessment. Moving towards better informed estimations of M may be timely.
Length based model where the selection of the retaining operation (or discard op-	Considering the fact that from most of the discards monitoring programmes,

eration) would be useful. Including the spatial dynamics of the fleet that is moving into more shallow areas increasing discards could be necessary but also complicated.	comprehensive age composition information is currently available, it is considered that this should be used rather than a length-based model. Assessing fleet dynamics on an international scale would be informative. It would require bringing VMS and logbook data together for all countries.
Since around 1995 landings and discards have been in the same order of magnitude but before that landings were twice the discard. Any reason for this change?	Any number of reasons could have led to this change, such as changes in regulations which had an effect on the fisheries. In order to understand this better, the reconstructed part of the discards time series would have to be examined in detail. Regardless of the observed change – and its causes – it is unlikely to have a substantial effect on the assessed status of the stock in recent years.
The introduction paragraph to the section needs to be expanded. See section 12 for an introduction paragraph that is very useful to reviewers.	The stock annex should provide sufficient information to serve as a comprehensive introduction to the specifics of the stock.
Tables are not presented in the text in the numerical order that they appear in the section.	This has been resolved.
Estimates of F, recruits and SSB have consistent retro patterns.	Yes.

Technical comments by the review group

As in previous years, discard uncertainty is still the major issue for this assessment. Annual sampling trips are not enough to properly estimate discards. Can sampling be increased to deal with this major issue?	Discards data are available from Dutch, Danish, German and UK (up to 2007) for the period 2000-2012. These monitoring programmes cover a part of the fleet responsible for approximately 60% of the overall landings. From the majority of these programmes, age composition data is also available. Therefore, discards may still be a factor of uncertainty in the assessment, but they are not regarded as a major problem as the assessment has been rather robust consistent between years in recent years.
Using indices from separate areas for tuning as if they both represent the	This has been resolved partly by combiningof the BTS-indices. The problem re-

whole stock can lead to wrong results if spatial distribution changes much. The exercise of splitting the SNS and Tridens index (8.3.2) is a good way of testing the effects of the changes in spatial distribution without too much work.	mains for the SNS index. However, due to improved internal consistency for the combined BTS-index, this index receives more weighting in the assessment now, 'at the expense' of the SNS-index. And so the problem related to the SNS-index has been reduced as well.
"Unrealistically" low fishing mortality of the oldest fish in recent years? Survey indices up to age 9 are used but looking at the indices BT-Isis and BTS-Tridens, they show many year-classes dropping incredibly slowly in recent years. Their numbers drops much more in the landings. Is this the shift in spatial distribution of the fisheries, some not fishing the old ones, or an artefact of the surveys. The problem here does not seem to be related to model settings like a similar problem with the haddock but rather the pattern seems to be in survey data.	This issue has not been addressed during this year's WG.
Research to better understand the stock structure in this area would be very beneficial to the assessment. The varied distribution of abundance throughout the region coupled with the sampling issues above drive the uncertainty.	Indeed. See also section 8.1.1.
As mentioned by reviewers last year, the assumption of M = 0.1 may need to be re-examined for all plaice stocks. From 2011 Review: Same issue as other plaice stocks with an M of 0.1. There has to be better method of estimating natural mortality for plaice than an assumption based on estimates from 50+ years ago? What do life history equations based on Tmax (Hoenig 1983, Hewett and Hoenig 2005) and mean size at age (Gislason et al. 2010) predict M to be? It seems like some additional support for M other than "probably derived from war time estimates" could be provided very easily.	This issue has not been addressed during this year's WG. It could be addressed at the next benchmark of the stock.
Section 8.10, Status of the Stock, has not been updated with 2011 values.	This has been resolved.

8.3.2 Adaptations to the assessment in comparison to last year

The main difference of this year's assessment in comparison to previous years is the combination of the BTS-indices. See section 8.2.6.

During previous years' assessments, the SOP correction was performed on landings weights at age, rather than on landings numbers at age. This year, the SOP-correction was reversed, and the landings numbers at age were corrected so that they – multiplied by the landings weights at age – match the total landings in weight.

Another difference with last years' assessments is the way that data (landings and discards) have been raised internationally, through the use of InterCatch. See section 8.2.7.

8.3.3 Exploratory catch-at-age-based analyses

The following exploratory analyses has been carried out:

1. Stock assessment using the statistical catch-at-age model as described in Aarts & Poos (2009).

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 mortality that can be estimated from the tuning series, while the fishing mortality can be estimated from the landings, and 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 of course for the recruitment and F estimates in 2009 and 2010. The SCA model estimates similar stock trends compared to the XSA in the final run (figure 8.3.2). As previously, the main difference between the assessment models is in the estimate of the discard levels in recent years (2009-2012), which are estimated to be lower in the SCA model. Consequently, lower estimates of mean F (ages 2-6) are obtained using the SCA model.

Final XSA assessment

The settings for the final assessment that is used for the catch option table is given below:

Year	2012
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + DE fleets and BE (2012 only)
Fleets (years; ages)	BTS-Isis-early 1985–1995; 1–8 BTS-combined 1996–2012; 1–9 SNS 1982–2011 (excl. 2003); 1–3
Plus group	10
First tuning year	1982
Last data year	2012
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 37 iterations. Figure 8.3.4. shows internal consistency plots for the three tuning indices used. With the combined BTS-indices, the model fits better to the tuning indices, since overall, the residuals are substantially reduced in size and most importantly, the strong pattern observed in past years in the youngest ages in the BTS-Tridens (see WGNSSK 2012) index is completely removed in the combined BTS index. Combining the BTS indices has not affected the residuals of the BTS-Isis-early index or the SNS index. The SNS tuning index shows strong negative values until the late 1990's and exclusively positive values in the most recent period. 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. This posed a substantial problem in assessments in recent years, 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, however, has substantially improved the residual pattern of the BTS indices and consequently, these receive 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.

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 historic estimates for SSB in 2006 and 2007 were much lower compared to the current estimate but since then the retrospective differences have been insignificant. This is reflected correspondingly in the estimates of fishing mortality. This may be the result of the increase of younger individuals in the more northern and offshore region (surveyed by the BTS surveys but not by the SNS). The retrospective pattern of recruits shows a tendency of the model to underestimate recruitment. This too can be explained by the change in distribution of juveniles and the relative weightings given to the different indices for the younger ages (SNS still getting a higher weighting than is perhaps appropriate due to historically better representing the level of recruitment).

8.4 Historic Stock Trends

8.4.1 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 (2012) estimated at 0.23. Over the last five years SSB has been rapidly increasing and is currently (2012) estimated at a record high 540 kt, about 0.5 kt higher compared to the 494 kt in 2011. Recruitment varies inter-annually around the long term geometric mean of approximately 1 million recruits. It appears to have been slightly lower on average during the 1960's in comparison to the rest of the time series.

The stock dynamics are affected by the occurrence of strong year classes, but increased stock size in the more northern region of the North Sea is most likely the direct consequence of reduced fishing mortality in this region, given that no exceptionally strong year classes have been observed in recent years.

The predominant age in the landings is currently (2012) age-4, as it has been in the past decade on average as well. 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 2012 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 2012 may be for a number of reasons. When considering the age distribution in the catches (figure 8.11.3.) age-2 fish were also lacking in the catches in the 1960's, while this is not the case in 2012. 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 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 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 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.

8.4.2 The Fishers' North Sea Stock Survey

The Fishers' North Sea Stock Survey (FNSSS) again took place in 2012. The 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 from 2011 to 2012. Most respondents reported similar or higher abundances of fish, although the proportions reporting higher levels were somewhat less than in 2010. 184 completed questionnaires were included in the analysis. Of these in 158 cases (86%) fishermen provided information on plaice.

Overall, 66% of the respondents reported that plaice were 'more' or 'much more' abundant in 2012 than in 2011. This is an increase from the 44% who reported this last year and is in line with the assessment which suggests an increase in SSB over this period. 24% reported 'no change' in the abundance of plaice, which is less than in 2011. About three-quarters of respondents overall reported catching 'all sizes' of plaice in 2012, while of the remainder, twice as many reported 'mostly small' plaice as 'mostly large'. This is different from last year's results, where the percentages approximately equal. This impression coincides with the increased discards which were observed in the monitoring programmes, consisting mostly of age-2 fish. This could suggest a relatively strong 2010 year class being recruited by the fishery. Overall, more than half (60%) of respondents reported 'no change' in the level of discarding of plaice, while 24% reported higher and 16% reported lower discards respectively. The proportion reporting 'more' or 'much more' discarding of plaice had been significantly lower in 2011 than in 2010 as well as in comparison to 2009. This year, the trend is reversed, and respondents seemed slightly more inclined to report more discards. Whereas the vast majority (67%) of respondents reported 'moderate' levels of recruitment 2010, the majority (52%) reported high levels of recruitment this year. Overall the perceptions of the fishing industry reflect the high and increasing abundances of plaice estimated during WGNSSK 2013. It possibly also reflects the increase of discards in 2012.

8.5 Recruitment estimates

Input to the RCT3 analysis is presented in Table 8.5.1. Estimates from the RCT3 analysis of age 1 are presented in Table 8.5.2, and of age 2 in Table 8.5.3. For year class 2012 (age 1 in 2013) 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 (Table 8.5.2.). Therefore the geometric mean, slightly lower than the RCT3 estimate, was accepted for the short-term forecasts as in previous years. For year class 2011 (age 2 in 2013), the estimates from BTS 1-group and the VPA mean were relatively comparable, while the SNS 0-group was an order of magnitude higher. The other survey indices provide estimates an order of magnitude lower than the VPA mean. All received low weightings and had relatively high standard errors. Hence, the WG decided to use the XSA estimate rather than the RCT3 estimate for the 2011 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 2013	XSA Survivors	RCT3	GM 1957–2010	Accepted estimate
2011	2	**590490**	497663	684591	XSA survivors
2012	1		1177482	**930070**	GM 1957–2010
2013	0			**930070**	GM 1957–2010

8.6 Short-term forecasts

Short-term prognoses have been carried out in FLR using FLCore (2.3), projecting the stock forward three years from the 2012 (the last data year) into 2013 (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 2012 ("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 (1957-2010). 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	F_{2013}	SSB_{2014}	$Landings_{2013}$
$F_{2012} = F_{2011}$ (Fsq)	0.23	663207 t	97688 t

Resulting management options for 2014 are given in Tables 8.6.2. The detailed table for forecasts based on the Fsq scenario is given in Table 8.6.3.

8.7 Biological reference points

8.7.1 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.

8.7.2 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.

8.8 Quality of the assessment

The assessment had in recent years repeatedly been undermined by the use of two separate BTS-survey indices covering different areas. The change in distribution of juvenile plaice further offshore resulted in conflicting estimates of abundance between the SNS survey (mainly inshore) and the Tridens and BTS-Isis surveys (offshore). This issue was resolved in 2013 by combing both indices into a single standardized time series through an Inter Benchmark Protocol (Miller and Coers 2013). Combining the indices has led to a substantial upwards revision of recruitment estimates for recent years in comparison to previous assessments.

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.

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, 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 Skag-

errak, 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 2013.

8.9 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 2013 is estimated around 663 thousand tonnes which is well above Bpa (230 000 t). Fishing mortality is estimated to have remained constant from 2011 to 2012 at a value of 0.23 (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 0.12. Projected landings for 2013 at Fsq are 97.7 kt. Projected discards for 2013 are somewhat lower than the projected discards for 2012 at Fsq, but this is mainly based on the estimates of the abundance of year classes 2010 and 2011 coming in. Therefore, development of discarding in the next couple of years will depend on the true size of these year classes.

8.10 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.

8.10.1 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 (ICES 2010a). 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.

8.10.2 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.

8.10.3 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.

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Table 8.2.1. North Sea Plaice. Nominal landings

YEAR	Belgium	Denmark	France	Germany	Nether-lands	Norway	Sweden	UK	Others	Total	Un-allocated	WG 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

*** Official estimates not available.**

Table 8.2.2 . Plaice in IV . landings.n (including 1st quarter of VIId NS plaice catches)

2013-04-26 17:49:25 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

Table 8.2.3 . Plaice in IV . discards.n

2013-04-26 17:49:37 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

Table 8.2.4 . Plaice in IV . catch.n (including 1st quarter of VIId NS plaice catches)

2013-04-26 17:49:50 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

Table 8.2.5 . Plaice in IV . stock.wt

2013-04-26 17:50:02 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

Table 8.2.6 . Plaice in IV . landings.wt

2013-04-26 17:50:15 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

Table 8.2.7 . Plaice in IV . discards.wt

2013-04-26 17:50:28 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

Table 8.2.8 . Plaice in IV . catch.wt

2013-04-26 17:50:40 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

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

SNS units= NA

	1	2	3	4	5
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
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	56	10
2011	1	18349	1143	308	75	60
2012	1	5893	2928	681	82	30

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

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 2013-05-17 13:29:52

CPUE data from indices

Catch data for 56 years. 1957 to 2012. 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      2012  0.66 0.75
3            SNS         1        3       1982      2012  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   2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
    year
age   2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
  1  0.144 0.213 0.144 0.289 0.075 0.149 0.154 0.146 0.078 0.137
  2  0.617 0.648 0.485 0.564 0.468 0.340 0.308 0.275 0.181 0.276
  3  0.614 0.459 0.460 0.440 0.442 0.263 0.227 0.214 0.200 0.271
  4  0.470 0.493 0.352 0.394 0.216 0.291 0.211 0.212 0.281 0.241
  5  0.676 0.237 0.436 0.238 0.274 0.160 0.235 0.153 0.211 0.225
  6  0.631 0.512 0.237 0.224 0.170 0.144 0.120 0.180 0.126 0.150
  7  0.456 0.342 0.428 0.118 0.112 0.143 0.097 0.092 0.109 0.073
  8  0.271 0.137 0.278 0.290 0.087 0.093 0.083 0.073 0.088 0.066
  9  0.111 0.094 0.082 0.192 0.092 0.020 0.035 0.032 0.050 0.038
  10 0.111 0.094 0.082 0.192 0.092 0.020 0.035 0.032 0.050 0.038


 XSA population number (Thousand)
      age
year         1       2      3      4      5      6      7      8     9    10
  2003  535148 1277425 229854 189299  65279  36248  64809   7076  6497  8560
  2004 1277425  419160 623390 112518 107092  30035  17450  37183  4882  6394
  2005  757746  933775 198303 356443  62194  76462  16284  11211 29323  8193
  2006  925023  593880 520340 113306 226767  36389  54580   9601  7686  8140
  2007 1141959  626906 305814 303257  69143 161735  26320  43877  6499 15175
  2008 1033808  958607 355248 177881 221193  47571 123433  21296 36380 48424
  2009 1105451  806331 617550 247158 120323 170609  37278  96814 17565 24303
  2010 1301776  857386 536009 445297 181165  86109 136874  30610 80598 41446
  2011 1639567 1018155 589239 391542 325879 140633  65093 112941 25747 58610
  2012  748405 1371745 768417 436606 267429 238788 112148  52803 93618 50716
```

Estimated population abundance at 1st Jan 2013

year	age 1	2	3	4	5	6	7	8	9	10
2013	0	590505	942103	530204	310579	193308	186019	94375	44715	81528

Fleet: BTS-Isis-early

Log catchability residuals.

age \ year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	-1.151	-0.495	-0.733	0.476	0.490	-0.338	0.294	0.650	0.387	0.550	-0.128
2	0.018	-0.589	0.270	-0.567	0.292	-0.184	0.078	0.336	0.905	-0.013	-0.546
3	-0.248	0.205	-0.445	0.338	-0.445	0.320	-0.196	-0.137	0.743	0.207	-0.342
4	-0.353	-0.200	-0.600	-0.166	0.444	0.569	0.026	-0.447	0.061	0.450	0.217
5	-0.510	0.080	-0.284	0.359	0.743	-0.259	0.154	0.280	-0.604	0.336	-0.294
6	0.249	-0.693	-0.743	-0.045	0.138	-0.351	0.818	0.662	0.131	-0.232	0.065
7	0.021	0.067	-0.279	-0.250	-0.249	-0.672	-0.737	-0.006	-0.380	0.702	-0.066
8	-0.145	-0.076	-0.426	-1.183	0.886	0.604	0.156	0.469	-0.367	0.476	1.747

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	-8.1019	-8.0936	-8.8336	-9.5477	-10.2277	-10.455	-10.4550	-10.4550
S.E_Logq	0.6054	0.4579	0.3854	0.3909	0.4196	0.492	0.3913	0.7746

Fleet: BTS-Combined

Log catchability residuals.

age \ year	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.097	0.362	0.367	0.18	-0.098	0.168	0.098	-0.169
2	0.415	-0.786	0.288	0.192	-0.275	-0.22	-0.159	0.098
3	0.122	-0.516	0.185	0.344	-0.127	-0.222	-0.531	0.083
4	-0.308	-0.202	-0.062	0.078	-0.356	-0.21	-0.068	-0.214
5	-0.151	-0.156	0.135	-0.04	0.184	-0.413	0.082	0.385
6	-0.152	-0.068	0.015	0.466	-0.018	-0.333	-0.505	0.342
7	-0.582	-0.802	0.127	-0.27	0.365	-0.525	-0.122	-0.1
8	-0.263	0.268	0.397	0.437	0.233	-0.292	0.055	0.284
9	-0.288	0.23	-0.059	-0.031	-0.393	0.027	-0.108	0.295

age \ year	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	-0.352	-0.238	-0.59	-0.019	-0.211	0.272	-0.063	0.107	0.284
2	0.098	-0.409	0.038	-0.049	0.139	0.13	-0.05	0.306	0.246
3	0.148	-0.017	-0.247	0.115	0.158	0.048	0.06	0.148	0.249
4	0.407	-0.247	0.377	0.083	0.421	0.071	0.114	0.083	0.036
5	-0.497	-0.305	-0.359	0.102	0.147	0.335	0.202	0.272	0.076
6	0.38	0.13	-0.33	-0.146	0.446	-0.192	-0.043	0.219	-0.211
7	0.174	0.323	-0.184	-0.092	0.216	-0.044	0.271	0.022	-0.33
8	0.067	-0.42	0.135	0.015	0.372	0.176	0.149	0.177	-0.293
9	-0.096	0.314	0.193	-0.456	0.687	-0.018	0.112	-0.735	0.013

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	-8.8682	-9.1050	-9.1608	-9.2027	-9.2453	-9.1992	-9.1992	-9.1992	-9.1992
S.E_Logq	0.2654	0.3004	0.2498	0.2432	0.2693	0.2905	0.3327	0.2607	0.3321

```
 Fleet:  SNS

 Log catchability residuals.

   year
age     1982   1983   1984   1985   1986   1987   1988   1989   1990   1991
1       0.498  0.211  0.573  -0.311 -0.037 -0.221 -0.023 0.299  0.083  1.089
2       0.755  0.45   0.616  0.945  0.013  0.585  0.569  0.863  0.304  0.884
3       0.411  -1.055 0.469  0.434  0.229  0.036  1.507  1.173  0.895  0.495

   year
age     1992   1993   1994   1995   1996   1997   1998   1999   2000   2001
1       1.03   0.664  0.663  -0.077 -0.273 0.624  0.663  0.57   0.003  -0.117
2       1.259  0.986  0.703  0.235  0.589  -0.199 0.964  0.986  -0.576 -0.394
3       1.105  0.407  0.309  -0.091 1.176  -0.444 2.031  1.87   0.098  -0.498

   year
age     2002   2003   2004   2005   2006   2007   2008   2009   2010   2011   2012
1       -0.199 NA     -0.413 -0.527 -0.44  -0.648 -0.46  -0.513 -0.901 -0.75  -1.06
2       -0.9   NA     -0.567 -1.186 -0.824 -0.639 -0.919 -1.059 -1.252 -1.95  -1.241
3       -1.029 NA     -0.239 -1.123 -1.104 -1.583 -0.661 -1.18  -0.975 -1.621 -1.043

 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 -3.6173 -4.6433 -5.7241
S.E_Logq   0.5667  0.8850  1.0170
```

Terminal year survivor and F summaries:

```
Age =  1 .  Catchability constant w.r.t. time and dependent on age
 Year class =  2011

Fleet =  BTS-Combined
                     1
Survivors   784391.000
Raw weights      9.689


Fleet =  fshk
                    1
Survivors   676935.00
Raw weights      0.25


Fleet =  SNS
                     1
Survivors   204611.000
Raw weights      2.628


 Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "784391"     "0.3"     "Inf"     "Inf"     "1" "0.771"     "0.105"
[2,] "fshk"         "676935"     "1.868"   "Inf"     "Inf"     "1" "0.02"      "0.121"
[3,] "SNS"          "204611"     "0.576"   "Inf"     "Inf"     "1" "0.209"     "0.353"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "590505" ""       ""       ""        "0.137"


Age =  2 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2010

Fleet =  BTS-Combined
                       2           1
Survivors   1205320.000 1047995.000
Raw weights       7.946       7.798
```

```
Fleet =  fshk
                    2
Survivors   806942.00
Raw weights      0.25


Fleet =  SNS
                     2          1
Survivors   272250.000 445177.000
Raw weights      0.938      2.115


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimat-
ed F
[1,] "BTS-Combined" "1124647"    "0.215"   "0.07"    "0.326"   "2" "0.827"     "0.236"
[2,] "fshk"         "806942"     "1.742"   "Inf"     "Inf"     "1" "0.013"     "0.315"
[3,] "SNS"          "382758"     "0.485"   "0.227"   "0.468"   "2" "0.16"      "0.577"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "942103" ""       ""       ""        "0.276"


Age =  3 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2009

Fleet =  BTS-Combined
                     3          2          1
Survivors   680314.000 720020.000 498040.000
Raw weights      8.473      6.658      6.108


Fleet =  fshk
                    3
Survivors   533280.00
Raw weights      0.25


Fleet =  SNS
                     3         2         1
Survivors   186855.000 75399.000 215448.000
Raw weights      0.713     0.786     1.657


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimat-
ed F
[1,] "BTS-Combined" "633108"     "0.177"   "0.109"   "0.616"   "3" "0.862"     "0.232"
[2,] "fshk"         "533280"     "1.746"   "Inf"     "Inf"     "1" "0.01"      "0.27"
[3,] "SNS"          "160629"     "0.443"   "0.311"   "0.702"   "3" "0.128"     "0.707"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "530204" ""       ""       ""        "0.271"


Age =  4 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2008

Fleet =  BTS-Combined
                     4          3          2          1
Survivors   321875.000 360242.000 295328.000 407754.000
Raw weights      8.735      7.153      5.119      4.657


Fleet =  fshk
                    4
Survivors   307697.00
Raw weights      0.25


Fleet =  SNS
                     3         2         1
```

```
Survivors   61392.000 88819.000 185948.000
Raw weights     0.602     0.604      1.263


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "340800"     "0.156"   "0.063"   "0.404"   "4" "0.904"     "0.221"
[2,] "fshk"         "307697"     "1.773"   "Inf"     "Inf"     "1" "0.009"     "0.243"
[3,] "SNS"          "118439"     "0.446"   "0.339"   "0.76"    "3" "0.087"     "0.538"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "310579" ""       ""       ""        "0.241"


Age =  5 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2007

Fleet =  BTS-Combined
                     5        4          3          2          1
Survivors   208578.000 209929.0 205311.000 220184.000 156494.000
Raw weights      8.876      6.7      5.409      3.744      3.425


Fleet =  fshk
                    5
Survivors   211828.00
Raw weights      0.25


Fleet =  SNS
                    3         2          1
Survivors   72874.000 67051.000 121988.000
Raw weights     0.455     0.442      0.929


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "202566"     "0.143"   "0.049"   "0.343"   "5" "0.931"     "0.215"
[2,] "fshk"         "211828"     "1.788"   "Inf"     "Inf"     "1" "0.008"     "0.207"
[3,] "SNS"          "92818"      "0.447"   "0.198"   "0.443"   "3" "0.06"      "0.422"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "193308" ""       ""       ""        "0.225"


Age =  6 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2006

Fleet =  BTS-Combined
                    6          5          4          3          2          1
Survivors   1.506e+05 244142.000 208435.000 195130.000 213653.000 182427.000
Raw weights 9.565e+00      7.746      6.265      4.993      3.349      3.298


Fleet =  fshk
                    6
Survivors   188001.00
Raw weights      0.25


Fleet =  SNS
                   3         2         1
Survivors   57128.00 74201.000 97261.000
Raw weights     0.42     0.395     0.894


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "193766"     "0.132"   "0.079"   "0.598"   "6" "0.947"     "0.144"
[2,] "fshk"         "188001"     "1.856"   "Inf"     "Inf"     "1" "0.007"     "0.148"
[3,] "SNS"          "80160"      "0.446"   "0.157"   "0.352"   "3" "0.046"     "0.318"
```

```
 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "186019" ""       ""       ""        "0.15"


Age =  7 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2005

Fleet =  BTS-Combined
                    7          6          5          4          3         2
1
Survivors   67820.000 117462.000 115522.000 101322.000 110473.000 89826.000 52285.000
Raw weights     7.349      9.107      7.813      6.329      4.866     2.871     2.283


Fleet =  fshk
                   7
Survivors   60665.00
Raw weights     0.25


Fleet =  SNS
                   3        2         1
Survivors   48730.00 4.98e+04 60786.000
Raw weights     0.41 3.39e-01     0.619


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "96419"      "0.127"   "0.101"   "0.795"   "7" "0.962"     "0.071"
[2,] "fshk"         "60665"      "1.929"   "Inf"     "Inf"     "1" "0.006"     "0.111"
[3,] "SNS"          "54149"      "0.462"   "0.075"   "0.162"   "3" "0.032"     "0.123"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "94375"  ""       ""       ""        "0.073"


Age =  8 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2004

Fleet =  BTS-Combined
                    8         7         6         5         4         3         2
1
Survivors   33370.000 45724.00 42813.000 62523.000 68132.000 50135.00 46430.000 35253.000
Raw weights    10.398     6.63     7.788     6.159     4.605     2.96     1.587     1.459


Fleet =  fshk
                   8
Survivors   34619.00
Raw weights     0.25


Fleet =  SNS
                   3         2         1
Survivors   9181.000 19615.000 26397.000
Raw weights    0.249     0.187     0.396


     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
F
[1,] "BTS-Combined" "45608"      "0.126"   "0.093"   "0.738"   "8" "0.975"     "0.065"
[2,] "fshk"         "34619"      "1.935"   "Inf"     "Inf"     "1" "0.006"     "0.085"
[3,] "SNS"          "17995"      "0.46"    "0.322"   "0.7"     "3" "0.02"      "0.157"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "44715"  ""       ""       ""        "0.066"
```

```
                Age =  9 .  Catchability constand w.r.t. time and dependant on age
                 Year class =  2003

Fleet =  BTS-Combined
                    9         8          7        6         5         4         3         2         1
Survivors   82560.000 97286.000 106844.000 67293.00 94439.000 88569.000 63669.000 54159.000 57326.000
Raw weights     8.215     9.796      6.353     7.92     6.752     5.442     3.505     2.034     1.744


                Fleet =  fshk
                                  9
                Survivors   19552.00
                Raw weights     0.25


                Fleet =  SNS
                                   3        2         1
                Survivors   27017.000 24912.00 53945.000
                Raw weights     0.295     0.24     0.473


                     Fleet          Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated
                F
                [1,] "BTS-Combined" "83381"      "0.116"   "0.069"   "0.595"   "9" "0.976"     "0.038"
                [2,] "fshk"         "19552"      "1.962"   "Inf"     "Inf"     "1" "0.005"     "0.151"
                [3,] "SNS"          "36655"      "0.459"   "0.258"   "0.562"   "3" "0.019"     "0.083"


                 Weighted prediction:

                     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
                [1,] "81528"  ""       ""       ""        "0.038"
```

Table 8.3.2 . Plaice in IV . harvest

2013-05-17 13:29:52 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	0.575	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	0.729	0.717	0.584	0.677	0.791	0.791
1987	0.218	0.645	0.685	0.741	0.789	0.659	0.801	0.528	0.730	0.730
1988	0.233	0.624	0.668	0.685	0.727	0.703	0.681	1.000	0.816	0.816
1989	0.212	0.584	0.614	0.629	0.655	0.644	0.639	0.664	1.391	1.391
1990	0.162	0.477	0.579	0.571	0.694	0.608	0.544	0.505	0.652	0.652
1991	0.239	0.607	0.662	0.692	0.633	0.725	0.694	0.697	0.751	0.751
1992	0.214	0.557	0.655	0.679	0.789	0.569	0.602	0.753	1.195	1.195
1993	0.220	0.486	0.604	0.642	0.749	0.695	0.401	0.425	1.040	1.040
1994	0.163	0.481	0.603	0.703	0.621	0.646	0.867	0.300	0.328	0.328
1995	0.121	0.460	0.643	0.766	0.743	0.589	0.670	0.592	0.156	0.156
1996	0.096	0.546	0.685	0.719	0.733	0.643	0.725	0.666	0.762	0.762
1997	0.065	0.793	0.927	0.752	0.757	0.699	0.583	0.525	0.706	0.706
1998	0.154	0.495	0.995	1.071	0.631	0.431	0.518	0.413	0.456	0.456
1999	0.174	0.479	0.519	1.168	0.633	0.498	0.297	0.412	0.418	0.418
2000	0.119	0.366	0.334	0.579	0.546	0.476	0.284	0.177	0.267	0.267
2001	0.070	0.720	0.989	0.904	0.801	0.420	0.383	0.190	0.123	0.123
2002	0.208	0.591	0.516	0.628	0.688	0.443	0.491	0.230	0.164	0.164
2003	0.144	0.617	0.614	0.470	0.676	0.631	0.456	0.271	0.111	0.111
2004	0.213	0.648	0.459	0.493	0.237	0.512	0.342	0.137	0.094	0.094
2005	0.144	0.485	0.460	0.352	0.436	0.237	0.428	0.278	0.082	0.082
2006	0.289	0.564	0.440	0.394	0.238	0.224	0.118	0.290	0.192	0.192
2007	0.075	0.468	0.442	0.216	0.274	0.170	0.112	0.087	0.092	0.092
2008	0.149	0.340	0.263	0.291	0.160	0.144	0.143	0.093	0.020	0.020
2009	0.154	0.308	0.227	0.211	0.235	0.120	0.097	0.083	0.035	0.035
2010	0.146	0.275	0.214	0.212	0.153	0.180	0.092	0.073	0.032	0.032
2011	0.078	0.181	0.200	0.281	0.211	0.126	0.109	0.088	0.050	0.050
2012	0.137	0.276	0.271	0.241	0.225	0.150	0.073	0.066	0.038	0.038

Table 8.3.3 . Plaice in IV . stock.n

2013-05-17 13:29:52 units= thousands

year \ age	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	863656	824074	649344	91063	61664	50167	33777	16196	10472	49969
1976	690882	547455	450763	344032	46232	29867	23863	18564	8669	36768
1977	988525	447474	328495	264542	200135	28227	17326	12697	10564	23797
1978	916912	647274	251974	180542	144557	92475	16708	10044	6704	20610
1979	897641	612800	383517	144885	103268	83662	50562	9670	6014	19781
1980	1133017	532100	294784	179378	67118	47408	37487	22744	4798	13829
1981	864110	808920	302023	136514	86718	36325	25445	20629	12406	15024
1982	2017349	654034	450283	151916	66861	43405	20768	13758	10828	20823
1983	1300623	1430938	351400	201885	69115	32706	23138	11511	7203	19759
1984	1253402	927055	766452	179537	85600	33826	17285	13156	6426	15433
1985	1843646	838501	481337	385693	88388	40547	17642	9536	6695	14158
1986	4742670	1282473	471676	266102	173186	49389	21988	9520	5204	13133
1987	1940786	3226921	629924	225498	126593	75589	21818	11093	4378	10956
1988	1763947	1412208	1531883	287384	97239	52052	35395	8858	5917	11553
1989	1179418	1264489	684770	711005	131120	42529	23317	16216	2948	7657
1990	1032279	863113	637946	335377	342973	61608	20220	11136	7554	8294
1991	910966	794367	484625	323643	171410	155086	30337	10624	6080	10709
1992	776050	648742	391764	226217	146572	82380	67948	13712	4788	10207
1993	530851	567022	336473	184085	103815	60248	42213	33673	5841	9331
1994	443156	385443	315661	166469	87628	44418	27212	25576	19912	20090
1995	1164559	340601	215606	156253	74592	42602	21070	10352	17151	27582
1996	1293234	933340	194586	102570	65748	32117	21398	9752	5182	9599
1997	2150529	1063307	489351	88775	45240	28589	15276	9373	4536	8696
1998	772178	1822661	435386	175155	37851	19192	12856	7713	5015	8900
1999	841934	599072	1005704	145693	54289	18221	11288	6933	4617	9358
2000	990682	640189	335607	541641	40996	26083	10016	7593	4153	9218
2001	543329	795559	401663	217516	274590	21482	14658	6823	5754	20864
2002	1738750	458512	350361	135145	79714	111581	12776	9041	5106	10936
2003	535148	1277425	229854	189299	65279	36248	64809	7076	6497	8560
2004	1277425	419160	623390	112518	107092	30035	17450	37183	4882	6394
2005	757746	933775	198303	356443	62194	76462	16284	11211	29323	8193
2006	925023	593880	520340	113306	226767	36389	54580	9601	7686	8140
2007	1141959	626906	305814	303257	69143	161735	26320	43877	6499	15175
2008	1033808	958607	355248	177881	221193	47571	123433	21296	36380	48424
2009	1105451	806331	617550	247158	120323	170609	37278	96814	17565	24303
2010	1301776	857386	536009	445297	181165	86109	136874	30610	80598	41446
2011	1639567	1018155	589239	391542	325879	140633	65093	112941	25747	58610
2012	748405	1371745	768417	436606	267429	238788	112148	52803	93618	50716

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	863656	297129	195235	108536	86699	0.58	0.39	0.43	0.37
1976	690882	308563	166917	113670	53247	0.42	0.30	0.27	0.37
1977	988525	312575	176689	119188	57501	0.51	0.34	0.31	0.38
1978	916912	298626	159639	113984	45655	0.46	0.35	0.22	0.38
1979	897641	296725	213282	145347	67935	0.67	0.49	0.36	0.49
1980	1133017	272366	171485	140405	31080	0.56	0.50	0.15	0.52
1981	864110	262318	173596	140565	33031	0.55	0.48	0.16	0.54
1982	2017349	260518	204508	155381	49127	0.61	0.52	0.22	0.60
1983	1300623	309625	219386	144903	74483	0.60	0.49	0.27	0.47
1984	1253402	317004	227848	157032	70816	0.59	0.43	0.28	0.50
1985	1843646	339039	221419	160870	60549	0.53	0.44	0.23	0.47
1986	4742670	365451	296472	166519	129953	0.67	0.50	0.34	0.46
1987	1940786	441993	345628	155104	190524	0.70	0.49	0.51	0.35
1988	1763947	382317	312684	156261	156423	0.68	0.41	0.52	0.41
1989	1179418	405147	279112	171319	107793	0.63	0.39	0.47	0.42
1990	1032279	365679	229016	157791	71225	0.59	0.40	0.40	0.43
1991	910966	335153	230278	149343	80935	0.66	0.43	0.48	0.45
1992	776050	272722	183326	126277	57049	0.65	0.43	0.41	0.46
1993	530851	236245	153043	118027	35016	0.64	0.50	0.28	0.50
1994	443156	213939	135227	111442	23785	0.61	0.51	0.24	0.52
1995	1164559	203486	121063	99235	21828	0.64	0.55	0.21	0.49
1996	1293234	182194	134647	82598	52049	0.66	0.51	0.34	0.45
1997	2150529	207232	184297	84152	100145	0.79	0.51	0.69	0.41
1998	772178	229179	176282	72531	103751	0.72	0.38	0.60	0.32
1999	841934	203872	152696	81720	70976	0.66	0.37	0.39	0.40
2000	990682	230893	126783	82472	44311	0.46	0.31	0.26	0.36
2001	543329	274860	183182	82873	100309	0.77	0.31	0.71	0.30
2002	1738750	199705	125777	71387	54390	0.57	0.37	0.42	0.36
2003	535148	230255	144964	67172	77792	0.60	0.38	0.45	0.29
2004	1277425	211780	116536	62070	54466	0.47	0.28	0.43	0.29
2005	757746	250590	110133	56257	53876	0.39	0.20	0.37	0.22
2006	925023	258787	120299	58453	61846	0.37	0.19	0.39	0.23
2007	1141959	266148	89783	50348	39435	0.31	0.15	0.36	0.19
2008	1033808	367312	95309	49434	45875	0.24	0.14	0.22	0.13
2009	1105451	401206	100671	55446	45225	0.22	0.12	0.21	0.14
2010	1301776	500323	106980	61163	45817	0.21	0.11	0.19	0.12
2011	1639567	493596	108523	67963	40560	0.20	0.11	0.14	0.14
2012	748405	540278	132903	73830	59073	0.23	0.11	0.23	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	1132775	822021	7183	15366.4	8168.4	-11	-11	-11
1974	864859	548602	568.1	11628.2	2402.6	-11	-11	-11
1975	693092	449542	314.4	8536.5	3423.8	-11	-11	-11
1976	989338	648015	1166	18536.7	12678	-11	-11	-11
1977	914118	610233	372.5	14012	9828.8	-11	-11	-11
1978	895153	529846	267.5	21495.4	12882.3	-11	-11	-11
1979	1133652	809508	29058.1	59174.2	18785.3	-11	-11	-11
1980	868626	658124	210.4	24756.2	8642	-11	-11	-11
1981	2035162	1447072	35506.4	69993.3	13908.6	-11	-11	-11
1982	1312130	937458	24401.9	33974.2	10412.8	-11	-11	-11
1983	1263687	847805	32941.9	44964.5	13847.8	-11	173.9	-11
1984	1853892	1291741	7918.3	28100.5	7580.4	136.8	131.7	-11
1985	4775439	3256552	47256.4	93551.9	32991.1	667.4	764.2	-11
1986	1970104	1438737	8819.9	33402.4	14421.1	225.8	147	-11
1987	1776234	1275608	21334.9	36608.6	17810.2	680.2	319.3	-11
1988	1189264	872002	15669.7	34276.3	7496	467.9	146.1	-11
1989	1039262	800662	24585.3	25036.6	11247.2	185.3	159.4	-11
1990	918015	655070	368.5	57221.3	13841.8	291.4	174.5	439.59
1991	781976	572330	7256.7	46798.2	9685.6	360.9	283.4	332.36
1992	532656	387004	472.5	22098.3	4976.6	189	77.1	180.31
1993	445836	342990	234.3	19188.4	2796.4	193.3	40.6	216.99
1994	1167369	935840	26781.3	24767	10268.2	265.6	206.9	283.44
1995	1296449	1066201	12541.3	23015.4	4472.7	310.3	59.2	146.08
1996	2160323	1831514	84041.8	95900.9	30242.2	1046.8	402.7	619.61
1997	777736	604098	7344.1	33665.7	10272.1	347.6	121.6	229.24
1998	845152	643092	5521.6	32951.3	2493.4	293.3	69.3	-11
1999	987140	792274	9262.3	22855	2898.5	267.5	72.2	-11
2000	544499	459528	4213.5	11510.5	1102.7	206.5	44.5	124.93
2001	1729930	1269420	99628	30809.2	-11	519.2	159.1	313.18
2002	528876	413472	1202	-11	1349.7	132.8	39.6	122.91
2003	1270058	927104	-11	18201.6	1818.9	233.7	66.2	238.63
2004	770698	605542	3537.2	10118.4	1571	163	36.4	126.74
2005	937388	638099	7390.6	12164.2	2133.9	128.6	67.2	85.88
2006	1168187	982324	1124.2	14174.5	2700.4	312	120.7	167.99
2007	1014800	789129	40580.9	14705.8	2018.7	221.6	105.2	98.25
2008	150193	196121	50179.3	14860	1811.5	409	84.3	129.71
2009	-11	-11	53258.8	11946.9	1142.515	261	148.2	141.87
2010	-11	-11	49347.24	18348.6	2928.6	486	191.5	179.61
2011	-11	-11	52643	5893.4	-11	241.8	-11	92.96
2012	-11	-11	-11	-11	-11	-11	-11	181.12

Table 8.5.2. North Sea plaice. RCT3 results for age 1 in 2013.

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 40 years : 1973 - 2012
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 0.7493    7.3801 1.3149  0.1636 35  10.715      15.41  1.3976      0.1234
     SNS1 1.5820   -2.1898 0.8052  0.3347 35      NA         NA      NA          NA
     SNS2 0.9561    5.4850 0.7051  0.3997 35      NA         NA      NA          NA
     BTS1 3.1918   -4.2112 1.6091  0.1482 25      NA         NA      NA          NA
     BTS2 1.3058    7.6265 0.7617  0.4279 26      NA         NA      NA          NA
     DFS0 2.5305    0.2675 1.2736  0.1986 17   5.199      13.42  1.3960      0.1237
 VPA Mean     NA        NA     NA      NA 36      NA      13.84  0.5659      0.7528

                  WAP logWAP int.se
yearclass:2012 1177482  13.98  0.491
```

Table 8.5.3. North Sea plaice. RCT3 results for age 2 in 2013.

```
Analysis by RCT3 ver4.0

Plaice

Data for 6 surveys over 40 years : 1973 - 2012
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:2011
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     SNS0 0.5218    9.0447 0.8496  0.2799 35  10.871      14.72  0.9054     0.15054
     SNS1 1.3545   -0.1782 0.6665  0.3782 35   8.682      11.58  0.7502     0.21927
     SNS2 0.9057    5.6310 0.6852  0.3682 35      NA         NA      NA          NA
     BTS1 2.3378    0.3598 1.1289  0.2185 25   5.488      13.19  1.2025     0.08535
     BTS2 1.1075    8.3091 0.6227  0.4685 26      NA         NA      NA          NA
     DFS0 2.1537    2.0268 1.0738  0.2136 17   4.532      11.79  1.2394     0.08034
 VPA Mean     NA        NA     NA      NA 36      NA      13.54  0.5154     0.46450

                  WAP logWAP int.se
yearclass:2011 497663  13.12 0.3513
```

Table 8.6.1. North Sea plaice. Input to the short term forecast (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	1	2013	0.131	0.13	0.00	930070	0.05	0.21	0.05	0.05	0.0	0.1
2	2	2013	0.266	0.25	0.02	590490	0.11	0.25	0.10	0.10	0.5	0.1
3	3	2013	0.249	0.16	0.09	942072	0.21	0.29	0.15	0.17	0.5	0.1
4	4	2013	0.267	0.09	0.17	530181	0.29	0.35	0.19	0.25	1.0	0.1
5	5	2013	0.214	0.04	0.18	310564	0.37	0.40	0.19	0.35	1.0	0.1
6	6	2013	0.166	0.02	0.15	193295	0.44	0.47	0.20	0.43	1.0	0.1
7	7	2013	0.100	0.01	0.09	186004	0.52	0.54	0.21	0.46	1.0	0.1
8	8	2013	0.083	0.01	0.07	94368	0.52	0.56	0.22	0.49	1.0	0.1
9	9	2013	0.044	0.00	0.04	44711	0.60	0.60	0.00	0.53	1.0	0.1
10	10	2013	0.044	0.00	0.04	125683	0.70	0.70	0.00	0.62	1.0	0.1
11	1	2014	0.131	0.13	0.00	930070	0.05	0.21	0.05	0.05	0.0	0.1
12	2	2014	0.266	0.25	0.02	NA	0.11	0.25	0.10	0.10	0.5	0.1
13	3	2014	0.249	0.16	0.09	NA	0.21	0.29	0.15	0.17	0.5	0.1
14	4	2014	0.267	0.09	0.17	NA	0.29	0.35	0.19	0.25	1.0	0.1
15	5	2014	0.214	0.04	0.18	NA	0.37	0.40	0.19	0.35	1.0	0.1
16	6	2014	0.166	0.02	0.15	NA	0.44	0.47	0.20	0.43	1.0	0.1
17	7	2014	0.100	0.01	0.09	NA	0.52	0.54	0.21	0.46	1.0	0.1
18	8	2014	0.083	0.01	0.07	NA	0.52	0.56	0.22	0.49	1.0	0.1
19	9	2014	0.044	0.00	0.04	NA	0.60	0.60	0.00	0.53	1.0	0.1
20	10	2014	0.044	0.00	0.04	NA	0.70	0.70	0.00	0.62	1.0	0.1
21	1	2015	0.131	0.13	0.00	930070	0.05	0.21	0.05	0.05	0.0	0.1
22	2	2015	0.266	0.25	0.02	NA	0.11	0.25	0.10	0.10	0.5	0.1
23	3	2015	0.249	0.16	0.09	NA	0.21	0.29	0.15	0.17	0.5	0.1
24	4	2015	0.267	0.09	0.17	NA	0.29	0.35	0.19	0.25	1.0	0.1
25	5	2015	0.214	0.04	0.18	NA	0.37	0.40	0.19	0.35	1.0	0.1
26	6	2015	0.166	0.02	0.15	NA	0.44	0.47	0.20	0.43	1.0	0.1
27	7	2015	0.100	0.01	0.09	NA	0.52	0.54	0.21	0.46	1.0	0.1
28	8	2015	0.083	0.01	0.07	NA	0.52	0.56	0.22	0.49	1.0	0.1
29	9	2015	0.044	0.00	0.04	NA	0.60	0.60	0.00	0.53	1.0	0.1
30	10	2015	0.044	0.00	0.04	NA	0.70	0.70	0.00	0.62	1.0	0.1

Table 8.6.2. North Sea plaice. Results from the short term forecast assuming $F_{2013} = F_{2012}$ (rescaled)

	year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb2013
25	2013	1	0.232	0.2	0.12	97688	48551	146077	663207

	year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb	ssb2015
2	2014	0.2	0.046	0.04	0.02	21661	9514	31147	735330	868293
5	2014	0.3	0.070	0.06	0.04	32168	14106	46233	735330	852834
8	2014	0.4	0.093	0.08	0.05	42465	18591	61002	735330	837708
11	2014	0.5	0.116	0.10	0.06	52557	22972	75463	735330	822908
14	2014	0.6	0.139	0.12	0.07	62448	27252	89622	735330	808426
17	2014	0.7	0.163	0.14	0.08	72144	31433	103487	735330	794254
20	2014	0.8	0.186	0.16	0.10	81649	35517	117064	735330	780386
23	2014	0.9	0.209	0.18	0.11	90966	39507	130360	735330	766814
26	2014	1.0	0.232	0.20	0.12	100100	43405	143382	735330	753532
29	2014	1.1	0.256	0.22	0.13	109056	47214	156135	735330	740532
32	2014	1.2	0.279	0.24	0.15	117836	50935	168626	735330	727808
35	2014	1.3	0.302	0.26	0.16	126446	54570	180861	735330	715354
38	2014	1.4	0.325	0.29	0.17	134888	58122	192846	735330	703163
41	2014	1.5	0.349	0.31	0.18	143166	61593	204586	735330	691230
44	2014	1.6	0.372	0.33	0.19	151285	64985	216087	735330	679548
47	2014	1.7	0.395	0.35	0.21	159247	68299	227354	735330	668111
50	2014	1.8	0.418	0.37	0.22	167057	71538	238394	735330	656915
53	2014	1.9	0.442	0.39	0.23	174716	74703	249210	735330	645953
56	2014	2.0	0.465	0.41	0.24	182230	77796	259808	735330	635219

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

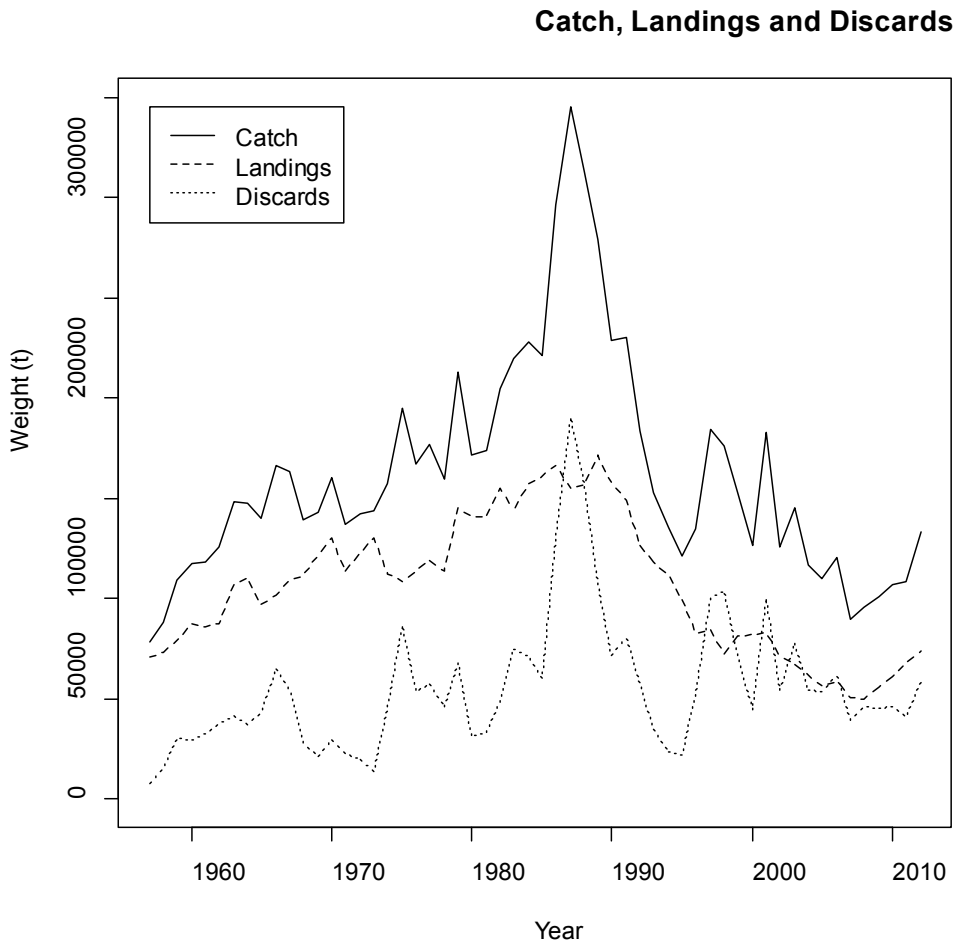


Figure 8.2.1 North Sea plaice. Time series of catch (solid line), landings (dashed line) and discards (dotted line) estimates.

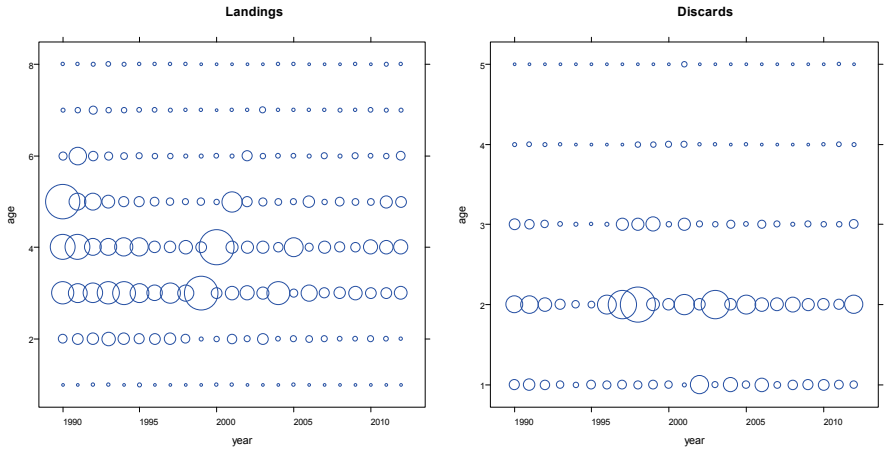


Figure 8.2.2 North Sea plaice. Landing numbers-at-age (left) and discards numbers-at-age (right).

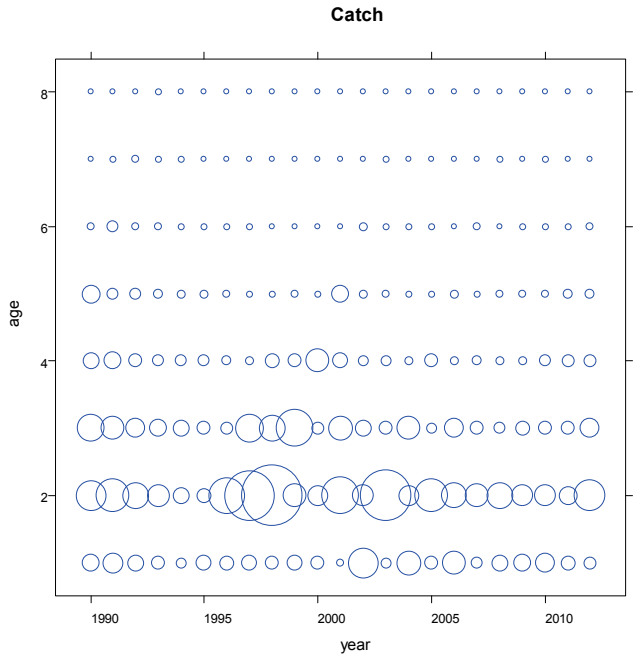


Figure 8.2.3 North Sea plaice. Catch numbers-at-age.

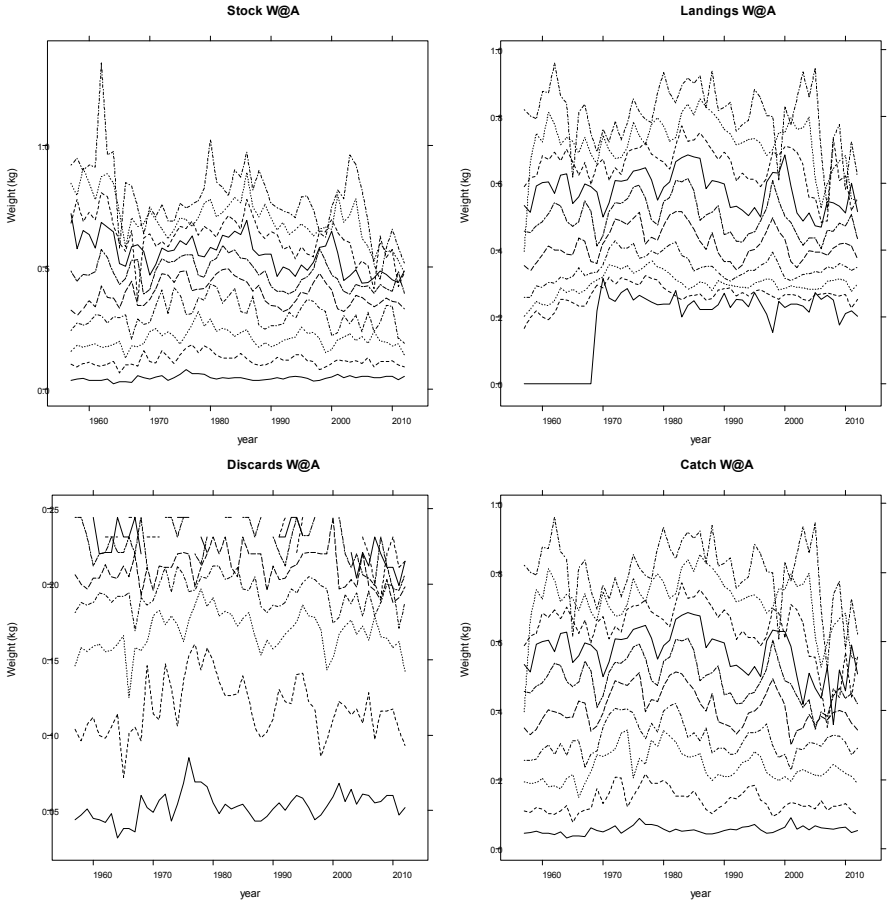


Figure 8.2.4 North Sea plaice. Stock weight-at-age (top left), landings weight-at-age (top right), discards weight-at-age (bottom left) and catch weight-at-age (bottom right).

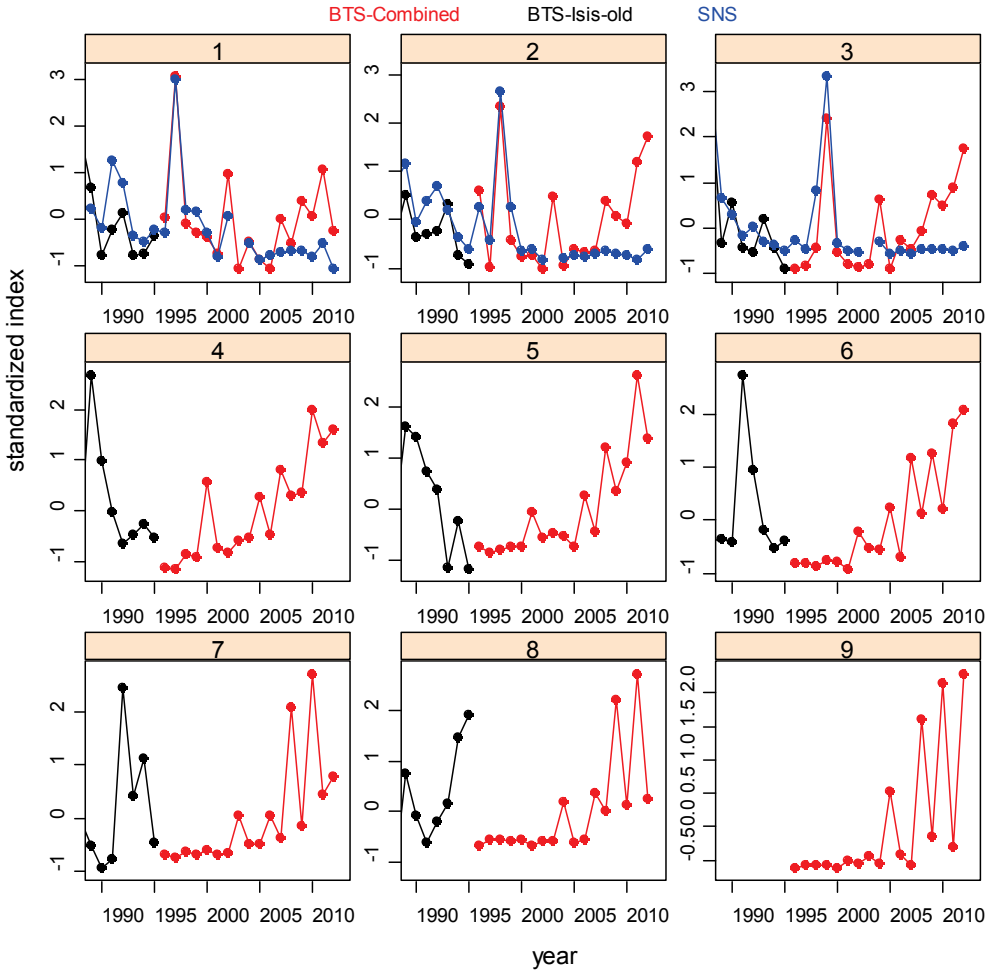


Figure 8.2.5 North Sea plaice. Standardized survey tuning indices used for tuning XSA: BTS-combined (red), BTS-Isis-old (black) and SNS (blue). Note: only ages used in the assessment are presented. The BTS-combined index combines BTS-Tridens and BTS-Isis indices.

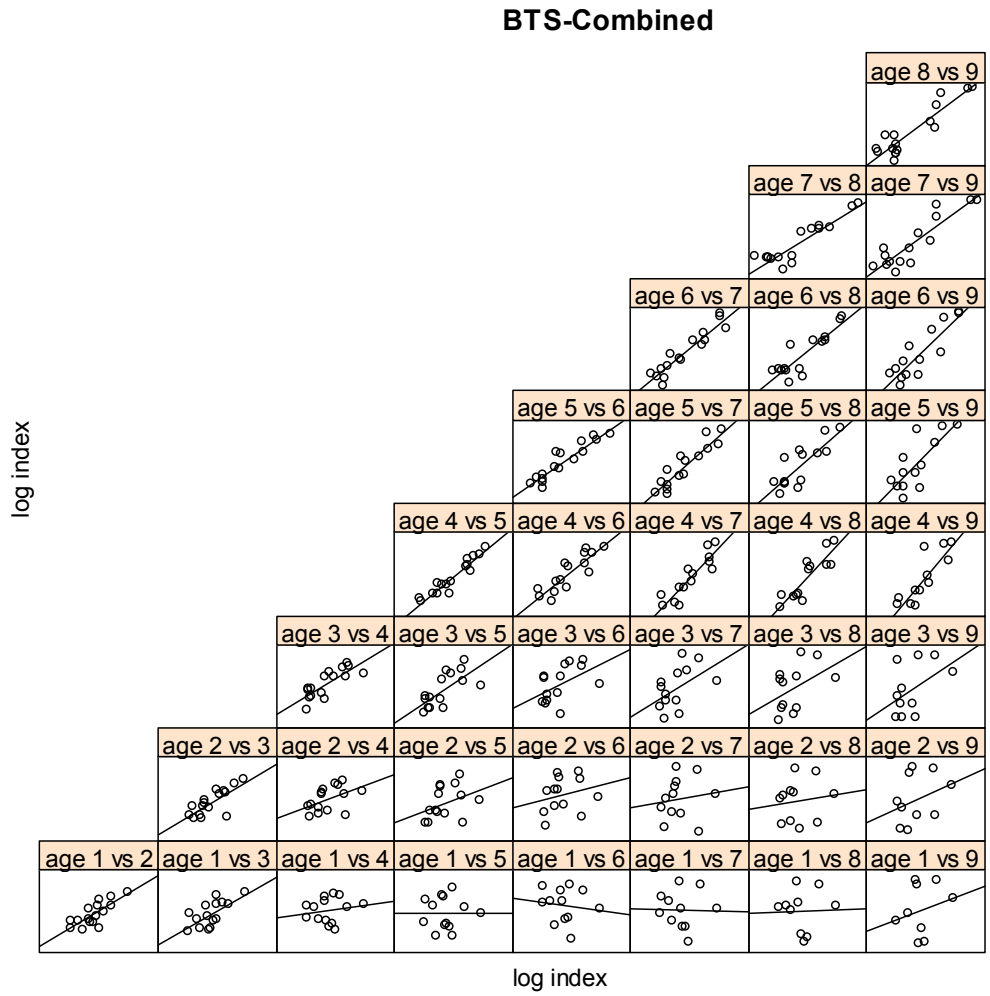


Figure 8.2.6 North Sea plaice. Internal consistency plot for the BTS-combined survey index.

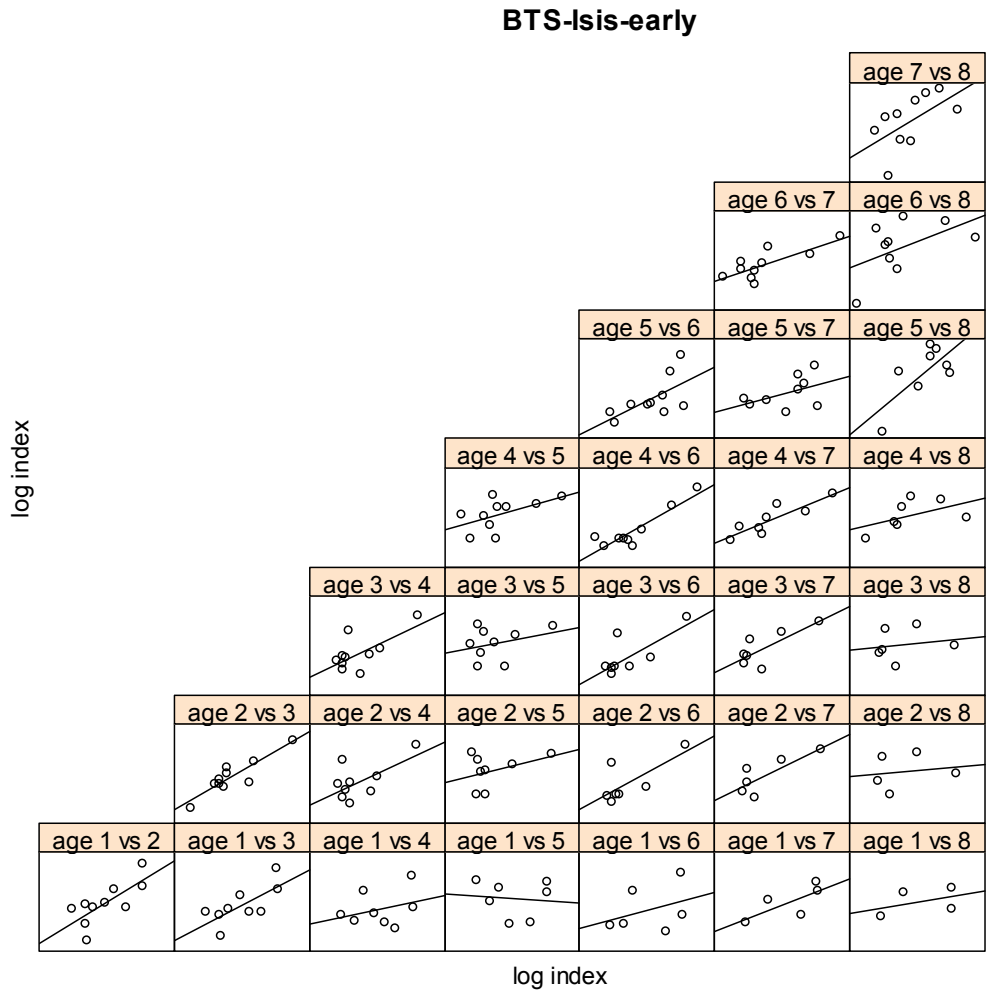


Figure 8.2.7. North Sea plaice. Internal consistency plot for the BTS-Isis-early survey index.

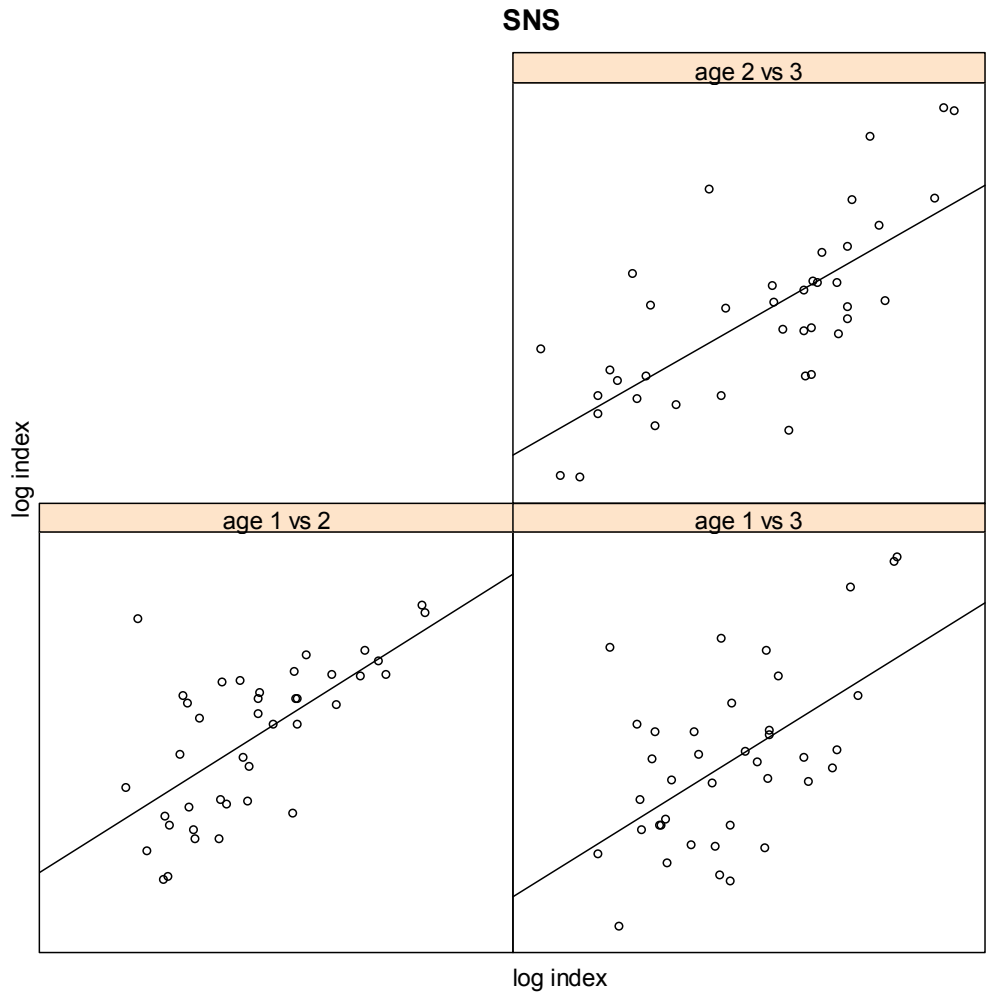


Figure 8.2.8. North Sea plaice. Internal consistency plot for the SNS survey index.

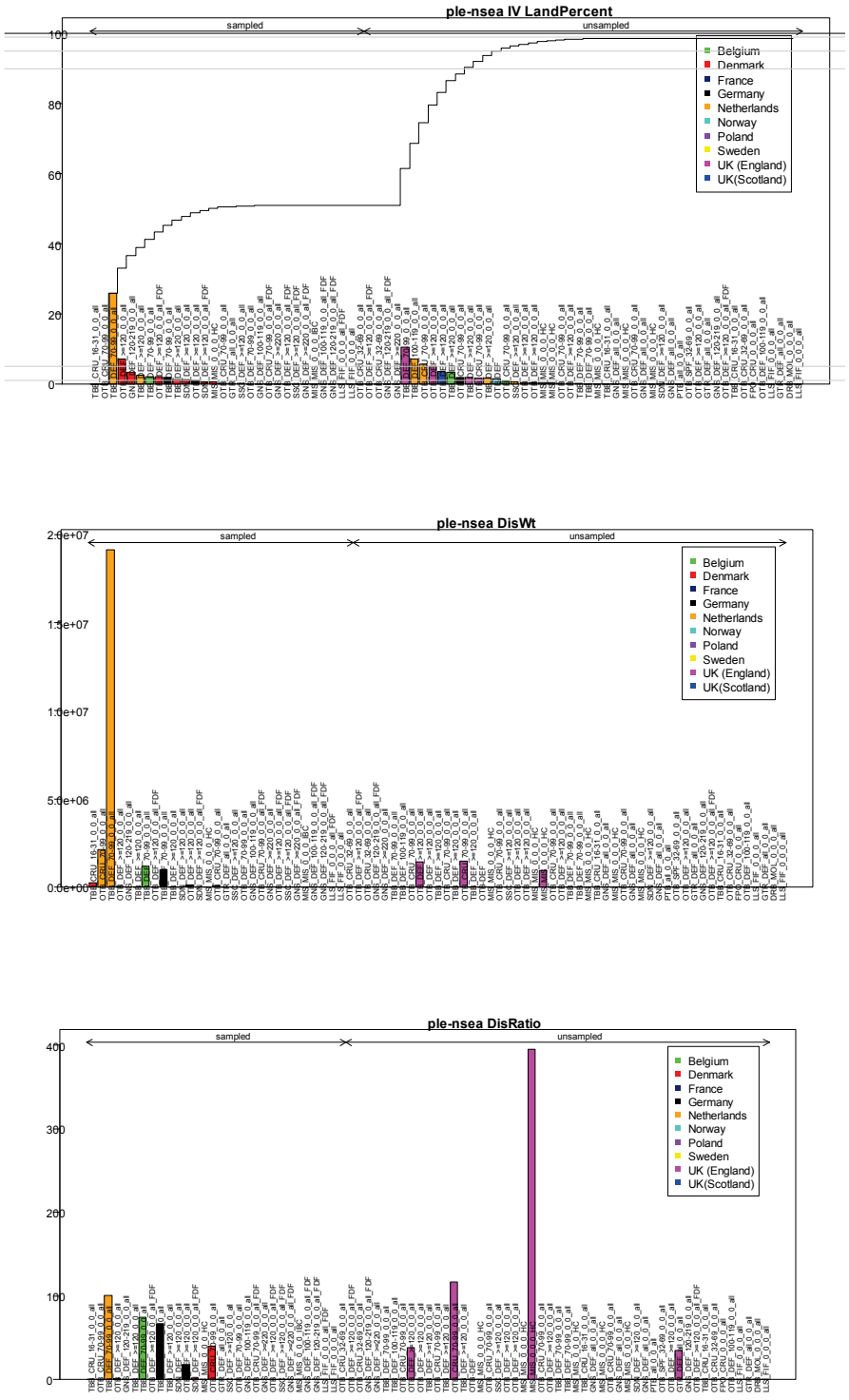


Figure 8.2.9. Data upload in Intercatch: landings % by country by metier (top); discards in weight (kg) by country by metier (middle) and observed discard rates by country by metier (bottom). Sampled and unsampled refers to availability of age-composition information.

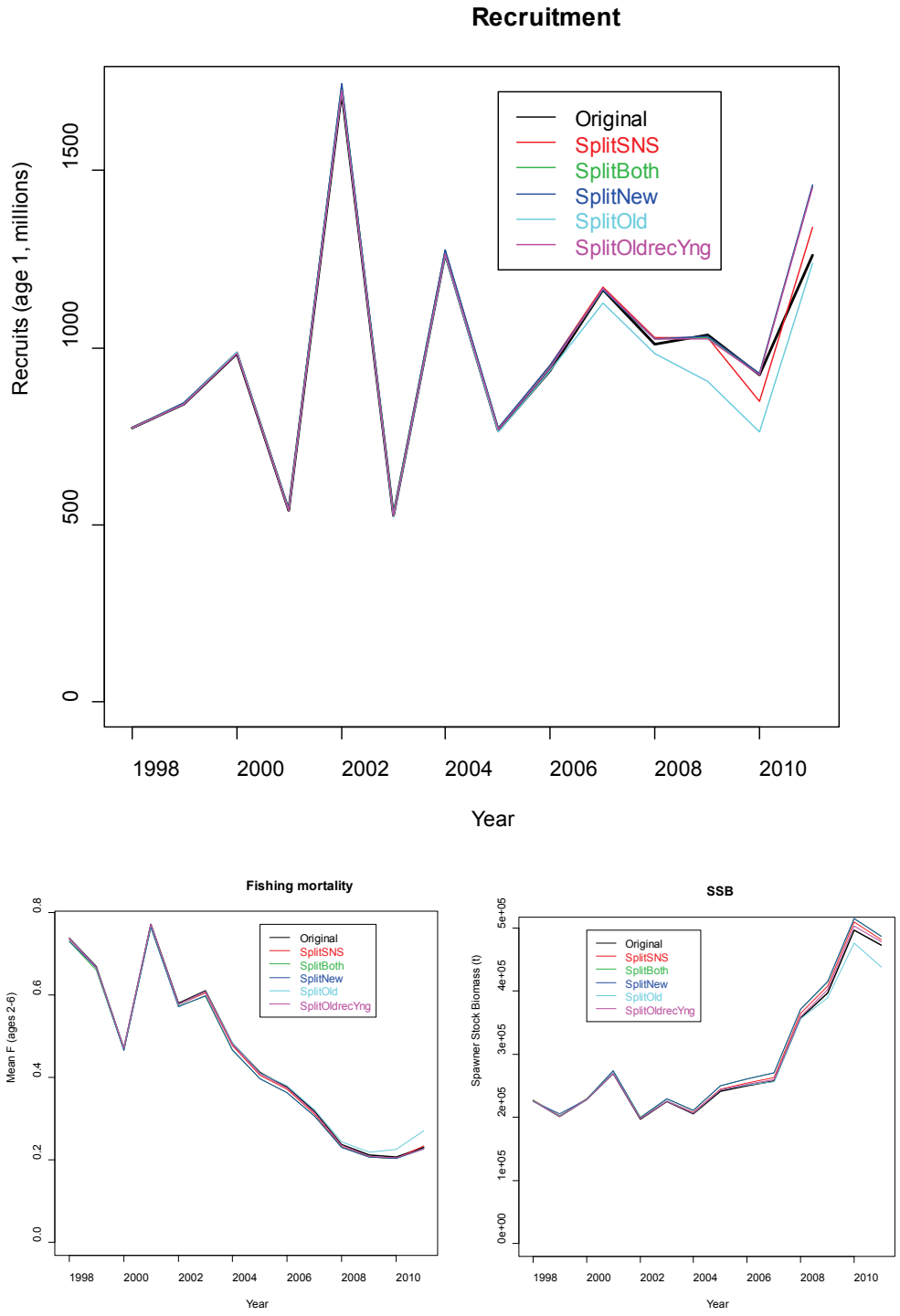


Figure 8.3.1. North Sea plaice. Sensitivity of the assessment with respect to assumptions on catchability of indices over time (by splitting the SNS and/or BTS Tridens indices at the year 200 – see text for details). XSA results with respect to recruitment (top), F (bottom left) and SSB (bottom right) estimates. Note: some lines may be hidden due to near identical outputs.

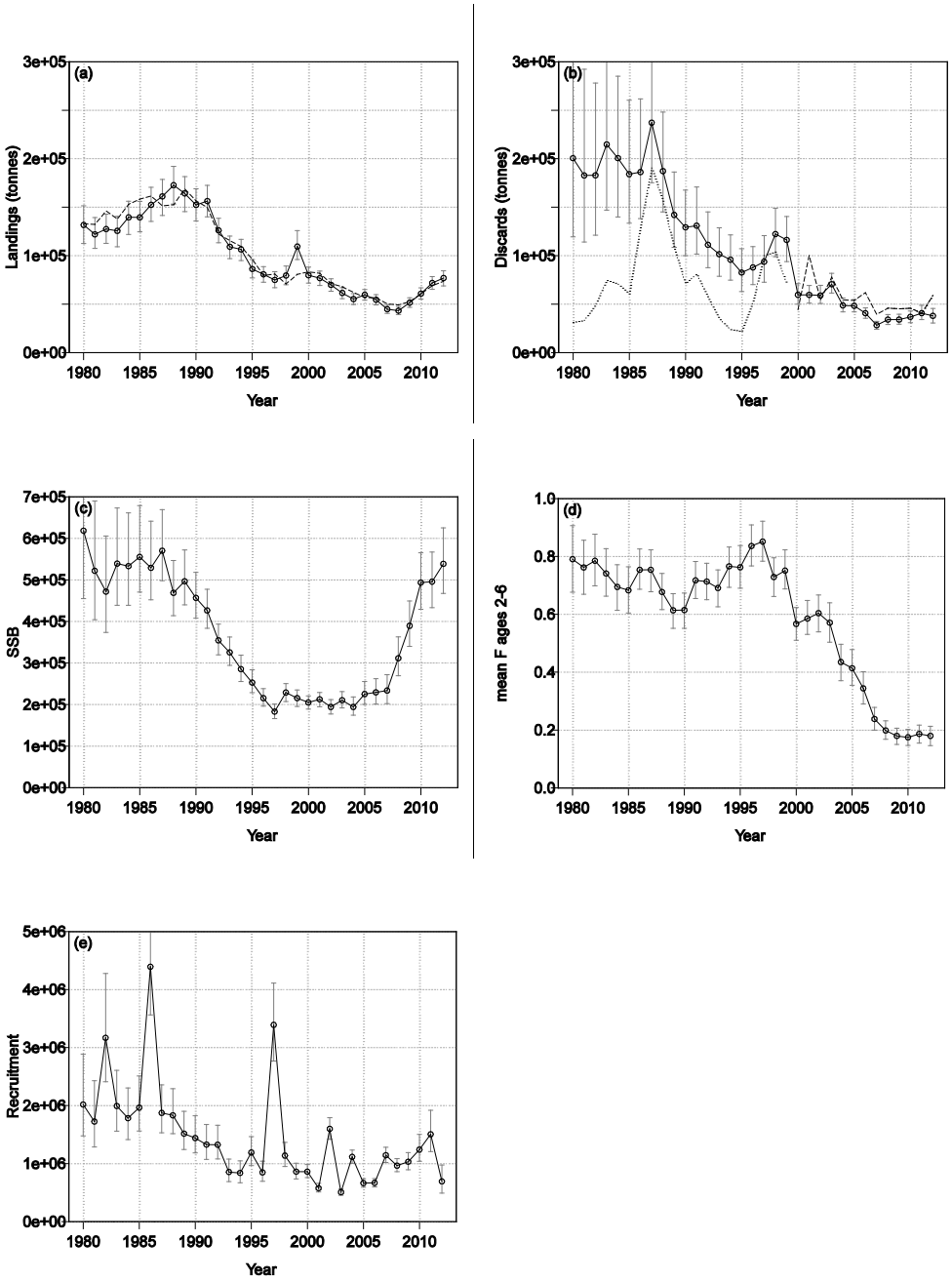


Figure 8.3.2. Statistical Catch at Age model results (see Aarts & Poos 2009) assessment results: (a) Estimated Landings, (b) Discard estimates, (c) SSB, (d) Mean F (ages 2-6), (e) recruitment. Horizontal bars indicate 95% confidence levels.

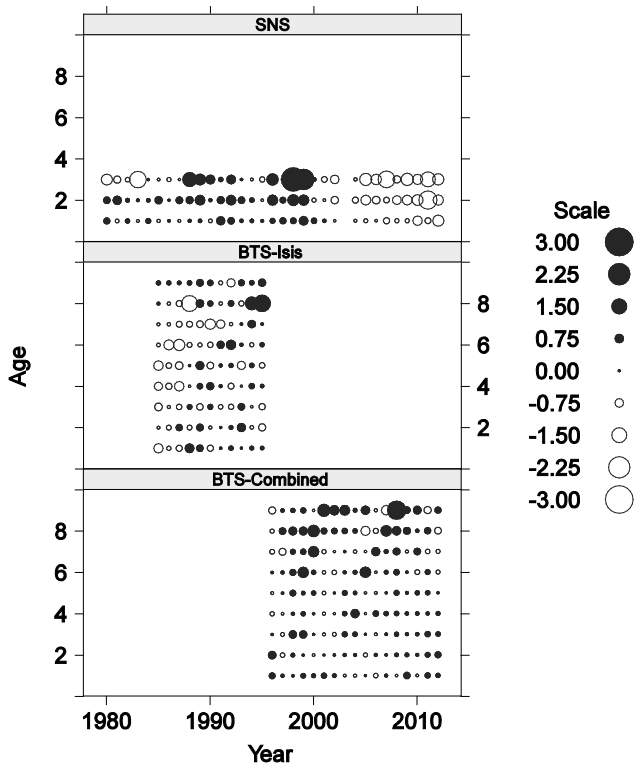


Figure 8.3.3. North Sea plaice. Log catchability residuals for the landings and discard estimates from the SCA model (Aarts and Poos 2009).

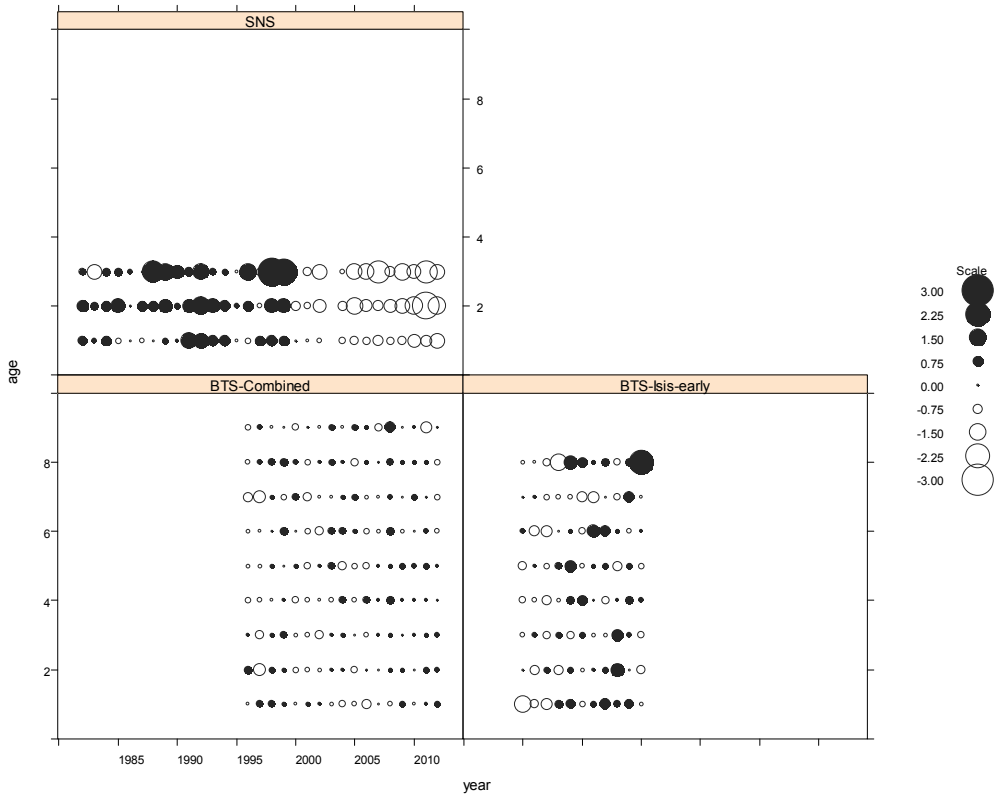


Figure 8.3.4. North Sea plaice. Log catchability residuals for the final XSA run from the three tuning series.

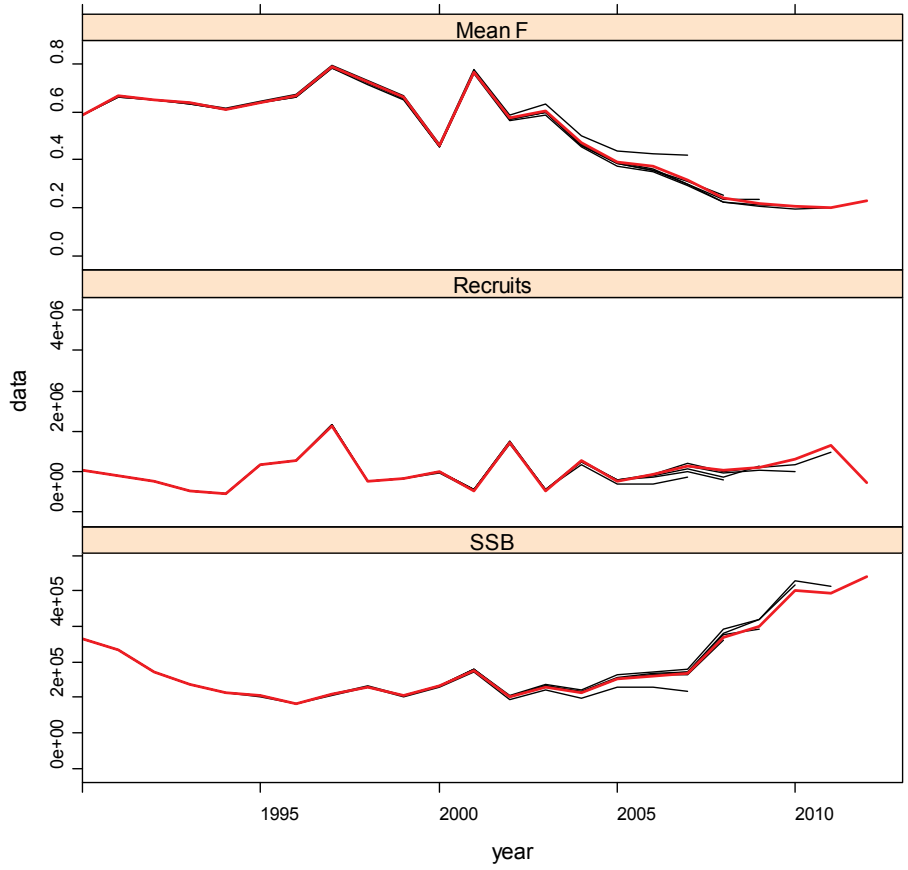


Figure 8.3.5. North Sea plaice. Retrospective pattern of the final XSA run with respect to SSB, recruitment and F.

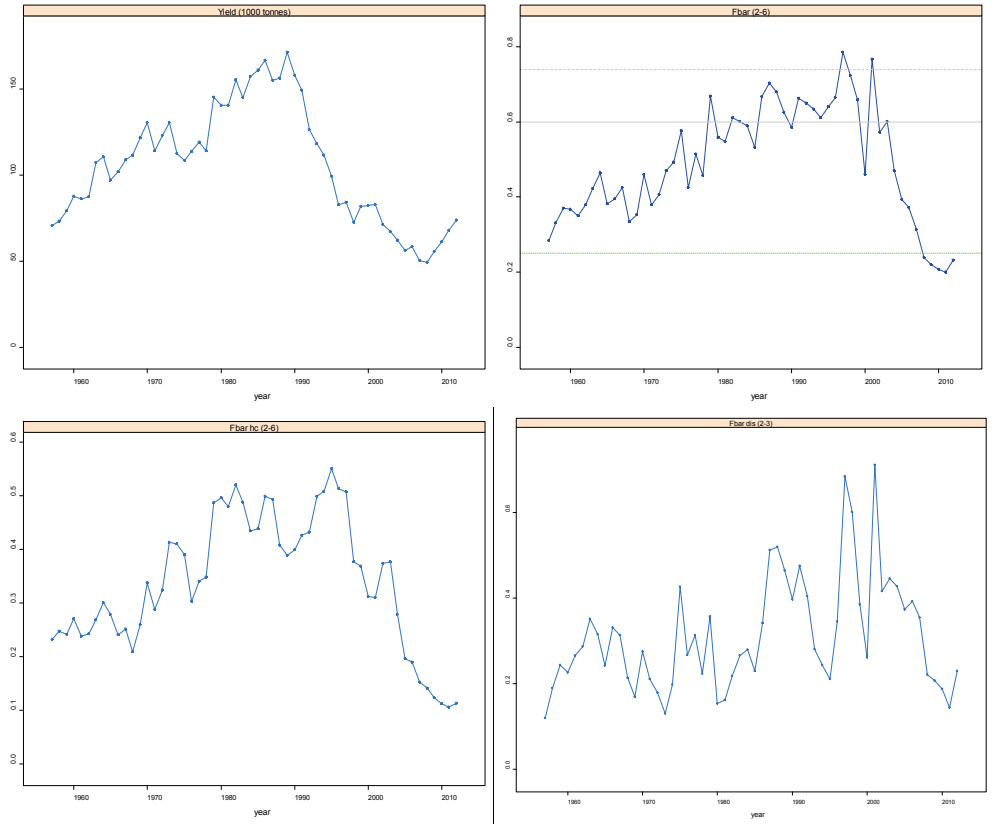


Figure 8.4.1. North Sea plaice. Stock summary figure, time series on Yield (top left), fishing mortality for ages 2-6 (drawn grey line indicates F_{pa}, dashed grey line indicates F_{lim}, green dashed line indicates MP target F; top right), human consumption fishing mortality(bottom left) and fishing mortality of discards ages 2-3 (bottom right)

.

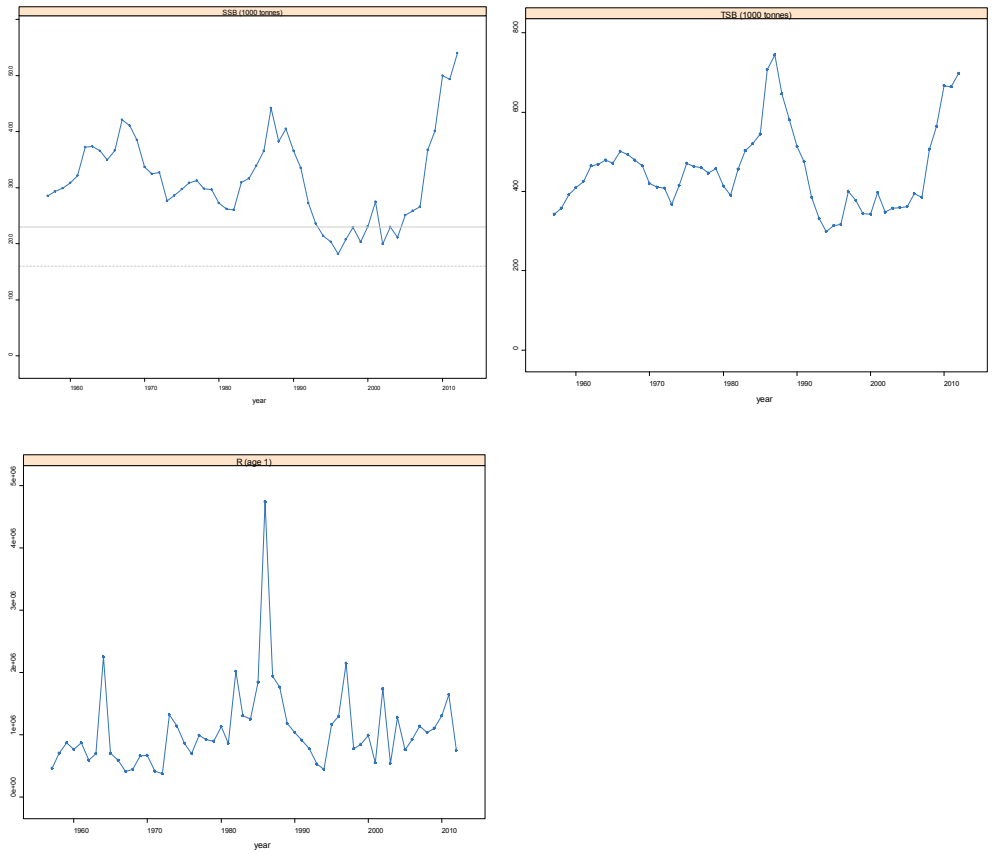


Figure 8.4.2. North Sea plaice. Stock summary figure. Time series of SSB (grey solid line indicates B_{pa}, dashed line indicates B_{lim}; top left), total stock biomass (top right) and recruitment at age 1 (bottom left).

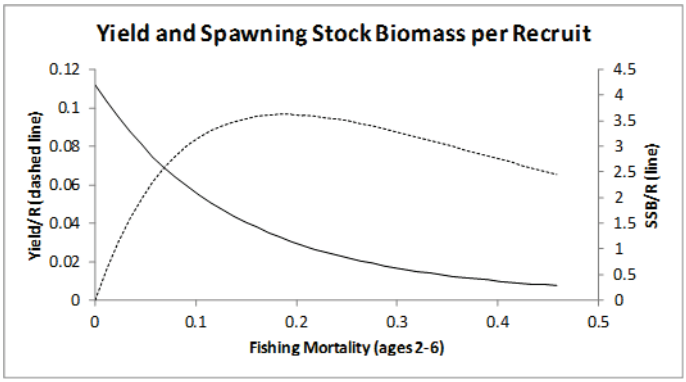


Figure 8.6.1 North Sea plaice. Yield and SSB per recruit following the latest assessment of the stock.

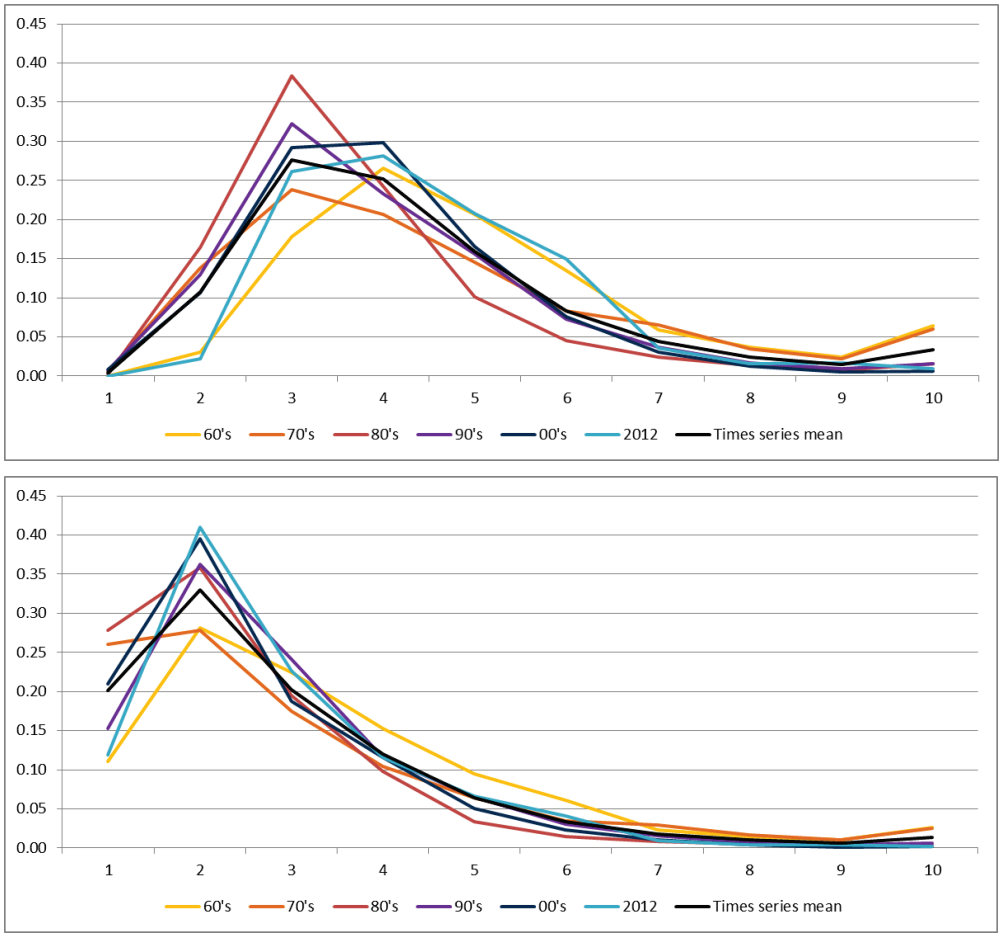


Figure 8.11.3. Relative age distribution in the landings (top) and catch (bottom) for different parts of the time series.

9 Sole in Sub-area 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 2013.

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 2011 the stock status was presented as follows:

F (Fishing Mortality)				
	2008	2009	**2010**	
MSY (F_{MSY})	✗	✗	✗	Above target
Precautionary approach (F_{pa},F_{lim})	✓	o	o	Risk harvested unsustainably
SSB (Spawning-Stock Biomass)				
	2009	2010	**2011**	
MSY ($B_{trigger}$)	✓	✓	✓	Above trigger
Precautionary approach (B_{pa},B_{lim})	✓	✓	✓	Full reproductive capacity

The ICES advice for 2012 was as follows:

ICES advises on the basis of the transition to the MSY approach that landings in 2012 should be no more than 5600 t.

MSY approach

Following the ICES MSY framework implies fishing mortality to be reduced to 0.29 resulting in landings of less than 4300 t in 2012. This is expected to lead to a record high SSB of 15 000 t in 2013.

*Following the transition scheme towards the ICES MSY framework implies that (F(2010)*0.6) + (0.4*FMSY) is 0.39, resulting in landings of less than 5600 t in 2012. This is expected to lead to an SSB of 13 600 t in 2013.*

PA approach

The fishing mortality in 2012 should be no more than Fpa, corresponding to landings of less than 5700 t in 2012. This is expected to keep SSB well above Bpa in 2013.

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 2013was 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.

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 2012 and 2013 are 5580t and 5900t 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 gears 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.

For 2009, the cod plan covered by 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. The area's are Kattegat, 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.

For 2010, 2011, 2012 and 2013, Council Regulation (EC) N°53/2010, Council Regulation (EC) N°57/2011, Council Regulation (EC) N°43/2012 and Council Regulation (EC) N°39 and 40/2013 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 2011 landings data provided last year by Belgian, France and UK.

The 2012 landings used by the Working Group were 4047t (Table 9.2.1) which is 27% below the agreed TAC of 5580t and 39% below the predicted landings at a status quo fishing mortality in 2012 (6670t). The advice for 2013 was based on a TAC constraint for 2012.The contribution of France, Belgium and the UK to the landings in 2012 is 62%, 23% and 16% respectively.

Landing data reported to ICES are shown in Table 9.2.1 together with the total landings estimated by the Working Group. 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 for 2010, 2011 and 2012 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 9% 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.

Belgium, UK, France and The Netherlands 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. 4 groups of metiers with age distributions were set up, as follows: All-TBB metiers, All-GTR metiers, All-GNS 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 GTR metiers without age distributions with All-GTR and the GNS metiers without age distributions with All-GNS. The rest of the metiers without age distributions were allocated to the group Overall.

9.2.2 Age compositions

Quarterly data for 2012 were available for landing numbers and weight at age, for the French, Belgian, and UK fleets. These comprise 99.99% of the international landings. The annual age compositions of the landings are presented in Table 9.2.2. The quarterly age composition for 2012 (numbers and weights at age) are presented in Table 9.2.3

9.2.3 Weight at age

Weight at age in the catch is presented in Table 9.2.4 and Figure 9.2.1; and weight at age in the stock in Table 9.2.5 and Figure 9.2.2. 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 9.2.6a,b and Figures 9.2.3a-c. Slight revisions have been made to the UK effort and LPUE series for 2011. 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 five years to the level of the early 2000's. 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 2012 is the third 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 2009-2012 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 and 2012, before the next Expert group. It appears that for the 3 main French fleets (Gill/trammel nets, Otter trawls and Beam trawls), effort decreased further in the last years.

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. After a small decline in 2007 and 2008, the Belgian beam trawl LPUE again reached the higher levels of the mid 2000's.

Survey and commercial data used for calibration of the assessment are presented in Table 9.2.7.

The data for 2012 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

Apart from small layout features and a number of corrections, the RG did not report any major deficiencies for the sole assessment in the Eastern English Channel. The RG asked for an explanation of the high fishing mortalities on age 4 in 2010 and age 5 in 2011. (see section 9.3.5 in this report). It was noted that the status quo forecast assumed a 39% TAC overshoot which was unlikely to be the case taking into account the available information of the last 14 year and agreed that a TAC constraint in 2012 should be used in the forecast for the advice on sole in the Eastern English Channel (VIId). It appeared to be the correct decision as the TAC again was not taken in 2012 (TAC2012=5580t; Landings2012= 4047t). The RG also asked for plots of catch and stock weight at age to be presented. (This request has been accommodated in this year's report.)

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 untapered), using data for each of the four fleets individually (in ICES files). Apart from the first few year's 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. 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 com-

ponent. 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 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 2011 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. It should be noted that both surveys, (UK(E&W)-BTS) and (FR-YFS) are estimating this year class differently. The UK(E&W)-BTS estimates that year class to be very weak whereas the FR-YFS estimates it to be above average. However, it should also 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 not to use this estimate in the forecast (see section 9.5).

At age 2, the 2010 year-class is predominantly estimated by the commercial UK beam trawl fleet and UK beam trawl survey, with weightings of 43% and 40% respectively. Both these tuning fleets estimate the survivors of that year class to be weak with somewhat different values (8316 and 15371). The Belgian commercial beam trawl fleet estimate this year class to be even weaker (4653) with a weighting of 10%. The French component of the Young Fish Survey estimates this year class to be about average (25374) but only accounts for 6% 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 Working 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.

9.3.4 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 by 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 2011) by XSA resulted from 2 substantially different estimates through the two surveys (UK-BTS and FR-YFS), each with a very high internal standard error. The Expert Group decided not to accept this value and to investigate if results of RCT3 runs for this year class could be used in the forecast.

9.3.5 Final assessment

The final settings used in this year's assessment are specified as in the stock annex and are detailed below:

	2013 assessment		
Fleets	Years	Ages	α-β
BE-CBT commercial	86-12	2-10	0-1
UK(E&W)-CBT commercial	86-12	2-10	0-1
UK(E&W)-BTS survey	88-12	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	87-12	1-1	0.5-0.75

-First data year	1982
-Last data year	2011
-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 (0.67), at age 5 (0.67) and age 6 (1.04) was investigated for possible errors in raw data or raising procedures. 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 6 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 and 5 (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 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 67% (i.e. 43 527 to 14 282 fish). It should be noted that the high XSA estimate (157912) in the 2010 assessment was replaced with an RCT3 estimate of 47475 in the forecast.

Fishing mortality for 2011 has been revised upward by 2% SSB downward by 10% respectively.

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 7 years fishing mortality has increased again above the Fpa value.

Recruitment has fluctuated around 25 million recruits with occasional strong year classes. Five of the highest values in the time series have been recorded in the last 11 years. The last two year classes are predicted to be 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.

9.5 Recruitment estimates

The 2010 year class in 2011 was estimated to be around 14 million fish at age 1, which is below average and 67% lower than estimated last year. This strong 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 2011 year class in 2012 was estimated by XSA to be 10 million one year olds which is far below average. Both surveys (UK-BTS (age1) and FR-YFS (age1)) estimate the 2011 year class with estimates that differ 5.7 times from each other (5 955 and 33 774 respectively). The internal standard errors of both surveys are around 1.0, indicating a high variability and therefore provide very uncertain estimates for this year class strength. The Expert group decided not to use this estimate in the forecast.

RCT3 runs, including the French Young fish survey-index for age 0 (not included in the XSA) have been conducted for comparison with the XSA results. The input is presented in Table 9.5.1 and the results in Tables 9.5.2a and b. The estimates for the 2011 year class at age 2 from RCT3 (Table 9.5.2b) are more balanced between the UK-BTS (age1), the FR-YFS (age1), the FR-YFS (age2) and the VPA mean. The internal standard errors of the UK-BTS (age1) and FR-YFS (age1) is lower than in the XSA and the

VPA mean has a 47% weighting. The Expert Group decided that the RCT3 survivor estimate for this year class should be used for further prediction.

The long term GM recruitment (24 million, 1982-2010) was assumed for the 2012 and subsequent year classes.

Although the RCT3 results for the 2012 year class are not used for prediction (highly variable with a standard error close to 1.0, it should be noted that the French Young fish survey (FR-YFS) at age 0 indicates a below average 2012 year class.

The working group estimates of year class strength used for prediction can be summarised as follows:

Year class	At age in 2013	XSA	GM 82-10	RCT3	Accepted Estimate
2010	3	10617	15677	-	XSA
2011	2	9165	20982	18553	RCT3
2012	1	-	24101	24847	GM 1982-10
2013 & 2014	recruits	-	24101	-	GM 1982-10

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 2010-2012.

Input to the short term predictions and the sensitivity analysis are presented in Table 9.6.1. Last year the advice drafting group decided that a TAC constrain should be used for the intermediate year as a *status quo* fishing mortality resulted in a much higher landings in the intermediate year than the agreed TAC, and TAC's have not been taken in the last 14 years. This years a *status quo* assumption for 2013(intermediate year) resulted in a lower landings (4 752t) than the agreed TAC of 5900t (Table 9.6.2). The working group therefore decided to use a *status quo* fishing mortality for the intermediate year 2013. The Results are presented in Table 9.6.2 (management options) and Table 9.6.3 (detailed output).

Assuming *status quo* F, implies a catch in 2013 of 4752 t (the agreed TAC is 5900 t) and a catch of 4264 t in 2014. The corresponding SSB's in 2014 and 2015 are 10 181t and 9918t respectively.

Assuming a status quo F for 2013 and 2014, the proportional contributions of recent year classes to the landings in 2014 and SSB in 2015 are given in Table 9.6.4. The assumed GM recruitment accounts for 11 % of the landings in 2014 and 32 % of the 2015 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 2014 are 3250t and 5500t. There is less then 5% probability that at current fishing mortality SSB will fall below the B_{pa} of 8000t in 2015.

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 2013, are given in Table 9.7.1 and Figure 9.7.1. F_{max} is calculated by this year's assessment to be 0.35 (0.46 = 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	

9.9 Quality of the assessment

- This year's assessment revised fishing mortality in 2011 upward only by 2% and SSB downward by 10%. The XSA recruitment estimate in 2011 (year class 2010) was revised downward by 67% mainly due to the availability in this year's assessment of survivor estimates of two commercial fleets. Estimates of the incoming recruitment are based on 2 surveys, the UK-BTS and FR-YFS at age1 which have high standard errors and sometimes differ substantially in their survival estimates. This year the XSA estimates were replaced with an RCT3 estimate in which the VPA mean estimate had most of the weighting.
- The trends and estimates of fishing mortality, SSB and recruitment were consistent with last year's assessment apart from the downward revision of the 2010 year class (see above).
- Except year classes 2002, 2003, 2006, 2007 and 2010, all year classes from 1998 are estimated to be at or above long term average which explains the increasing trend in SSB since 1998.
- Information available on discards suggests that discards are not substantial 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 estimate the incoming year class strength very consistently and, provide 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).
- 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 and in this year 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 6 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.

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°39 and 40/2013 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.

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	29	4047	5580

* Unallocated mainly due to misreporting

** Preliminary

Table 9.2.2 - Sole VIId - Landing numbers at age (kg)

Run title : Sole in Division VIId - 2013 WG.

At 19/04/2013 12:41

Table 1 Catch numbers at age Numbers*10**-3

	YEAR	1982
	AGE	
	1	155
	2	2625
	3	5256
	4	1727
	5	570
	6	653
	7	549
	8	240
	9	122
	10	83
	+gp	202
0	TOTALNUM	12182
	TONSLAND	3190
	SOPCOF %	97

Table 1 Catch numbers at age Numbers*10**-3

	YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	AGE										
	1	0	24	49	49	9	95	163	1245	383	105
	2	852	1977	3693	1251	3117	2162	3484	2851	7166	4046
	3	3452	3157	5211	5296	3730	7174	3220	5580	4105	8789
	4	3930	2610	1646	3195	3271	1602	4399	1151	4160	1888
	5	897	1900	1027	904	2053	1159	1434	1496	604	1993
	6	735	742	1860	768	1042	856	840	301	996	288
	7	627	457	144	1056	1090	388	571	390	257	368
	8	333	317	158	155	784	255	201	260	247	135
	9	108	136	156	190	111	256	166	129	258	171
	10	89	99	69	212	163	83	224	126	92	95
	+gp	193	238	128	372	459	275	282	489	382	231
0	TOTALNUM	11216	11657	14141	13448	15829	14305	14984	14018	18650	18109
	TONSLAND	3458	3575	3837	3932	4791	3853	3805	3647	4351	4072
	SOPCOF %	99	99	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

	YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	AGE										
	1	85	31	838	9	24	33	168	138	168	707
	2	5028	694	2977	1825	1489	1376	3268	3586	6042	7011
	3	6442	6203	4375	7764	6068	5609	8506	4852	6194	7513
	4	5444	5902	4765	3035	5008	2704	3307	4395	1595	3767
	5	1008	3404	2968	3206	2082	1636	1311	1076	2491	1414
	6	563	584	1980	1823	1670	609	869	505	728	655
	7	162	567	375	1283	916	558	350	319	290	298
	8	188	109	278	271	775	441	672	148	128	129
	9	116	147	88	319	239	354	351	328	56	97
	10	62	93	106	112	169	239	192	150	81	57
	+gp	129	258	241	344	267	301	359	248	265	197
0	TOTALNUM	19227	17992	18991	19991	18707	13860	19353	15745	18038	21845
	TONSLAND	4299	4383	4420	4797	4764	3363	4135	3476	4025	4733
	SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

	YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	AGE										
	1	379	1030	206	608	175	149	231	139	0	4
	2	10957	4254	3468	7370	6511	2702	3006	5276	4636	1131
	3	5086	8623	4034	3753	7316	8516	4418	4453	6230	7159
	4	3178	2545	5458	2821	2990	4145	7092	3289	2884	4227
	5	1805	2272	1543	3433	1500	1267	2378	3083	1510	1411
	6	671	1108	1143	1103	2038	849	798	1327	1432	937
	7	588	371	633	796	751	751	615	328	554	649
	8	198	448	218	403	467	356	642	267	179	480
	9	70	94	283	191	257	164	277	336	148	124
	10	88	88	127	208	162	134	251	99	105	57
	+gp	245	233	271	307	230	247	451	290	222	396
0	TOTALNUM	23265	21066	17384	20993	22397	19280	20159	18887	17900	16575
	TONSLAND	5038	4826	4383	4833	5166	4517	5266	4409	4133	4047
	SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 9.2.3 - Sole VIId - Quaterly landings composition for 2012

	Q1		Q2		Q3		Q4	
Age	Numbers	Weights	Numbers	Weights	Numbers	Weights	Numbers	Weights
1	0.1	0.173	0.1	0.172	4.0	0.173	0.1	0.173
2	70.1	0.161	138.5	0.164	619.6	0.182	303.1	0.172
3	2003.7	0.190	1707.6	0.183	2199.9	0.215	1247.8	0.223
4	1479.3	0.238	1481.1	0.241	630.7	0.260	636.3	0.246
5	613.1	0.291	360.7	0.259	234.1	0.307	202.7	0.304
6	410.9	0.311	286.8	0.280	168.6	0.286	70.3	0.324
7	277.8	0.374	170.2	0.351	116.6	0.359	84.3	0.404
8	215.8	0.381	106.2	0.336	84.8	0.331	73.3	0.335
9	61.6	0.486	19.2	0.342	29.7	0.465	13.4	0.549
10	33.7	0.302	8.8	0.479	3.5	0.552	11.2	0.397
11	77.5	0.552	23.2	0.389	34.5	0.577	7.0	0.538
12	20.1	0.367	8.0	0.547	14.2	0.757	2.2	0.448
13	44.5	0.375	8.4	0.457	4.8	0.576	4.4	0.405
14	47.1	0.521	5.0	0.419	2.8	0.468	8.8	0.330
15+	49.5	0.544	9.5	0.526	13.8	0.683	9.8	0.434

Nominal landings (t)	1394.3	996.1	1000.8	655.3

Table 9.2.4 - Sole VIId - Catch weights at age (kg)

Run title : Sole in Division VIId - 2013 WG.

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Table 2 Catch weights at age (kg)

YEAR	1982
AGE	
1	0.102
2	0.171
3	0.225
4	0.312
5	0.386
6	0.428
7	0.439
8	0.509
9	0.502
10	0.463
+gp	0.6729
0 SOPCOFAC	0.9713

Table 2 Catch weights at age (kg)

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0.000	0.100	0.090	0.135	0.095	0.102	0.106	0.12	0.114	0.103
2	0.173	0.178	0.182	0.180	0.175	0.152	0.154	0.178	0.161	0.153
3	0.230	0.234	0.230	0.212	0.236	0.226	0.192	0.238	0.208	0.203
4	0.302	0.314	0.281	0.306	0.295	0.278	0.271	0.289	0.266	0.267
5	0.404	0.380	0.368	0.363	0.353	0.360	0.293	0.349	0.354	0.29
6	0.436	0.436	0.394	0.387	0.407	0.409	0.358	0.339	0.394	0.403
7	0.435	0.417	0.516	0.437	0.411	0.459	0.388	0.47	0.421	0.391
8	0.524	0.538	0.543	0.520	0.482	0.514	0.472	0.465	0.43	0.462
9	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434	0.459
10	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478	0.463
+gp	0.6283	0.7135	0.8005	0.6015	0.6176	0.6647	0.7014	0.5621	0.5656	0.5661
0 SOPCOFAC	0.991	0.9884	0.998	1.0006	1.0004	1.0001	0.9994	0.9995	1.0001	1.0001

Table 2 Catch weights at age (kg)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0.085	0.099	0.129	0.142	0.139	0.132	0.130	0.145	0.108	0.120
2	0.147	0.150	0.176	0.165	0.153	0.159	0.151	0.142	0.152	0.162
3	0.197	0.186	0.179	0.178	0.188	0.172	0.189	0.176	0.211	0.204
4	0.247	0.235	0.230	0.229	0.233	0.235	0.215	0.223	0.283	0.253
5	0.335	0.288	0.255	0.269	0.292	0.286	0.260	0.332	0.288	0.316
6	0.384	0.355	0.333	0.324	0.343	0.343	0.280	0.377	0.334	0.375
7	0.537	0.381	0.357	0.361	0.390	0.383	0.290	0.424	0.367	0.376
8	0.553	0.505	0.385	0.405	0.404	0.417	0.341	0.427	0.374	0.393
9	0.515	0.484	0.490	0.435	0.503	0.484	0.358	0.384	0.493	0.469
10	0.766	0.496	0.494	0.465	0.474	0.435	0.374	0.459	0.511	0.420
+gp	0.6666	0.6156	0.6536	0.5854	0.6509	0.6162	0.5354	0.68	0.5445	0.5308
0 SOPCOFAC	1.0002	1.0001	0.9997	0.9999	1	1.0013	0.9992	1.0009	1.0005	0.9995

Table 2 Catch weights at age (kg)

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE										
1	0.114	0.120	0.135	0.139	0.163	0.148	0.143	0.124	0.123	0.173
2	0.170	0.179	0.172	0.162	0.190	0.164	0.177	0.161	0.161	0.176
3	0.208	0.205	0.208	0.192	0.202	0.201	0.203	0.195	0.204	0.202
4	0.257	0.255	0.253	0.249	0.227	0.244	0.260	0.239	0.252	0.243
5	0.277	0.296	0.303	0.284	0.276	0.262	0.279	0.287	0.295	0.288
6	0.357	0.304	0.337	0.328	0.294	0.321	0.358	0.340	0.326	0.298
7	0.381	0.348	0.368	0.353	0.315	0.435	0.321	0.342	0.342	0.369
8	0.438	0.403	0.433	0.402	0.378	0.411	0.464	0.355	0.399	0.355
9	0.482	0.492	0.570	0.457	0.441	0.377	0.406	0.512	0.352	0.466
10	0.494	0.509	0.445	0.450	0.439	0.498	0.476	0.438	0.441	0.363
+gp	0.5274	0.525	0.5369	0.557	0.5206	0.5127	0.6185	0.4504	0.5216	0.5076
0 SOPCOFAC	1.0002	0.9983	0.9989	1	1.0026	0.9991	1.0009	0.9998	1.0004	0.9998

Table 9.2.5 - Sole VIId - Stock weights at age (kg)

Run title : Sole in Division VIId - 2013 WG.

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Table 3 Stock weights at age (kg)

YEAR	1982
AGE	
1	0.059
2	0.114
3	0.167
4	0.217
5	0.263
6	0.306
7	0.347
8	0.384
9	0.418
10	0.45
+gp	0.53

Table 3 Stock weights at age (kg)

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0.070	0.067	0.065	0.070	0.072	0.050	0.05	0.05	0.05	0.05
2	0.135	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138	0.144
3	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225	0.199
4	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279	0.277
5	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.4	0.38	0.305
6	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384	0.454
7	0.406	0.403	0.436	0.403	0.417	0.477	0.48	0.476	0.41	0.405
8	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449	0.459
9	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474	0.43
10	0.5220	0.5290	0.6110	0.5120	0.5360	0.6360	0.536	0.507	0.451	0.528
+gp	0.6008	0.6265	0.7798	0.5761	0.6156	0.7498	0.7135	0.5765	0.6203	0.5269

Table 3 Stock weights at age (kg)

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.130	0.116	0.126	0.155	0.139	0.140	0.128	0.122	0.127	0.136
3	0.189	0.161	0.129	0.176	0.165	0.158	0.180	0.148	0.157	0.179
4	0.246	0.215	0.220	0.258	0.220	0.233	0.205	0.208	0.216	0.209
5	0.366	0.273	0.234	0.286	0.264	0.299	0.253	0.402	0.226	0.258
6	0.377	0.316	0.333	0.308	0.317	0.374	0.277	0.440	0.223	0.254
7	0.545	0.368	0.357	0.366	0.376	0.363	0.298	0.395	0.231	0.301
8	0.560	0.530	0.330	0.391	0.404	0.357	0.324	0.554	0.253	0.234
9	0.559	0.461	0.614	0.438	0.563	0.450	0.336	0.443	0.256	0.326
10	0.813	0.470	0.382	0.466	0.494	0.372	0.323	0.420	0.301	0.404
+gp	0.5664	0.6122	0.6292	0.6304	0.6536	0.5768	0.5118	0.6822	0.4204	0.4170

Table 3 Stock weights at age (kg)

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
AGE										
1	0.050	0.050	0.144	0.141	0.139	0.131	0.141	0.143	0.050	0.172
2	0.151	0.137	0.157	0.161	0.163	0.158	0.169	0.149	0.142	0.164
3	0.207	0.185	0.203	0.185	0.195	0.191	0.186	0.185	0.189	0.183
4	0.249	0.236	0.241	0.246	0.239	0.250	0.243	0.210	0.244	0.241
5	0.314	0.265	0.267	0.272	0.286	0.294	0.278	0.267	0.277	0.259
6	0.376	0.267	0.309	0.326	0.297	0.368	0.352	0.316	0.318	0.280
7	0.399	0.273	0.349	0.339	0.340	0.401	0.341	0.341	0.336	0.351
8	0.418	0.331	0.401	0.394	0.400	0.476	0.430	0.326	0.375	0.336
9	0.446	0.504	0.608	0.416	0.433	0.463	0.449	0.440	0.386	0.342
10	0.444	0.409	0.425	0.461	0.446	0.402	0.456	0.416	0.501	0.479
+gp	0.5032	0.4501	0.5602	0.5553	0.5182	0.5663	0.6598	0.4192	0.5147	0.4512

Table 9.2.6a **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*	4.36	35.93
2011		61.75*	73.60*	17.59*	3.00	34.80
2012		n/a	n/a	n/a	3.15	30.27

[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 9.2.6b 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	30.73	26.36

[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 9.2.7 - Sole VIId - tuning files

Bolded numbers = used in XSA

SOLE 7d,TUNING - Tun7d.txt - 2013WG

105														
BE-CBT														
1980	**2012**													
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
UK(E&W)-CBT														
1986	**2012**													
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
3.2	**44.11**	**319.55**	**58.84**	**33.89**	**5.8**	**15.78**	**8.43**	**1.39**	**1.4**	3.63	0.67	0.27	0.87	1.54

Table 9.2.7 - Sole VIId - tuning files - continued

Bolded numbers = used in XSA

UK(E&W)-BTS-Q3

1988	**2012**					
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**

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	**2012**					
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**				

Table 9.3.1 - Sole VIId - XSA diagnostics

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Extended Survivors Analysis

Sole in Division VIId - 2013 WG.

CPUE data from file sol7dTUN.txt

Catch data for 31 years. 1982 to 2012. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BE-CBT	1986	2012	2	10	0	1
UK(E&W)-CBT	1986	2012	2	10	0	1
UK(E&W)-BTS-Q3	1988	2012	1	6	0.5	0.75
UK(E&W)-YFS	1987	2012	1	1	0.5	0.75
FR-YFS	1987	2012	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 converged after 67 iterations

Regression weights

1	1	1	1	1	1	1	1	1	

Fishing mortalities

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.019	0.058	0.006	0.016	0.01	0.008	0.007	0.004	0	0
2	0.327	0.275	0.25	0.288	0.206	0.188	0.185	0.209	0.141	0.097
3	0.445	0.41	0.403	0.414	0.457	0.401	0.467	0.405	0.362	0.3
4	0.37	0.371	0.438	0.483	0.601	0.45	0.604	0.672	0.442	0.396
5	0.397	0.437	0.357	0.481	0.454	0.487	0.447	0.509	0.665	0.358
6	0.407	0.401	0.363	0.415	0.519	0.446	0.575	0.427	0.416	1.044
7	0.334	0.367	0.373	0.412	0.489	0.324	0.597	0.435	0.282	0.299
8	0.271	0.406	0.34	0.384	0.401	0.401	0.45	0.497	0.399	0.374
9	0.169	0.178	0.431	0.497	0.4	0.212	0.552	0.398	0.502	0.471
10	0.324	0.296	0.344	0.575	0.925	0.333	0.511	0.344	0.185	0.325

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7	8	9	10
2003	2.10E+04	4.13E+04	1.49E+04	1.08E+04	5.79E+03	2.11E+03	2.18E+03	8.77E+02	4.73E+02	3.34E+02
2004	1.93E+04	1.86E+04	2.70E+04	8.64E+03	6.75E+03	3.52E+03	1.27E+03	1.41E+03	6.05E+02	3.61E+02
2005	3.44E+04	1.65E+04	1.28E+04	1.62E+04	5.40E+03	3.94E+03	2.14E+03	7.96E+02	8.50E+02	4.58E+02
2006	4.13E+04	3.09E+04	1.16E+04	7.74E+03	9.46E+03	3.42E+03	2.48E+03	1.33E+03	5.13E+02	5.00E+02
2007	1.85E+04	3.68E+04	2.10E+04	6.96E+03	4.32E+03	5.29E+03	2.04E+03	1.49E+03	8.20E+02	2.82E+02
2008	2.08E+04	1.66E+04	2.71E+04	1.20E+04	3.45E+03	2.48E+03	2.85E+03	1.13E+03	9.01E+02	4.98E+02
2009	3.27E+04	1.87E+04	1.25E+04	1.64E+04	6.94E+03	1.92E+03	1.44E+03	1.86E+03	6.87E+02	6.60E+02
2010	4.10E+04	2.94E+04	1.41E+04	7.07E+03	8.13E+03	4.01E+03	9.77E+02	7.16E+02	1.08E+03	3.58E+02
2011	1.43E+04	3.70E+04	2.16E+04	8.48E+03	3.27E+03	4.42E+03	2.37E+03	5.72E+02	3.94E+02	6.54E+02
2012	1.01E+04	1.29E+04	2.90E+04	1.36E+04	4.93E+03	1.52E+03	2.64E+03	1.62E+03	3.47E+02	2.16E+02

Estimated population abundance at 1st Jan 2013

0.00E+00	9.16E+03	1.06E+04	1.95E+04	8.29E+03	3.12E+03	4.84E+02	1.77E+03	1.01E+03	1.96E+02

Taper weighted geometric mean of the VPA populations:

2.30E+04	2.10E+04	1.62E+04	8.87E+03	4.75E+03	2.73E+03	1.65E+03	9.85E+02	6.07E+02	3.85E+02

Standard error of the weighted Log(VPA populations) :

0.4073	0.38	0.3599	0.4113	0.4284	0.4606	0.4779	0.4861	0.476	0.5103

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Log catchability residuals.

Fleet : BE-CBT

Age	1986	1987	1988	1989	1990	1991	1992
1	No data for this fleet at this age						
2	0.01	0.55	-0.75	-2.59	1.09	-0.79	-0.06
3	0.72	-0.21	-0.44	0	0.09	0.83	0.09
4	0.19	0.36	-0.73	-0.4	-0.15	0.07	0.4
5	-0.08	0.59	-0.22	1.02	-0.07	-0.03	0.25
6	-0.15	0.88	-0.25	0.26	-0.2	0.62	-0.51
7	-0.18	0.62	0.07	0.36	0.59	0.09	-0.19
8	0.04	-0.07	-0.74	-0.05	-0.23	0	-0.13
9	0.79	0.28	-0.72	-0.33	0.35	-0.63	0.01
10	0.1	2.26	1.31	-2.07	-0.11	0.54	-0.63

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	No data for this fleet at this age									
2	1.28	-0.32	-0.78	-0.14	-0.76	-0.36	0.36	0.04	0.45	0.82
3	0.25	-0.03	-0.29	-0.05	0.38	-0.22	0.03	0.42	0.04	0.08
4	-0.04	0.56	-0.34	0.27	0.35	0.27	0.51	0.34	-0.34	-0.12
5	-0.03	0.28	-0.06	-0.11	0.47	-0.15	0.47	-0.31	0.13	-0.26
6	-0.87	0.38	0.06	0.1	0.12	-0.29	-0.11	0.05	0.67	-0.85
7	0.04	0.06	0	0.28	0.25	-0.19	0.01	-0.21	0.17	-0.22
8	-0.21	0.33	-1.06	-0.01	-0.17	0.1	-0.18	0.53	-0.64	-0.32
9	0.72	-0.14	0.22	-0.09	0.08	-0.01	0.02	-0.23	-0.61	-0.58
10	-0.52	1.42	-0.71	1.16	-0.9	-0.08	-0.49	-0.31	-1.32	0.35

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No data for this fleet at this age									
2	0.44	0.54	0.98	0.21	0.08	-0.89	0.54	0.62	0.27	-0.82
3	0.13	-0.35	0.07	-0.23	-0.39	-0.8	-0.08	0.16	0.16	-0.36
4	-0.02	-0.23	-0.2	0.03	-0.2	-0.07	-0.31	-0.31	0.1	0
5	-0.11	0.24	-0.65	-0.41	-0.57	-0.12	0.01	-0.14	-0.05	-0.1
6	0.43	-0.13	-0.6	0.02	-0.3	-0.33	0.31	0.3	-0.29	0.66
7	-0.37	-0.53	-0.25	0.17	-0.35	-0.14	0.21	0.46	-0.49	-0.28
8	-0.16	-0.49	-0.03	-0.14	0.14	-0.04	-0.23	0.03	-0.09	0.26
9	-1.47	-0.86	-0.72	0.24	-0.05	-0.49	-0.1	0.31	0.35	0.64
10	0.11	0.22	-0.98	0.26	0.34	0.01	-0.13	0.14	-0.56	-1.01

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	-7.0465	-5.815	-5.6796	-5.5701	-5.7254	-5.7132	-5.7132	-5.7132	-5.7132
S.E(Log q)	0.8131	0.3489	0.3154	0.3549	0.4515	0.3082	0.3515	0.5397	0.9104

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	0.75	0.785	7.77	0.29	27	0.62	-7.05
3	1.47	-1.78	3.97	0.36	27	0.49	-5.82
4	0.94	0.438	5.9	0.65	27	0.3	-5.68
5	1.12	-0.644	5.22	0.53	27	0.4	-5.57
6	1.18	-0.787	5.32	0.42	27	0.54	-5.73
7	1.1	-0.68	5.55	0.66	27	0.34	-5.71
8	1.17	-1.161	5.66	0.65	27	0.38	-5.84
9	1.44	-1.474	5.56	0.31	27	0.74	-5.83
10	-6.83	-4.617	7.49	0.01	27	4.65	-5.77
1							

Fleet : UK(E&W)-CBT

Age	1986	1987	1988	1989	1990	1991	1992
1	No data for this fleet at this age						
2	-0.39	0.36	0.55	-0.08	-0.24	-0.11	-0.43
3	0.49	-0.1	0.32	-0.05	0.07	-0.31	-0.14
4	0.54	0.42	-0.03	0.25	-0.11	0.06	-0.42
5	0.28	0.53	0.41	-0.5	0	-1.23	0.48
6	0.4	-0.27	0.28	0.14	-0.37	-0.25	-0.59
7	0.65	-0.28	-0.14	0.22	-0.26	-0.93	-0.18
8	-0.76	0.39	0.28	-0.26	0.03	-0.58	-0.4
9	0.12	-0.75	0.08	-0.35	-0.18	0.16	0.44
10	0	-1.26	0.47	0.32	0.51	-0.01	-0.24

Age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	No data for this fleet at this age									
2	-0.38	-1.24	-0.21	0.22	0.1	-0.02	0.32	-0.16	0.03	0.32
3	-0.54	-0.14	-0.67	-0.53	0.12	-0.3	0.07	0.22	-0.17	0.24
4	-0.18	-0.3	-0.07	-0.78	-0.22	-0.04	0.14	0.19	-0.08	0.18
5	-0.36	-0.05	-0.15	-0.07	-0.54	0.12	0.16	0.26	0.22	0.17
6	0.08	0	0.05	-0.24	0.21	-0.09	0.3	0.26	0.24	0
7	-0.54	0.51	-0.16	-0.09	-0.13	0.2	0.23	0.44	0.2	0.1
8	-0.12	-0.16	0.41	-0.2	0.14	0.09	0.18	0.24	0.62	0.53
9	0.02	0.39	0.22	0.24	-0.11	0.22	-0.05	0.52	0.17	-0.26
10	-0.41	0.45	0.42	0.22	0.25	0.36	-0.25	0.11	0.18	-0.13

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	No data for this fleet at this age									
2	0.12	-0.03	0.29	0.53	-0.36	0.11	0.63	-0.09	0.41	-0.24
3	-0.05	0.35	-0.02	0.77	0.23	0.43	-0.45	0.05	-0.25	0.34
4	-0.14	0.03	0.52	0.08	0.43	0.07	0.22	-0.23	0.01	-0.54
5	-0.23	-0.09	0	0.51	-0.25	-0.06	0.11	0.36	-0.1	0.02
6	-0.08	-0.1	0.36	-0.29	0.67	-0.25	-0.41	-0.06	0.3	-0.27
7	0.1	-0.23	0.34	-0.01	0.23	-0.04	-0.24	0.39	-0.3	-0.07
8	0.22	0.32	0.61	-0.13	0.49	-0.08	0.19	0.3	-0.28	-0.17
9	-0.2	-0.38	0.47	0.47	0.17	-0.99	0	0.44	0.14	-0.39
10	0.26	-0.11	0.72	0.02	-0.49	0.03	0.6	0.46	-0.49	0.03

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	-6.4865	-5.8061	-5.8113	-5.9257	-5.9269	-6.0074	-6.0074	-6.0074	-6.0074
S.E(Log q)	0.3941	0.3452	0.3088	0.3757	0.2965	0.3408	0.3632	0.3736	0.429

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	0.99	0.041	6.52	0.49	27	0.4	-6.49
3	0.91	0.554	6.18	0.58	27	0.32	-5.81
4	0.94	0.442	6.02	0.66	27	0.29	-5.81
5	0.71	2.572	6.67	0.76	27	0.24	-5.93
6	0.76	2.826	6.41	0.84	27	0.2	-5.93
7	0.82	1.643	6.27	0.76	27	0.27	-6.01
8	0.82	1.671	6.11	0.77	27	0.28	-5.94
9	0.82	1.452	6.06	0.73	27	0.3	-5.99
10	0.91	0.637	5.94	0.67	27	0.39	-5.93
1							

Fleet : UK(E&W)-BTS

Age	1986	1987	1988	1989	1990	1991	1992
1	99.99	99.99	0.21	-0.51	0.08	-0.01	-1.82
2	99.99	99.99	0.97	0.15	-0.81	0.05	-0.41
3	99.99	99.99	0.62	0.59	-0.51	-0.4	0.09
4	99.99	99.99	-0.3	-0.06	0.02	0.03	-0.65
5	99.99	99.99	0.44	0.16	-0.15	-0.23	-0.08
6	99.99	99.99	-0.01	-0.91	-0.38	-0.03	0.24
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	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	-2.16	-0.36	-0.33	-0.33	0.97	-0.84	1.42	0.26	0.29	0.98
2	0.02	-1.07	-0.28	-0.3	-0.34	0.32	0.05	0.49	0.31	-0.05
3	0.03	0.09	-1	-0.36	-0.15	-0.5	0.74	0.22	0.4	-0.09
4	0.59	-0.02	-0.34	-0.8	-0.28	-0.25	0.56	0.59	-0.14	0.45
5	0	0.4	-0.43	-0.3	-1.22	0.14	1	0.29	0.49	-1.05
6	0.22	-0.96	0.12	-0.16	-0.69	-1.2	1.18	0.47	0.16	-0.02
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	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.19	0.42	1.04	-0.52	-0.82	-0.61	1.29	0.41	1.17	-0.43
2	0.28	-0.16	-0.58	0.57	0.06	-0.37	0.23	0.61	0.09	0.16
3	-0.12	-0.11	-0.36	-0.28	0.69	-0.19	0.34	0.17	0.49	-0.42
4	0	-0.23	-0.02	0.19	-0.14	0.61	0.28	0.24	-0.43	0.11
5	0.24	0.03	0.32	-0.01	-0.11	-1.25	0.97	0.54	0.01	-0.19
6	-0.41	0.27	0.16	-0.88	0.13	-0.03	0.08	1.04	1.02	0.6
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	-8.1991	-7.2978	-7.7339	-8.0911	-8.1362	-8.1354
S.E(Log q)	0.8999	0.4584	0.4408	0.3799	0.5653	0.6179

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	0.6	1.459	8.98	0.36	25	0.52	-8.2
2	0.79	1.086	7.87	0.53	25	0.36	-7.3
3	0.94	0.228	7.84	0.43	25	0.42	-7.73
4	0.76	1.801	8.34	0.71	25	0.28	-8.09
5	0.8	0.937	8.21	0.48	25	0.45	-8.14
6	0.89	0.447	8.11	0.42	25	0.56	-8.14
1							

Fleet : UK(E&W)-YFS

Age	1986	1987	1988	1989	1990	1991	1992
1	99.99	0.64	0.1	-0.58	-0.41	0.48	-0.39
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	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.18	0.42	0.85	-0.78	-0.49	-0.06	-0.16	0.18	-1.52	0.31
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	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.05	0.79	0.59	-0.2	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	-9.5632
S.E(Log q)	0.5892

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	-0.567	9.41	0.21	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
1	99.99	-0.39	-0.35	-0.11	0.28	0.16	-0.36
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	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	-1.66	1.03	0.46	-0.17	-2.16	-0.52	0.36	0.06	1.59	-1.36
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	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	0.5	-0.15	0.94	0.77	-0.77	-1.17	2.21	-1.34	0.87	1.3
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	-11.5149
S.E(Log q)	1.0369

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	1.08	-0.147	11.63	0.12	26	1.14	-11.51

Terminal year survivor and F summaries :

Age 1 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	1	0	0	0	0	0	0
UK(E&W)-CBT	1	0	0	0	0	0	0
UK(E&W)-BTS-Q3	5955	0.918	0	0	1	0.509	0.001
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	33774	1.057	0	0	1	0.384	0
F shrinkage mean	664	2				0.107	0.006

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
9165	0.65	0.89	3	1.36	0

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 2 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	4653	0.828	0	0	1	0.1	0.208
UK(E&W)-CBT	8316	0.401	0	0	1	0.425	0.122
UK(E&W)-BTS-Q3	15371	0.417	0.408	0.98	2	0.395	0.068
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	25374	1.057	0	0	1	0.061	0.042
F shrinkage mean	5259	2				0.019	0.186

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10617	0.26	0.23	6	0.886	0.097

Age 3 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	14822	0.327	0.217	0.66	2	0.272	0.378
UK(E&W)-CBT	28208	0.265	0.035	0.13	2	0.4	0.216
UK(E&W)-BTS-Q3	17055	0.306	0.213	0.7	3	0.295	0.336
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	5076	1.057	0	0	1	0.023	0.851
F shrinkage mean	13068	2				0.01	0.419

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
19469	0.17	0.14	9	0.85	0.3

Age 4 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	9058	0.233	0.101	0.43	3	0.324	0.367
UK(E&W)-CBT	5699	0.208	0.13	0.63	3	0.389	0.534
UK(E&W)-BTS-Q3	11898	0.247	0.175	0.71	4	0.27	0.291
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	75418	1.057	0	0	1	0.01	0.052
F shrinkage mean	5407	2				0.007	0.556

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
8287	0.13	0.13	12	1.001	0.396

Age 5 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	3247	0.205	0.08	0.39	4	0.364	0.346
UK(E&W)-CBT	3428	0.192	0.113	0.59	4	0.388	0.33
UK(E&W)-BTS-Q3	2631	0.237	0.138	0.58	5	0.234	0.412
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	964	1.057	0	0	1	0.006	0.872
F shrinkage mean	1995	2				0.007	0.514

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3121	0.12	0.07	15	0.549	0.358

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 6 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	561	0.218	0.209	0.96	5	0.316	0.951
UK(E&W)-CBT	385	0.192	0.056	0.29	5	0.48	1.199
UK(E&W)-BTS-Q3	623	0.27	0.15	0.56	6	0.184	0.888
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	224	1.057	0	0	1	0.003	1.605
F shrinkage mean	1453	2				0.018	0.478

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
484	0.13	0.09	18	0.72	1.044

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2005

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1323	0.19	0.064	0.33	6	0.407	0.383
UK(E&W)-CBT	2050	0.173	0.093	0.54	6	0.46	0.263
UK(E&W)-BTS-Q3	2780	0.252	0.196	0.78	6	0.117	0.201
UK(E&W)-YFS	1447	0.604	0	0	1	0.007	0.355
FR-YFS	3827	1.057	0	0	1	0.002	0.15
F shrinkage mean	1159	2				0.007	0.427

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1769	0.12	0.08	21	0.674	0.299

Age 8 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	946	0.172	0.137	0.8	7	0.436	0.394
UK(E&W)-CBT	910	0.161	0.073	0.45	7	0.463	0.407
UK(E&W)-BTS-Q3	2270	0.243	0.089	0.36	6	0.088	0.183
UK(E&W)-YFS	1812	0.604	0	0	1	0.005	0.225
FR-YFS	2570	1.057	0	0	1	0.002	0.164
F shrinkage mean	848	2				0.007	0.431

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1007	0.11	0.08	23	0.721	0.374

Age 9 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	246	0.184	0.122	0.67	8	0.415	0.392
UK(E&W)-CBT	169	0.172	0.129	0.75	8	0.518	0.529
UK(E&W)-BTS-Q3	137	0.252	0.227	0.9	6	0.053	0.62
UK(E&W)-YFS	434	0.604	0	0	1	0.003	0.24
FR-YFS	168	1.057	0	0	1	0.001	0.531
F shrinkage mean	230	2				0.01	0.414

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
196	0.12	0.08	25	0.678	0.471

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2002

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	135	0.198	0.149	0.75	9	0.355	0.337
UK(E&W)-CBT	147	0.183	0.063	0.34	9	0.586	0.314
UK(E&W)-BTS-Q3	136	0.243	0.081	0.33	6	0.043	0.336
UK(E&W)-YFS	149	0.604	0	0	1	0.002	0.311
FR-YFS	232	1.057	0	0	1	0.001	0.21
F shrinkage mean	81	2				0.012	0.511

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
141	0.13	0.06	27	0.445	0.325

Table 9.3.2 - Sole VIId - Fishing mortality (F) at age

Run title : Sole in Division VIId - 2013 WG.

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Table 8 Fishing mortality (F) at age
YEAR 1982

AGE	
1	0.0129
2	0.1861
3	0.31
4	0.4841
5	0.2303
6	0.2258
7	0.4661
8	0.4088
9	0.345
10	0.3361
+gp	0.3361
0 FBAR 3- 8	0.3542

Table 8 Fishing mortality (F) at age

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	0	0.0012	0.004	0.002	0.0009	0.0039	0.0102	0.03	0.0116	0.0033
2	0.0820	0.1138	0.2226	0.1199	0.152	0.26	0.1714	0.2219	0.2153	0.1465
3	0.3527	0.4306	0.4327	0.5027	0.5444	0.5408	0.6709	0.402	0.503	0.394
4	0.3571	0.4361	0.3713	0.4571	0.5904	0.4208	0.6658	0.4743	0.5237	0.4039
5	0.4424	0.2605	0.2714	0.3186	0.5302	0.3785	0.7288	0.4393	0.4338	0.4532
6	0.4604	0.7106	0.3885	0.298	0.6502	0.3889	0.4597	0.2861	0.5207	0.3371
7	0.3131	0.5139	0.251	0.3537	0.7866	0.473	0.4315	0.3558	0.3748	0.3271
8	0.5075	0.2299	0.2966	0.4147	0.4279	0.3699	0.4251	0.3168	0.3555	0.3065
9	0.2892	0.3544	0.1515	0.6142	0.5221	0.2141	0.3887	0.4712	0.5255	0.3954
10	0.4038	0.4152	0.2725	0.282	1.6308	0.8361	0.2625	0.5083	0.6433	0.3303
+gp	0.4038	0.4152	0.2725	0.282	1.6308	0.8361	0.2625	0.5083	0.6433	0.3303
0 FBAR 3- 8	0.4055	0.4303	0.3353	0.3908	0.5883	0.4286	0.5636	0.3791	0.4519	0.3703

Table 8 Fishing mortality (F) at age

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	0.0053	0.0012	0.0464	0.0005	0.0009	0.0019	0.0067	0.0046	0.0067	0.0161
2	0.1913	0.0495	0.1396	0.1213	0.0959	0.0593	0.2371	0.1739	0.2545	0.3700
3	0.3253	0.3389	0.4357	0.5656	0.6423	0.5433	0.5402	0.5783	0.4502	0.5080
4	0.4014	0.4932	0.4193	0.5424	0.7811	0.5863	0.6353	0.5261	0.3347	0.4815
5	0.3476	0.4175	0.4374	0.4900	0.7895	0.5576	0.5573	0.3845	0.5686	0.4934
6	0.1972	0.3095	0.4051	0.4660	0.4526	0.4922	0.5766	0.3821	0.4317	0.2517
7	0.2866	0.2779	0.2976	0.4427	0.3999	0.2374	0.5173	0.3804	0.3500	0.2800
8	0.2465	0.2835	0.1907	0.3242	0.4648	0.3033	0.4411	0.3807	0.2298	0.2307
9	0.4164	0.2765	0.3459	0.3098	0.4671	0.3548	0.3735	0.3554	0.2153	0.2438
10	0.2161	0.6118	0.2928	0.8705	0.2391	1.0729	0.2948	0.2406	0.1238	0.3151
+gp	0.2161	0.6118	0.2928	0.8705	0.2391	1.0729	0.2948	0.2406	0.1238	0.3151
0 FBAR 3- 8	0.3008	0.3534	0.3643	0.4718	0.5884	0.4533	0.5446	0.4387	0.3941	0.3742

Table 8 Fishing mortality (F) at age

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	FBAR 10-12
AGE											
1	0.0192	0.0577	0.0063	0.0156	0.0100	0.0076	0.0074	0.0036	0.0000	0.0004	0.0013
2	0.3269	0.2748	0.2496	0.2883	0.2057	0.1876	0.1852	0.2091	0.1414	0.0965	0.1490
3	0.4446	0.4099	0.4026	0.4141	0.4567	0.4007	0.4666	0.4050	0.3616	0.2999	0.3555
4	0.3703	0.3705	0.4376	0.4831	0.6009	0.4501	0.6044	0.6717	0.4422	0.3956	0.5032
5	0.3969	0.4371	0.3574	0.4807	0.4542	0.4874	0.4469	0.5089	0.6652	0.3577	0.5106
6	0.4073	0.4012	0.3635	0.4147	0.5190	0.4457	0.5749	0.4269	0.4163	1.0443	0.6292
7	0.3340	0.3670	0.3735	0.4116	0.4888	0.3245	0.5970	0.4353	0.2820	0.2993	0.3389
8	0.2709	0.4063	0.3396	0.3835	0.4007	0.4009	0.4496	0.4973	0.3990	0.3739	0.4234
9	0.1691	0.1782	0.4308	0.4970	0.3997	0.2123	0.5518	0.3980	0.5020	0.4706	0.4569
10	0.3240	0.2957	0.3443	0.5751	0.9248	0.3329	0.5109	0.3437	0.1849	0.3251	0.2846
+gp	0.3240	0.2957	0.3443	0.5751	0.9248	0.3329	0.5109	0.3437	0.1849	0.3251	
0 FBAR 3- 8	0.3707	0.3987	0.3790	0.4313	0.4867	0.4182	0.5232	0.4909	0.4277	0.4618	

Table 9.3.3 - Sole VIId - Stock numbers at age

Run title : Sole in Division VIId - 2013 WG.

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Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1982
AGE	
1	12738
2	16252
3	20730
4	4731
5	2913
6	3397
7	1549
8	752
9	440
10	306
+gp	742
0 TOTAL	64549

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
AGE										
1	21346	21526	12913	25726	10981	25793	16817	44287	34888	33658
2	11378	19315	19455	11638	23231	9927	23249	15062	38888	31204
3	12209	9485	15596	14091	9340	18056	6926	17722	10917	28371
4	13757	7763	5580	9155	7712	4903	9513	3204	10728	5973
5	2638	8710	4542	3483	5245	3867	2913	4423	1804	5750
6	2094	1534	6074	3133	2291	2793	2396	1272	2579	1058
7	2452	1196	682	3726	2104	1082	1713	1369	864	1387
8	880	1622	647	480	2367	867	610	1007	868	538
9	452	479	1166	435	287	1396	542	361	664	550
10	282	306	304	907	213	154	1020	332	204	355
+gp	608	734	563	1587	592	507	1281	1284	842	861
0 TOTAL	68097	72670	67522	74362	64365	69346	66980	90323	103246	109704

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
AGE										
1	16801	26570	19442	18921	27791	18019	26284	31385	26516	46399
2	30356	15121	24012	16795	17112	25124	16273	23623	28267	23833
3	24386	22684	13022	18895	13461	14067	21424	11616	17964	19830
4	17311	15937	14625	7621	9712	6408	7393	11294	5895	10362
5	3609	10485	8806	8701	4009	4024	3226	3544	6039	3817
6	3307	2306	6249	5145	4823	1647	2085	1672	2183	3094
7	683	2457	1531	3771	2921	2775	911	1060	1032	1283
8	905	464	1683	1029	2192	1772	1981	491	656	658
9	358	640	316	1259	673	1246	1184	1153	304	471
10	335	214	439	203	836	382	791	737	731	222
+gp	696	589	995	617	1317	477	1474	1216	2389	764
0 TOTAL	98746	97468	91123	82957	84847	75940	83025	87791	91975	110734

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	GMST 82-10	AMST 82-10
AGE													
1	20968	19324	34403	41326	18538	20818	32733	41005	14282	10133*	0**	24101	25790
2	41311	18612	16506	30934	36815	16607	18695	29398	36971	12923	9165	20982	22379
3	14896	26957	12795	11636	20979	27118	12456	14057	21582	29043	10617	15677	16610
4	10796	8641	16189	7740	6959	12024	16437	7069	8483	13602	19469	8755	9498
5	5793	6746	5398	9457	4320	3452	6937	8127	3267	4933	8287	4807	5268
6	2108	3525	3943	3416	5291	2482	1919	4014	4421	1520	3121	2743	3029
7	2177	1270	2135	2480	2042	2849	1438	977	2370	2638	484	1604	1790
8	877	1410	796	1330	1487	1133	1864	716	572	1618	1769	987	1106
9	473	605	850	513	820	901	687	1076	394	347	1007	628	700
10	334	361	458	500	282	498	660	358	654	216	196	386	439
+gp	928	954	975	734	398	914	1180	1045	1380	1495	1119		
0 TOTAL	100662	88406	94448	110066	97931	88797	95005	107842	94375	78467	55235		

* Replaced with RCT3 estimate 20512 in prediction
** Replaced with GM (24101) in prediction

Table 9.3.4 - Sole VIId - Summary

Run title : Sole in Division VIId - 2013 WG.

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Table 16 Summary (without SOP correction)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1982	12738	10439	7835	3190	0.4072	0.3542
1983	21346	12633	9603	3458	0.3601	0.4055
1984	21526	12984	9012	3575	0.3967	0.4303
1985	12913	13364	10015	3837	0.3831	0.3353
1986	25726	14017	10634	3932	0.3698	0.3908
1987	10981	13043	9023	4791	0.5310	0.5883
1988	25793	12892	10163	3853	0.3791	0.4286
1989	16817	11939	8471	3805	0.4492	0.5636
1990	44287	13915	9623	3647	0.3790	0.3791
1991	34888	15909	8798	4351	0.4945	0.4519
1992	33658	17396	11220	4072	0.3629	0.3703
1993	16801	17967	13181	4299	0.3262	0.3008
1994	26570	15659	12576	4383	0.3485	0.3534
1995	19442	15127	11129	4420	0.3971	0.3643
1996	18921	15732	12182	4797	0.3938	0.4718
1997	27791	14349	10581	4764	0.4502	0.5884
1998	18019	12571	8152	3363	0.4125	0.4533
1999	26284	12483	9086	4135	0.4551	0.5446
2000	31385	13021	8569	3476	0.4056	0.4387
2001	26516	12567	7651	4025	0.5260	0.3941
2002	46399	14149	8588	4733	0.5511	0.3742
2003	20968	17731	10445	5038	0.4823	0.3707
2004	19324	14967	11451	4826	0.4215	0.3987
2005	34403	19026	11481	4383	0.3818	0.3790
2006	41326	20766	9959	4833	0.4853	0.4313
2007	18538	19115	10537	5166	0.4903	0.4867
2008	20818	18282	12931	4517	0.3493	0.4182
2009	32733	19369	11594	5266	0.4542	0.5232
2010	41005	19394	9150	4409	0.4819	0.4909
2011	14282	16624	10660	4133	0.3877	0.4277
2012	10133[1]	16524	12662	4047	0.3196	0.4618
2013	24101[2]	17174[3]	11428[3]			0.4601[4]
Arith. Mean	24914	15289	10225	4243	0.4204	0.4313
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

[1] Replaced with RCT3 estimate 20512

[2] Geometric mean 1982-2010

[3] From forecast

[4] $F_{(10-12)}$ NOT rescaled to F_{2012}

Table 9.5.1 - Sole VIId – RCT3 input

Yearclass	XSA (Age 1)	XSA (Age 2)	FR-YF0	FR-YF1	BTS1	BTS2
1981	12738	11378	3.33	0.07	-11	-11
1982	21346	19315	1.04	0.02	-11	-11
1983	21526	19455	0.79	-11	-11	-11
1984	12913	11638	-11	-11	-11	-11
1985	25726	23231	-11	-11	-11	-11
1986	10981	9927	-11	0.07	-11	14.20
1987	25793	23249	0.75	0.17	8.20	15.40
1988	16817	15062	0.04	0.14	2.60	3.70
1989	44287	38888	17.43	0.54	12.10	22.80
1990	34888	31204	0.57	0.38	8.90	12.00
1991	33658	30356	1.04	0.22	1.40	17.50
1992	16801	15121	0.48	0.03	0.50	3.20
1993	26570	24012	0.27	0.70	4.80	10.60
1994	19442	16795	4.04	0.28	3.50	7.30
1995	18921	17112	3.50	0.15	3.50	7.30
1996	27791	25124	0.28	0.03	19.00	21.20
1997	18019	16273	0.07	0.10	2.00	9.44
1998	26284	23623	10.52	0.35	28.14	22.03
1999	31385	28267	2.84	0.31	10.49	21.01
2000	26516	23833	2.41	1.21	9.09	11.42
2001	46399	41311	4.32	0.11	31.76	28.48
2002	20968	18612	0.94	0.32	6.47	8.49
2003	19324	16506	0.21	0.15	7.35	5.04
2004	34403	30934	7.29	0.82	25.00	29.20
2005	41326	36815	0.05	0.83	6.30	21.86
2006	18538	16607	1.04	0.08	2.14	6.50
2007	20818	18695	0.03	0.06	2.90	13.3
2008	32733	29398	6.58	2.78	30.5	30.1
2009	-11	-11	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	-11
2012	-11	-11	0.44	-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   32 years :  1981 - 2012

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 =   2010
         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    1.14   9.03    .89   .128     25    .18    9.24     .966     .047
FR-YF1    2.57   9.37    .69   .230     25    .28   10.09     .739     .080
BTS1       .56   9.01    .39   .420     22   2.56   10.44     .417     .253
BTS2       .85   7.91    .35   .520     23   2.32    9.88     .381     .302

                                       VPA Mean =   10.07     .371     .318
Yearclass =   2011
         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    1.14   9.03    .89   .128     25   1.33   10.54     .953     .070
FR-YF1    2.57   9.37    .69   .230     25    .30   10.15     .739     .117
BTS1       .56   9.01    .39   .420     22   1.01    9.57     .427     .350
BTS2

                                        VPA Mean =   10.07     .371     .463
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    1.14   9.03    .89   .128     25    .36    9.45(12708)     .959
.130
FR-YF1
BTS1
BTS2

                                       VPA Mean =   10.07(23624)     .371
.870

Year     Weighted      Log     Int     Ext     Var     VPA      Log
Class     Average      WAP     Std     Std    Ratio             VPA
         Prediction           Error   Error
2010       23594     10.07     .21     .14      .45
2011       20726      9.94     .25     .17      .45
2012       21803      9.99     .35     .21      .37
```

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   32 years :  1981 - 2012

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 =   2010

          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    1.16   8.90    .91   .124     25    .18    9.11     .988     .044
FR-YF1    2.57   9.26    .69   .231     25    .28    9.98     .738     .080
BTS1       .57   8.88    .39   .415     22   2.56   10.33     .423     .243
BTS2       .84   7.83    .34   .535     23   2.32    9.77     .370     .317

                                      VPA Mean =    9.96     .371     .316
Yearclass =   2011

          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    1.16   8.90    .91   .124     25   1.33   10.44(34201)     .975     .068
FR-YF1    2.57   9.26    .69   .231     25    .30   10.03(22697)     .738     .119
BTS1       .57   8.88    .39   .415     22   1.01    9.46(12836)     .434     .343
BTS2

                                     VPA Mean =    9.96(21163)     .371     .470
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    1.16   8.90    .91   .124     25    .36    9.32     .981     .125
FR-YF1
BTS1
BTS2

                                      VPA Mean =    9.96     .371     .875
Year     Weighted      Log     Int     Ext     Var     VPA      Log
Class     Average      WAP     Std     Std    Ratio             VPA
         Prediction           Error   Error

2010       21031      9.95     .21     .14      .45
2011       18553      9.83     .25     .17      .45
2012       19553      9.88     .35     .21      .37
```

Table 9.6.1 - Sole in VIId
Input for catch forecast and linear sensitivity analysis

Label	Value	CV	Label	Value	CV
Number at age			Weight in the stock		
N1	24101	0.38	WS1	0.122	0.52
N2	18553	0.25	WS2	0.152	0.07
N3	10617	0.26	WS3	0.186	0.02
N4	19469	0.17	WS4	0.232	0.08
N5	8287	0.13	WS5	0.268	0.03
N6	3121	0.12	WS6	0.305	0.07
N7	484	0.13	WS7	0.343	0.02
N8	1769	0.12	WS8	0.346	0.07
N9	1007	0.11	WS9	0.389	0.13
N10	196	0.13	WS10	0.465	0.09
N11	1119	0.13	WS11	0.462	0.11
H.cons selectivity			Weight in the HC catch		
sH1	0.0013	1.52	WH1	0.140	0.20
sH2	0.1490	0.38	WH2	0.166	0.05
sH3	0.3555	0.15	WH3	0.200	0.02
sH4	0.5032	0.29	WH4	0.245	0.03
sH5	0.5106	0.30	WH5	0.290	0.02
sH6	0.6292	0.57	WH6	0.321	0.07
sH7	0.3389	0.25	WH7	0.351	0.04
sH8	0.4234	0.15	WH8	0.370	0.07
sH9	0.4569	0.12	WH9	0.443	0.19
sH10	0.2846	0.31	WH10	0.414	0.11
sH11	0.2846	0.31	WH11	0.493	0.08
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		
HF13	1	0.09	K13	1	0.1
HF14	1	0.09	K14	1	0.1
HF15	1	0.09	K15	1	0.1
Recruitment in 2007 and 2008					
R13	24101	0.38			
R14	24101	0.38			

Table 9.6.2 Sole in VIId - Management option table

MFDP version 1a **F - status quo**
Run: SOL7D_fin_SQ
Sole in VIId
Time and date: 09:38 26/04/2013
Fbar age range: 3-8

2013 Biomass	SSB	FMult	FBar	Landings
17174	11428	1.0000	0.4601	4752

2014 Biomass	SSB	FMult	FBar	Landings	2015 Biomass	SSB
16416	10181	0.0000	0.0000	0	20529	14290
.	10181	0.1000	0.0460	514	20001	13761
.	10181	0.2000	0.0920	1006	19495	13256
.	10181	0.3000	0.1380	1477	19011	12772
.	10181	0.4000	0.1840	1928	18547	12309
.	10181	0.5000	0.2301	2360	18104	11866
.	10181	0.6000	0.2761	2774	17680	11442
.	10181	0.7000	0.3221	3171	17273	11036
.	10181	0.8000	0.3681	3550	16884	10648
.	10181	0.9000	0.4141	3915	16511	10275
.	10181	1.0000	0.4601	4264	16154	9918
.	10181	1.1000	0.5061	4598	15811	9577
.	10181	1.2000	0.5521	4919	15483	9249
.	10181	1.3000	0.5982	5227	15169	8935
.	10181	1.4000	0.6442	5523	14867	8633
.	10181	1.5000	0.6902	5806	14578	8345
.	10181	1.6000	0.7362	6079	14300	8067
.	10181	1.7000	0.7822	6340	14034	7802
.	10181	1.8000	0.8282	6591	13778	7546
.	10181	1.9000	0.8742	6832	13533	7301
.	10181	2.0000	0.9202	7064	13297	7066

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.87						
.	10181	0.8700	0.4003	3807	16621	10385
Fmult corresponding to Fmsy = 0.63						
.	10181	0.6300	0.2899	2895	17556	11319
Fmult corresponding to Fmsy transition = 0.72						
.	10181	0.7200	0.3313	3248	17194	10957

Bpa/Btrigger = 8 000 t

Table 9.6.3 Sole in VIId. Detailed results

MFDP version 1a
Run: SOL7D_fin_SQ
Time and date: 09:38 26/04/2013
Fbar age range: 3-8

F - status quo

Year: 2013 F multiplier: 1 Fbar: 0.4601

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0013	31	4	24101	2932	0	0	0	0
2	0.1490	2447	406	18553	2814	0	0	0	0
3	0.3555	3032	607	10617	1971	10617	1971	10617	1971
4	0.5032	7356	1800	19469	4510	19469	4510	19469	4510
5	0.5106	3167	918	8287	2218	8287	2218	8287	2218
6	0.6292	1394	448	3121	951	3121	951	3121	951
7	0.3389	133	47	484	166	484	166	484	166
8	0.4234	583	216	1769	611	1769	611	1769	611
9	0.4569	353	156	1007	392	1007	392	1007	392
10	0.2846	46	19	196	91	196	91	196	91
11	0.2846	264	130	1119	517	1119	517	1119	517
Total		18806	4752	88723	17174	46069	11428	46069	11428

Year: 2014 F multiplier: 1 Fbar: 0.4601

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0013	31	4	24101	2932	0	0	0	0
2	0.1490	2873	477	21778	3303	0	0	0	0
3	0.3555	4130	827	14464	2685	14464	2685	14464	2685
4	0.5032	2544	622	6733	1560	6733	1560	6733	1560
5	0.5106	4070	1180	10651	2851	10651	2851	10651	2851
6	0.6292	2010	646	4500	1371	4500	1371	4500	1371
7	0.3389	413	145	1505	516	1505	516	1505	516
8	0.4234	103	38	312	108	312	108	312	108
9	0.4569	367	163	1048	408	1048	408	1048	408
10	0.2846	136	56	577	269	577	269	577	269
11	0.2846	211	104	895	413	895	413	895	413
Total		16888	4264	86564	16416	40685	10181	40685	10181

Year: 2015 F multiplier: 1 Fbar: 0.4601

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0013	31	4	24101	2932	0	0	0	0
2	0.1490	2873	477	21778	3303	0	0	0	0
3	0.3555	4848	971	16978	3152	16978	3152	16978	3152
4	0.5032	3465	848	9172	2125	9172	2125	9172	2125
5	0.5106	1407	408	3683	986	3683	986	3683	986
6	0.6292	2584	830	5784	1762	5784	1762	5784	1762
7	0.3389	595	209	2170	744	2170	744	2170	744
8	0.4234	320	118	971	335	971	335	971	335
9	0.4569	65	29	185	72	185	72	185	72
10	0.2846	142	59	601	279	601	279	601	279
11	0.2846	237	117	1002	463	1002	463	1002	463
Total		16566	4070	86425	16154	40545	9918	40545	9918

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	2009	2010	2011	2012	2013
Stock No. (thousands) of 1 year-olds	41005	14282	20512	24101	24101
Source	XSA	XSA	RCT3	GM82-10	GM82-10
Status Quo F:					
% in 2013 landings	37.9	12.8	8.5	0.1	-
% in 2014 landings	27.7	14.6	19.4	11.2	0.1
% in 2013 SSB	39.5	17.2	0.0	0.0	-
% in 2014 SSB	28.0	15.3	26.4	0.0	0.0
% in 2015 SSB	17.8	9.9	21.4	31.8	0.0

GM : geometric mean recruitment

Sole VIId : Year-class % contribution to

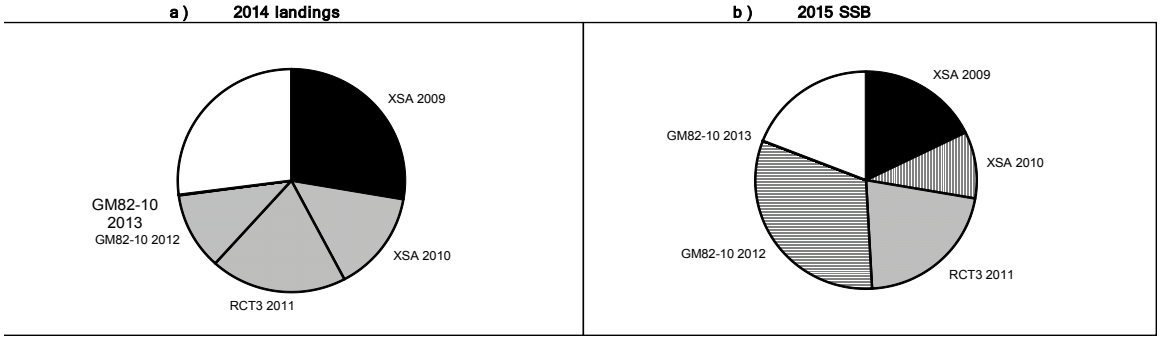


Table 9.7.1 - Sole in VIId Yield per recruit summary table

MFYPR version 2a
Run: S7d_Yield_fin
Time and date: 09:53 26/04/2013
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0.0000	0.0000	0.0000	0.0000	10.5083	3.4553	8.6035	3.1964	8.6035	3.1964
0.1000	0.0460	0.2395	0.0816	8.1166	2.4219	6.2118	2.1630	6.2118	2.1630
0.2000	0.0920	0.3813	0.1224	6.7016	1.8287	4.7970	1.5699	4.7970	1.5699
0.3000	0.1380	0.4728	0.1439	5.7893	1.4589	3.8848	1.2000	3.8848	1.2000
0.4000	0.1840	0.5357	0.1557	5.1636	1.2142	3.2593	0.9553	3.2593	0.9553
0.5000	0.2301	0.5810	0.1621	4.7136	1.0446	2.8093	0.7858	2.8093	0.7858
0.6000	0.2761	0.6149	0.1655	4.3771	0.9226	2.4730	0.6638	2.4730	0.6638
0.7000	0.3221	0.6412	0.1671	4.1174	0.8319	2.2134	0.5731	2.2134	0.5731
0.8000	0.3681	0.6621	0.1678	3.9113	0.7626	2.0075	0.5038	2.0075	0.5038
0.9000	0.4141	0.6790	0.1678	3.7441	0.7083	1.8403	0.4496	1.8403	0.4496
1.0000	0.4601	0.6932	0.1675	3.6055	0.6649	1.7019	0.4062	1.7019	0.4062
1.1000	0.5061	0.7051	0.1670	3.4887	0.6294	1.5852	0.3707	1.5852	0.3707
1.2000	0.5521	0.7153	0.1664	3.3888	0.6000	1.4854	0.3413	1.4854	0.3413
1.3000	0.5982	0.7242	0.1657	3.3021	0.5751	1.3989	0.3165	1.3989	0.3165
1.4000	0.6442	0.7320	0.1650	3.2261	0.5539	1.3230	0.2952	1.3230	0.2952
1.5000	0.6902	0.7390	0.1644	3.1588	0.5355	1.2558	0.2769	1.2558	0.2769
1.6000	0.7362	0.7452	0.1637	3.0986	0.5194	1.1957	0.2608	1.1957	0.2608
1.7000	0.7822	0.7508	0.1630	3.0444	0.5052	1.1416	0.2466	1.1416	0.2466
1.8000	0.8282	0.7559	0.1624	2.9953	0.4925	1.0926	0.2340	1.0926	0.2340
1.9000	0.8742	0.7606	0.1618	2.9504	0.4812	1.0479	0.2226	1.0479	0.2226
2.0000	0.9202	0.7649	0.1612	2.9093	0.4709	1.0068	0.2124	1.0068	0.2124

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4751
FMax	0.7404	0.3518
F0.1	0.2946	0.1399
F35%SPR	0.2896	0.1376

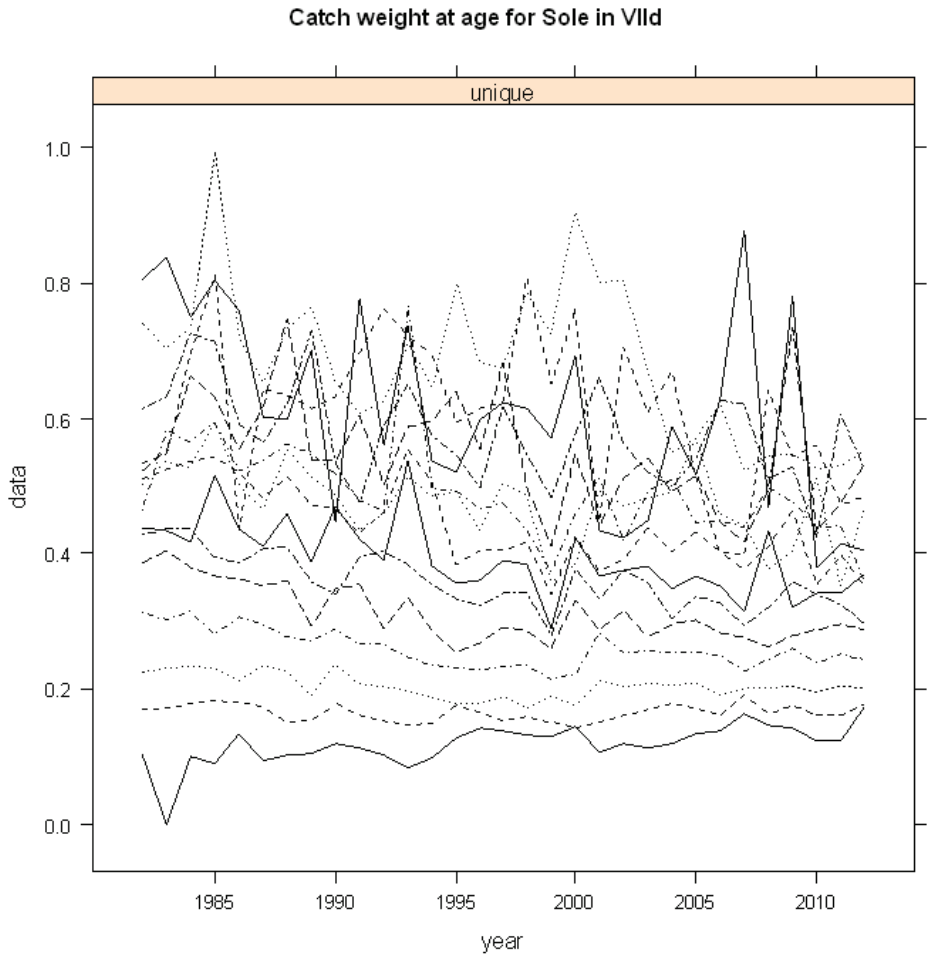


Figure 9.2.1 - Sole in VIId - Catch weight at age



Figure 9.2.2 - Sole in VIId - Stock weight at age

Figure 9.2.3a

Sole VIId - Effort series

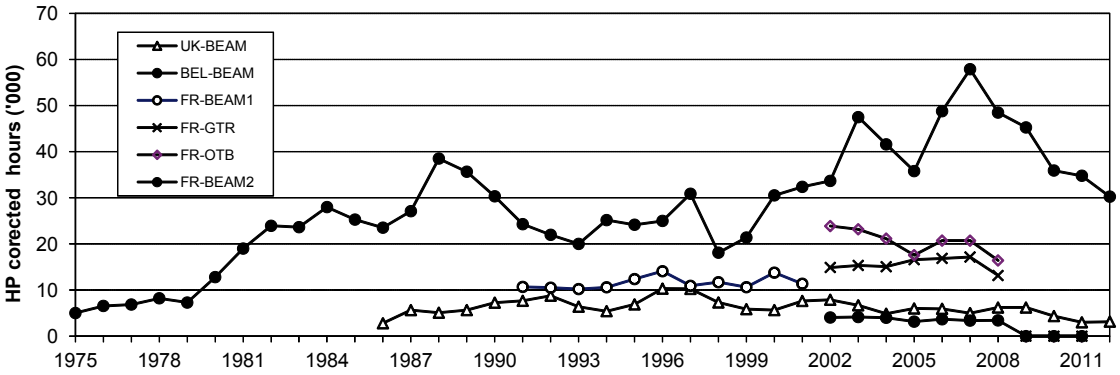


Figure 9.2.3b

Sole VIId - Relative Effort series

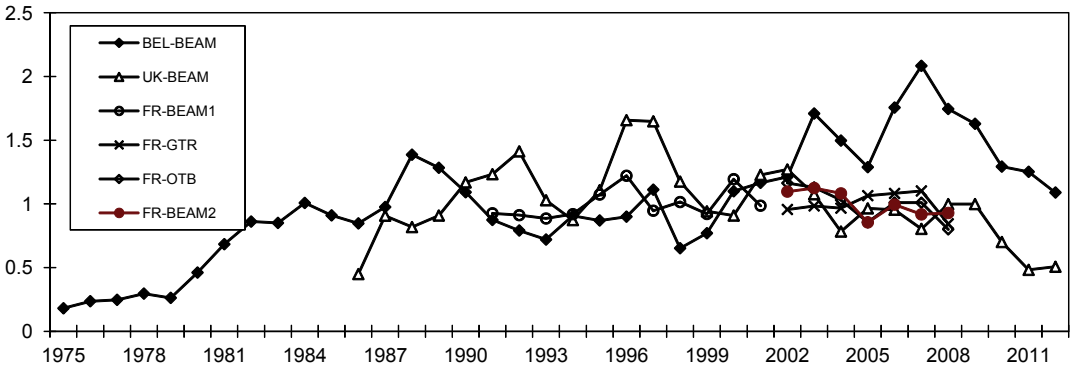
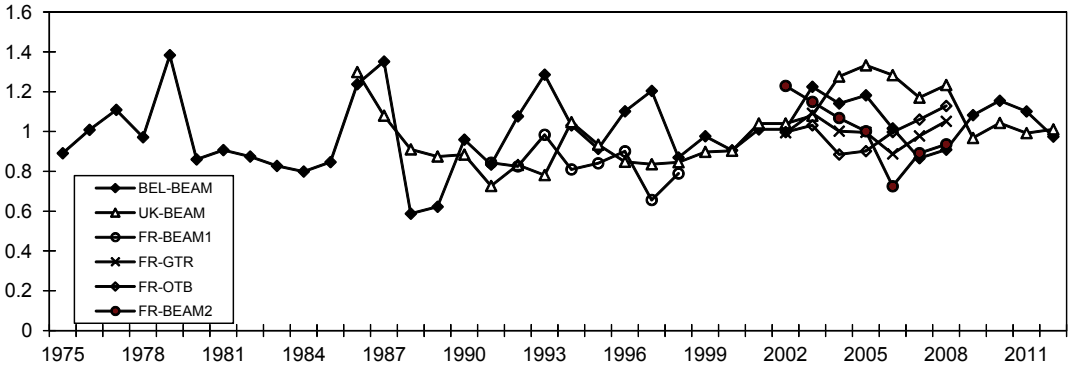


Figure 9.2.3c

Sole VIId - Relative LPUE series



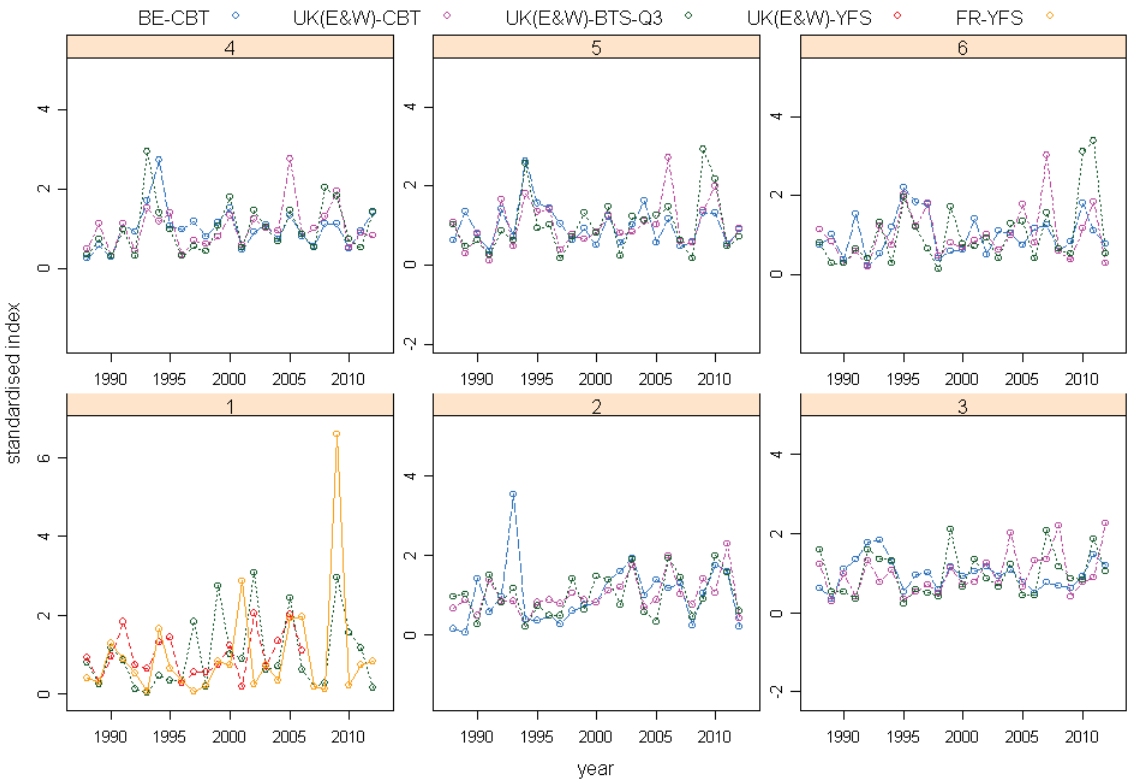


Figure 9.3.1 Sole in VIId. Standardized tuning indices used for tuning XSA: BE-CBT (blue), UK(E&W)-CBT (pink), UK-BTS (green) UK(E&W)YFS (red) and FR-YFS (orange).

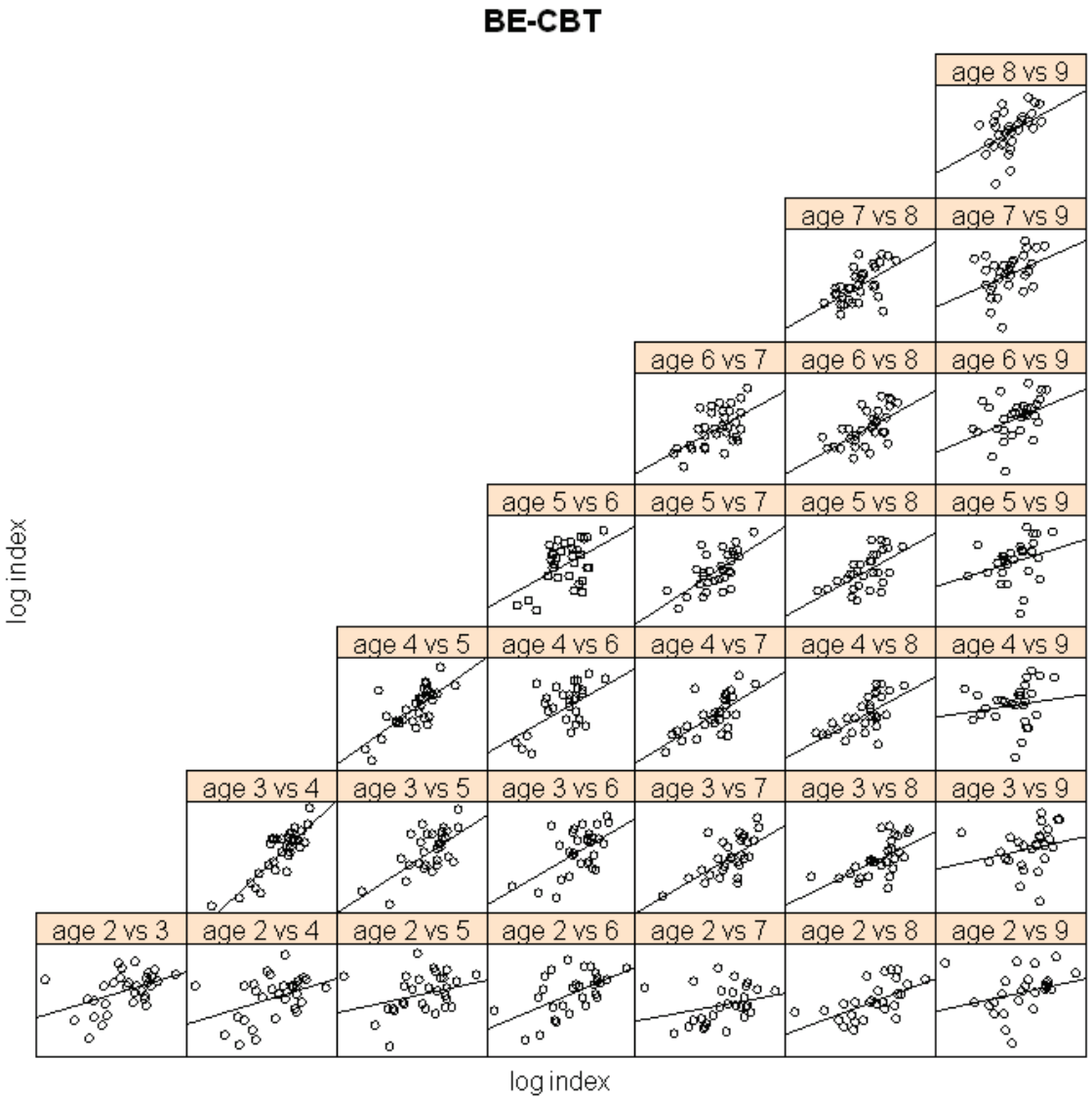


Figure 9.3.2 Sole in VIId. Internal concistency plot for the Belgian commercial fleet (BE-CBT).

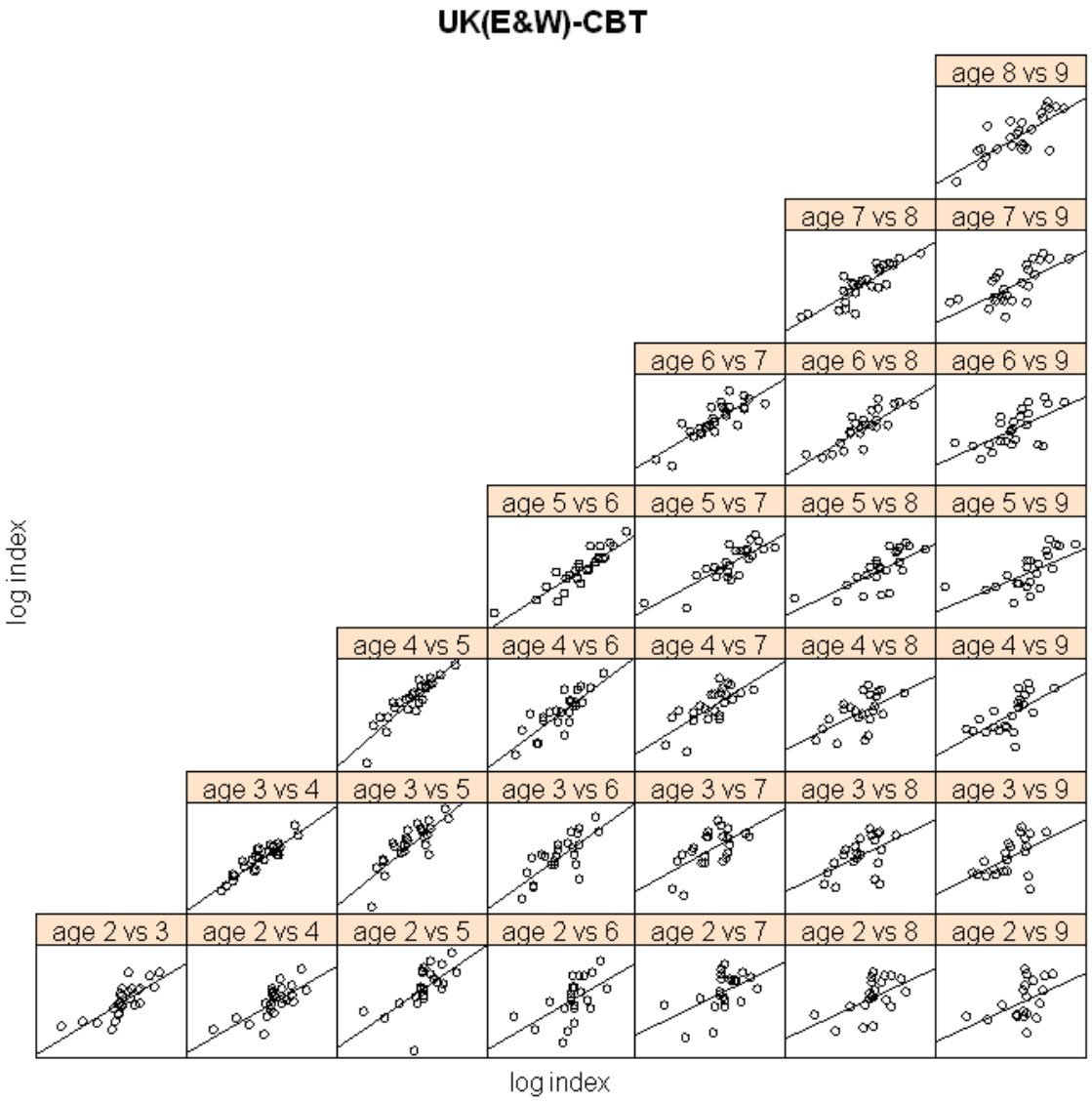


Figure 9.3.3 Sole in VIId. Internal concistency plot for the UK commercial fleet (UK(E&W)-CBT).

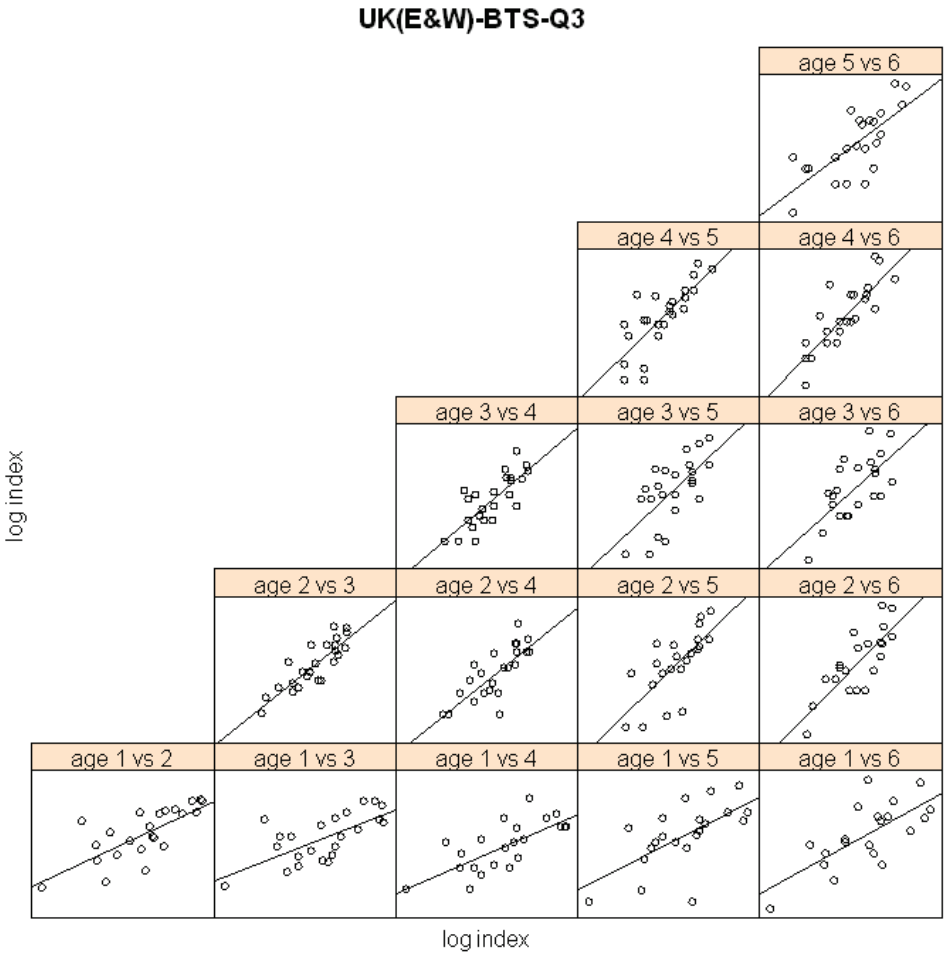


Figure 9.3.4 Sole in VIId. Internal concistency plot for the UK beam trawl survey (UK(E&W)-BTS).

Figure 9.3.5a - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

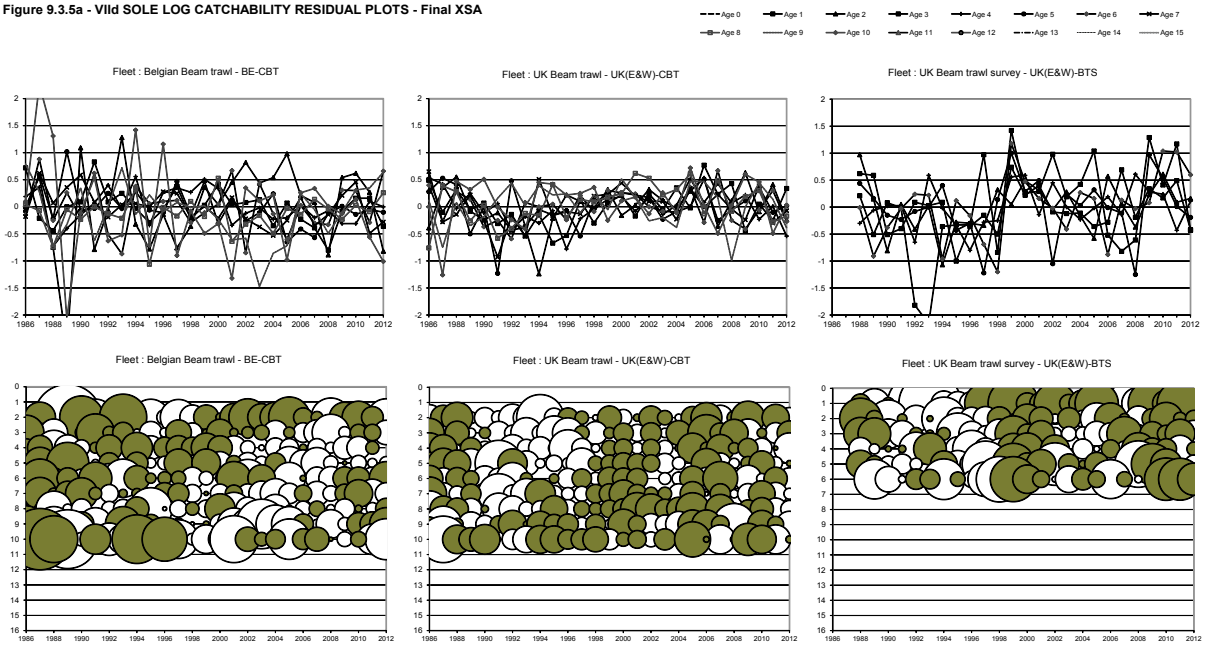


Figure 9.3.5b - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

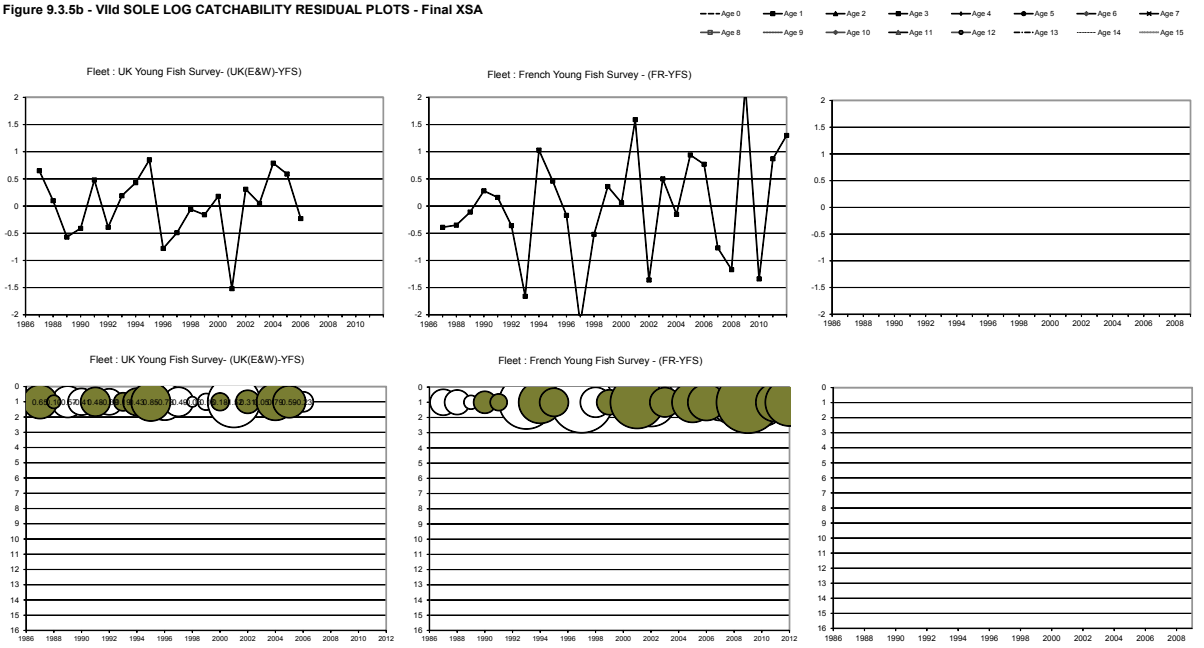


Figure 9.3.6 Sole in VIId. Estimates of survivors from different fleets and shrinkage, as well as their different weighting in the final XSA-run

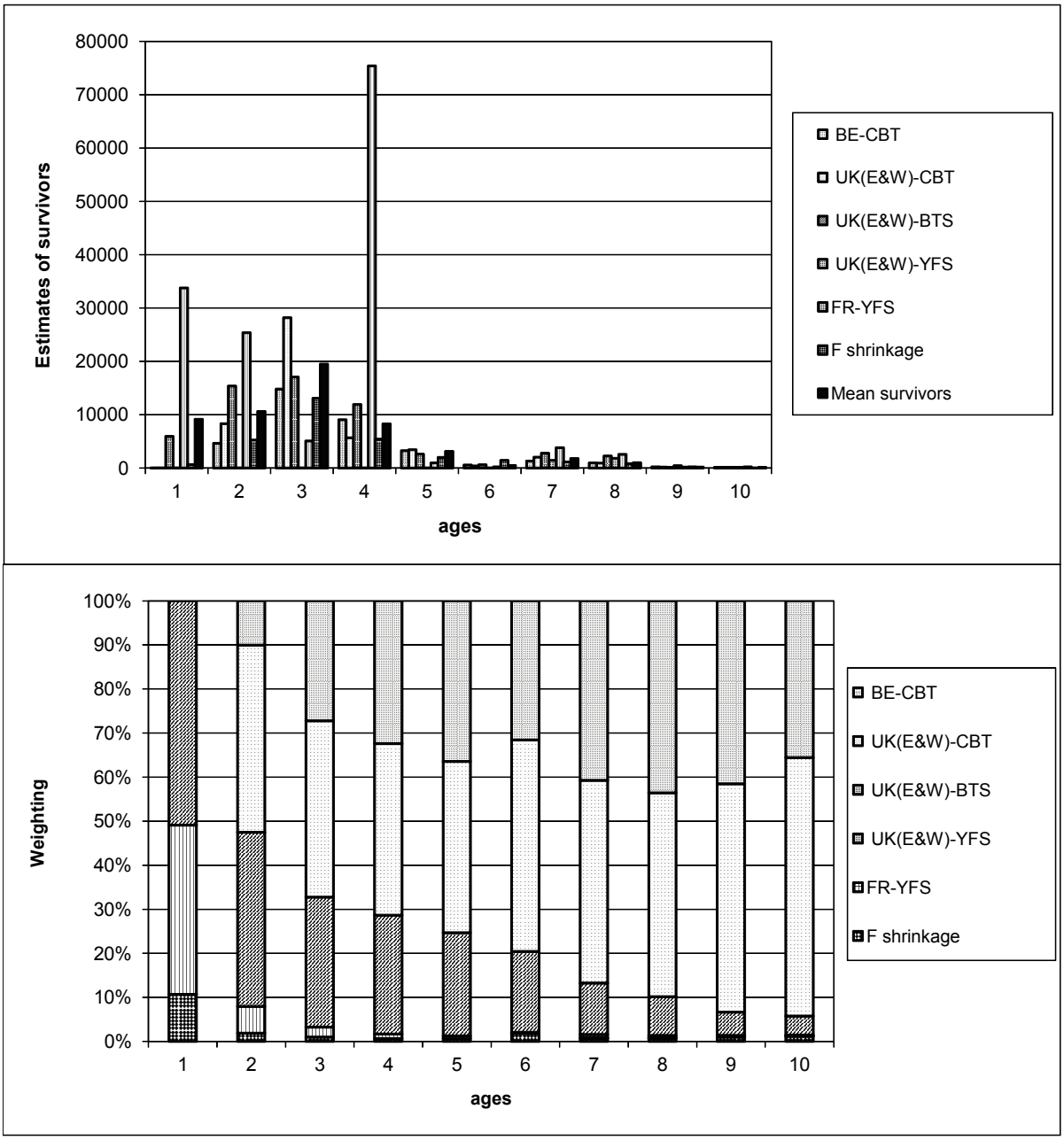
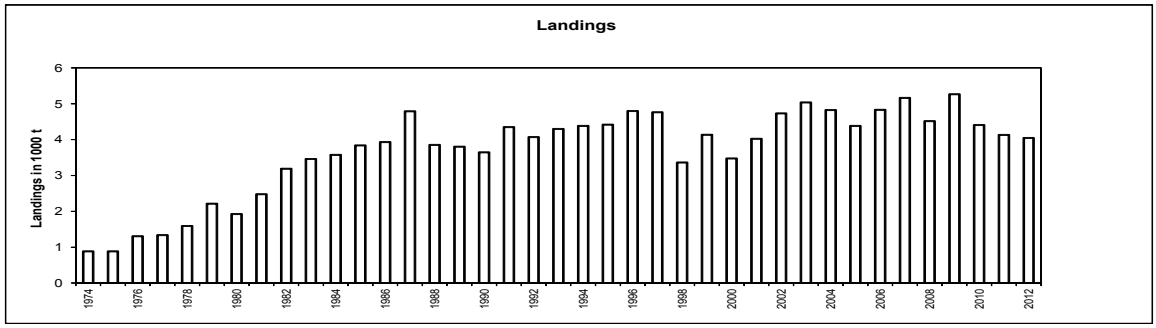
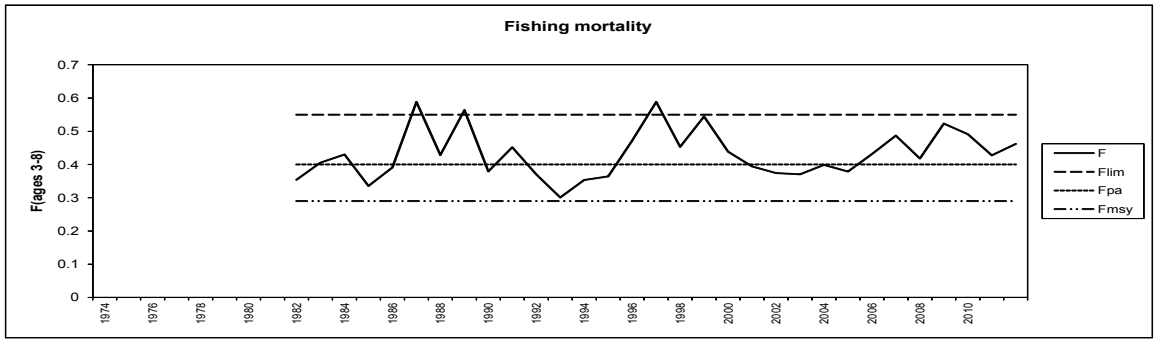
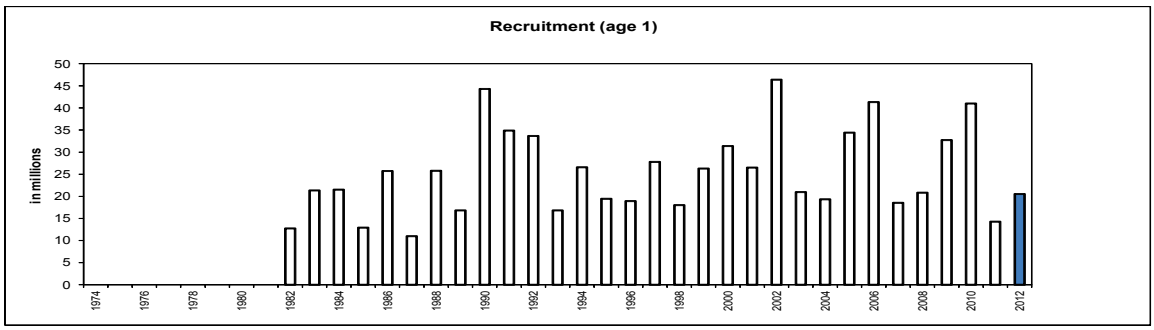


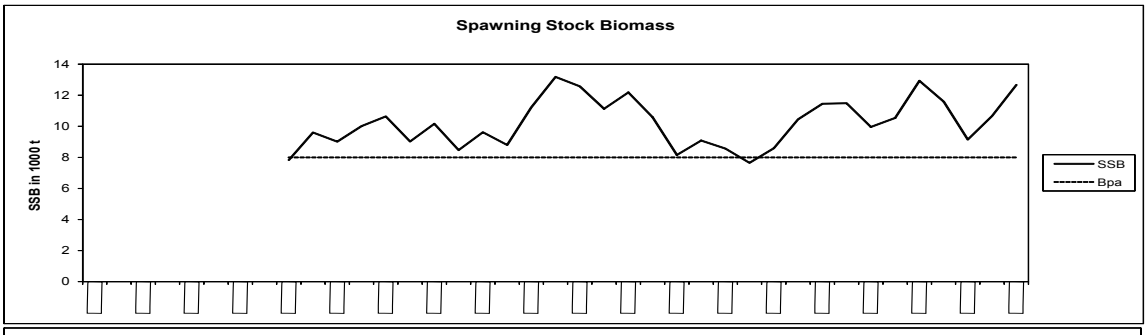
Figure 9.3.7 Sole in VIId. Summary plots







Shaded bar = RCT3 estimate



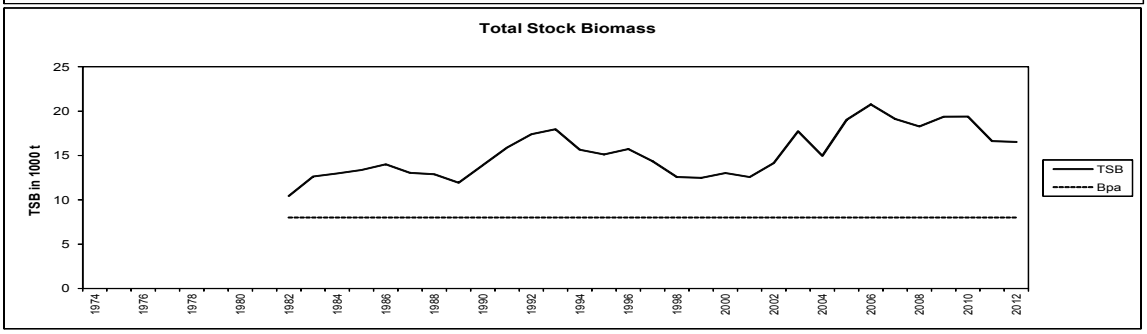


Figure 9.3.8 - Sole VIId retrospective XSA analysys (shinkage SE=2.0)

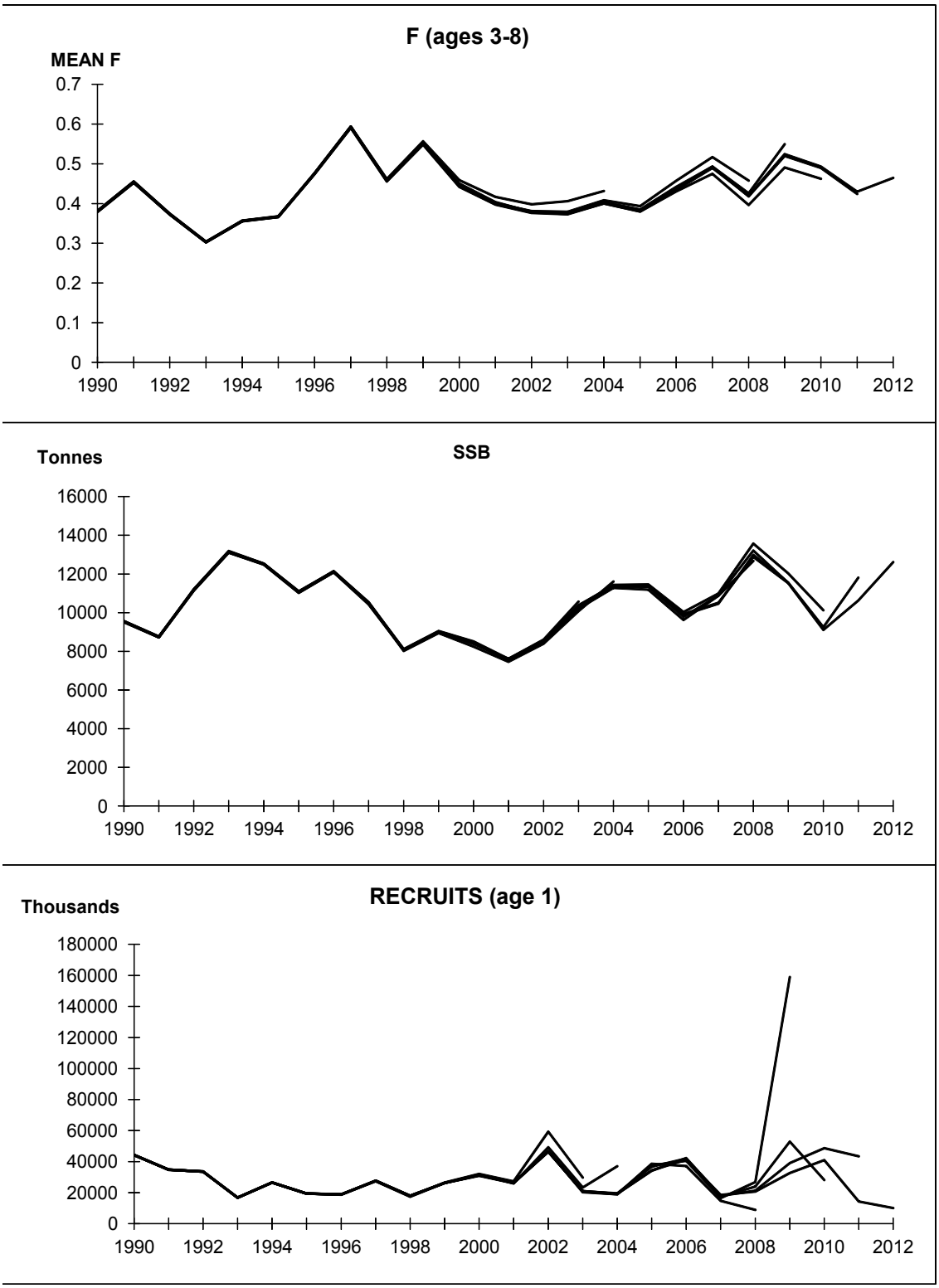
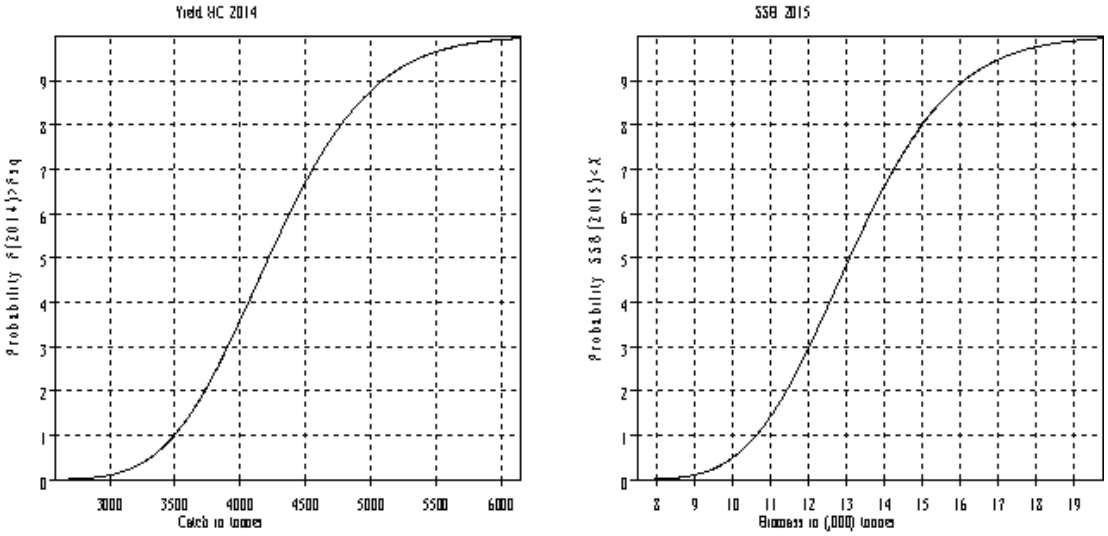
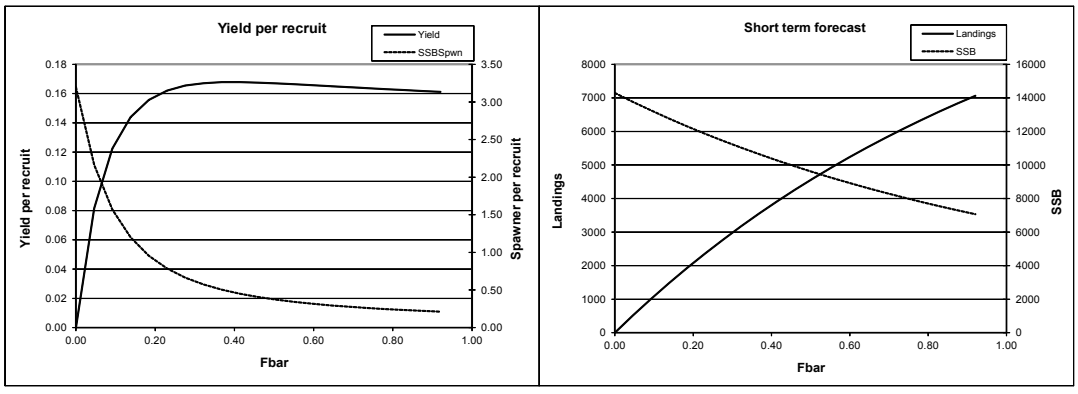


Figure 9.6.1 - Sole VIId - Probability profiles for short term forecast.



Data from file:D:\ILVO\2013\WGNSSK_2013\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: 09:53 26/04/2013

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4751
FMax	0.7404	0.3518
F0.1	0.2946	0.1399
F35%SPR	0.2896	0.1376

MFDP version 1a
Run: SOL7D_fin_SQ
Sole in VIId
Time and date: 09:38 26/04/2013
Fbar age range: 3-8

Input units are thousands and kg - output in tonnes

Figure 9.9.1 - Sole VIId - Stock/recruiment plot

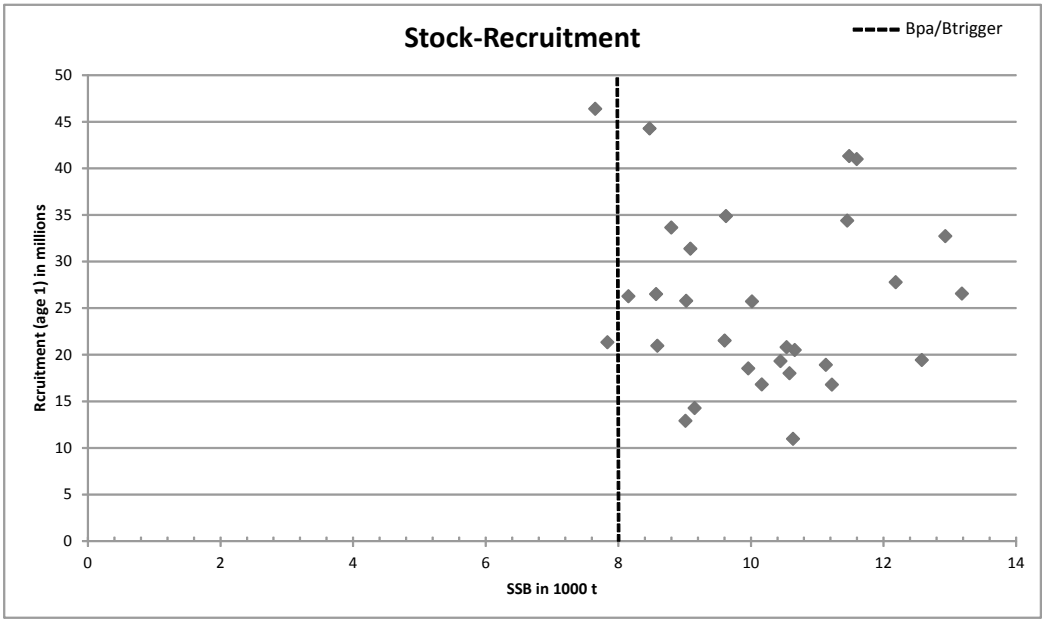
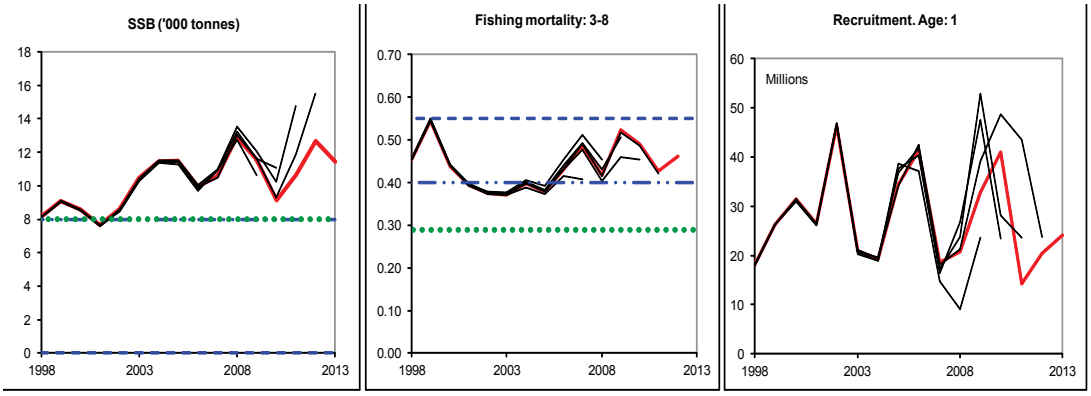


Figure 9.9.2 Sole in VIId. Historical Performance of assessment of successive WG assessment and forecast



10 Sole in Subarea IV

The assessment of sole in Subarea IV is presented as an update assessment with minor analysis requested by the review group. 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

More information is available on the North Sea sole fishery in the Stock Annex. It is worth mentioning here, however, a change in mesh size that took place in 2010 with the introduction of the OMEGA mesh size meter by the Dutch Inspection Service. Fishermen had to get rid of their old cod-ends or face a fine. Mesh sizes that were previously measured by hand at 80 mm, are now measured at 75-78 mm with the OMEGA meter hence fishermen were forced to increase their 'effective' mesh size. No 'official' change in minimum mesh size was needed. According to fisheries representatives it is possible that the introduction of the OMEGA meter resulted in stricter control and more fines, and that less fishermen dared to use double cod-ends.

The Dutch fleet, which takes the majority of the TAC did not fully utilise its quota in 2012, which is not customary for this fleet considering the relatively high value of this species in the mixed fishery. However, the same trend was seen in 2010 and 2011. Only 11 610 tonnes of their quota of 16 200 tonnes were utilised which represents only 72%. According to the Dutch industry, one of the reasons is that many fishermen prefer to target plaice because the plaice stock is doing well and because the value of plaice has increased. In addition, the value of sole has decreased and is unstable. Another reason may be that the average size in the sole landings was relatively low in 2012.

10.1.3 ICES Advice for 2013

The information in this section is taken from the Advice summary sheet 2012, section 6.4.10.

Advice for 2013

ICES advises on the basis of the EU management plan (Council Regulation No. 676/2007) that landings in 2013 should be no more than 14 000 tonnes. ICES notes that the advice is based on stage one of the plan. The implementation of stage two of the plan (as stipulated in article 5 of the EC regulation) is not yet defined.

Management plan

Following the EU multiannual plan would imply a 10% reduction of F to 0.27, resulting in a TAC of 14 000 t in 2013 (an exact 15% reduction in comparison to 2012, without applying the 15% TAC change bounds of the plan) and implying a 10% reduction in fishing effort. This is expected to lead to an SSB of 49 000 t in 2014. ICES has evaluated this management plan and considers it to be precautionary. Both the North Sea plaice and sole stocks have 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)

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 - 2013.

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. ICES has evaluated the plan (Miller and Poos 2010; Simmonds 2010; see section 8.8.2)

and found it to be in agreement with the precautionary approach (ICES, 2010). See Section 19 (Management Plan Evaluations) of this report for further details. In 2012 the plan was evaluated again (Coers and Miller 2012). However, this plan has not been reviewed by ICES yet.

10.3 Data available

10.3.1 Catch

Annual landings data by country and TACs are presented in Table 10.2.1 and total landings are presented in Figure 10.2.1B. In 2010 - 2012 approximately 70-90% of the TAC was taken. The discards percentages observed in the Dutch discard sampling programme sampling beam trawl vessels fishing for sole with 80-89mm mesh size are much lower for sole (e.g. for 2002–2008, between 10–17% by weight, see Table 10.2.2) than for plaice. No significant trends in discard percentages were observed. Inclusion of a stable time series of discards in the assessment will have minor effect on the relative trends in stock indicators (Kraak *et a*l 2002; Van Keeken *et al* 2003). In addition, gaps in the discard sampling programs result in incomplete time series. The inclusion of discards in the assessment of this stock will be considered further in future benchmarks, which is planned in 2015.

10.3.2 Age compositions

The age composition of the landings is presented in Table 10.2.3. The age compositions were combined separately by sex on a quarterly basis and then raised to the annual international total (see also section 1.2.4).

Peaks in the historical time-series of SSB of North Sea sole correspond with the occasional occurrence of strong year classes. Due to high fishing mortality, SSB declined during the nineties. Fishing opportunities and SSB are now much more dependent on incoming year classes and can therefore fluctuate considerably between years. These fluctuations are also reflected in the catch composition. The mean age in the landings is estimated at 3.8 in 2012, (compared to around age 6 in the late 1950s and early 1960s). A lower exploitation level is expected to improve the survival of sole to the spawning population, which should enhance stability in the catch composition as well as estimates of SSB and thus fishing opportunities. Recently the sole population (Figure 10.2.1) has been dominated by the strong 2005 year class which were age 7 in 2012. The proportion of this year class in the catches is now decreasing. Log catch ratios and catch curves for sole ages 2 to 9 are summarised in Figures 10.2.2 A and B (1957 to 2012).

InterCatch

For WGNSSK 2013, InterCatch was used for raising the landings for the second time (see Table below). The comparison with the 'so far used' tools could not be made because the data was not available in the right format. In addition, this year the raising was done by metier for the first time, 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 and for which the age distribution is known. International landings results in >90% of landings for which the age distribution is known. Discards are not used in the sole assessment. Therefore, the use of intercatch will probably not result in major differences from the 'so far used' tools.

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 are given in table 10.2.4.

10.3.3 Weight at age

Weights at age in the landings for both sexes combined (Table 10.2.5) are measured weights from the various national market sampling programs. Weights at age in the stock (stock weights, Table 10.2.6) are the average weights from the 2nd Quarter landings. Over the entire time series, weights were higher between the mid 1970s and mid 1980s (Figures 10.2.1c & 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.

10.3.4 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 1957–2011 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 winters of 2009-2010 & 2010-2011

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 was available during WGNSSK2011-2013. There is no proven relationship between winter water temperature and sole mortality, so ad hoc adjustments as were made for 1963 are only done in extreme circumstances.

10.3.5 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. Effort increased between 1997 and 1998 where it peaked and has since steadily declined. Effort during 2009 was <50% of the level in 1998 in the series (Table 10.2.7 and 10.2.8 cont.). After 2009 the effort was more or less stable.

The lpue estimated for 2012 (377kg hpday^{-1}) was substantially above the 1997-2011 mean (267 kg hpday^{-1}).

The BTS (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 omitted (Table 10.2.8 and Figure 10.2.5). In 2012, the SNS was carried out with the research vessel Tridens, whereas in other years the Isis was used. In addition, the survey was carried out 2 weeks later than usual. The reason for these changes is that the Isis was unavailable due to technical problems.

The 2012 SNS survey was for some ages inconsistent with the trends observed in the BTS-Isis (figure 10.2.4). However, comparing the inshore SNS and offshore BTS-Isis with another inshore survey in the German bight (Solea, consisting of 3 components), showed that the SNS was not inconsistent with the trends in this survey (10.2.4b).

10.4 Data analyses

The assessment of North Sea sole was carried out using the FLR version of XSA (FLXSA 2.0) in R version 2.13.1.

Reviews of last year's assessment

Comments made in 2012 by the Review Group (Technical Minutes), which accepted last year's assessment, are summarised below in italics, and it is explained how this WG addressed the comments.

General comments

The text of the report was well written and very easy to follow.

The TAC of this high valued species was not fully utilized in 2011 (11,485t of 14,100t) for a number of reasons – low gill net catch rates, gear change, and test fishing.

Discards of North Sea sole are considered minimal and are not included in the assessment. They will likely need to be included in the near future, perhaps the next benchmark. The shift in fishing effort concentration to the south coupled with movement of juvenile plaice to deeper waters may drastically increase discards of juveniles and should be continued to be monitored. As with sole in Division VIId, the mixed fishery for sole in the North Sea catches substantial quantities of undersize plaice which are discarded.

WGNSSK answer:

We agree that we need to explore the effect of discards in the assessment. A benchmark is planned in 2015 in which we will explore the effects of including discards in the assessment.

As recommended by the WKFLAT 2010, XSA continue to be used for providing advice, but SAM should be run concurrently. The NS sole stock is dependent upon the occurrence of strong year classes. In addition to the 2005 strong year class, the 2009 years class is estimated to be well above average and the 2008 around the geometric mean.

Many of the tables seem to be text file outputs from modeling software and are unpleasant to interpret. A small bit of formatting of these tables would be helpful to reviewers.

WGNSSK answer:

We have improved the formatting of the tables

While the figures in this report are small, they are well formatted and spread out so they are easy to interpret and read.

Have any additional model runs been conducted with different values of M in an attempt to account for environmental conditions (cold winters)?

WGNSSK answer:

No. This is something that should also be considered in the 2015 benchmark

Technical comments

InterCatch was used for the first time to raise the landings. Unfortunately, no comparisons were made between the so far tool and InterCatch. This work should be undertaken.

WGNSSK answer:

Because landings are also submitted by metier since two years, it is impossible to know if a possible difference is caused by InterCatch or by the different allocation methods due to the data submission by metier. In addition, we do not have the separate datafiles as we used to receive them, making it impossible to do the same data raisings. However, for sole ~80% of the landings are from the Dutch fleet, for which the age distribution is known. More than 90% of the total landings for sole the age structure is known. Discards are not included. Therefore, it is unlikely that the transfer to intercatch will have caused large changes.

Comparison of XSA and SAM results showed similar outputs and time trends. Estimates for 2011 were XSA SSB = 34,747 t and SAM SSB = 34,400. SAM may replace XSA after the next benchmark if no problems are encountered. Update assessment used XSA results.

WGNSSK answer:

Replacing the XSA with the SAM model should be considered during the next benchmark.

As with the previous assessment there is good correspondence in trends for all ages in the 3 indices of abundance throughout the time series. Truncating the NL-BT survey before 1997 appears to have removed the persistent retrospective pattern, especially for F, that plagued this stock assessment prior to the 2010 benchmark assessment. Internal consistency plots of all tuning indices appear strong, tracking most year classes well. The current retrospective pattern appears unbiased for SSB, F and recruitment.

Natural mortality is set at 0.1 for the entire time series except in 1963 when it was adjusted to account for an extreme winter. A knife-edge maturity at age 3 is used for the assessment implying that SSB is artificial. This is acknowledged by the working group.

Recruitment estimates Age 1 in 2012 from RCT3 predict recruitment (62 million) well below the geometric mean (92 million). Because of the large standard error the geometric mean was accepted for short term projections.

Short-term forecasts for Fsq indicate an increase in SSB for both 2012 and 2013 to well over the B_{pa}. Landings in 2012 are expected to be around 15,000t which is below the 2012 TAC.

Because of rounding different numbers for SSB are found throughout the section. The status of the stock lists it "at about 35,000 t", section 10.4.1 lists SSB as 34,700t, and the summary table for the assessment lists the correct value as 34,747 t. Why not just put the correct value throughout the document?

WGNSSK answer:

There was discussion about rounding of values during the 2012 meeting. For this assessment, rounding mattered, because the value of 35,000 tonnes would mean that the second phase of the management plan would be implemented. In the end it was decided that the rounded values would be used for the advice. This year we will be more consistent in the use of the numbers and will refrain from rounding.

Conclusions

The RG agrees with the WG on the conclusions. The assessment update was conducted consistent with previous XSA formulations updated for another year. Overall the stock appears to be relatively stable and to be harvested at a sustainable level. Improvements are being predicted for the relatively near future for status quo.

10.4.1 Exploratory catch-at-age based analysis

Three tuning indices were included in the assessment. During the Benchmark Assessment (WKFLAT 2010) a large range of exploratory analyses were carried out to explore the sensitivity of the assessment to various combinations of input data. Sex separated assessments were done and a range of commercial tuning indices - including one derived from 'specialist sole boats' suggested by the fishing industry – were tried (see WKFLAT 2010 Final Report for details).

The main problem in the North Sea sole stock assessment was a consistent bias in the retrospective pattern, particularly on fishing mortality. When survey data (BTS-ISIS and SNS) were used alone in the assessment the retrospective pattern reversed, suggesting conversely that F estimates have been too low over the last few years. Hence survey data suggest higher Fs, and commercial data lower Fs; the different tuning series thus conveying different information. This problem was investigated exhaustively during the Benchmark Assessment (WKFLAT 2010). The conclusion was to recommend an XSA model tuned with commercial fleet data *cut off* before 1997 (see Table 10.2.8). This eliminated the retrospective bias problem because the smaller subset of the commercial data clearly has less of a problem with time-dependent or evolving catchabilities. This corroborated the finding of a breakpoint in the catchability estimates for the commercial tuning index in the mid 90s described in the 2005 WGNSSK Report.

The log catchability residual plots for the combined fleets of the 3 tuning series are shown in Figure 10.3.1. Figure 10.3.2 presents the retrospective analysis of F, SSB and recruitment when the 3 fleets of the tuning series were combined in the final XSA run. The plots suggest that mean F and SSB are estimated without much bias.

In addition to XSA, the SAM model (a state-space assessment model) was fitted to the North Sea sole data. Here the results from a SAM fit to the latest data for North Sea

sole are displayed (see Figure 10.3.3a,b,c). The model gives similar time trends to the XSA. The values however, differed more than in previous years. SSB, for example, estimated by SAM was 38 101 tonnes and 43 748 tonnes for the Final XSA run (see Table 10.4.1). However, the XSA value falls within the 95% confidence bounds estimated by the SAM model (upper: 57 729, lower: 32 672). The F value of the XSA was 0.25, which does not fall within the confidence bounds of the SAM model (upper: 0.262, lower: 0.376).

10.4.2 Exploratory single fleet analyses

Three tuning indices were included in the assessment. SNS data suggest higher Fs, and the BTS and commercial data lower Fs (see Figure 10.3.2), the different tuning series thus conveying conflicting information.

Standardized log catchability residual plots of the 3 tuning series included as single fleets in XSA assessments are shown in Figure 10.3.4 and the log catchability residual plots for the combined fleets of the 3 tuning series are shown in Figure 10.3.1. Figure 10.3.5 presents the F and SSB estimates for different combinations of the tuning series. The figures show that mean F was lowest with only the commercial tuning fleet and highest with only the SNS as tuning fleet.

10.4.3 Conclusions drawn from exploratory analyses

The WG concluded that the 2012 update assessment would be done with an XSA tuned with two survey series (BTS-ISIS and SNS) and one commercial series (NL beam trawl LPUE). See also recommendations from WKFLAT 2010.

10.4.4 Final assessment

Catch at age analysis was carried out with XSA using the settings given below.

Year	2011	2012	2013
Catch at age	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
Plus group	10	10	10
First tuning year	1970	1970	1970
Last data year	2010	2011	2012
Time series weights	No taper	No taper	No taper
Catchability dependent on stock size for age <	2	2	2
Catchability independent of ages for ages >=	7	7	7
Survivor estimates shrunk towards the mean F	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
Minimum standard error for population estimates	0.3	0.3	0.3
Prior weighting	Not applied	Not applied	Not applied

The full diagnostics are presented in Table 10.3.1. The XSA model converged after 30 iterations. Summaries of the input data are given in Figure 10.2.1A-D. Figure 10.3.1 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 10.3.2 and 10.3.3 respectively. The SSB in 2011 was estimated at around 32 567 t (Table 10.4.1) which has increased to around 43 748 t in 2012. Mean F(2–6) was estimated at 0.24 (see Table 10.4.1). Recruitment of the 2011 year class, age 1 in 2012, was estimated by the XSA at 56 million. Retrospective analysis is presented in Figure 10.3.2. Estimations of mean F, recruitment and SSB were relatively unbiased (Figure 10.3.2) between 2005 and 2011, although the retrospective adjusts the F upwards and SSB downwards slightly every year.

10.5 Historic Stock Trends

Table 10.4.1 and Figure 10.4.1 present the trends in landings, mean F(2–6), recruitment and SSB since 1957 estimated using the XSA final run. Reported landings increased to the end of the 1960s, showed a period of lower landings until the end of the 1980s and a period of higher landings (30 000 t) again during the early 1990s. In 2012 landings were estimated to be around 11 610 t. Recruitment was high in 1959 and 1964 and SSB increased from the end of the 1950s to a peak in early 1960s, followed by a period of declining SSB until the 1990s. Recruitment was high in 1988 and 1992. Between 1990–1995 a period of higher SSB was observed. The SSB in 2012 is estimated to be 43 748 t. Recruitment in 2012 of the 2011 year class at the age of 1 was estimated at 56 million, lower than the long term geometric mean of 94 million.

Fishing mortality on age 2–6 was around 0.2 when the time-series began in 1957. After then it increased steadily with large variation from circa 0.4–0.5 per year around 1970, to 0.5 to 0.6 per year up to 2000. In recent years fishing mortality has decreased gradually and the 2012 value is 0.24 (see Table 10.4.1).

10.6 Recruitment estimates

Recruitment estimation was carried out using RCT3. Input to the RCT3 model is presented in Table 10.5.1. Results are presented in Table 10.5.2 for age-1 and Table 10.5.3 for age-2. Average recruitment of 1-year-old-fish in the period 1957–2009 was around 94 million (geometric mean). For year class 2012 (age 1 in 2013) the value predicted by the RCT3 was 65 million, lower than the geometric mean (Table 10.5.2.). The estimate was based on the estimate of the DFS0 survey and had a low standard error (0.45) . Therefore the RCT3 estimate was accepted for the short-term forecasts.

For year class 2011 (age 2 in 20123), the data also have relatively low s.e. values compared to other years (all < 1, Table 10.5.3). However, apart from DFS0 data the RCT3 estimate is based on the same data as the XSA; the WG finds it undesirable to use the same data twice and therefore accepts the XSA estimate. The year class strength estimates from the different sources are rather similar and forecasts will not be affected much by the decision-making process here. The results are summarized in the table below and the estimates used for the short-term forecast are bold-underlined.

Year Class	Age in 2013	XSA thousands	RCT3 thousands	GM(1957–2008) thousands
2011	2	50 733	32 711	82 260
2012	1		64 976	94 097
2013	Recruit			94 097

Additional recruitment information will be available from the 3rd quarter surveys. ICES will only issue an updated advice if these surveys provide a very different perspective on the short-term developments.

10.7 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 2009 year-class are taken from the long-term geometric mean (1957–2010: 94 million).

Input to the short term forecast is presented in Table 10.6.1. The management options are given in Table 10.6.2 (A-C). The management options are given for three different assumptions on the F values for 2012; A) F2013 is assumed to be equal to Fsq, F in 2012 rescaled to the average selection pattern from 2010 to 2012; B) F2013 is 0.9 times Fsq, rescaled; and C) F2013 is set such that the landings in 2013 equal the TAC of that same year. The table below shows the predicted F values in the intermediate year, SSB for 2014 and the corresponding landings for 2013, given the different assumptions about F in the intermediate year in the different scenarios.

Scenario	Assumption	F_{2013}	SSB_{2014}	$Landings_{2013}$
A	$F_{2013} = F_{sq}$	24	48 151	12 757
B	$F_{2013} = 0.9F_{sq}$	0.21	49 361	11 629
C	$F\sim Landings_{2013} = TAC_{2013}$	0.26	46 819	14 000

The detailed tables for a forecast based on these 3 scenarios are given in Table 10.6.3A-C. At *status quo* fishing mortality in 2013 and 2014, SSB is expected to increase to 48 151t in 2014. The landings at Fsq are expected to be around 12 757 t in 2013 which is below the 2013 TAC (14 000t). The landings in 2014 are predicted to be around 11 986t at Fsq.

Figure 10.5.1 shows the projected contribution of different sources of information to estimates of the landings in 2015 and of the SSB in 2015, when fishing at Fsq. Less than 1/4th of the predicted landings in 2015 will consist of uncertain year classes (2011–2013) relying on assumptions of the forecast (i.e. geometric mean recruitment and RCT3 estimates). The contribution of these assumed year classes to the SSB forecasted in 2015 is slightly higher, approximately 1/3th Yield and SSB, per recruit, under the condition of the current exploitation pattern and assuming Fsq as exploitation rate in 2010 are given in Figure 10.5.2 (NB. This plot was not updated during WGNSSK 2011-2013 as no difference was apparent, see also Table 10.6.4 which was updated). Fmax is poorly defined at 0.56.

10.8 Medium-term forecasts

No medium term projections were done this year.

10.9 Biological reference points

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 equi-

librium 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.

	Type	Value	Technical basis
MSY Approach	MSY $B_{trigger}$	35 000 t	Default to value of B_{pa}
	F_{MSY}	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	B_{lim}	25 000 t	B_{loss}
	B_{pa}	35 000 t	B_{pa}1.4*B_{lim}
	F_{lim}	Not defined	
	F_{pa}	0.4	F_{pa} = 0.4 implies $B_{eq} > B_{pa}$ and $P(SSB_{MT} < B_{pa}) < 10\%$

10.10 Quality of the assessment

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 suggested that F, SSB and recruitment have been well estimated (Figure 10.4.1).

The XSA assessment showed higher SSB in 2012 (43 748t) compared to 2011 (32 567t) probably due in part to a higher than average yearclass coming in the SSB (3 year old in 2012). The historic performance of the assessment is summarized in Figure 10.4.2 which shows that SSB, Fbar and the recruitment have been reliably estimated over the last 5 years.

10.11 Status of the Stock

Fishing mortality was estimated at 0.24 in 2012 which is below F_{pa} (=0.4). The SSB in 2012 was estimated at about 43 748t which is well above both B_{lim} (25 000t) and (35 000 t). A higher than average yearclass entered the SSB in 2012. Projected landings for 2014 at Fsq are 11 986, a little bit lower as projected landings for 2013 (12 757).

10.12 Management Considerations

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.

10.12.1 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) 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 (Miller and Poos 2010; Simmonds 2010; see section 8.8.2) and found it to be in agreement with the precautionary approach (ICES, 2010). This year's assessments confirms that the objectives of stage one are met, despite the fact that the SSB of sole in 2010 and 2011 was perceived as slightly lower, bringing it under Bpa (SSB in 2012 and 2013 are perceived well above 35 kt respectively). Based on agreement between ICES secretariat and the European Commission the WGNSSK interpreted that the stipulated TAC setting procedure in the current plan should be used as the basis for the advice as a transitional measure. At the same time, WGNSSK urges that a process for conducting a full evaluation of the proposed amended management plan commences as soon as possible. See Section 19 (Management Plan Evaluations) for further details on the multi annual plan's objectives, TAC setting methodology and effort limitations.

10.12.2 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.

10.12.3 Technical measures

Sole is mainly taken by beam trawlers in a mixed fishery with 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 both sole and plaice. 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 generates considerable discards of undersized plaice (which has a minimum landing size of 27 cm). Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole catches. The combination of effort regulations, high oil prices, and the constrained TAC for plaice (due to the 15% limitation in the multiannual plan) have led to a more southern fishing pattern in the North Sea, where sole has become relatively more abundant. This concentration of fishing effort in the South has resulted in an increase in discarding of juvenile plaice that are mainly distributed in those areas. This process could be aggravated by the movement of juvenile plaice to deeper waters in recent years where they become more susceptible to the fishery.

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.

Table 10.2.1 Sole in Sub-Area IV: Nominal landings and landings as estimated by the Working Group (tonnes).

Year	BE	DK	FR	GE	NL.	UK (E/W/NI)	Other	Total reported	Unallocated landings	ICES Total	TAC
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	15579	776	16355	18600
2006	980	585	648	475	8299	910		11933	667	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	11752	142	11610	16200

Table 10.2.2 Sole in sub-area IV: Overview of landings and discards numbers and weights (kg) per hour and their percentages in the Dutch discards. Currently, no official estimates are available since 2009.

		Numbers			Weight		
Period	trips	Landings	Discards	%D	Landings	Discards	%D
	n	$n \cdot h^{-1}$	$n \cdot h^{-1}$		$kg \cdot h^{-1}$	$kg \cdot h^{-1}$	
1976–1979	21	116	8	6%	38	1	3%
1980–1983	22	84	23	21%	27	3	9%
1989–1990	6	286	83	22%	72	11	13%
1999–2001	20	92	21	19%	22	2	8%
2002	6	124	37	24%	18	3	13%
2003	9	95	32	25%	20	3	14%
2004	8	174	58	25%	28	5	17%
2005	9	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%

Table 10.2.3 Sole in sub-area IV: Landings numbers at age (x1000)

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

Table 10.2.4 North Sea Sole. Numbers-at-age (x1000) and weights-at-age (kilograms) in the landings by quarter in 2012.

	Q1		Q2		Q3		Q4	
Age	numbers	weight	numbers	weight	numbers	weight	numbers	weight
1	0.07	0.170	0.05	0.170	0.32	0.170	0.01	0.170
2	113.2	0.177	46.5	0.184	1143.4	0.143	4946.7	0.179
3	6494.9	0.198	5386.3	0.171	7822.8	0.179	6466.7	0.223
4	3196.6	0.257	2925.4	0.230	2266.6	0.235	1652.9	0.290
5	1351.5	0.278	1048.6	0.259	778.1	0.258	647.6	0.316
6	612.7	0.296	540.8	0.291	452.9	0.264	277.5	0.284
7	1087.2	0.317	1061.4	0.287	646.8	0.271	611	0.309
8	159.3	0.342	187.0	0.307	55.4	0.399	36.7	0.413
9	30.2	0.542	44.1	0.481	82.7	0.281	40.8	0.350
10	61	0.413	94.5	0.288	24.1	0.416	12.6	0.511
11	33.8	0.588	90.4	0.346	36.7	0.434	43.2	0.388
12	3.3	0.526	10.1	0.416	11.4	0.305	1.7	0.745
13	41.0	0.293	22.9	0.527	6.8	0.411	7.0	0.471
14	13.6	0.537	2.7	0.496	4.2	0.538	1.1	0.450
15	8.5	0.915	9.5	0.604	3.7	0.689	3.2	0.783

Table 10.2.5 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

Table 10.2.6 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

Table 10.2.7 Sole in subarea IV: Effort and lpue series. Note: see Table 10.2.1 for source of landings estimates (Netherlands).

year	*landings (tons)*	*Effort HP days (10^6)*	*LPUE kg 1000HP days^{-1}*
1997	11894	72.0	165.2
1998	17606	70.2	250.8
1999	19086	67.3	283.6
2000	16751	68.4	244.9
2001	16197	64.8	250.0
2002	13789	59.1	233.3
2003	14443	55.7	259.3
2004	14863	51.5	288.6
2005	12776	52.4	243.8
2006	8397	46.9	179.0
2007	11085	45.1	245.8
2008	9456	32.5	290.9
2009	12038	34.0	354.1
2010	12603	34.3	367.4
2011	11485	33.3	344.9
2012	11610	30.8	376.9

Table 10.2.8 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	0.000	0.141
2012	5.149	18.212	8.863	1.692	0.764	0.257	0.229	0.046	0.00

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					

Table 10.2.8 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

Table 10.3.1. Sole in sub area IV: XSA diagnostics

```
FLR XSA Diagnostics 2013-04-29 14:08:42

CPUE data from xsa.indices

Catch data for 56 years. 1957 to 2012. Ages 1 to 10.

          fleet first age last age first year last year alpha beta

1      BTS-ISIS         1        9       1985      2012  0.66 0.75

2           SNS         1        4       1970      2012  0.66 0.75

3 NL Beam Trawl         2        9       1997      2012     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   2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

  all    1    1    1    1    1    1    1    1    1    1

 Fishing mortalities

    year

age   2003  2004  2005  2006  2007  2008  2009  2010  2011  2012

  1  0.014 0.012 0.025 0.037 0.006 0.030 0.018 0.003 0.000 0.000

  2  0.230 0.243 0.216 0.282 0.267 0.146 0.197 0.151 0.095 0.074

  3  0.612 0.552 0.618 0.480 0.495 0.385 0.351 0.369 0.365 0.263

  4  0.640 0.711 0.673 0.512 0.545 0.498 0.459 0.459 0.371 0.289

  5  0.647 0.615 0.695 0.514 0.578 0.455 0.494 0.401 0.482 0.261

  6  0.836 0.469 0.666 0.562 0.465 0.451 0.445 0.497 0.298 0.302

  7  0.501 0.406 0.607 0.557 0.548 0.374 0.543 0.416 0.486 0.234

  8  0.505 0.336 0.463 0.595 0.476 0.583 0.348 0.520 0.316 0.503

  9  0.545 1.230 0.434 0.515 0.962 0.608 0.937 0.445 0.305 0.250

  10 0.545 1.230 0.434 0.515 0.962 0.608 0.937 0.445 0.305 0.250


 XSA population number (Thousand)

      age

year        1      2      3     4     5     6     7    8    9   10

  2003  81546 165436  40137 35764 12834  7238  6471 1059  320 1122

  2004  43974  72790 118973 19691 17072  6082  2838 3546  578  572

  2005  48353  39298  51633 61989  8751  8349  3443 1710 2294 1167

  2006 203831  42676  28658 25190 28623  3953  3881 1697  974 1437

  2007  54421 177768  29136 16041 13656 15490  2039 2012  847  912

  2008  69705  48942 123141 16070  8420  6929  8804 1066 1132 1053

  2009  98360  61208  38269 75821  8838  4833  3993 5480  539 1482

  2010 154732  87449  45475 24381 43353  4878  2802 2100 3501 2013

  2011  97535 139654  68037 28445 13948 26269  2686 1672 1130 3050

  2012  56069  88211 114956 42739 17768  7797 17647 1495 1103 3519
```

Estimated population abundance at 1st Jan 2013

year	1	2	3	4	5	6	7	8	9	10
2013	4.934329e+257	50733	74147	79961	28957	12388	5215	12633	818	777

Fleet: BTS-ISIS

Log catchability residuals.

age	1	2	3	4	5	6	7	8	9
1985	-0.206	0.031	-0.042	0.246	-0.038	0.136	0.000	0.000	0.000
1986	-0.678	-0.558	-0.253	-0.258	0.203	-0.415	0.286	0.000	-0.093
1987	-0.119	-0.268	-0.514	-0.288	0.021	0.078	0.433	0.059	0.000
1988	-0.145	0.517	-0.589	-0.044	-0.968	-0.445	0.137	0.170	-0.441
1989	-0.270	0.288	0.545	0.907	0.268	-0.137	0.547	0.000	-0.055
1990	0.132	0.722	0.151	-0.218	0.417	1.211	0.286	0.500	-0.314
1991	-0.385	0.362	0.472	-0.185	-1.053	-0.880	-0.729	-0.022	-0.667
1992	0.036	1.043	0.362	0.319	-0.235	-0.513	-0.065	0.027	-0.032
1993	-0.133	0.117	-0.755	0.639	1.555	1.308	-1.106	-0.035	0.157
1994	0.112	-0.068	0.428	-2.167	0.296	-0.914	-0.025	-1.316	0.000
1995	0.438	0.428	0.843	0.161	-0.244	0.482	1.223	0.218	0.936
1996	-0.134	-0.178	0.227	0.806	0.436	0.737	0.484	0.492	-0.309
1997	0.618	-0.087	0.054	0.349	0.981	-0.411	0.232	-0.960	1.577
1998	0.034	0.022	0.105	0.303	-0.985	-1.789	0.352	0.000	0.000
1999	0.082	0.414	0.667	0.029	1.763	1.415	1.540	1.499	-0.748
2000	-0.103	-0.309	0.048	-0.553	0.115	0.252	0.613	-1.059	0.756
2001	0.059	-0.189	-0.214	0.189	-0.334	-0.286	-0.416	0.771	0.000
2002	-0.217	-0.434	-0.053	-0.094	-0.312	0.020	-0.610	1.194	0.000
2003	0.011	-0.654	0.215	0.256	-0.122	0.135	0.472	0.000	0.739
2004	-0.027	-0.650	-0.546	-0.050	0.124	-0.410	-0.288	-0.519	0.000
2005	0.056	-0.301	-0.067	-0.519	-0.474	-0.217	-0.244	-0.140	0.000
2006	-0.389	-0.713	-1.721	-0.340	-0.732	0.333	-0.266	0.000	-1.444
2007	0.124	-0.026	-0.066	-0.093	-0.366	0.168	-0.672	-1.946	0.000
2008	0.329	0.412	0.544	0.716	-0.319	0.308	-0.383	-0.101	0.376
2009	0.098	-0.371	0.229	0.431	-0.213	-0.147	0.824	-0.866	0.000
2010	0.417	0.002	-0.274	-0.258	-0.266	0.022	0.287	-2.546	-1.424
2011	0.360	-0.021	0.001	-0.128	0.449	-0.045	-1.86	0.000	1.262
2012	-0.099	0.470	0.199	-0.156	0.033	0.003	-1.051	0.001	0.000

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	-8.8326	-9.4137	-9.7066	-9.8332	-10.0393	-9.9654	-9.9654	-9.9654
S.E_Logq	0.4382	0.5147	0.5718	0.6597	0.6735	0.7198	0.8430	0.6598

Regression statistics

Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7281324	9.553653

Fleet: SNS

Log catchability residuals.

age \ year	1	2	3	4
1970	0.287	0.806	0.543	0.102
1971	0.167	0.858	0.224	-2.552
1972	-0.012	0.062	-0.245	NA
1973	0.503	0.681	0.298	-0.402
1974	-0.025	-0.611	-0.665	NA
1975	-0.121	0.271	-0.034	-0.696
1976	-0.331	-1.308	0.274	-0.777
1977	0.062	0.139	0.307	-0.181
1978	0.373	0.461	0.493	0.146
1979	-0.153	0.326	0.337	0.390
1980	0.079	0.136	0.313	-0.034
1981	0.017	0.434	0.822	-0.177
1982	0.261	0.232	0.030	0.027
1983	-0.137	0.262	-0.674	-0.378
1984	0.355	0.293	0.453	0.108
1985	0.454	0.574	-0.132	-0.046

1986	-0.030	-0.144	-0.387	-0.492
1987	0.199	-0.016	-0.847	-0.350
1988	-0.196	0.309	0.165	0.650
1989	0.114	0.518	0.549	-0.214
1990	-0.250	0.477	-0.013	0.957
1991	-0.023	0.768	0.886	0.705
1992	-0.005	-1.159	0.001	0.983
1993	0.005	0.441	0.090	0.611
1994	-0.229	0.112	0.384	-1.458
1995	-0.189	-0.363	0.070	0.864
1996	-0.741	-0.423	-0.943	0.129
1997	0.152	-0.711	0.307	0.266
1998	0.285	0.691	0.539	1.000
1999	0.018	0.315	0.130	-0.812
2000	-0.284	-1.356	-0.138	0.142
2001	-0.084	-0.072	-0.210	-0.355
2002	0.259	0.004	0.088	NA
2003	NA	NA	NA	NA
2004	0.375	0.247	0.260	0.943
2005	-0.187	-0.498	-0.013	NA
2006	-0.379	-0.866	-1.122	-0.276
2007	-0.057	-0.250	-0.851	0.486
2008	-0.011	-0.304	-0.082	NA
2009	-0.034	-0.207	-0.595	-0.182
2010	-0.204	-0.969	-0.677	0.055
2011	-0.280	-0.161	0.0650	0.820
2012	NA	NA	NA	NA

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	-4.7646	-5.513	-6.0253
S.E_Logq	0.5767	0.482	0.7256

Regression statistics

Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7499355	5.715027

Fleet: NL Beam Trawl

Log catchability residuals.

age	2	3	4	5	6	7	8	9
1997	-0.726	-0.243	-0.329	-0.161	0.116	-0.633	0.388	-0.301
1998	-0.048	-0.547	-0.118	-0.542	-0.270	-0.112	-0.709	-0.185
1999	-0.605	-0.230	-0.521	-0.097	-0.419	-0.543	-0.094	0.230
2000	-0.022	0.081	-0.218	-0.306	0.110	0.215	0.373	-0.114
2001	0.079	-0.261	0.169	0.167	-0.444	-0.081	0.016	0.064
2002	0.073	0.106	-0.061	0.147	0.288	-0.186	0.601	-0.023
2003	0.105	0.004	0.165	-0.149	0.484	0.179	-0.175	-0.249
2004	0.170	0.140	0.079	0.029	-0.288	-0.081	-0.503	0.303
2005	-0.038	0.165	0.215	0.427	-0.015	0.162	-0.362	0.093
2006	0.316	0.063	0.013	0.047	0.057	0.157	0.407	0.264
2007	0.510	0.072	0.115	0.044	0.041	-0.201	-0.248	-0.115
2008	0.117	0.232	0.100	0.126	0.097	0.039	0.264	0.104
2009	0.480	0.024	0.257	0.127	0.267	0.435	-0.134	-0.108
2010	0.115	0.123	0.081	0.117	0.218	0.399	0.339	0.282
2011	-0.264	0.193	0.070	0.170	-0.065	0.160	0.064	-0.350
2012	-0.262	0.078	-0.017	-0.146	-0.178	0.089	-0.011	-0.273

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	-5.8171	-4.9352	-4.8934	-4.8505	-5.0138	-5.1071	-5.1071	-5.1071
S.E_Logq	0.3370	0.2107	0.2088	0.2278	0.2634	0.2955	0.3658	0.2207

Terminal year survivor and F summaries:

Age 1 Year class =2011

	scaledWts	survivors	yrcls
BTS-ISIS	0.784	44278	2011
nshk	0.216	83145	2011

Age 2 Year class =2010

	scaledWts	survivors	yrcls
BTS-ISIS	0.37	118588	2010
NL Beam Trawl	0.61	57075	2010
fshk	0.02	30315	2010

Age 3 Year class =2009

	scaledWts	survivors	yrcls
BTS-ISIS	0.242	97580	2009
NL Beam Trawl	0.737	86483	2009
fshk	0.022	49790	2009

Age 4 Year class =2008

	scaledWts	survivors	yrcls
BTS-ISIS	0.205	24775	2008
NL Beam Trawl	0.772	28475	2008
fshk	0.023	16290	2008

Age 5 Year class =2007

	scaledWts	survivors	yrcls
BTS-ISIS	0.162	12805	2007
NL Beam Trawl	0.814	10707	2007
fshk	0.024	5929	2007

Age 6 Year class =2006

	scaledWts	survivors	yrcls
BTS-ISIS	0.157	5229	2006
NL Beam Trawl	0.818	4366	2006
fshk	0.025	3399	2006

Age 7 Year class =2005

	scaledWts	survivors	yrcls
BTS-ISIS	0.139	4415	2005
NL Beam Trawl	0.836	13812	2005
fshk	0.025	5485	2005

Age 8 Year class =2004

	scaledWts	survivors	yrcls
BTS-ISIS	0.114	819	2004
NL Beam Trawl	0.837	809	2004
fshk	0.049	941	2004

Age 9 Year class =2003

	scaledWts	survivors	yrcls
NL Beam Trawl	0.972	591	2003
fshk	0.028	589	2003

Table 10.3.2. 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	0.173	0.249	0.249
1958	0.000	0.017	0.150	0.237	0.277	0.363	0.347	0.297	0.305	0.305
1959	0.000	0.034	0.132	0.250	0.208	0.242	0.184	0.371	0.252	0.252
1960	0.000	0.029	0.158	0.241	0.323	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	0.308	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	0.487	0.487
1968	0.011	0.304	0.687	0.636	0.500	0.293	0.265	0.390	0.418	0.418
1969	0.008	0.338	0.698	0.560	0.690	0.478	0.322	0.417	0.495	0.495
1970	0.010	0.152	0.640	0.545	0.318	0.329	0.380	0.366	0.389	0.389
1971	0.011	0.337	0.562	0.678	0.583	0.412	0.377	0.373	0.486	0.486
1972	0.005	0.233	0.649	0.510	0.524	0.354	0.223	0.304	0.384	0.384
1973	0.007	0.210	0.701	0.613	0.563	0.457	0.367	0.539	0.510	0.510
1974	0.001	0.183	0.582	0.628	0.502	0.489	0.550	0.377	0.511	0.511
1975	0.007	0.277	0.549	0.665	0.472	0.512	0.347	0.645	0.510	0.510
1976	0.010	0.108	0.569	0.514	0.570	0.374	0.466	0.390	0.644	0.644
1977	0.013	0.266	0.559	0.621	0.499	0.374	0.181	0.480	0.280	0.280
1978	0.001	0.232	0.565	0.529	0.516	0.510	0.652	0.526	0.488	0.488
1979	0.001	0.224	0.658	0.630	0.484	0.460	0.367	0.664	0.367	0.367
1980	0.004	0.129	0.558	0.594	0.587	0.408	0.586	0.507	0.639	0.639
1981	0.003	0.259	0.533	0.608	0.540	0.590	0.457	0.442	0.510	0.510
1982	0.019	0.234	0.703	0.570	0.635	0.607	0.514	0.527	0.534	0.534
1983	0.003	0.312	0.602	0.727	0.335	0.475	0.466	0.561	0.648	0.648
1984	0.003	0.295	0.727	0.687	0.673	0.738	0.539	0.431	0.588	0.588
1985	0.002	0.318	0.744	0.772	0.597	0.551	0.409	0.424	0.445	0.445
1986	0.002	0.143	0.620	0.698	0.679	0.757	0.736	0.350	0.575	0.575
1987	0.001	0.239	0.509	0.611	0.529	0.567	0.440	0.651	0.417	0.417
1988	0.000	0.240	0.667	0.712	0.616	0.618	0.548	0.429	0.893	0.893
1989	0.001	0.125	0.525	0.685	0.420	0.431	0.423	0.402	0.356	0.356
1990	0.005	0.138	0.404	0.529	0.587	0.546	0.474	0.670	0.637	0.637
1991	0.002	0.090	0.424	0.522	0.747	0.431	0.533	0.614	1.015	1.015
1992	0.003	0.119	0.436	0.466	0.468	0.604	0.681	0.405	0.737	0.737
1993	0.001	0.182	0.424	0.560	0.830	0.537	0.805	0.547	0.422	0.422
1994	0.013	0.140	0.482	0.637	0.682	0.888	0.461	0.555	0.974	0.974
1995	0.054	0.307	0.448	0.774	0.616	0.551	0.809	0.424	0.741	0.741
1996	0.004	0.275	0.698	0.986	0.716	0.852	0.752	1.042	0.384	0.384
1997	0.006	0.154	0.580	0.704	0.821	0.785	0.623	0.926	1.265	1.265
1998	0.002	0.282	0.621	0.797	0.776	0.765	0.676	1.000	1.378	1.378
1999	0.004	0.177	0.615	0.720	0.798	0.595	0.569	0.586	1.564	1.564
2000	0.020	0.242	0.588	0.809	0.631	0.793	0.906	0.810	0.534	0.534
2001	0.014	0.280	0.552	0.745	0.747	0.532	0.581	0.784	0.737	0.737
2002	0.006	0.231	0.624	0.643	0.728	0.663	0.470	1.015	0.574	0.574
2003	0.014	0.230	0.612	0.640	0.647	0.836	0.501	0.505	0.545	0.545
2004	0.012	0.243	0.552	0.711	0.615	0.469	0.406	0.336	1.230	1.230
2005	0.025	0.216	0.618	0.673	0.695	0.666	0.607	0.463	0.434	0.434
2006	0.037	0.282	0.480	0.512	0.514	0.562	0.557	0.595	0.515	0.515
2007	0.006	0.267	0.495	0.545	0.578	0.465	0.548	0.476	0.962	0.962
2008	0.030	0.146	0.385	0.498	0.455	0.451	0.374	0.583	0.608	0.608
2009	0.018	0.197	0.351	0.459	0.494	0.445	0.543	0.348	0.937	0.937
2010	0.003	0.151	0.369	0.459	0.401	0.497	0.416	0.520	0.445	0.445
2011	0.000	0.095	0.365	0.371	0.482	0.298	0.486	0.316	0.305	0.305
2012	0.000	0.074	0.263	0.289	0.261	0.302	0.234	0.503	0.250	0.250

Table 10.3.3 Sole in sub area IV: stock numbers at age

year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1957	128371	72371	89502	59639	17464	15185	27304	11902	2521	31064
1958	127931	116155	64084	70943	41455	12080	10847	18256	9054	26273
1959	484247	115756	103329	49917	50647	28428	7599	6939	12276	26711
1960	60767	438165	101227	81949	35180	37209	20184	5718	4334	32338
1961	98206	54984	385086	78236	58274	23034	25760	13683	3668	31745
1962	22509	88861	48827	300432	52335	40767	16315	19506	8255	29554
1963	20440	20367	78897	38309	215876	32844	26921	10199	13761	31743
1964	538666	8310	7853	26804	10165	58551	7984	6735	2614	9602
1965	122937	487355	7377	5164	19004	5697	37047	4352	4431	9283
1966	40156	111238	398001	5681	3213	12631	2890	22116	2517	8756
1967	75765	36335	89099	234403	4209	1796	7958	1915	14061	8080
1968	100019	68555	29292	55641	129302	1908	1104	5334	994	19933
1969	51165	89518	45771	13328	26667	70942	1288	767	3268	14413
1970	138343	45911	57785	20599	6892	12107	39796	845	457	17025
1971	42367	123942	35701	27558	10804	4539	7882	24631	530	12631
1972	76712	37931	80029	18419	12656	5459	2719	4892	15343	9099
1973	105971	69075	27177	37830	10010	6781	3467	1968	3267	15459
1974	111571	95206	50650	12201	18541	5156	3883	2174	1039	12417
1975	41341	100859	71714	25618	5891	10151	2862	2026	1350	9111
1976	114354	37153	69199	37463	11919	3324	5504	1831	962	5991
1977	141807	102460	30175	35436	20280	6101	2069	3125	1122	9243
1978	47993	126620	71072	15604	17231	11140	3797	1563	1750	4321
1979	11840	43401	90865	36568	8315	9304	6055	1789	835	5275
1980	153486	10704	31394	42570	17622	4638	5316	3797	833	2716
1981	149544	138261	8513	16266	21265	8864	2790	2678	2068	2440
1982	152556	134901	96583	4521	8016	11214	4447	1599	1558	3276
1983	140856	135473	96571	43278	2314	3844	5529	2406	854	2586
1984	70394	127080	89721	47857	18924	1498	2162	3141	1243	2109
1985	81523	63513	85652	39251	21775	8732	648	1142	1846	2814
1986	158271	73610	41822	36814	16416	10850	4553	389	676	3997
1987	71930	142856	57755	20358	16578	7531	4604	1974	248	2119
1988	452837	64996	101775	31401	10001	8839	3863	2684	932	559
1989	106703	409734	46249	47254	13938	4886	4309	2022	1581	1611
1990	174849	96439	327318	24751	21550	8283	2874	2554	1224	1856
1991	69567	157397	76022	197832	13201	10843	4342	1619	1183	1751
1992	349071	62835	130112	45021	106160	5658	6376	2306	792	2328
1993	68424	314934	50454	76149	25554	60154	2799	2919	1392	2532
1994	56389	61862	237526	29886	39369	10081	31830	1132	1528	1502
1995	94962	50348	48641	132785	14308	18013	3755	18172	588	1324
1996	48824	81392	33501	28127	55396	6990	9398	1514	10763	3206
1997	267465	44016	55945	15088	9498	24493	2697	4009	483	2422
1998	112053	240515	34132	28345	6753	3783	10113	1309	1437	1166
1999	80949	101160	164204	16605	11564	2814	1593	4654	436	1055
2000	121643	72976	76693	80346	7316	4710	1405	816	2343	1789
2001	62656	107852	51830	38551	32373	3522	1928	514	328	1406
2002	183935	55878	73765	26993	16562	13872	1872	976	212	864
2003	81546	165436	40137	35764	12834	7238	6471	1059	320	1122
2004	43974	72790	118973	19691	17072	6082	2838	3546	578	572
2005	48353	39298	51633	61989	8751	8349	3443	1710	2294	1167
2006	203831	42676	28658	25190	28623	3953	3881	1697	974	1437
2007	54421	177768	29136	16041	13656	15490	2039	2012	847	912
2008	69705	48942	123141	16070	8420	6929	8804	1066	1132	1053
2009	98360	61208	38269	75821	8838	4833	3993	5480	539	1482
2010	154732	87449	45475	24381	43353	4878	2802	2100	3501	2013
2011	97535	139654	68037	28445	13948	26269	2686	1672	1130	3050
2012	56069	88211	114956	42739	17768	7797	17647	1495	1103	3519

Table 10.4.1. Sole in sub area IV: XSA summary

year	*recruits*	*ssb*	*catch*	*landings*	*fbar2-6*	*Y/ssb*
1957	128371	55489	12067	12067	0.18	0.22
1958	127931	60836	14287	14287	0.21	0.23
1959	484247	65349	13832	13832	0.17	0.21
1960	60767	72927	18620	18620	0.20	0.26
1961	98206	116183	23566	23566	0.19	0.20
1962	22509	115319	26877	26877	0.21	0.23
1963	20440	111935	26164	26164	0.32	0.23
1964	538666	36463	11342	11342	0.28	0.31
1965	122937	29722	17043	17043	0.31	0.57
1966	40156	84590	33340	33340	0.32	0.39
1967	75765	83922	33439	33439	0.41	0.40
1968	100019	72685	33179	33179	0.48	0.46
1969	51165	55893	27559	27559	0.55	0.49
1970	138343	50910	19685	19685	0.40	0.39
1971	42367	44054	23652	23652	0.51	0.54
1972	76712	47575	21086	21086	0.45	0.44
1973	105971	37205	19309	19309	0.51	0.52
1974	111571	36236	17989	17989	0.48	0.50
1975	41341	38981	20773	20773	0.50	0.53
1976	114354	39570	17326	17326	0.43	0.44
1977	141807	35367	18003	18003	0.46	0.51
1978	47993	36546	20280	20280	0.47	0.55
1979	11840	45617	22598	22598	0.49	0.50
1980	153486	34000	15807	15807	0.46	0.46
1981	149544	23311	15403	15403	0.51	0.66
1982	152556	33029	21579	21579	0.55	0.65
1983	140856	39890	24927	24927	0.49	0.62
1984	70394	43218	26839	26839	0.62	0.62
1985	81523	40499	24248	24248	0.60	0.60
1986	158271	34059	18201	18201	0.58	0.53
1987	71930	29313	17368	17368	0.49	0.59
1988	452837	38474	21590	21590	0.57	0.56
1989	106703	33614	21805	21805	0.44	0.65
1990	174849	89327	35120	35120	0.44	0.39
1991	69567	77127	33513	33513	0.44	0.43
1992	349071	76985	29341	29341	0.42	0.38
1993	68424	55574	31491	31491	0.51	0.57
1994	56389	73988	33002	33002	0.57	0.45
1995	94962	58877	30467	30467	0.54	0.52
1996	48824	38528	22651	22651	0.71	0.59
1997	267465	27203	14901	14901	0.61	0.55
1998	112053	20091	20868	20868	0.65	1.04
1999	80949	40811	23475	23475	0.58	0.58
2000	121643	37840	22641	22641	0.61	0.6
2001	62656	29550	19944	19944	0.57	0.67
2002	183935	30599	16945	16945	0.58	0.55
2003	81546	24896	17920	17920	0.59	0.72
2004	43974	36999	18757	18757	0.52	0.51
2005	48353	31466	16355	16355	0.57	0.52
2006	203831	23675	12594	12594	0.47	0.53
2007	54421	17398	14635	14635	0.47	0.84
2008	69705	35354	14071	14071	0.39	0.4
2009	98360	31968	13952	13952	0.39	0.44
2010	154732	31729	12603	12603	0.38	0.4
2011	97535	32567	11485	11485	0.32	0.35
2012	56069	43748	11610	11610	0.24	0.27

Table 10.5.1. Sole in sub area IV: RCT3 input table

year	*age1*	*age2*	*DFS0*	*SNS1*	*SNS2*	*BTS1*
1973	111571	100859		2348	864	
1974	41341	37153		525	74	
1975	114354	102460		1399	776	
1976	141807	126620		3743	1355	
1977	47993	43401		1548	408	
1978	11840	10704		94	89	
1979	153486	138261		4313	1413	
1980	149544	134901		3737	1146	
1981	152556	135473		5856	1123	
1982	140856	127080		2621	1100	
1983	70394	63513		2493	716	
1984	81523	73610		3619	458	7.03
1985	158271	142856		3705	944	7.17
1986	71930	64996		1948	594	6.97
1987	452837	409734		1122	5005	83.11
1988	106703	96439		2831	1120	9.01
1989	174849	157397		2856	2529	37.84
1990	69567	62835		1254	144	4.03
1991	349071	314934	167.56	11114	3420	81.63
1992	68424	61862	9.26	1291	498	6.35
1993	56389	50348	15.32	652	224	7.66
1994	94962	81392	22.06	1362	349	28.13
1995	48824	44016	7.06	218	154	3.98
1996	267465	240515	40.27	10279	3126	169.34
1997	112053	101160	26.93	4095	972	17.11
1998	80949	72976		1649	126	11.96
1999	121643	107852		1639	655	14.59
2000	62656	55878	9.50	970	379	8.00
2001	183935	165436	51.42	7547		20.99
2002	81546	72790	58.58		624	10.51
2003	43974	39298	10.60	1370	163	4.19
2004	48353	42676	31.25	568	117	5.53
2005	203831	177768	40.98	2726	911	17.09
2006	54421	48942	12.56	849	259	7.50
2007	69705	61208	13.72	1259	344	15.25
2008	98360	87449	11.76	1932	237	15.95
2009			27.33	2637	884	54.80
2010			42.86	1248	159	26.20
2011			12.12	227		5.10
2012			11.22			

Table 10.5.2. Sole in sub area IV: RCT3 analysis – age 1

yearclass:2012									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	0.9614	8.459	0.5304	0.6144	16	2.418	10.78	0.5957	0.5671
VPAMean	NA	NA	NA	NA	36	NA	11.47	0.6819	0.4329
WAP	logWAP	int.se							
64976	11.08	0.4486							

Table 10.5.3. Sole in sub area IV: Output RCT3 – age 2

yearclass:2011									
index	slope	intercept	se	rsquare	n	indices	prediction	se.pred	WAP.weights
DFS0	0.9637	8.337	0.533	0.6127	16	2.495	10.742	0.5962	0.1571
SNS1	0.7432	5.732	0.3306	0.8183	35	5.425	9.764	0.3664	0.416
BTS1	0.7562	9.464	0.3939	0.7289	25	1.629	10.696	0.4267	0.3068
VPAMean	NA	NA	NA	NA	36	NA	11.362	0.6819	0.1201
WAP	logWAP	int.se							
32711	10.4	0.2363							

Table 10.6.1. Sole in sub area IV: STF Input table (F values presented are for Fsq)

age	*year*	*f*	*stock.n*	*landings.wt*	*stock.wt*	*mat*	*M*
1	2013	0.001	64976	0.16	0.05	0	0.1
2	2013	0.090	50733	0.17	0.16	0	0.1
3	2013	0.282	74147	0.20	0.18	1	0.1
4	2013	0.317	79961	0.24	0.23	1	0.1
5	2013	0.324	28957	0.26	0.26	1	0.1
6	2013	0.310	12388	0.29	0.29	1	0.1
7	2013	0.322	5215	0.28	0.31	1	0.1
8	2013	0.379	12633	0.31	0.33	1	0.1
9	2013	0.283	818	0.35	0.43	1	0.1
10	2013	0.283	3256	0.37	0.39	1	0.1
1	2014	0.001	94097	0.16	0.05	0	0.1
2	2014	0.081	NA	0.17	0.16	0	0.1
3	2014	0.254	NA	0.20	0.18	1	0.1
4	2014	0.284	NA	0.24	0.23	1	0.1
5	2014	0.291	NA	0.26	0.26	1	0.1
6	2014	0.279	NA	0.29	0.29	1	0.1
7	2014	0.289	NA	0.28	0.31	1	0.1
8	2014	0.341	NA	0.31	0.33	1	0.1
9	2014	0.254	NA	0.35	0.43	1	0.1
10	2014	0.254	NA	0.37	0.39	1	0.1
1	2015	0.001	94097	0.16	0.05	0	0.1
2	2015	0.081	NA	0.17	0.16	0	0.1
3	2015	0.254	NA	0.2	0.18	1	0.1
4	2015	0.284	NA	0.24	0.23	1	0.1
5	2015	0.291	NA	0.26	0.26	1	0.1
6	2015	0.279	NA	0.29	0.29	1	0.1
7	2015	0.289	NA	0.28	0.31	1	0.1
8	2015	0.341	NA	0.31	0.33	1	0.1
9	2015	0.254	NA	0.35	0.43	1	0.1
10	2015	0.254	NA	0.37	0.39	1	0.1

Table 10.6.2. (A) Sole in sub area IV: STF option table, assuming F(2013) = F(sq)

year	*fmult*	*f2-6*	*f_dis2-3*	*f_hc2-6*	*landings*	*discards*	*catch*	*ssb2013*	
2013	1	0.238	0	0.24	12757	0	12757	50546	
year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	Catch	Ssb	ssb2015
2014	0.2	0.048	0	0.05	2655	0	2655	48151	55857
2014	0.3	0.071	0	0.07	3930	0	3930	48151	54504
2014	0.4	0.095	0	0.1	5173	0	5173	48151	53187
2014	0.5	0.119	0	0.12	6383	0	6383	48151	51905
2014	0.6	0.143	0	0.14	7562	0	7562	48151	50657
2014	0.7	0.166	0	0.17	8711	0	8711	48151	49443
2014	0.8	0.19	0	0.19	9830	0	9830	48151	48260
2014	0.9	0.214	0	0.21	10919	0	10919	48151	47108
2014	1	0.238	0	0.24	11981	0	11981	48151	45987
2014	1.1	0.262	0	0.26	13016	0	13016	48151	44896
2014	1.2	0.285	0	0.29	14023	0	14023	48151	43833
2014	1.3	0.309	0	0.31	15005	0	15005	48151	42798
2014	1.4	0.333	0	0.33	15962	0	15962	48151	41791
2014	1.5	0.357	0	0.36	16894	0	16894	48151	40810
2014	1.6	0.38	0	0.38	17803	0	17803	48151	39854
2014	1.7	0.404	0	0.4	18688	0	18688	48151	38924
2014	1.8	0.428	0	0.43	19550	0	19550	48151	38018
2014	1.9	0.452	0	0.45	20391	0	20391	48151	37136
2014	2	0.476	0	0.48	21210	0	21210	48151	36276

Table 10.6.2. (B) Sole in sub area IV: STF option table, assuming F(2013) = 0.9*F(sq)

year	*fmult*	*f2-6*	*f_dis2-3*	*f_hc2-6*	*landings*	*discards*	*catch*	*ssb2013*	
2013	1	0.214	0	0.21	11629	0	11629	50546	
year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	Ssb	ssb2015
2014	0.2	0.048	0	0.05	2717	0	2717	49361	56999
2014	0.3	0.071	0	0.07	4023	0	4023	49361	55614
2014	0.4	0.095	0	0.1	5294	0	5294	49361	54267
2014	0.5	0.119	0	0.12	6533	0	6533	49361	52955
2014	0.6	0.143	0	0.14	7740	0	7740	49361	51678
2014	0.7	0.166	0	0.17	8915	0	8915	49361	50434
2014	0.8	0.19	0	0.19	10060	0	10060	49361	49224
2014	0.9	0.214	0	0.21	11175	0	11175	49361	48046
2014	1	0.238	0	0.24	12261	0	12261	49361	46899
2014	1.1	0.262	0	0.26	13320	0	13320	49361	45782
2014	1.2	0.285	0	0.29	14351	0	14351	49361	44694
2014	1.3	0.309	0	0.31	15355	0	15355	49361	43635
2014	1.4	0.333	0	0.33	16334	0	16334	49361	42605
2014	1.5	0.357	0	0.36	17288	0	17288	49361	41601
2014	1.6	0.38	0	0.38	18217	0	18217	49361	40623
2014	1.7	0.404	0	0.4	19122	0	19122	49361	39672
2014	1.8	0.428	0	0.43	20005	0	20005	49361	38745
2014	1.9	0.452	0	0.45	20864	0	20864	49361	37842
2014	2	0.476	0	0.48	21702	0	21702	49361	36963

Table 10.6.2. (C) Sole in sub area IV: STF option table, assuming F(2013)~Landings for 2012=TAC for 2012

year	*fmult*	*f2-6*	*f_dis2-3*	*f_hc2-6*	*Landings*	*discards*	*catch*	*ssb2013*	
2013	1	0.265	0	0.26	14000	0	14000	50546	
year	fmult	f2-6	f_dis2-3	f_hc2-6	Landings	discards	catch	ssb	ssb2015
2014	0.2	0.048	0	0.05	2586	0	2586	46819	54600
2014	0.3	0.071	0	0.07	3829	0	3829	46819	53282
2014	0.4	0.095	0	0.1	5039	0	5039	46819	51999
2014	0.5	0.119	0	0.12	6219	0	6219	46819	50750
2014	0.6	0.143	0	0.14	7367	0	7367	46819	49535
2014	0.7	0.166	0	0.17	8486	0	8486	46819	48351
2014	0.8	0.19	0	0.19	9576	0	9576	46819	47199
2014	0.9	0.214	0	0.21	10638	0	10638	46819	46077
2014	1	0.238	0	0.24	11673	0	11673	46819	44985
2014	1.1	0.262	0	0.26	12681	0	12681	46819	43921
2014	1.2	0.285	0	0.29	13663	0	13663	46819	42886
2014	1.3	0.309	0	0.31	14620	0	14620	46819	41877
2014	1.4	0.333	0	0.33	15553	0	15553	46819	40895
2014	1.5	0.357	0	0.36	16461	0	16461	46819	39939
2014	1.6	0.38	0	0.38	17347	0	17347	46819	39008
2014	1.7	0.404	0	0.4	18209	0	18209	46819	38101
2014	1.8	0.428	0	0.43	19050	0	19050	46819	37218
2014	1.9	0.452	0	0.45	19870	0	19870	46819	36358
2014	2	0.476	0	0.48	20668	0	20668	46819	35520

Table 10.6.3. (A) Sole in sub area IV: STF detailed, assuming F(2013) = F(sq).

age	*year*	*f*	*stock.n*	*catch.wt*	*stock.wt*	*mat*	*M*	*catch.n*	*catch*	*SSB*	*TSB*
1	2013	0.001	64976	0.16	0.05	0	0.1	47	8	0	3249
2	2013	0.081	50733	0.17	0.16	0	0.1	3768	648	0	8016
3	2013	0.254	74147	0.2	0.18	1	0.1	15838	3204	13594	13594
4	2013	0.284	79961	0.24	0.23	1	0.1	18881	4500	18204	18204
5	2013	0.291	28957	0.26	0.26	1	0.1	6969	1830	7645	7645
6	2013	0.279	12388	0.29	0.29	1	0.1	2876	828	3609	3609
7	2013	0.289	5215	0.28	0.31	1	0.1	1248	355	1639	1639
8	2013	0.341	12633	0.31	0.33	1	0.1	3479	1066	4223	4223
9	2013	0.254	818	0.35	0.43	1	0.1	175	61	351	351
10	2013	0.254	3256	0.37	0.39	1	0.1	697	257	1281	1281
1	2014	0.001	94097	0.16	0.05	0	0.1	68	11	0	4705
2	2014	0.081	58748	0.17	0.16	0	0.1	4363	750	0	9282
3	2014	0.254	42325	0.2	0.18	1	0.1	9040	1829	7760	7760
4	2014	0.284	52063	0.24	0.23	1	0.1	12294	2930	11853	11853
5	2014	0.291	54441	0.26	0.26	1	0.1	13101	3441	14372	14372
6	2014	0.279	19591	0.29	0.29	1	0.1	4548	1310	5708	5708
7	2014	0.289	8481	0.28	0.31	1	0.1	2030	577	2666	2666
8	2014	0.341	3535	0.31	0.33	1	0.1	974	298	1182	1182
9	2014	0.254	8132	0.35	0.43	1	0.1	1741	609	3486	3486
10	2014	0.254	2859	0.37	0.39	1	0.1	612	226	1125	1125
1	2015	0.001	94097	0.16	0.05	0	0.1	68	11	0	4705
2	2015	0.081	85077	0.17	0.16	0	0.1	6319	1087	0	13442
3	2015	0.254	49011	0.2	0.18	1	0.1	10469	2118	8985	8985
4	2015	0.284	29719	0.24	0.23	1	0.1	7018	1673	6766	6766
5	2015	0.291	35447	0.26	0.26	1	0.1	8530	2241	9358	9358
6	2015	0.279	36833	0.29	0.29	1	0.1	8551	2463	10731	10731
7	2015	0.289	13412	0.28	0.31	1	0.1	3210	912	4216	4216
8	2015	0.341	5748	0.31	0.33	1	0.1	1583	485	1922	1922
9	2015	0.254	2275	0.35	0.43	1	0.1	487	170	975	975
10	2015	0.254	7711	0.37	0.39	1	0.1	1651	608	3034	3034

Table 10.6.3. (B) Sole in sub area IV: STF detailed, assuming F(2013) = 0.9*F(sq).

age	*year*	*f*	*stock.n*	*catch.wt*	*stock.wt*	*mat*	*M*	*catch.n*	*catch*	*SSB*	*TSB*
1	2013	0.001	64976	0.16	0.05	0	0.1	42	7	0	3249
2	2013	0.073	50733	0.17	0.16	0	0.1	3405	586	0	8016
3	2013	0.228	74147	0.2	0.18	1	0.1	14425	2919	13594	13594
4	2013	0.256	79961	0.24	0.23	1	0.1	17221	4104	18204	18204
5	2013	0.262	28957	0.26	0.26	1	0.1	6358	1670	7645	7645
6	2013	0.251	12388	0.29	0.29	1	0.1	2623	755	3609	3609
7	2013	0.26	5215	0.28	0.31	1	0.1	1139	323	1639	1639
8	2013	0.306	12633	0.31	0.33	1	0.1	3181	974	4223	4223
9	2013	0.229	818	0.35	0.43	1	0.1	160	56	351	351
10	2013	0.229	3256	0.37	0.39	1	0.1	635	234	1281	1281
1	2014	0.001	94097	0.16	0.05	0	0.1	68	11	0	4705
2	2014	0.081	58752	0.17	0.16	0	0.1	4364	751	0	9283
3	2014	0.254	42670	0.2	0.18	1	0.1	9114	1844	7823	7823
4	2014	0.284	53401	0.24	0.23	1	0.1	12609	3005	12158	12158
5	2014	0.291	56012	0.26	0.26	1	0.1	13479	3541	14787	14787
6	2014	0.279	20169	0.29	0.29	1	0.1	4683	1349	5876	5876
7	2014	0.289	8721	0.28	0.31	1	0.1	2087	593	2741	2741
8	2014	0.341	3638	0.31	0.33	1	0.1	1002	307	1216	1216
9	2014	0.254	8413	0.35	0.43	1	0.1	1802	630	3607	3607
10	2014	0.254	2932	0.37	0.39	1	0.1	628	231	1154	1154
1	2015	0.001	94097	0.16	0.05	0	0.1	68	11	0	4705
2	2015	0.081	85077	0.17	0.16	0	0.1	6319	1087	0	13442
3	2015	0.254	49015	0.2	0.18	1	0.1	10470	2118	8986	8986
4	2015	0.284	29961	0.24	0.23	1	0.1	7075	1686	6821	6821
5	2015	0.291	36358	0.26	0.26	1	0.1	8750	2298	9598	9598
6	2015	0.279	37896	0.29	0.29	1	0.1	8798	2534	11040	11040
7	2015	0.289	13808	0.28	0.31	1	0.1	3305	939	4340	4340
8	2015	0.341	5911	0.31	0.33	1	0.1	1628	499	1976	1976
9	2015	0.254	2342	0.35	0.43	1	0.1	502	175	1004	1004
10	2015	0.254	7961	0.37	0.39	1	0.1	1705	628	3132	3132

Table 10.6.3. (C) Sole in sub area IV: STF detailed, assuming F(2013) = TAC

age	*year*	*f*	*stock.n*	*catch.wt*	*stock.wt*	*mat*	*M*	*catch.n*	*catch*	*SSB*	*TSB*
1	2013	0.001	64976	0.16	0.05	0	0.1	52	8	0	3249
2	2013	0.09	50733	0.17	0.16	0	0.1	4176	718	0	8016
3	2013	0.282	74147	0.2	0.18	1	0.1	17395	3520	13594	13594
4	2013	0.317	79961	0.24	0.23	1	0.1	20705	4935	18204	18204
5	2013	0.324	28957	0.26	0.26	1	0.1	7639	2007	7645	7645
6	2013	0.31	12388	0.29	0.29	1	0.1	3155	909	3609	3609
7	2013	0.322	5215	0.28	0.31	1	0.1	1369	389	1639	1639
8	2013	0.379	12633	0.31	0.33	1	0.1	3805	1166	4223	4223
9	2013	0.283	818	0.35	0.43	1	0.1	192	67	351	351
10	2013	0.283	3256	0.37	0.39	1	0.1	766	282	1281	1281
1	2014	0.001	94097	0.16	0.05	0	0.1	68	11	0	4705
2	2014	0.081	58743	0.17	0.16	0	0.1	4363	750	0	9281
3	2014	0.254	41937	0.2	0.18	1	0.1	8958	1812	7689	7689
4	2014	0.284	50590	0.24	0.23	1	0.1	11946	2847	11518	11518
5	2014	0.291	52716	0.26	0.26	1	0.1	12686	3332	13917	13917
6	2014	0.279	18957	0.29	0.29	1	0.1	4401	1268	5523	5523
7	2014	0.289	8217	0.28	0.31	1	0.1	1967	559	2583	2583
8	2014	0.341	3421	0.31	0.33	1	0.1	942	289	1144	1144
9	2014	0.254	7824	0.35	0.43	1	0.1	1676	586	3354	3354
10	2014	0.254	2777	0.37	0.39	1	0.1	595	219	1093	1093
1	2015	0.001	94097	0.16	0.05	0	0.1	48	8	0	4705
2	2015	0.081	85077	0.17	0.16	0	0.1	4409	758	0	13442
3	2015	0.254	49007	0.2	0.18	1	0.1	10577	2140	6704	6704
4	2015	0.284	29447	0.24	0.23	1	0.1	6953	1657	6704	6704
5	2015	0.291	34444	0.26	0.26	1	0.1	8289	2177	9093	9093
6	2015	0.279	35666	0.29	0.29	1	0.1	8280	2385	10391	10391
7	2015	0.289	12978	0.28	0.31	1	0.1	3106	882	4079	4079
8	2015	0.341	5569	0.31	0.33	1	0.1	1534	470	1862	1862
9	2015	0.254	2202	0.35	0.43	1	0.1	472	165	944	944
10	2015	0.254	7439	0.37	0.39	1	0.1	1593	587	2927	2927

Table 10.6.4 Yield and spawning biomass per Recruit F-reference points.

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.31	0.16	0.48
Fmax	0.56	0.16	0.28
F0.1	0.13	0.14	0.99
Fmed	0.35	0.16	0.43

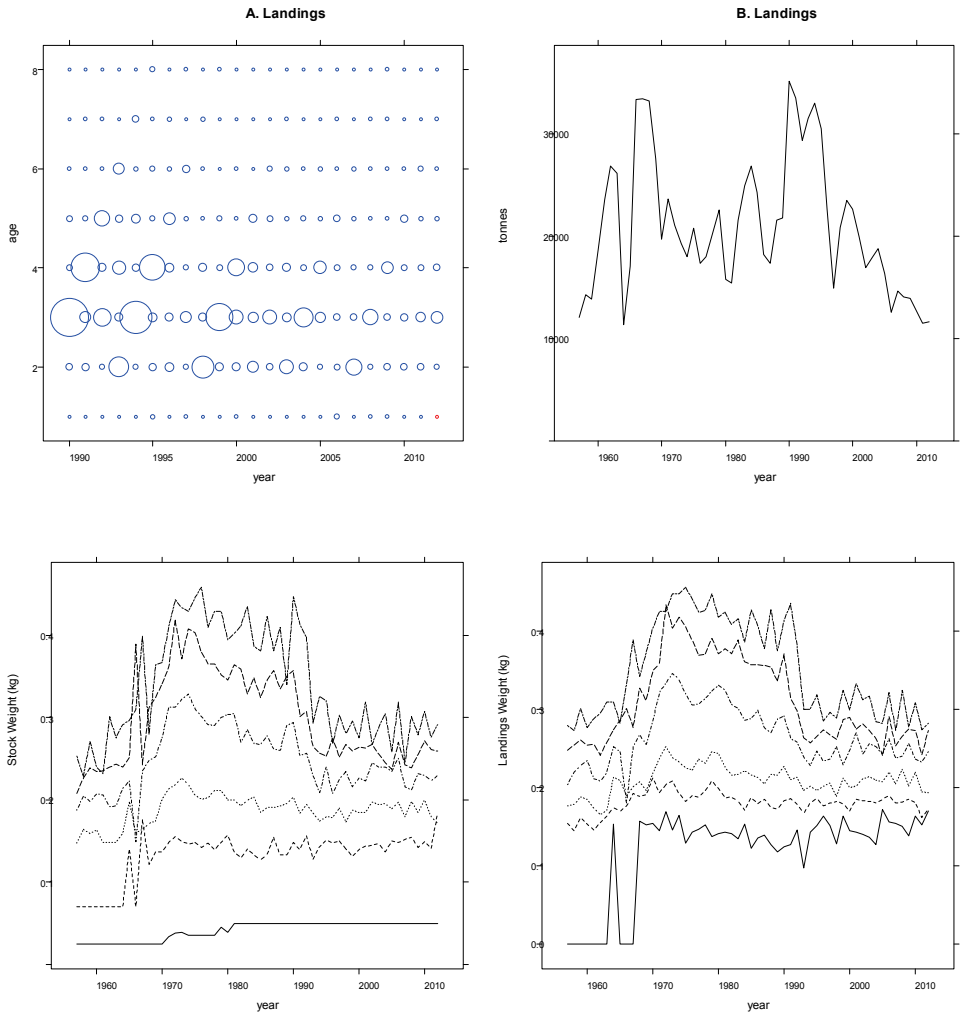


Figure 10.2.1. Sole in SubArea IV. A: bubble plot of landings (n) by age and year; B: time series of landings (total tonnages) 1957-2011; bottom left: time-series of stock-weights by age 1957-2012; Bottom right: time-series of landing-weights by age 1957-2012.

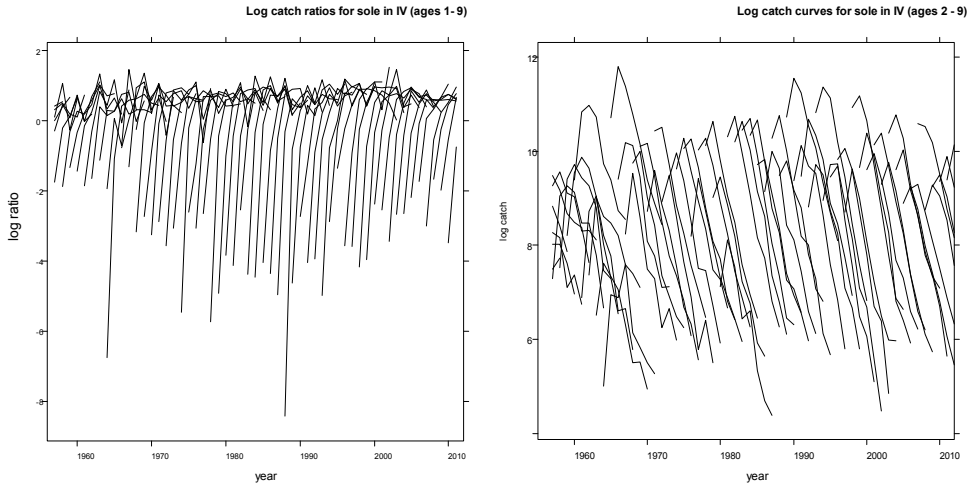


Figure 10.2.2. Sole in Sub-Area IV: Log catch ratios (left) and catch curves (right) from 1957 to 2012.

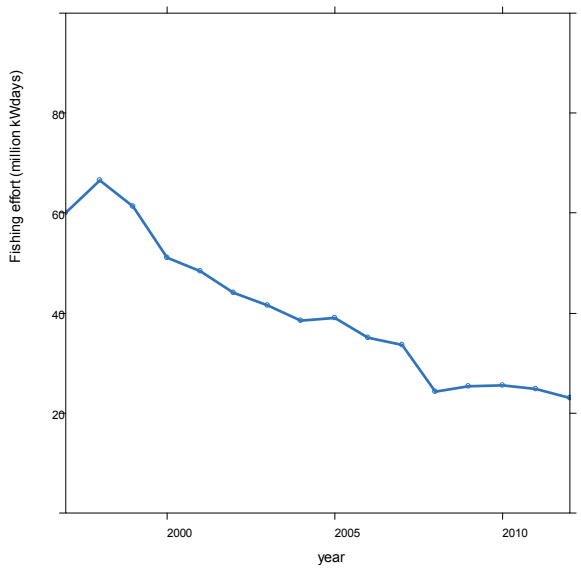


Figure 10.2.3. Sole in Sub-Area IV: Trends in the Dutch beam trawl fleet fishing effort based on days at sea records in the Dutch logbook database from vessels landings into the Netherlands.

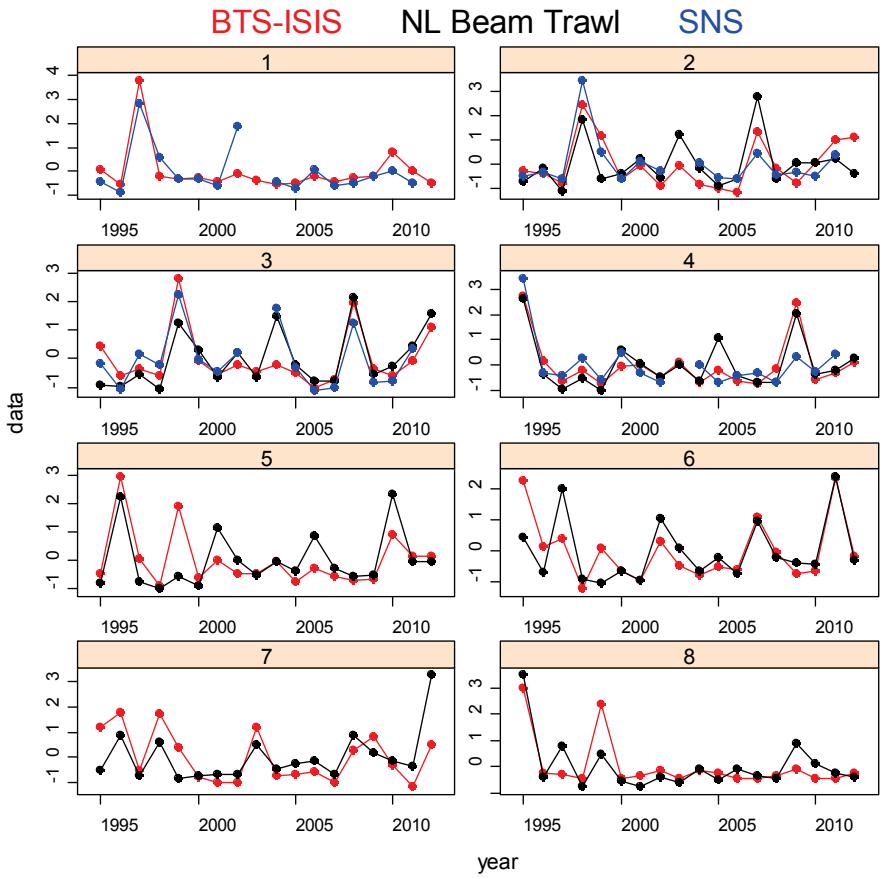


Figure 10.2.4a Sole in sub-area IV. Time series of the standardized indices age 1 to 8 from the three tuning fleets used in the final XSA assessment (BTS-ISIS, SNS and NL beam trawl).

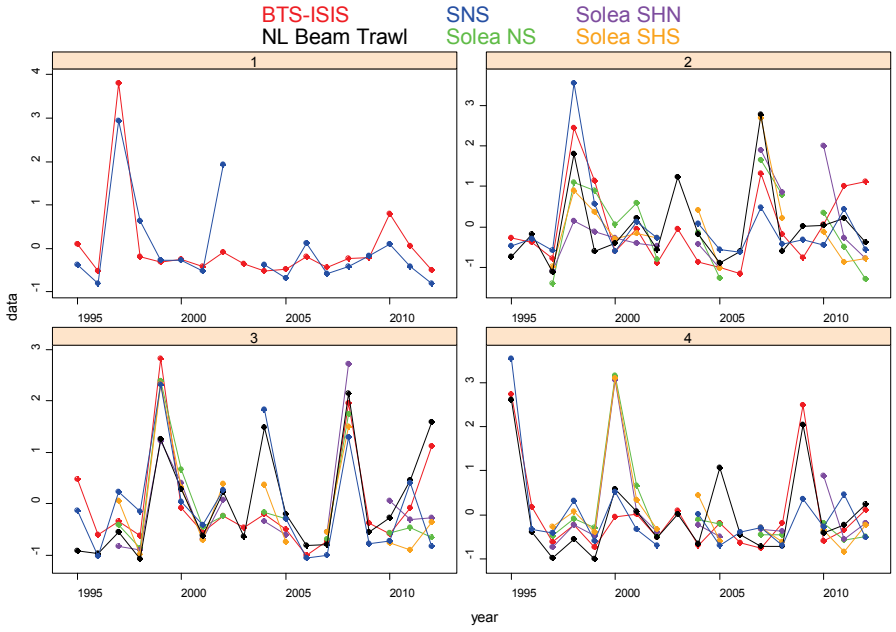


Figure 10.2.4b Sole in sub-area IV. Time series of the standardized indices age 1 to 4 from the three tuning fleets used in the final XSA assessment (BTS-ISIS, SNS and NL beam trawl) and trends from the survey in the German bight (Solea NS, Solea SHN and Solea SHS)

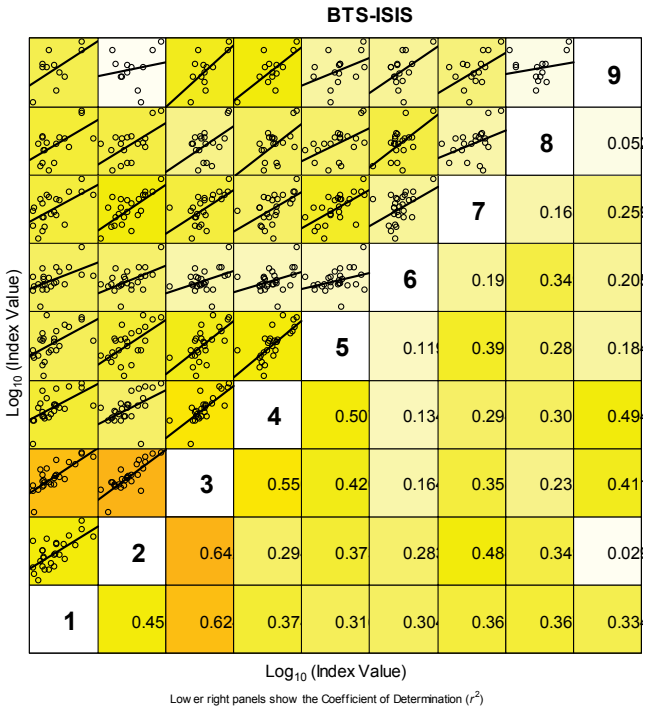


Figure 10.2.5 Sole in sub-area IV. Internal consistency in BTS-ISIS survey tuning index.

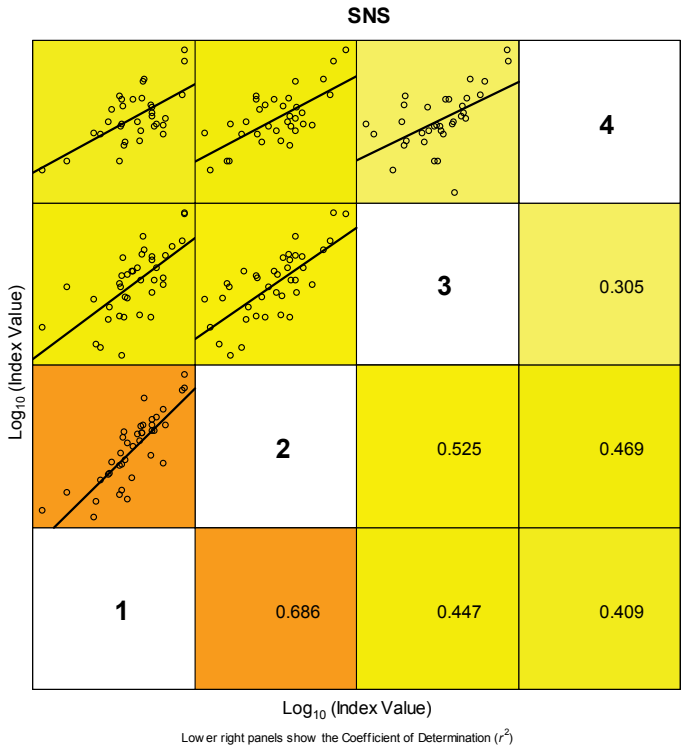


Figure 10.2.6 Sole in sub-area IV. Internal consistency in SNS survey tuning index.

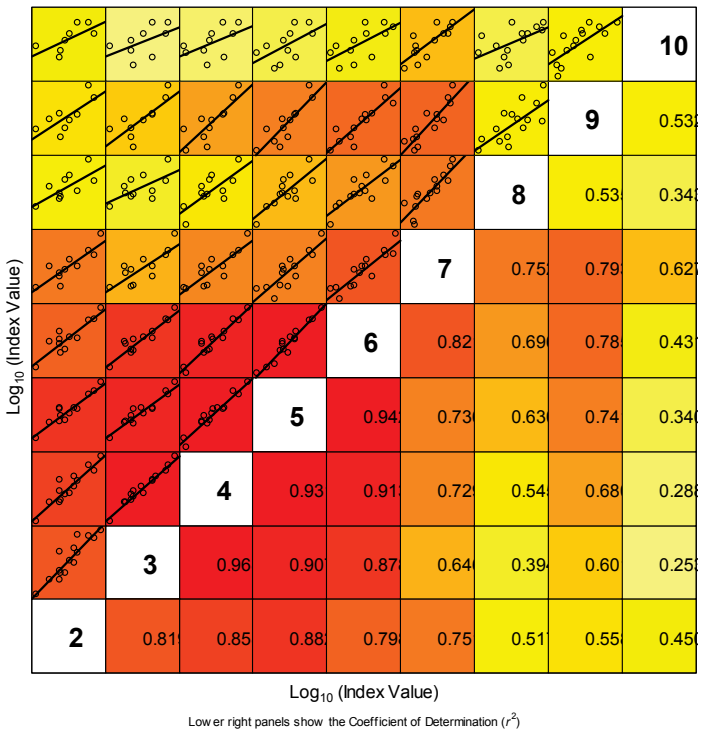


Figure 10.2.7 Sole in sub-area IV. Internal consistency in NL Beam trawl commercial tuning index.

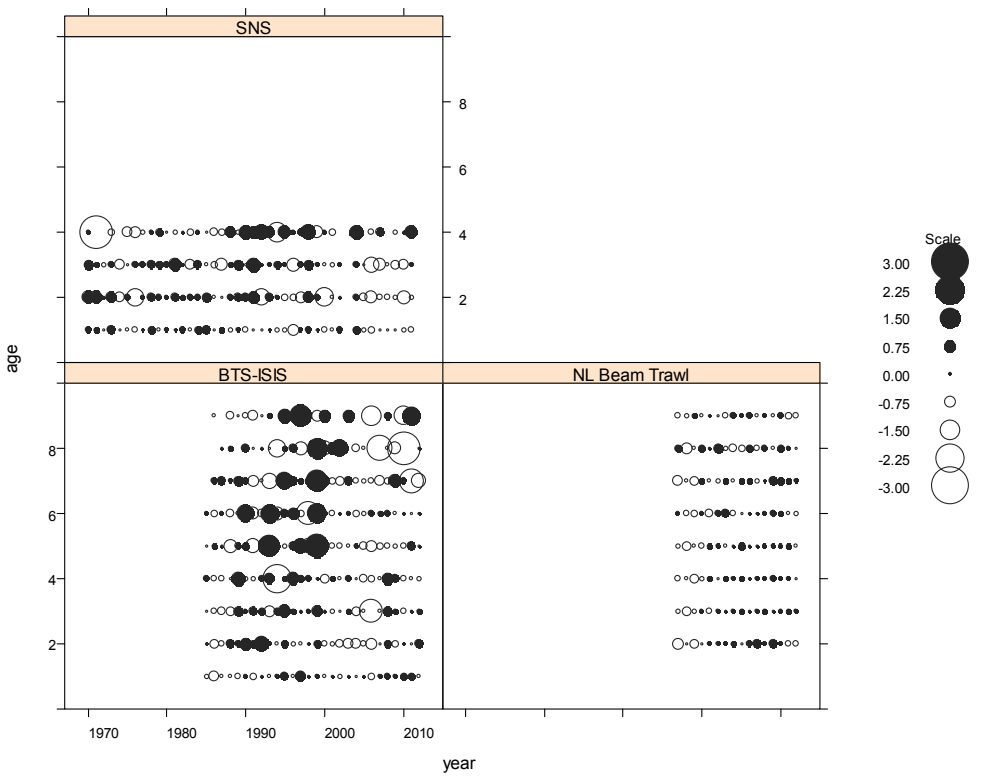


Figure 10.3.1. Sole in sub-area IV. log catchability residuals for the tuning fleets, BTS, SNS and NL beam trawl, in the final run. Closed and dark- circles indicate positive residuals, open circles indicate negative residuals

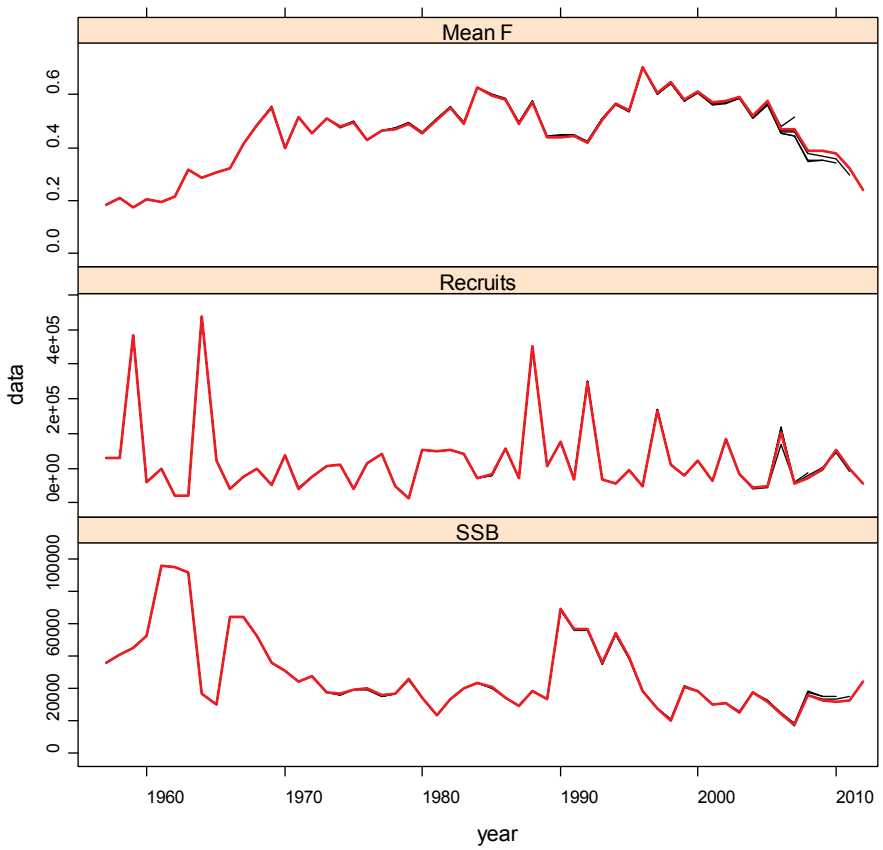


Figure 10.3.2 Sole in sub-area IV. Retrospective analysis of F, SSB and recruitment for 1995–2012 for the final XSA run.

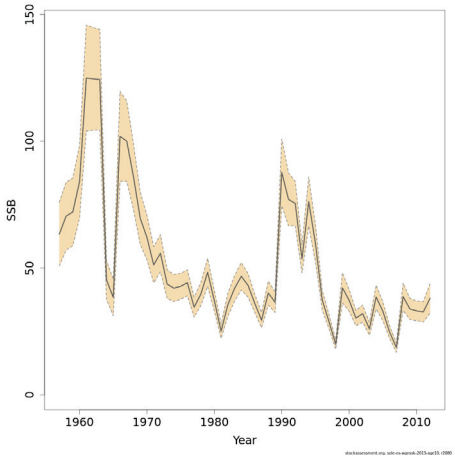


Figure 10.3.3a Sole in sub-area IV: SSB 1957–2012 output by SAM model.

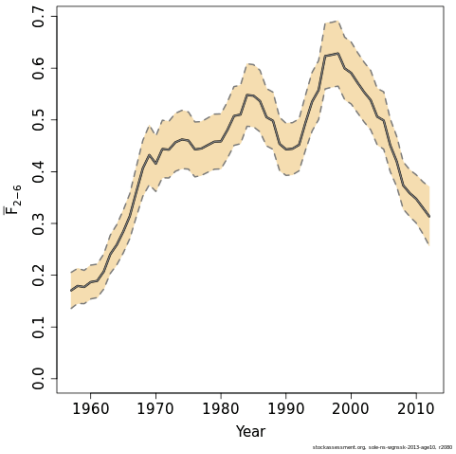


Figure 10.3.3b Sole in sub-area IV: Fishing mortality on ages 2-6 1957–2012 output by SAM model.

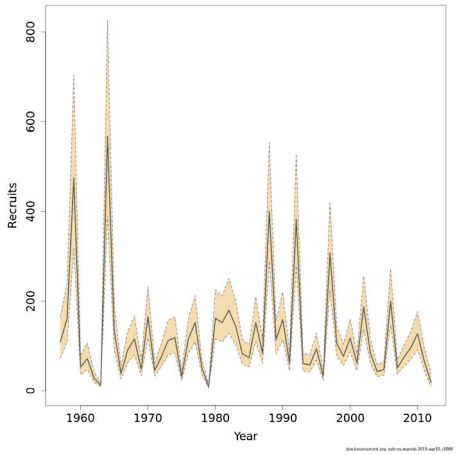


Figure 10.3.3c Sole in sub-area IV: Recruitment 1957–2011 output by SAM model.

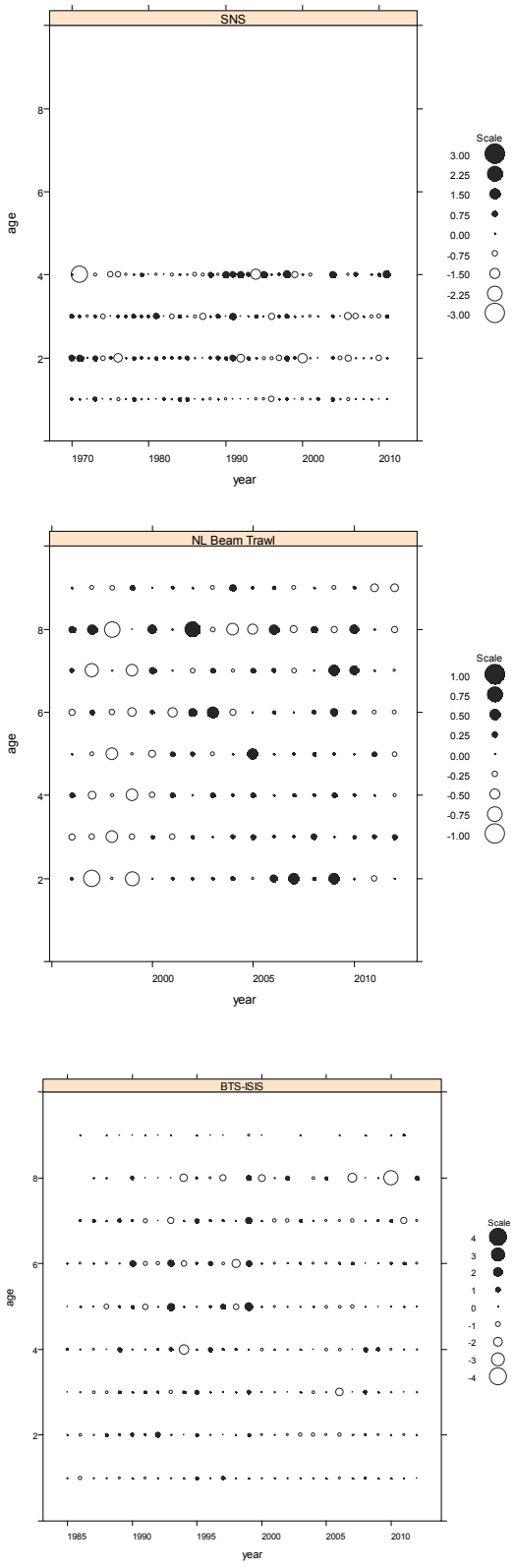


Figure 10.3.4 Sole in sub-area IV. log catchability residuals for the tuning fleets in the single fleet XSA assessments, BTS, SNS and NL beam trawl. Closed and dark- circles indicate positive residuals, open circles indicate negative residuals

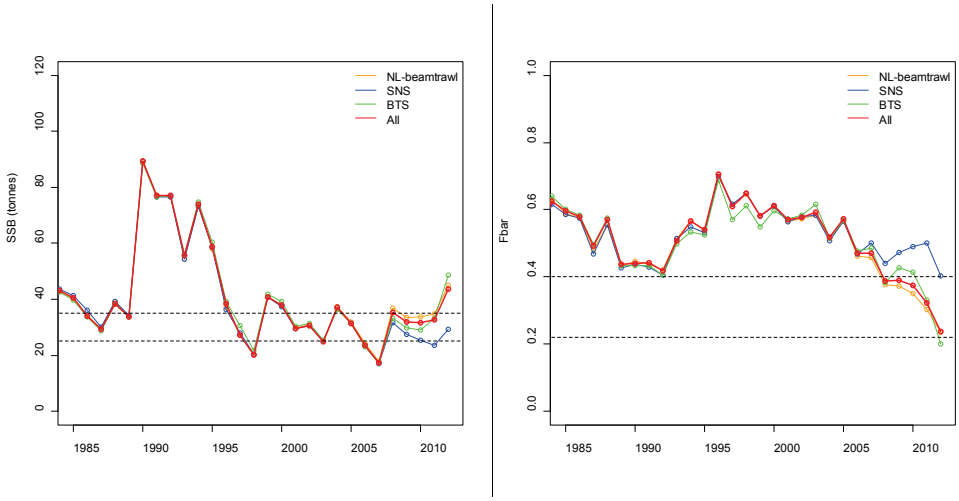


Figure 10.3.5 Sole in sub-area IV. F (right) and SSB (left) estimates for single fleet runs.

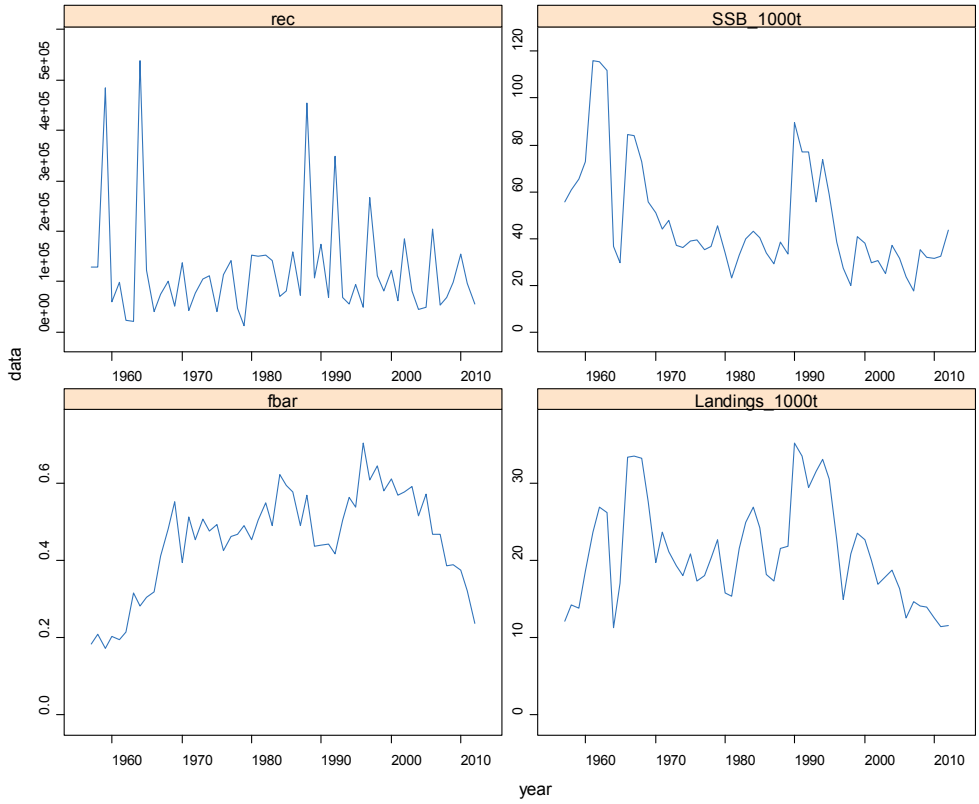


Figure 10.4.1 Sole in sub-area IV 1957-2012. XSA summary plots. Time series of recruitment (top left), SSB (top right), mean fishing mortality one ages 2-6 (bottom left) and landings (bottom right).

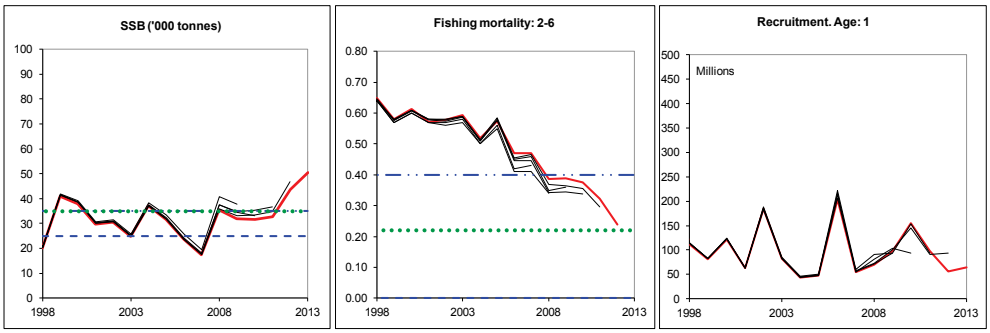


Figure 10.4.2 Sole in Subarea IV (North Sea). Historical assessment results (final year recruitment estimates included).

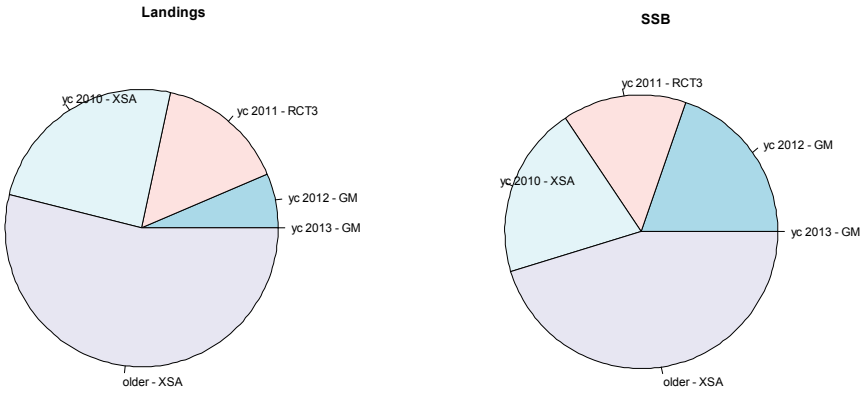
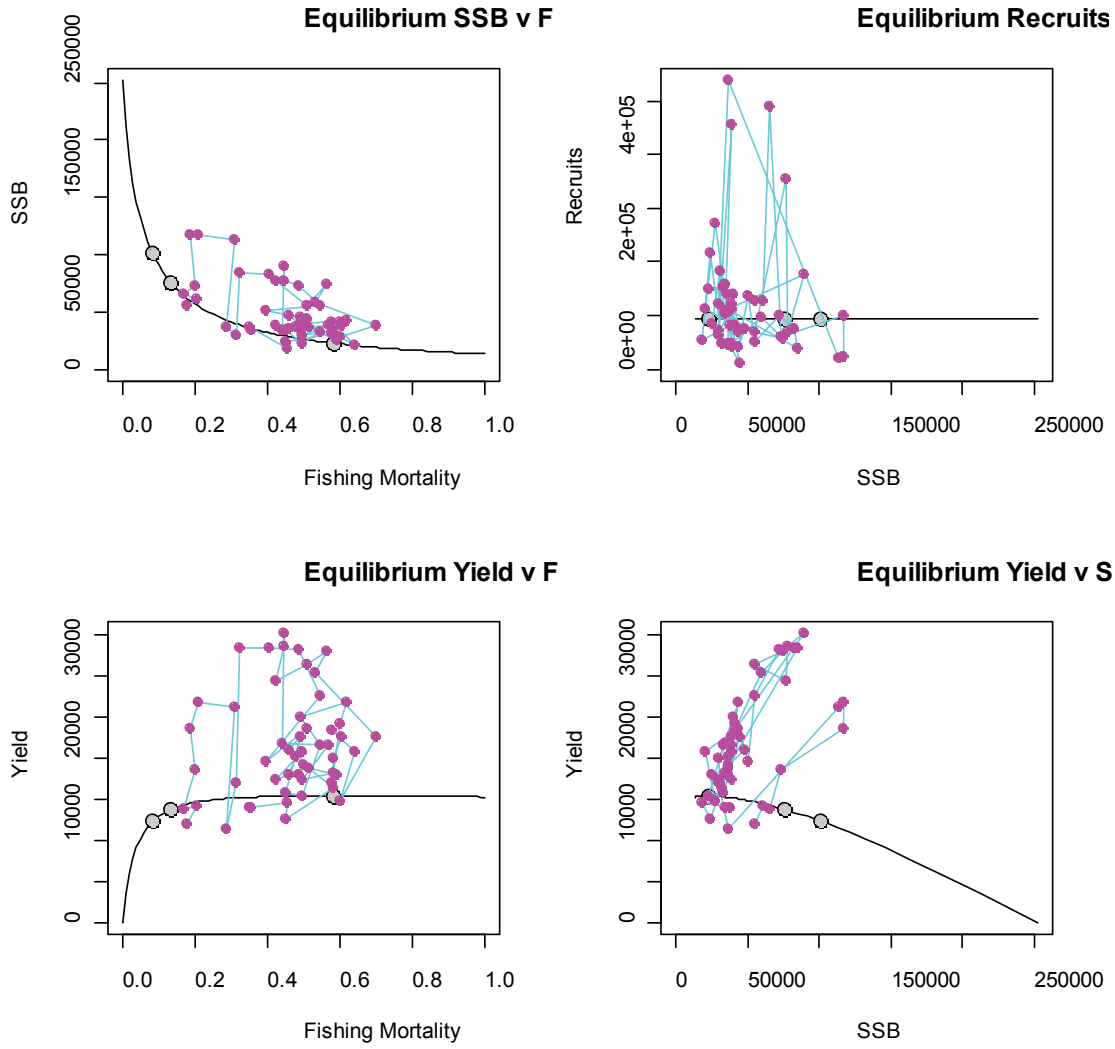


Figure 10.5.1 Sole in sub-area IV. Relative year class contribution to 2014 predicted SSB (right) and 2014 landings (left).



Yield and spawning biomass per Recruit

F-reference points:

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.31	0.16	0.48
Fmax	0.56	0.16	0.28
F0.1	0.13	0.14	0.99
Fmed	0.35	0.16	0.43

Figure 10.5.2 Sole in sub-area IV. YPR results. Figure not updated since 2010

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 2013. 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). 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 in effort and catch 2009–2011 (Figure 11.1.3). Most of the catch and effort for the French and Norwegian trawler fleets was from the second quarter (Figures 11.1.4, 11.1.5).

Discarding of fish in the offshore fisheries is assumed to be minimal and only Scottish vessels are currently reporting high amounts of discards. 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 2013

The information in this section is taken from the Advice summary sheet 2013, section 6.4.21.

Advice for 2013

ICES advises on the basis of the EU–Norway management plan that landings in 2014 should be no more than 85 528 tonnes for the whole assessment area.

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

of 82 648 t in 2014. However, paragraph 5 restricts the amount of TAC reduction to 15%, leading to a of no more than TAC of 85 528 t and a SSB of 176 056 t in 2015.

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 2012 were approximately 68 933 t in Subarea IV and Division IIIa and 7 564 t in Subarea VI, which are 87% and 92% of the TACs, respectively (Table 11.3.1). The Working Group estimated landings for Subarea IV and Division IIIa as 78 621 t (99% of the TAC) and for Subarea VI, 7 215 t (88% of the TAC).

Large discards are observed only for Scottish trawlers, 4 707 and 2 536 t in Subareas IV and VI, respectively. However, Scottish discarding rates are not believed to be considered representative for the saithe fisheries, therefore discard numbers have not been used in the current assessment. The total level of reported discards from the remaining fishing nations in Subarea IV and Division IIIa are 106 t and 104 t, respectively.

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. 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 not raised or allocated for the assessment.

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 (Figure 11.3.4). The catch in 2012 was predominantly made up of the 2007 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 11.3.5. 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. The decline is still present in the plus group (10+), but weight-at-age for ages 6–9 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 three 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, 1990–2012 ("FRATRB_IV "),
- German bottom trawl CPUE, ages 3–9, 1995–2012 ("GER_OTB_IV"),
- Norwegian bottom trawl CPUE, ages 3–9, 1993–2012 ("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. The French and Norwegian fleets appeared to have moved back to the original fishing grounds in 2012.

The Norwegian bottom trawl index was updated and revised for this assessment.

The surveys are:

- Acoustic survey of pre-recruits along the Norwegian coast on "seamounts" from approximately 59° N to 62° N, ages 3–5, 2006–2012 ("NORASS"),
- IBTS quarter 3, ages 3–5, 1991–2012 ("IBTS-Q3"),
- Norwegian acoustic saithe survey in the North Sea, run concurrently with the IBTS survey, ages 3–6, 1995–2012 ("NORACU").

The NORACU index was investigated and updated for this assessment. 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 in 2010.

The NORASS index, which was the sole recruitment index, does not track cohorts well. Vessel effects were apparent in 2011, when a larger (more stable) vessel was used for the survey, which resulted in the omission of this year from the tuning index (ICES, 2012b). Furthermore, the survey was discontinued by the Norwegian Institute of Marine Research in 2012. Two assessments were trialled; one including the index and one excluding it. Excluding the index did not change the assessment, so it was deemed uninformative and removed. Therefore, this survey was excluded from the analysis.

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 2012 by the Review Group (Technical Minutes) are summarised below in italics, along with an explanation of how this WG addressed the comments.

Given the current low recruitment and low growth rates in the stock a re-evaluation of the management plan reference points should be considered.

Answer: 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).

Poor estimates of recruitment are still a serious concern for this assessment. An in-consistent retro pattern is present for recruitment estimates coming out of the final assessment.

Answer: Unfortunately, this could not be addressed. The NORASS survey has been discontinued by the Norwegian Institute of Marine Research and there is no other survey on saithe prior to recruiting to the fishery. The Institute of Marine Research is currently re-assessing the survey and hopes to have a either a re-continuation or an improved young saithe survey in place in 2014.

Figures 11.1.1 and 11.1.3 would benefit from a legend quantifying the relative bubble sizes.

Answer: Text was added to the legend to quantify smallest and largest bubble size.

In section 11.2.3, Weights at age: I do not get the sense from the 11.2.2 that the decline in weights at age for older fish has halted, especially for the plus group. Almost all weight at age estimates have declined from 2010 to 2011.

Answer: The decline in weights at age for the plus group has not ceased (Figure 11.3.5). Ages 6–9 appear to have stabilized, if not showing a slight increase. Ages 3-5 appear to be relatively stabilize (with some variation) over the last decade. The text has been modified to reflect the observed trends.

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, NORASS) and 3 to 6 (NORACU) on the log-scale, linked by cohort. A strong year effect is apparent in all surveys in 2011; this is reflected in the sharp increase in age 4 when compared to earlier cohorts. The NORACU and IBTS indices are similar, which is not surprising as these surveys occur concurrently.

Within-cohort correlations between ages for the three 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, but show poor (or negative) correlations between ages for the NORASS index. The NORACU and IBTS-Q3 data are not independent; since 2008, data for both are based on the same age and length samples. The revision of the NORACU data has strengthened the correlations between ages.

The three research surveys track similar trends until 2006; age 3 in the NORASS survey does not track similar patterns in the IBTS or NORACU surveys after 2006 (Figure 11.4.3). The IBTS and NORACU index are similar except for age 3 and 5 after 2009, when they reflect opposite trends. The NORACU index is currently under revision.

11.4.3 Exploratory catch-at-age-based analyses

The catch-at-age data are shown in Figure 11.4.4 and present numbers-at-age for saithe ages 3 to 9 on the log-scale, linked by cohort. The curves show that age 3 is 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 a change in exploitation occurred. The proportion of catch taken by the Norwegian purse seine fishery declined 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 2011–2012.

11.4.4 Conclusions drawn from the exploratory analysis

All indices except NORASS 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. There was no assessment in 2010.

Year of assessment:	2009	2011	2011 REOPENING	2012	2013
Assessment model:	XSA	XSA	XSA		XSA (SAM)
Fleets:	FRATRB_IV (ages 3-9, 1990–2009)	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)
	GER_OTB_IV (ages 3-9, 1995–2009)	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)
		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)
	NORACU (ages 3-6, 1996 –2009)	NORACU (ages 3-6, 1996 –2011)	NORACU (ages 3-6, 1996 –2010)	NORACU (ages 3-6, 1996–2011)	NORACU (ages 3-6, 1996–2012)

	IBT-Q3 (ages 3-5, 1992 – 2009)	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)
		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:	1967–2008	1967–2010	1967–2010	1967–2011	1967–2012
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	Tricubic over 20 years; (NA)
Power model for ages:	No	No	No	No	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	5 years/ 3 ages; (NA)
S.E. of mean (F-shrinkage):	1.0	1.0	1.0	1.0	1.0; (NA)
Min. S.E. of population estimates:	0.3	0.3	0.3	0.3	0.3; (NA)
Prior weighting:	No	No	No	No	No
Number of iterations before convergence:	47	53	60	60	47; (NA)

Thirty-six parameters were estimated in the SAM model; the negative log-likelihood value was 691.59. Estimated catchabilities for the NORACU index were high (range 233– 502), while all other indices were < 0.01. Fishing mortality-at-age is given in Table 11.4.1 and 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 11.4.2.

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, positive values in the final year of the NORACU index. The retrospective analysis is generally quite good for SSB and F, but shows that recruitment tends to be overestimated.

Recruitment and SSB estimates are lower for the XSA model compared to the SAM model. FLXSA estimates of recuitment and SSB were 37 432 individuals and 196 487 t, respectively. However, the XSA SSB estimate is within the 95% confidence interval generated by the SAM model.

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} and has been for the last 3 years. 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.

11.6 Recruitment estimates

There is currently no survey that provides an estimate of incoming recruitment. The 1988–2010 geometric mean value (116 945) used in the short-term forecast is higher than the estimated recruitment for 2011 and 2012.

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 2013. A TAC constraint for the intermediate year was chosen, i.e., the fishing mortality for 2013 was determined such that the landings in 2013 matched the TAC. Population numbers-at-age for ages 4 and older in 2013 were XSA survivor estimates, while numbers at age 3 were the geometric mean estimate of recruitment for the years 1988–2010. 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 2013 are scaled to the TAC in 2013 results in an F_{2013} of 0.37 and a SSB in 2014 of 162 125, which is a 17% decline from the 2013 estimated SSB. Because estimated SSB in 2013 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 a TAC of no more than 82 648 t, resulting in an SSB in 2015 of 178 386 t. However, the change in TAC would be greater than 15%, therefore, paragraph 5 of the management plan applies. A TAC constraint of 15% would result in a TAC of no more than 85 528 t, an F of 0.304, and an SSB in 2015 of 176 056 t (a 10% decrease in SSB).

The contribution of recruitment of the 2007–2011 year classes to landings in 2014 and to SSB in 2015 are shown in Table 11.7.3 and Figure 11.7.1. The 2007 and 2010 year classes contribute the most to the forecasts. These were the two most recent large year classes.

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. The Institute of Marine Research in Norway began an acoustic survey in 2006, directed towards assessing pre-recruits (ages 2–4) on seamounts near the Norwegian coast. This survey was discontinued in 2012. Currently, IMR is re-assessing the survey and either a re-instatement of NORASS or an improved recruitment survey should be in place in 2014 or 2015. The index was excluded from the current assessment because its inclusion did not noticeably alter the assessment; it was deemed uninformative.

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 next 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 slightly 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 10 % 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).

References

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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, 2001-2012, as officially reported to ICES and estimated by the Working Group.

SAITHE IV and IIIa

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012*
Belgium	107	45	22	28	16	18	7	27	15	2	1
Denmark	5668	6954	7991	7498	7471	5458	8069	8802	8019	6325	5170
Faroe Isl.	872	495	558	184	62	15	108	-	146	0	8
France	25441	18001	13628	10768	15739	13043	15302	5445*	4582*	13856	14093
Germany	10999	8956	9589	12401	14390	12790	14141	13689	11192	10234	8007
Greenland	62	1616	403	-	-	-	-	-	-	0	-
Ireland	-	-	1	-	0	-	81	81	-	0	0
Netherlands	6	11*	3	40	28	5	3	17	3	24	34
Norway	60013	61735	62783	67365	61268	45395	62055	57708	53031	46778	33028
Poland	752	734*	0	1100	-	-	1407	988	654	584	-
Russia	-	-	-	35	2	5	5	13	-	0	-
Sweden	1863	1876	2249	2114	1695	1380	1639	1363	1545	1331	1305
UK (E/W/NI)	2521	1215	457	1190	9129**	9628**	11701**	12545**	11887**	10148**	7287**
UK (Scotland)	6596	5829	5924	7703							
Total reported	114900	107467	103608	110575	109800	87377	114517	100678	91074	89282	68933
Unallocated	1291	-5809	-3646	968	7312	6241	-3084	4851	4026	422	10387
WG estimate	116191	101658	99962	111543	117112	93618	111433	105529	95100	89704	78621
TAC	135000	165000	190000	145000	123250	135900	135900	125934	107000	93600	79320

*Preliminary, [2]Preliminary data reported in IVa, **Scotland+E/W/NI combined

SAITHE VI

Country	2002	2003	2004*	2005*	2006	2007*	2008*	2009	2010	2011*	2012*
Faroe Islands	-	2	34	21	76	32	23	-	24	5	6
France	3062	3499	3053	3452	5782	3956	2617	2093	2003	2382	2612
Germany	467	54	4	373	532	580	147	298	257	0	9
Ireland	91	170	95	168	243	322	208	208	519	359	341
Netherlands	-	-	-	-	-	-	1	-		0	0
Norway	12	28	16	20	28	377	78	68	249	160	47
Russia	1	6	6	25	7	2	50	4	2	0	-
Spain	4	6	2	3	-	-	-	-		0	-
UK (E/W/NI)	307	263	37	203	2748**	1419**	2887**	3501**	3168**	4399**	4549**
UK (Scotland)	1567	1189	1563	4433							
Total reported	5513	5215	4810	8699	9416	6688	6011	6172	6222	7305	7564
Unallocated	-327	35	-296	-2960	848	98	1223	791	666	95	666
WG estimate	5186	5250	4514	5739	8568	6786	7234	6963	6840	7400	7215
TAC	14000	17119	20000	15044	12787	14100	14100	13066	11000	9570	8230

*Preliminary **Scotland+E/W/NI combined

SAITHE IV, IIIa and VI

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
WG estimate	121377	106908	104476	117282	125680	100404	118667	112492	101940	97104	76497
TAC	149000	182119	210000	160044	136037	150000	150000	139000	118000	103170	87550

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	16674	4970	10604	3600	2226	3191
2010	7355	8299	7842	6159	3281	4052	2153	3919
2011	9364	20559	5943	4414	2488	1510	2635	4485
2012	5892	8828	17659	3509	2010	1071	577	3232

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	0.930	1.362	2.103	3.185	3.754	5.315	5.890	7.718
1968	1.279	1.652	1.989	3.010	4.041	4.428	6.136	7.406
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	1.012	1.261	1.761	2.424	2.869	3.362	3.634	3.996
2012	1.003	1.337	1.418	2.297	3.220	3.541	3.995	4.242

Table 11.3.4. Saithe in Subareas IV and VI and Division IIIa. Tuning indices considered for use in the 2012 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

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

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

```
 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

 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  1.03  3.921  1.333
1999 1  2.10  2.019  2.949
2000 1  3.48  8.836  1.081
2001 1 21.50  6.173  3.937
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 29.820  2.934
2007 1 34.02  5.594 11.763
2008 1  3.47  5.860  1.122
2009 1  1.35  1.703  0.568
2010 1  1.36  0.962  0.465
2011 1  4.54  8.496  1.067
2012 1 11.11  2.521  2.799

[1] NORASS  units= NA
            3       4       5
2006 1   7.66  17.890  1.860
2007 1  55.47   6.280  20.010
2008 1  30.89  23.420   2.400
2009 1  27.68  11.830   4.350
2010 1  30.79   5.070   1.350
2011 1  28.86 286.410  17.860
2012 1   1.14   0.215   0.738
```

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	0.234	0.372	0.410	0.428	0.367	0.299	0.399
1968	0.241	0.390	0.402	0.400	0.330	0.278	0.379
1969	0.244	0.410	0.393	0.405	0.355	0.311	0.382
1970	0.270	0.456	0.412	0.414	0.353	0.314	0.357
1971	0.314	0.483	0.404	0.396	0.360	0.340	0.381
1972	0.360	0.508	0.397	0.406	0.375	0.361	0.379
1973	0.410	0.537	0.401	0.401	0.388	0.368	0.382
1974	0.451	0.563	0.422	0.417	0.415	0.387	0.384
1975	0.460	0.575	0.444	0.432	0.435	0.414	0.394
1976	0.480	0.599	0.482	0.452	0.440	0.422	0.389
1977	0.429	0.568	0.502	0.469	0.461	0.449	0.392
1978	0.412	0.535	0.490	0.443	0.448	0.431	0.368
1979	0.377	0.493	0.492	0.456	0.475	0.432	0.367
1980	0.362	0.475	0.504	0.482	0.491	0.454	0.396
1981	0.347	0.472	0.507	0.502	0.508	0.487	0.426
1982	0.368	0.526	0.556	0.541	0.527	0.490	0.421
1983	0.383	0.584	0.606	0.596	0.561	0.517	0.430
1984	0.416	0.678	0.647	0.615	0.534	0.500	0.398
1985	0.423	0.783	0.689	0.587	0.515	0.477	0.414
1986	0.388	0.850	0.738	0.585	0.514	0.474	0.459
1987	0.380	0.808	0.754	0.569	0.510	0.482	0.484
1988	0.372	0.752	0.767	0.587	0.522	0.494	0.487
1989	0.364	0.733	0.752	0.617	0.514	0.486	0.461
1990	0.356	0.709	0.738	0.608	0.514	0.471	0.443
1991	0.331	0.681	0.730	0.591	0.518	0.458	0.462
1992	0.282	0.627	0.724	0.593	0.534	0.470	0.482
1993	0.244	0.562	0.667	0.573	0.584	0.520	0.554
1994	0.213	0.528	0.636	0.531	0.576	0.500	0.571
1995	0.184	0.479	0.596	0.509	0.603	0.527	0.604
1996	0.163	0.418	0.558	0.505	0.572	0.516	0.559
1997	0.150	0.378	0.506	0.464	0.517	0.507	0.537
1998	0.141	0.352	0.477	0.435	0.459	0.494	0.535
1999	0.128	0.326	0.448	0.415	0.426	0.489	0.560
2000	0.115	0.295	0.415	0.386	0.383	0.425	0.508
2001	0.111	0.290	0.388	0.359	0.364	0.401	0.463
2002	0.115	0.279	0.362	0.352	0.383	0.412	0.506
2003	0.113	0.264	0.354	0.360	0.392	0.419	0.496
2004	0.111	0.259	0.347	0.359	0.393	0.421	0.458
2005	0.116	0.267	0.359	0.370	0.404	0.421	0.405
2006	0.120	0.270	0.370	0.378	0.410	0.427	0.381
2007	0.120	0.271	0.370	0.386	0.407	0.423	0.347
2008	0.123	0.284	0.396	0.400	0.410	0.408	0.349
2009	0.124	0.293	0.414	0.417	0.440	0.403	0.366
2010	0.115	0.287	0.404	0.423	0.454	0.404	0.384
2011	0.118	0.288	0.396	0.421	0.438	0.413	0.400

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	98617	63895	48291	6177	4467	1041	620	573
1968	113210	71111	41898	24662	2650	1815	497	554
1969	189852	66769	42916	25084	16841	2358	1616	543
1970	190422	183689	40741	31288	14973	8811	1376	1144
1971	266465	152055	105768	19372	16305	9937	6207	2094
1972	167544	178260	87728	62380	12287	9691	5944	5332
1973	162430	96858	95703	57757	31540	7455	5046	7407
1974	167209	82785	45433	63007	42277	18424	4854	7153
1975	174905	71611	34544	24222	37911	26108	11319	8078
1976	389648	101824	31163	18424	13208	19157	13157	11503
1977	103053	148747	37421	13506	9463	7935	11494	14554
1978	103881	65382	57182	13415	4678	3823	3245	12982
1979	66503	46537	32696	27945	7511	2516	2006	8767
1980	65513	38139	23695	18021	15636	3665	1566	7605
1981	123871	32435	21683	11134	9176	8215	1986	6426
1982	110415	98125	21483	14817	5931	4571	3483	4150
1983	108771	57642	56557	11554	9094	3237	2684	3883
1984	215346	67711	28710	26082	4661	3545	1310	2711
1985	314268	103777	29173	12754	9361	2173	1503	2404
1986	212777	143918	31288	12425	6726	4461	1229	2429
1987	109426	162105	33356	9700	5364	3551	2391	1910
1988	115266	60114	64537	10435	4680	2784	1936	1940
1989	81797	63895	26056	23225	4451	2088	1269	1588
1990	131663	42959	24343	10664	8322	2186	956	1283
1991	142201	63196	15924	9497	4901	3420	1117	1290
1992	86336	76803	24053	6915	4477	2378	1687	1304
1993	194658	58221	30061	7690	3060	2736	1653	2142
1994	114005	106511	29290	12258	2829	1181	1124	1996
1995	182225	70898	38177	11361	6564	1466	910	1713
1996	90853	132986	29733	17732	6908	2419	641	1194
1997	123500	70404	86509	11491	7066	2747	874	796
1998	80741	108662	44936	50312	6994	3494	1511	783
1999	82951	51586	74161	25235	29319	4561	1882	1355
2000	87466	86336	30455	42830	12837	13342	2009	1238
2001	203618	73350	72766	14442	17895	7351	6136	1016
2002	175606	179872	37609	37384	7783	9539	4419	3911
2003	117712	105873	96955	21043	22315	4561	4934	3160
2004	67982	82207	72766	52261	13115	12721	2831	2761
2005	135131	54231	59397	58747	36717	9061	7064	1979
2006	89501	122884	39262	32630	35172	18283	5307	4708
2007	180232	43739	87291	25109	19050	15818	7892	4352
2008	89859	111413	25771	57068	16597	11365	9143	6921
2009	71040	50869	48776	14769	29882	11710	7770	10937
2010	97343	40417	26796	20024	8122	14287	7228	12712
2011	87992	90400	21895	14049	8440	4362	8337	13014
2012	59814	38988	58105	11716	6838	3847	2035	11242

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}), 1967–2012. Low and High refer to the lower and upper 95% confidence interval estimates.

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F_{3-6}	Low	High
1967	98617	65271	149000	330380	264601	412512	132323	103619	168977	0.361	0.288	0.453
1968	113210	78714	162823	445521	360959	549894	168552	132853	213844	0.358	0.290	0.442
1969	189852	130259	276709	534988	435530	657158	227294	183825	281042	0.363	0.298	0.443
1970	190422	132606	273446	721437	597406	871218	283793	234291	343754	0.388	0.323	0.466
1971	266465	187524	378640	868914	726512	1039229	395537	324524	482089	0.399	0.335	0.475
1972	167544	118786	236315	817495	690734	967519	434087	358772	525212	0.418	0.353	0.494
1973	162430	115239	228946	787800	670027	926275	476870	393527	577864	0.437	0.371	0.515
1974	167209	118071	236797	866312	739287	1015161	562980	465869	680335	0.463	0.393	0.545
1975	174905	124470	245777	807744	688417	947754	527023	433639	640518	0.478	0.406	0.562
1976	389648	268434	565599	820771	684036	984840	406769	332282	497953	0.503	0.425	0.595
1977	103053	73034	145411	606221	511195	718912	343520	279076	422845	0.492	0.418	0.580
1978	103881	73837	146149	493856	416640	585383	293314	236906	363153	0.470	0.401	0.551
1979	66503	46810	94480	434956	368341	513618	266465	218556	324877	0.454	0.387	0.533
1980	65513	46289	92720	397122	339415	464641	253216	209907	305462	0.456	0.389	0.534
1981	123871	86913	176547	433653	368487	510343	242559	201410	292115	0.457	0.390	0.536
1982	110415	78610	155087	482145	409541	567620	209609	176607	248778	0.498	0.429	0.578
1983	108771	77460	152738	464632	397048	543719	228662	190517	274444	0.542	0.468	0.628
1984	215346	152061	304967	482145	406844	571384	191568	161450	227305	0.589	0.507	0.684
1985	314268	218198	452634	504842	417195	610901	164062	139496	192955	0.620	0.531	0.724
1986	212777	151252	299329	452707	381209	537615	158578	135001	186271	0.640	0.545	0.752
1987	109426	78028	153458	379269	322460	446086	163407	139364	191597	0.628	0.539	0.732
1988	115266	82145	161742	329720	281522	386170	160171	134400	190884	0.620	0.533	0.720
1989	81797	58227	114909	272393	233554	317690	127007	107670	149817	0.616	0.531	0.716
1990	131663	94344	183744	279288	236778	329431	110636	94773	129154	0.603	0.519	0.700
1991	142201	102191	197877	283509	239220	335998	98027	84600	113585	0.583	0.502	0.678
1992	86336	62150	119934	273758	232936	321734	99708	86307	115190	0.556	0.478	0.648
1993	194658	141221	268316	365127	304136	438349	109974	94619	127821	0.511	0.440	0.595
1994	114005	83022	156551	343176	291107	404559	117360	101314	135947	0.477	0.409	0.555
1995	182225	136607	243079	421258	358699	494727	137173	118633	158611	0.442	0.379	0.515
1996	90853	67819	121710	386930	332153	450741	144784	125687	166784	0.411	0.352	0.480
1997	123500	92175	165472	397520	341695	462465	176663	150064	207976	0.374	0.320	0.438
1998	80741	60226	108244	374745	324206	433162	185907	158372	218229	0.351	0.299	0.412
1999	82951	61441	111989	364397	316276	419840	213630	181491	251460	0.329	0.280	0.387
2000	87466	64686	118267	399512	345253	462298	205664	175408	241139	0.303	0.256	0.358
2001	203618	151324	273983	470711	402921	549907	208772	177806	245132	0.287	0.242	0.340
2002	175606	130710	235923	490902	420071	573676	196418	167980	229671	0.277	0.233	0.329
2003	117712	87530	158302	423369	364806	491334	217728	185515	255534	0.273	0.230	0.324
2004	67982	50259	91955	416649	359827	482444	250446	213242	294141	0.269	0.226	0.320
2005	135131	100469	181752	456800	396005	526927	284361	241424	334934	0.278	0.235	0.329
2006	89501	66343	120741	477825	413317	552401	271848	230729	320296	0.284	0.241	0.336
2007	180232	134164	242118	452254	388993	525804	242559	205397	286445	0.287	0.242	0.339
2008	89859	66729	121007	464167	400683	537710	259627	219421	307200	0.301	0.254	0.356
2009	71040	52376	96356	390038	335465	453489	261712	219198	312472	0.312	0.262	0.371
2010	97343	71445	132630	376623	322352	440032	242802	200442	294114	0.307	0.256	0.368
2011	87992	64469	120098	433653	367063	512323	220356	179258	270877	0.306	0.252	0.371
2012	59814	–	–	–	–	–	198590	160653	245487	–	–	–

Table 11.4.4. Saithe in Subareas IV and VI and Division IIIa. FLR XSA: Diagnostics

```
FLR XSA Diagnostics 2013-04-28 20:43:43

CPUE data from xsa.indices

Catch data for 46 years. 1967 to 2012. Ages 3 to 10.

       fleet first age last age first year last year alpha beta
1  FRATRB_IV         3        9       1990      2012     0    1
2 NORTRL_IV2         3        9       1993      2012     0    1
3 GER_OTB_IV         3        9       1995      2012     0    1
4     NORACU         3        6       1996      2012   0.5 0.75
5    IBTS-Q3         3        5       1992      2012   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
     year
age    2003 2004  2005  2006  2007  2008 2009  2010 2011 2012
  all 0.751 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1


 Fishing mortalities
    year
age   2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
  3  0.105 0.060 0.084 0.186 0.186 0.171 0.211 0.066 0.184 0.191
  4  0.172 0.191 0.196 0.243 0.225 0.437 0.367 0.295 0.263 0.264
  5  0.324 0.224 0.341 0.302 0.295 0.376 0.598 0.394 0.357 0.380
  6  0.288 0.279 0.369 0.322 0.297 0.408 0.418 0.461 0.403 0.371
  7  0.379 0.285 0.414 0.428 0.328 0.303 0.480 0.542 0.341 0.323
  8  0.397 0.396 0.356 0.389 0.356 0.338 0.417 0.339 0.519 0.241
  9  0.464 0.581 0.394 0.335 0.193 0.275 0.386 0.475 0.387 0.382
  10 0.464 0.581 0.394 0.335 0.193 0.275 0.386 0.475 0.387 0.382


 XSA population number ( NA )
      age
year        3      4      5     6     7     8     9    10
  2003 129410 141383 102927 27699 24727  5096  5890  3062
  2004 100905  95400  97469 60962 17005 13856  2804  2000
  2005 191674  77805  64546 63789 37775 10466  7631  1549
  2006  64356 144323  52384 37590 36124 20446  6001  5524
  2007 113814  43759  92635 31709 22303 19283 11348  6113
  2008  68029  77361  28604 56441 19295 13158 11055  7925
  2009  54114  46928  40929 16072 30725 11670  7680 10924
  2010 128045  35867  26617 18422  8662 15561  6298 11352
  2011  61662  98179  21856 14696  9509  4123  9074 15322
  2012  37432  42011  61780 12517  8038  5534  2010 11160

Estimated population abundance at 1st Jan  2013
      age
year     3     4     5     6    7    8    9   10
  2013 769 25315 26409 34603 7073 4763 3562 1123
```

Fleet: FRATRB_IV
Log catchability residuals.

year / age	1990	1991	1992	1993	1994	1995	1996	1997	1998
3	0.115	-0.583	-0.284	0.421	-0.091	-0.364	-1.037	-0.988	-0.479
4	0.111	0.219	0.146	0.104	0.188	-0.348	-0.519	-0.421	-0.552
5	0.018	0.045	0.266	0.204	0.262	-0.424	-0.217	-0.080	0.026
6	-0.427	0.162	-0.458	-0.437	0.268	-0.474	0.089	-0.707	0.074
7	0.790	0.484	-0.621	-1.704	-0.002	0.011	0.096	-0.046	-0.828
8	-0.349	0.382	-1.230	-1.492	-1.578	0.244	-0.16	-0.768	-0.723
9	-0.031	-0.342	-0.818	-1.24	-1.959	0.002	0.444	0.193	-0.597

year / age	1999	2000	2001	2002	2003	2004	2005	2006
3	-1.233	-0.273	-1.028	0.111	-0.212	-0.507	-0.680	1.240
4	-0.426	-0.309	0.065	0.388	-0.286	-0.381	-0.015	0.310
5	0.003	0.479	0.625	-0.136	-0.26	-0.388	0.167	-0.434
6	-0.157	0.798	0.373	0.336	-0.795	-0.262	0.142	-1.076
7	0.034	0.569	0.305	0.619	0.271	0.046	0.676	0.037
8	-1.000	0.345	-0.776	0.319	0.463	-0.653	-0.660	-1.026
9	-0.574	0.522	-0.713	-0.301	0.686	0.437	-0.422	-0.921

year / age	2007	2008	2009	2010	2011	2012
3	1.217	0.322	-0.209	-0.494	0.823	0.023
4	0.022	0.091	0.306	0.129	-0.147	0.187
5	0.252	-0.810	0.449	0.254	0.026	0.142
6	-0.775	0.234	0.920	-0.112	-0.235	0.988
7	-0.586	0.212	-0.444	-0.519	-0.288	0.087
8	-3.909	-0.959	0.219	-0.097	0.070	-1.780
9	NA	-0.843	-0.299	-0.212	-0.598	1.376

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	-13.3478	-12.5739	-12.5295	-12.8856	-13.5895	-13.5895	-13.5895
S.E_Logq	0.6669	0.2920	0.3363	0.5500	0.5680	0.9803	0.7233

Fleet: NORTRL_IV2
Log catchability residuals.

year / age	1993	1994	1995	1996	1997	1998	1999	2000	2001
3	1.506	0.970	0.174	0.510	-0.021	0.487	-0.654	-0.979	0.591
4	0.657	1.487	1.140	0.353	0.133	0.607	0.498	-0.522	0.707
5	0.486	0.611	0.521	0.277	-0.003	0.476	0.533	0.553	0.318
6	0.566	-0.413	-0.652	0.133	-0.410	0.137	0.109	0.804	-0.360
7	0.310	-0.429	0.825	0.010	-0.248	-0.030	0.305	0.053	-0.380
8	0.116	-1.265	0.336	-0.572	-0.439	0.202	0.949	0.124	-0.612
9	0.332	0.065	0.39	-1.952	-0.716	0.426	0.729	0.345	-0.951

year / age	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.089	-0.500	-0.931	-1.033	-0.157	0.082	0.769	0.335	-1.268
4	0.182	-0.569	-0.637	-0.357	-0.515	-0.244	1.043	0.442	-0.030
5	-0.358	-0.172	-0.527	-0.225	-0.186	-0.425	0.331	0.640	0.200
6	-0.479	-0.243	-0.193	0.073	0.036	0.056	0.188	-0.361	0.687
7	-0.438	-0.029	-0.132	0.188	0.435	-0.004	-0.291	0.317	0.914
8	-0.083	-0.164	0.281	0.053	0.378	0.316	-0.178	0.075	0.296
9	0.164	-0.041	0.567	0.199	-0.010	-0.487	-0.304	-0.082	0.705

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	-14.3628	-13.1434	-12.5018	-12.1998	-12.0510	-12.0510	-12.0510
S.E_Logq	0.8355	0.6502	0.3938	0.4008	0.4107	0.4896	0.7024

Fleet: GER_OTB_IV
Log catchability residuals.

year / age	1995	1996	1997	1998	1999	2000	2001	2002	2003
3	-0.436	-0.461	-0.497	0.121	-1.276	0.190	-0.068	-0.356	-0.347
4	0.384	-0.219	0.079	-0.107	-0.052	0.206	0.273	0.275	-0.684
5	-0.074	-0.014	-0.127	-0.326	-0.066	0.243	0.391	0.061	-0.135
6	0.260	0.037	-0.654	0.003	0.163	0.618	0.290	0.210	-0.469
7	0.055	0.451	-0.258	-0.064	0.367	-0.008	0.702	-0.457	-0.221
8	-0.261	1.117	-0.202	-0.006	-0.442	0.237	0.597	-0.264	-0.544
9	-0.539	0.923	-0.125	-0.025	-0.205	0.006	0.050	-0.283	-0.443

year / age	2004	2005	2006	2007	2008	2009	2010	2011	2012
3	-0.463	-0.673	0.397	0.592	0.404	0.107	0.286	0.616	-0.288
4	0.156	-0.866	-0.256	-0.016	0.975	-0.239	0.421	0.014	-0.154
5	-0.377	0.075	-0.511	0.168	-0.142	0.039	-0.142	0.315	0.346
6	-0.301	0.211	-0.040	-0.130	0.330	-0.329	-0.074	-0.031	0.120
7	-0.502	0.286	0.277	0.035	0.013	0.061	-0.563	0.255	0.046
8	-0.086	0.199	0.157	0.223	-0.063	0.188	-0.356	0.058	0.036
9	-0.016	-0.012	0.491	-0.190	0.096	0.445	0.202	-0.070	0.015

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	-14.6466	-13.3374	-12.8671	-13.0295	-13.2336	-13.2336	-13.2336
S.E_Logq	0.4980	0.4147	0.2497	0.3109	0.3387	0.3913	0.3436

Fleet: NORACU
Log catchability residuals.

year / age	1996	1997	1998	1999	2000	2001	2002	2003	2004
3	-0.329	-0.655	-0.176	-0.826	0.288	0.162	0.481	0.684	0.219
4	-0.715	-0.649	0.086	0.186	0.637	0.064	0.942	0.634	0.139
5	-0.221	-0.035	0.044	0.447	0.689	-0.106	0.325	0.379	0.096
6	0.674	0.197	0.306	0.090	1.031	0.471	-0.4	-0.004	-0.463

year / age	2005	2006	2007	2008	2009	2010	2011	2012
3	-0.058	0.156	1.003	-0.885	NA	0.008	0.155	-1.065
4	0.165	0.041	-0.349	-0.334	NA	0.964	0.528	-2.466
5	0.454	-0.257	0.217	-0.607	NA	1.101	0.03	-1.905
6	0.009	0.259	-0.787	0.165	NA	0.833	0.876	-1.719

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	-1.1401	-0.6738	-0.9567	-1.4907
S.E_Logq	0.5795	0.8265	0.6583	0.6945

Fleet: IBTS-Q3
Log catchability residuals.

year / age	1992	1993	1994	1995	1996	1997	1998	1999	2000
3	-1.628	-0.072	-1.703	-0.028	-0.636	-1.031	-1.451	-1.496	-0.589
4	-0.388	-0.35	-1.194	-0.525	-0.611	-0.605	-0.806	-0.542	0.024
5	-0.285	0.055	-0.224	0.050	-0.115	0.571	-0.462	0.044	-0.075

year / age	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	0.370	-0.139	0.844	-0.288	-0.335	0.999	1.591	-0.187	-0.879
4	0.145	0.408	0.743	-0.090	0.113	0.993	0.501	0.109	-0.670
5	0.220	-0.440	1.057	-0.396	0.547	0.200	1.015	-0.101	-1.011

year / age	2010	2011	2012
3	-1.817	0.189	1.587
4	-1.017	0.135	-0.231
5	-0.908	0.097	0.036

```
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 -9.4660 -9.2007 -9.677
S.E_Logq   1.0207  0.5706  0.522


 Terminal year survivor and F summaries:

 Age 3 Year class = 2009

source
           survivors N scaledWts
FRATRB_IV      25902 1     0.150
NORTRL_IV2    150193 1     0.107
GER_OTB_IV     18986 1     0.346
NORACU          8724 1     0.214
IBTS-Q3       123799 1     0.073
fshk           29865 1     0.110

 Age 4 Year class = 2008

source
           survivors N scaledWts
FRATRB_IV      34160 2     0.400
NORTRL_IV2     17556 2     0.115
GER_OTB_IV     31491 2     0.237
NORACU         12452 2     0.096
IBTS-Q3        22763 2     0.110
fshk           21229 1     0.042

 Age 5 Year class = 2007

source
           survivors N scaledWts
FRATRB_IV      32460 3     0.300
NORTRL_IV2     33115 3     0.170
GER_OTB_IV     45479 3     0.328
NORACU         18693 3     0.077
IBTS-Q3        30218 3     0.096
fshk           31799 1     0.028

 Age 6 Year class = 2006

source
           survivors N scaledWts
FRATRB_IV       8845 4     0.227
NORTRL_IV2      5185 4     0.228
GER_OTB_IV      8769 4     0.403
NORACU          3687 3     0.055
IBTS-Q3         4428 3     0.060
fshk            6450 1     0.026

 Age 7 Year class = 2005

source
           survivors N scaledWts
FRATRB_IV       5540 5     0.237
NORTRL_IV2      4539 5     0.244
GER_OTB_IV      4659 5     0.414
NORACU          7677 3     0.042
IBTS-Q3         2271 3     0.038
fshk            3679 1     0.025

 Age 8 Year class = 2004

source
           survivors N scaledWts
FRATRB_IV       3197 6     0.163
NORTRL_IV2      3275 6     0.290
GER_OTB_IV      3938 6     0.478
NORACU          7250 3     0.022
IBTS-Q3         2552 3     0.021
fshk            1991 1     0.025
```

```
Age 9 Year class = 2003

source
           survivors N scaledWts
FRATRB_IV       1401 7     0.147
NORTRL_IV2      1134 7     0.236
GER_OTB_IV      1038 7     0.554
NORACU           869 3     0.013
IBTS-Q3         1465 3     0.017
fshk            1419 1     0.033
```

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	0.937	0.572	0.692	0.723	0.668	0.668
1989	0.375	0.726	0.687	0.886	0.484	0.639	0.676	0.676
1990	0.475	0.675	0.654	0.564	0.582	0.452	0.537	0.537
1991	0.458	0.785	0.597	0.442	0.411	0.402	0.421	0.421
1992	0.245	0.729	0.972	0.555	0.340	0.290	0.398	0.398
1993	0.320	0.485	0.619	0.677	0.590	0.675	0.654	0.654
1994	0.238	0.671	0.648	0.477	0.443	0.244	0.405	0.405
1995	0.138	0.559	0.562	0.389	0.936	0.664	0.773	0.773
1996	0.114	0.305	0.535	0.657	0.667	0.575	0.443	0.443
1997	0.106	0.297	0.413	0.314	0.491	0.464	0.420	0.420
1998	0.175	0.332	0.444	0.405	0.319	0.436	0.516	0.516
1999	0.075	0.374	0.535	0.431	0.481	0.660	0.679	0.679
2000	0.084	0.193	0.441	0.510	0.285	0.277	0.374	0.374
2001	0.081	0.312	0.410	0.293	0.270	0.256	0.217	0.217
2002	0.120	0.316	0.254	0.282	0.360	0.376	0.470	0.470
2003	0.105	0.172	0.324	0.288	0.379	0.397	0.464	0.464
2004	0.060	0.191	0.224	0.279	0.285	0.396	0.581	0.581
2005	0.084	0.196	0.341	0.369	0.414	0.356	0.394	0.394
2006	0.186	0.243	0.302	0.322	0.428	0.389	0.335	0.335
2007	0.186	0.225	0.295	0.297	0.328	0.356	0.193	0.193
2008	0.171	0.437	0.376	0.408	0.303	0.338	0.275	0.275
2009	0.211	0.367	0.598	0.418	0.480	0.417	0.386	0.386
2010	0.066	0.295	0.394	0.461	0.542	0.339	0.475	0.475
2011	0.184	0.263	0.357	0.403	0.341	0.519	0.387	0.387
2012	0.191	0.264	0.380	0.371	0.323	0.241	0.382	0.382

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	172856	39151	28790	10788	8490	6998	1592	6076
1982	109993	117836	24509	17473	5507	3933	2657	3358
1983	118271	61195	59751	11765	8896	2568	1904	2400
1984	205298	71277	31459	25383	4495	2856	751	1428
1985	312013	94852	29246	14033	9009	2181	1206	2223
1986	288609	134185	27345	11928	7177	4657	1169	2336
1987	113918	186134	27319	8648	4897	3521	2496	1899
1988	116392	65019	64199	9708	4223	2371	1760	1522
1989	78287	65816	29339	20600	4485	1731	942	1084
1990	119247	44074	26060	12089	6957	2263	748	958
1991	138663	60707	18365	11091	5633	3184	1179	1460
1992	93520	71799	22674	8280	5838	3058	1744	1409
1993	152768	59916	28369	7024	3890	3401	1874	2332
1994	104109	90852	30209	12509	2923	1766	1417	2613
1995	228903	67178	38015	12940	6353	1536	1133	1619
1996	113491	163284	31445	17735	7179	2040	647	1501
1997	164641	82905	98523	15080	7525	3016	939	922
1998	71510	121192	50414	53359	9020	3772	1553	751
1999	143682	49171	71158	26466	29139	5366	1997	1454
2000	96723	109105	27705	34115	14078	14745	2271	1551
2001	228431	72798	73679	14594	16766	8668	9153	1385
2002	194694	172499	43635	40036	8918	10482	5493	4735
2003	129410	141383	102927	27699	24727	5096	5890	3062
2004	100905	95400	97469	60962	17005	13856	2804	2000
2005	191674	77805	64546	63789	37775	10466	7631	1549
2006	64356	144323	52384	37590	36124	20446	6001	5524
2007	113814	43759	92635	31709	22303	19283	11348	6113
2008	68029	77361	28604	56441	19295	13158	11055	7925
2009	54114	46928	40929	16072	30725	11670	7680	10924
2010	128045	35867	26617	18422	8662	15561	6298	11352
2011	61662	98179	21856	14696	9509	4123	9074	15322
2012	37432	42011	61780	12517	8038	5534	2010	11160

Table 11.5.1. Saithe in Subareas IV and VI and Division IIIa. Historic stock and fishery trends, 1967–2012.

Year	Recruitment	SSB	Catch	Landings	TSB	fbar3-6	Y/ssb
1967	127456	150815	88326	88326	395575	0.322	0.59
1968	114114	211741	113751	113751	520457	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	752449	0.760	0.98
1977	118019	263129	216395	216395	509447	0.615	0.82
1978	92456	268133	155141	155141	463899	0.477	0.58
1979	77657	241084	128360	128360	419194	0.396	0.53
1980	67153	235195	131908	131908	396847	0.443	0.56
1981	172856	241263	132278	132278	495291	0.306	0.55
1982	109993	210525	174351	174351	511910	0.469	0.83
1983	118271	214389	180044	180044	467502	0.548	0.84
1984	205298	176850	200834	200834	466293	0.677	1.14
1985	312013	161184	220869	220869	491132	0.714	1.37
1986	288609	152328	198596	198596	488404	0.818	1.30
1987	113918	154290	167514	167514	387323	0.644	1.09
1988	116392	149967	135172	135172	324213	0.619	0.90
1989	78287	117853	108877	108877	262513	0.668	0.92
1990	119247	107534	103800	103800	268028	0.592	0.97
1991	138663	107034	108048	108048	288745	0.570	1.01
1992	93520	109031	99742	99742	284555	0.625	0.91
1993	152768	114343	111491	111491	332692	0.525	0.98
1994	104109	126566	109622	109622	328788	0.509	0.87
1995	228903	139862	121810	121810	467203	0.412	0.87
1996	113491	154002	114997	114997	449829	0.403	0.75
1997	164641	203824	107327	107327	480216	0.283	0.53
1998	71510	204879	106123	106123	398515	0.339	0.52
1999	143682	216628	110716	110716	418347	0.354	0.51
2000	96723	217608	91322	91322	454366	0.307	0.42
2001	228431	234378	95042	95042	526183	0.274	0.41
2002	194694	233076	115395	115395	561372	0.243	0.50
2003	129410	264585	105569	105569	526965	0.222	0.40
2004	100905	324720	104237	104237	563538	0.188	0.32
2005	191674	330407	124532	124532	582640	0.247	0.38
2006	64356	318113	125681	125681	531357	0.263	0.40
2007	113814	312876	101202	101202	487111	0.251	0.32
2008	68029	297758	119305	119305	463023	0.348	0.40
2009	54114	263298	115747	115747	374312	0.399	0.44
2010	128045	247548	101940	101940	436877	0.304	0.41
2011	61662	212912	96267	96267	395602	0.302	0.45
2012	37432	196487	77100	77100	310938	0.301	0.39

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	2013	0.177	116945	1	1	0	0.2
4	2013	0.332	25315	1.34	1.34	0.15	0.2
5	2013	0.456	26408	1.70	1.70	0.7	0.2
6	2013	0.498	34603	2.43	2.43	0.9	0.2
7	2013	0.486	7073	3.05	3.05	1	0.2
8	2013	0.443	4763	3.46	3.46	1	0.2
9	2013	0.501	3562	3.85	3.85	1	0.2
10+	2013	0.501	7359	4.39	4.39	1	0.2

Table 11.7.2. Saithe in Subareas IV and VI and Division IIIa. Management option table. Basis: F (2013) = 0.37, estimated from TAC constraint 2013 = 100.684; R (2012-2014) = GM (1988–2010) = 116.945; SSB (2014) = 162.125; landings (2013) = 100.684. Weights are in 1000 t.

Rationale	Landings 2014	Landings IIIa & IV 2014[1]	Landings VI 2014[1]	Basis	F 2014	SSB 2015	% SSB change [2]	% TAC change [3]
Management plan	85.5	77.5	8.0	15% TAC constraint	0.304	176.1	8.5%	-15%
MSY approach	84.6	76.6	7.95	F_{MSY}	0.3	176.8	9%	-16%
Precautionary approach	107.5	97.4	10.1	Fpa	0.4	158.4	-2%	67%
Zero catch	0	0	0	F = 0	0.0	246.9	52%	-100%
Other option	85.2	77.2	8.0	F_{2012}	0.302	176.3	8.7%	-15%
F management plan	82.6	74.9	7.8		0.29	178.4	9%	-16%
B_{pa} constraint	56.2	50.9	5.3	B_{pa}	0.19	200.0	23%	-44%

[1)] Landings split according to the average in 1993–1998, i.e. 90.6% in Subarea IV and Division IIIa West and 9.4% in Subarea VI.

[2)] SSB 2015 relative to SSB 2014.

[3)] Landings 2014 relative to TAC 2013.

[4)] Assuming stock status is determined at the beginning of the TAC year.

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	2007	2008	2009	2010	2011
Stock no. (thousands) of 3 years old	128045	61662	37432	116945	116945
Source	XSA	XSA	XSA	GM88-10	GM88-10
Status Quo F:					
% in 2012 landings	29.87	14.95	8.68	17.15	-
% in 2013 landings	18.65	12.02	8.53	27.59	17.01
% in 2012 SSB	38.49	16.06	2.6	-	-
% in 2013 SSB	32.42	18.45	10.95	9.96	-
% in 2014 SSB	18.50	12.87	10.34	33.77	9.44

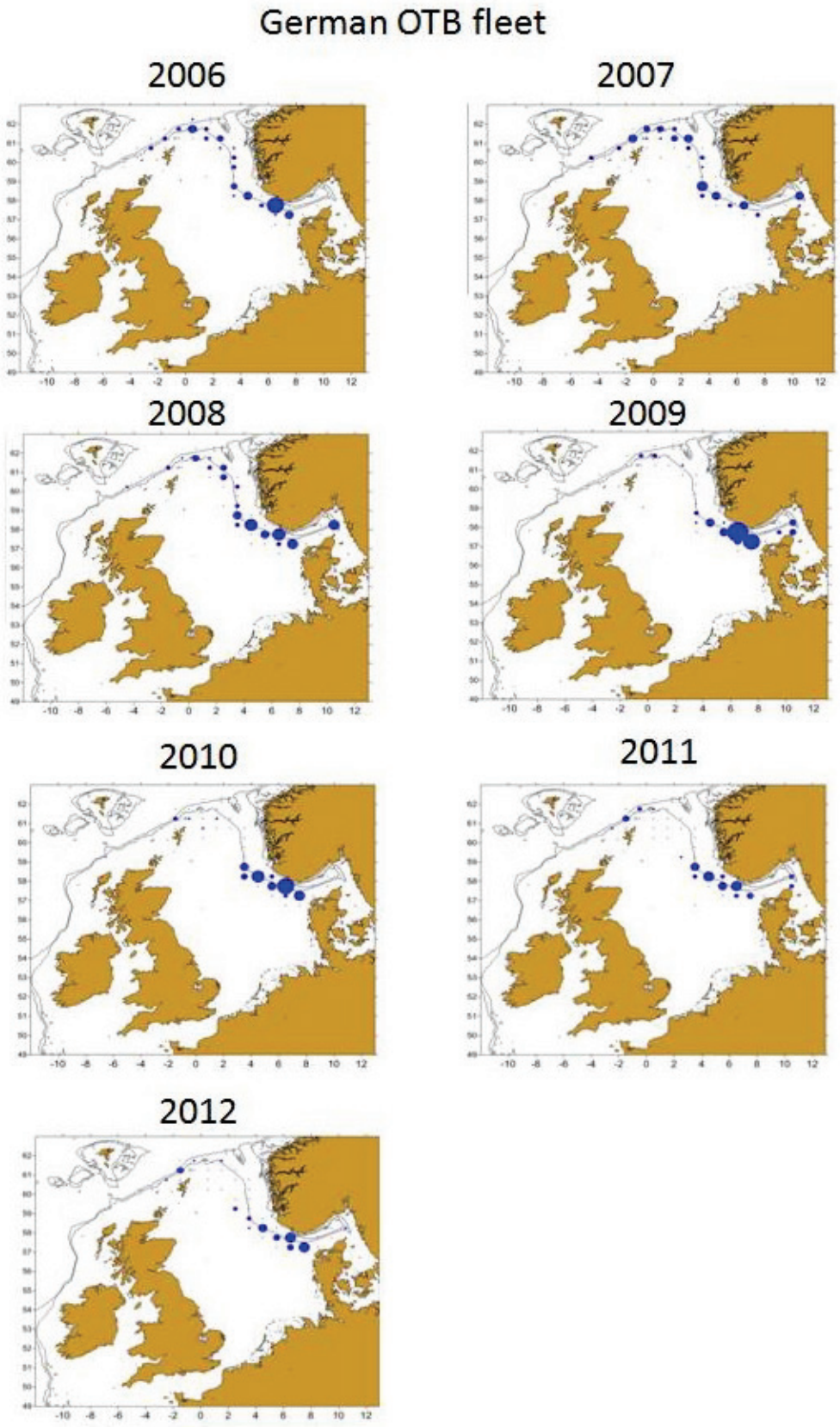


Figure 11.1.1. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of the German trawl catches 2006–2012.

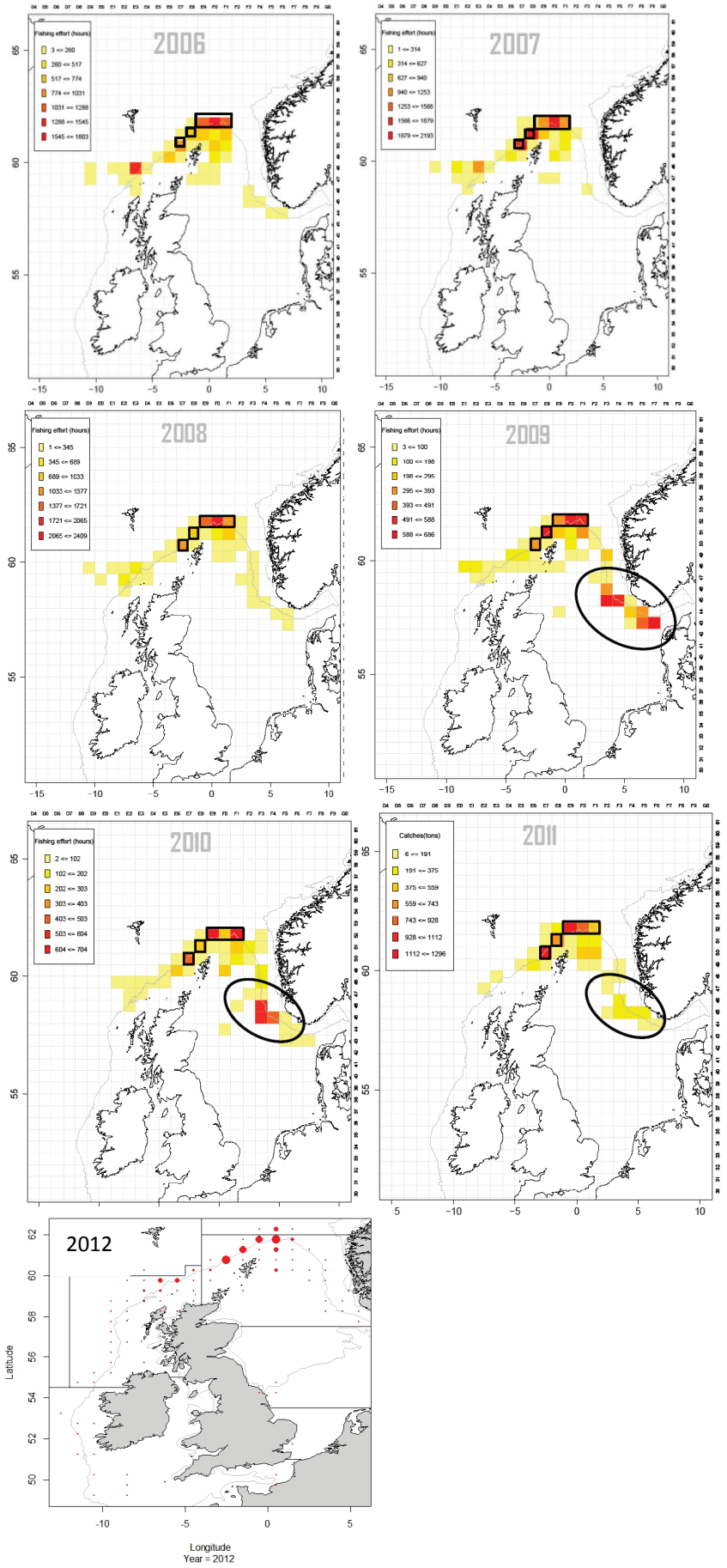


Figure 11.1.2. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of the French trawl fleet effort 2006–2011 and catches for 2012.

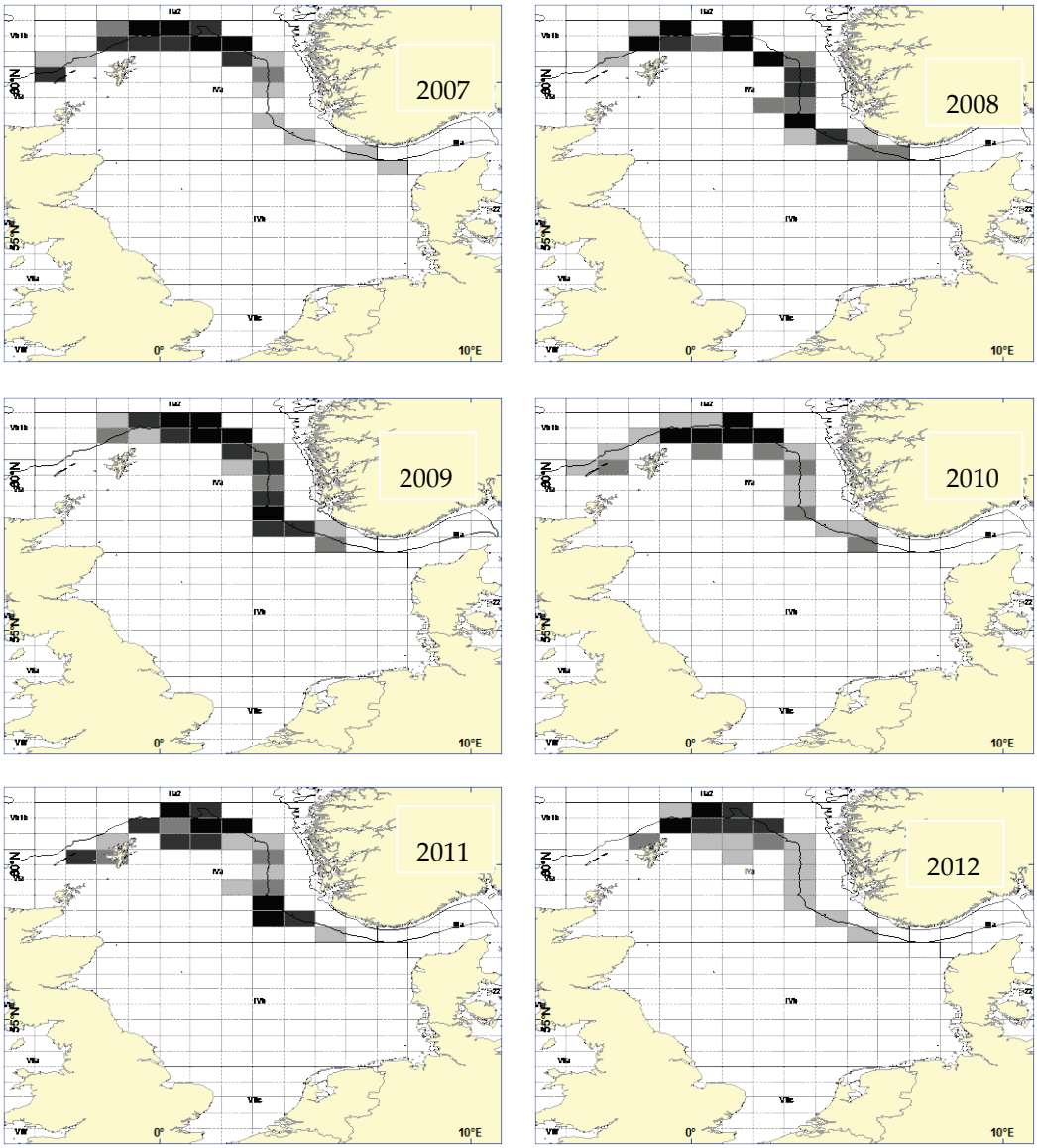


Figure 11.1.3. Saithe in Subareas IV and VI and Division IIIa. Spatial distribution of the Norwegian trawl fleet unstandardized CPUE 2007–2012

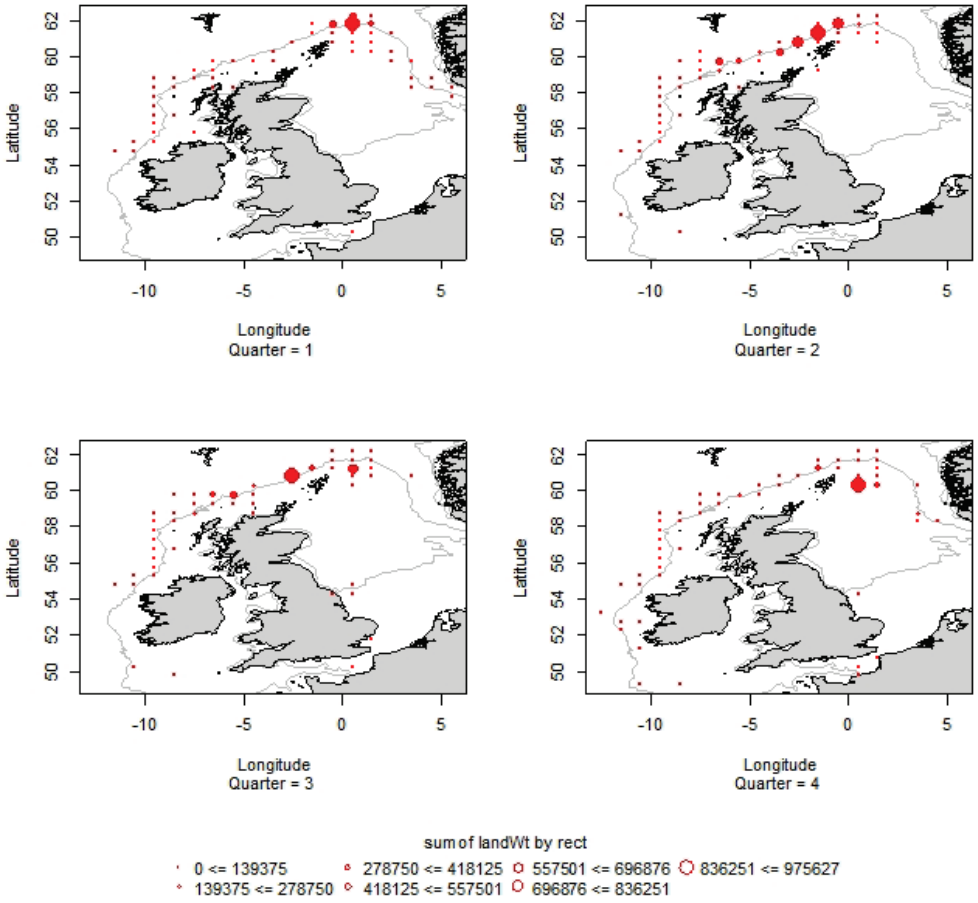


Figure 11.1.4. Saithe in Subareas IV and VI and Division IIIa. Quarterly spatial distribution of the French trawl fleet catches in 2012.

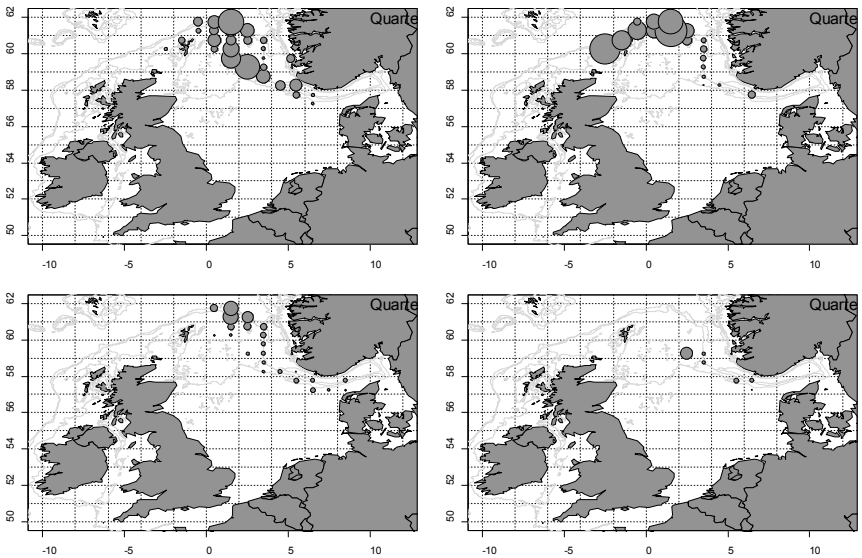


Figure 11.1.5. Saithe in Subareas IV and VI and Division IIIa. Quarterly spatial distribution of the Norwegian trawl fleet unstandardized CPUE in 2012.

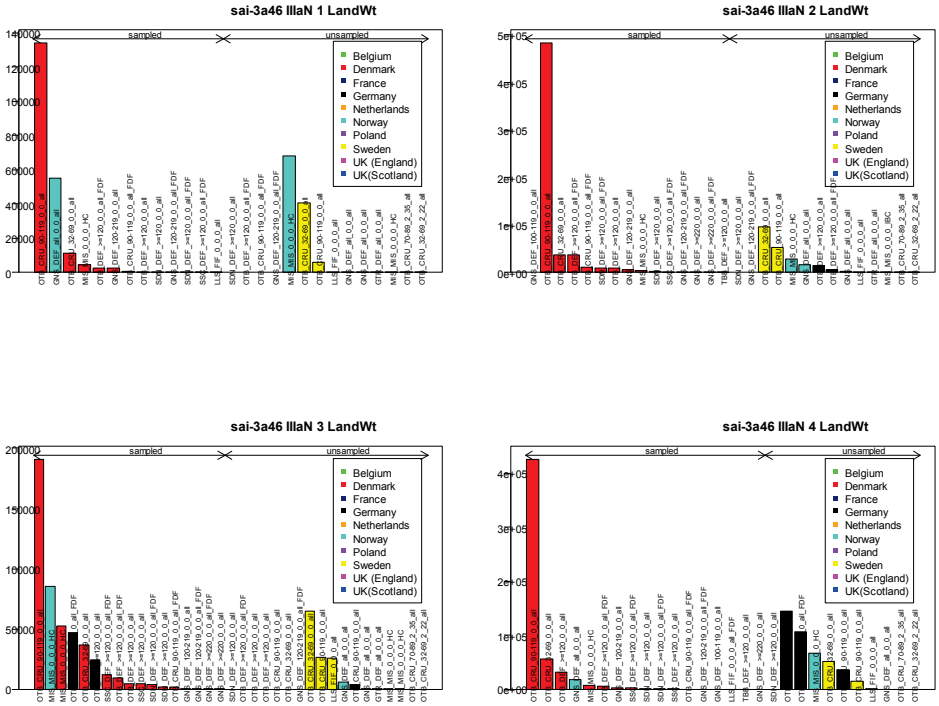


Figure 11.3.1. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet for saithe catches in Subdivsion IIIa.

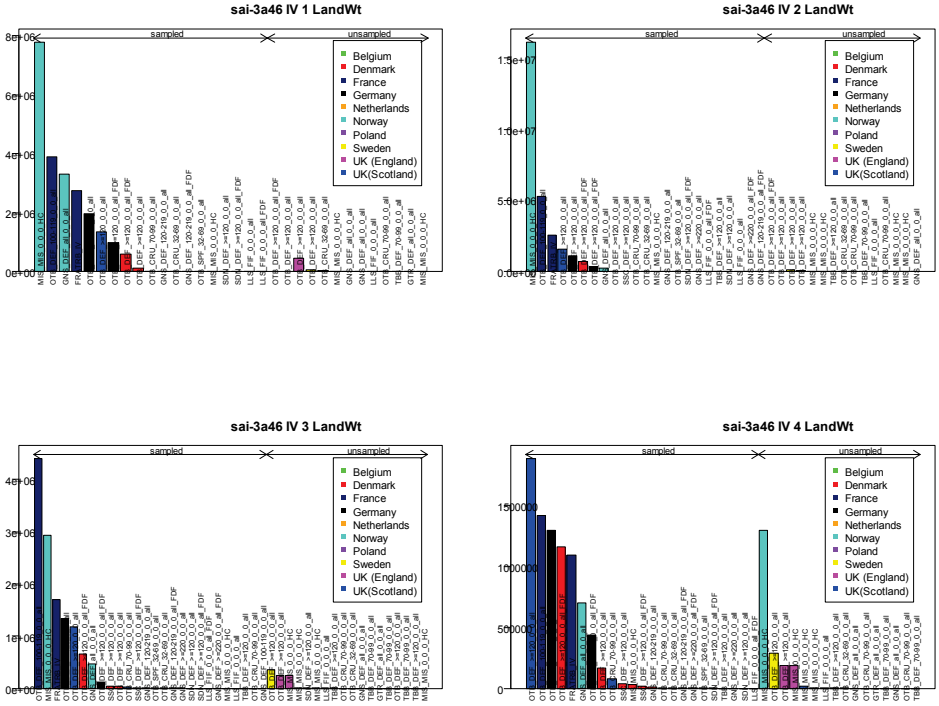


Figure 11.3.2. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet for saithe catches in Subarea IV.

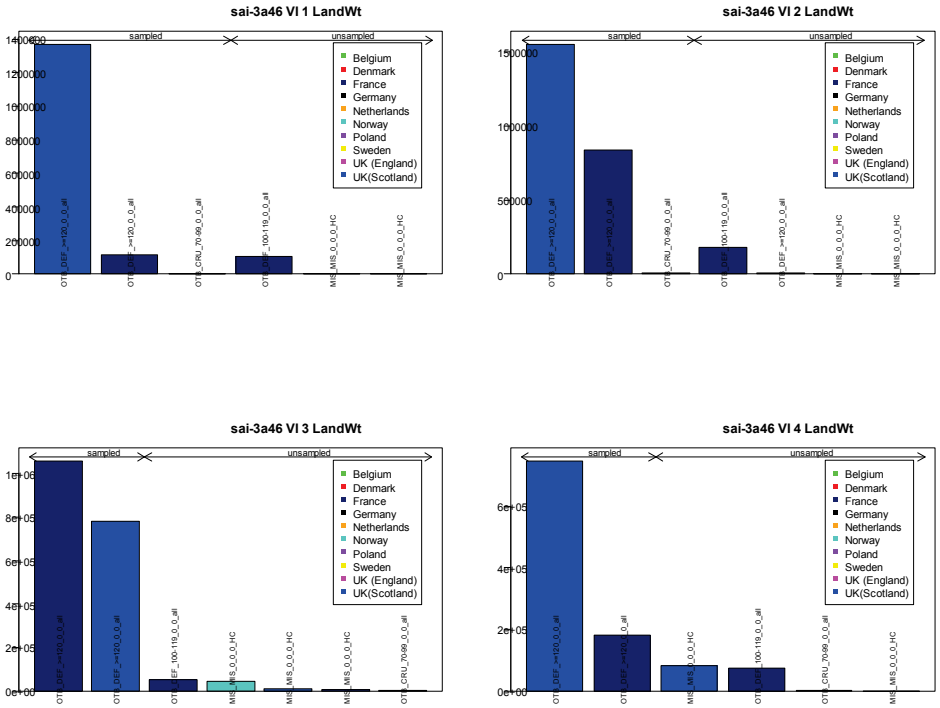


Figure 11.3.3. Saithe in Subareas IV and VI and Division IIIa. Overview of sampled and unsampled catches by fleet for saithe catches in Subarea VI.

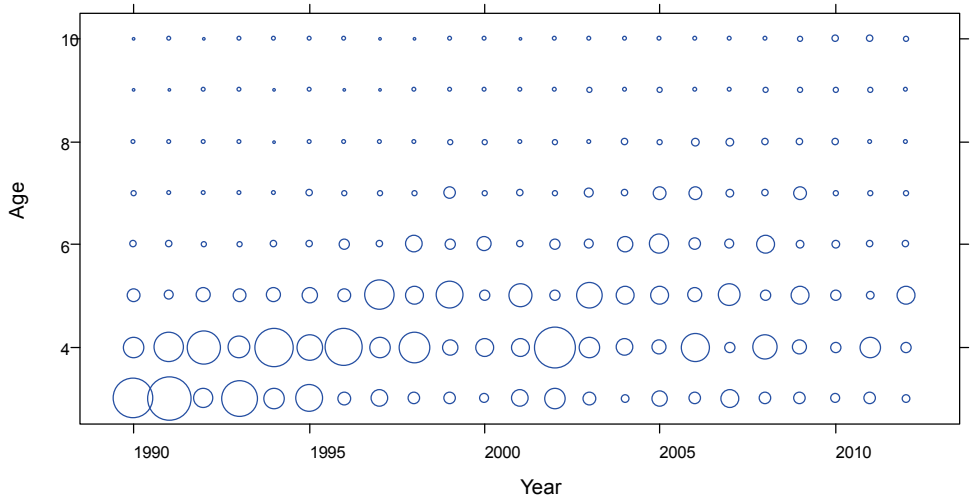


Figure 11.3.4. Saithe in Subareas IV and VI and Division IIIa. Landings-at-age for saithe ages 3–10+, 1990-2012. Smallest bubble corresponds to 209 000 individuals and largest to 46.117 million individuals.

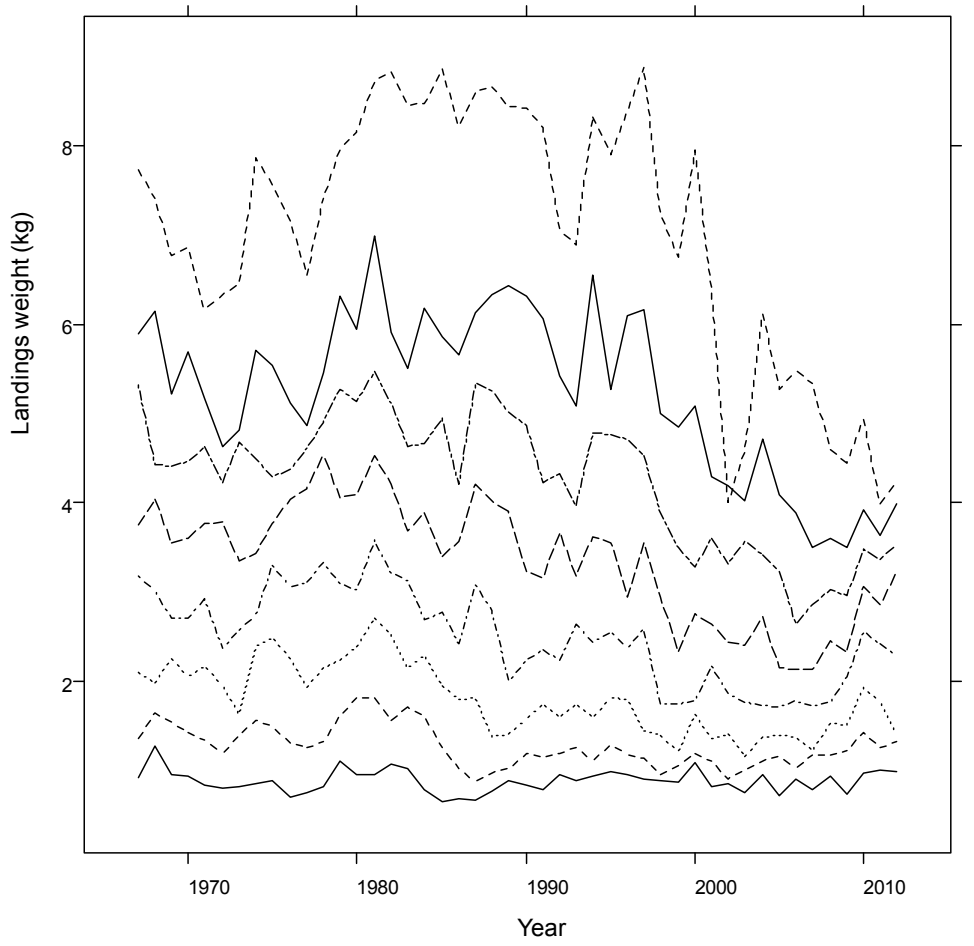


Figure 11.3.5. Saithe in Subareas IV and VI and Division IIIa. Landings weight-at-age (kg) for saithe ages 3–10+, 1967–2012. Landings weight-at-age are also stock weight-at-age in the assessment.

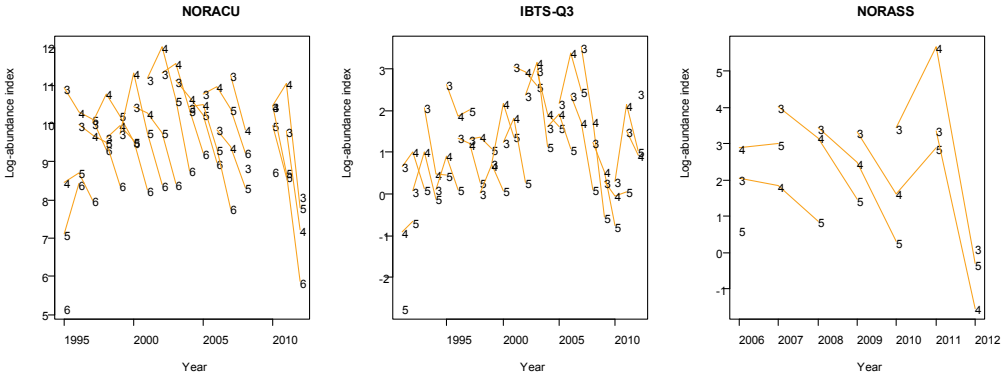


Figure 11.4.1. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the research survey indices for total catches for ages 3 to 6.

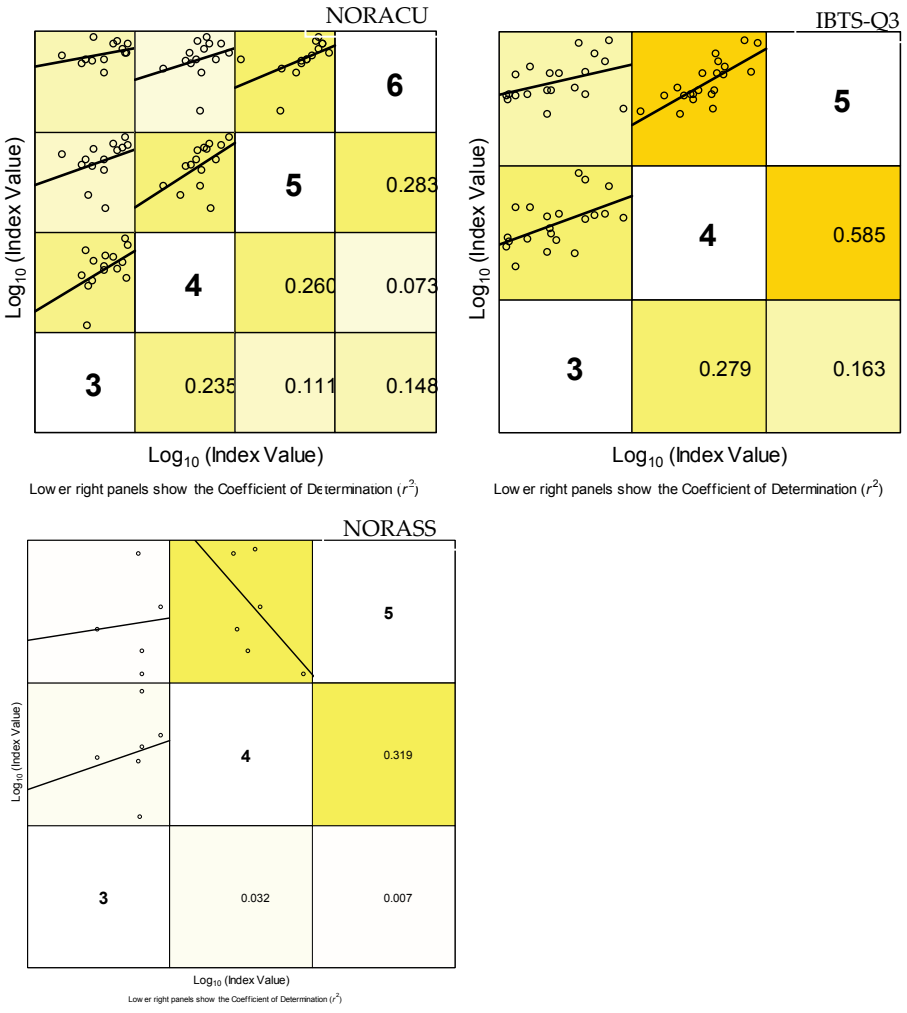


Figure 11.4.2. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the three research indices for ages 3 to 6 (NORACU) and 3 to 5 (IBTS, NORASS).

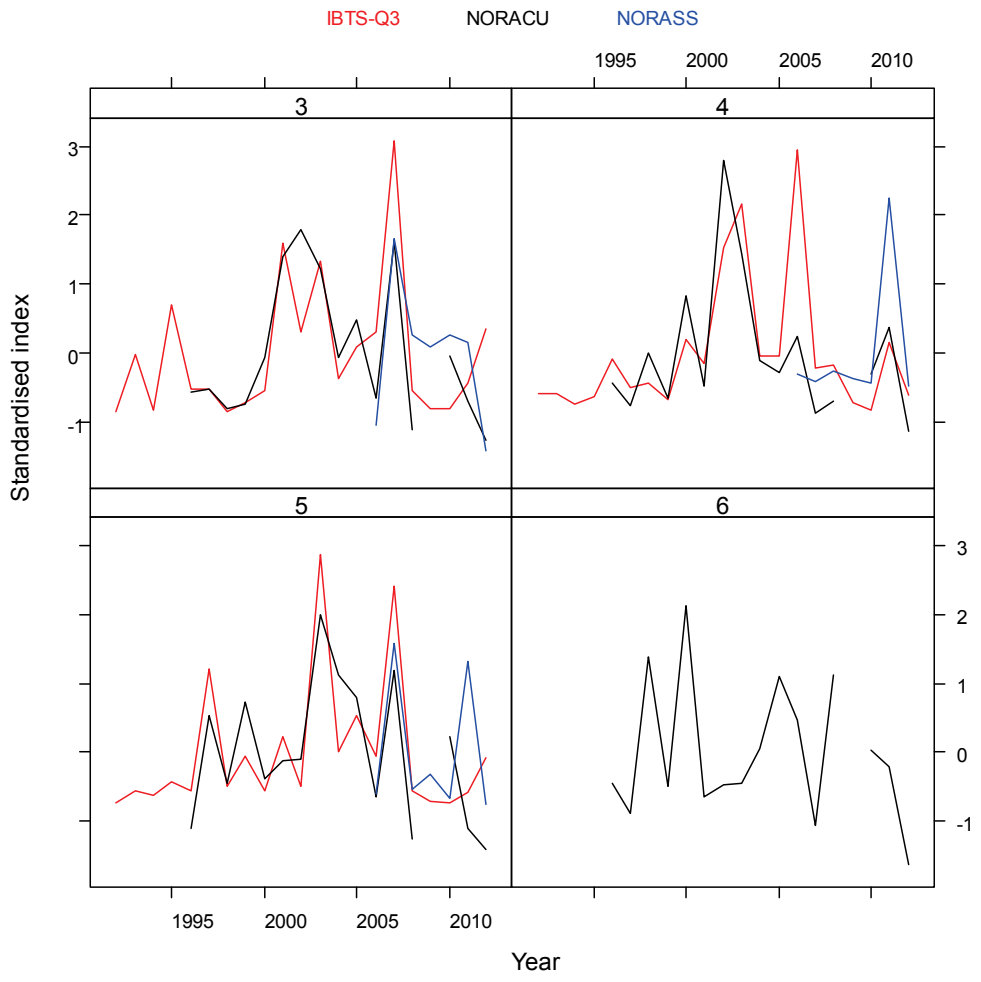


Figure 11.4.3. Saithe in Subareas IV and VI and Division IIIa. Standardised indices from the three research tuning series.

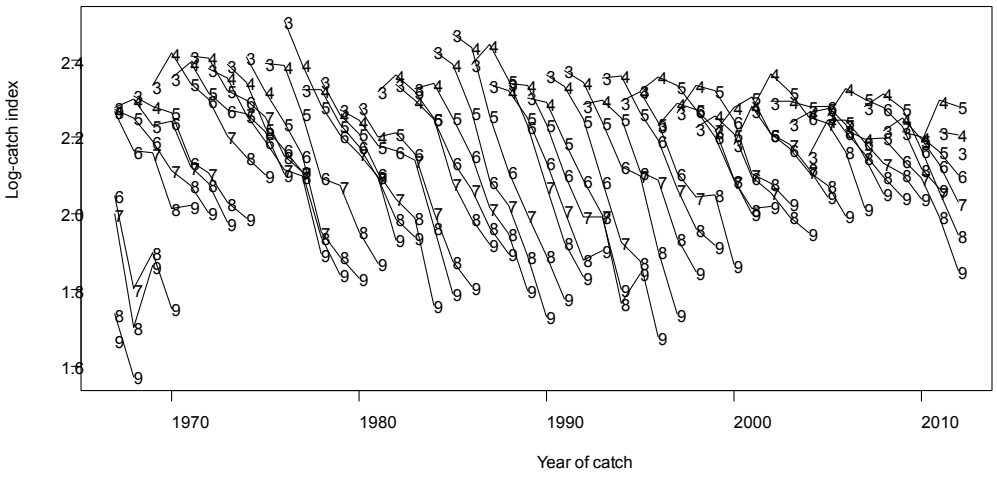


Figure 11.4.4. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort for total catches for ages 3 to 9.

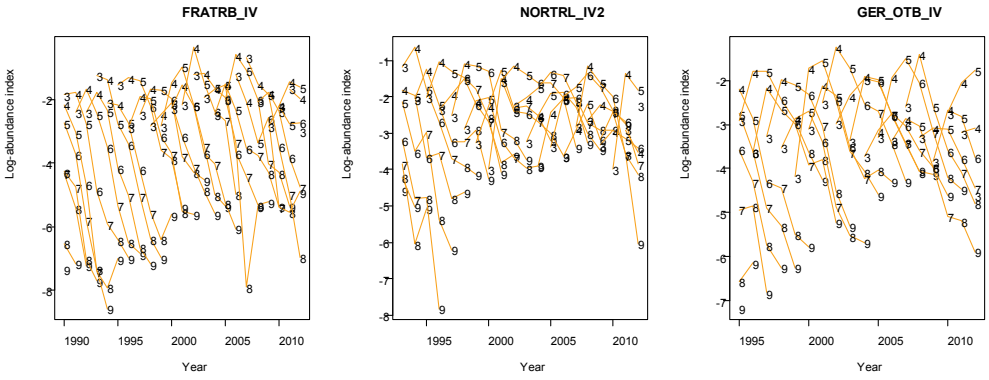


Figure 11.4.5. Saithe in Subareas IV and VI and Division IIIa. Log catch curves by cohort from the three commercial indices for ages 3 to 9.

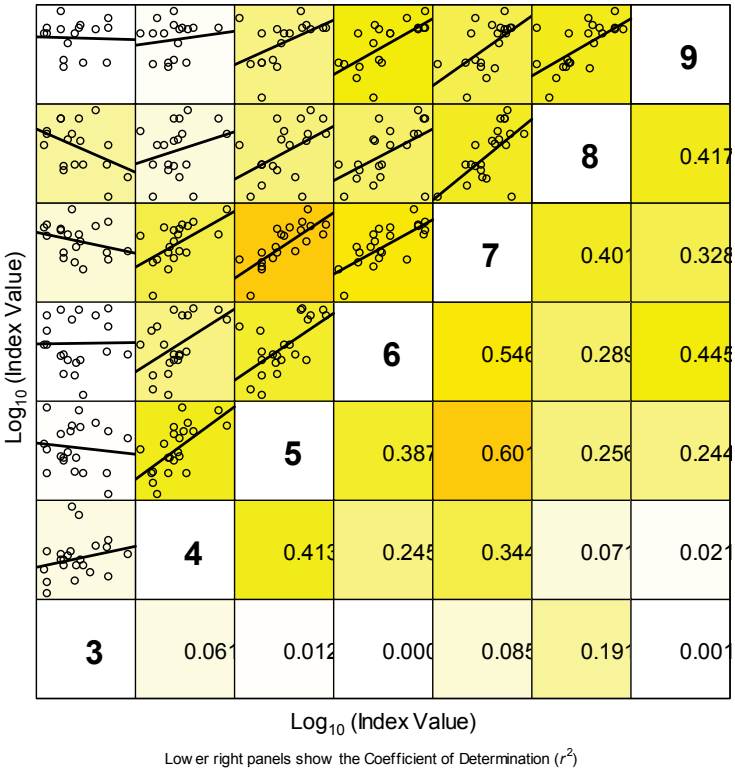


Figure 11.4.6. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the French unstandardized CPUE index. Straight line indicates a linear regression.

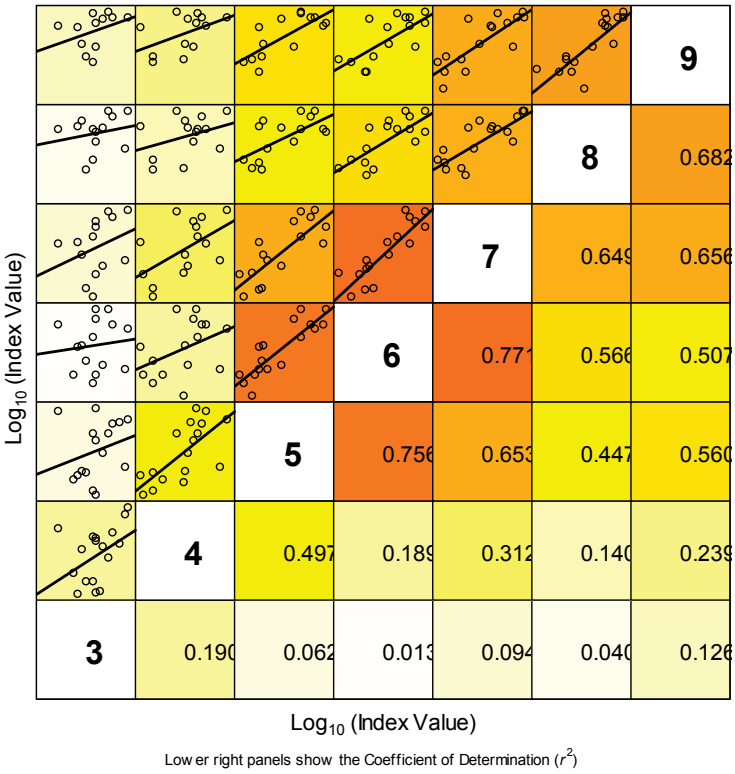


Figure 11.4.7. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the German unstandardized CPUE index. Straight line indicates a linear regression.

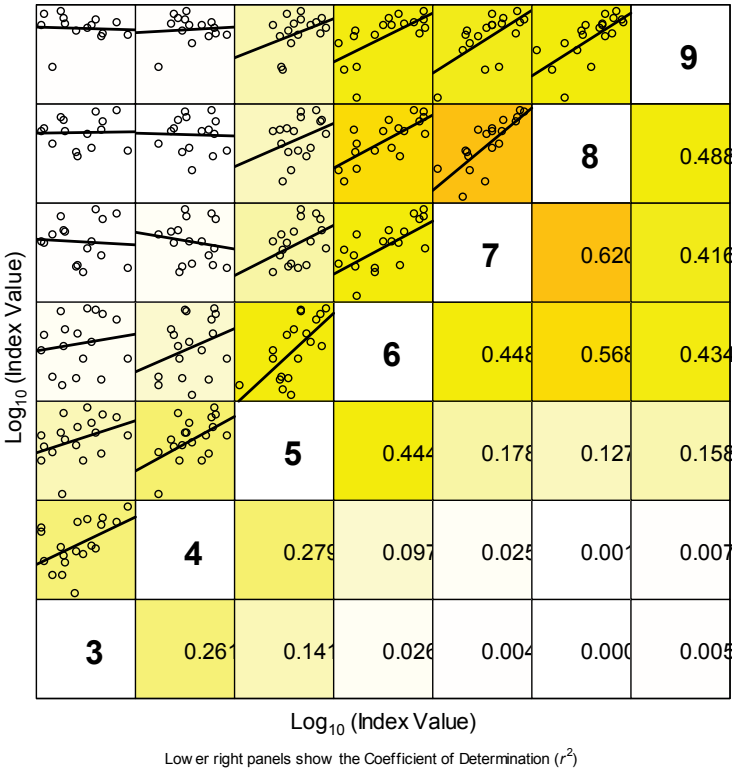


Figure 11.4.8. Saithe in Subareas IV and VI and Division IIIa. Correlations in the catch-at-age matrix ages 3 to 9 for the Norwegian unstandardized CPUE index. Straight line indicates a linear regression.

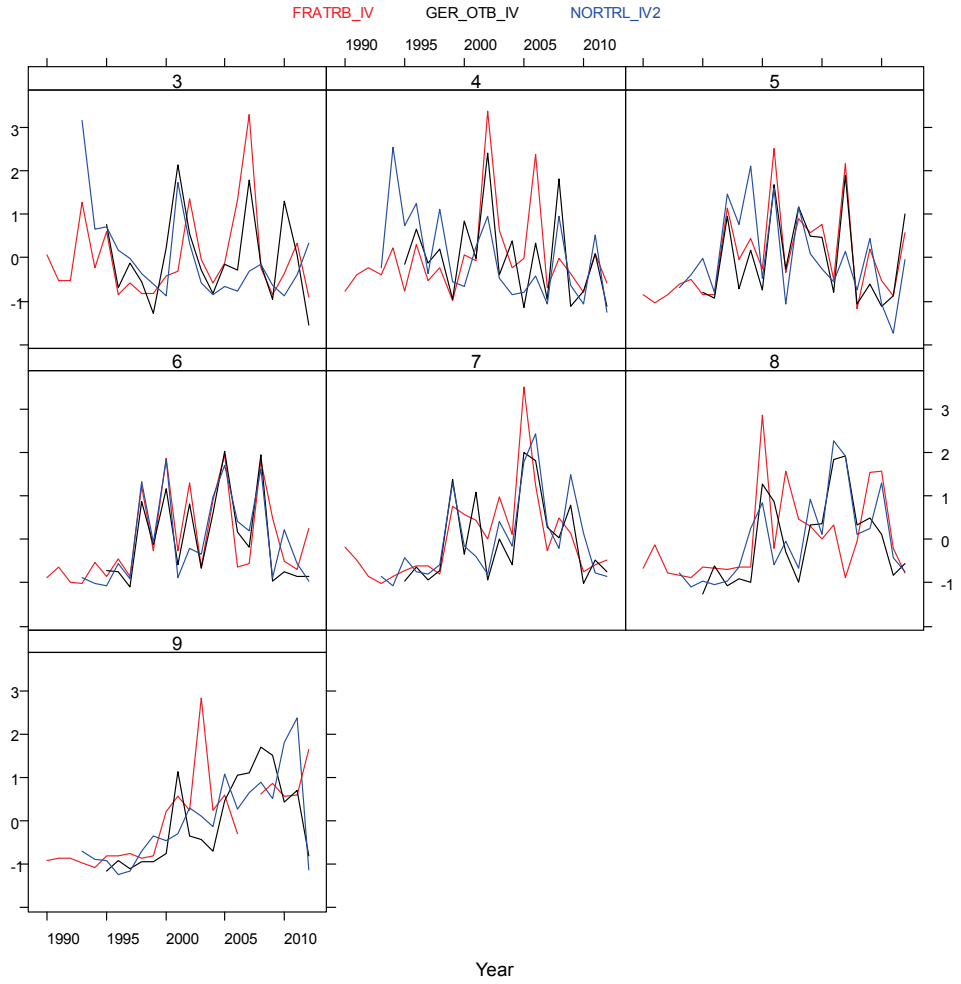


Figure 11.4.9. Saithe in Subareas IV and VI and Division IIIa. Standardised indices from the three commercial tuning series.

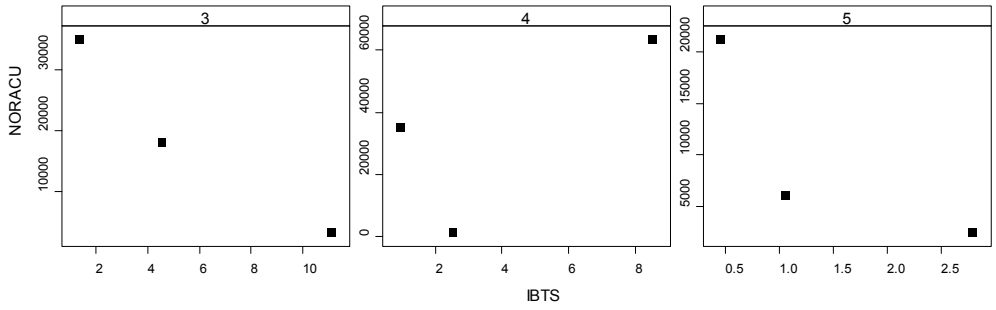


Figure 11.4.10. Saithe in Subareas IV and VI and Division IIIa. Relationship between NORACU and IBTS-Q3 indices for ages 3-5.

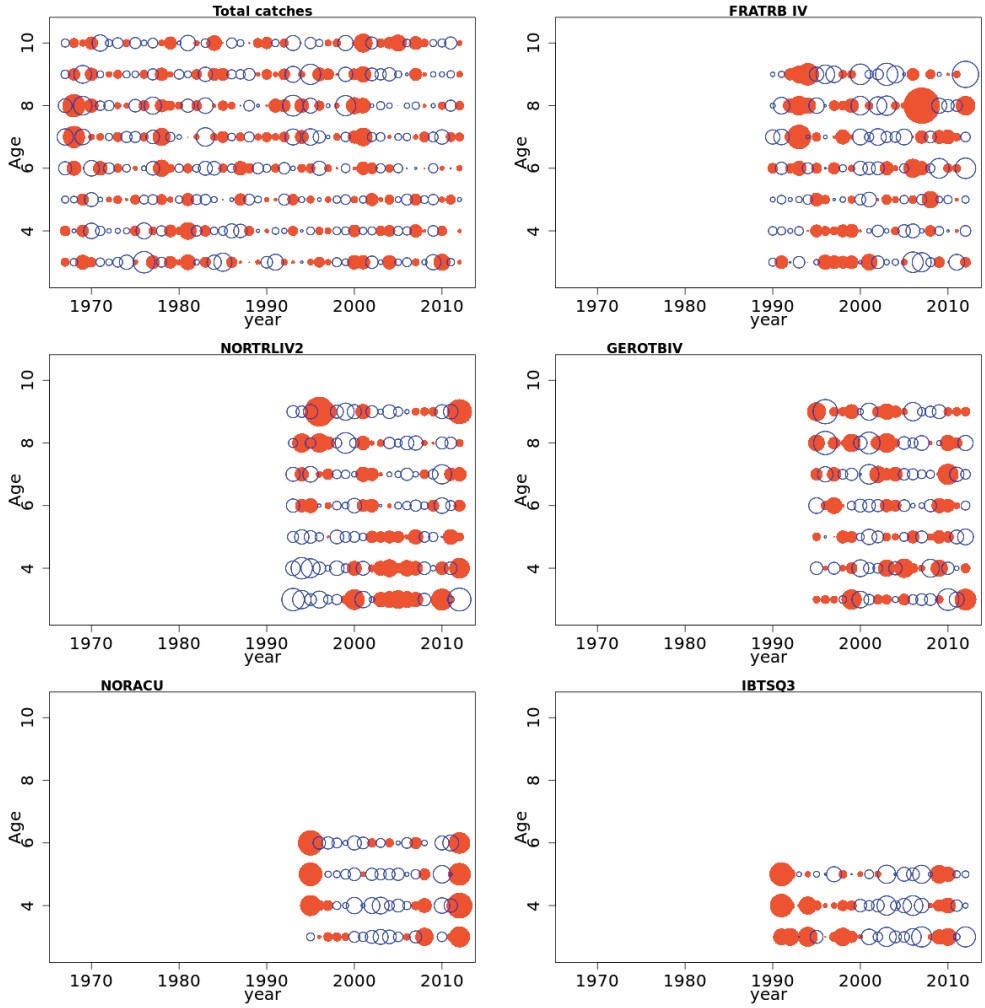


Figure 11.4.11. Saithe in Subareas IV and VI and Division IIIa. Normalized residuals from the SAM model. Blue circles indicate positive residuals and filled red circles indicate negative residuals.

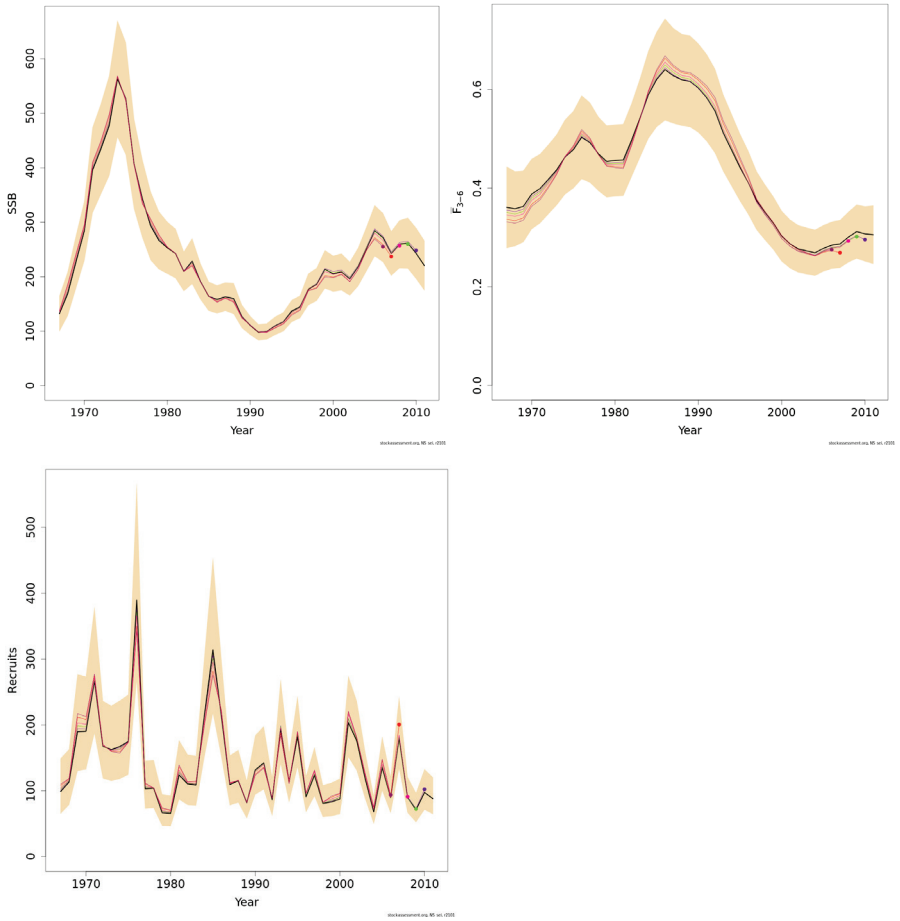


Figure 11.4.12. Saithe in Subareas IV and VI and Division IIIa. SAM model: Results of the retrospective analysis for SSB (top left), averge fishing mortality (ages 3-6, top right), and recruitment (lower left).

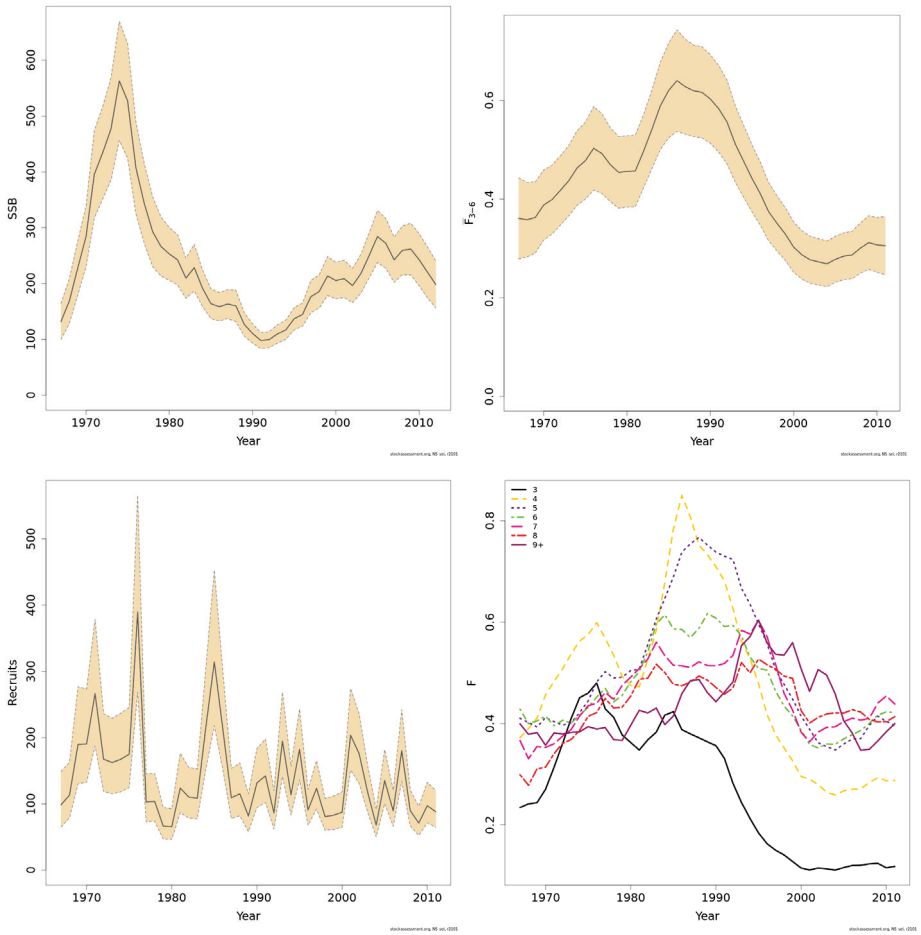


Figure 11.4.13. Saithe in Subareas IV and VI and Division IIIa. SAM model: Trends in SSB (top left), average F (ages 3–6, top right), recruitment (lower left), and fishing mortality-at-age (lower right).

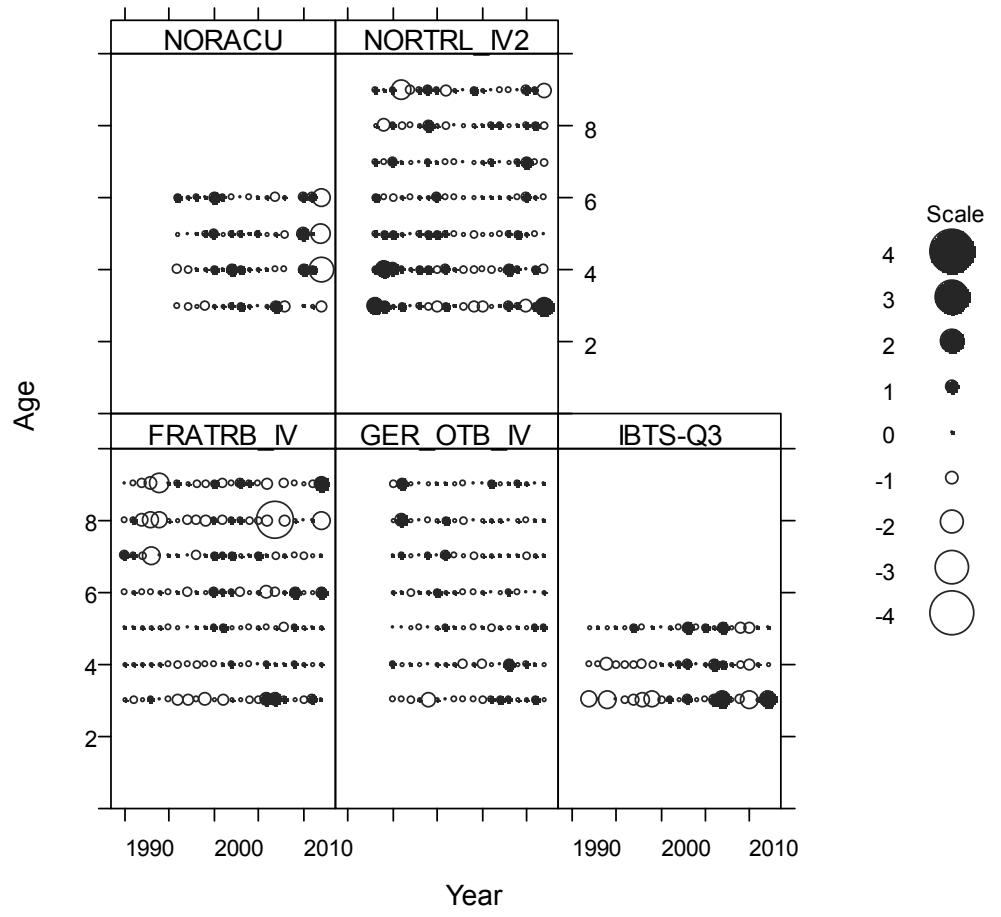


Figure 11.4.14. Saithe in Subareas IV and VI and Division IIIa. XSA: Log catchability residuals from the alternative XSA shown for each tuning fleet.

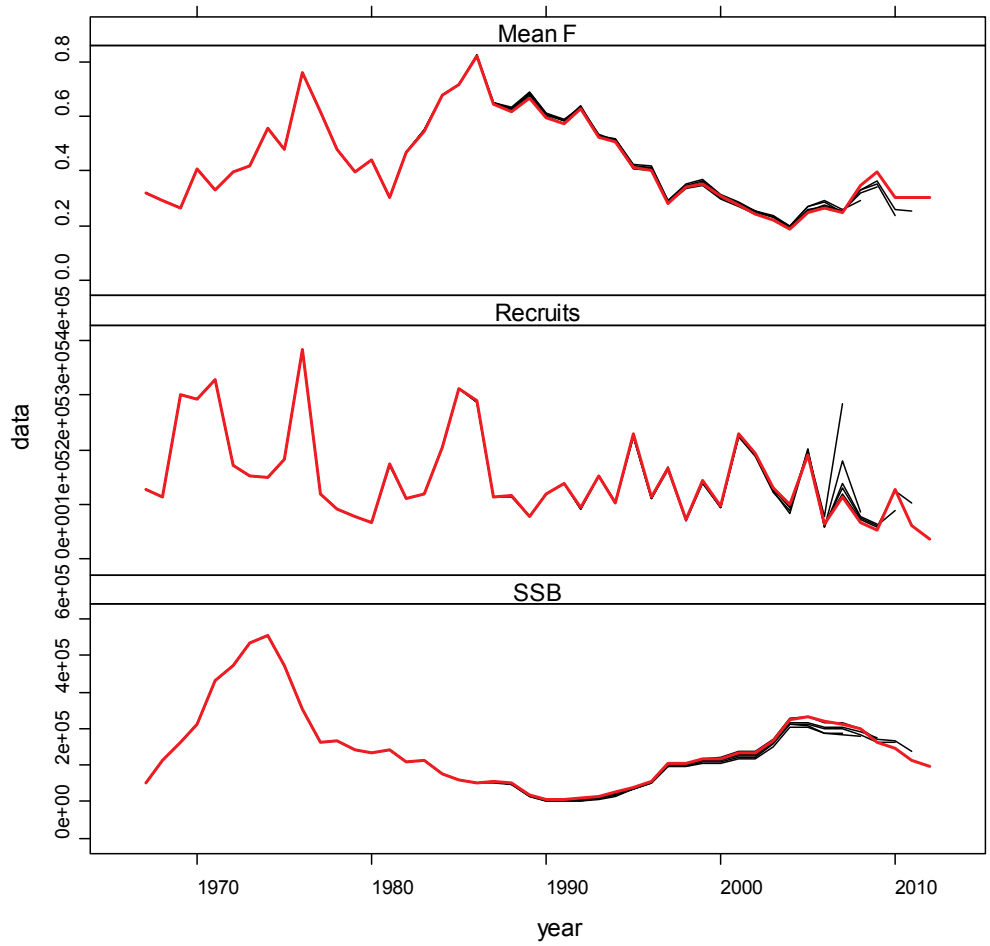


Figure 11.4.15. Saithe in Subareas IV and VI and Division IIIa. XSA: Retrospective plot.

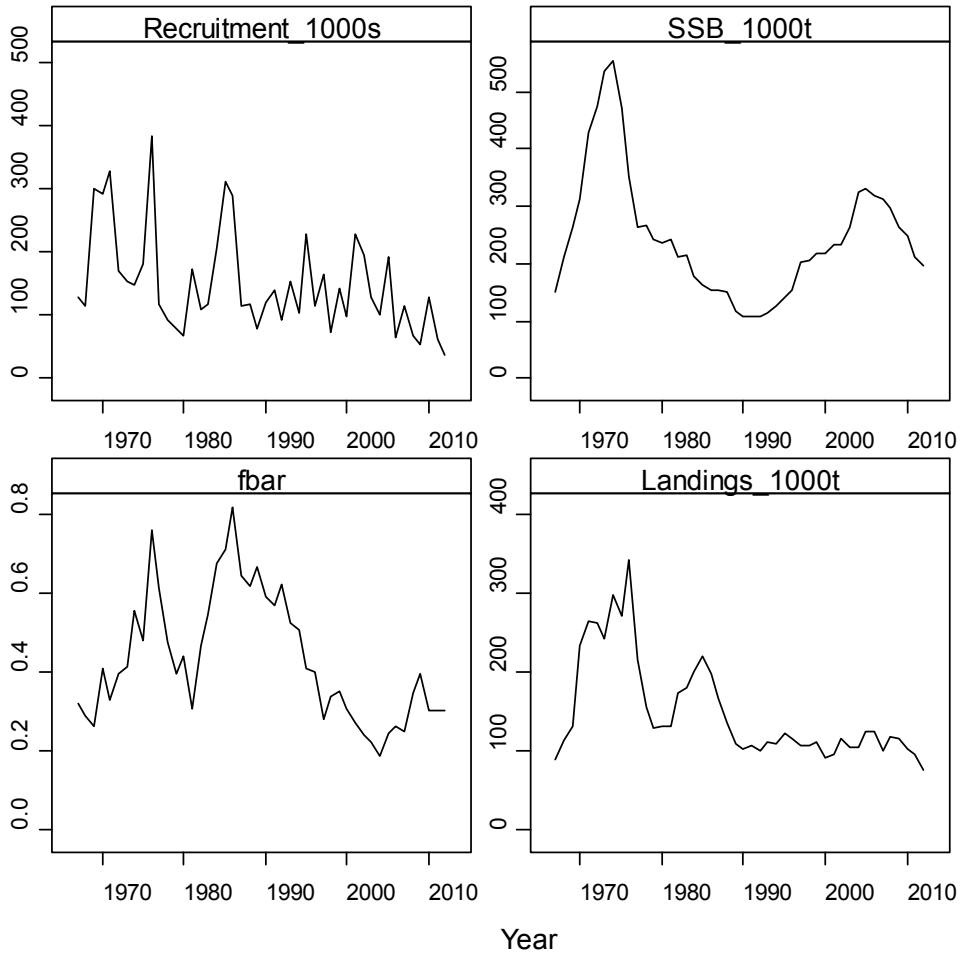


Figure 11.5.1. Saithe in Subareas IV and VI and Division IIIa. XSA: Stock summary of trends in recruitment, SSB, F_{3-6} and landings.

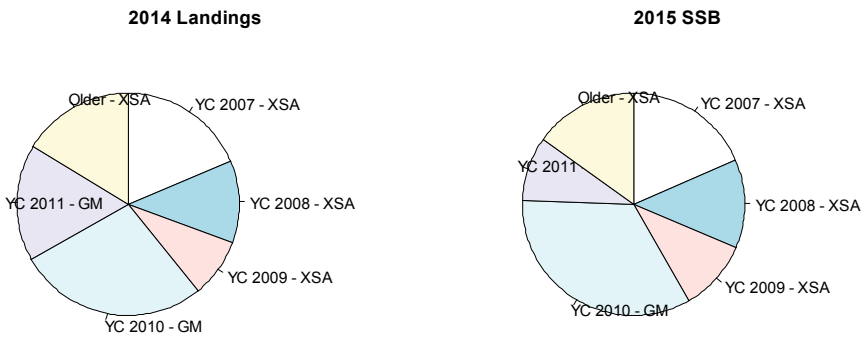


Figure 11.7.1. Saithe in Subareas IV and VI and Division IIIa. Contibution of recruitment of the 2007–2011 year classes to landings in 2014 and SSB in 2015. XSA and GM refers to how recruitment was estimated; GM is the geometric mean 1988–2010.

12 Whiting in Subarea IV and Divisions VIId and IIIa

12.1.1 Whiting in Division IIIa

12.1.2 General

12.1.2.1 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.

12.1.2.2 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).

12.1.2.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the spatial distribution of the Swedish landings in 2012 using logbooks information. The plot is reported in Figure 12.12.1a and showed that higher landings were taken along the Swedish coastline than in the offshore Skagerrak. Spatial distribution of the all combined fisheries in 2011 by statistical rectangle is reported in Figure 12.12.1b. A summary of available information on fisheries is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.1.3 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 12.12.1.

The WGNSSK in 2013 used IBTS indices per area (Skagerrak and Kattegat) and BITS indices (Kattegat) for plotting CPUE per quarter. Plots of the IBTS Q1 and IBTS Q3 are shown in Figures 12.12.2 and BITS Q1 and Q4 in Figure 12.12.3. 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 1991-2011 are plotted in Figure 12.12.4.

12.1.4 Data analyses

12.1.4.1 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 12.12.5 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 12.12.6. 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 12.12.7.

The retrospective analysis plots for mean total mortality (Z) over ages 2 and 4, relative SSB, relative TSB, and relative recruitment reported in Figure 12.12.8, providing further evidence of great uncertainty based on the 90% CI.

12.1.4.2 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.

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	970[1]	1,031[1]	27	126	+	1,184[1]	
2002	101	975[1]	1,076[1]	23	127	1	1,227[1]	
2003	93	654[1]	747[1]	20	71.9	2	840.9[1]	429
2004	93	1,120[1]	1,213[1]	17	74	1	1,305[1]	909
2005	49	907[1]	956[1]	13	73	0	1,042[1]	299
2006	59[1]	290[1]	349[1]	n/a	85.9[2]	n/a	434.9[2]	331
2007	53[2]	278[2]	331[2]	14	82	1	428[2]	561
2008	52[2]	288[2]	340[2]	14	52	n/a	406[2]	241
2009	71[2]	173[2]	244[2]	10.3	33.8[2]	-	288.1[2]	128
2010	41	165	206	9.7	29.7	-	245.4	291
2011	40	44	84	8.3	20.4	0.2	112.9	794
2012	30	6.8	37	15.5	9.6	0.8	62.9	291

[1] Values from 1992 updated by WGNSSK (2007).
[2] Values updated by WGNSSK (2011).

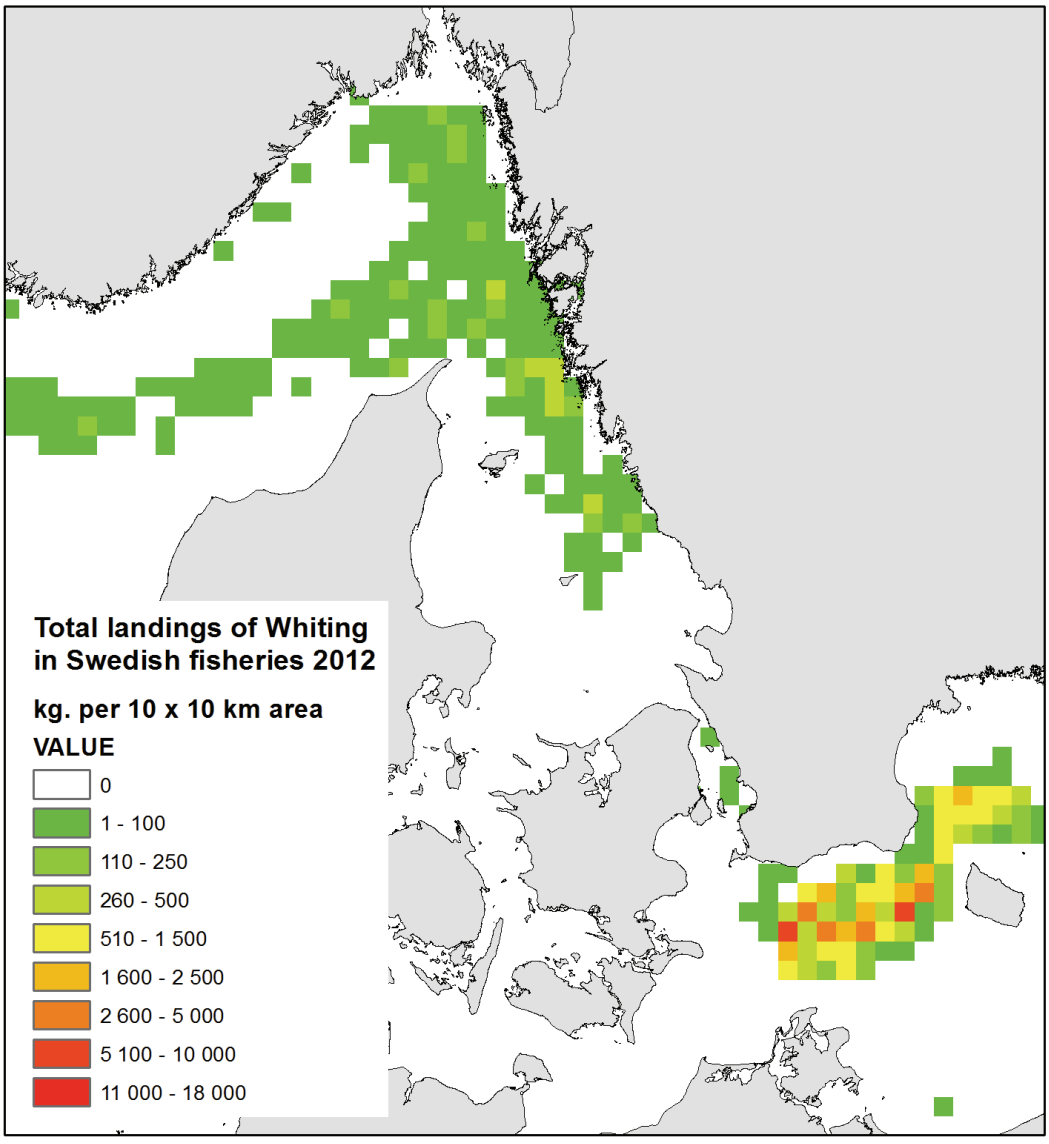


Figure 12.1.1a. Whiting in Division IIIa. Spatial distribution of the total landings of whiting IIIa in Swedish fisheries 2012 from logbooks information.

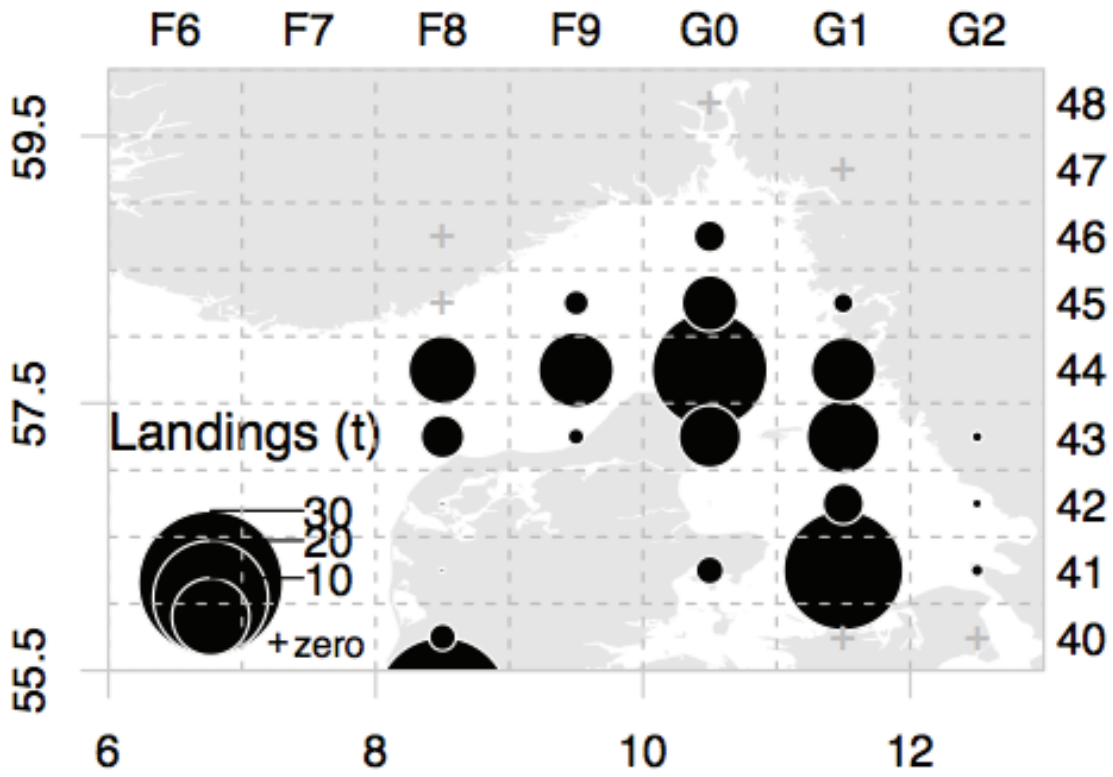


Figure 12.1.1b. Whiting in Division IIIa. Spatial distribution of the total landings of whiting IIIa by statistical rectangle for all combined fisheries in 2011.

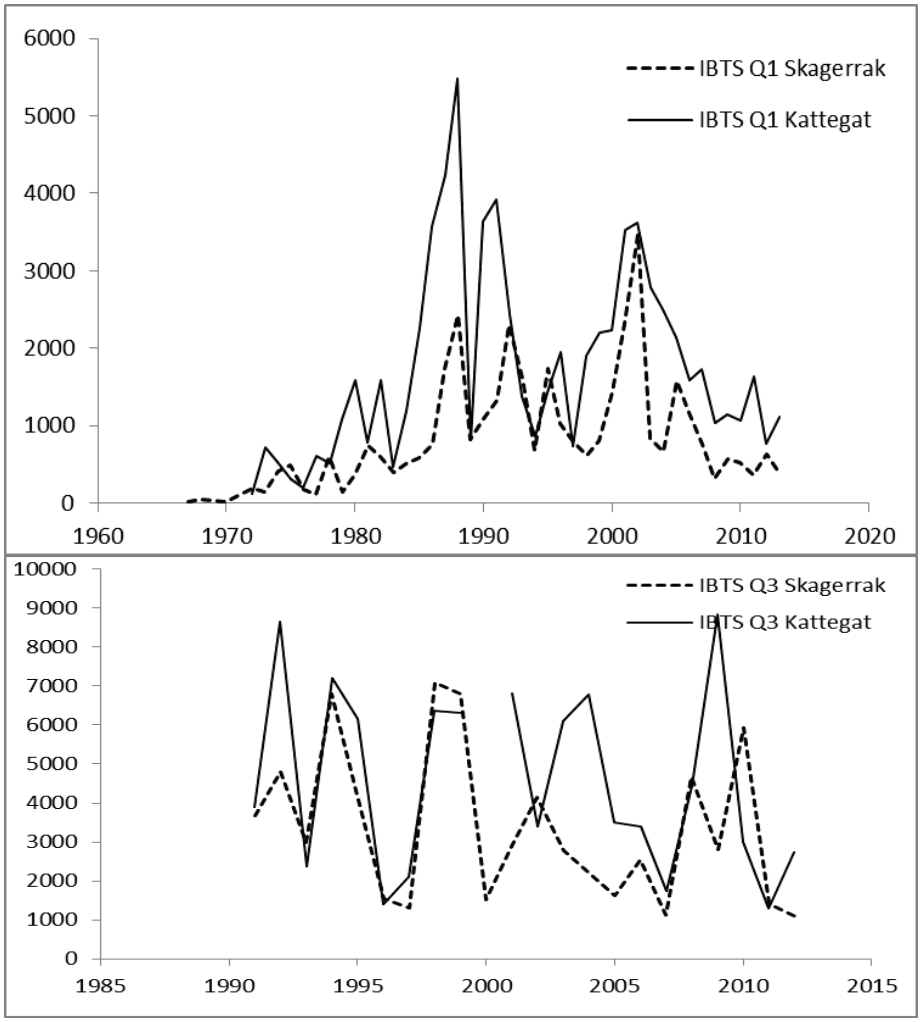


Figure 12.1.2. Whiting in Division IIIa (Skagerrak and Kattegat). IBTS CPUE per area Q1 covering the years 1967-2013 and Q3 covering the years 1991-2012.

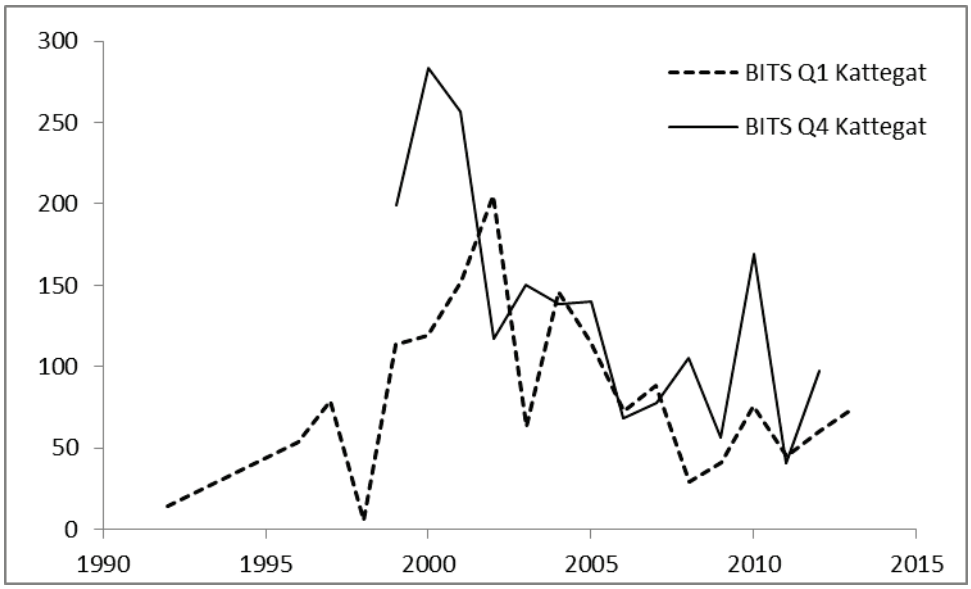
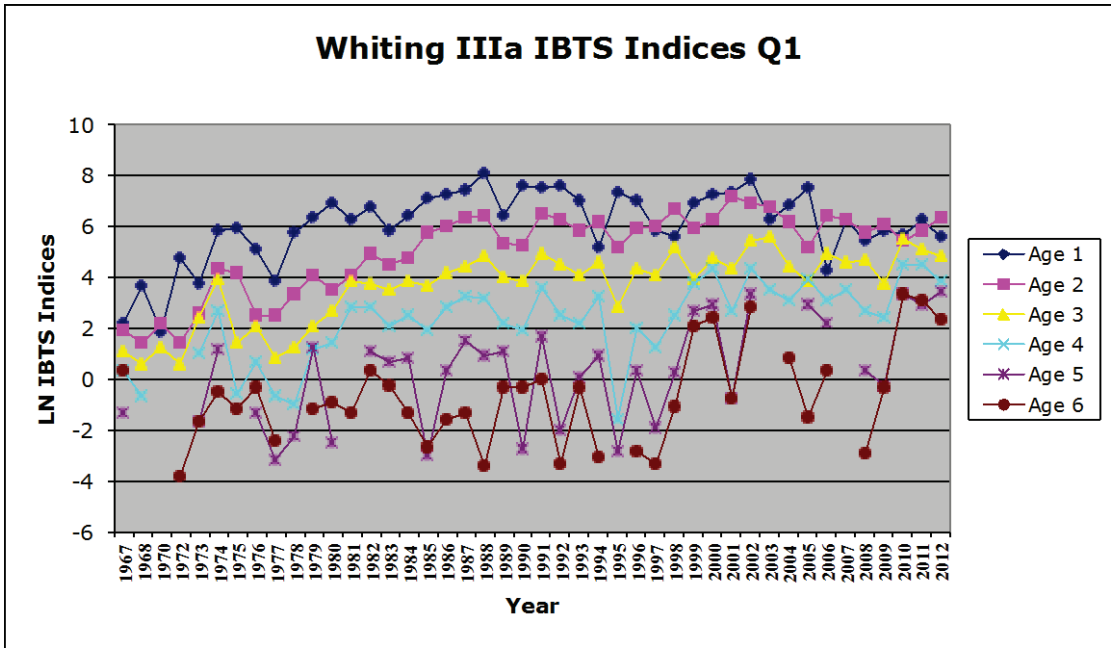


Figure 12.1.3. Whiting in Division IIIa S (Kattegat). BITS CPUE per Q1 and Q4 covering the years 1992-2012.



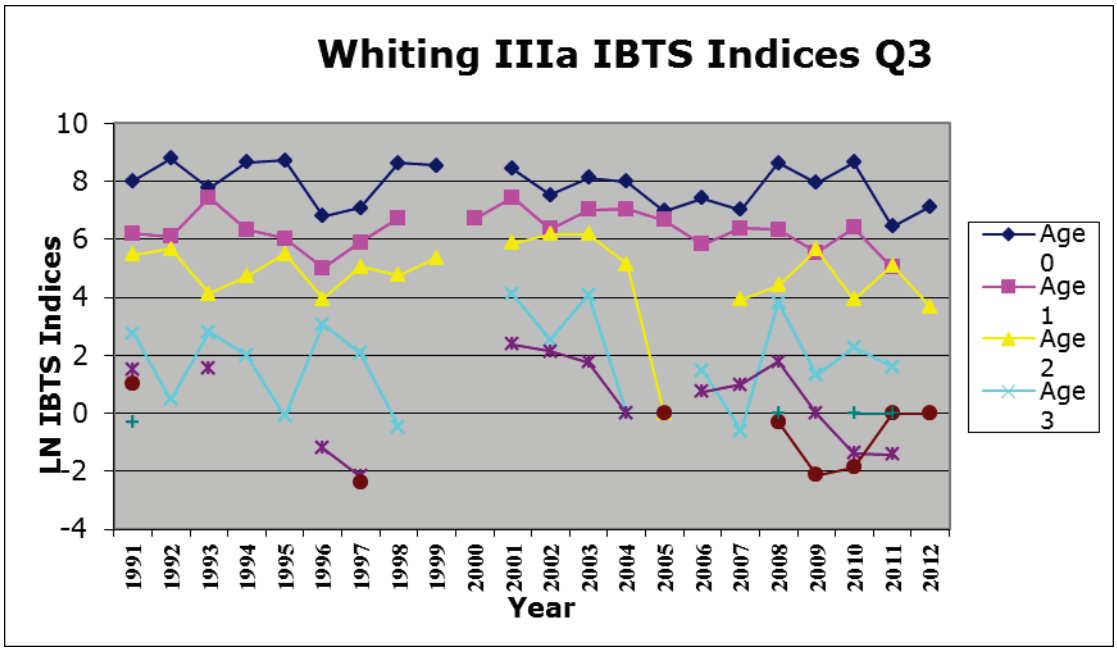


Figure 12.1.4. Whiting in Division IIIa. IBTS indices per age class for Q1 covering the years 1967-2013 and Q3 covering the years 1991-2012.

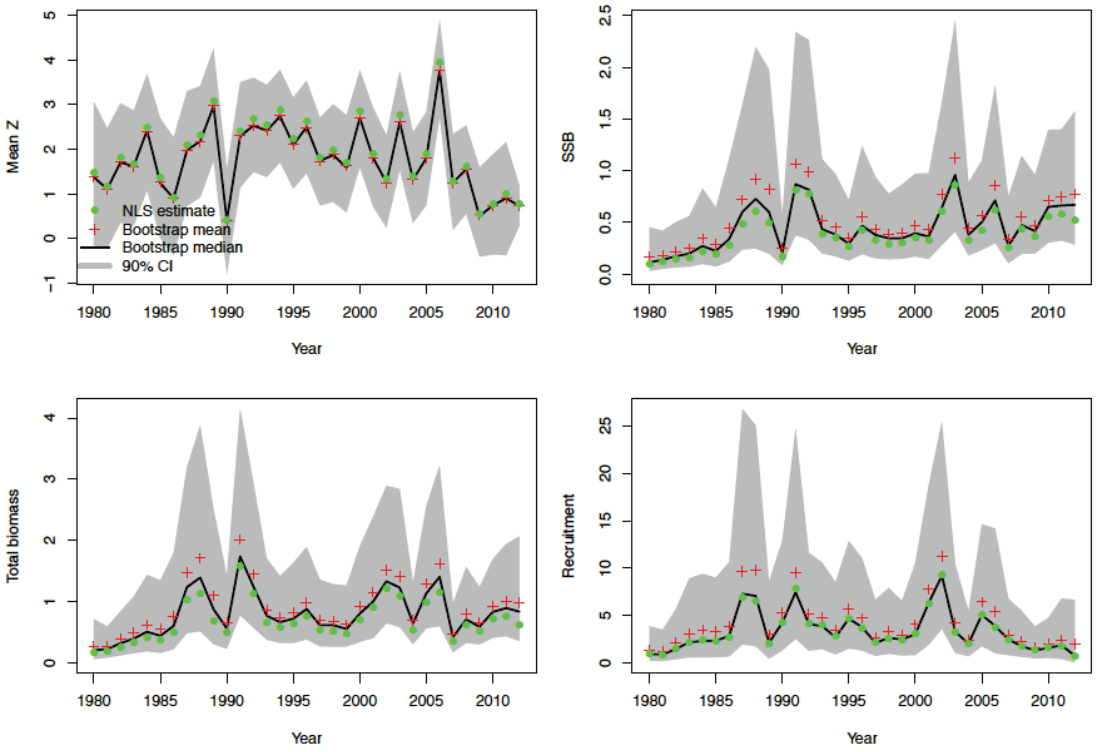


Figure 12.1.5. Whiting in Division IIIa. SURBAR analysis. Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

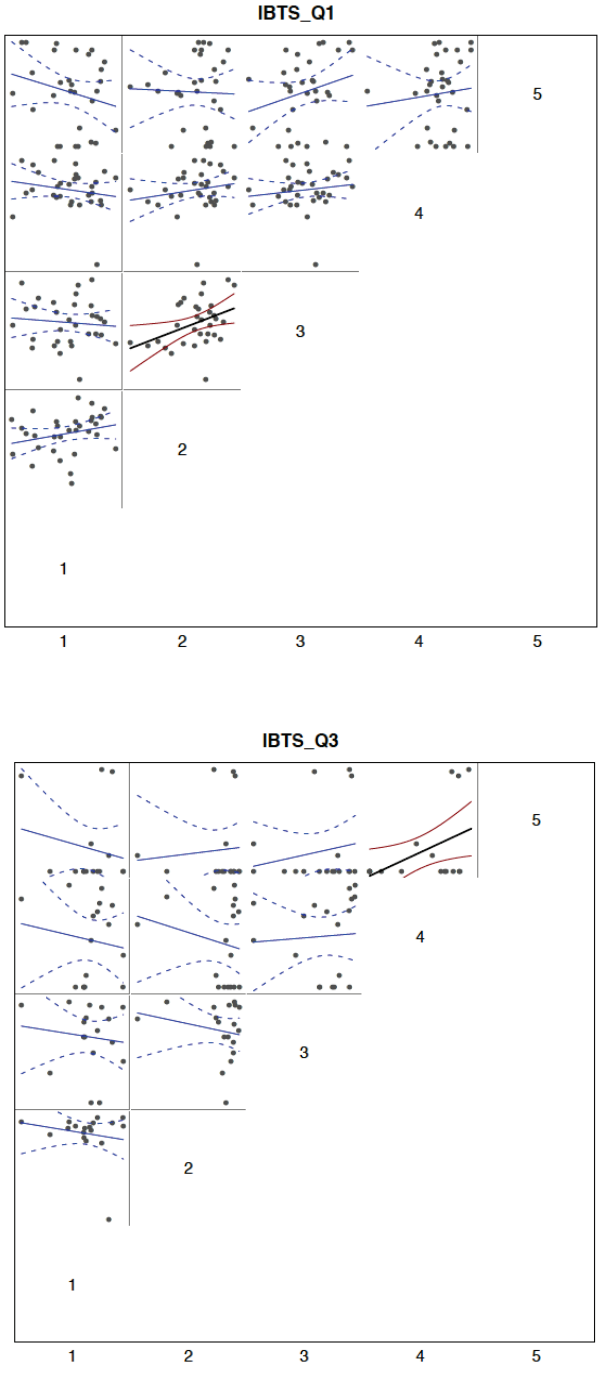


Figure 12.1.6 Whiting in Division IIIa. SURBAR analysis. IBTS indices per age class 1-5 for Q1 covering the years 1980-2012 and Q3 covering the years 1991-2011. The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year.

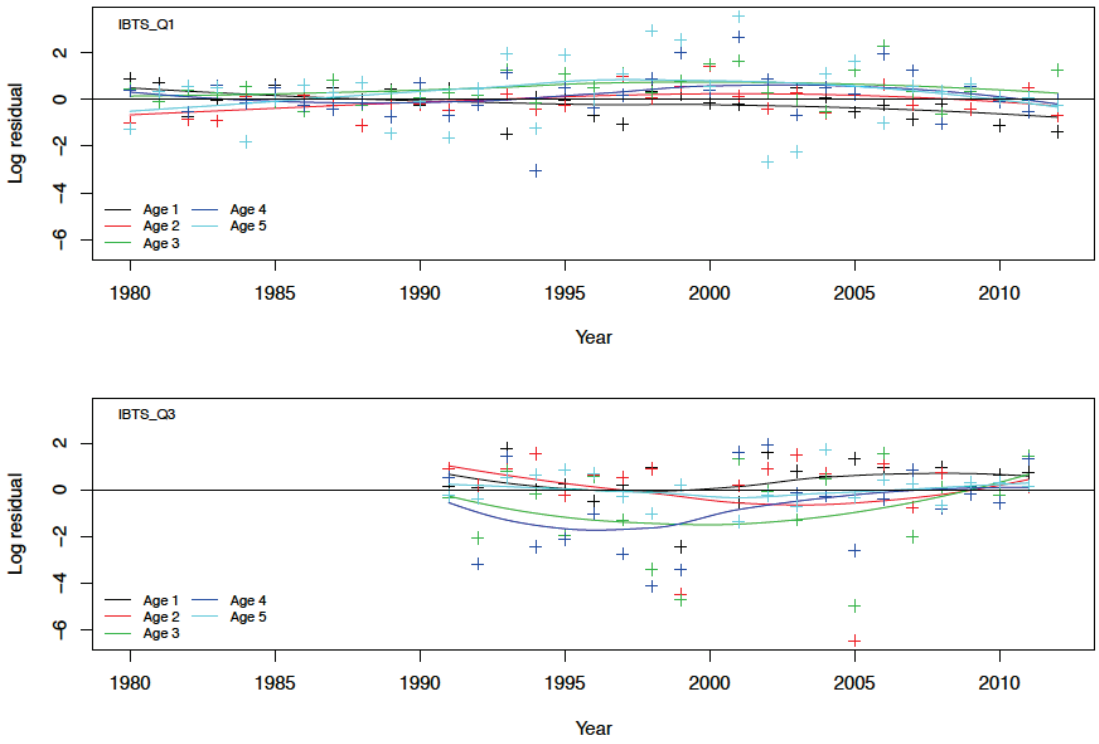


Figure 12.1.7 Whiting in Division IIIa. SURBAR analysis. Log residual estimates per age class for IBTS Q1 (upper line plots) and IBTS Q3 (lower line plots).

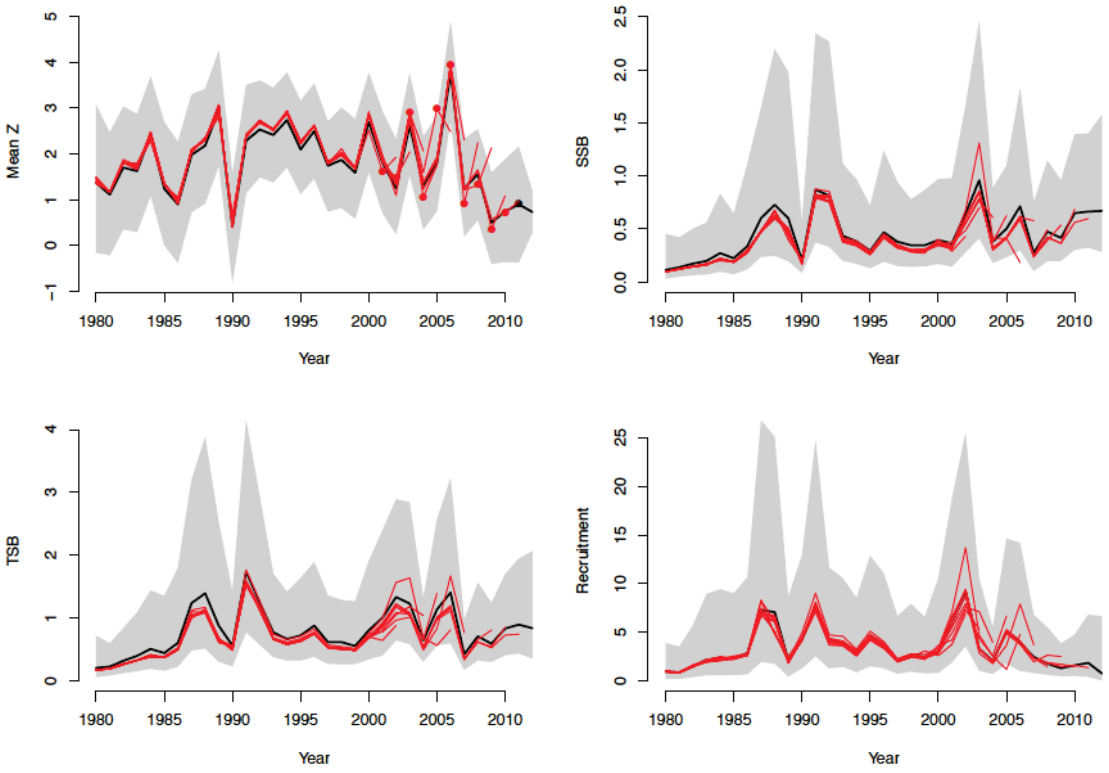


Figure 12.1.8. Whiting in Division IIIa. SURBAR analysis. Retrospective analysis plots for mean total mortality Z over ages 2 to 4, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment. The full time-series run is indicated by a black line, the retrospective runs by 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. The conclusions from the 2013 benchmark are presented in Section 12.3.

Available information on whiting in Division IIIaN (Skagerrak) is presented in Section 12.12.

12.3 General

12.3.1 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).

12.3.2 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).

12.3.3 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared by ICES-WKROUND (2013).

12.3.4 ICES advice

ICES advice for 2012

In October 2011, ICES concluded as follows:

> ICES advises, on the basis of the EU-Norway interim management plan, a TAC of 21 300 t
>
> (human consumption for the combined area) in 2012.

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.

12.3.5 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 17056 t in 2012, and 18932 t in 2013. There is no separate TAC for Division VIId; landings from this Division are counted against the TAC for Divisions VIIb-k combined (19053 t in 2012). The TAC for this area in 2013 is not yet available. 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, and in 2013, 64 closures had been implemented by 10th 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 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 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.

12.4 Data available

12.5 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 sam- pled 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 83% of the overall landings. However, although the unsampled fleets provide con- siderable 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 unsam- pled whiting fleet components in Subarea IV and Division VIId were obtained from samples provided by Denmark, Germany, France and the UK.

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. Total catch in 2012 was lower than in 2011, despite an increase in the available TAC. The estimated tonnages of the Subarea IV catch components remain among the lowest in the series, and whiting industrial by-catch also remains low. For Division VIId, the total catch in 2012 represents a decrease from the preceding three 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 decrease in discards for ages 1-3 in 2012 (Figure 12.3).

12.5.1 Age compositions

Age compositions in the landings and discards were based on samples provided by France, UK(England) and UK(Scotland). Limited sampling of the industrial bycatch component resulted in the 2006 data ap- pearing 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 $\hat{n}_{a,y}$ given by:

$$\hat{n}_{a,y} = \hat{N}_y \hat{p}_{a,y}, \tag{12.1}$$

where $\hat{p}_{a,y}$ is the mean proportion at age over the years 1990 to 2005, and $\hat{N}_y$ is estimated to give a sums of products correction (SOP) factor of 1 by

$$\hat{N}_y = \frac{\sum_a \hat{p}_{a,y}\hat{w}_{a,y}}{W_y}, \tag{12.2}$$

where W_y is the reported weight of industrial bycatch. Here $\hat{w}_{a,y}$ 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 InterCatch 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 Ta- ble 12.3. Numbers for human consumption landings, discards, and industrial bycatch are given in Ta- bles 12.4 to 12.6.

12.5.2 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).

12.5.3 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.

12.5.4 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 2010 and 1991 to 2010 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 2012 and 2013 respec- tively. 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

2012 and 2013, and they also demonstrate that the northern North Sea whiting stock is not spatially separate from the northern Division VIa stock.

12.6 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 measure- ments accordingly (new camera and annotation systems, automated image analysis, and length-based assessments). Work is proceeding towards possible implementation by 2014.

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 discrep- ancy, 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.

F_{msy} estimation WKROUND concluded that no reliable estimate of F_{msy} 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.

Report generation WKROUND considered the possibility of report generation via LaTeX and Sweave, on the premise that manual reruns of update assessments are unnecessary and prone to errors (both numerical and software errors). WKROUND concluded that this was a useful approach, and the current stock section for North Sea whiting has consequently been produced using this framework.

12.6.1 Exploratory survey-based analyses

Figure 12.8 presents time-series of survey log CPUE at age, and suggests that while broad trends are cap- tured 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 indi- cate 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.

12.6.2 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.

12.6.3 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.

12.6.4 Final assessment

The final assessment used an FLXSA model fitted to the combined landings, discard and industrial by-catch data for the period 1990–2012. 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	1990-2012
	Ages 1-8+
Calibration period	1990-2012
Survey: IBTS Q1	1990-2012
Ages 1-5	
Survey: IBTS Q3	1991-2012
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 con-

siderable 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.

12.7 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.

12.8 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 2013 (that is, the 2012 year-class) was 2139 million. The geometric mean of all recruitments excluding the most recent two years is 4139 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 2013, and the long-term geometric mean for recruitment in 2014 and beyond.

12.9 Short-term forecasts

A short-term forecast was carried out based on the final FLXSA assessment. FLXSA survivors from 2012 were used as input population numbers for ages 2 and older in 2013. Recruitment assumptions are detailed in the preceding section.

The exploitation pattern was chosen as the mean exploitation pattern over the years 2010–2012. 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 2012 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 2010–2012. The F at age used in the forecast is compared with the F at age estimates for 2010–2012 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 2012 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 Ta- ble 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_{2013} to equal mean F_{2012}, results in human consumption landings in 2013 of 17466 t from a total catch of 26145 t, giving an SSB in 2014 of 271218 t (a small decrease from the 2013 value of 281593 t. Carrying the same fishing mortality forward into 2014 (the status quo F option) would result in landings of 16953 t out of total catches of 25963 t, and would result in an SSB of 320610 t in 2015 (an increase of 18%). Applying the proposed target F (0.225) from the management plan to the stock in 2014 would generate landings of 24389 t out of total catches of 36992 t, and result in an SSB of 311434 t in 2015 (a 15% increase).

12.10 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting. A full re-evaluation of the EU-Norway management plan was called for last year to account for substantially revised natural mortality estimates (ICES-WGNSSK 2012), and this was in the process of being addressed during the 2013

WGNSSK meeting. The new evaluation should be available in time for the ACOM advisory schedule in June 2013.

12.11 Biological reference points

The precautionary fishing mortality and biomass reference points agreed by the EU and Norway (and un- changed since 1999) are as follows:

$$B_{lim} = 225,000\text{t};\ B_{pa} = 315,000\text{t};\ F_{lim} = 0.90;\ F_{pa} = 0.65.$$

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.

12.12 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 commer-

cial 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.

12.13 Status of the stock

WGNSSK considers the status of the stock unknown with respect to existing biological reference points and MSY reference points for the reasons given in the preceding Sections. 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.

12.14 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 straight- forward 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.

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 2013 if this is the case for this year.

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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.

	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
belgium.iv	248	144	105	93	45	115	162	147	74	43	NA
denmark.iv	89	62	57	251	79	42	80	158	135	131	NA
france.iv	2675	1721	1261	2711	3312	3051	2304	2631	2546	1925	NA
germany.iv	334	296	149	252	76	76	125	156	111	18	NA
netherlands.iv	1442	977	805	702	618	656	718	615	514	468	NA
norway.iv	39	23	16	17	11	92	73	118	28	93	NA
sweden.iv	10	2	0	1	1	1	4	8	6	3	NA
england.wales.iv	680	1209	2560	3539	3048	1541	1397	NA	NA	NA	NA
scotland.iv	5734	5057	3441	8093	9063	8850	7456	NA	NA	NA	NA
uk.iv	NA	NA	NA	NA	NA	NA	NA	7841	8891	9862	NA
total.landings.iv	11251	9491	8394	15659	16253	14424	12319	11527	12305	12547	NA
unallocated.landings.iv	801	541	-2286	562	587	945	545	-754	-1000	-382	NA
wg.landings.iv	10450	8950	10680	15097	15666	13479	11774	12281	13305	12929	NA
wg.discards.iv	26135	18142	10300	14018	5206	8356	5223	7853	8180	5929	NA
wg.ibc.iv	2730	1210	890	2190	1240	0	1020	1350	1750	78	NA
wg.catch.iv	39315	28302	21870	31305	22112	21835	18017	21484	23235	18936	NA
tac.iv.iia	16000	16000	28500	23800	23800	17850	15173	12897	14832	17056	18932

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
belgium.viid	45	73	75	69	71	88	78	63	NA
france.viid	4638	3487	3135	2875	6266	5436	4438	3093	NA
netherland.viid	128	117	118	162	112	270	282	438	NA
england.wales.viid	90	53	50	54	86	253	271	258	NA
total.landings.viid	4901	3730	3378	3160	6535	5959	5069	3852	NA
unallocated.landings.viid	111	287	124	-1311	-111	20	5	-251	NA
wg.landings.viid	4790	3443	3254	4471	6646	5939	5064	4103	NA
wg.discards.viid	2219	2291	1763	1943	2477	3727	3538	2446	NA
wg.catch.viid	7009	5734	5017	6414	9123	9666	8602	6549	NA
tac.viib.k	21600	19940	19940	19940	16949	14407	16568	19053	NA

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 1990–2012 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

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 1990–2012 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

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 1990–2012 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

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 1990–2012 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

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 1990–2012 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

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 1990–2012 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

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 1990–2012 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	0.158	0.195	0.230	0.279	0.240	0.280	0.338	0.578	0.188	0.391	0.596	0.489	0.288		0	0.344

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 1990–2012 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

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

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	1.25040	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	1.26620	1.25028	1.09999	0.76427	0.32203
1984	4.34487	1.77966	0.88980	0.30258	0.25363
1985	3.39177	3.62255	0.65850	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	0.32980	0.12608
1989	14.46080	5.38563	4.14762	1.09900	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	6.78590	4.48484	2.39448	0.58074	0.11867
1996	5.02361	4.85968	2.44699	0.69740	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	6.76270	3.05445	0.94675	0.57451	0.25825
2000	7.41490	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	0.63280	0.20805
2003	1.31035	2.96422	2.36526	1.32594	0.48289
2004	1.84472	0.89604	1.72741	1.00170	0.49223
2005	1.42047	0.50037	0.30146	0.30338	0.25755
2006	1.84564	1.25260	0.45540	0.18403	0.27178
2007	0.64588	1.50441	0.66288	0.17721	0.07564
2008	2.68484	2.05862	0.65651	0.22110	0.07538
2009	2.11006	2.95618	0.93508	0.27189	0.11936
2010	3.26994	2.25541	2.43766	0.94942	0.28550
2011	1.84287	3.36844	1.56429	0.92650	0.19633
2012	2.30452	5.78418	1.15411	0.48936	0.32549
2013	0.49468	1.56380	2.41649	0.87986	0.26914

IBTS-Q3					
	age.1	age.2	age.3	age.4	age.5
1991	7.03368	1.58594	0.79024	0.14568	0.05183
1992	6.00867	2.96100	0.72451	0.57498	0.10273
1993	6.38722	1.77377	0.66118	0.14711	0.15904
1994	6.77645	2.19541	0.74710	0.19506	0.04722
1995	6.19786	2.91180	1.07195	0.21512	0.06013
1996	5.45708	2.78218	1.29356	0.34003	0.06893
1997	3.32968	1.80681	1.08985	0.28006	0.10711
1998	3.30600	1.50205	0.52766	0.31010	0.11179
1999	12.03503	1.90645	0.53932	0.24452	0.09529
2000	9.41658	3.26943	0.64113	0.13625	0.06532
2001	6.45003	2.82320	0.94854	0.19281	0.04315
2002	7.32137	2.37372	1.25148	0.33960	0.05275
2003	2.46155	3.02054	1.34824	0.66058	0.16452
2004	1.88577	0.49050	0.75850	0.48675	0.32286
2005	1.79500	0.70531	0.27609	0.45385	0.29211
2006	1.72790	0.84975	0.31910	0.13207	0.22853
2007	0.95645	0.64042	0.37929	0.11604	0.08459
2008	3.56898	0.66197	0.30935	0.13565	0.04057
2009	5.85543	3.84805	0.40992	0.12296	0.08038
2010	2.66397	1.57670	0.60982	0.13734	0.06527
2011	4.45203	1.43796	0.46864	0.16001	0.06884
2012	2.58443	1.94627	0.57388	0.19997	0.10565

Table 12.14: Whiting in Subarea IV and Division VIId. FLXSA tuning diagnostics.

```
FLR XSA Diagnostics 2013-05-10 14:07:18

CPUE data from x.index

Catch data for 23 years. 1990 to 2012. Ages 1 to 8.

    fleet first age last age first year last year alpha beta
1 IBTS-Q1         1        5       1990      2012     0 0.25
2 IBTS-Q3         1        5       1991      2012   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   2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
   year
age  2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
  1 0.114 0.062 0.046 0.074 0.042 0.035 0.013 0.018 0.017 0.026
  2 0.188 0.129 0.183 0.165 0.137 0.119 0.121 0.150 0.154 0.055
  3 0.172 0.130 0.161 0.298 0.247 0.227 0.148 0.125 0.166 0.138
  4 0.219 0.200 0.149 0.249 0.334 0.318 0.263 0.165 0.152 0.230
  5 0.213 0.252 0.213 0.267 0.263 0.361 0.298 0.280 0.139 0.135
  6 0.170 0.277 0.231 0.398 0.318 0.278 0.285 0.393 0.257 0.207
  7 0.129 0.203 0.226 0.266 0.480 0.414 0.206 0.238 0.359 0.335
  8 0.129 0.203 0.226 0.266 0.480 0.414 0.206 0.238 0.359 0.335

XSA population number (Thousand)
      age
year         1      2      3      4      5     6     7     8
  2003 1863855 974818 472897 281872  97917 19863  5148  4241
  2004 1929401 287664 358019 222022 129376 45468  9715  2158
  2005 2524939 315031 110507 174475 103278 57523 19876  4174
  2006 2450362 424376 113065  52065  85182 47595 26221  8066
  2007 2202521 409771 153153  46376  22956 37121 18315 10461
  2008 4141709 391631 150583  66140  18804 10055 15461 11172
  2009 3444175 767943 145314  66468  27320  7490  4366 19761
  2010 3193385 677579 282243  69593  29116 11632  3236  9213
  2011 4175681 649428 240357 138782  33767 12676  4527  1331
  2012 2406418 849854 229386 113433  68217 16921  5651  2468
```

```
Estimated population abundance at 1st Jan  2013
      age
year   1      2      3      4     5     6    7    8
  2013 0 485464 331274 111409 51569 34328 7926 2304


 Fleet:  IBTS-Q1

 Log catchability residuals.

   year
age   1990  1991   1992  1993   1994   1995   1996   1997   1998   1999   2000
  1  0.011 0.645  0.594 0.606  0.260  0.293  0.342  0.055  0.362  0.072 -0.038
  2 -0.153 0.500  0.391 0.256  0.267 -0.009  0.169  0.175 -0.300  0.044 -0.031
  3  0.044 0.131  0.298 0.185  0.013  0.053  0.122 -0.211 -0.132 -0.147  0.130
  4  0.028 0.312  0.049 0.131  0.153  0.031 -0.069 -0.201 -0.273  0.050 -0.218
  5 -0.488 0.439 -0.371 0.123 -0.412 -0.391  0.098 -0.422 -0.622 -0.106 -0.433
   year
age   2001   2002   2003   2004   2005   2006   2007   2008   2009   2010   2011
  1  0.073  0.070 -0.244  0.057 -0.477 -0.184 -1.135 -0.346 -0.410  0.100 -0.742
  2 -0.005 -0.304 -0.275 -0.256 -0.921 -0.302 -0.086  0.271 -0.039 -0.180  0.264
  3  0.230 -0.200 -0.046 -0.086 -0.653 -0.246 -0.180 -0.176  0.204  0.495  0.217
  4  0.731 -0.435  0.038 -0.005 -0.965 -0.243 -0.155 -0.291 -0.096  1.096  0.380
  5  0.603  0.024  0.084 -0.170 -0.597 -0.344 -0.312 -0.105 -0.027  0.779  0.239
   year
age   2012
  1  0.034
  2  0.524
  3 -0.044
  4 -0.047
  5  0.041


 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 -13.6995 -12.3061 -12.0668 -12.2092 -12.2092
S.E_Logq    0.4273   0.3267   0.2382   0.3984   0.3745

Fleet:  IBTS-Q3

 Log catchability residuals.

   year
age   1991  1992   1993   1994   1995   1996   1997   1998   1999   2000   2001
  1  0.122 0.045 -0.054  0.063  0.071  0.298  0.082 -0.241  0.557  0.096 -0.031
  2 -0.338 0.170 -0.218 -0.211  0.126  0.168  0.090  0.170  0.144  0.181 -0.242
  3 -0.791 0.004 -0.158  0.055  0.151  0.370  0.257 -0.179  0.160  0.120 -0.129
  4 -0.290 0.035 -0.336 -0.037 -0.012  0.169 -0.045  0.074  0.146 -0.077 -0.017
  5 -0.398 0.362 -0.140 -0.192 -0.025 -0.149  0.019 -0.009 -0.151 -0.083 -0.215
   year
age   2002   2003   2004   2005   2006   2007   2008   2009   2010   2011   2012
  1  0.252  0.345  0.009 -0.327 -0.332 -0.855 -0.195  0.448 -0.285 -0.040 -0.027
  2 -0.154  0.321 -0.304  0.010 -0.105 -0.364 -0.292  0.801  0.056  0.009 -0.018
  3 -0.133  0.190 -0.131  0.055  0.263  0.101 -0.100  0.167 -0.116 -0.194  0.038
  4 -0.205  0.187  0.112  0.253  0.291  0.329  0.119 -0.021 -0.019 -0.565 -0.092
  5 -0.482 -0.153  0.270  0.373  0.354  0.669  0.192  0.461  0.175 -0.007 -0.284


 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 -12.7233 -12.3819 -12.4863 -12.6657 -12.6657
S.E_Logq    0.3051   0.2692   0.2402   0.2130   0.2952


 Terminal year survivor and F summaries:

 Age 1 Year class =2011
```

```
source
        scaledWts survivors yrcls
IBTS-Q1     0.333    502327  2011
IBTS-Q3     0.651    472518  2011
fshk        0.016    712624  2011

 Age 2 Year class =2010

source
        scaledWts survivors yrcls
IBTS-Q1     0.441    559346  2010
IBTS-Q3     0.546    325203  2010
fshk        0.013    118855  2010

 Age 3 Year class =2009

source
        scaledWts survivors yrcls
IBTS-Q1     0.494    106600  2009
IBTS-Q3     0.494    115698  2009
fshk        0.013    101940  2009

Age 4 Year class =2008

source
        scaledWts survivors yrcls
IBTS-Q1     0.346     49177  2008
IBTS-Q3     0.636     47045  2008
fshk        0.018     61222  2008

 Age 5 Year class =2007

source
        scaledWts survivors yrcls
IBTS-Q1     0.362     35763  2007
IBTS-Q3     0.622     25830  2007
fshk        0.016     17959  2007

 Age 6 Year class =2006

source
     scaledWts survivors yrcls
fshk         1      4865  2006

 Age 7 Year class =2005

source
     scaledWts survivors yrcls
fshk         1      4618  2005
```

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	0.345	0.594	0.750	0.944	0.690	0.766	0.766
1991	0.053	0.320	0.356	0.512	0.858	0.601	0.598	0.598
1992	0.098	0.247	0.405	0.455	0.453	0.894	1.063	1.063
1993	0.081	0.286	0.530	0.607	0.664	0.387	0.787	0.787
1994	0.073	0.216	0.457	0.674	0.847	0.981	0.293	0.293
1995	0.062	0.208	0.407	0.454	0.656	0.949	1.186	1.186
1996	0.052	0.188	0.374	0.466	0.487	0.655	1.089	1.089
1997	0.048	0.182	0.337	0.401	0.481	0.288	0.413	0.413
1998	0.053	0.149	0.235	0.355	0.435	0.450	0.272	0.272
1999	0.066	0.214	0.336	0.445	0.457	0.495	0.365	0.365
2000	0.023	0.177	0.375	0.451	0.616	0.641	0.991	0.991
2001	0.019	0.087	0.166	0.301	0.478	0.569	0.494	0.494
2002	0.022	0.085	0.203	0.238	0.270	0.265	0.506	0.506
2003	0.114	0.188	0.172	0.219	0.213	0.170	0.129	0.129
2004	0.062	0.129	0.130	0.200	0.252	0.277	0.203	0.203
2005	0.046	0.183	0.161	0.149	0.213	0.231	0.226	0.226
2006	0.074	0.165	0.298	0.249	0.267	0.398	0.266	0.266
2007	0.042	0.137	0.247	0.334	0.263	0.318	0.480	0.480
2008	0.035	0.119	0.227	0.318	0.361	0.278	0.414	0.414
2009	0.013	0.121	0.148	0.263	0.298	0.285	0.206	0.206
2010	0.018	0.150	0.125	0.165	0.280	0.393	0.238	0.238
2011	0.017	0.154	0.166	0.152	0.139	0.257	0.359	0.359
2012	0.026	0.055	0.138	0.230	0.135	0.207	0.335	0.335

Table 12.19: Whiting in Subarea IV and Division VIId. Final abundance estimates from FLXSA.

	1	2	3	4	5	6	7	8+
1990	5589678	2551310	380279	208995	66114	5015	1732	252
1991	5728263	1053216	819945	118442	57549	15261	1507	740
1992	5462339	1128373	349376	325342	41504	14494	5014	210
1993	6398115	1018858	404247	132481	120983	15697	3552	1708
1994	6069489	1198326	352056	135752	42396	37034	6387	2551
1995	5528000	1127727	444810	127479	40621	10801	8311	823
1996	3899647	1020034	422481	169434	47525	12508	2497	2018
1997	2980408	713553	389969	166252	62347	17299	3873	1695
1998	4150333	536835	274513	158999	65166	22737	7710	2157
1999	6933390	729840	213148	123699	65074	24807	8587	2778
2000	8465955	1181789	270699	86557	46114	24139	8928	2481
2001	6635602	1480106	452797	105404	31988	14529	7484	4109
2002	5725704	1146692	615581	216221	45054	11518	4817	2406
2003	1863855	974818	472897	281872	97917	19863	5148	4241
2004	1929401	287664	358019	222022	129376	45468	9715	2158
2005	2524939	315031	110507	174475	103278	57523	19876	4174
2006	2450362	424376	113065	52065	85182	47595	26221	8066
2007	2202521	409771	153153	46376	22956	37121	18315	10461
2008	4141709	391631	150583	66140	18804	10055	15461	11172
2009	3444175	767943	145314	66468	27320	7490	4366	19761
2010	3193385	677579	282243	69593	29116	11632	3236	9213
2011	4175681	649428	240357	138782	33767	12676	4527	1331
2012	2406418	849854	229386	113433	68217	16921	5651	2468

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	5589678	970318	526272	152602	45662	55603	51337	0.087	0.664	
1991	5728263	1006935	464402	126742	51929	35058	39755	0.112	0.530	
1992	5462339	871396	442845	108555	50946	32564	25045	0.115	0.491	
1993	6398115	834800	404478	116911	51818	44370	20723	0.128	0.495	
1994	6069489	878549	408466	101650	48486	35692	17473	0.119	0.635	
1995	5528000	876305	423150	105494	45938	32176	27379	0.109	0.535	
1996	3899647	713644	373037	76123	40503	30505	5116	0.109	0.434	
1997	2980408	585156	321342	61435	35563	19660	6213	0.111	0.338	
1998	4150333	612905	270982	47475	28288	15693	3494	0.104	0.325	
1999	6933390	779266	287554	60845	30130	25677	5038	0.105	0.390	
2000	8465955	1315334	418301	63806	28583	26063	9160	0.068	0.452	
2001	6635602	1114463	492490	45242	25061	19237	944	0.051	0.320	
2002	5725704	785231	420322	46450	20675	18501	7275	0.049	0.212	
2003	1863855	425258	321403	45640	16161	26745	2734	0.050	0.192	
2004	1929401	443322	249125	33557	13295	19048	1214	0.053	0.198	
2005	2524939	499515	215977	28883	15471	12525	888	0.072	0.187	
2006	2450362	491809	199275	37038	18535	16310	2193	0.093	0.276	
2007	2202521	382443	184313	27125	18915	6971	1239	0.103	0.260	
2008	4141709	600340	209623	28247	17951	10296	0	0.086	0.260	
2009	3444175	577160	280282	27139	18418	7705	1016	0.066	0.223	
2010	3193385	567811	306627	31147	18224	11577	1346	0.059	0.223	
2011	4175681	714721	311516	32626	18899	11977	1750	0.061	0.174	
2012	2406418	517781	319340	25485	17032	8375	78	0.053	0.153	

Table 12.21: Whiting in Subarea IV and Division VIId. RCT3 input table.

	yearclass	recruitment	IBTSq11	IBTSq12	IBTSq30	IBTSq31	IBTSq32
1	1989	5589678	1007.621	665.714	NA	NA	158.594
2	1990	5728263	907.297	522.811	NA	703.368	296.1
3	1991	5462339	1075.624	627.406	536.99	600.867	177.377
4	1992	6398115	721.709	448.484	1379.459	638.722	219.541
5	1993	6069489	678.59	485.968	919.193	677.645	291.18
6	1994	5528000	502.361	342.212	610.743	619.786	278.218
7	1995	3899647	287.733	160.695	729.246	545.708	180.681
8	1996	2980408	543.117	305.445	316.501	332.968	150.205
9	1997	4150333	676.27	460.697	2062.67	330.6	190.645
10	1998	6933390	741.49	598.388	2631.69	1203.503	326.943
11	1999	8465955	648.649	343.308	2498.55	941.658	282.32
12	2000	6635602	557.353	296.422	1968.07	645.003	237.372
13	2001	5725704	131.035	89.604	3031.442	732.137	302.054
14	2002	1863855	184.472	50.037	264.063	246.155	49.05
15	2003	1929401	142.047	125.26	363.406	188.577	70.531
16	2004	2524939	184.564	150.441	1012.818	179.5	84.975
17	2005	2450362	64.588	205.862	162.592	172.79	64.042
18	2006	2202521	268.484	295.618	201.578	95.645	66.197
19	2007	4141709	211.006	225.541	821.741	356.898	384.805
20	2008	3444175	326.994	336.844	757.814	585.543	157.67
21	2009	3193385	184.287	578.418	593.814	266.397	143.796
22	2010	NA	230.452	156.38	508.117	445.203	194.627
23	2011	NA	49.468	NA	246.898	258.443	NA
24	2012	NA	NA	NA	307.397	NA	NA

Table 12.22: Whiting in Subarea IV and Division VIId. RCT3 output.

```
Analysis by RCT3 ver4.0

Whiting

Data for 5 surveys over 24 years : 1989 - 2012
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
  IBTSq11 0.8366    10.284 0.4854  0.4809 21      NA         NA      NA          NA
  IBTSq12 1.1646     8.634 0.6791  0.3213 21      NA         NA      NA          NA
  IBTSq30 0.6722    10.726 0.3768  0.6196 19   5.728      14.58  0.4206           1
  IBTSq31 0.7762    10.534 0.2333  0.8053 20      NA         NA      NA          NA
  IBTSq32 0.8493    10.883 0.2513  0.7757 21      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 21      NA      15.24  0.4554           0

                  WAP logWAP int.se
yearclass:2012 2139711  14.58 0.3090
```

Table 12.23: Whiting in Subarea IV and Division VIId. Short-term forecast inputs for 2013.

```
MFDP version 1a
Run: 01
Time and date: 00:11 27/04/2013
Fbar age range (Total) : 2-6
Fbar age range Fleet 1 : 2-6
Fbar age range Fleet 2 : 2-6

2013
Age N         M           Mat  PF     PM      SWt
1   2139711   1.575    0.11 0  0      0.087
2       485450    0.887        0.92 0  0       0.193
3       331265    0.585        1        0      0       0.279
4       111405    0.558        1        0      0       0.385
5       51566     0.552        1        0      0       0.398
6       34326     0.551        1        0      0       0.413
7       7925      0.562        1        0      0       0.421
8       3285      0.587        1        0      0       0.462

Catch
Age     Sel         CWt     DSel        DCWt
1       0.003   0.135   0.014   0.076
2       0.042   0.236   0.053   0.158
3       0.072   0.337   0.048   0.195
4       0.106   0.468   0.048   0.230
5       0.109   0.443   0.038   0.279
6       0.153   0.501   0.079   0.240
7       0.192   0.478   0.077   0.280
8       0.220   0.498   0.048   0.344

IBC
Age     Sel         CWt
1       0.002   0.087
2       0.003   0.193
3       0.004   0.279
4       0.006   0.385
5       0.003   0.398
6       0.003   0.413
7       0.004   0.421
8       0.003   0.462

2014
Age     N           M       Mat     PF  PM      SWt
1       4139101 1.575   0.11    0       0       0.087
2       .           0.887       0.92    0       0       0.193
3       .           0.585       1           0   0       0.279
4       .           0.558       1           0   0       0.385
5       .           0.552       1           0   0       0.398
6       .           0.551       1           0   0       0.413
7       .           0.562       1           0   0       0.421
8       .           0.587       1           0   0       0.462

Catch
Age     Sel         CWt     DSel        DCWt
1       0.003   0.135   0.014   0.076
2       0.042   0.236   0.053   0.158
3       0.072   0.337   0.048   0.195
4       0.106   0.468   0.048   0.230
5       0.109   0.443   0.038   0.279
6       0.153   0.501   0.079   0.240
7       0.192   0.478   0.077   0.280
8       0.220   0.498   0.048   0.344

IBC
Age     Sel     CWt
1       0.002   0.087
2       0.003   0.193
3       0.004   0.279
4       0.006   0.385
5       0.003   0.398
6       0.003   0.413
7       0.004   0.421
8       0.003   0.462
```

2015

Age	N	M	Mat	PF	PM	SWt	
1	4139101	1.575	0.11	0	0	0.087	
2	.	0.887	0.92	0	0	0	0.193
3	.	0.585	1	0	0	0	0.279
4	.	0.558	1	0	0	0	0.385
5	.	0.552	1	0	0	0	0.398
6	.	0.551	1	0	0	0	0.413
7	.	0.562	1	0	0	0	0.421
8	.	0.587	1	0	0	0	0.462

Catch

Age	Sel	CWt	DSel	DCWt
1	0.003	0.135	0.014	0.076
2	0.042	0.236	0.053	0.158
3	0.072	0.337	0.048	0.195
4	0.106	0.468	0.048	0.230
5	0.109	0.443	0.038	0.279
6	0.153	0.501	0.079	0.240
7	0.192	0.478	0.077	0.280
8	0.220	0.498	0.048	0.344

IBC

Age	Sel	CWt
1	0.002	0.087
2	0.003	0.193
3	0.004	0.279
4	0.006	0.385
5	0.003	0.398
6	0.003	0.413
7	0.004	0.421
8	0.003	0.462

Input 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.

2013																															
		Catch				Landings					Discards			IBC		Landings															
Biomass	SSB	FMult	FBar	Yield		FBar	IV+VIId yield	IV yield	VIId yield		FBar	Yield		FMult		FBar	Yield				0.115										
453865	281593	1	0.153	26145		0.096	17466	13259	4207		0.053	7780		1		0.0038	899														
	2014	Catch				Landings					Discards			IBC		Landings			2015		2013 TAC IV		18932							
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							
596677	271218	0.00	0.004	1068		0.000	0	0	0		0.000	0		0		1	0.004		1068	673451	341495	-100%	-26%	No HC fishery						
.	271218	0.10	0.019	3691		0.010	1797	1364	433		0.005	831				1	0.004		1063	671218	339283	-93%	-25%							
.	271218	0.20	0.034	6285		0.019	3571	2711	860		0.011	1655				1	0.004		1059	669013	337100	-86%	-24%							
.	271218	0.30	0.049	8846		0.029	5321	4039	1282		0.016	2471				1	0.004		1054	666836	334945	-79%	-23%							
.	271218	0.40	0.064	11379		0.039	7049	5351	1698		0.021	3280				1	0.004		1050	664687	332817	-72%	-23%							
.	271218	0.50	0.078	13881		0.048	8754	6645	2109		0.027	4082				1	0.004		1045	662566	330717	-65%	-22%							
.	271218	0.60	0.093	16355		0.058	10437	7923	2514		0.032	4877				1	0.004		1041	660471	328644	-58%	-21%							
.	271218	0.70	0.108	18799		0.067	12098	9184	2914		0.037	5664				1	0.004		1037	658403	326597	-51%	-20%							
.	271218	0.75	0.116	20007		0.072	12918	9806	3112		0.040	6055				1	0.004		1035	657382	325587	-48%	-20%	0.75 * F(sq)						
.	271218	0.80	0.123	21214		0.077	13737	10428	3309		0.042	6445				1	0.004		1032	656361	324576	-45%	-20%							
.	271218	0.90	0.138	23603		0.087	15356	11657	3699		0.048	7219				1	0.004		1028	654344	322580	-38%	-19%							
.	271218	1.00	0.153	25963		0.096	16953	12869	4094		0.053	7986				1	0.004		1024	652353	320610	-32%	-18%	F(sq)						
.	271218	1.10	0.168	28296		0.106	18530	14066	4464		0.058	8746				1	0.004		1020	650387	318665	-26%	-17%							
.	271218	1.20	0.183	30602		0.115	20087	15248	4839		0.064	9500				1	0.004		1015	648445	316744	-19%	-17%							
.	271218	1.25	0.190	31742		0.120	20856	15832	5024		0.066	9874				1	0.004		1013	647486	315796	-16%	-16%	1.25 * F(sq)						
.	271218	1.27	0.194	32251		0.122	21199	16092	5106		0.067	10040				1	0.004		1012	647058	315372	-15%	-16%	15% TAC decrease (IV)						
.	271218	1.30	0.198	32882		0.125	21624	16415	5209		0.069	10247				1	0.004		1011	646527	314847	-13%	-16%							
.	271218	1.40	0.213	35137		0.135	23142	17568	5574		0.074	10988				1	0.004		1007	644633	312974	-7%	-15%							
.	271218	1.48	0.225	36992		0.143	24389	18514	5875		0.079	11600				1	0.004		1004	643076	311434	-2%	-15%	F(msy) proposed						
.	271218	1.50	0.228	37366		0.144	24640	18705	5935		0.080	11723				1	0.004		1003	642762	311124	-1%	-15%							
.	271218	1.52	0.231	37812		0.146	24939	18932	6007		0.081	11870				1	0.004		1002	642388	310754	0%	-15%	Rollover TAC						
.	271218	1.60	0.242	39570		0.154	26120	19828	6292		0.085	12451				1	0.004		999	640914	309297	5%	-14%							
.	271218	1.70	0.257	41748		0.164	27580	20936	6644		0.090	13173				1	0.004		995	639089	307493	11%	-13%							
.	271218	1.78	0.269	43391		0.171	28680	21772	6909		0.094	13719				1	0.004		992	637714	306134	15%	-13%	15% TAC increase (IV)						
.	271218	1.80	0.272	43803		0.173	29023	22032	6991		0.095	13889				1	0.004		991	637286	305711	16%	-13%							
.	271218	1.90	0.287	46033		0.183	30447	23113	7334		0.101	14599				1	0.004		987	635506	303951	22%	-12%							
.	271218	1.99	0.300	47843		0.191	31655	24030	7625		0.105	15205				1	0.004		984	633994	302458	27%	-12%	F(msy) previous proxy						
.	271218	2.00	0.302	48140		0.192	31853	24180	7673		0.106	15304				1	0.004		983	633746	302213	28%	-11%							

Input units are thousands and kg - output in tonnes

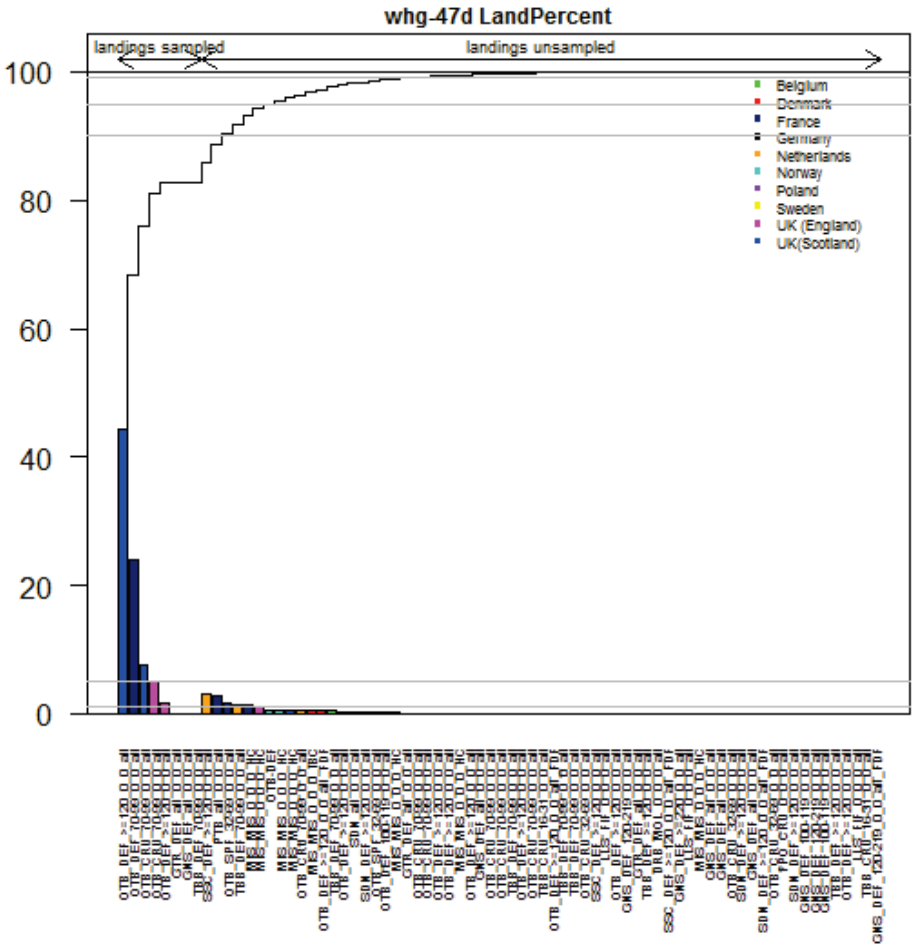


Figure 12.1: Whiting in Subarea IV and Division VIId. Reported landings for each sampled and unsampled fleet, along with cumulative landings for fleets in descending order of yield.

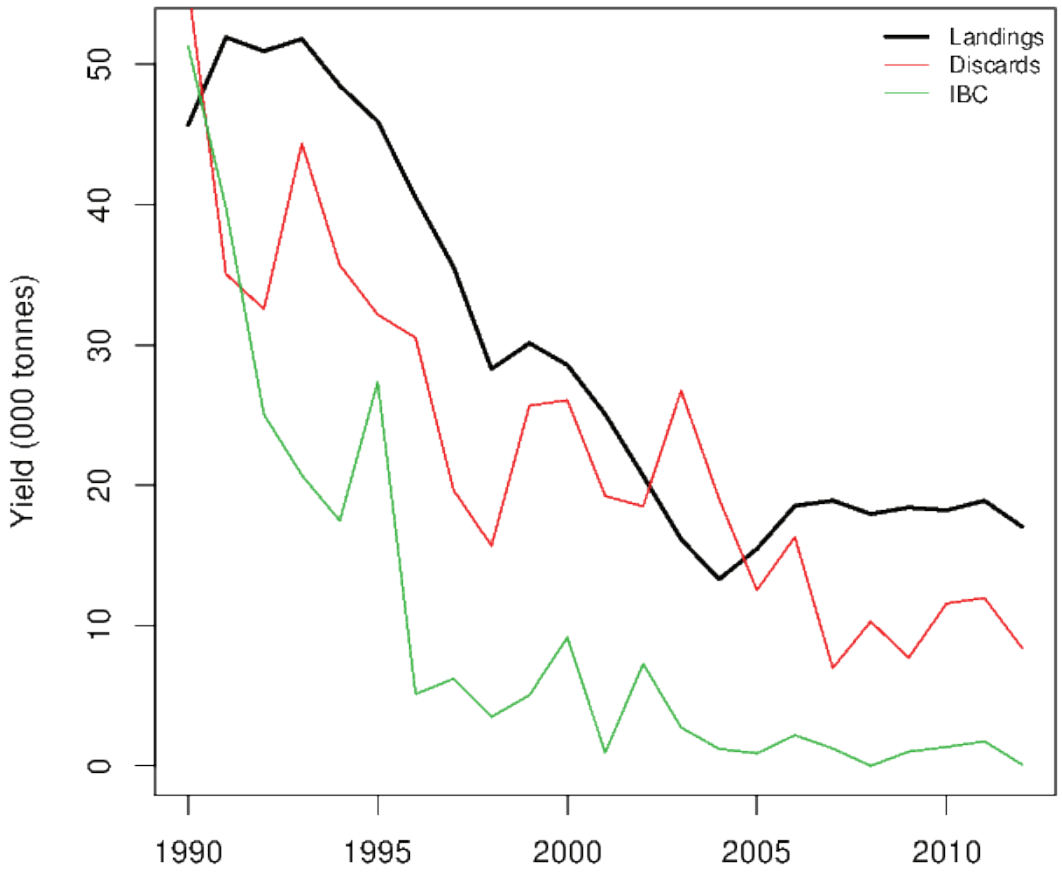


Figure 12.2: Whiting in Subarea IV and Division VIId. Yield by catch component.

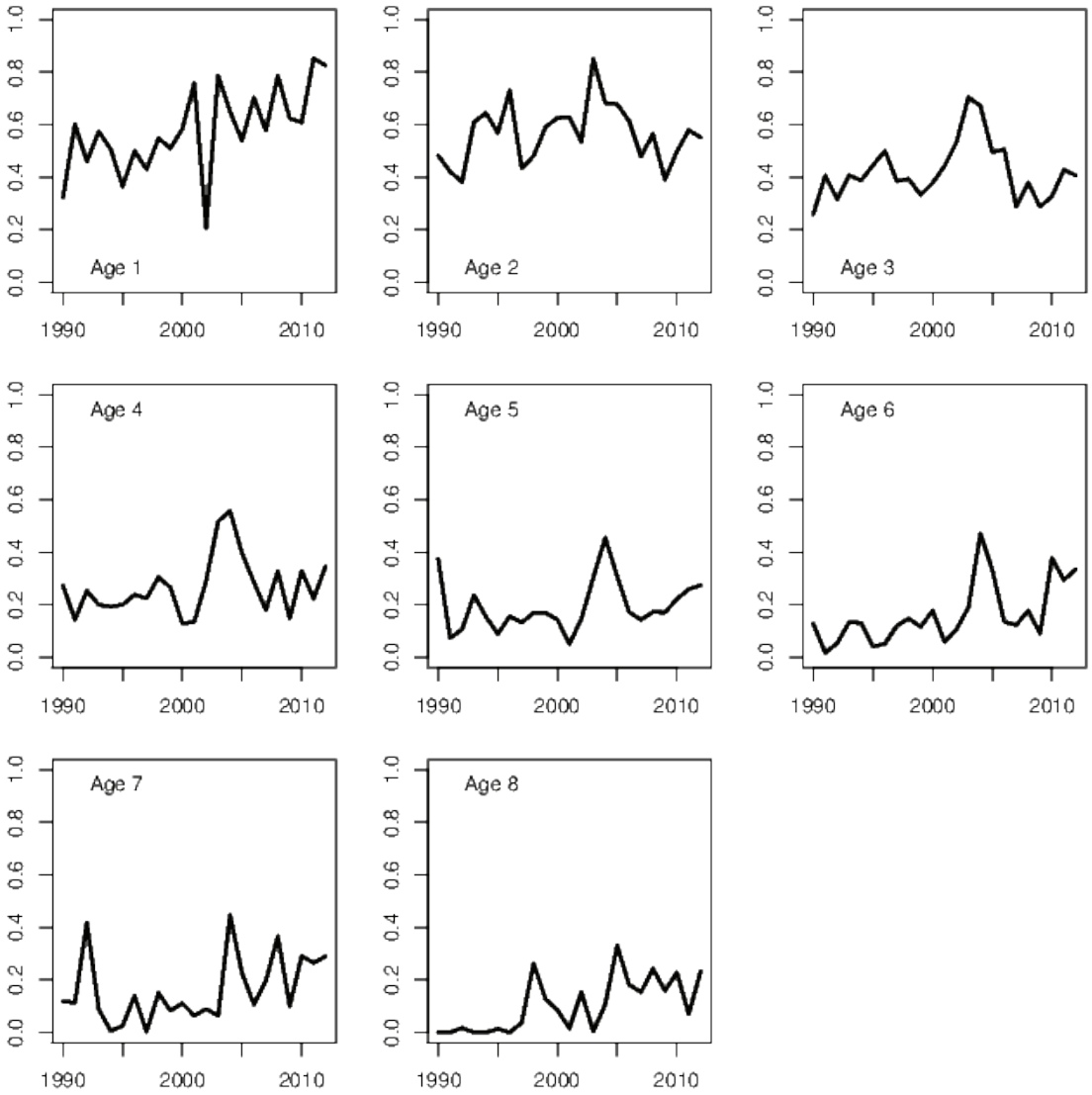


Figure 12.3: Whiting in Subarea IV and Division VIId. Proportion of total catch discarded, by age and year.

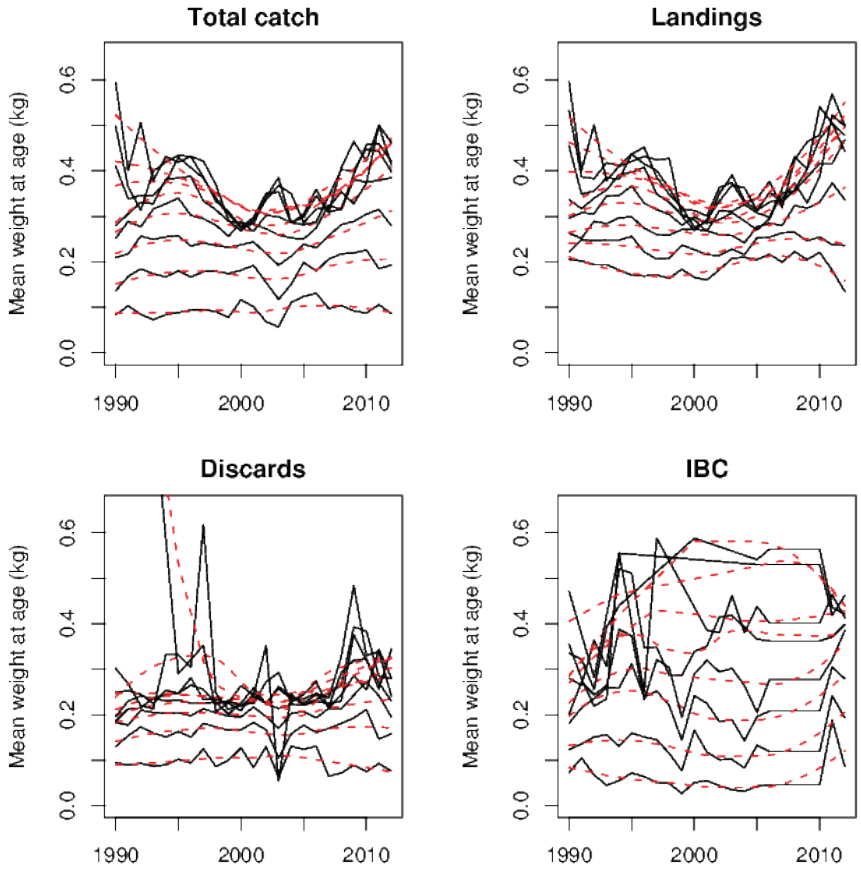


Figure 12.4: Whiting in Subarea IV and Division VIId. Mean weights-at-age (kg) by catch component. Catch mean weights are also used as stock mean weights. Red dotted line give loess smoothers through each time-series of mean weights-at-age.

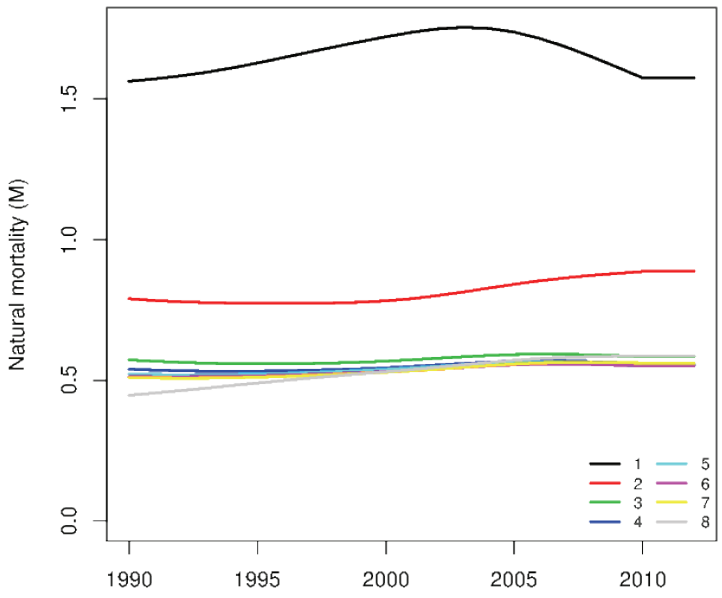


Figure 12.5: Whiting in Subarea IV and Division VIId. Natural mortality estimates from the 2012 SMS key run, used in this year's assessment.

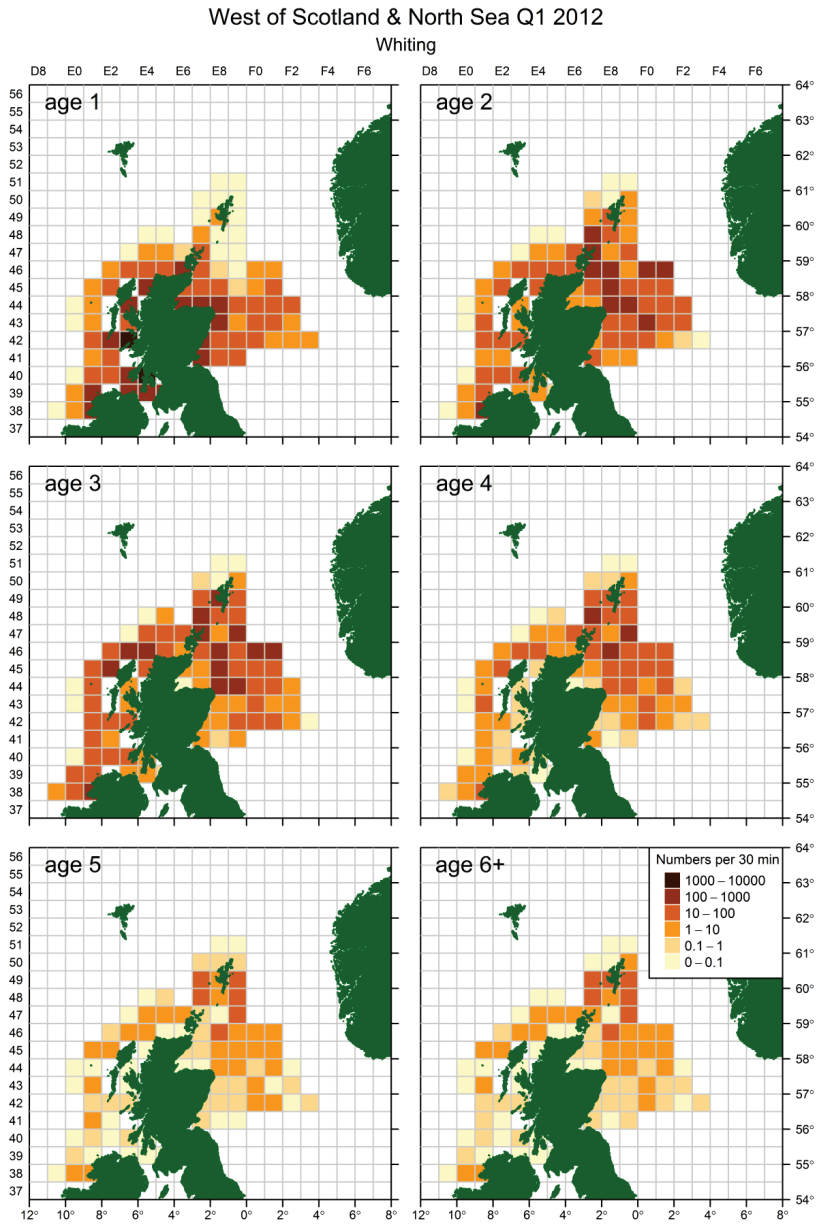


Figure 12.6: Whiting in Subarea IV and Division VIId. Survey distribution maps for Q1 2012. Colours indicate numbers caught per 30 minutes for each age (on a $\log_{10}$ scale). The maps are based on the Scottish Q1 groundfish surveys in the North Sea (which forms part of the IBTS-Q1 survey) and Division VIa (which takes place a week later).

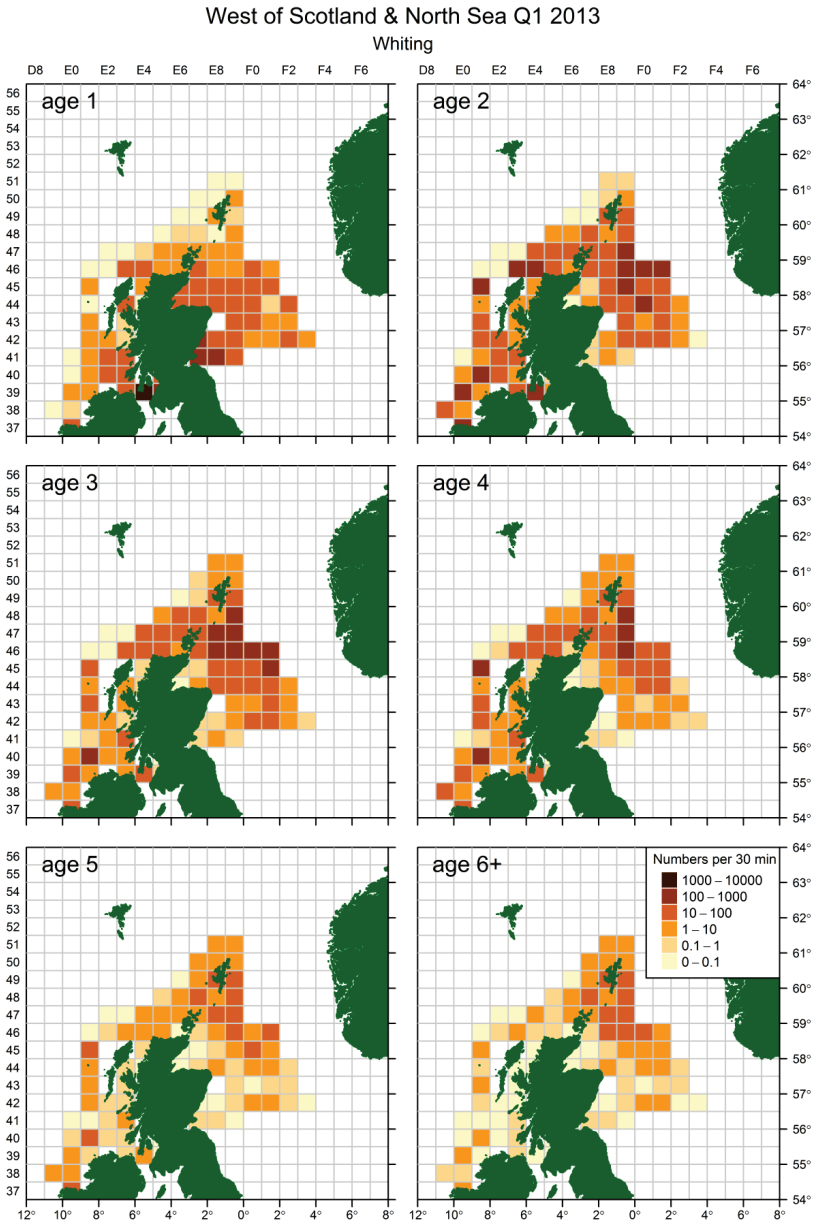


Figure 12.7: Whiting in Subarea IV and Division VIId. Survey distribution maps for Q1 2013. Colours indicate numbers caught per 30 minutes for each age (on a $\log_{10}$ scale). The maps are based on the Scottish Q1 groundfish surveys in the North Sea (which forms part of the IBTS-Q1 survey) and Division VIa (which takes place a week later).

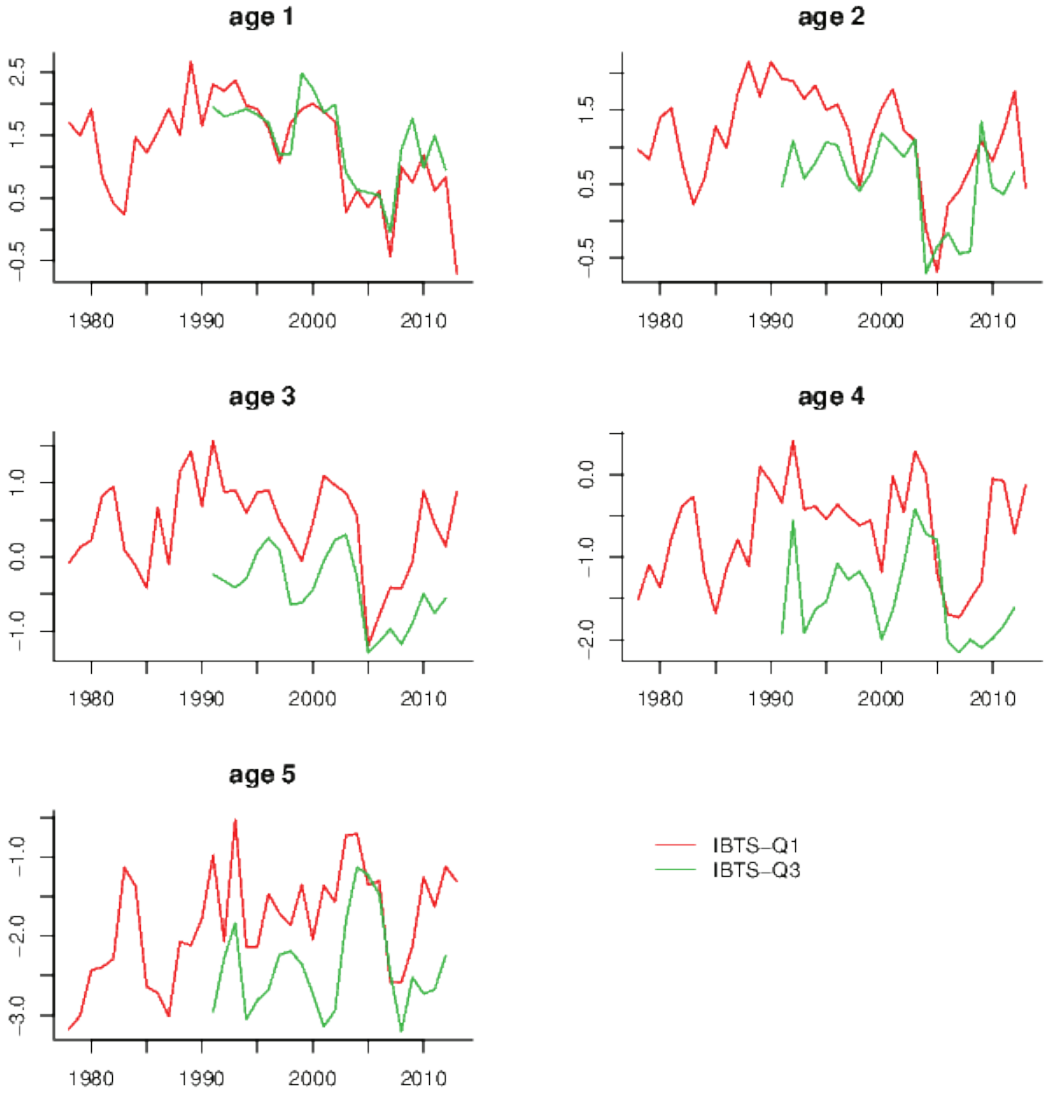


Figure 12.8: Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) at age.

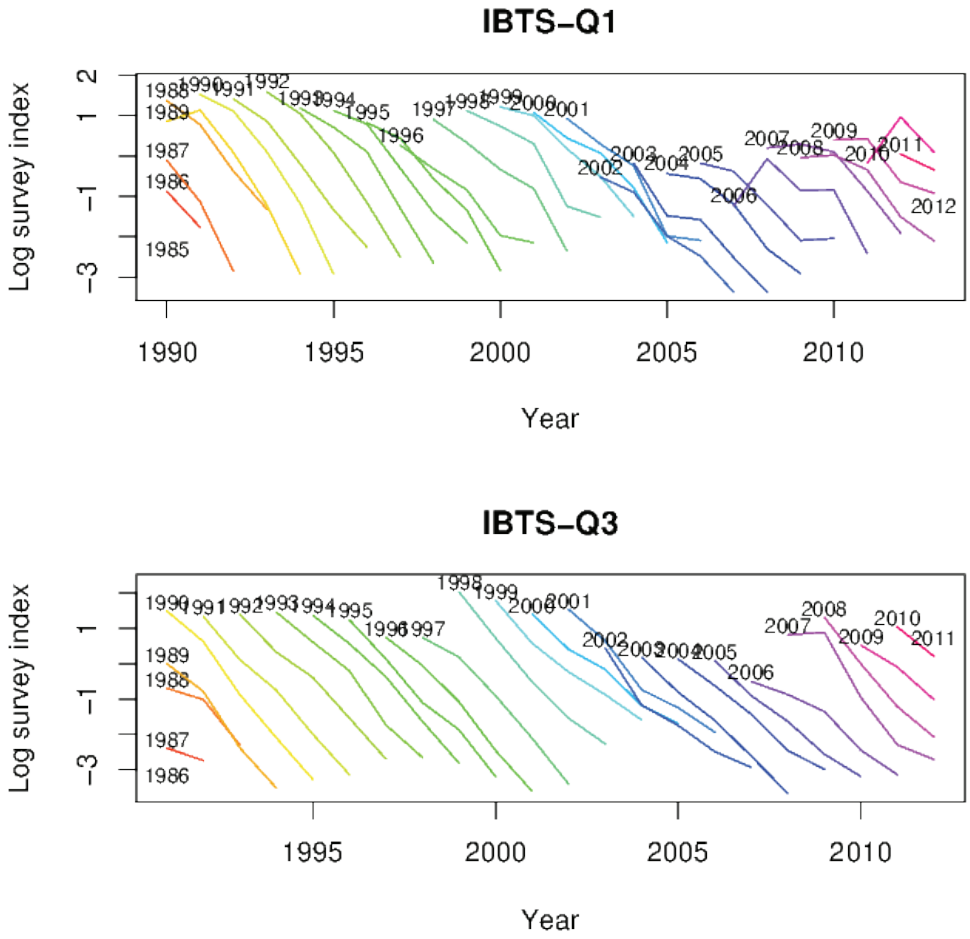


Figure 12.9: Whiting in Subarea IV and Division VIId. Log abundance indices by cohort for each of the two survey indices. The spawning year for each cohort is indicated at the start of each line.

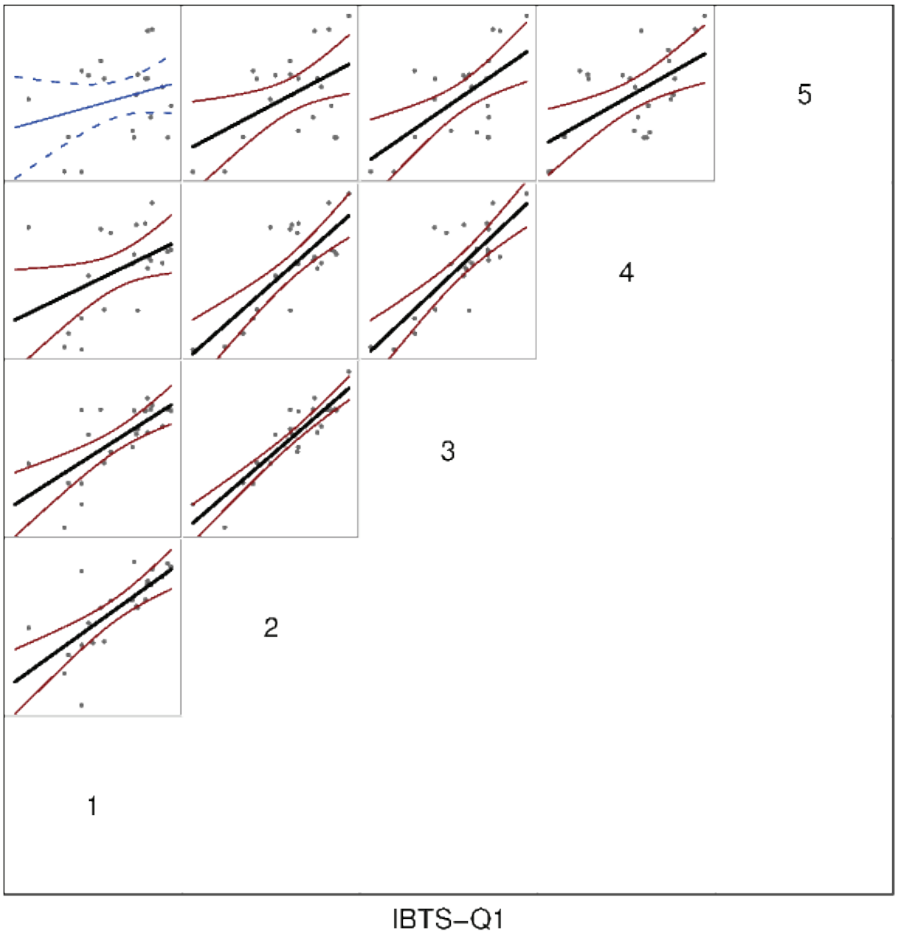


Figure 12.10: Within-survey correlations for the IBTS Q1 survey series, comparing index values at dif- ferent ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

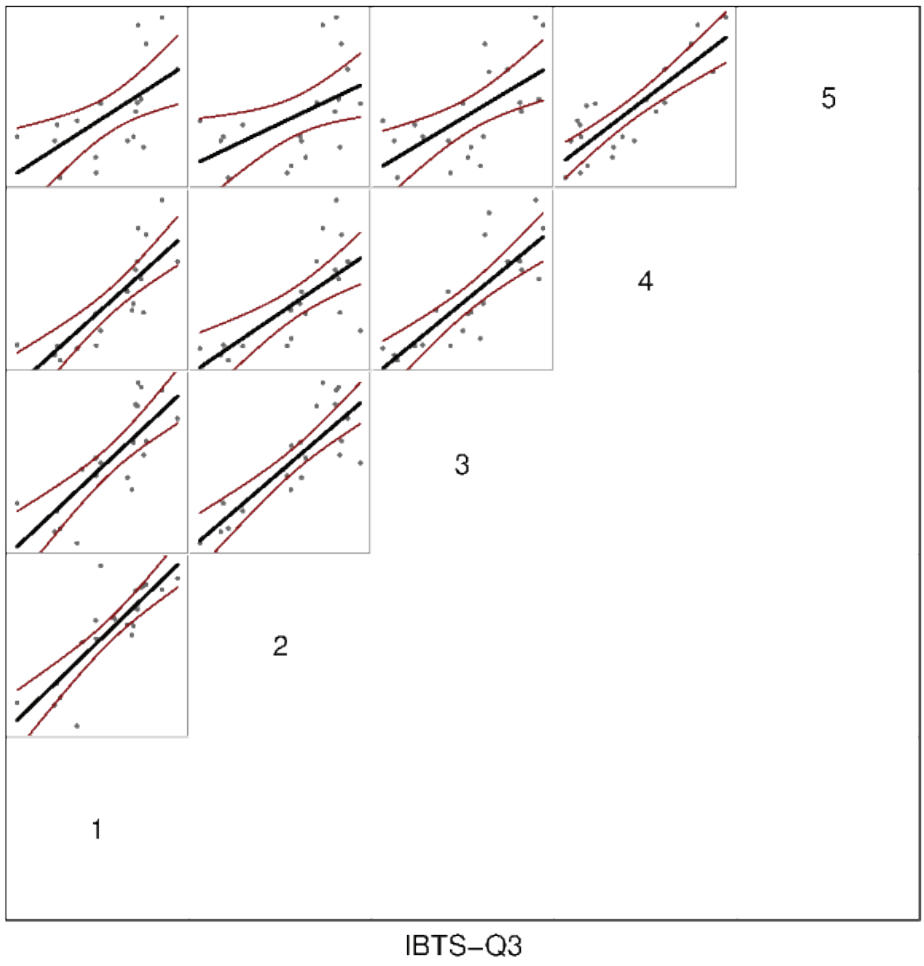


Figure 12.11: Within-survey correlations for the IBTS Q3 survey series, comparing index values at dif- ferent ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown.

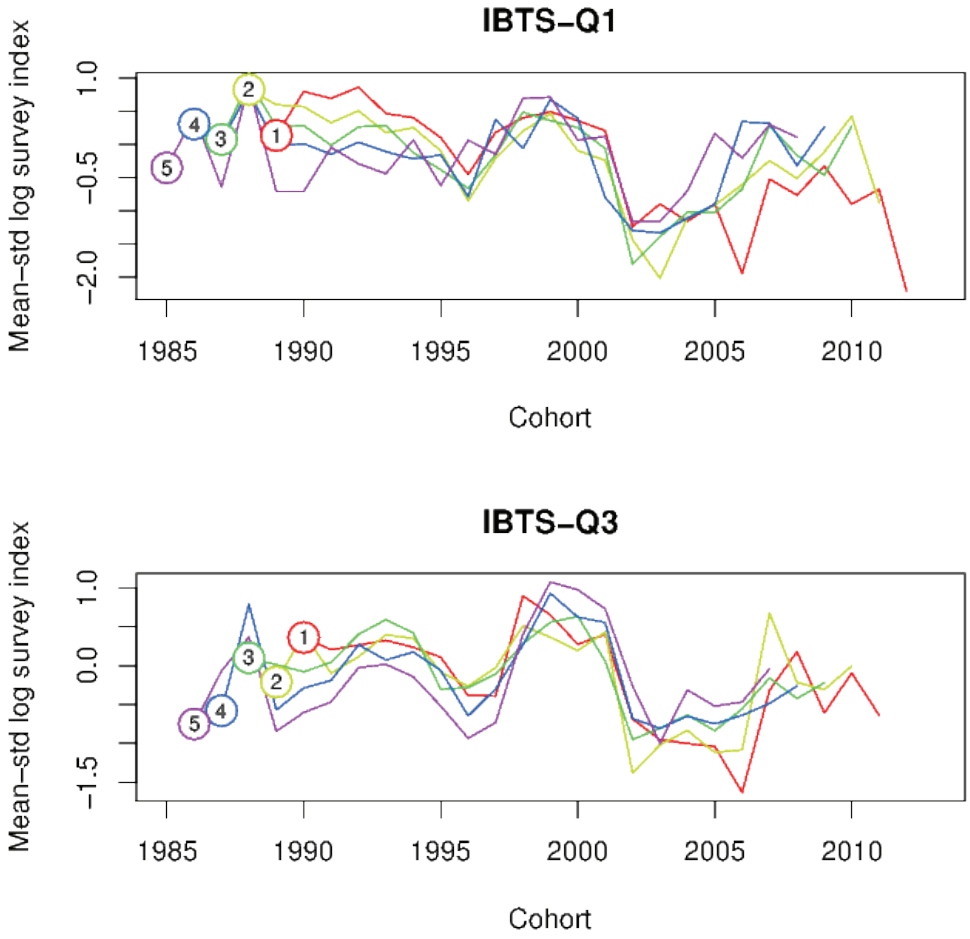


Figure 12.12: Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) for the IBTS Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

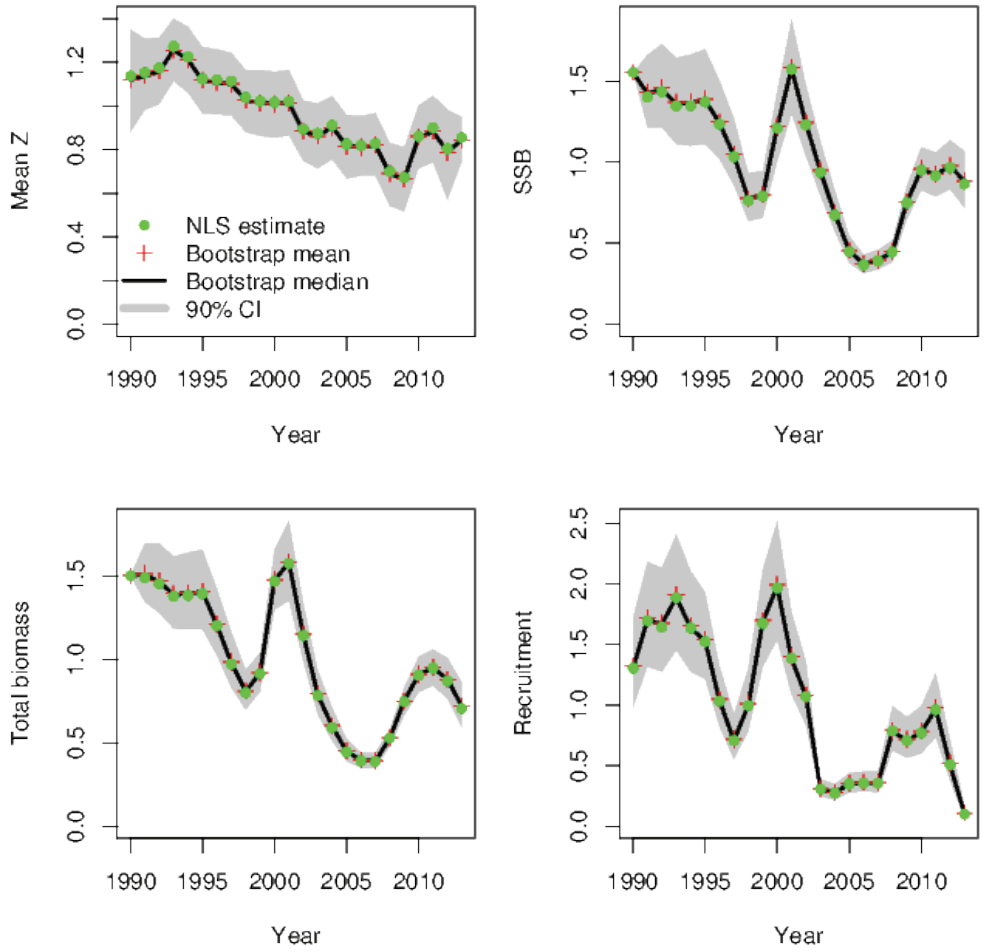


Figure 12.13: Whiting in Subarea IV and Division VIId. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond 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.

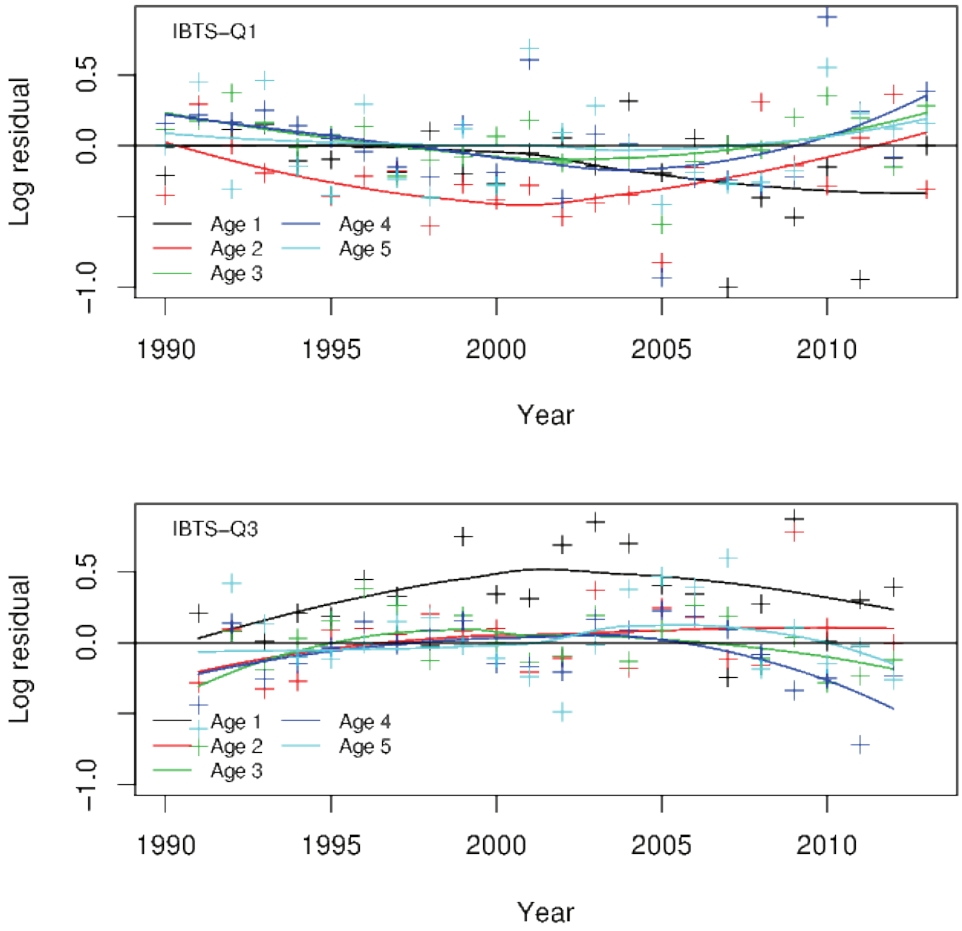


Figure 12.14: Whiting in Subarea IV and Division VIId. Log survey residuals from the SURBAR analysis. Ages are colour-coded, and a loess smoother (span = 2) has been fitted through each age time-series.

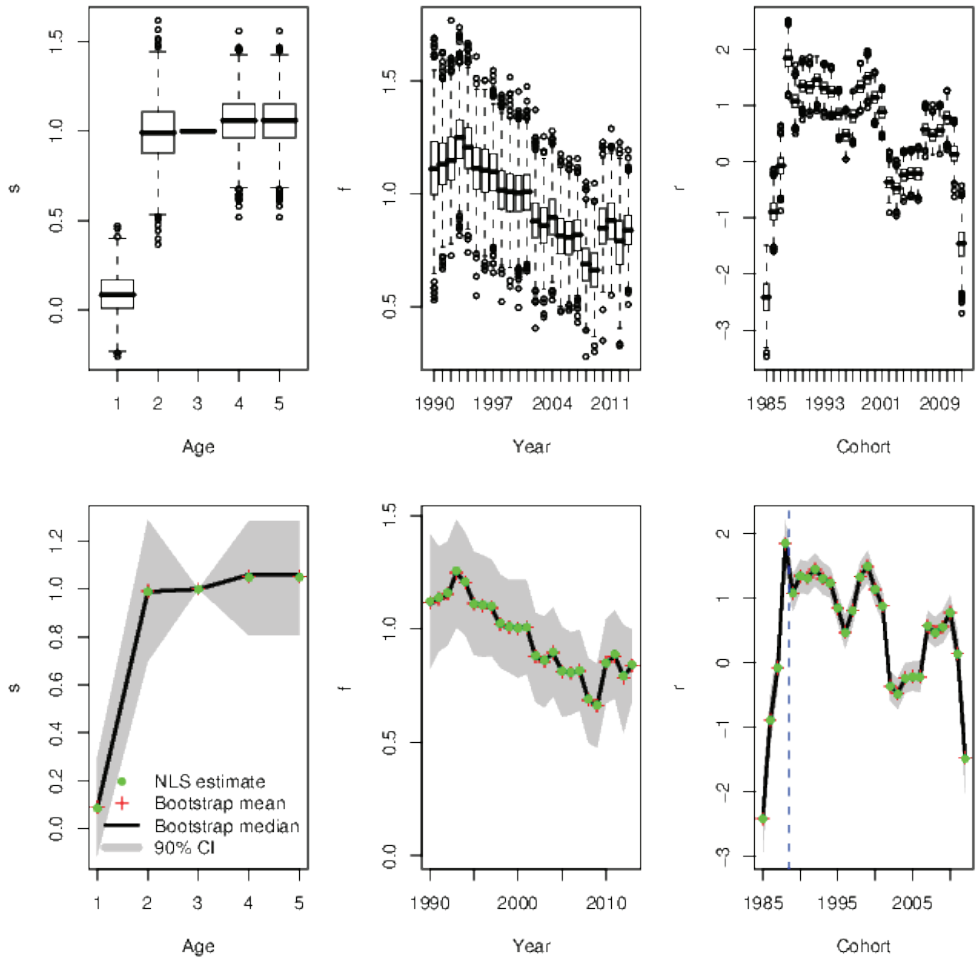


Figure 12.15: Whiting in Subarea IV and Division VIId. Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

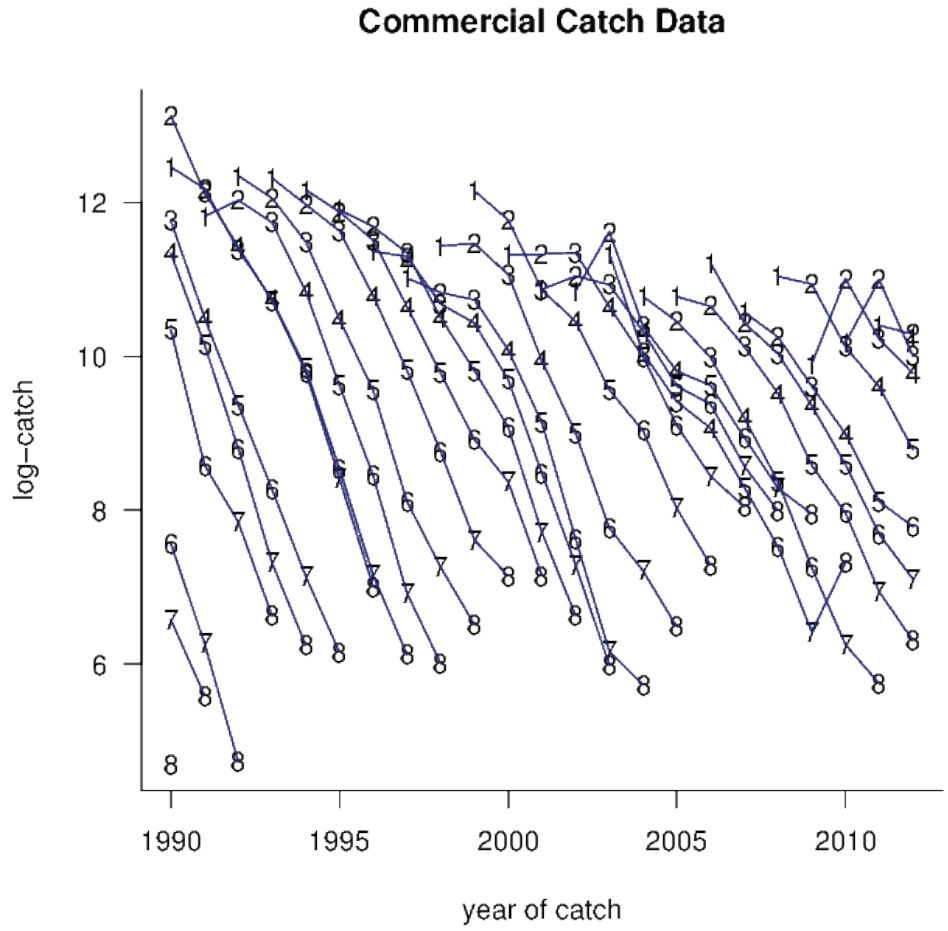


Figure 12.16: Whiting in Subarea IV and Division VIId. Log catch curves by cohort for total catches.

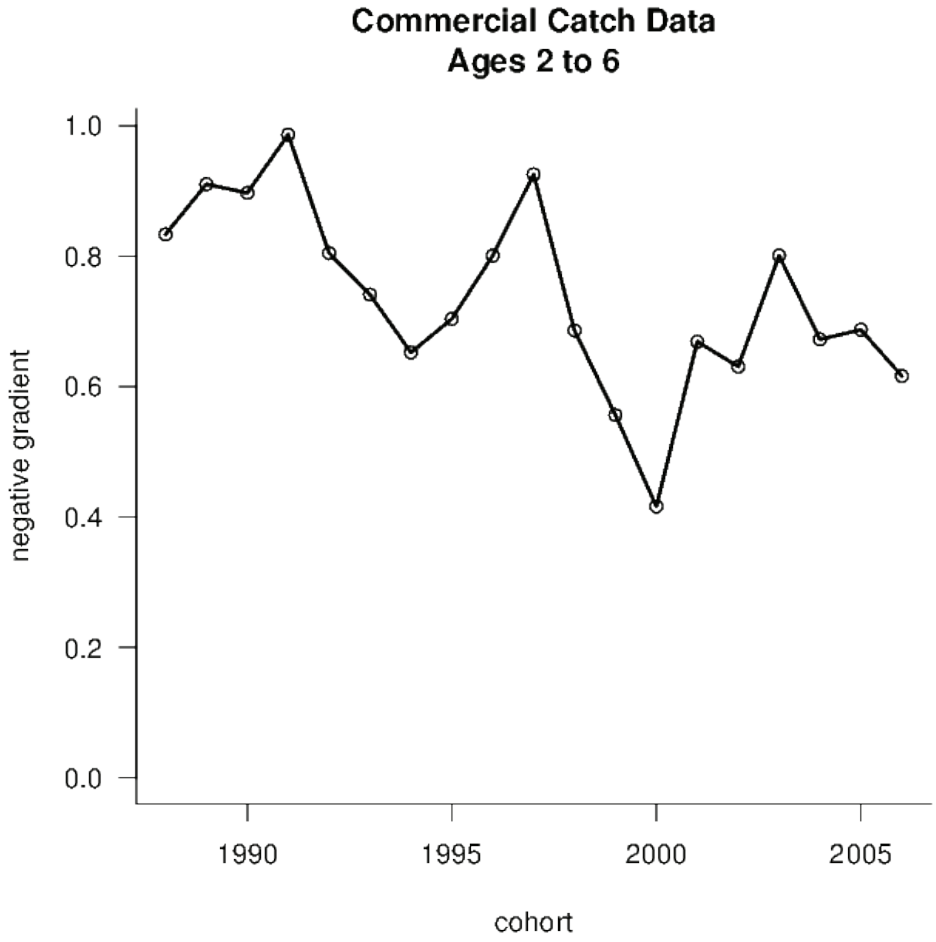


Figure 12.17: Whiting in Subarea IV and Division VIId. Negative gradients of log catches per cohort, averaged over ages 2-6. The x-axis represents the spawning year of each cohort.

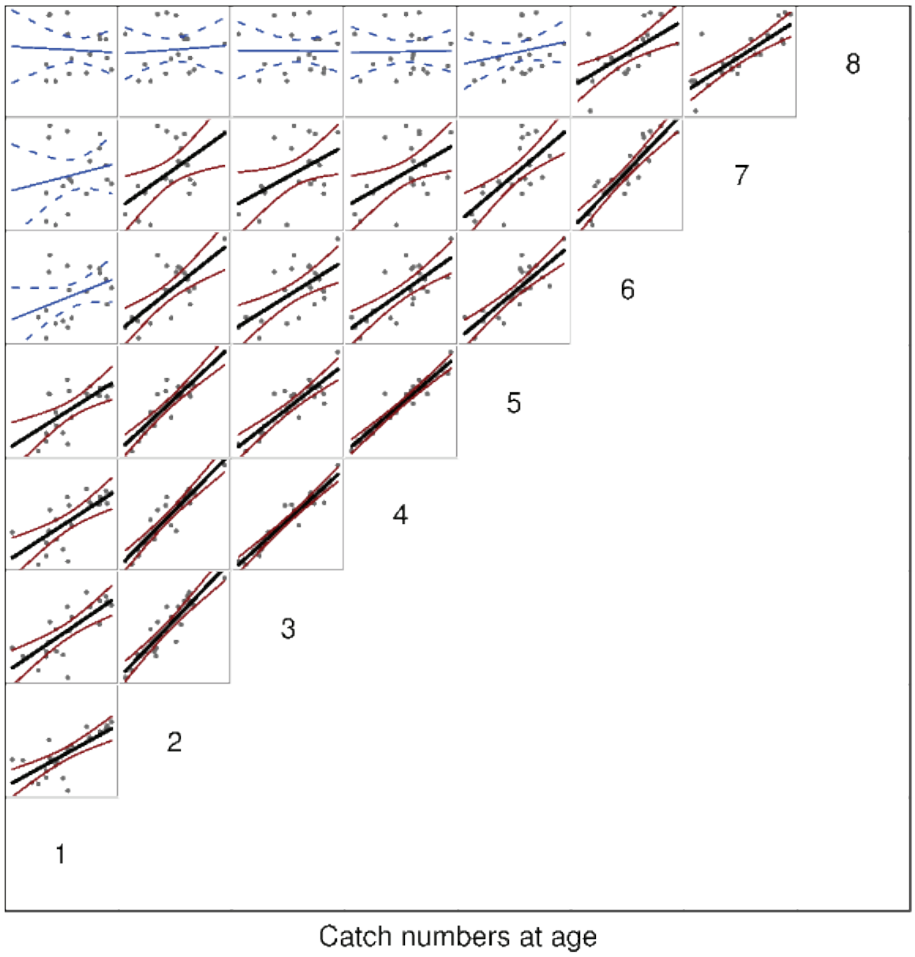


Figure 12.18: Whiting in Subarea IV and Division VIId. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black 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.

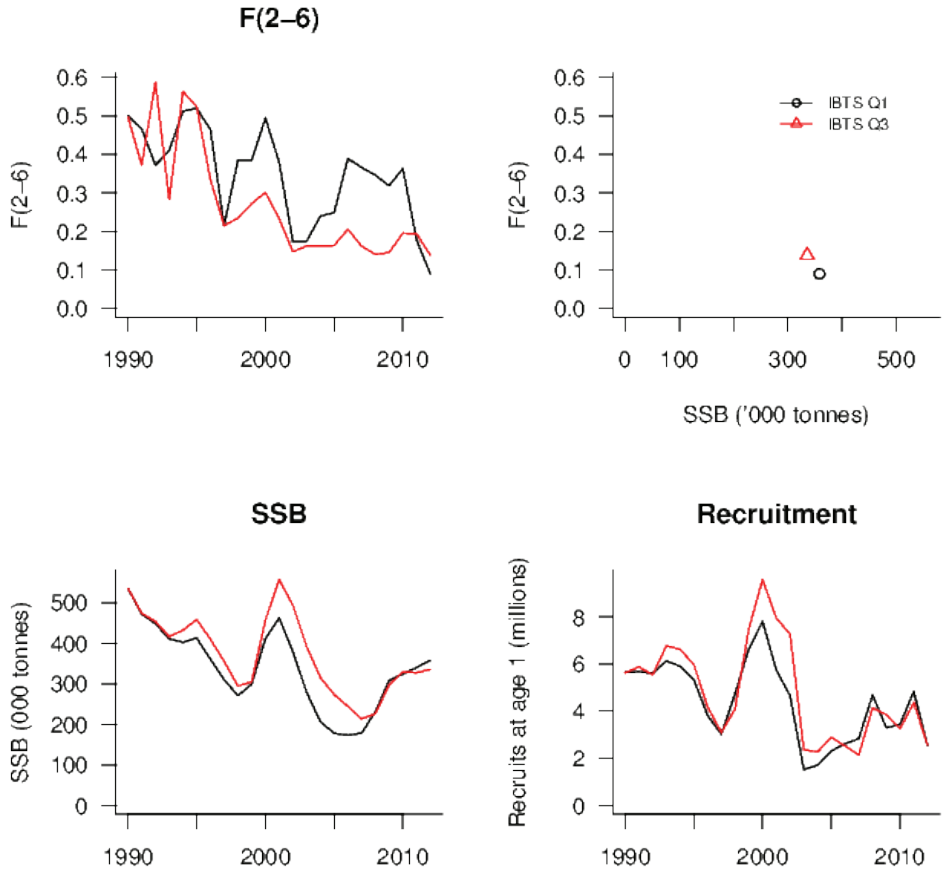


Figure 12.19: Whiting in Subarea IV and Division VIId. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2012) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

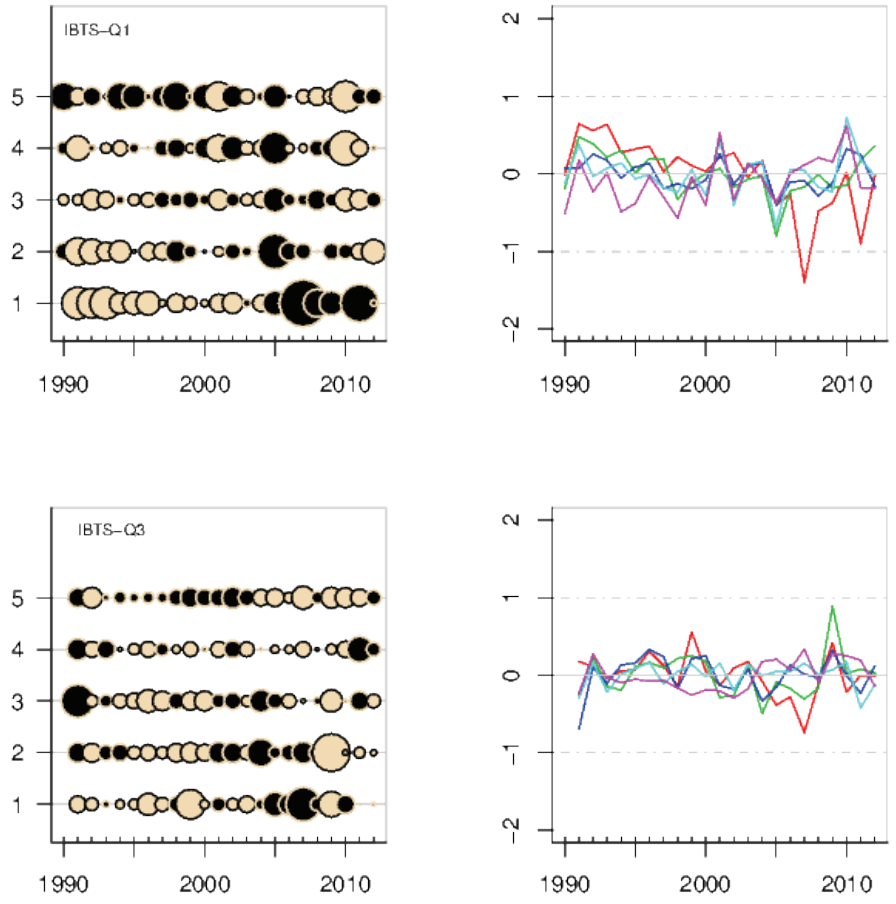


Figure 12.20: Whiting in Subarea IV and Division VIId. Log catchability residuals for single-fleet FLXSA assessments.

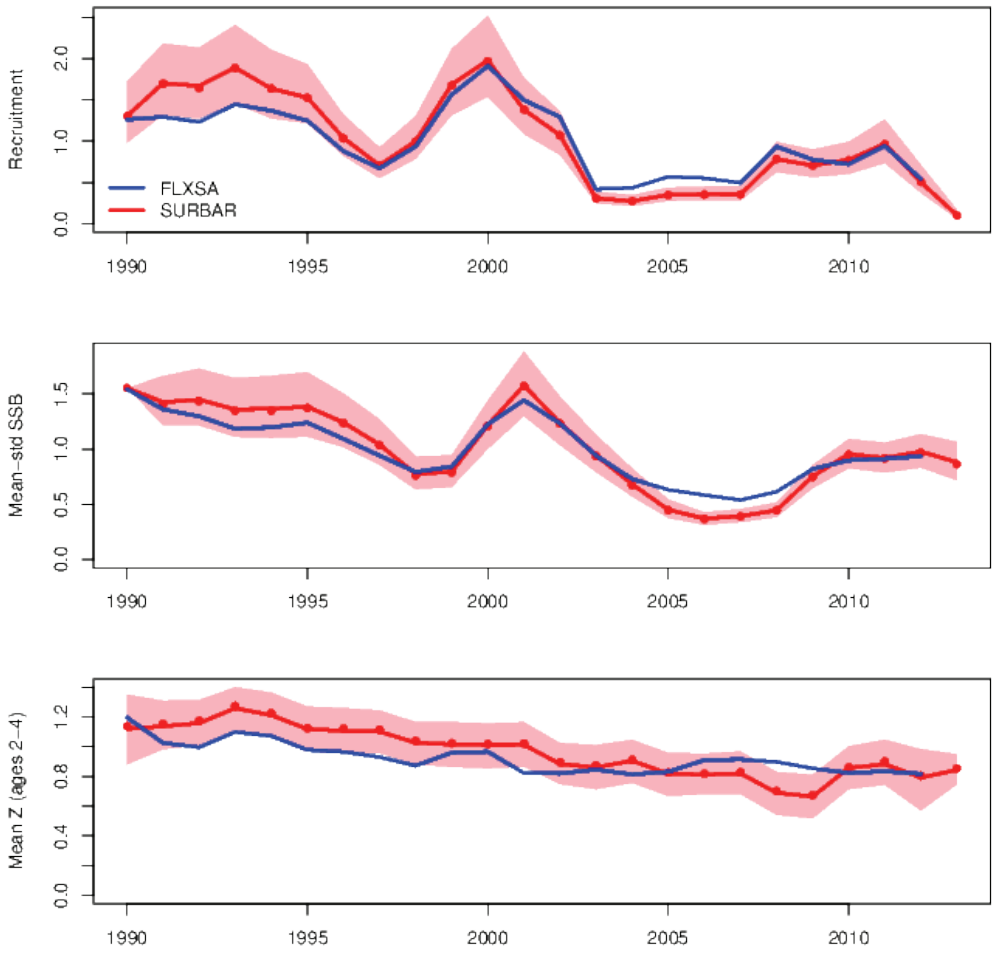


Figure 12.21: Whiting in Subarea IV and Division VIId. Comparisons of stock summary estimates from the final XSA (blue) and SURBAR (red) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models. The SURBAR estimates are plotted along with their 90% confidence bounds (shaded pink regions).

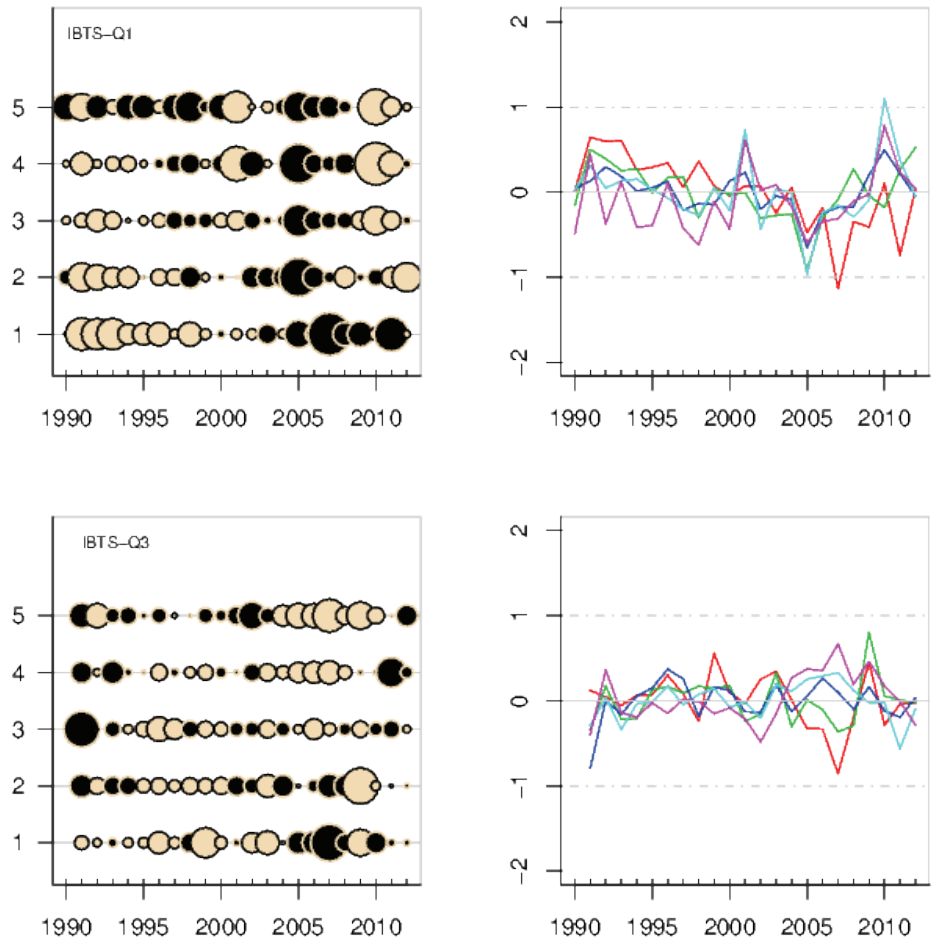


Figure 12.22: Whiting in Subarea IV and Division VIId. Log catchability residuals for final FLXSA assessment.

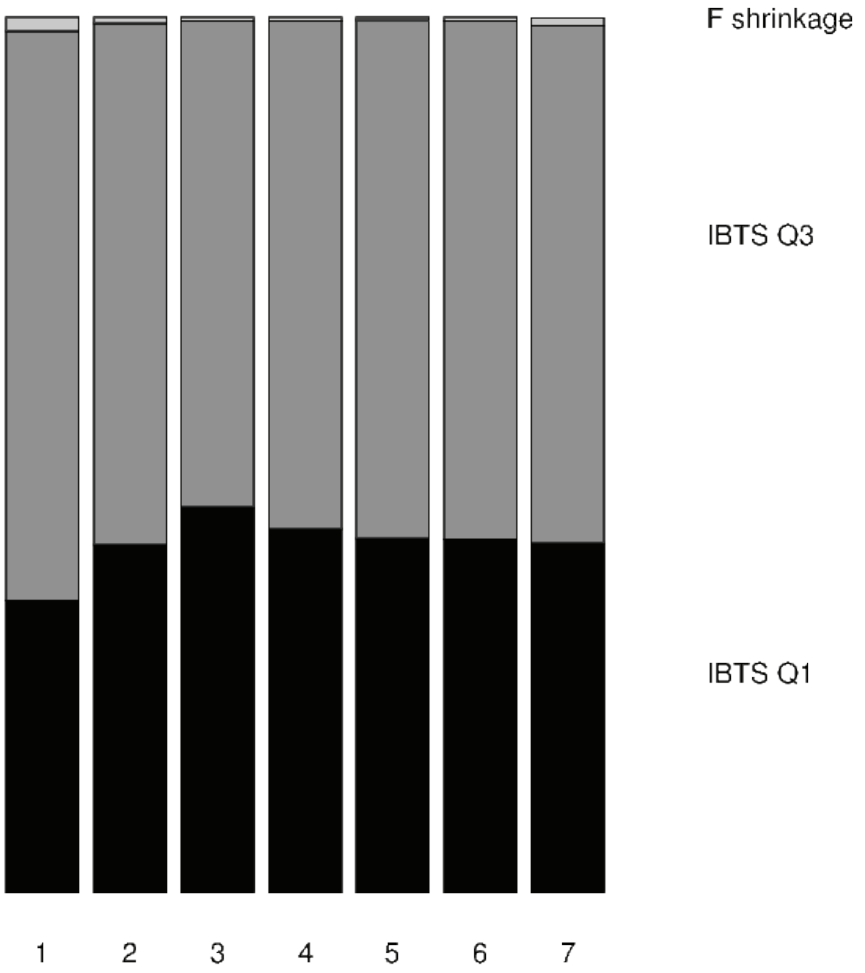


Figure 12.23: Whiting in Subarea IV and Division VIId. Contribution to survivors' estimates in final FLXSA assessment.

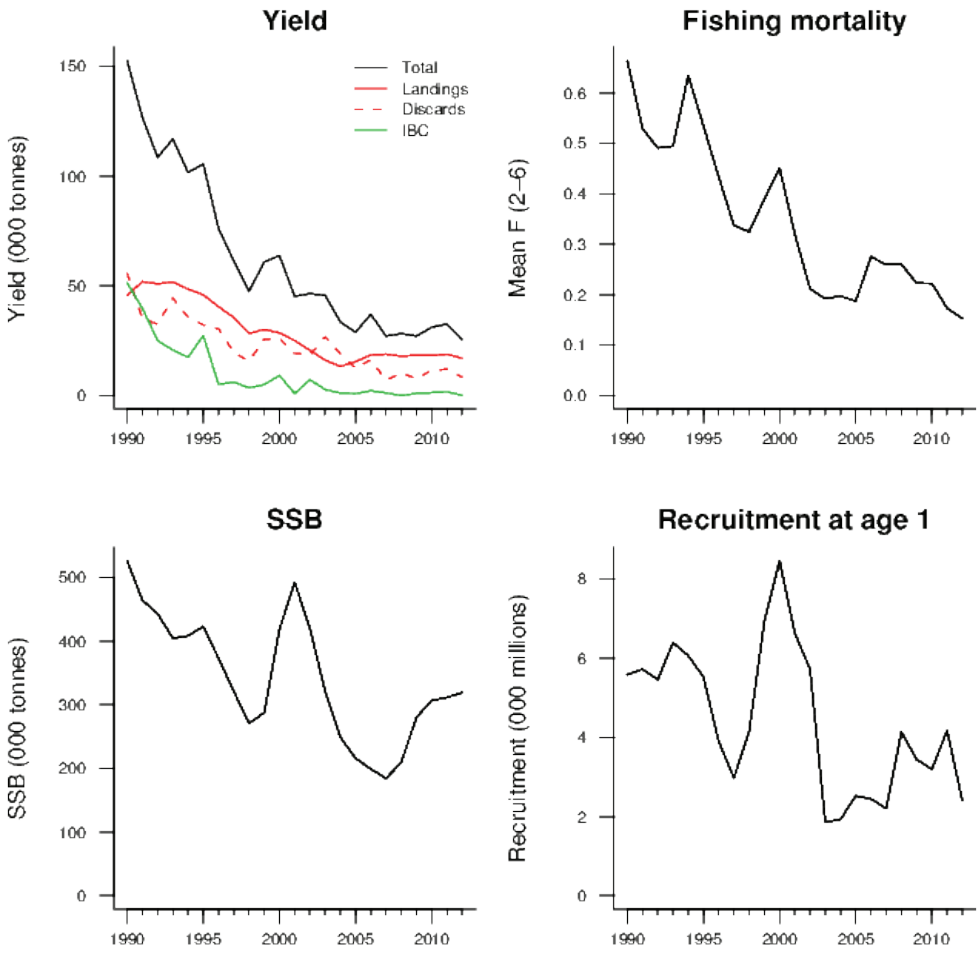


Figure 12.24: Whiting in Subarea IV and Division VIId. Summary plots for final FLXSA assessment.

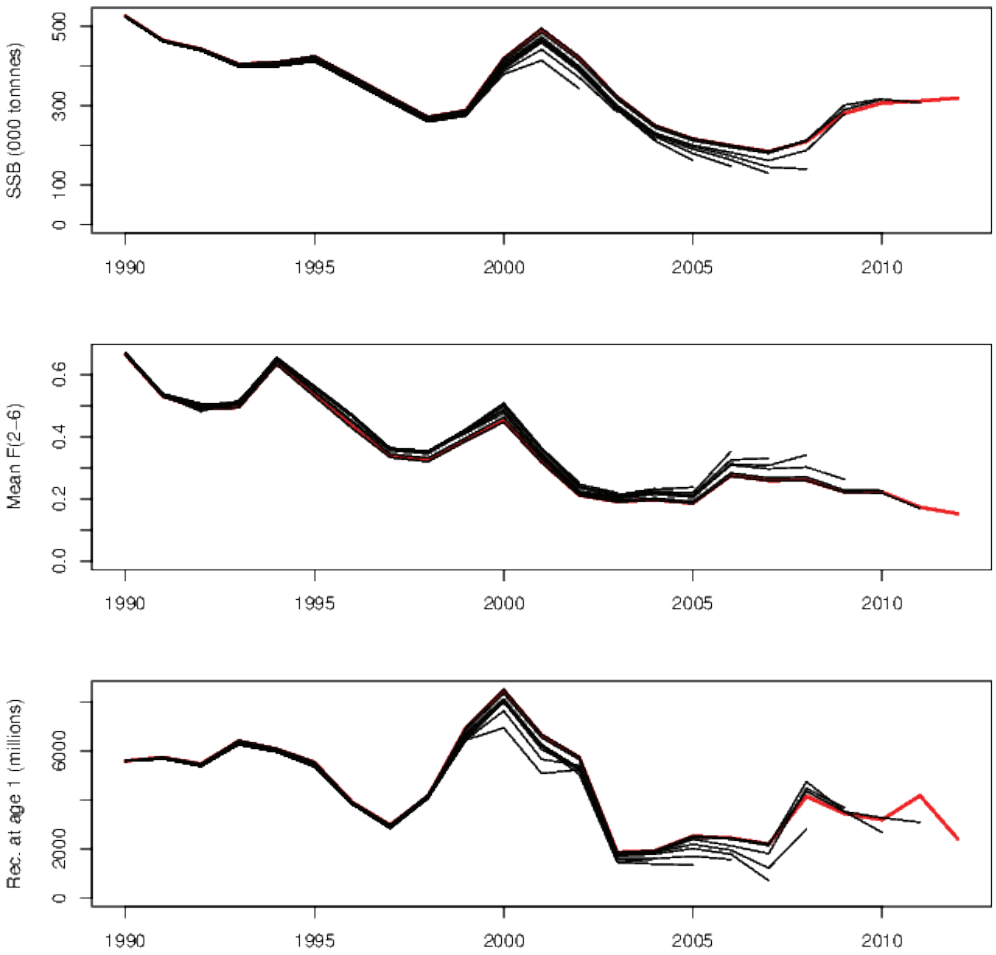


Figure 12.25: Whiting in Subarea IV and Division VIId. Retrospective plots for final FLXSA assessment.

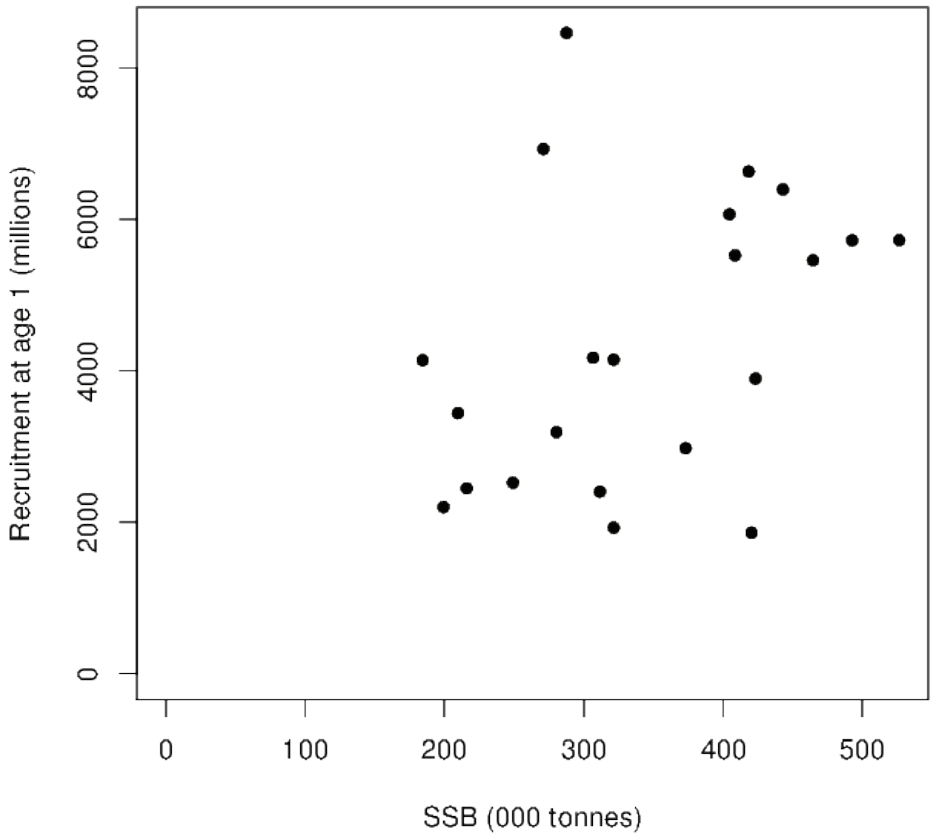


Figure 12.26: Whiting in Subarea IV and Division VIId. Stock-recruitment plot from final FLXSA assess- ment.

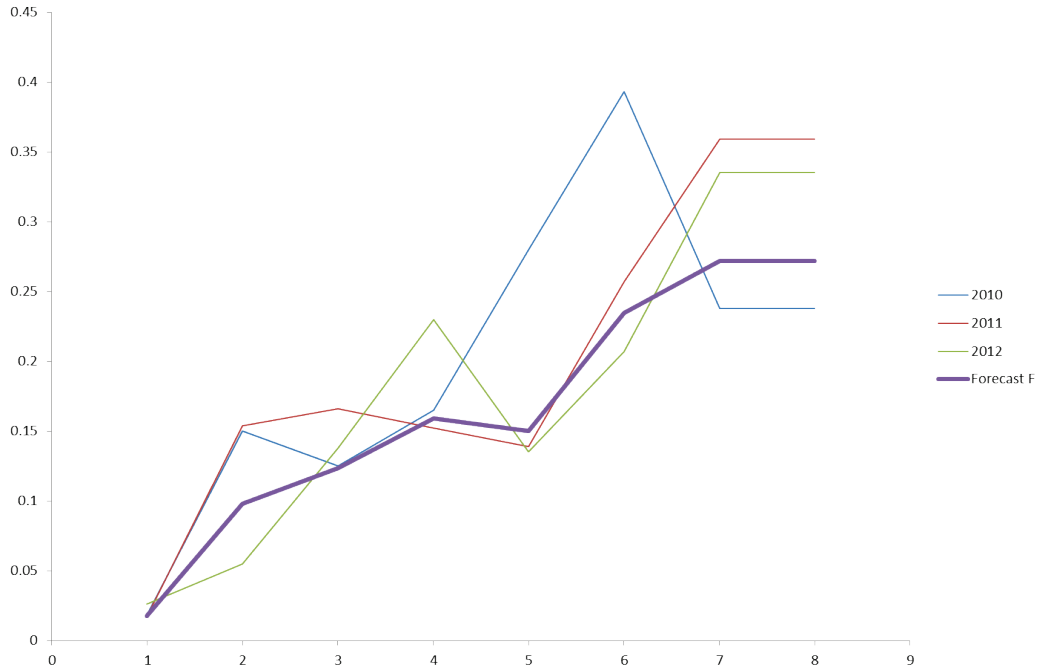


Figure 12.27: Whiting in Subarea IV and Division VIId. FLXSA F at age estimates for 2010-2012, along with scaled mean exploitation used for the forecast.

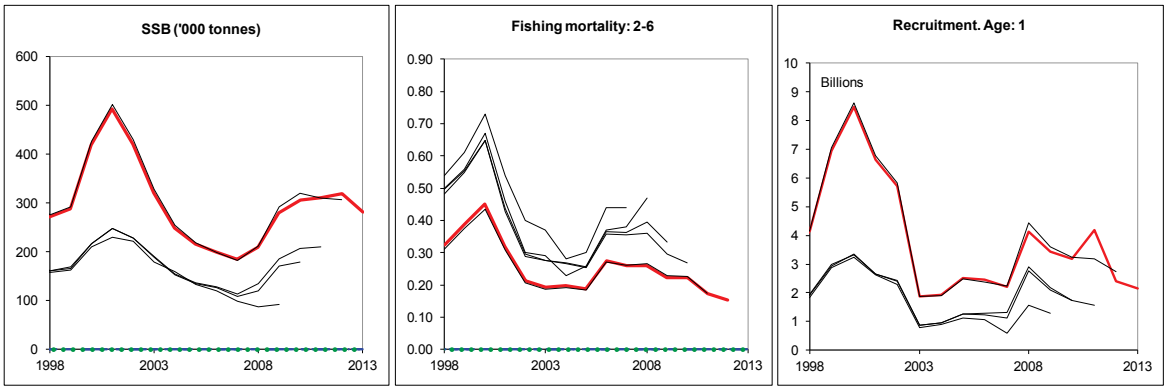


Figure 12.28: Whiting in Subarea IV and Division VIId. Historical assessment comparison plot.

13 Haddock in Subarea IV and Division IIIa (N)

The assessment of haddock presented in this section is an update assessment.

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 North Sea, as vessels will sometimes operate in Divisions VIa (off the west coast of Scotland), 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. 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 2011). 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 moderate 2005 and 2009 year-classes now form the bulk of haddock catches, and discarding rates for the 2005 year-class fish declined during 2008-2010 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 2010-2012 was not provided to WGNSSK. A more complete history of the North Sea haddock fishery is given in the Stock Annex. It is difficult to conclude what will be the likely effect of the recent fishery changes on haddock mortality. Changes in gear that are required to qualify for the Scottish CCS are likely to reduce 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.

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, Swe-

den 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.

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. Quota uptake for the international fleet for 2012 was around 80%. The projected quota uptake for 2013 is thought to be in line with last year.

13.1.3 ICES advice

ICES advice for 2012

In June 2011, ICES concluded the following:

> *Fishing mortality has been below Fpa and SSB has been above 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 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 43000 t in 2012. This is expected to lead to an SSB of 227 000 t in 2013. Following the management plan implies a TAC of 41575 in 2012 which is expected to lead to a TAC reduction of 15% and an F increase of 23%.*

Following the 2011 Q3 North Sea surveys for haddock (EngGFS and ScoGFS), 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 2011, but the difference was not significant enough to warrant reconsideration of the advice.

ICES advice for 2013

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.

13.1.4 Management

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 interannual quota flexibility, 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 2011, 185 closures have been implemented. In 2012, 173 closures have been implemented. In 2013, 51 closures have been implanted by 29th April. 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 are summarised in the Stock Annex.

13.2 Data available

Collation issues for catch data

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 a large number of fleet components for which haddock 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.

13.2.1 Catch

Official landings data for each country participating in the fishery are presented in Table 13.2.1.1, together with the corresponding WG estimates and the agreed international quota (listed as "total allowable catch" or TAC). The full time series of landings, discards and industrial by-catch (IBC) is presented in Table 13.2.1.2. These data are illustrated further in Figure 13.2.1.1. The total landed yield of the international fishery has been stable since 2007. The WG estimates (Table 13.2.1.2) suggest that haddock discarding increased slightly (as a proportion of the total catch) during 2010. This may be due in part to fleet behaviour changes related to cod avoidance measures. Subarea IV discard estimates are derived from data submitted by Scotland, England and Denmark. 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 Denmark, Germany, Scotland and England, although only Denmark is obliged to do so. Industrial bycatch (IBC) has declined considerably from the high levels observed until the late 1970s. In 2012, for age 2, haddock discards decreased significantly (both in absolute terms, and as a proportion of total catch). For all other ages, discards remained stable

The approach used to collate discard data changed last year to conform with the EU Data Collection Framework (DCF), beginning with the 2009 data year. The new approach is described in detail in Miller and Fryer (2005) and Fernandes *et al* (in press) and can be summarised as follows:

1) Observer trips that fish in more than one sampling area have historically been split with landings and discard components being recorded for each area. These are also stored on FMD (the Scottish fisheries database) with different trip identification numbers. Hence "trips" extracted from FMD are in fact trips within sampling area, and do not equate to a voyage of a fishing vessel from leaving port, fishing, and returning to port. Where the sampling area is smaller than the reporting area (e.g. sampling area IVa inshore within reporting area ICES area IV) this can lead to pseudo replication of trips in the calculation of confidence intervals on numbers at length or age. To rectify this trips are now merged so that they correspond to a voyage where that voyage has occurred wholly within a reporting area. Hence the correct numbers of replicates are used in the calculation of discard estimates confidence intervals.

2) The auxiliary variable in the calculation of discard estimates is the landed weight of the species of interest, plus the landed weight of gadoids: cod, haddock, whiting and saithe and *Nephrops*. This auxiliary variable overcomes the problem of estimating discard contribution of a trip to the fleet

level where the trip has not landed the species of interest. In 2009 the auxiliary variable was a collection of gadoids and other demersal fish, but there was no weighting by *Nephrops*.

Direct comparisons with the previous method are not available, but the plot of discard rates by age in Figure 13.2.1.2 shows that the 2010 and 2011 estimates are well within the range of recent variation. This suggests that the new collation method did not change the perception of discard rates for haddock.

13.2.2 Age compositions

Total catch-at-age data are given in Table 13.2.2.1, while catch-at-age data for each catch component are given in Tables 13.2.2.2 to 13.2.2.4. The fishery in 2012 (landings for human consumption) was strongly reliant on the 2005 and 2009 year-classes. The strong 1999 year-class has faded from the fishery, and the size of the plus-group is continuing to decline from its recent high. 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 13.2.3.1. 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 13.2.3.2-4 and are illustrated in Figure 13.2.3.1: 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 and natural mortality are assumed to be fixed over time and are given below. The basis for these estimates is described in the Stock Annex.

AGE	0	1	2	3	4	5	6	7	8+
Natural mortality	2.05	1.65	0.40	0.25	0.25	0.20	0.20	0.20	0.20
Proportion mature	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00	1.00

13.2.5 Catch, effort and research vessel data

Data available for calibration of the assessment are presented in Table 13.2.6.1. FLXSA cannot use data from the current year (2013). For this reason, the IBTS Q1 time series is backshifted before being used in FLXSA – that is, all ages and years are reduced by one, and the survey is considered to have taken place at the very end of the previous year.

Trends in survey indices are shown in Figure 13.2.6.2. These indicate reasonably good consistency in stock signals from different surveys.

The survey data available are summarised in the following table: data used in the final assessment are highlighted in bold.

Country	Fleet	Quarter	Code	Year range	Age range available	Age range used
Scotland	Groundfish survey	Q3	**ScoGFS Aberdeen Q3**	**1982-1997**	0-8	**0-6**
	Groundfish survey	Q3	**ScoGFS Q3 GOV**	**1998-2012**	0-8	**0-6**
England	Groundfish survey	Q3	**EngGFS Q3 GRT**	**1977-1991**	0-15+	**0-6**
	Groundfish survey	Q3	**EngGFS Q3 GOV**	**1992-2012**	0-15+	**0-6**
International	Groundfish survey	Q1	**IBTS Q1 (backshifted)**	**1982-2012**	1-5+	**0-4**

13.3 Data analyses

The assessment this year has been done using FLXSA (the FLR implementation of XSA) as the main assessment method. The results of SURBAR analysis are also shown, to corroborate (or otherwise) the update assessment. This year, due to time constrains the SAM analyses stipulated in the Stock Annex was not performed

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 13.3.2.1), indicates partial recruitment to the fishery for most cohorts up to age 2. Gradients between consecutive values within a cohort have reduced 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 13.3.2.2 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 except for an apparent rise in the 2004 cohort, although this has been followed by a sharp decrease to a lower level for the 2005 and 2006 cohorts.

Cohort correlations in the catch-at-age matrix (plotted as log-numbers) are shown in Figure 13.3.2.3. 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).

Single-fleet FLXSAs for the final assessment were produced to investigate the sensitivity of FLXSA to the effects of tuning by individual fleets. Results are shown in Figure 13.3.2.5 for the latter halves of the EngGFS Q3 and ScoGFS Q3 series, as well as for the IBTS Q1 series, with corresponding log-catchability residual plots shown in Figure 13.3.2.6. Overall trends are similar for the three tuning fleets, although the IBTS-Q1 survey indicates lower *F* in recent years than the two Q3 surveys.

13.3.2 Exploratory survey-based analyses

A SURBAR run (ICES-WKADSAM 2010) was carried out using the same combination of tuning indices as in the update FLXSA assessments, except that the IBTS Q1 survey was not backshifted as SURBA can accommodate survey data from the current year. The summary plot from this run is given is Figure 13.3.3.1, which indicates good precision in relative trend estimates for mortality, biomass and recruitment. The results are discussed further in Section 13.3.3 below.

Log catch curves for the survey indices are given in Figure 13.3.3.2. Overall, these show good tracking of cohort strength, although there is a slight tendency for reduced survey catchability on younger ages (shown by the "hooks" at the start of some of the curves). It is also noticeable that catchability characteristics appear to be quite different for each time-period of the ScoGFS survey: the Aberdeen trawl did not appear to catch young haddock as well as the GOV trawl. Cohort correlations in the index-at-age matrices (plotted as log-numbers) are shown in Figure 13.3.3.3. These correlations show good consistency for nearly all of the cohorts and ages used in the final assessment (with a few minor exceptions).

13.3.3 Conclusions drawn from exploratory analyses

Mean-standardising results (using a common year-range for the mean) enables the comparison between FLXSA and SURBAR shown in Figure 13.3.4.1. Although dimensionless, mortality is also mean-standardised in this Figure as SURBAR estimates total mortality Z rather than F, and without standardisation the comparison is difficult. It is noticeable that the SURBAR SSB is slightly overestimated in relation to the FLXSA. The recruitment plot follows a similar pattern for both SURBAR and FLXSA.

13.3.4 Final assessment

The final FLXSA assessment uses the following settings. XSA and FLXSA settings from a number of recent years are compared in the Stock Annex.

ASSESSMENT YEAR		2013
q plateau		6
Tuning fleet year ranges	EngGFS Q3	77-91; 92-12
	ScoGFS Q3	82-97; 98-12
	IBTS Q1*	82-12
Tuning fleet age ranges	EngGFS Q3	0-7
	ScoGFS Q3	0-7
	IBTS Q1*	0-4
*Backshifted		

The final assessment tuning diagnostics are presented in Table 13.3.5.1. We note that the current FLXSA implementation does not generate diagnostics entirely correctly: survivor's estimates for the older ages in Table 13.3.5.1 are incorrect, but this has been rectified in analyses for the short-term forecast.

Log-catchability residuals are given in Figure 13.3.5.1, and a comparison of fleet-based contributions to survivors in Figure 13.3.5.2. These do not indicate any reason to deviate from the update procedure. Fishing mortality estimates for the final FLXSA assessment are presented in Table 13.3.5.2, the stock numbers in Table 13.3.5.3, and the assessment summary in Table 13.3.5.4..

13.4 Historical Stock Trends

The historical stock and fishery trends are presented in Figure 13.4.1.

Landings yield has 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. Discards have fluctuated in the same period due to the appearance and subse-

quent 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 13.2.1.1).

Estimated fishing mortality for 2008 to 2012 appeared to have stabilised at or just above 0.2, and is still just below the management plan target of 0.3 in 2012. 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 2010-2012 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 FLXSA 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)

The retrospective summary plot (Figure 13.4.2) shows very little bias or noise in retrospective analyses. This is a relatively well-sampled stock for which catch and survey data appear to be consistent and in good agreement, at least within the context of the FLXSA assessment model. Finally, the stock-recruitment plot in Figure 13.4.3 shows the usual lack of pattern for North Sea haddock.

13.5 Recruitment estimates

There are no indications of incoming year-class strength available to the WG. The ScoGFS and EngGFS Q3 survey indices for 2013 are not yet available. The IBTS Q1 indices are available, but do not include age-0 recruiting fish as these are too small to be caught (or are not yet hatched) when the survey takes place. For this reason, recruitment estimates of the 2013 year-class are based on a mean of previous recruitment.

In the past, a strong year-class has generally been followed by a sequence of low recruitments (Figure 13.5.1.1). In order to take this feature into account, the geometric mean of the five lowest recruitment values over the period 1994–2010 (3103 millions) has been assumed for recruitment in 2013-2015. Recruitment estimates for 2011 and 2012 are not included in this calculation, because the two most recent FLXSA estimates of recruitment are thought to be relatively uncertain. The following table summarises the recruitment, age 1 and age 2 assumptions for the short term forecast.

YEAR CLASS	AGE IN 2013	FLXSA ESTIMATE (MILLIONS)	GEOMETRIC MEAN OF 5 LOWEST RECRUITMENTS 1994-2010
2011	2	52	
2012	1	98	
2013	0		3103
2014	Age 0 in 2014		3103
2015	Age 0 in 2015		3103

13.6 Short-term forecasts

Weights-at-age

The following text is taken from the extant Stock Annex (ICES-WKROUND 2011) – it is included here as this approach represents a change from the weights-forecasting method used in previous years.

Jaworski (2011) applied twenty different growth forecasting methods in a hindcast analysis, in which weights-at-age forecasts from 12 years ago were compared with the observed outcomes. The test statistics were the ratio of forecast to observed

weights, and the variance of the forecast. There was a general tendency to overestimate weights in forecasts, while the most beneficial model, in terms of both test statistics, was a simple cohort-based linear model.

Jaworski's analysis provided an extensive hindcast testing procedure of a wide variety of methods for forecasting weights-at-age in North Sea haddock, and explored the issue in far more depth and breadth than had previously been possible. His conclusion on the method that generates the estimate with the least bias and variance appears to be robust and has been extensively peer-reviewed. Therefore, WKBENCH recommended that weights-at-age for North Sea haddock forecasts be modelled using a linear cohort-based approach. 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 be generated for these cohorts). This procedures is applied separately for each catch component (catch/stock, landings, discard), except for industrial bycatch for which there is insufficient cohort-based weight information (a simple three-year mean is used here instead).

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 (2010-2012) means by age are used for all forecast years.

Finally, the weights-at-age for 2013-15 assumed in the forecast presented at last year's WG are compared with the equivalent values set in this year's WG in Figure 13.6.4.

Fishing mortality

Estimated mean fishing mortality in 2012 was lower than that in 2011, at just under 0.2. The WG decided that it would be reasonable to assume that this level would continue into the forecast period. Rather than just use the 2012 fishing mortalities at age for the forecast, a three-year average exploitation pattern scaled to the level of the mean 2012 fishing mortality was used. To be precise: the exploitation pattern for each year (2010, 2011 and 2012) is calculated by dividing the Fs for a given year by the average F over ages 2-4 for that year, The average exploitation pattern is then calculated for each age by taking the mean of the exploitation pattern for that age, and over 2010, 2011 and 2012. The vector of mean exploitation is then scaled by multiplying by the average F over ages 2-4 in the last historical assessment year (2012). With this approach, the forecast fishing mortalities are less subject to noise in the most recent assessment year (see Figure 13.6.5).

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 2010-2012) of each component to the total catch.

Forecast results

The inputs to the short-term forecast are presented in Table 13.6.1. Results for the short-term forecasts are presented in Table 13.6.2.

Assuming *status quo* F in both 2013 and 2014, SSB is expected to decrease to 242 848 t in 2014, before falling again in 2015 to 221 609 t. In this case, human consumption yield will be around 22 697 t in 2013, with associated discards of 2 518 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 management plan (F = 0.3, also used as a proxy for F_{msy}), and forecasts using a range of multipliers of F_{sq} as the basis. Under the management plan, the 2014 landings yield of 37 146 t) and discards of 4 174 t lead to SSB in 2015 of 204 082 t. All of the SSB forecasts for 2015 are above B_{pa} (140000 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 haddock (most recently by Needle 2008a, b), as discussed briefly in Section 13.1.4 above.

Extensive work on estimation of F_{msy} was carried out during the 2010 meeting (ICES-WGNSSK 2010) to determine that the mean point estimates of F_{msy} lay in the range 0.25 - 0.43: this widened to 0.18 - 0.60 when confidence intervals were included. WGNSSK concluded that F_{msy} is likely to lie above the target value in the EU-Norway management plan (0.3) and the *status quo* assessment estimate (around 0.23). It is not straightforward to understand how these F_{msy} estimates could be this high. In any case, the management evaluations carried out for this stock (Needle 2008a,b), which used more dynamic recruitment simulations and did not assume equilibrium conditions, concluded that the maximum sustainable yield was likely to occur at or around an F value of 0.3. This has been proposed by ICES as a suitable proxy for F_{msy} for this stock.

13.8 Biological reference points

Biological reference points for this stock are given in the Stock Annex.

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 quite similar. Only minor changes were made to the data collation or assessment methodology from last year's assessment. There is very little retrospective bias. The stock estimates from the current and previous assessments are compared in Figure 13.9.1.

Several issues remain of some concern with the assessment, and will need to be addressed during the forthcoming benchmark process early in 2014:-

1) The issue of stock structure and identity for haddock in the north-east Atlantic is potentially very important. A number of studies in recent years have suggested that haddock spawned on the west coast of Scotland (Division VIa) may contribute to the North Sea population, and there is evidence of strong links between the two stocks. This was considered briefly at the benchmark meeting in 2009 (ICES-WKROUND 2009), and the interim joint assessment carried out at WGNSSK in 2010 suggested that a "northern shelf" haddock assessment would be dominated by data from the North Sea, but this needs further consideration.

2) The issue of FLXSA convergence has not been solved, and must be addressed at the earliest opportunity. This year, the FLXSA run took 116 iterations to converge. Consideration also needs to be given to an assessment method that can account for and estimate uncertainty.

13.10 Status of the Stock

The historical perception of the haddock stock remains unchanged from last year's assessment. Fishing mortality is now estimated to have remained at a low level in 2012 and now at the historical minimum. This is well below F_{pa} (0.7), and is also below the mortality rate recommended in the management plan (0.3) and most estimates of F_{msy}. Discards have decreased significantly in 2012. Spawning stock biomass is predicted to decrease in the near future, but will still remain above B_{pa} (140 kt). The 2006-2008 and 2010-2012 year-classes were estimated to be weak, but the 2009 year-class is stronger.

13.11 Management Considerations

In 2006 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 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. Fishing mortality fell while the 1999 year-class dominated the fishery, and this year-class was allowed to contribute to the fishery and the stock for much longer than if the plan had not been in place. SSB declined as the 1999 year-class passed out of the stock, although the decline has been slowed temporarily by the growth of the moderately-sized 2005 and 2009 year-classes. The slightly less abundant 2009 year-class is predicted in short-term forecasts to lead to future increases in SSB, but further good year-classes will be required to maintain this rise. F now appears to fluctuating well below the target level (0.3).

Keeping fishing mortality close to the target level would be preferable to encourage the sustainable exploitation of the 2005 and 2009 year-classes. As the 2005 year-class entered the fishery, discards were fairly substantial in 2006 and 2007, although they were considerably lower in 2008 and 2009. 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 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.

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Table 13.2.1.1. Haddock in Subarea IV and Division IIIa. Nominal landings (000 t) during 2005–2012, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2012 are preliminary. Quota uptake estimates are also given, calculated as the WG estimates of landings divided by available quota.

COUNTRY	DIV.	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	III a	0	0	0	0	0	0	0	0
Denmark	III a	615	1001	1054	1052	1263	1139	1661	1916
Germany	III a	69	186	206	87	105	65	102	117
Netherlands	III a	0	0	0	0	0	1	0	0
Norway	III a	93	113	152	170	121	81	125	239
Portugal	III a	0	30	37	0	0	0	0	0
Sweden	III a	180	246	278	276	166	126	198	209
UK -E+W+NI	III a	0	0	0	0	0	0	0	0
UK - Scot	III a	0	0	0	0	0	0	0	0
Official landings	III a	957	1576	1727	1585	1655	1412	2086	2481
WG landings	III a	764	1537	1515	1374	1515	1287	9850	2620
WG discards	III a	217	970	816	646	556	608	1744	730
WG total catch	III a	981	2507	2332	2020	2072	1896	11595	3350
TAC	III a	4018	3189	3360	2856	2590	2201	2095	2770
Belgium	IV	190	106	178	112	108	78	106	76
Denmark	IV	1274	759	645	501	552	725	697	947
Faeroe Islands	IV	22	4	0	3	32	5	0	0
France	IV	439	444	498	448	135	276	272	175
Germany	IV	733	726	727	393	657	634	575	512
Netherlands	IV	64	33	55	29	24	41	71	191
Norway	IV	2089	1798	1706	1482	1278	1126	1195	1033
Poland	IV	0	8	8	16	0	0	0	0
Portugal	IV	0	76	0	0	0	0	0	0
Sweden	IV	135	100	130	83	141	90	128	103
UK - E+W+NI	IV	651	485	1799	1378	2155	2362		
UK – Scot	IV	25319	31905	24919	25987	26238	22622		
UK – all	IV						24983	23340	27341
Official landings	IV	30916	36444	30665	30432	31320	27959	26384	30379
WG landings	IV	47616	36074	29418	28893	31264	27770	26275	30348
WG discards	IV	8416	16943	27805	12532	9986	9515	10249	3738
WG IBC	IV	168	535	48	199	52	431	23	1
WG total catch	IV	56200	53551	57271	41624	41302	37717	36547	34086
TAC	IV	66000	51850	54640	46444	42110	35794	34057	45040
WG landings	IV & IIIa	48380	37611	30934	30267	32779	29058	36125	33059
WG discards	IV & IIIa	8633	17913	28621	13178	10543	10124	11993	4501
WG IBC	IV & IIIa	168	535	48	199	52	431	23	1
WG total catch	IV & IIIa	57181	56058	59603	43644	43374	39612	48141	37561
TAC	IV & IIIa	70018	55039	58000	49300	44700	37995	36152	41575
WG quota uptake		69%	68%	53%	61%	73%	76%	100%	80%

Table 13.2.1.2. Haddock in Subarea IV and Division IIIa. Working Group estimates of catch components by weight (000 tonnes).

	Subarea IV				Division IIIa				Combined			
Year	Landings	Discards	IBC	Total	Landings	Discards	IBC	Total	Landings	Discards	IBC	Total
1963	68.4	189.3	13.7	271.4	0.4	-	-	0.4	68.8	189.3	13.7	271.8
1964	130.6	160.3	88.6	379.5	0.4	-	-	0.4	131.0	160.3	88.6	379.9
1965	161.7	62.3	74.6	298.6	0.7	-	-	0.7	162.4	62.3	74.6	299.3
1966	225.6	73.5	46.7	345.8	0.6	-	-	0.6	226.2	73.5	46.7	346.3
1967	147.4	78.2	20.7	246.3	0.4	-	-	0.4	147.7	78.2	20.7	246.7
1968	105.4	161.8	34.2	301.4	0.4	-	-	0.4	105.8	161.8	34.2	301.8
1969	331.1	260.1	338.4	929.5	0.5	-	-	0.5	331.6	260.1	338.4	930.0
1970	524.1	101.3	179.7	805.1	0.7	-	-	0.7	524.8	101.3	179.7	805.8
1971	235.5	177.8	31.5	444.8	2.0	-	-	2.0	237.5	177.8	31.5	446.8
1972	193.0	128.0	29.6	350.5	2.6	-	-	2.6	195.5	128.0	29.6	353.1
1973	178.7	114.7	11.3	304.7	2.9	-	-	2.9	181.6	114.7	11.3	307.6
1974	149.6	166.4	47.5	363.5	3.5	-	-	3.5	153.1	166.4	47.5	367.0
1975	146.6	260.4	41.5	448.4	4.8	-	-	4.8	151.3	260.4	41.5	453.2
1976	165.7	154.5	48.2	368.3	7.0	-	-	7.0	172.7	154.5	48.2	375.3
1977	137.3	44.4	35.0	216.7	7.8	-	-	7.8	145.1	44.4	35.0	224.5
1978	85.8	76.8	10.9	173.5	5.9	-	-	5.9	91.7	76.8	10.9	179.4
1979	83.1	41.7	16.2	141.0	4.0	-	-	4.0	87.1	41.7	16.2	145.0
1980	98.6	94.6	22.5	215.7	6.4	-	-	6.4	105.0	94.6	22.5	222.1
1981	129.6	60.1	17.0	206.7	6.6	-	-	6.6	136.1	60.1	17.0	213.2
1982	165.8	40.6	19.4	225.8	7.5	-	-	7.5	173.3	40.6	19.4	233.3
1983	159.3	66.0	12.9	238.2	6.0	-	-	6.0	165.3	66.0	12.9	244.2
1984	128.2	75.3	10.1	213.6	5.4	-	-	5.4	133.6	75.3	10.1	218.9
1985	158.6	85.2	6.0	249.8	5.6	-	-	5.6	164.1	85.2	6.0	255.4
1986	165.6	52.2	2.6	220.4	2.7	-	-	2.7	168.2	52.2	2.6	223.1
1987	108.0	59.1	4.4	171.6	2.3	-	-	2.3	110.3	59.1	4.4	173.9
1988	105.1	62.1	4.0	171.2	1.9	-	-	1.9	107.0	62.1	4.0	173.1
1989	76.2	25.7	2.4	104.2	2.3	-	-	2.3	78.4	25.7	2.4	106.5
1990	51.5	32.6	2.6	86.6	2.3	-	-	2.3	53.8	32.6	2.6	88.9
1991	44.7	40.2	5.4	90.2	3.1	-	-	3.1	47.7	40.2	5.4	93.3
1992	70.2	47.9	10.9	129.1	2.6	-	-	2.6	72.8	47.9	10.9	131.7
1993	79.6	79.6	10.8	169.9	2.6	-	-	2.6	82.2	79.6	10.8	172.5
1994	80.9	65.4	3.6	149.8	1.2	-	-	1.2	82.1	65.4	3.6	151.0
1995	75.3	57.4	7.7	140.4	2.2	-	-	2.2	77.5	57.4	7.7	142.6
1996	76.0	72.5	5.0	153.5	3.1	-	-	3.1	79.2	72.5	5.0	156.6
1997	79.1	52.1	6.7	137.9	3.4	-	-	3.4	82.5	52.1	6.7	141.3
1998	77.3	45.2	5.1	127.6	3.8	-	-	3.8	81.1	45.2	5.1	131.3
1999	64.2	42.6	3.8	110.7	1.4	-	-	1.4	65.6	42.6	3.8	112.0
2000	46.1	48.8	8.1	103.0	1.5	-	-	1.5	47.6	48.8	8.1	104.5
2001	39.0	118.3	7.9	165.2	1.9	-	-	1.9	40.9	118.3	7.9	167.1
2002	54.2	45.9	3.7	103.8	4.1	-	-	4.1	58.3	45.9	3.7	107.9
2003	40.1	23.5	1.1	64.8	1.8	0.2	-	2.0	41.9	23.7	1.1	66.8
2004	47.3	15.4	0.6	63.2	1.4	0.1	-	1.6	48.7	15.6	0.6	64.8
2005	47.6	8.4	0.2	56.2	0.8	0.2	-	1.0	48.4	8.6	0.2	57.2
2006	36.1	16.9	0.5	53.6	1.5	1.0	-	2.5	37.6	17.9	0.5	56.1
2007	29.4	27.8	0.0	57.3	1.5	0.8	-	2.3	30.9	28.6	0.0	59.6
2008	28.9	12.5	0.2	41.6	1.4	0.6	-	2.0	30.3	13.2	0.2	43.6
2009	31.3	10.0	0.1	41.3	1.5	0.6	-	2.1	32.8	10.5	0.1	43.4
2010	27.8	9.5	0.4	37.7	1.3	0.6	-	1.9	29.1	10.1	0.4	39.6
2011	26.3	10.2	0.0	36.5	9.9	1.7	-	11.6	36.1	12.0	0.0	48.1
2012	30.3	3.7	1.15	35	2.6	0.7	-	3.4	31.7	20.7	1.0	52.4
Min	28.9	8.4	0.0	41.6	0.4	0.1	-	0.4	30.3	8.6	0.0	43.6
Mean	118.1	81.0	27.3	226.3	2.9	0.5	-	2.9	121.0	81.1	27.3	229.3
Max	524.1	260.4	338.4	929.5	7.8	1.0	-	7.8	524.8	260.4	338.4	930.0

- denotes missing data.

Table 13.2.2.1. Haddock in Subarea IV and Division IIIa. Numbers at age data (thousands) 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+
1963	1359	1305779	334952	20959	13025	5780	502	653	566	59	18	0	0	0	0	0	642
1964	139777	7425	1295364	135110	9067	5348	2405	287	236	231	25	0	0	0	0	0	492
1965	649768	367501	15151	649053	29485	4659	1971	452	107	90	41	0	0	0	0	0	238
1966	1666973	1005922	25657	6423	412510	9978	1045	601	165	90	23	2	0	0	0	0	280
1967	305249	837154	89068	4863	3585	177851	2443	215	216	57	34	0	0	0	0	0	307
1968	11105	1097030	439210	19592	1947	2529	45971	325	40	13	5	0	0	0	0	0	59
1969	72559	20469	3575922	303333	7595	2410	2515	19128	200	24	7	0	0	0	0	0	231
1970	924601	266150	218362	1908087	57430	1177	1197	256	5954	67	11	19	0	0	0	0	6051
1971	330673	1810248	70951	47518	400415	10372	462	195	147	1592	160	3	5	0	0	0	1907
1972	240896	676000	586824	40591	21211	157994	3563	190	34	27	408	11	0	0	0	0	480
1973	59872	364918	570428	240603	6192	4467	39459	1257	108	29	109	49	5	0	0	0	299
1974	601412	1214415	175587	331871	54206	1873	1348	10917	242	23	32	4	5	0	0	0	306
1975	44946	2097588	639003	58836	108892	15809	982	620	2714	266	63	11	0	8	0	0	3062
1976	167173	167693	1055190	210308	9950	31186	4996	206	76	759	60	3	0	0	0	0	899
1977	114954	250593	106012	390343	40051	4304	6262	1300	135	29	200	3	0	1	0	0	368
1978	285842	454920	146179	30321	113601	8703	1264	2075	402	116	15	64	13	2	0	0	613
1979	841439	345399	203196	41225	7402	28006	2236	262	483	152	54	12	11	1	0	0	714
1980	374959	660144	331838	72505	10392	1897	8061	598	121	162	75	31	9	3	1	0	403
1981	646419	134440	421347	142948	15204	2034	457	2498	125	64	23	30	4	1	3	0	251
1982	278705	275385	85474	299211	41383	3377	713	279	784	30	15	7	2	2	0	0	840
1983	639814	156256	251703	73666	127173	16480	1708	297	61	191	53	6	4	4	0	0	319
1984	95502	432178	167411	122783	22067	32649	3789	596	84	41	112	16	5	1	1	0	261
1985	139579	178878	533698	78633	37430	5303	7355	965	212	52	21	88	4	0	0	0	378
1986	56503	160359	178798	323638	27683	9690	1237	1810	237	117	49	32	36	13	4	1	489

Table 13.2.2.1 (cont). Haddock in Subarea IV and Division IIIa. Numbers at age data (thousands) 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+
1987	9419	277704	250003	47379	67864	4761	2877	545	778	135	36	50	27	29	5	8	1068
1988	10808	29420	484481	89071	13431	18579	1602	639	166	141	50	18	11	10	15	1	412
1989	10704	47271	35096	182331	18037	2631	4045	508	200	83	30	13	6	2	2	1	338
1990	55473	81335	101513	18673	56696	3732	877	1320	206	78	41	11	11	1	4	2	355
1991	123910	224136	78092	23167	3882	12524	976	401	614	148	54	6	5	1	2	1	830
1992	270758	194249	252884	32483	6550	1250	4861	454	301	293	124	22	6	2	0	0	749
1993	141209	345275	261834	108395	7105	1697	450	1138	146	103	144	59	3	2	0	0	457
1994	85966	96850	296528	100466	29609	1920	573	191	509	115	32	27	25	5	0	0	713
1995	201260	296237	85826	167801	25875	7645	511	127	45	62	19	8	6	2	1	0	142
1996	148437	46689	357942	56894	55147	7503	3052	756	52	31	25	5	8	3	1	0	125
1997	28855	132262	85854	213293	15272	15406	1892	679	62	15	12	4	4	4	2	0	103
1998	22115	82770	166732	49550	107995	5741	3562	472	140	14	6	5	2	2	1	1	171
1999	84408	80970	121249	87242	24739	39860	2338	1595	342	41	6	2	1	1	0	0	393
2000	6632	349062	88624	43351	26356	6026	8707	560	234	32	12	2	1	1	0	0	282
2001	2531	85435	632880	32343	8886	4122	1561	1305	195	64	17	3	1	0	0	0	280
2002	50754	18400	66343	242196	6547	2038	1066	549	458	265	15	8	5	0	0	0	752
2003	9072	19547	14261	44747	109063	1970	602	271	110	89	38	5	1	0	0	0	244
2004	1030	10538	18122	6574	34945	91121	723	147	56	35	35	10	1	0	0	0	137
2005	4814	10505	18394	11385	3329	25077	58753	314	89	34	10	7	4	1	0	0	145
2006	2412	106505	26164	16813	7482	2970	13685	30229	123	30	16	6	4	0	0	0	179
2007	1788	18788	155750	13899	6463	2353	1426	5973	6776	69	7	14	3	1	0	0	6871
2008	1940	12595	29534	70920	4170	1441	648	311	1247	2448	5	8	1	1	0	0	3710
2009	8462	6044	14868	20335	71832	1348	510	313	160	236	538	6	2	0	0	0	941
2010	1557	70768	15442	17412	10721	33501	595	258	96	44	58	124	9	0	0	3	335
2011	2939	4361	60149	16676	13838	11169	21488	589	225	95	17	5	60	0	0	0	403
2012	1291	1633	5004	58170	4987	2865	2258	5988	83	94	40	42	57	24	4	0	344

Table 13.2.2.2. Haddock in Subarea IV and Division IIIa. 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+
1963	0	27353	118185	16692	12212	5644	498	653	566	59	18	0	0	0	0	0	642
1964	0	48	250523	86368	8166	4689	2283	286	236	231	25	0	0	0	0	0	492
1965	0	2636	3445	335396	23479	4063	1852	446	107	90	41	0	0	0	0	0	238
1966	0	12976	6724	4250	372535	9188	1018	599	165	90	23	2	0	0	0	0	280
1967	0	54953	33894	3845	3345	174011	2421	215	216	57	34	0	0	0	0	0	307
1968	0	18443	139035	14557	1806	2495	45047	324	40	13	5	0	0	0	0	0	59
1969	0	139	713860	166997	6542	2014	2381	18876	200	24	7	0	0	0	0	0	231
1970	0	2259	51861	1133133	50823	1012	1131	254	5954	67	11	19	0	0	0	0	6051
1971	0	34019	25862	35168	369443	10006	455	195	147	1592	160	3	5	0	0	0	1907
1972	0	12778	207267	33215	19853	156344	3550	190	34	27	408	11	0	0	0	0	480
1973	0	6024	205717	193852	5829	4238	39336	1257	108	29	109	49	5	0	0	0	299
1974	0	23993	52416	227998	46793	1785	1232	10693	242	23	32	4	5	0	0	0	306
1975	0	24144	200961	38295	90302	15524	978	620	2709	266	63	11	0	8	0	0	3057
1976	0	2301	223465	142803	9721	28103	4978	206	76	759	60	3	0	0	0	0	899
1977	0	8484	31741	249285	37092	4057	6021	1300	135	29	200	3	0	1	0	0	368
1978	0	12883	54630	25305	100036	8568	1152	2070	402	116	15	64	13	2	0	0	612
1979	0	14009	110008	36486	7284	27543	2219	262	483	152	54	12	11	1	0	0	714
1980	0	8982	141895	61901	9063	1843	7975	591	121	161	75	31	9	3	1	0	402
1981	0	1759	153466	112407	14679	2025	455	2498	125	64	23	30	4	1	3	0	251
1982	0	7373	38819	236209	37728	2913	713	279	784	30	15	7	2	2	0	0	840
1983	0	7101	109201	52566	117819	15760	1603	297	61	190	53	6	4	4	0	0	319
1984	0	19501	75963	104651	21372	31874	3788	596	84	41	112	16	5	1	1	0	261
1985	0	2120	248125	70806	36734	5076	7329	965	212	52	21	88	4	0	0	0	378

Table 13.2.2.2. cont. Haddock in Subarea IV and Division IIIa. 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+
1986	0	12132	62362	261225	27548	9671	1237	1810	237	117	49	32	36	13	4	1	489
1987	0	6896	113196	37763	66221	4760	2877	545	778	135	36	50	27	29	5	8	1068
1988	0	1524	146403	76925	12024	18310	1602	639	166	141	50	18	11	10	15	1	412
1989	0	4519	16387	128051	16762	2574	3916	498	199	83	30	13	6	2	2	1	337
1990	0	5493	43168	14338	45015	3269	775	1242	202	78	41	11	11	1	4	2	350
1991	0	19482	46902	21841	3812	12337	976	401	614	148	54	6	5	1	2	1	830
1992	0	2853	117953	28828	6485	1247	4779	454	300	293	124	22	6	2	0	0	748
1993	0	2488	77820	86806	6976	1686	450	1119	146	103	144	59	3	2	0	0	457
1994	0	467	69457	70354	27587	1860	524	191	509	115	32	27	25	5	0	0	713
1995	0	1870	29177	101663	24715	7565	511	127	45	62	19	8	6	2	1	0	142
1996	0	742	74892	36685	47168	7501	3052	756	52	31	25	5	8	3	1	0	125
1997	0	1409	23943	123178	14028	15208	1892	679	62	15	12	4	4	4	2	0	103
1998	0	822	38321	36736	92738	5607	3543	472	140	14	6	5	2	2	1	1	171
1999	0	994	25856	53192	23301	37630	2155	1595	342	41	6	2	1	1	0	0	393
2000	0	4750	30316	28653	23407	5873	8644	560	234	32	12	2	1	1	0	0	282
2001	0	611	67196	16117	7406	3929	1561	1295	191	64	17	3	1	0	0	0	276
2002	0	639	13666	111346	5640	2004	1066	419	458	265	15	8	5	0	0	0	752
2003	0	32	1091	13925	73059	1920	571	270	109	89	38	5	1	0	0	0	243
2004	0	481	2897	4101	22159	73191	710	139	56	35	35	10	1	0	0	0	137
2005	0	782	5490	8086	2926	21703	54742	313	89	34	10	7	4	1	0	0	145
2006	0	2062	9849	10267	6302	2705	12486	28158	116	28	15	6	3	0	0	0	169
2007	0	1111	28030	10083	5932	2290	1422	5918	6705	69	7	14	3	1	0	0	6800
2008	0	278	6176	48247	3915	1401	625	309	1241	2444	5	8	1	1	0	0	3700
2009	0	481	4548	9477	58043	1289	506	312	160	235	534	6	2	0	0	0	936
2010	0	1044	4891	12219	9723	31468	594	258	94	44	58	123	9	0	0	3	333
2011	0	224	15981	14941	13057	11067	21275	589	225	95	16	5	60	0	0	0	401
2012	0	168	3129	45469	4485	2856	2251	5973	83	94	40	42	57	24	4	0	344

Table 13.2.2.3. Haddock in Subarea IV and Division IIIa. 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+
1963	42	1047925	193718	3476	708	51	2	0	0	0	0	0	0	0	0	0	0
1964	2395	4182	623111	13597	262	21	10	0	0	0	0	0	0	0	0	0	0
1965	5307	110628	4020	130369	3641	4	1	0	0	0	0	0	0	0	0	0	0
1966	7880	444111	12388	1166	24114	35	2	0	0	0	0	0	0	0	0	0	0
1967	6250	389691	49635	863	216	1576	9	0	0	0	0	0	0	0	0	0	0
1968	39	615649	219022	3006	94	15	186	0	0	0	0	0	0	0	0	0	0
1969	1732	5152	1158445	37686	420	16	8	0	0	0	0	0	0	0	0	0	0
1970	51717	92978	77992	289679	2640	13	4	0	0	0	0	0	0	0	0	0	0
1971	7586	1205838	35117	8960	24590	66	2	0	0	0	0	0	0	0	0	0	0
1972	4231	424657	322547	6353	1212	1212	13	0	0	0	0	0	0	0	0	0	0
1973	18540	241423	352310	46740	352	33	123	0	0	0	0	0	0	0	0	0	0
1974	24758	915157	90904	57011	2814	6	4	0	0	0	0	0	0	0	0	0	0
1975	630	1478590	353422	15781	13388	143	0	0	0	0	0	0	0	0	0	0	0
1976	2191	98420	648662	38317	183	137	0	0	0	0	0	0	0	0	0	0	0
1977	11812	95090	44918	73431	605	9	0	0	0	0	0	0	0	0	0	0	0
1978	5250	316339	80219	4207	12085	72	106	0	0	0	0	0	0	0	0	0	0
1979	1824	205555	75517	3232	34	84	0	0	0	0	0	0	0	0	0	0	0
1980	644	369727	168124	2346	39	0	0	0	0	0	0	0	0	0	0	0	0
1981	1509	33434	237524	25928	86	3	0	0	0	0	0	0	0	0	0	0	0
1982	3703	93865	31915	49462	1845	0	0	0	0	0	0	0	0	0	0	0	0
1983	151108	85338	128171	15966	7112	717	105	0	0	0	0	0	0	0	0	0	0
1984	2915	314421	80803	13430	327	240	0	0	0	0	0	0	0	0	0	0	0
1985	17501	165086	267747	6088	149	4	8	0	0	0	0	0	0	0	0	0	0
1986	23807	108204	114606	61612	31	12	0	0	0	0	0	0	0	0	0	0	0

Table 13.2.2.3 (cont). Haddock in Subarea IV and Division IIIa. 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+
1987	1166	188582	133010	9320	1506	0	0	0	0	0	0	0	0	0	0	0	0
1988	1528	24588	325259	9684	788	67	0	0	0	0	0	0	0	0	0	0	0
1989	1790	40211	16959	51491	814	20	42	0	0	0	0	0	0	0	0	0	1
1990	52477	68625	56359	3977	10190	235	77	0	0	0	0	0	0	0	0	0	0
1991	7001	182162	27942	725	27	145	0	0	0	0	0	0	0	0	0	0	0
1992	29056	110995	123961	3298	38	0	65	0	0	0	0	0	0	0	0	0	0
1993	16715	235123	170794	18375	48	3	0	1	0	0	0	0	0	0	0	0	0
1994	16059	82033	217538	29100	1862	53	48	0	0	0	0	0	0	0	0	0	0
1995	3228	191807	54448	65250	1095	79	0	0	0	0	0	0	0	0	0	0	0
1996	3968	35340	275597	16870	7872	2	0	0	0	0	0	0	0	0	0	0	0
1997	7162	85588	50976	85664	1061	182	0	0	0	0	0	0	0	0	0	0	0
1998	3132	72793	112075	10165	13766	71	18	0	0	0	0	0	0	0	0	0	0
1999	14588	69196	90861	31119	1094	2064	180	0	0	0	0	0	0	0	0	0	0
2000	2474	272894	36568	12614	2764	148	64	0	0	0	0	0	0	0	0	0	0
2001	545	61878	529908	6100	1446	186	0	10	4	0	0	0	0	0	0	0	4
2002	946	3872	48189	127212	403	8	0	130	0	0	0	0	0	0	0	0	0
2003	4927	13533	11069	29537	34480	37	31	1	0	0	0	0	0	0	0	0	1
2004	1030	9467	14960	2388	12528	17177	5	3	0	0	0	0	0	0	0	0	0
2005	4814	9546	12807	3273	394	3369	3810	0	0	0	0	0	0	0	0	0	0
2006	2412	102672	15599	6304	1133	219	1125	1963	6	1	1	0	0	0	0	0	8
2007	1788	17650	127501	3810	530	63	4	55	71	0	0	0	0	0	0	0	71
2008	1928	12235	23078	22492	202	22	18	1	6	4	0	0	0	0	0	0	10
2009	8447	5527	10224	10809	13770	53	2	0	0	1	4	0	0	0	0	0	5
2010	1557	65556	10196	5157	998	2033	1	0	2	0	0	1	0	0	0	0	2
2011	2938	4137	44169	1734	781	102	212	0	0	0	1	1	0	0	0	0	2
2012	1291	1465	1875	12701	502	9	7	15	0	0	0	0	0	0	0	0	0

Table 13.2.2.4. Haddock in Subarea IV and Division IIIa. 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+
1963	1317	230502	23050	791	105	85	3	0	0	0	0	0	0	0	0	0	0
1964	137382	3195	421729	35144	638	638	112	1	0	0	0	0	0	0	0	0	0
1965	644461	254237	7686	183288	2365	592	118	6	0	0	0	0	0	0	0	0	0
1966	1659093	548835	6546	1007	15861	755	25	2	0	0	0	0	0	0	0	0	0
1967	298999	392510	5539	155	24	2264	12	0	0	0	0	0	0	0	0	0	0
1968	11066	462938	81153	2029	46	19	738	1	0	0	0	0	0	0	0	0	0
1969	70826	15178	1703617	98650	632	380	126	252	0	0	0	0	0	0	0	0	0
1970	872884	170914	88509	485275	3967	153	61	2	0	0	0	0	0	0	0	0	0
1971	323088	570391	9972	3390	6381	299	6	0	0	0	0	0	0	0	0	0	0
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	32267	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	275003	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	122079	11672	17826	1739	547	223	17	0	0	0	0	0	0	0	0	0	0

Table 13.2.2.4 (cont). Haddock in Subarea IV and Division IIIa. 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+
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	198033	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

Table 13.2.3.1. Haddock in Subarea IV and Division IIIa. 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+
1963	0.012	0.123	0.253	0.473	0.695	0.807	1.004	1.131	1.173	1.576	1.825	0.000	0.000	0.000	0.000	0.000	1.228
1964	0.011	0.118	0.239	0.403	0.664	0.814	0.909	1.382	1.148	1.470	1.781	0.000	0.000	0.000	0.000	0.000	1.331
1965	0.010	0.069	0.226	0.366	0.648	0.845	1.193	1.173	1.482	1.707	2.239	0.000	0.000	0.000	0.000	0.000	1.696
1966	0.010	0.088	0.247	0.367	0.533	0.949	1.266	1.525	1.938	1.727	2.963	2.040	0.000	0.000	0.000	0.000	1.955
1967	0.011	0.115	0.281	0.461	0.594	0.639	1.057	1.501	1.922	2.069	2.348	0.000	0.000	0.000	0.000	0.000	1.996
1968	0.010	0.126	0.253	0.510	0.731	0.857	0.837	1.606	2.260	2.702	2.073	0.000	0.000	0.000	0.000	0.000	2.342
1969	0.011	0.063	0.216	0.406	0.799	0.891	1.031	1.094	2.040	3.034	3.264	0.000	0.000	0.000	0.000	0.000	2.178
1970	0.013	0.073	0.222	0.352	0.735	0.873	1.191	1.362	1.437	2.571	3.950	3.869	0.000	0.000	0.000	0.000	1.462
1971	0.011	0.107	0.247	0.362	0.506	0.887	1.267	1.534	1.337	1.275	1.969	4.306	3.543	0.000	0.000	0.000	1.349
1972	0.024	0.116	0.243	0.388	0.506	0.606	1.000	1.366	2.241	2.006	1.651	2.899	0.000	0.000	0.000	0.000	1.742
1973	0.044	0.112	0.241	0.373	0.586	0.649	0.725	1.044	1.302	2.796	1.726	2.020	2.158	0.000	0.000	0.000	1.731
1974	0.024	0.128	0.227	0.344	0.549	0.892	0.896	0.952	1.513	2.315	2.508	4.152	2.264	0.000	0.000	0.000	1.723
1975	0.020	0.101	0.242	0.357	0.450	0.680	1.245	1.124	1.093	1.720	2.217	2.854	0.000	3.426	0.000	0.000	1.183
1976	0.013	0.125	0.225	0.402	0.512	0.589	0.922	1.933	1.784	1.306	2.425	2.528	0.000	0.000	0.000	0.000	1.426
1977	0.019	0.109	0.243	0.347	0.602	0.614	0.803	1.181	1.943	2.322	1.780	3.189	0.000	4.119	0.000	0.000	1.900
1978	0.011	0.144	0.256	0.420	0.443	0.719	0.745	0.955	1.398	2.124	2.868	1.849	2.454	4.782	0.000	0.000	1.654
1979	0.009	0.096	0.292	0.444	0.637	0.664	0.934	1.187	1.187	1.468	2.679	1.624	1.760	1.643	0.000	0.000	1.377
1980	0.012	0.104	0.286	0.488	0.733	1.046	0.936	1.394	1.599	1.593	1.726	3.328	1.119	3.071	3.111	0.000	1.761
1981	0.009	0.074	0.265	0.477	0.745	1.148	1.480	1.180	1.634	1.764	1.554	1.492	3.389	4.273	1.981	0.000	1.688
1982	0.011	0.100	0.293	0.462	0.785	1.170	1.441	1.672	1.456	2.634	2.164	1.924	1.886	3.179	0.000	0.000	1.520
1983	0.022	0.136	0.298	0.449	0.651	0.916	1.215	1.162	1.920	1.376	1.395	1.907	2.853	4.689	0.000	0.000	1.555
1984	0.010	0.141	0.302	0.489	0.671	0.805	1.097	1.100	1.868	2.425	1.972	2.247	2.422	2.822	4.995	0.000	2.051
1985	0.013	0.149	0.280	0.481	0.668	0.858	1.049	1.459	1.833	2.124	2.145	2.003	2.387	2.471	2.721	3.970	1.937
1986	0.025	0.124	0.242	0.397	0.613	0.863	1.257	1.195	1.715	1.525	2.484	2.653	2.538	3.075	2.778	2.894	1.915
1987	0.008	0.126	0.267	0.406	0.615	1.029	1.276	1.433	1.529	1.877	2.054	1.940	2.471	2.411	2.996	2.638	1.673

Table 13.2.3.1 (cont). Haddock in Subarea IV and Division IIIa. 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+
1988	0.024	0.166	0.217	0.418	0.590	0.748	1.284	1.424	1.551	1.627	1.680	3.068	2.468	2.885	3.337	2.863	1.783
1989	0.027	0.198	0.304	0.372	0.606	0.811	0.982	1.364	1.655	1.684	2.248	2.166	2.364	2.389	2.307	1.146	1.756
1990	0.044	0.195	0.293	0.434	0.474	0.772	0.971	1.168	1.530	2.037	2.653	2.530	2.392	3.444	1.852	4.731	1.860
1991	0.029	0.179	0.322	0.473	0.640	0.651	1.042	1.232	1.481	1.776	1.996	2.253	2.404	1.070	3.509	2.936	1.583
1992	0.018	0.108	0.307	0.486	0.748	1.016	0.896	1.395	1.537	1.912	1.997	2.067	2.441	1.781	0.000	0.000	1.784
1993	0.010	0.116	0.282	0.447	0.680	0.894	1.173	1.102	1.592	1.737	1.920	1.718	2.274	2.516	0.000	0.000	1.753
1994	0.017	0.116	0.251	0.420	0.597	0.943	1.209	1.570	1.469	1.620	2.418	2.108	2.849	2.403	2.580	0.000	1.616
1995	0.013	0.102	0.301	0.366	0.597	0.768	1.118	1.444	1.761	1.873	1.881	2.508	1.674	1.699	2.243	0.000	1.866
1996	0.019	0.128	0.248	0.398	0.491	0.795	0.879	0.855	1.833	2.018	1.623	2.393	2.369	2.598	3.439	0.000	1.924
1997	0.021	0.134	0.286	0.362	0.591	0.621	0.921	0.974	1.647	2.209	2.146	2.032	2.757	2.262	2.867	2.782	1.893
1998	0.023	0.154	0.258	0.405	0.442	0.660	0.769	1.113	1.200	1.834	2.340	2.150	1.115	2.423	2.085	2.509	1.345
1999	0.023	0.168	0.244	0.365	0.480	0.500	0.691	0.785	0.758	1.258	1.559	1.913	2.232	2.392	2.912	2.225	0.838
2000	0.048	0.120	0.256	0.370	0.501	0.618	0.653	1.104	1.100	1.757	1.963	2.323	2.385	2.315	3.595	1.843	1.232
2001	0.021	0.110	0.217	0.315	0.472	0.706	0.762	0.975	1.892	1.216	2.144	2.891	3.237	2.534	1.239	3.425	1.769
2002	0.016	0.100	0.270	0.329	0.541	0.745	0.931	0.849	1.426	1.942	2.346	1.840	2.349	2.762	0.000	0.000	1.637
2003	0.030	0.097	0.214	0.329	0.406	0.682	0.791	1.158	1.384	1.657	2.181	2.209	2.506	2.606	1.981	3.092	1.635
2004	0.053	0.177	0.256	0.410	0.404	0.445	0.744	1.070	1.372	1.741	1.777	2.355	2.172	0.000	0.000	0.000	1.646
2005	0.055	0.200	0.295	0.387	0.522	0.484	0.521	0.882	1.119	1.360	1.835	2.682	2.553	2.319	3.431	0.000	1.345
2006	0.048	0.122	0.289	0.358	0.470	0.545	0.546	0.549	0.997	1.584	2.130	2.516	1.834	2.878	2.764	2.580	1.270
2007	0.039	0.163	0.227	0.423	0.498	0.624	0.718	0.716	0.749	0.909	2.278	0.954	1.712	2.348	4.244	0.000	0.753
2008	0.038	0.181	0.257	0.365	0.607	0.701	0.842	1.109	0.947	0.877	1.681	1.969	0.914	0.224	3.792	3.024	0.904
2009	0.048	0.208	0.306	0.323	0.386	0.718	0.908	1.008	1.509	1.366	1.013	0.983	1.150	3.158	2.115	0.000	1.186
2010	0.030	0.084	0.302	0.412	0.457	0.467	0.704	0.987	1.549	1.937	1.649	1.474	2.766	2.214	2.677	2.588	1.633
2011	0.017	0.174	0.260	0.400	0.433	0.466	0.527	0.637	0.802	0.559	1.484	1.787	1.593	0	0	0	0.906
2012	0.035	0.233	0.442	0.408	0.571	0.776	0.705	0.651	1.717	1.06	2.081	2.278	2.12	2.122	2.368	0	1.751

Table 13.2.3.2. Haddock in Subarea IV and Division IIIa. 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+
1963	0.000	0.233	0.326	0.512	0.715	0.817	1.009	1.131	1.173	1.576	1.825	0.000	0.000	0.000	0.000	0.000	1.228
1964	0.000	0.221	0.313	0.459	0.695	0.870	0.934	1.386	1.148	1.470	1.781	0.000	0.000	0.000	0.000	0.000	1.331
1965	0.000	0.310	0.357	0.410	0.679	0.907	1.242	1.182	1.482	1.707	2.239	0.000	0.000	0.000	0.000	0.000	1.696
1966	0.000	0.301	0.384	0.416	0.553	0.995	1.288	1.529	1.938	1.727	2.963	2.040	0.000	0.000	0.000	0.000	1.955
1967	0.000	0.260	0.404	0.510	0.614	0.645	1.063	1.501	1.922	2.069	2.348	0.000	0.000	0.000	0.000	0.000	1.996
1968	0.000	0.256	0.361	0.591	0.761	0.863	0.846	1.610	2.260	2.702	2.073	0.000	0.000	0.000	0.000	0.000	2.342
1969	0.000	0.178	0.302	0.506	0.870	0.984	1.065	1.102	2.040	3.034	3.264	0.000	0.000	0.000	0.000	0.000	2.178
1970	0.000	0.242	0.310	0.403	0.786	0.949	1.235	1.370	1.437	2.571	3.950	3.869	0.000	0.000	0.000	0.000	1.462
1971	0.000	0.256	0.335	0.399	0.524	0.905	1.281	1.534	1.337	1.275	1.969	4.306	3.543	0.000	0.000	0.000	1.349
1972	0.000	0.244	0.329	0.421	0.523	0.609	1.003	1.366	2.241	2.006	1.651	2.899	0.000	0.000	0.000	0.000	1.742
1973	0.000	0.225	0.315	0.406	0.606	0.663	0.726	1.044	1.302	2.796	1.726	2.020	2.158	0.000	0.000	0.000	1.731
1974	0.000	0.275	0.320	0.389	0.585	0.908	0.954	0.963	1.513	2.315	2.508	4.152	2.264	0.000	0.000	0.000	1.723
1975	0.000	0.258	0.345	0.408	0.487	0.686	1.248	1.124	1.094	1.720	2.217	2.854	0.000	3.426	0.000	0.000	1.184
1976	0.000	0.250	0.344	0.467	0.516	0.614	0.923	1.933	1.784	1.306	2.425	2.528	0.000	0.000	0.000	0.000	1.426
1977	0.000	0.286	0.362	0.396	0.614	0.630	0.817	1.181	1.943	2.322	1.780	3.189	0.000	4.119	0.000	0.000	1.900
1978	0.000	0.275	0.356	0.457	0.470	0.725	0.789	0.956	1.398	2.124	2.868	1.849	2.454	4.782	0.000	0.000	1.654
1979	0.000	0.274	0.361	0.468	0.642	0.668	0.935	1.187	1.187	1.468	2.679	1.624	1.760	1.643	0.000	0.000	1.377
1980	0.000	0.299	0.367	0.526	0.750	1.056	0.934	1.392	1.599	1.592	1.726	3.328	1.119	3.071	3.111	0.000	1.761
1981	0.000	0.339	0.385	0.525	0.754	1.149	1.481	1.180	1.634	1.764	1.554	1.492	3.389	4.273	1.981	0.000	1.688
1982	0.000	0.300	0.364	0.507	0.818	1.237	1.441	1.672	1.456	2.634	2.164	1.924	1.886	3.179	0.000	0.000	1.520
1983	0.000	0.312	0.387	0.482	0.663	0.925	1.243	1.162	1.920	1.376	1.395	1.907	2.853	4.689	0.000	0.000	1.555
1984	0.000	0.281	0.376	0.515	0.677	0.810	1.097	1.100	1.868	2.425	1.972	2.247	2.422	2.822	4.995	0.000	2.051
1985	0.000	0.277	0.359	0.502	0.671	0.871	1.051	1.459	1.833	2.124	2.145	2.003	2.387	2.471	2.721	3.970	1.937
1986	0.000	0.276	0.351	0.433	0.613	0.863	1.257	1.195	1.715	1.525	2.484	2.653	2.538	3.075	2.778	2.894	1.915
1987	0.000	0.274	0.345	0.451	0.622	1.029	1.276	1.433	1.529	1.877	2.054	1.940	2.471	2.411	2.996	2.638	1.673

Table 13.2.3.2. Haddock in Subarea IV and Division IIIa. 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+
1988	0.000	0.258	0.324	0.445	0.619	0.752	1.284	1.424	1.551	1.627	1.680	3.068	2.468	2.885	3.337	2.863	1.783
1989	0.000	0.310	0.388	0.415	0.617	0.810	0.982	1.361	1.653	1.684	2.236	2.166	2.364	2.389	2.307	1.146	1.753
1990	0.000	0.308	0.379	0.484	0.516	0.802	1.039	1.191	1.543	2.037	2.653	2.530	2.392	3.444	1.852	4.731	1.871
1991	0.000	0.319	0.377	0.480	0.643	0.653	1.042	1.232	1.481	1.776	1.996	2.253	2.404	1.070	3.509	2.936	1.583
1992	0.000	0.336	0.379	0.510	0.751	1.017	0.904	1.395	1.538	1.912	1.997	2.067	2.441	1.781	0.000	0.000	1.785
1993	0.000	0.326	0.393	0.483	0.684	0.896	1.173	1.111	1.592	1.737	1.920	1.718	2.274	2.516	0.000	0.000	1.753
1994	0.000	0.288	0.390	0.482	0.617	0.962	1.296	1.570	1.469	1.620	2.418	2.108	2.849	2.403	2.580	0.000	1.616
1995	0.000	0.323	0.403	0.425	0.608	0.772	1.118	1.444	1.761	1.873	1.881	2.508	1.674	1.699	2.243	0.000	1.866
1996	0.000	0.351	0.364	0.475	0.523	0.795	0.879	0.855	1.833	2.018	1.623	2.393	2.369	2.598	3.439	0.000	1.924
1997	0.000	0.388	0.416	0.417	0.614	0.624	0.921	0.974	1.647	2.209	2.146	2.032	2.757	2.262	2.867	2.782	1.893
1998	0.000	0.280	0.377	0.444	0.462	0.666	0.771	1.113	1.200	1.834	2.340	2.150	1.115	2.423	2.085	2.509	1.345
1999	0.000	0.291	0.349	0.423	0.489	0.511	0.729	0.785	0.758	1.258	1.559	1.913	2.232	2.392	2.912	2.225	0.838
2000	0.000	0.345	0.370	0.423	0.524	0.626	0.656	1.104	1.100	1.757	1.963	2.323	2.385	2.315	3.595	1.843	1.232
2001	0.000	0.433	0.355	0.447	0.505	0.723	0.762	0.980	1.922	1.216	2.144	2.891	3.237	2.534	1.239	3.425	1.788
2002	0.000	0.475	0.458	0.399	0.570	0.750	0.931	1.000	1.426	1.942	2.346	1.840	2.349	2.762	0.000	0.000	1.637
2003	0.000	0.311	0.438	0.476	0.443	0.687	0.798	1.159	1.386	1.659	2.181	2.209	2.506	2.606	1.981	3.092	1.636
2004	0.000	0.369	0.388	0.489	0.460	0.469	0.747	1.086	1.372	1.741	1.777	2.355	2.172	0.000	0.000	0.000	1.646
2005	0.000	0.400	0.401	0.429	0.551	0.512	0.533	0.883	1.119	1.360	1.835	2.682	2.553	2.319	3.431	0.000	1.345
2006	0.000	0.396	0.389	0.422	0.514	0.581	0.582	0.580	1.051	1.663	2.236	2.641	1.926	3.022	2.901	2.709	1.339
2007	0.000	0.383	0.386	0.473	0.515	0.631	0.718	0.719	0.753	0.909	2.278	0.954	1.712	2.348	4.244	0.000	0.757
2008	0.000	0.364	0.409	0.414	0.621	0.705	0.859	1.113	0.949	0.877	1.695	1.969	0.914	0.224	3.792	3.024	0.905
2009	0.000	0.444	0.433	0.409	0.412	0.732	0.912	1.009	1.511	1.369	1.017	0.983	1.150	3.158	2.115	0.000	1.190
2010	0.000	0.278	0.481	0.458	0.472	0.477	0.704	0.987	1.570	1.937	1.649	1.474	2.766	2.214	2.677	2.588	1.640
2011	0	0.266	0.358	0.412	0.440	0.467	0.529	0.637	0.802	0.559	1.456	1.698	1.593	0	0	0	0.900
2012	0	0.412	0.527	0.447	0.603	0.777	0.706	0.652	1.717	1.06	2.081	2.278	2.12	2.122	2.368	0	1.751

Table 13.2.3.3. Haddock in Subarea IV and Division IIIa. 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+
1963	0.064	0.139	0.218	0.327	0.397	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.065	0.177	0.249	0.306	0.337	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.064	0.131	0.200	0.341	0.613	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.063	0.141	0.208	0.244	0.310	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.064	0.171	0.209	0.274	0.306	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.063	0.186	0.212	0.256	0.318	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.064	0.129	0.216	0.237	0.301	0.321	0.321	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.063	0.129	0.210	0.238	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
1971	0.063	0.134	0.201	0.242	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
1972	0.063	0.139	0.206	0.237	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	0.063	0.131	0.201	0.235	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	0.062	0.145	0.200	0.233	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	0.050	0.123	0.200	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	0.079	0.176	0.197	0.237	0.292	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	0.071	0.196	0.197	0.216	0.309	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	0.037	0.180	0.199	0.222	0.224	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	0.053	0.118	0.219	0.242	0.259	0.340	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	0.149	0.231	0.274	0.324	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	0.073	0.160	0.198	0.290	0.650	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	0.072	0.197	0.248	0.271	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
1983	0.067	0.187	0.237	0.347	0.476	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	0.046	0.162	0.245	0.317	0.300	0.314	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	0.155	0.214	0.264	0.336	0.423	0.421	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.045	0.138	0.184	0.245	0.408	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	0.023	0.159	0.200	0.225	0.287	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	0.063	0.172	0.170	0.238	0.254	0.360	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 13.2.3.3 (cont). Haddock in Subarea IV and Division IIIa. 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+
1989	0.085	0.187	0.229	0.268	0.335	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	0.046	0.196	0.229	0.249	0.266	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	0.065	0.179	0.243	0.344	0.464	0.493	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	0.137	0.246	0.286	0.347	0.000	0.415	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.027	0.142	0.237	0.287	0.344	0.369	0.000	0.369	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1994	0.044	0.126	0.211	0.269	0.306	0.304	0.270	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1995	0.064	0.131	0.251	0.275	0.363	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	0.046	0.138	0.219	0.279	0.297	0.358	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1997	0.063	0.161	0.254	0.286	0.321	0.385	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1998	0.041	0.162	0.231	0.293	0.315	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	0.049	0.183	0.217	0.273	0.307	0.304	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2000	0.030	0.129	0.246	0.281	0.319	0.355	0.287	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2001	0.045	0.116	0.205	0.307	0.308	0.364	0.000	0.411	0.416	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.416
2002	0.042	0.166	0.226	0.268	0.352	0.378	0.000	0.357	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2003	0.046	0.125	0.222	0.265	0.332	0.536	0.654	0.951	0.946	1.154	0.000	0.000	0.000	0.000	0.000	0.000	1.015
2004	0.053	0.171	0.232	0.280	0.308	0.342	0.639	0.716	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2005	0.055	0.185	0.251	0.283	0.313	0.305	0.345	0.621	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2006	0.048	0.116	0.228	0.257	0.233	0.152	0.162	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2007	0.039	0.149	0.193	0.292	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	0.038	0.177	0.216	0.261	0.374	0.531	0.353	0.449	0.463	0.596	0.321	0.000	0.000	0.000	0.000	0.000	0.519
2009	0.048	0.188	0.250	0.248	0.279	0.409	0.433	0.425	0.366	0.409	0.452	0.000	0.000	0.000	0.000	0.000	0.442
2010	0.030	0.082	0.218	0.303	0.307	0.314	0.546	0.523	0.325	0.000	0.000	1.445	0.000	0.000	0.000	0.000	0.675
2011	0.017	0.169	0.224	0.298	0.308	0.354	0.349	0.000	0.000	0.000	2.027	2.215	0	0	0	0	2.121
2012	0.035	0.212	0.301	0.27	0.285	0.418	0.349	0.39	0	0	0	0	0	0	0	0	0

Table 13.2.3.4. Haddock in Subarea IV and Division IIIa. Mean weight at age data (kg) 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+
1963	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1964	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1965	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1966	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1967	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1968	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1969	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1970	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1971	0.010	0.040	0.180	0.302	0.400	0.420	0.440	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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

Table 13.2.3.4 (cont). Haddock in Subarea IV and Division IIIa. Mean weight at age data (kg) 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+
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	1.331	1.624	0	0	0	0.000
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	0	0

Table 13.2.6.1. Haddock in Subarea IV and Division IIIa. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

EngGFS Q3 GRT						
Years 1977 – 1991	Ages 0 - 6	Period 0.5 – 0.75				
53.48	6.681	3.206	6.163	0.925	0.073	0.091
35.827	13.688	2.618	0.239	2.22	0.214	0.005
87.551	29.555	5.461	0.872	0.108	0.438	0.035
37.403	62.331	16.732	2.57	0.273	0.042	0.142
153.746	17.318	43.91	7.557	0.742	0.064	0.003
28.134	31.546	7.98	11.8	1.025	0.237	0.098
83.193	21.82	10.952	2.143	2.174	0.265	0.04
22.847	59.933	6.159	3.078	0.418	0.478	0.103
24.587	18.656	23.819	2.111	0.698	0.196	0.128
26.6	14.974	4.472	3.382	0.277	0.175	0.038
2.241	28.194	4.31	0.532	0.686	0.048	0.033
6.073	2.856	18.352	1.549	0.16	0.279	0.041
9.428	8.168	1.447	3.968	0.253	0.031	0.061
28.188	6.645	1.983	0.287	0.878	0.048	0.026
26.333	11.505	0.961	0.231	0.048	0.219	0.005

EngGFS Q3 GOV						
Years 1992 – 2012	Ages 0 – 6	Period 0.5 – 0.75				
246.059	58.746	29.133	1.742	0.146	0.037	0.251
40.336	73.145	17.435	4.951	0.176	0.048	0.000
279.344	23.990	26.992	2.511	0.894	0.058	0.003
53.435	113.775	13.223	11.032	0.827	0.275	0.021
61.301	26.747	43.044	3.603	2.052	0.207	0.088
40.653	45.346	12.608	19.968	0.719	0.718	0.067
15.747	26.497	16.778	4.079	4.141	0.226	0.141
626.610	16.551	8.404	3.663	1.258	1.201	0.040
92.139	249.813	4.528	1.634	0.740	0.336	0.350
1.097	28.622	96.498	3.039	0.828	0.350	0.135
2.721	3.954	22.559	60.583	0.542	0.097	0.153
3.199	6.015	1.247	13.967	45.079	0.719	0.026
3.398	6.599	3.864	0.448	6.836	17.406	0.217
122.383	9.740	5.992	2.584	1.249	6.617	3.654
12.838	54.403	3.226	1.137	0.426	0.148	0.861
8.463	10.628	43.401	1.402	0.624	0.092	0.078
2.613	6.494	5.801	18.534	0.727	0.266	0.137
28.978	5.532	6.781	4.636	7.147	0.108	0.099
3.065	46.229	2.959	2.103	2.175	3.716	0.284
0.549	2.792	35.592	1.785	1.396	1.168	3.147
4.004	1.355	2.630	16.465	0.511	0.416	0.762

Table 13.2.6.1. cont. Haddock in Subarea IV and Division IIIa. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

ScoGFS Aberdeen Q3						
Years 1982 - 1997	Ages 0 - 6	Period 0.5 – 0.75				
1235	2488	996	1336	115	7	2
2203	1813	1611	372	455	53	12
873	4367	788	336	55	65	9
818	1976	2981	232	103	14	22
1747	2329	574	598	36	27	4
277	2393	704	106	128	8	5
406	467	1982	170	27	23	2
432	886	214	574	31	4	7
3163	1002	240	32	103	7	1
3471	1705	178	21	5	16	2
8270	3832	963	48	8	3	8
859	5836	1380	269	6	4	1
13762	1265	2080	210	53	2	0.5
1566	8153	734	926	74	28	2
1980	2231	4705	231	206	22	6
972	2779	849	1397	66	56	6

ScoGFS Q3 GOV						
Years 1998 - 2012	Ages 0 - 6	Period 0.5 – 0.75				
3280	6349	1924	490	511	24	18
66067	1907	1141	688	197	164	6
11902	30611	460	221	130	73	27
79	3790	11352	179	65	40	18
2149	675	2632	6931	70	37	18
2159	1172	307	2092	4344	22	17
1729	1198	547	101	819	1420	9
19708	761	657	153	112	347	483
2280	7275	272	158	33	14	73
1119	1810	5527	117	57	11	5
1885	733	1002	2424	28	24	6
9015	877	547	469	1185	37	8
115	8328	680	297	303	811	4
317	252	5192	284	127	101	285
580	69	270	1766	66	47	41

Table 13.2.6.1. cont. Haddock in Subarea IV and Division IIIa. Data available for calibration of the assessment. Only those data used in the final assessment are shown here.

IBTS Q1 (backshifted)				
Years 1982 - 2012	Ages 0 - 4	Period 0.99 – 1.0		
302.278	403.079	89.463	116.447	13.182
1072.285	221.275	127.77	20.41	20.9
230.968	833.257	107.598	32.317	3.575
573.023	266.912	303.546	17.888	6.49
912.559	328.062	45.201	58.262	4.345
101.691	677.641	97.149	12.684	13.965
219.705	98.091	274.788	16.653	2.113
217.448	139.114	32.997	50.367	3.163
680.231	134.076	25.032	4.26	8.476
1141.396	331.044	17.035	3.026	0.664
1242.121	519.521	152.384	8.848	1.076
227.919	491.051	97.656	23.308	1.566
1355.485	201.069	176.165	24.354	5.286
267.411	813.268	65.869	46.691	7.734
849.943	353.882	466.731	24.987	15.238
357.597	420.926	103.531	112.632	8.758
211.139	222.907	127.064	48.217	36.65
3471.461	99.409	44.915	23.230	14.879
890.441	1994.289	61.581	11.612	6.588
57.073	471.432	1302.933	8.732	6.714
89.991	39.267	241.529	532.024	5.354
71.877	79.617	35.471	173.617	329.991
69.976	60.993	32.625	10.997	61.287
1212.163	47.784	28.576	8.977	4.404
109.095	963.357	36.577	15.511	3.191
60.075	106.486	239.315	14.783	1.554
74.687	140.045	102.941	135.663	2.523
686.096	72.383	68.144	51.624	91.102
46.416	772.865	98.972	35.182	46.947
14.468	55.952	396.448	20.685	13.202
58.261	23.398	33.102	94.468	6.634

Table 13.3.5.1. Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics. Note that the diagnostics output from the FLXSA implementation used in the final assessment was incorrect: this has been corrected for the forecast procedure.

```
Lowestoft VPA Version 3.1


 Extended Survivors Analysis

 Haddock in the North Sea and Skagerrak: index

FLR XSA Diagnostics 2013-04-26 10:27:12

CPUE data from x.idx

Catch data for 50 years. 1963 to 2012. Ages 0 to 8.


               fleet first age last age first year last year alpha beta
1      EngGFS Q3 GRT         0        6       1977      1991   0.5 0.75
2      EngGFS Q3 GOV         0        6       1992      2012   0.5 0.75
3 ScoGFS Aberdeen Q3         0        6       1982      1997   0.5 0.75
4      ScoGFS Q3 GOV         0        6       1998      2012   0.5 0.75
5            IBTS Q1         0        4       1982      2012  0.99    1


 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  3 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   2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012
  all    1    1    1    1    1    1    1    1    1    1     1


Fishing mortalities
   year
age  2003  2004  2005  2006  2007  2008  2009  2010  2011  2012
  0 0.007 0.001 0.000 0.001 0.001 0.001 0.001 0.002 0.011 0.001
  1 0.106 0.051 0.053 0.046 0.038 0.041 0.027 0.042 0.036 0.039
  2 0.348 0.341 0.297 0.475 0.213 0.183 0.149 0.213 0.107 0.126
  3 0.159 0.309 0.436 0.575 0.592 0.162 0.213 0.303 0.438 0.165
  4 0.129 0.190 0.268 0.618 0.484 0.373 0.260 0.175 0.448 0.237
  5 0.197 0.155 0.208 0.422 0.411 0.191 0.202 0.190 0.287 0.158
  6 0.077 0.102 0.142 0.167 0.368 0.187 0.095 0.129 0.180 0.086
  7 0.033 0.024 0.059 0.101 0.102 0.126 0.129 0.064 0.181 0.069
  8 0.033 0.024 0.059 0.101 0.102 0.126 0.129 0.064 0.181 0.069
```

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

XSA population number (Thousand)

year \ age	0	1	2	3	4	5	6	7	8
2003	3749453	443420	59219	344827	1022906	12195	9008	9138	8142
2004	3608535	479430	76592	28020	229062	700393	8203	6831	6396
2005	42003728	464175	87456	36504	16021	147555	490983	6062	2792
2006	9049360	5405619	84542	43564	18382	9540	98117	348821	2036
2007	5523197	1164103	991474	35249	19091	7713	5123	67949	77890
2008	4090983	710386	215332	537088	15186	9165	4186	2904	34513
2009	30449019	525956	130910	120161	355699	8148	6200	2842	8547
2010	2173968	3916815	98361	75578	75637	213627	5451	4614	5957
2011	770959	279307	721211	53291	43494	49445	144590	3924	2673
2012	2506199	98195	51730	434180	26775	21652	30370	98927	5667

Estimated population abundance at 1st Jan 2013

year \ age	0	1	2	3	4	5	6	7	8
2013	0	322182	18144	30580	286823	16453	15137	22825	75590

Fleet: EngGFS Q3 GRT

Log catchability residuals.

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	0.538	-0.276	0.024	0.722	1.402	0.156	0.050	0.110	-0.147	-0.792	-0.795
1	-0.503	-0.241	-0.007	0.158	0.435	0.295	0.359	0.158	0.390	-0.208	-0.319
2	0.223	-0.304	-0.105	0.314	0.545	0.383	0.104	-0.038	0.058	0.074	-0.446
3	-0.246	-0.818	0.127	0.572	0.821	0.364	0.307	0.168	0.226	-0.411	-0.516
4	0.365	0.169	-0.148	0.386	0.508	0.036	0.002	0.039	0.086	-0.224	-0.476
5	0.196	0.197	-0.094	0.265	0.050	0.183	-0.069	-0.168	0.487	0.052	-0.499
6	0.221	-0.697	-0.402	0.203	-1.045	1.540	-0.721	0.281	-0.204	-0.049	-0.168

age \ year	1988	1989	1990	1991
0	-0.499	-0.091	-0.185	-0.217
1	-0.118	0.213	0.023	-0.636
2	0.176	0.057	-0.078	-0.962
3	0.169	0.033	-0.114	-0.682
4	-0.166	0.001	-0.039	-0.537
5	0.124	-0.403	-0.198	-0.125
6	0.953	0.157	0.925	-0.993

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

```
Fleet:  EngGFS Q3 GOV Log catchability residuals.

   year
age   1992   1993   1994   1995   1996   1997   1998   1999   2000   2001
  0  1.219  0.582  1.052  0.800  0.505  0.607 -0.097  0.979  0.712 -1.478
  1  0.293  0.115  0.165  0.219  0.164  0.286  0.260  0.054  0.091 -0.417
  2  0.469  0.019 -0.084  0.328 -0.047  0.089  0.101  0.041 -0.326 -0.270
  3  0.379  0.072 -0.505  0.225  0.230  0.198 -0.086 -0.181 -0.281  0.528
  4 -0.268 -0.382 -0.130 -0.123 -0.089 -0.101 -0.130 -0.164 -0.424  0.202
  5  0.089  0.266 -0.114  0.099 -0.079  0.144 -0.042  0.008 -0.486 -0.103
  6  1.240 -1.965 -0.627  0.081  0.375  0.067 -0.392 -0.539  0.005 -0.518
   year
age   2002   2003   2004   2005   2006   2007   2008   2009   2010   2011
  0 -0.819 -0.723 -0.628  0.502 -0.218 -0.141 -1.015 -0.617 -0.223 -0.901
  1 -0.114  0.056  0.037  0.460 -0.279 -0.382 -0.378 -0.247 -0.122 -0.292
  2 -0.145 -0.606  0.263  0.542  0.067  0.041 -0.462  0.170 -0.334  0.008
  3 -0.037  0.003 -0.833  0.734 -0.178  0.254 -0.155 -0.012 -0.283 -0.013
  4 -0.110  0.358  0.007  1.016  0.020  0.281  0.593 -0.345 -0.040  0.240
  5 -1.042  1.051  0.161  0.784 -0.144 -0.414  0.338 -0.439 -0.174  0.192
  6 -0.057 -1.530  0.702 -0.542 -0.361  0.314  0.967  0.193  1.396  0.555
   year
age   2012
  0 -0.099
  1  0.032
  2  0.137
  3 -0.059
  4 -0.411
  5 -0.095
  6  0.638


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                0       1       2       3       4       5       6
Mean_Logq -16.5824 -14.7800 -14.3009 -14.4672 -14.7571 -15.1470 -15.6582
S.E_Logq    0.7760   0.2543   0.2886   0.3452   0.3523   0.4349   0.8262
```

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

```
Fleet:  ScoGFS Aberdeen Q3


 Log catchability residuals.

   year
age   1982   1983   1984   1985   1986   1987   1988   1989   1990   1991
  0 -0.186 -0.798 -0.371 -0.766 -0.732 -0.102 -0.421 -0.390  0.411  0.540
  1 -0.221 -0.105 -0.437  0.169 -0.045 -0.761  0.095  0.016  0.155 -0.522
  2  0.288  0.173 -0.108 -0.034  0.007 -0.272 -0.063  0.132 -0.204 -0.663
  3  0.233  0.604  0.001  0.065 -0.096 -0.082  0.007  0.147 -0.260 -1.033
  4  0.025  0.615  0.188  0.350 -0.087  0.022  0.231  0.078 -0.005 -0.621
  5 -1.084  0.577  0.092  0.103  0.438 -0.035 -0.116 -0.196  0.131 -0.486
  6 -0.282  0.144 -0.087  0.105 -0.231  0.014  0.002  0.061 -0.264  0.160
   year
age   1992   1993   1994  1995  1996   1997
  0  0.993 -0.101  1.208 0.437 0.239  0.040
  1  0.317  0.341 -0.023 0.337 0.435  0.248
  2 -0.227  0.196  0.067 0.150 0.453  0.105
  3 -0.432 -0.060 -0.206 0.528 0.264  0.319
  4 -0.421 -1.009 -0.205 0.215 0.364  0.262
  5  0.179  0.383 -0.880 0.416 0.281  0.195
  6  0.109  0.351 -0.103 0.045 0.005 -0.030


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                0        1        2        3        4        5        6
Mean_Logq -12.8413 -10.6268 -10.1069 -10.3403 -10.6004 -10.8413 -11.0664
S.E_Logq 0.6022 0.3414 0.2627 0.3897 0.4062 0.4668 0.1674
```

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

```
Fleet:  ScoGFS Q3 GOV
  year
age   1998   1999   2000   2001   2002   2003   2004   2005   2006   2007
  0  0.161  0.556  0.493 -2.282  0.772  0.711  0.524  0.502 -0.119 -0.337
  1  0.932 -0.006  0.093 -0.338  0.219  0.522  0.432  0.011 -0.190 -0.051
  2  0.033  0.142 -0.515 -0.312 -0.195  0.090  0.406  0.429 -0.308  0.079
  3 -0.044  0.308 -0.121 -0.142 -0.044  0.266 -0.162  0.068  0.010 -0.068
  4 -0.058  0.147  0.002 -0.178  0.009  0.184  0.050  0.769 -0.373  0.053
  5 -0.128  0.174  0.144 -0.116  0.150 -0.280 -0.189 -0.007 -0.346 -0.381
  6 -0.056 -0.041 -0.163 -0.138  0.197  0.440 -0.086 -0.171 -0.434 -0.038
   year
age   2008   2009   2010   2011   2012
  0  0.485  0.042 -1.679  0.377 -0.204
  1 -0.459  0.012  0.265 -0.596 -0.845
  2 -0.120 -0.249  0.294  0.269 -0.041
  3 -0.028 -0.142 -0.079  0.310 -0.131
  4 -0.499  0.023  0.154  0.008 -0.293
  5  0.089  0.647  0.460 -0.099 -0.119
  6  0.234  0.072 -0.472  0.544  0.111


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                0       1       2       3        4        5        6
Mean_Logq -11.5014 -9.9732 -9.4912 -9.7205 -10.0144 -10.3957 -11.1453
S.E_Logq    0.8775  0.4541  0.2825  0.1647   0.2910   0.2859   0.2804
```

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

Fleet: IBTS Q1

Log catchability residuals.

year / age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	-0.336	-0.265	-0.452	0.127	-0.137	0.141	0.209	0.168	0.119	0.676	0.347
1	-0.142	-0.317	-0.212	0.079	-0.123	-0.149	0.420	0.038	0.047	-0.269	0.204
2	-0.074	-0.224	0.044	-0.197	-0.257	-0.020	0.148	0.400	-0.155	-0.825	0.094
3	0.013	-0.009	-0.048	-0.208	-0.032	0.126	0.104	0.008	0.085	-0.655	0.229
4	0.076	-0.151	-0.252	-0.100	0.224	0.137	0.066	0.179	-0.168	-0.390	-0.099

year / age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	-0.173	0.135	-0.072	0.643	0.286	0.003	0.197	0.488	-0.019	0.197	-0.106
1	-0.239	0.027	-0.096	0.452	0.240	0.117	-0.447	-0.010	0.093	-0.090	0.360
2	-0.263	-0.306	-0.185	0.198	0.047	0.044	-0.331	0.007	0.142	-0.021	0.570
3	-0.201	-0.048	-0.217	0.294	-0.048	0.379	-0.168	-0.249	-0.265	0.006	0.383
4	-0.093	-0.234	0.217	-0.013	0.410	0.103	0.057	-0.088	0.259	0.091	0.163

year / age	2004	2005	2006	2007	2008	2009	2010	2011	2012
0	-0.105	-0.161	-1.074	-0.679	-0.160	0.050	-0.004	-0.123	0.081
1	-0.039	-0.459	-0.860	-0.383	0.386	0.005	0.391	0.400	0.576
2	0.238	-0.347	-0.268	-0.474	0.176	0.225	0.954	0.244	0.414
3	0.226	-0.307	-0.385	0.631	-0.307	0.267	0.447	0.400	-0.451
4	0.000	-0.186	-0.424	-0.862	-0.264	0.054	0.863	0.419	0.007

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

```
 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                0        1        2        3        4
Mean_Logq -13.3148 -11.8429 -11.8507 -12.1748 -12.4301
S.E_Logq    0.3503   0.3207   0.3391   0.2950   0.3027
Terminal year survivor and F summaries:

 Age 0 Year class =2012

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.145    291933  2012
ScoGFS Q3 GOV     0.111    262765  2012
IBTS Q1           0.721    349510  2012
fshk              0.023    124464  2012

 Age 1 Year class =2011

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.438     18732  2011
ScoGFS Q3 GOV     0.179      7796  2011
IBTS Q1           0.372     32272  2011
fshk              0.010     17025  2011

 Age 2 Year class =2010

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.359     35062  2010
ScoGFS Q3 GOV     0.359     29336  2010
IBTS Q1           0.272     46280  2010
fshk              0.009     21396  2010

 Age 3 Year class =2009

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.262    270322  2009
ScoGFS Q3 GOV     0.364    251675  2009
IBTS Q1           0.364    182732  2009
fshk              0.010    124865  2009

 Age 4 Year class =2008

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.259     10908  2008
ScoGFS Q3 GOV     0.373     12279  2008
IBTS Q1           0.356     16559  2008
fshk              0.011     10477  2008

 Age 5 Year class =2007

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.307     13768  2007
ScoGFS Q3 GOV     0.675     13441  2007
fshk              0.018      8819  2007

 Age 6 Year class =2006

source
             scaledWts survivors yrcls
EngGFS Q3 GOV     0.109     43212  2006
ScoGFS Q3 GOV     0.869     25497  2006
fshk              0.021      9624  2006

 Age 7 Year class =2005

source
     scaledWts survivors yrcls
fshk         1     31028  2005
NULL
```

Table 13.3.5.2. Haddock in Subarea IV and Division IIIa. Estimates of fishing mortality at age from the final XSA 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+
1963	0.002	0.125	0.805	0.668	0.762	0.902	0.649	0.779	0.779
1964	0.043	0.059	0.457	1.174	0.751	0.886	1.365	1.012	1.012
1965	0.071	1.359	0.421	0.513	0.984	1.275	1.026	1.108	1.108
1966	0.070	1.304	0.828	0.367	0.792	1.237	1.225	1.098	1.098
1967	0.002	0.262	1.085	0.412	0.382	1.058	1.313	0.927	0.927
1968	0.002	0.051	0.578	0.908	0.304	0.529	0.900	0.582	0.582
1969	0.017	0.021	0.654	1.377	1.332	0.801	1.872	1.352	1.352
1970	0.030	0.503	1.036	1.145	1.274	0.781	1.364	1.153	1.153
1971	0.012	0.474	0.665	0.793	0.860	0.873	0.839	0.866	0.866
1972	0.032	0.168	0.793	1.380	1.183	1.121	0.880	1.074	1.074
1973	0.002	0.373	0.565	1.161	0.873	0.910	0.995	0.936	0.936
1974	0.013	0.351	0.934	0.945	1.007	0.751	0.791	0.859	0.859
1975	0.011	0.333	0.957	1.262	1.087	1.006	1.265	1.133	1.133
1976	0.029	0.306	0.809	1.312	0.798	1.219	1.106	1.053	1.053
1977	0.012	0.327	0.995	1.015	1.090	1.083	0.879	1.029	1.029
1978	0.020	0.373	0.990	1.124	1.071	0.771	1.207	0.843	0.843
1979	0.033	0.171	0.829	1.080	1.052	0.898	0.453	0.900	0.900
1980	0.068	0.182	0.690	1.014	0.993	0.912	0.716	0.207	0.207
1981	0.057	0.176	0.439	0.898	0.640	0.539	0.577	0.504	0.504
1982	0.039	0.173	0.418	0.781	0.778	0.287	0.365	0.872	0.872
1983	0.027	0.151	0.653	0.963	1.037	0.883	0.230	0.254	0.254
1984	0.016	0.125	0.670	0.974	0.976	0.880	0.508	0.117	0.117
1985	0.016	0.208	0.613	0.968	1.036	0.689	0.491	0.231	0.231
1986	0.003	0.129	1.029	1.240	1.338	0.891	0.332	0.211	0.211
1987	0.006	0.106	0.909	1.078	1.084	0.930	0.736	0.238	0.238
1988	0.004	0.135	0.787	1.312	1.223	1.110	0.996	0.350	0.350
1989	0.003	0.106	0.655	0.977	1.222	0.888	0.778	1.084	1.084
1990	0.005	0.184	1.113	1.145	1.084	0.968	0.872	0.634	0.634
1991	0.013	0.152	0.778	1.037	0.847	0.780	0.737	1.504	1.504
1992	0.018	0.136	0.726	1.134	1.081	0.772	0.820	0.965	0.965
1993	0.030	0.161	0.791	1.002	0.897	1.001	0.716	0.452	0.452
1994	0.004	0.145	0.541	1.022	0.927	0.675	1.237	0.783	0.783
1995	0.040	0.099	0.486	0.825	0.887	0.680	0.376	1.085	1.085
1996	0.019	0.062	0.431	0.854	0.779	0.730	0.645	1.748	1.748
1997	0.006	0.118	0.399	0.588	0.626	0.532	0.402	0.283	0.283
1998	0.006	0.123	0.581	0.496	0.734	0.527	0.221	0.163	0.163
1999	0.002	0.157	0.765	0.846	0.531	0.695	0.423	0.145	0.145
2000	0.001	0.046	0.729	0.840	0.726	0.240	0.312	0.167	0.167
2001	0.002	0.059	0.270	0.780	0.426	0.235	0.090	0.069	0.069
2002	0.039	0.122	0.141	0.180	0.367	0.165	0.087	0.041	0.041
2003	0.007	0.102	0.329	0.152	0.121	0.183	0.067	0.029	0.029
2004	0.001	0.049	0.323	0.286	0.180	0.144	0.094	0.021	0.021
2005	0.000	0.051	0.283	0.404	0.243	0.195	0.130	0.054	0.054
2006	0.001	0.046	0.456	0.534	0.544	0.367	0.155	0.092	0.092
2007	0.001	0.038	0.211	0.554	0.428	0.335	0.301	0.094	0.094
2008	0.001	0.043	0.184	0.160	0.335	0.162	0.143	0.098	0.098
2009	0.001	0.025	0.157	0.213	0.257	0.176	0.079	0.095	0.095
2010	0.002	0.039	0.201	0.322	0.176	0.187	0.109	0.052	0.052
2011	0.012	0.042	0.093	0.372	0.428	0.297	0.180	0.181	0.181
2012	0.001	0.039	0.126	0.165	0.237	0.158	0.086	0.069	0.069

Table 13.3.5.3. Haddock in Subarea IV and Division IIIa. Estimates of stock numbers at age from the final XSA 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+
1963	2314960	25450123	739725	48723	27674	10747	1164	1334	1295
1964	9155375	297529	4315455	221616	19449	10058	3569	498	839
1965	26286881	1128465	53886	1832183	53362	7146	3396	746	385
1966	68923158	3150905	55670	23717	854118	15538	1635	997	455
1967	388351133	8274712	164301	16310	12802	301149	3693	393	552
1968	17114813	49884823	1222288	37211	8410	6807	85634	814	144
1969	12133861	2199289	9099619	459729	11690	4833	3284	28515	336
1970	87605720	1536018	413403	3171940	90347	2403	1776	413	9575
1971	78203289	10946170	178355	98333	786428	19680	901	372	3579
1972	21425991	9948848	1308897	61465	34647	259107	6729	319	791
1973	72938535	2671841	1614428	396929	12048	8265	69179	2285	536
1974	132845377	9368253	353207	615156	96797	3918	2725	20935	578
1975	11406566	16886052	1266973	93003	186209	27548	1513	1011	4894
1976	16397329	1452296	2323728	326106	20508	48922	8251	350	1496
1977	26203002	2050927	205424	693724	68375	7191	11835	2236	621
1978	39808657	3331996	284062	50905	195796	17905	1993	4025	1169
1979	72620594	5022205	440548	70731	12887	52233	6784	488	1306
1980	15795472	9046900	813148	128945	18704	3504	17424	3532	2362
1981	32606103	1898895	1448158	273383	36437	5395	1152	6972	691
1982	20488195	3965611	305766	625759	86760	14959	2577	530	1571
1983	66943546	2537547	640912	134981	223288	31048	9192	1465	1559
1984	17180273	8388408	418858	223539	40113	61667	10508	5980	2599
1985	23917418	2177435	1421597	143705	65737	11766	20947	5176	2011
1986	49002387	3028926	339786	515970	42525	18164	4835	10496	2821
1987	4154844	6288044	511430	81377	116227	8689	6104	2839	5533
1988	8337202	531494	1085919	138137	21565	30627	2807	2394	1532
1989	8604153	1069411	89180	331254	28976	4941	8265	848	550
1990	28334295	1103814	184664	31044	97074	6650	1665	3107	823
1991	27456974	3627709	176343	40672	7697	25567	2068	570	1151
1992	41943346	3490212	598477	54270	11231	2569	9600	810	1310
1993	13122801	5302426	585168	194126	13600	2966	972	3461	1377
1994	55983396	1638697	867019	177878	55527	4321	892	389	1431
1995	14292721	7176173	272269	338403	49872	17115	1800	212	234
1996	21442638	1767760	1248362	112239	115464	16005	7096	1012	162
1997	12752842	2707157	319037	543744	37204	41257	6315	3048	459
1998	9957388	1631382	461948	143566	235238	15496	19837	3458	1247
1999	138417502	1273929	277034	173143	68081	87899	7492	13019	3195
2000	26490420	17788879	209174	86432	57853	31190	35899	4019	2015
2001	2843508	3407862	3263381	67654	29055	21796	20083	21512	4603
2002	3727538	365150	617039	1669351	24146	14786	14114	15030	20512
2003	3898976	461654	62064	359296	1086355	13027	10260	10591	9438
2004	3716574	498679	80094	29927	240331	749806	8884	7856	7357
2005	42319097	478083	91153	38852	17506	156331	531440	6619	3049
2006	9031849	5446218	87213	46042	20210	10696	105302	381944	2229
2007	5287388	1161849	999271	37039	21021	9137	6070	73832	84646
2008	4293403	680030	214899	542315	16580	10668	5352	3679	43746
2009	33107554	552015	125080	119871	359769	9234	7430	3796	11424
2010	1794179	4259062	103366	71670	75411	216797	6340	5622	7259
2011	680950	244094	826285	60814	45082	48058	144090	3925	2673
2012	2506199	98195	51730	434180	26775	21652	30370	98927	5667

Table 13.3.5.4. Haddock in Subarea IV and Division IIIa. Stock summary table.

	Recruitment	TSB	SSB	Catch	Landings	Discards	Bycatch	Yield/SSB	F (2-4)
1963	2314960	3412683	137050	271851	68821	189330	13700	0.502	0.745
1964	9155375	1281817	417713	379915	131006	160309	88600	0.314	0.794
1965	26286881	1080997	521738	299343	162418	62325	74600	0.311	0.639
1966	68923158	1480495	427838	346349	226184	73465	46700	0.529	0.662
1967	388351133	5527447	224790	246664	147742	78222	20700	0.657	0.626
1968	17114813	6852013	259397	301821	105811	161810	34200	0.408	0.597
1969	12133861	2477679	810544	930043	331625	260065	338353	0.409	1.121
1970	87605720	2541768	900221	805776	524773	101274	179729	0.583	1.152
1971	78203289	2546401	420401	446824	237502	177776	31546	0.565	0.773
1972	21425991	2182179	302976	353084	195545	127954	29585	0.645	1.119
1973	72938535	4087838	297147	307594	181592	114735	11267	0.611	0.866
1974	132845377	4710721	260752	366992	153057	166429	47505	0.587	0.962
1975	11406566	2385147	238279	453205	151349	260370	41487	0.635	1.102
1976	16397329	1097473	309487	375305	172680	154462	48163	0.558	0.973
1977	26203002	1069043	242297	224516	145118	44376	35022	0.599	1.033
1978	39808657	1137542	138098	179375	91683	76789	10903	0.664	1.062
1979	72620594	1352096	117086	145019	87069	41710	16240	0.744	0.987
1980	15795472	1470716	169227	222127	105041	94614	22472	0.621	0.899
1981	32606103	996405	257248	213240	136132	60067	17041	0.529	0.659
1982	20488195	1091776	320939	233283	173335	40564	19383	0.54	0.659
1983	66943546	2253195	276470	244212	165337	65977	12898	0.598	0.884
1984	17180273	1690885	224030	218946	133568	75298	10080	0.596	0.873
1985	23917418	1188181	261091	255366	164119	85249	5998	0.629	0.872
1986	49002387	1941134	237140	223081	168236	52203	2643	0.709	1.203
1987	4154844	1097088	166839	173852	110299	59143	4410	0.661	1.024
1988	8337202	630204	159929	173124	106973	62148	4002	0.669	1.108
1989	8604153	623382	127707	106526	78439	25677	2410	0.614	0.952
1990	28334295	1581748	80676	88934	53780	32565	2589	0.667	1.114
1991	27456974	1551974	63074	93287	47715	40185	5386	0.756	0.888
1992	41943346	1363931	103105	131650	72790	47934	10927	0.706	0.98
1993	13122801	1018311	138475	172551	82176	79609	10766	0.593	0.896
1994	55983396	1485103	161327	151020	82074	65370	3576	0.509	0.83
1995	14292721	1170059	162662	142524	77458	57371	7695	0.476	0.733
1996	21442638	1058031	201674	156609	79148	72461	5000	0.392	0.688
1997	12752842	975541	225758	141347	82574	52089	6684	0.366	0.537
1998	9957388	791581	202849	131316	81054	45160	5101	0.4	0.604
1999	138417502	3673171	156880	112021	65588	42598	3835	0.418	0.714
2000	26490420	3556209	135081	104457	47553	48770	8134	0.352	0.765
2001	2843508	1236908	316340	166960	40856	118225	7879	0.129	0.492
2002	3727538	896641	524367	107923	58348	45857	3717	0.111	0.229
2003	3898976	781120	517010	66805	41964	23691	1150	0.081	0.201
2004	3716574	775860	444700	64839	48734	15551	554	0.11	0.263
2005	42319097	2836645	386936	57162	48357	8637	168	0.125	0.31
2006	9031849	1422690	310074	56056	37613	17908	535	0.121	0.511
2007	5287388	775740	221317	59643	30939	28657	48	0.14	0.398
2008	4293403	605339	223563	43640	30248	13193	199	0.135	0.227
2009	33107554	1950891	192276	43407	32807	10548	52	0.171	0.209
2010	1794179	633149	182559	39640	29054	10155	431	0.159	0.233
2011	680950	415673	205468	46378	34840	11515	23	0.170	0.298
2012	2506199	438587	258458	37558	33052	4505	1	0.128	0.176

Table 13.6.1. Haddock in Subarea IV and Division IIIa. Short-term forecast input.

MFDP version 1a						
Run: 01						
Time and date: 11:24 28/04/2013						
Fbar age range (Total) : 2-4						
Fbar age range Fleet 1 : 2-4						
Fbar age range Fleet 2 : 2-4						
2013						
Age	N	M	Mat	PF	PM	SWt
0	3103226	2.05	0	0	0	0.027
1	322313	1.65	0.01	0	0	0.164
2	18137	0.4	0.32	0	0	0.335
3	30571	0.25	0.71	0	0	0.627
4	286707	0.25	0.87	0	0	0.514
5	16452	0.2	0.95	0	0	0.681
6	15136	0.2	1	0	0	0.813
7	22816	0.2	1	0	0	0.742
8	79925	0.2	1	0	0	0.92
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0	0.003	0.027		
1	0.001	0.319	0.028	0.154		
2	0.034	0.455	0.08	0.248		
3	0.144	0.439	0.065	0.27		
4	0.18	0.603	0.023	0.285		
5	0.146	0.777	0.006	0.418		
6	0.093	0.706	0	0.349		
7	0.071	0.652	0	0.39		
8	0.071	1.708	0	0		
IBC						
Age	Sel	CWt				
0	0	0.2335				
1	0.001	0.386				
2	0.001	0.5376				
3	0	0.7194				
4	0	1.1105				
5	0	1.2705				
6	0	1.324				
7	0	1.405				
8	0	0.4945				

Table 13.6.1 (cont). Haddock in Subarea IV and Division IIIa. Short-term forecast input.

2014							2015						
Age	N	M	Mat	PF	PM	SWt	Age	N	M	Mat	PF	PM	SWt
0	3103226	2.05	0	0	0	0.027	0	3103226	2.05	0	0	0	0.027
1	.	1.65	0.01	0	0	0.164	1	.	1.65	0.01	0	0	0.164
2	.	0.4	0.32	0	0	0.335	2	.	0.4	0.32	0	0	0.335
3	.	0.25	0.71	0	0	0.407	3	.	0.25	0.71	0	0	0.407
4	.	0.25	0.87	0	0	0.833	4	.	0.25	0.87	0	0	0.487
5	.	0.2	0.95	0	0	0.64	5	.	0.2	0.95	0	0	1.039
6	.	0.2	1	0	0	0.807	6	.	0.2	1	0	0	0.765
7	.	0.2	1	0	0	0.942	7	.	0.2	1	0	0	0.933
8	.	0.2	1	0	0	1.121	8	.	0.2	1	0	0	1.192

Catch					Catch				
Age	Sel	CWt	DSel	DCWt	Age	Sel	CWt	DSel	DCWt
0	0	0	0.003	0.027	0	0	0	0.003	0.027
1	0.001	0.319	0.028	0.154	1	0.001	0.319	0.028	0.154
2	0.034	0.455	0.08	0.248	2	0.034	0.455	0.08	0.248
3	0.144	0.439	0.065	0.29	3	0.144	0.439	0.065	0.29
4	0.18	0.505	0.023	0.358	4	0.18	0.505	0.023	0.3
5	0.146	0.587	0.006	0.387	5	0.146	0.574	0.006	0.439
6	0.093	0.744	0	0.483	6	0.093	0.628	0	0.447
7	0.071	0.66	0	0.439	7	0.071	0.828	0	0.55
8	0.071	1.154	0	0.657	8	0.071	1.346	0	0.695

IBC			IBC		
Age	Sel	CWt	Age	Sel	CWt
0	0	0.2335	0	0	0.2335
1	0.001	0.386	1	0.001	0.386
2	0.001	0.5376	2	0.001	0.5376
3	0	0.7194	3	0	0.7194
4	0	1.1105	4	0	1.1105
5	0	1.2705	5	0	1.2705
6	0	1.324	6	0	1.324
7	0	1.405	7	0	1.405
8	0	0.4945	8	0	0.4945

Input units are thousands and kg
- output in tonnes

Table 13.6.2. Haddock in Subarea IV and Division IIIa. Short-term forecast output. A number of management options are highlighted.

2013																		
		Catch			Landings		Discards		IBC	Landings								
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield							
423228	257701	1	0.1756	41798	0.1193	38693	0.056	3037	1	0.0003	68							

2014												2015		2013 TAC		41575	
		Catch			Landings		Discards		IBC	Landings							
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	TAC change	SSB change		
414190	242848	0.00	0.000	102	0.000	0	0.000	0	1	0.0003	102	421500	249379	-100%		-3%	F = 0
.	242848	0.10	0.018	2766	0.012	2402	0.006	262	1	0.0003	102	418398	246428	-94%		-4%	
.	242848	0.20	0.035	5396	0.024	4773	0.011	522	1	0.0003	101	415338	243518	-89%		-6%	
.	242848	0.30	0.053	7995	0.036	7114	0.017	780	1	0.0003	101	412319	240646	-83%		-7%	
.	242848	0.40	0.070	10561	0.048	9425	0.022	1035	1	0.0003	101	409341	237814	-77%		-8%	
.	242848	0.50	0.088	13097	0.060	11708	0.028	1288	1	0.0003	101	406402	235021	-72%		-9%	
.	242848	0.60	0.106	15601	0.072	13962	0.034	1538	1	0.0003	101	403502	232265	-66%		-10%	
.	242848	0.70	0.123	18073	0.084	16187	0.039	1786	1	0.0003	100	400641	229546	-61%		-11%	
	242848	0.75	0.132	19296	0.090	17286	0.042	1910	1	0.0003	100	399229	228206	-58%		-11%	0.75 * F2012
.	242848	0.80	0.141	20518	0.096	18385	0.045	2033	1	0.0003	100	397817	226865	-56%		-12%	
.	242848	0.90	0.158	22932	0.107	20555	0.050	2277	1	0.0003	100	395031	224219	-51%		-13%	
.	242848	1.00	0.176	25315	0.119	22697	0.056	2518	1	0.0003	100	392282	221609	-45%		-14%	F2012
.	242848	1.10	0.193	27671	0.131	24814	0.062	2758	1	0.0003	99	389569	219035	-40%		-15%	
.	242848	1.20	0.211	29998	0.143	26903	0.067	2996	1	0.0003	99	386892	216494	-35%		-16%	
	242848	1.25	0.219	31148	0.149	27935	0.070	3114	1	0.0003	99	385571	215241	-33%		-16%	1.25 * F2012
.	242848	1.30	0.228	32297	0.155	28967	0.073	3231	1	0.0003	99	384250	213988	-30%		-17%	
.	242848	1.40	0.246	34569	0.167	31005	0.078	3465	1	0.0003	99	381643	211516	-25%		-18%	
.	242848	1.50	0.263	36813	0.179	33018	0.084	3696	1	0.0003	99	379070	209077	-21%		-19%	
.	242848	1.60	0.281	39030	0.191	35006	0.090	3926	1	0.0003	98	376530	206670	-16%		-20%	
	242848	1.62	0.284	39401	0.193	35339	0.091	3964	1	0.0003	98	376105	206268	-15%		-20%	15% quota decrease
.	242848	1.70	0.298	41220	0.203	36969	0.095	4153	1	0.0003	98	374024	204296	-11%		-21%	
	242848	1.71	0.300	41418	0.204	37146	0.096	4174	1	0.0003	98	373798	204082	-11%		-21%	MP F target
.	242848	1.80	0.316	43385	0.215	38908	0.101	4379	1	0.0003	98	371551	201953	-6%		-22%	
.	242848	1.90	0.333	45524	0.227	40823	0.106	4603	1	0.0003	98	369110	199641	-2%		-23%	
	242848	1.94	0.340	46364	0.231	41575	0.109	4691	1	0.0003	98	368152	198734	0%		-23%	Rollover TAC
.	242848	2.00	0.351	47638	0.239	42715	0.112	4825	1	0.0003	98	366700	197360	3%		-23%	
	242848	2.20	0.387	53283	0.263	47811	0.123	5375	1	0.0003	97	360108	191083	15%		-26%	15% quota increase
	242848	3.99	0.700	95538	0.476	85775	0.223	9670	1	0.0003	93	311422	144873	106%		-44%	F(pa)

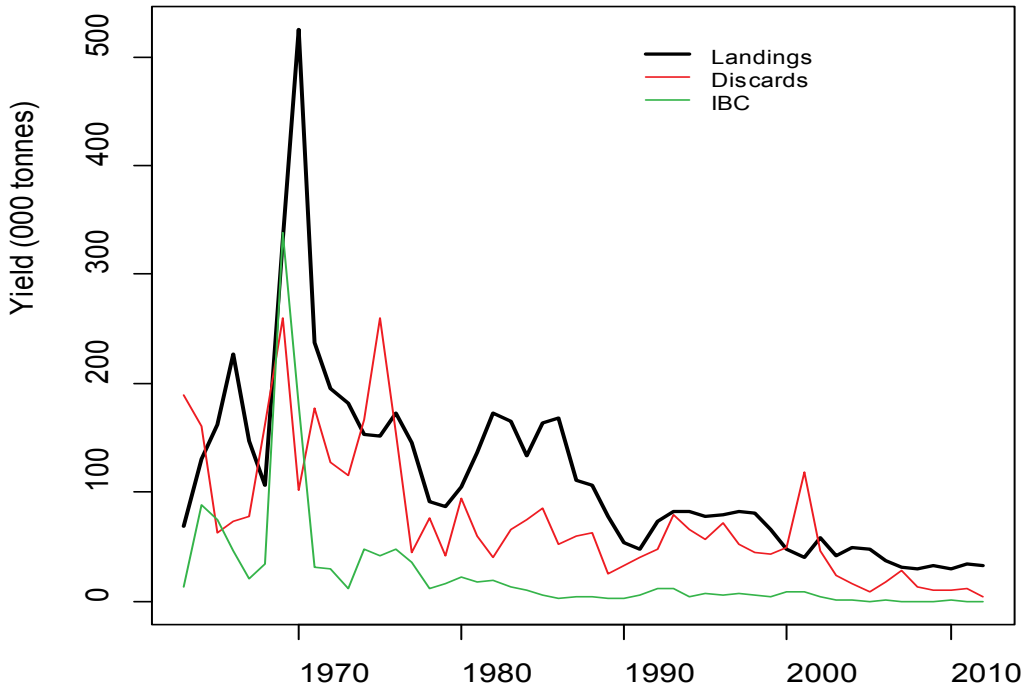


Figure 13.2.1.1. Haddock in Subarea IV and Division IIIa. Yield by catch component.

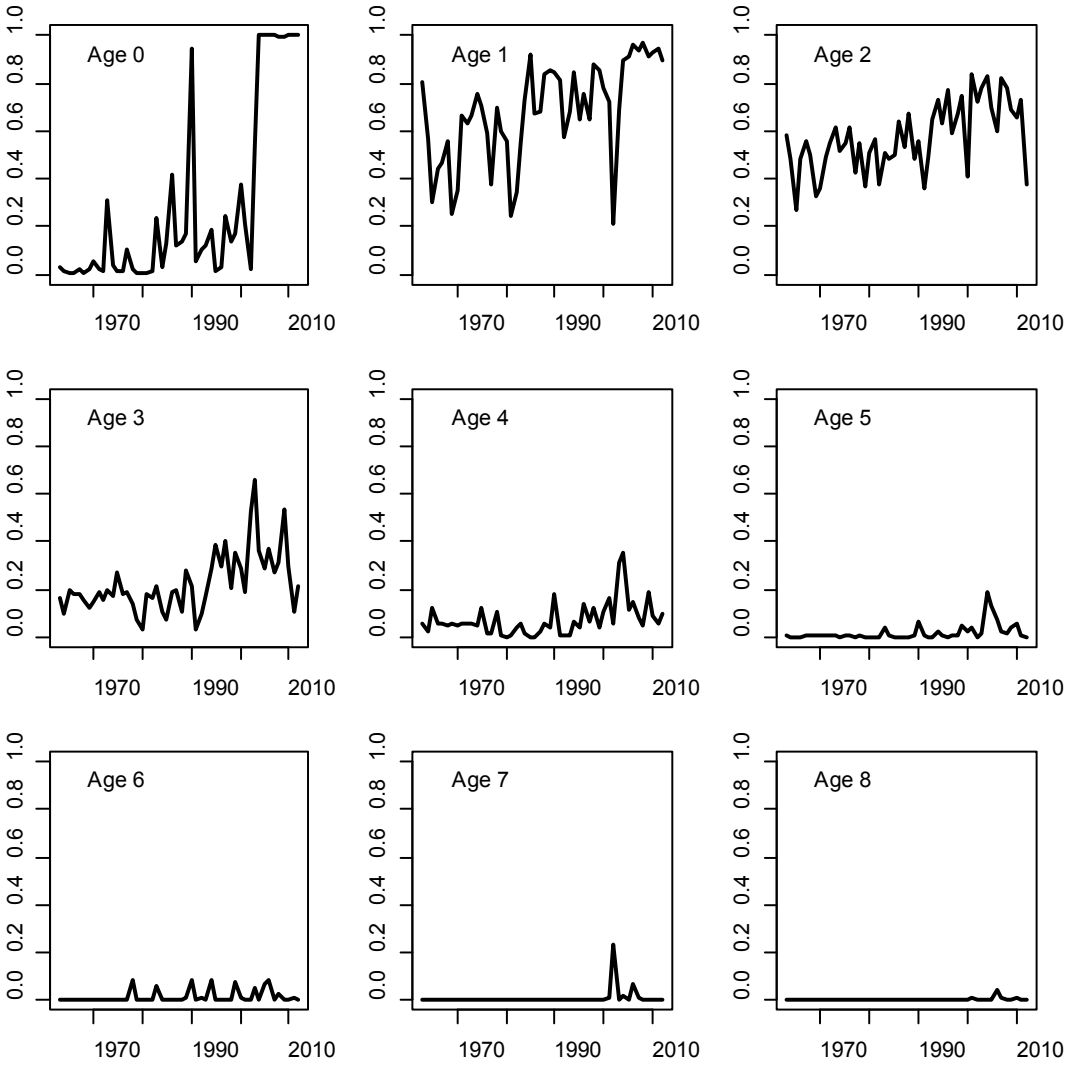


Figure 13.2.1.2. Haddock in Subarea IV and Divisions IIIa. Proportion of total catch discarded, by age and year.

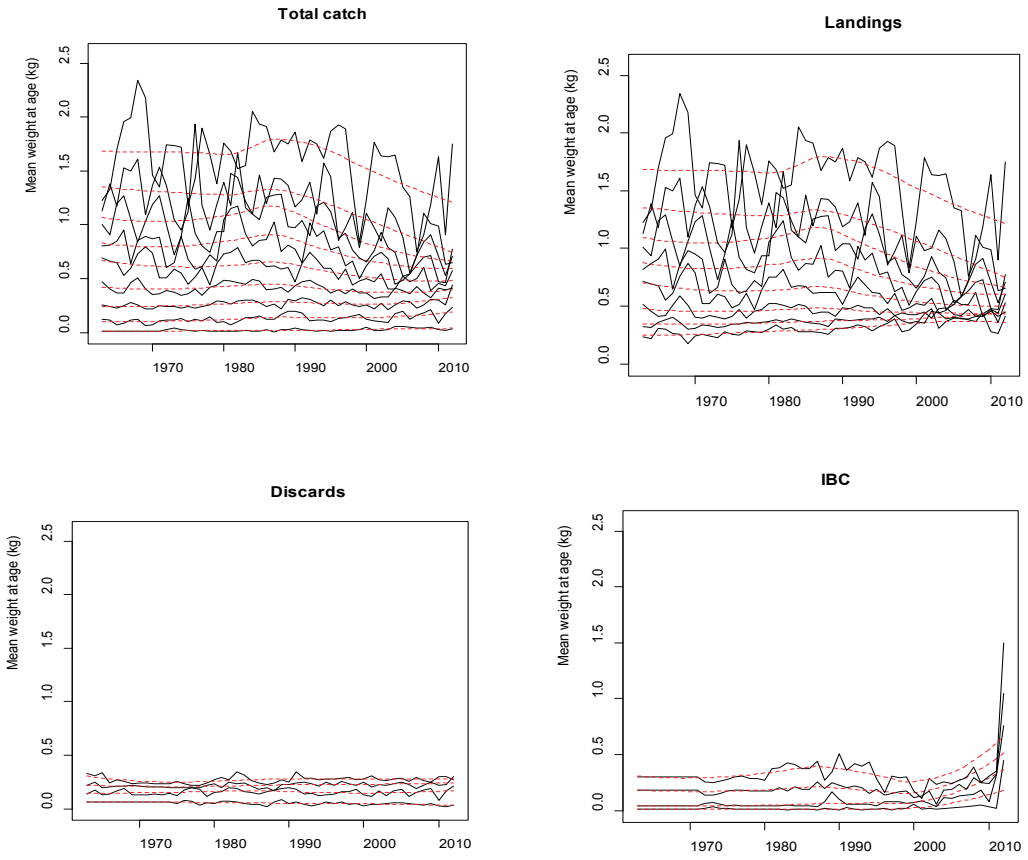


Figure 13.2.3.1. Haddock in Subarea IV and Division IIIa. Mean weights-at-age (kg) by catch component. Total catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

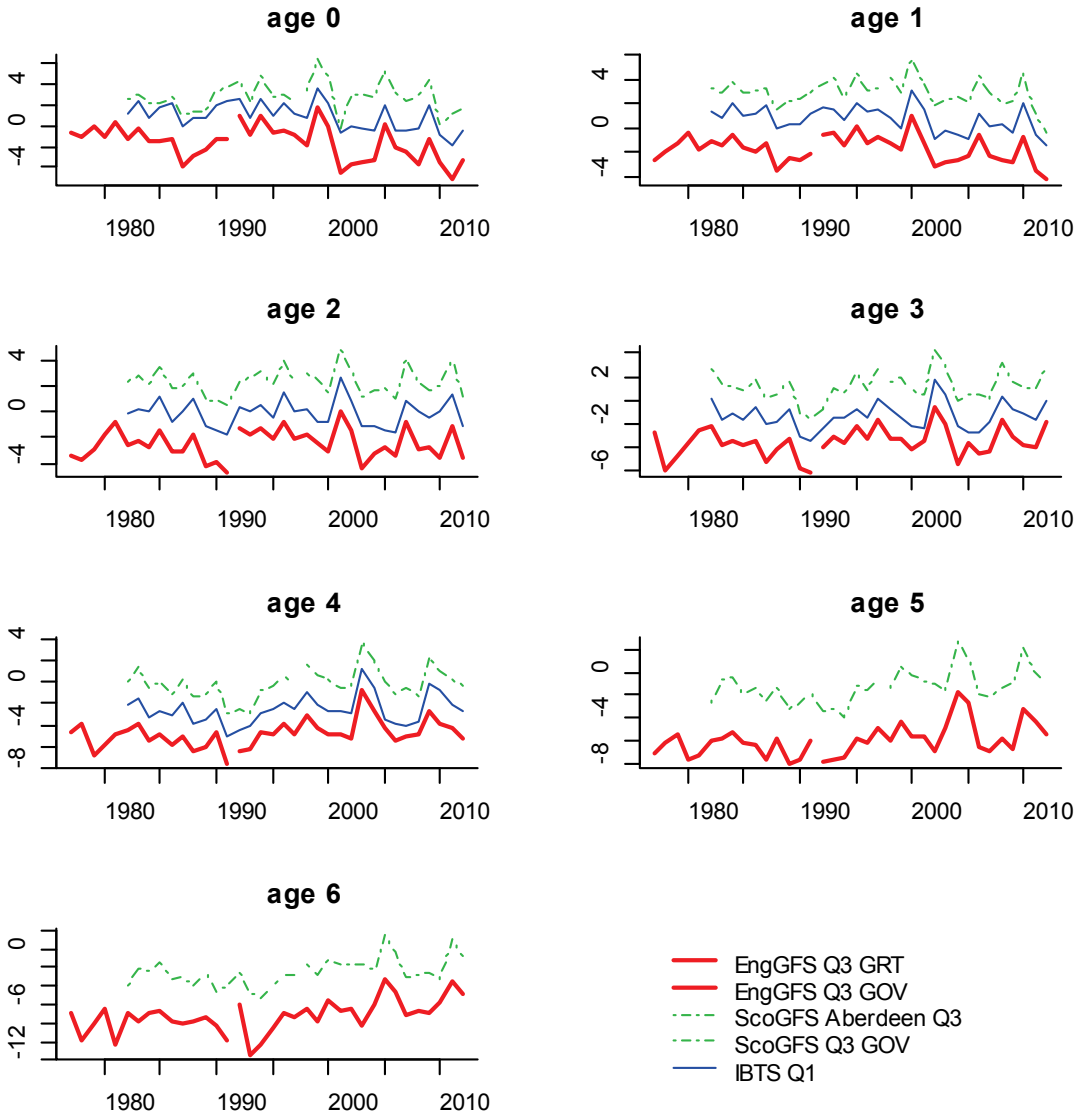


Figure 13.2.6.2. Haddock in Subarea IV and Division IIIa. Survey log CPUE (catch per unit effort) at age.

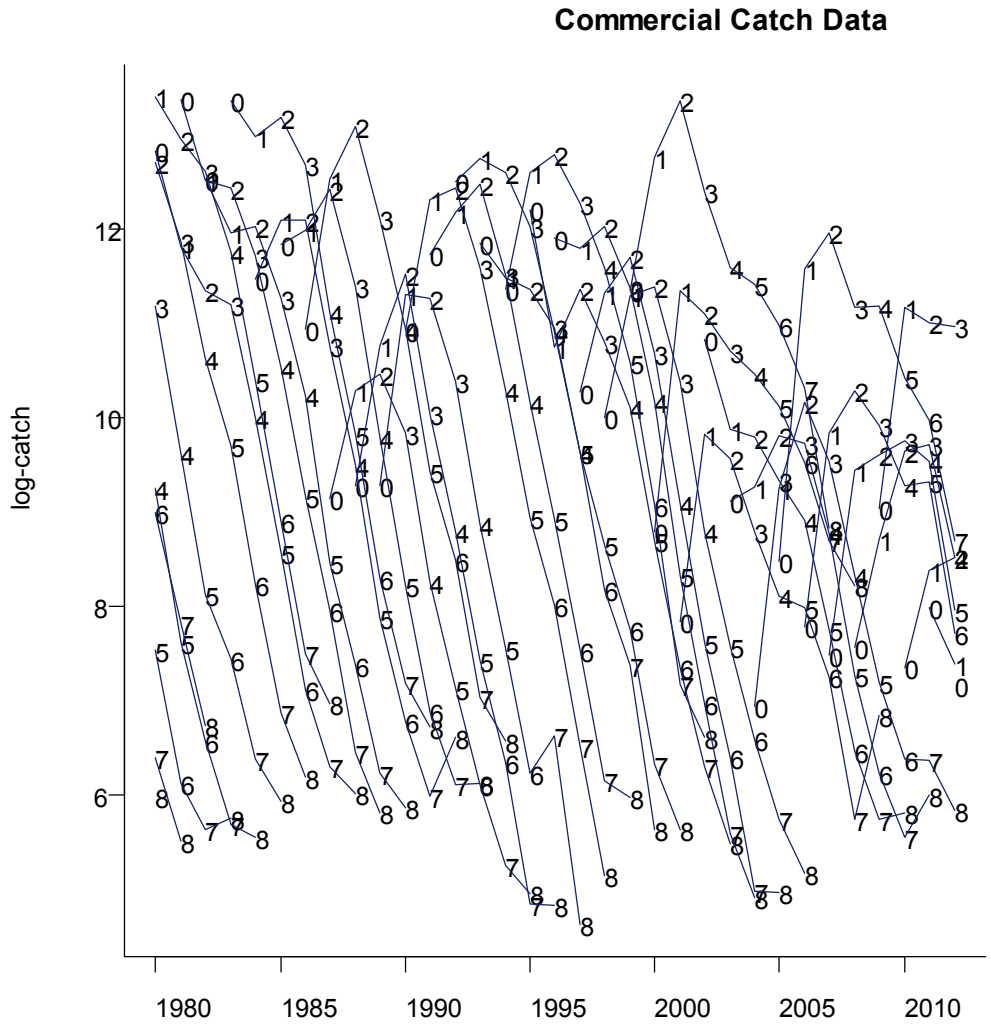


Figure 13.3.2.1. Haddock in Subarea IV and Division IIIa. Log catch curves by cohort for total catches.

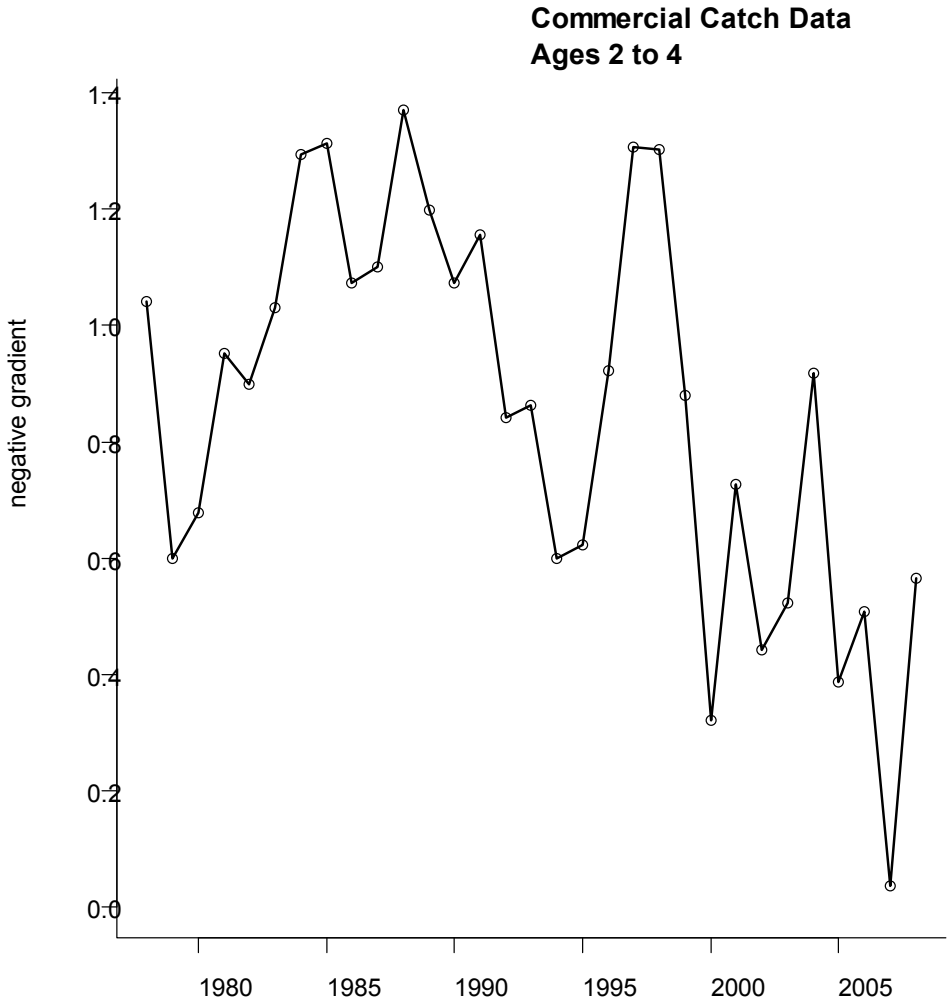


Figure 13.3.2.2. Haddock in Subarea IV and Division IIIa. Negative gradients of log catches per cohort, averaged over ages 2-4. The x-axis represents the spawning year of each cohort.

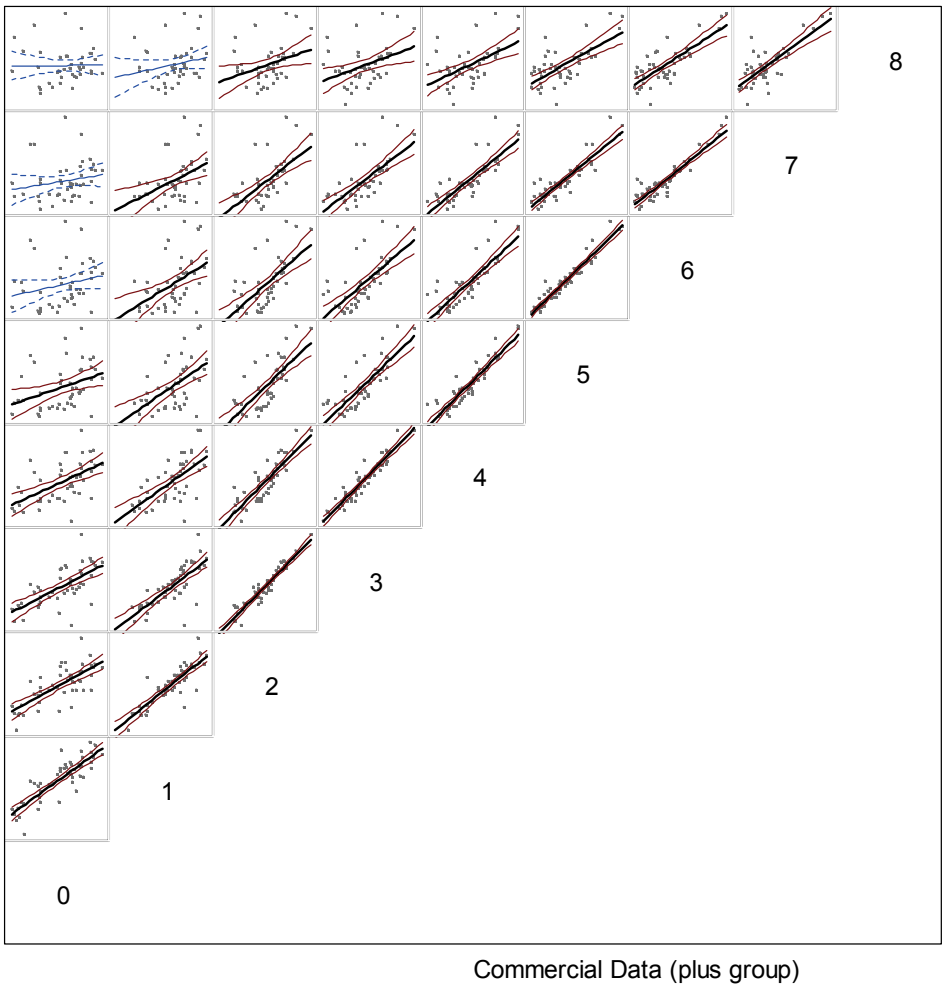


Figure 13.3.2.3. Haddock in Subarea IV and Division IIIa. Correlations in the catch-at-age matrix (including the plus-group for ages 8), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and black points) 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.

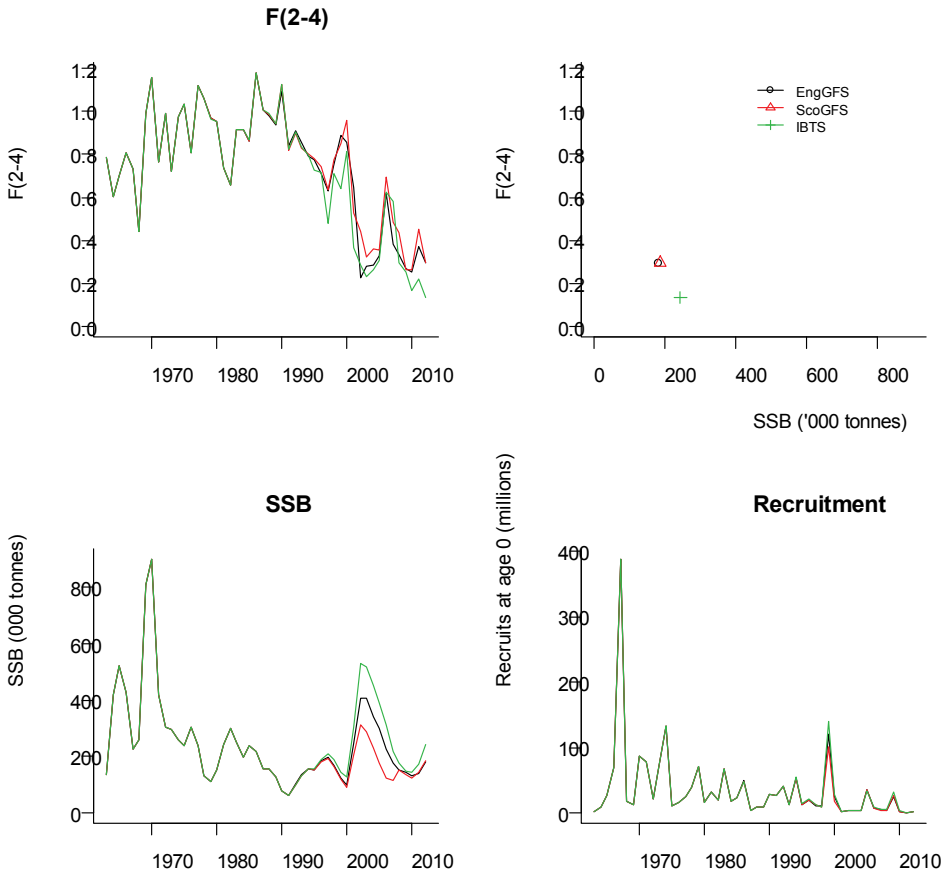


Figure 13.3.2.5. Haddock in Subarea IV and Division IIIa. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2012) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

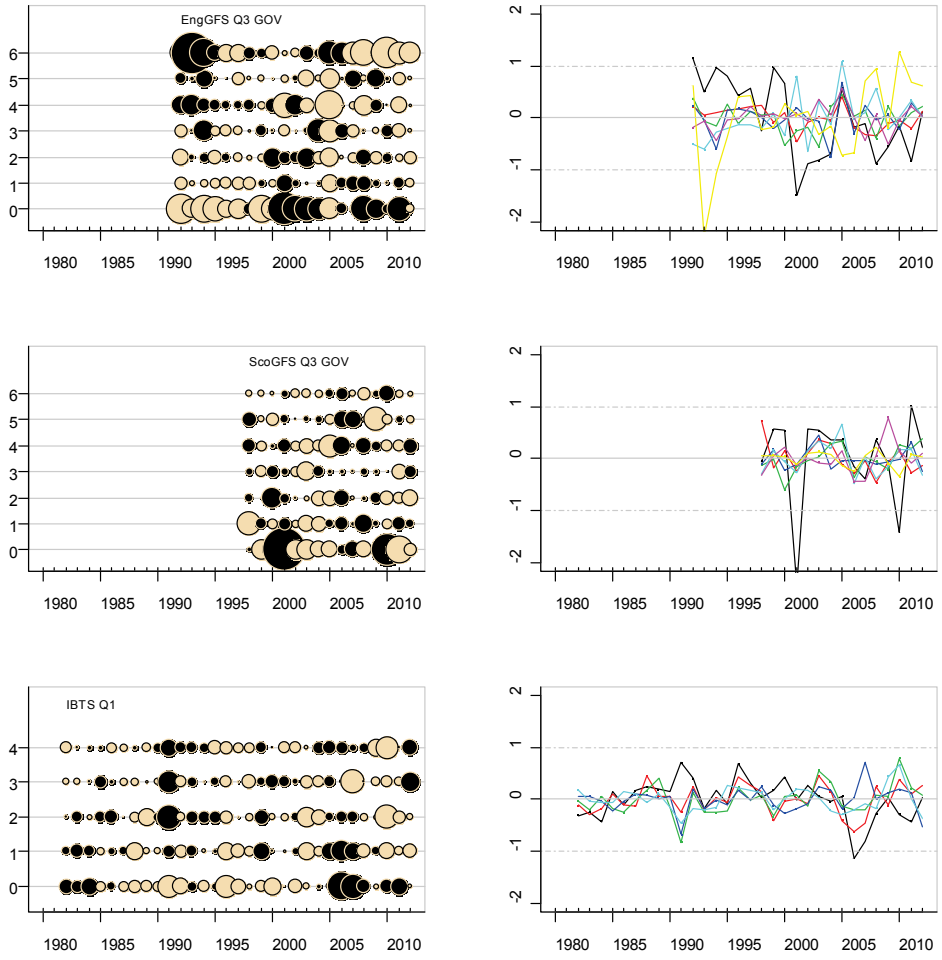


Figure 13.3.2.6. Haddock in Subarea IV and Division IIIa. Log catchability residuals from single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here.

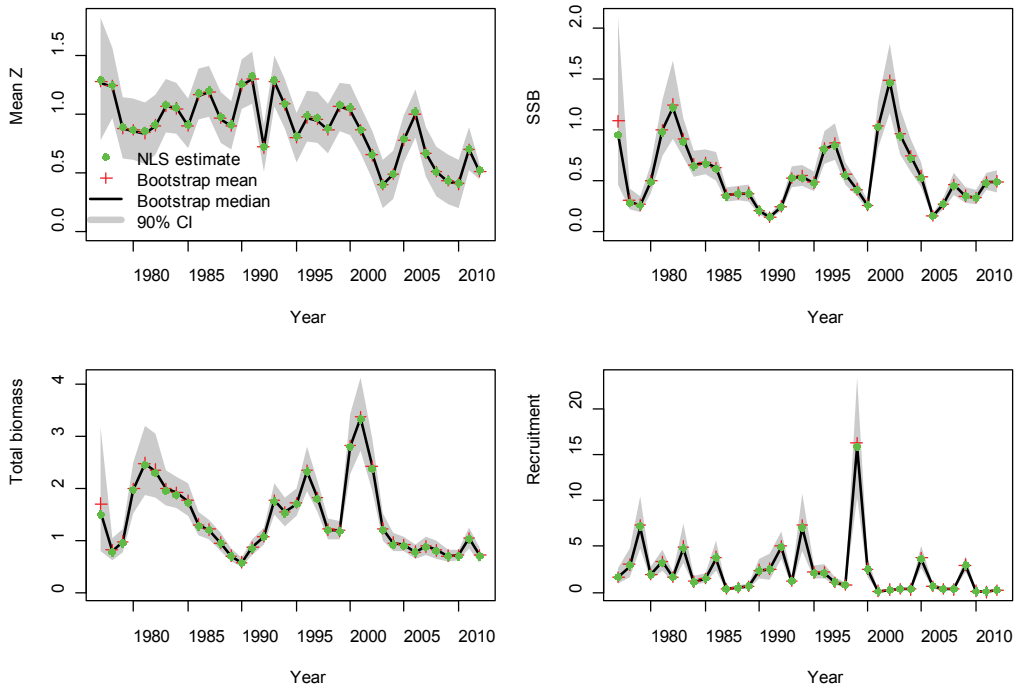


Figure 13.3.3.1. Haddock in Subarea IV and Division IIIa. Summary plots from an exploratory SURBAR assessment, using all available surveys (EngGFS Q3, ScoGFS Q3, IBTS Q1). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded 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.

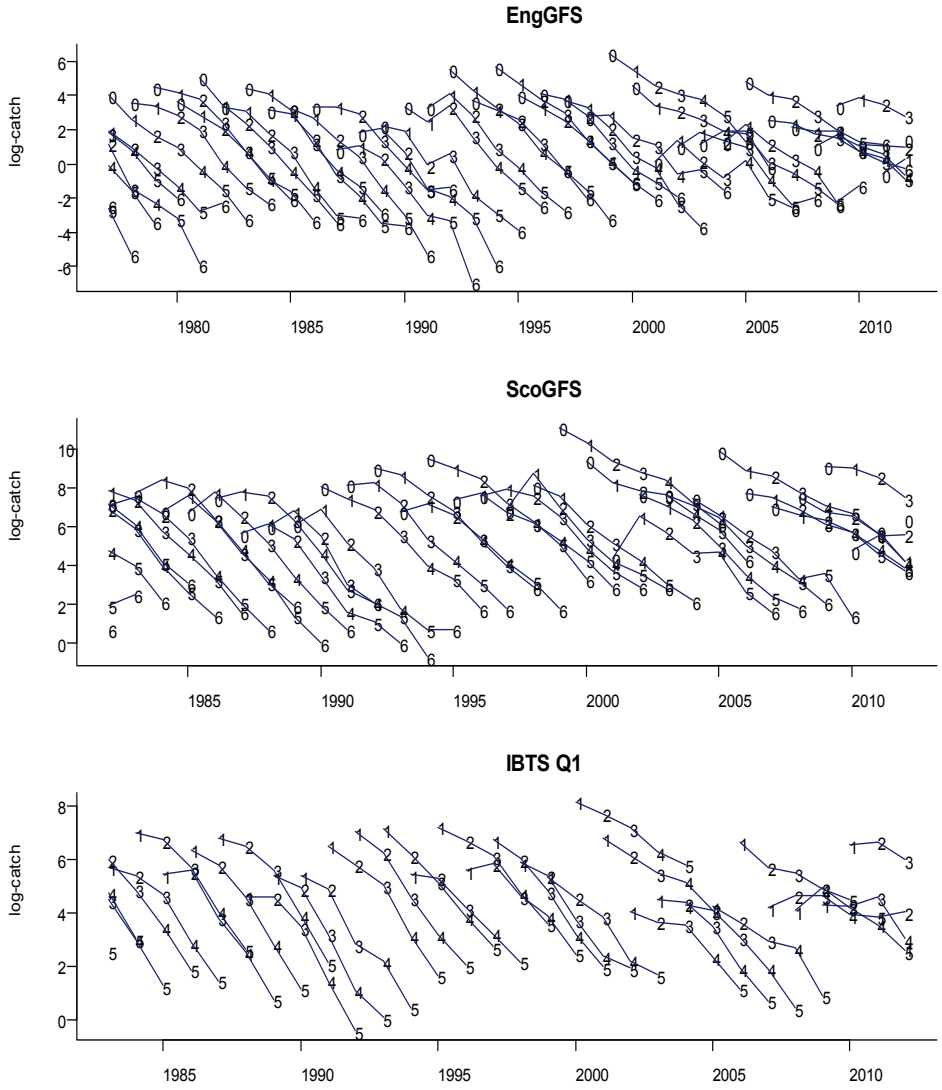


Figure 13.3.3.2. Haddock in Subarea IV and Division IIIa. Log abundance indices by cohort for each of the five survey indices. The separate sections of the ScoGFS and EngGFS Q3 surveys have been combined for the purposes of this plot.

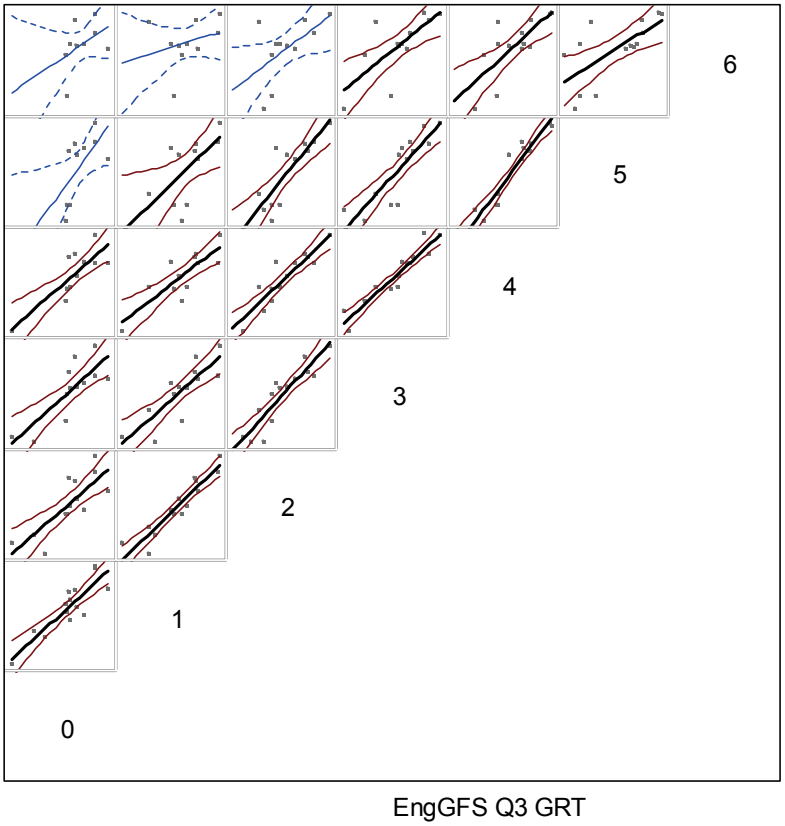


Figure 13.3.3.3. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GRT) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

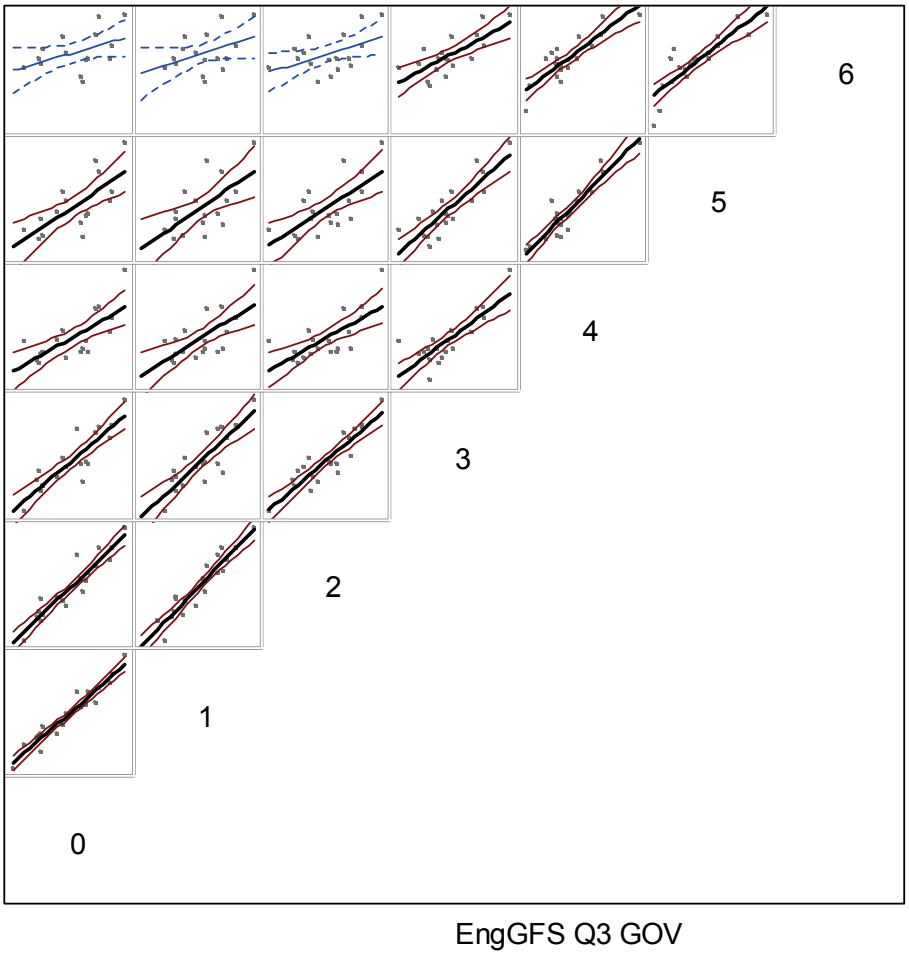


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

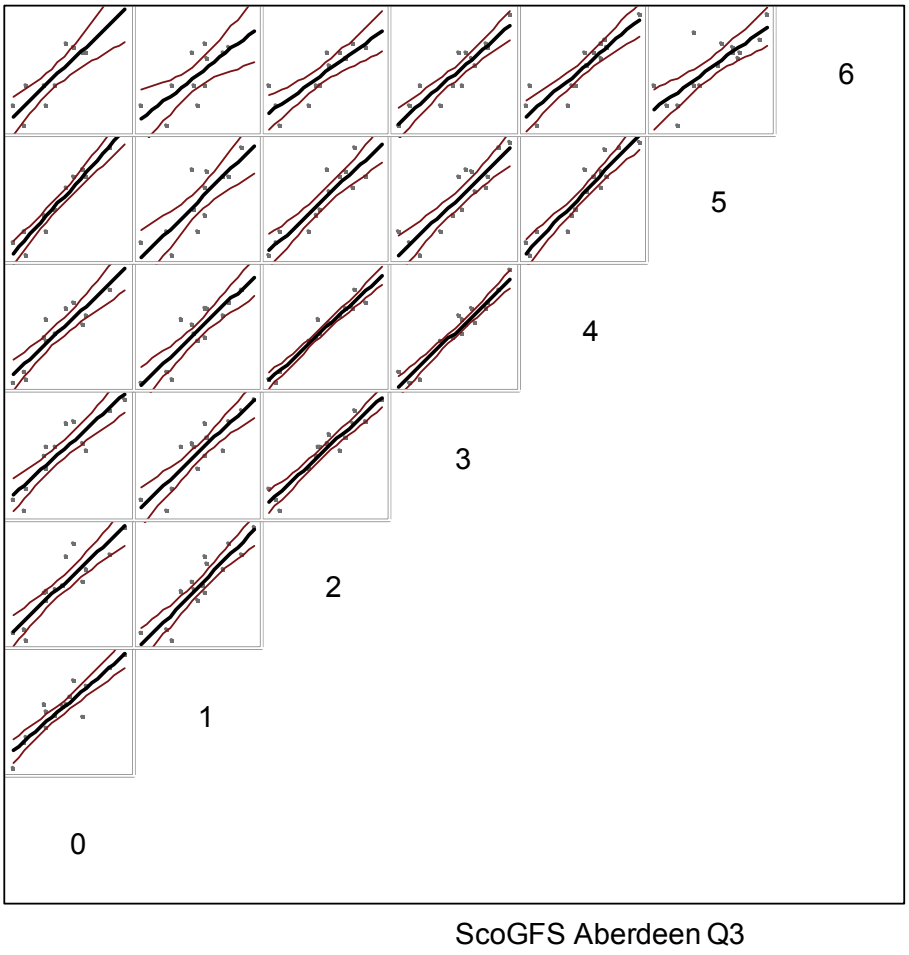


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (Aberdeen) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.

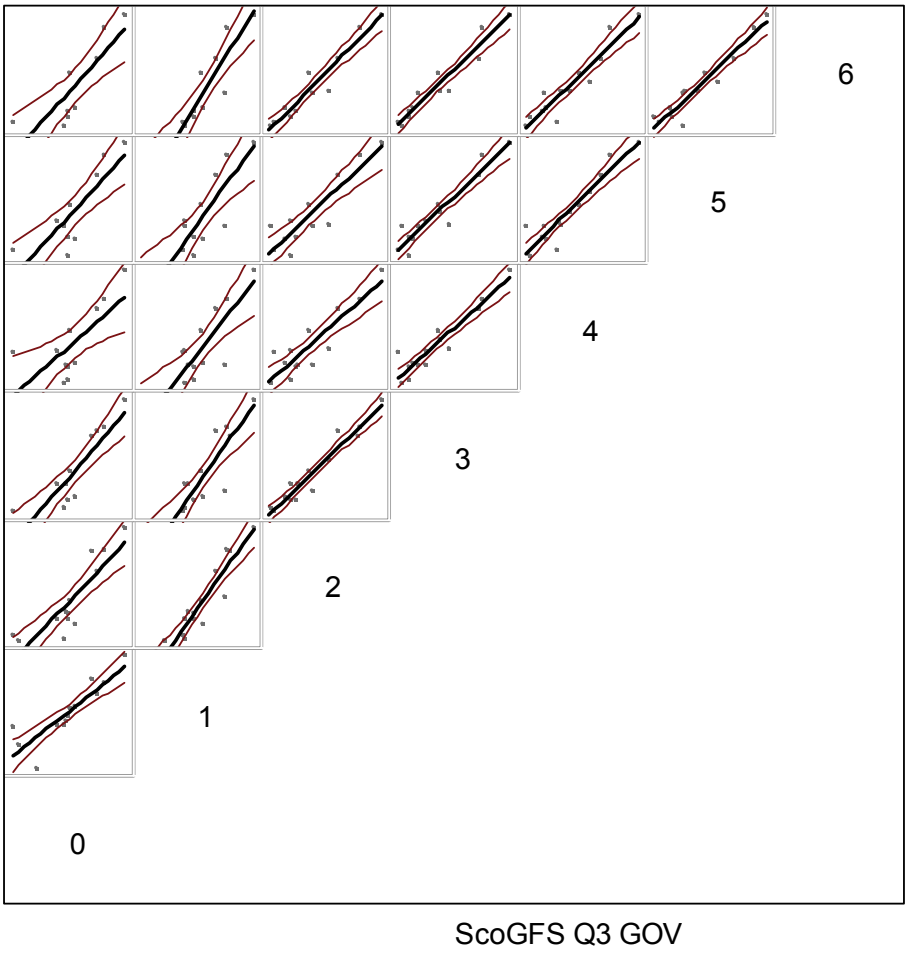


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

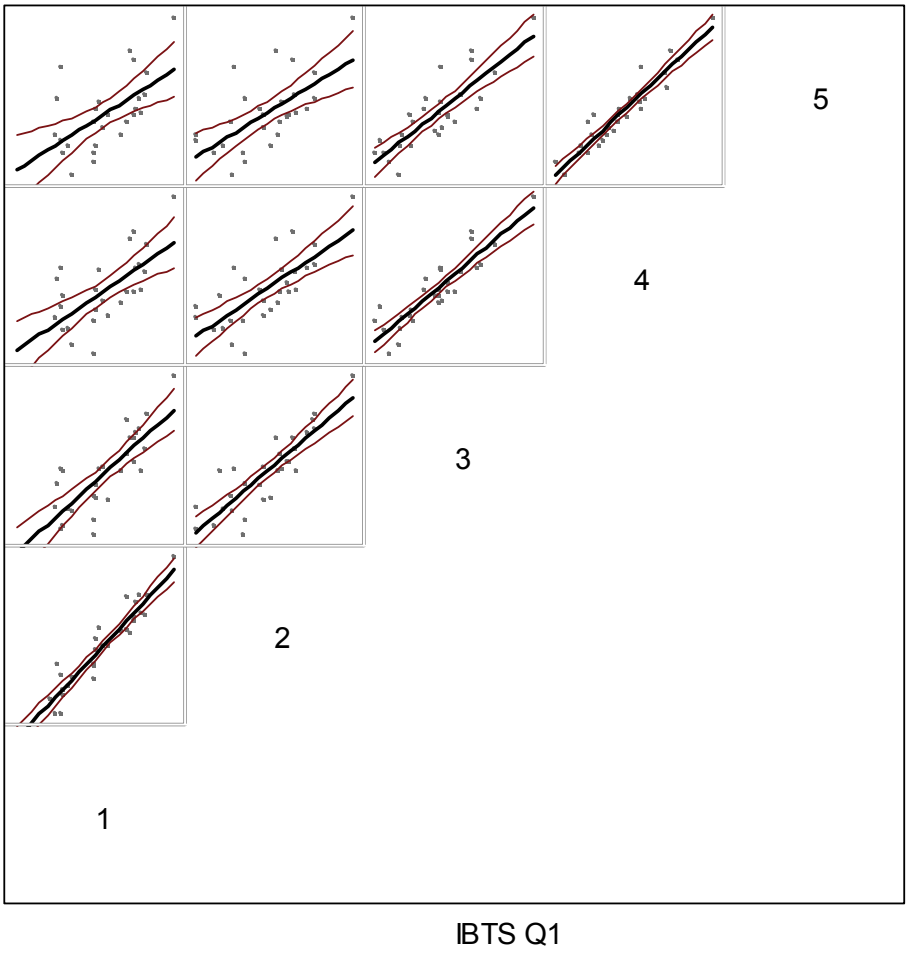


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the IBTS Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

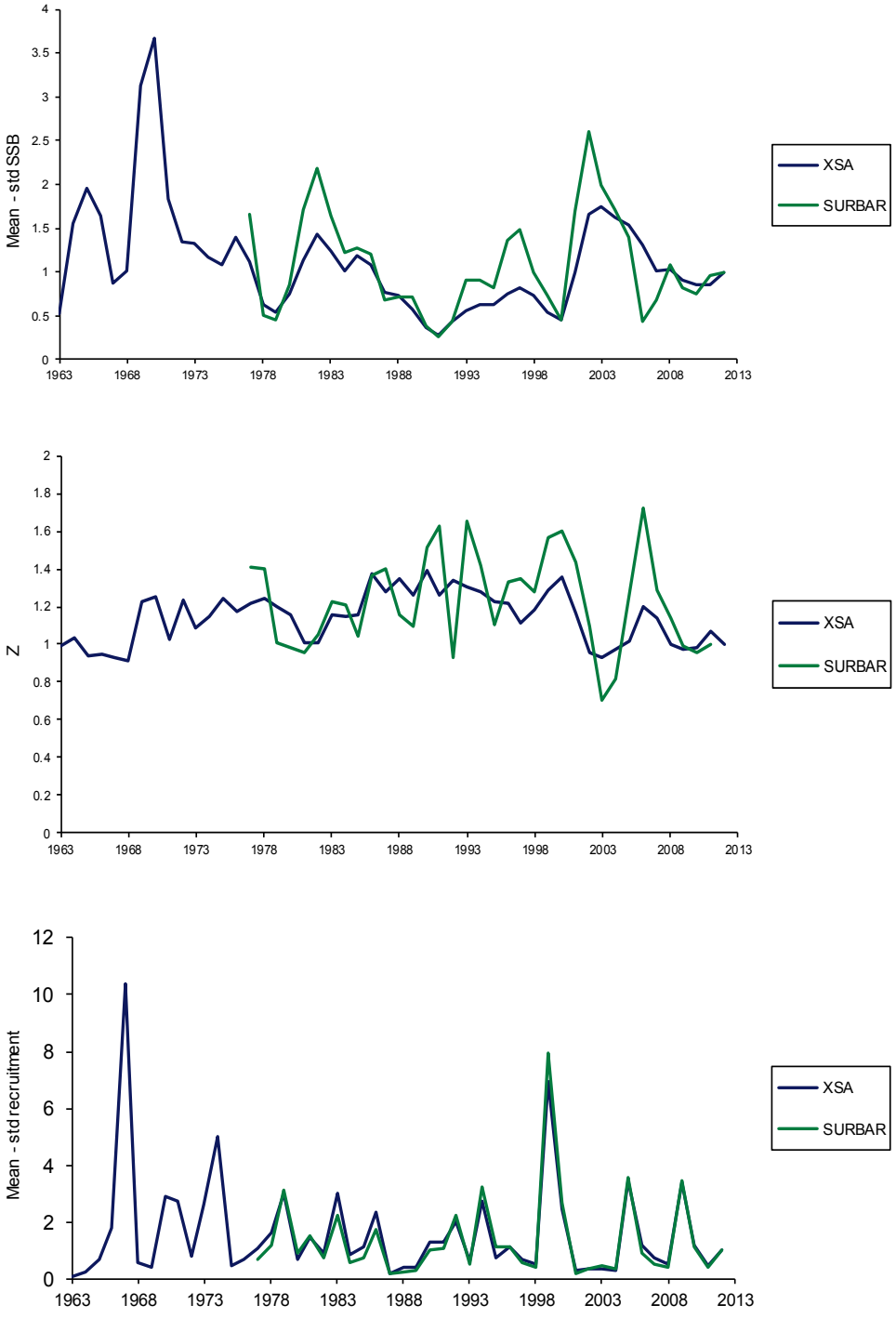


Figure 13.3.4.1. Haddock in Subarea IV and Division IIIa. Comparisons of stock summary estimates from XSA (blue) and SURBAR (green) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models. Top: SSB. Middle: mean F(2-4). Bottom: recruitment.

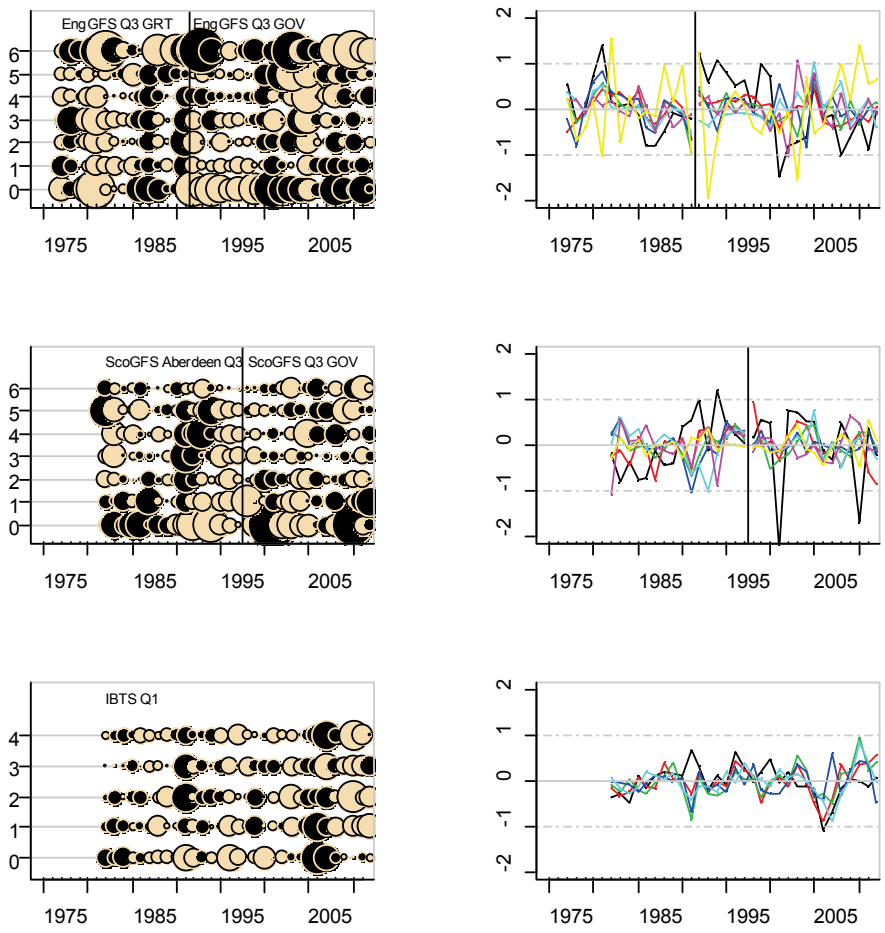


Figure 13.3.5.1 Haddock in Subarea IV and Division IIIa. Log catchability residuals for final XSA assessment. Both EngGFS and ScoGFS are split when used as tuning indices, and this split is shown by vertical lines on the relevant plots.

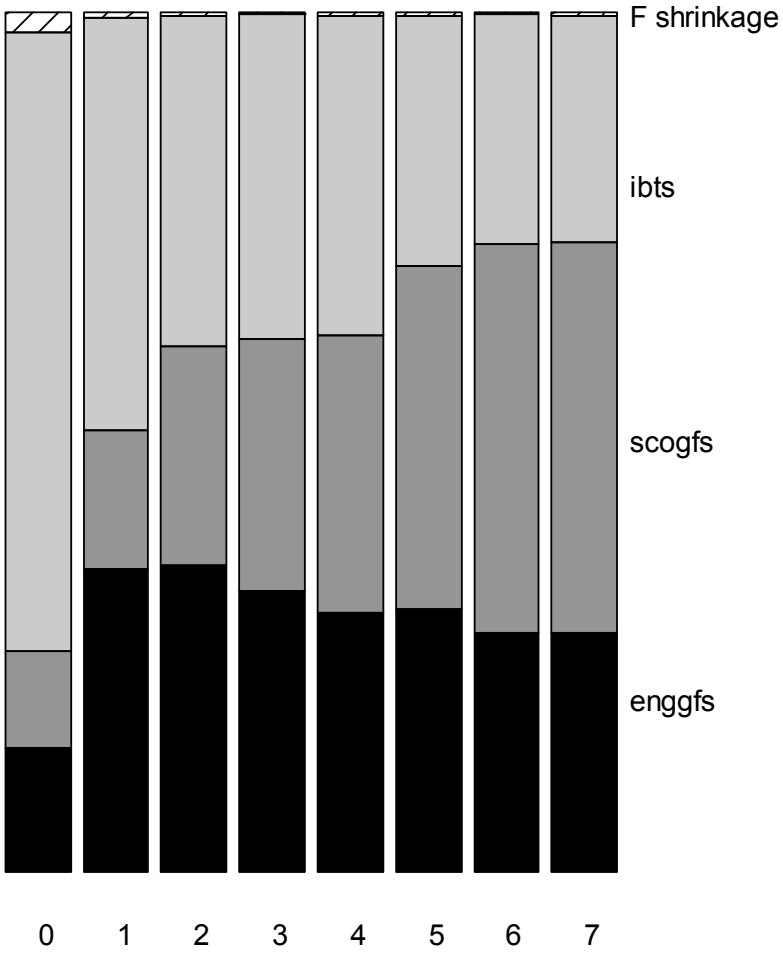


Figure 13.3.5.2. Haddock in Subarea IV and Division IIIa. Contribution to survivors' estimates in final XSA assessment.

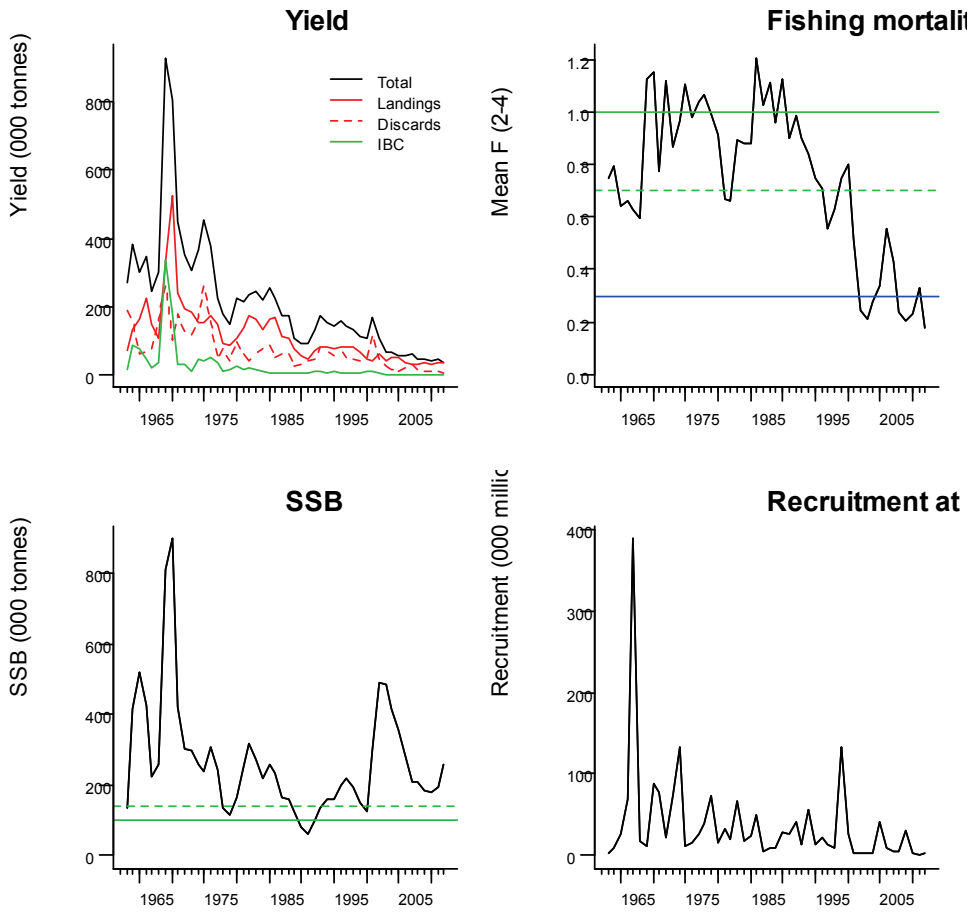


Figure 13.4.1. Haddock in Subarea IV and Division IIIa. Summary plots for final XSA assessment. Dotted horizontal green lines indicate F_{pa} (top right plot) and B_{pa} (bottom left plot), while solid horizontal green lines indicate F_{lim} and B_{lim} in the same plots. The solid blue line in the top right plot represents the target F (0.3) in the EU-Norway management plan, which is also considered to be a proxy for F_{msy}.

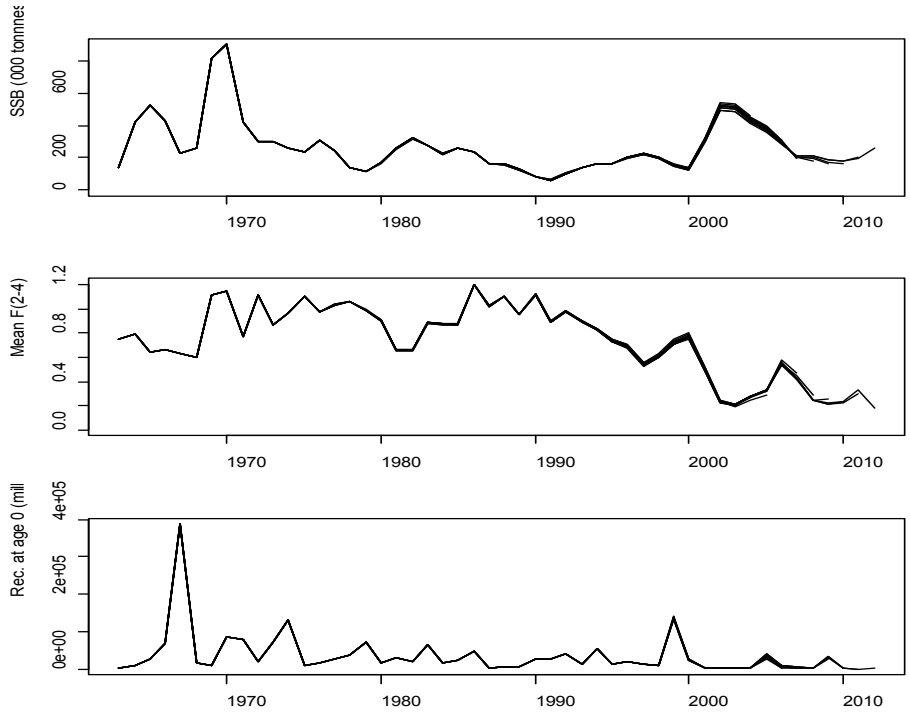


Figure 13.4.2. Haddock in Subarea IV and Division IIIa. Eight-year retrospective plots for final XSA assessment.

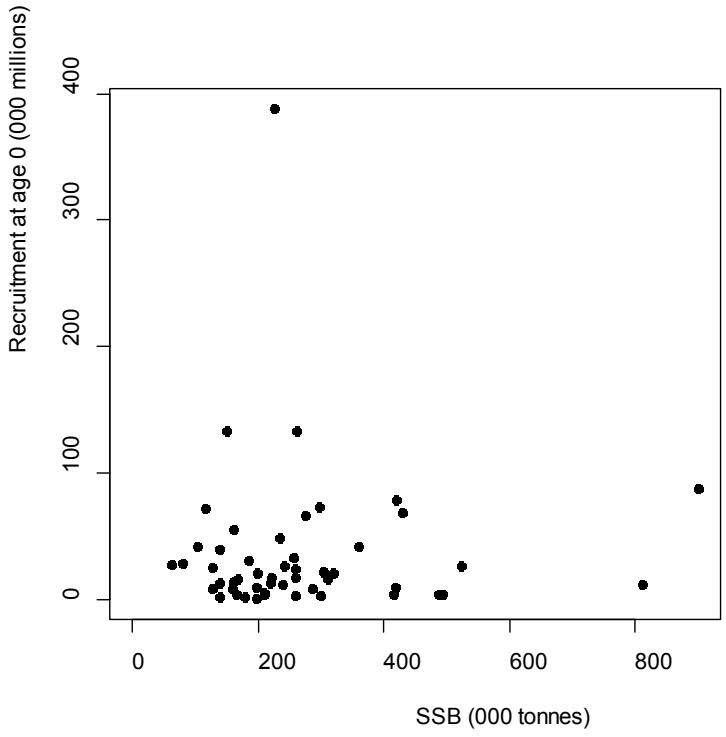


Figure 13.4.3. Haddock in Subarea IV and Division IIIa. Stock-recruitment plot from the update FLXSA assessment.

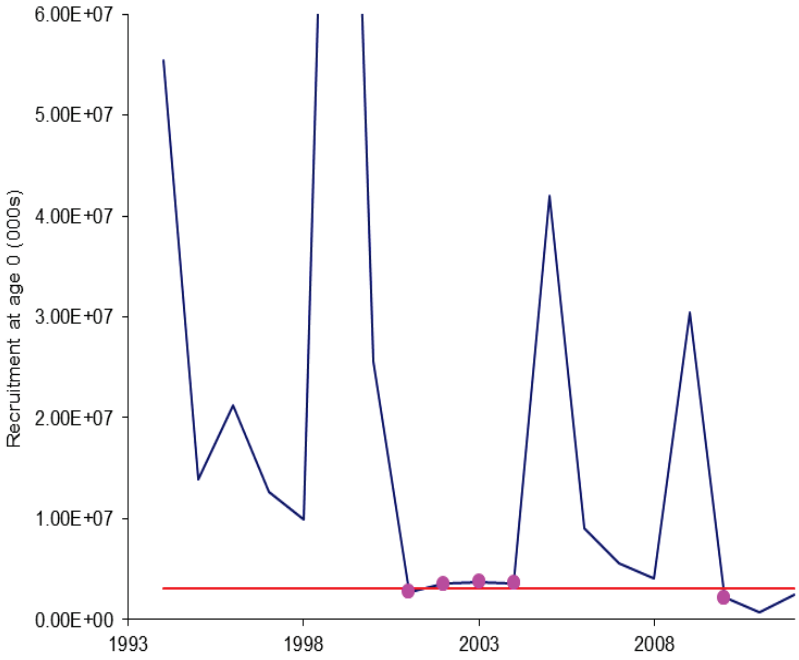


Figure 13.5.1.1. Haddock in Subarea IV and Division IIIa. Estimated recruitment from the final XSA assessment for 1994-2012 (black line), with 5 lowest values excluding the last two (pink dots) and the geometric mean of these (red line).

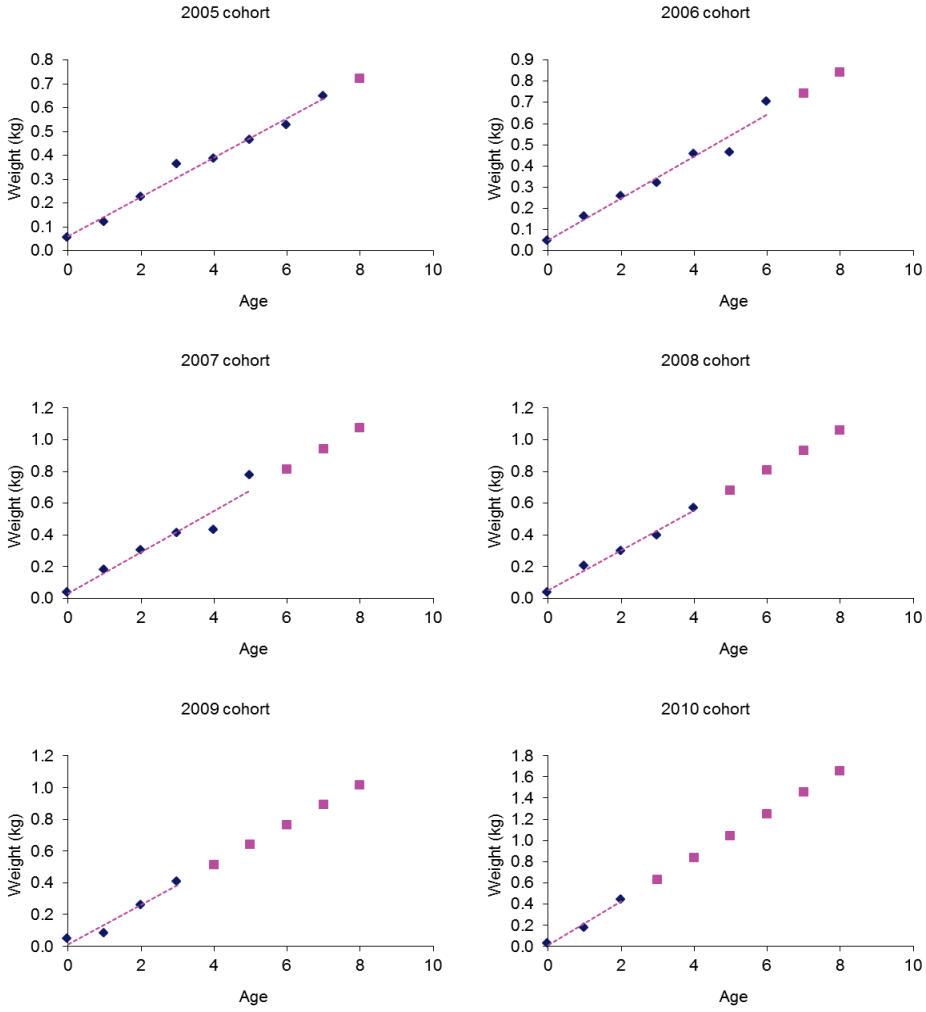


Figure 13.6.1. Haddock in Subarea IV and Division IIIa. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski 2011). Cohorts 2005-2010 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

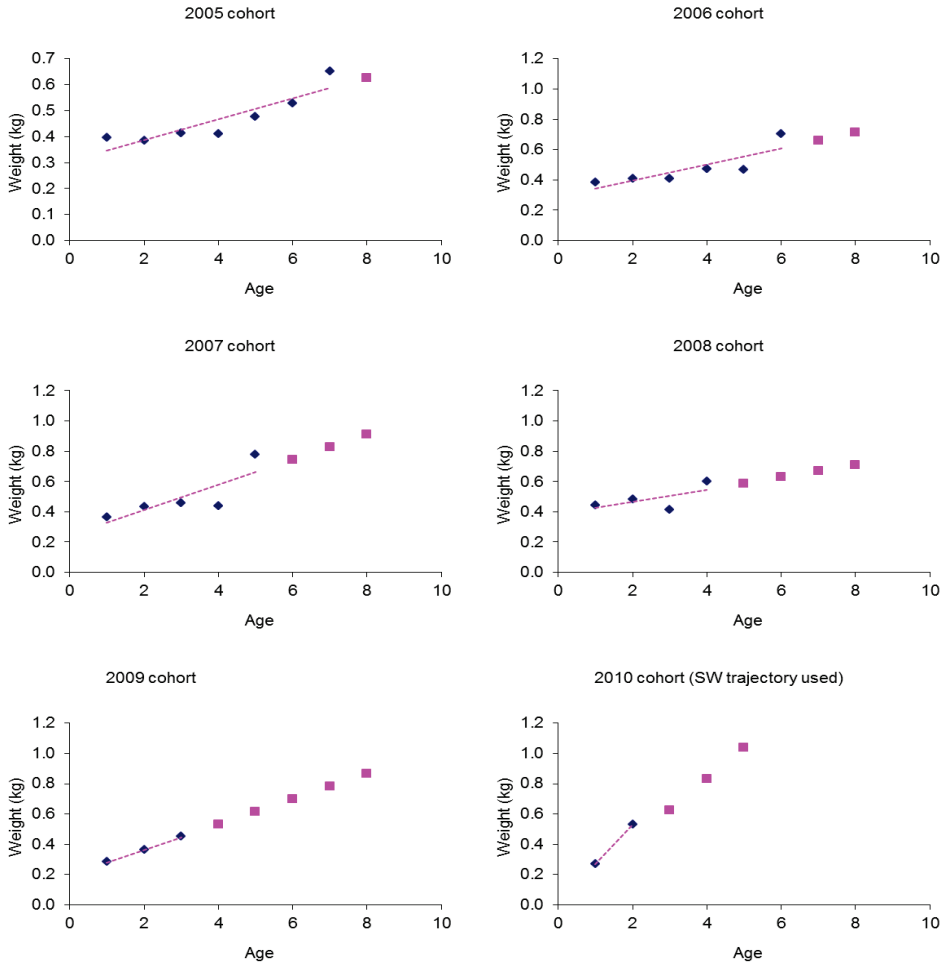


Figure 13.6.2. Haddock in Subarea IV and Division IIIa. Results of growth modelling for landings weights using cohort-based linear models (Jaworski 2011). Cohorts 2005-2010 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

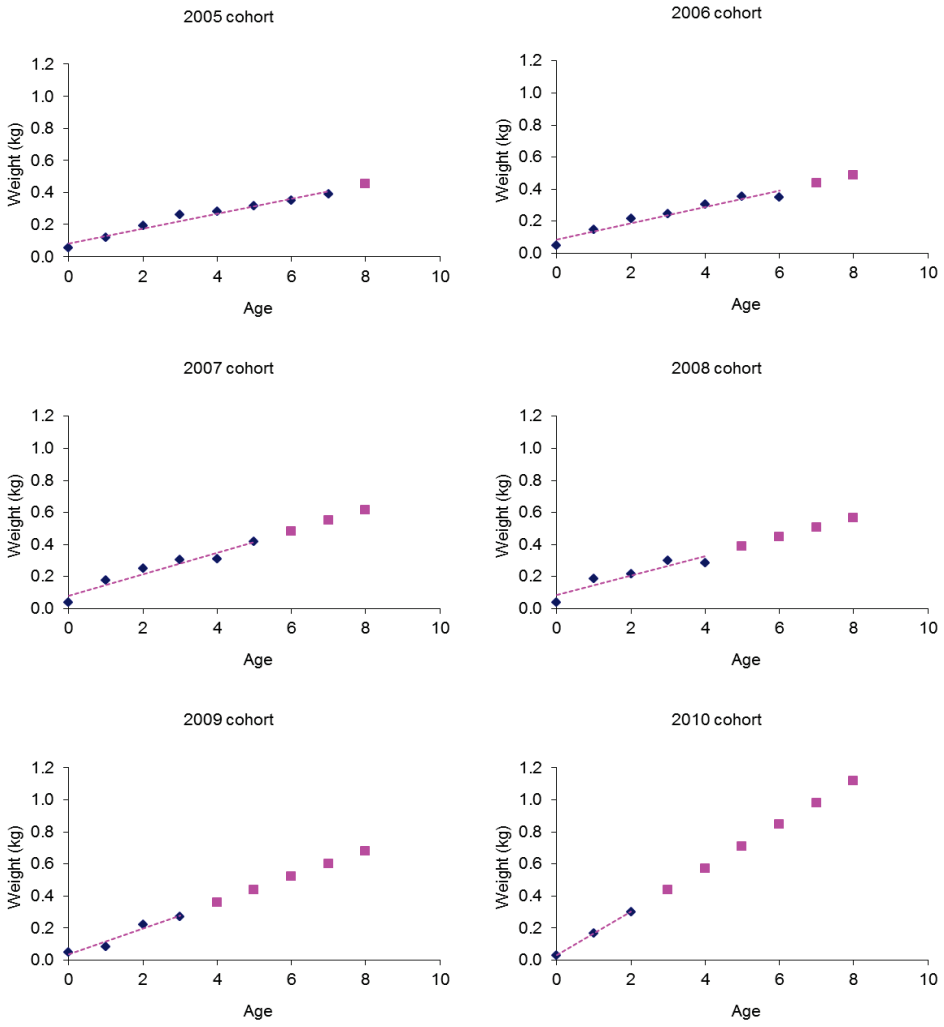


Figure 13.6.3. Haddock in Subarea IV and Division IIIa. Results of growth modelling for discard weights using cohort-based linear models (Jaworski 2011). Cohorts 2005-2010 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages

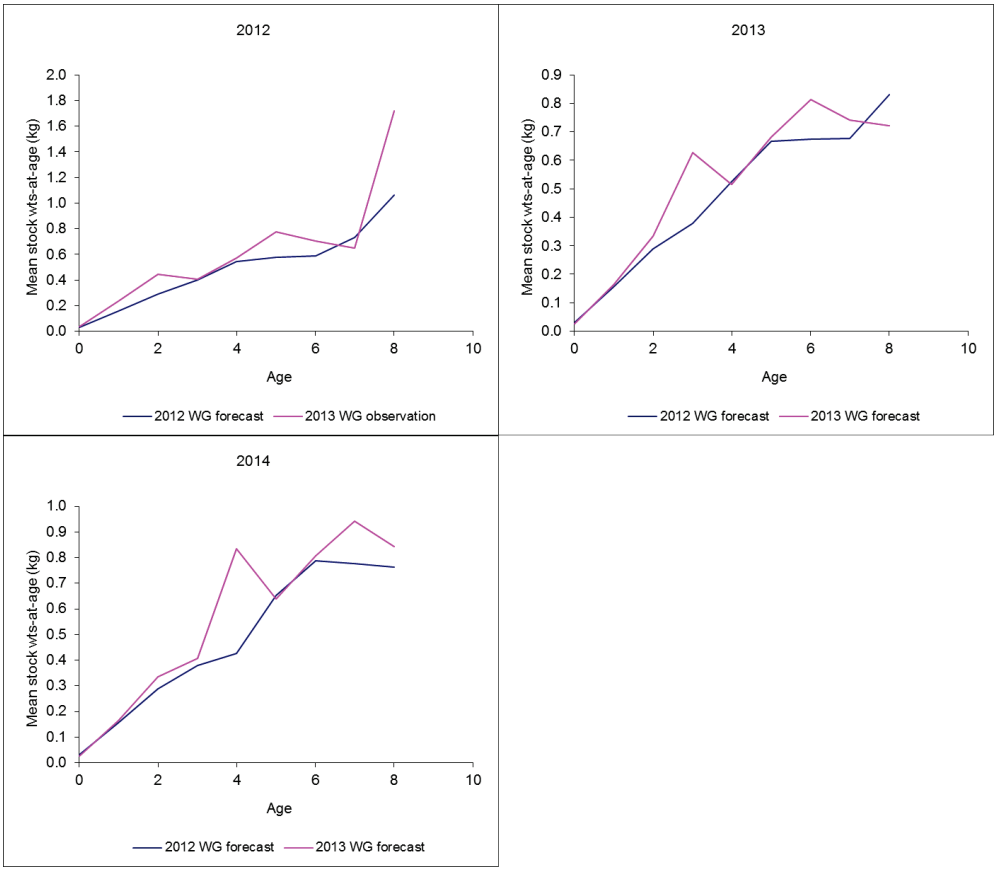


Figure 13.6.4. Haddock in Subarea IV and Division IIIa. Comparison of weights-at-age for 2012-14 from the 2012 WG, with the weights-at-age for 2012-14 from the 2013 WG.

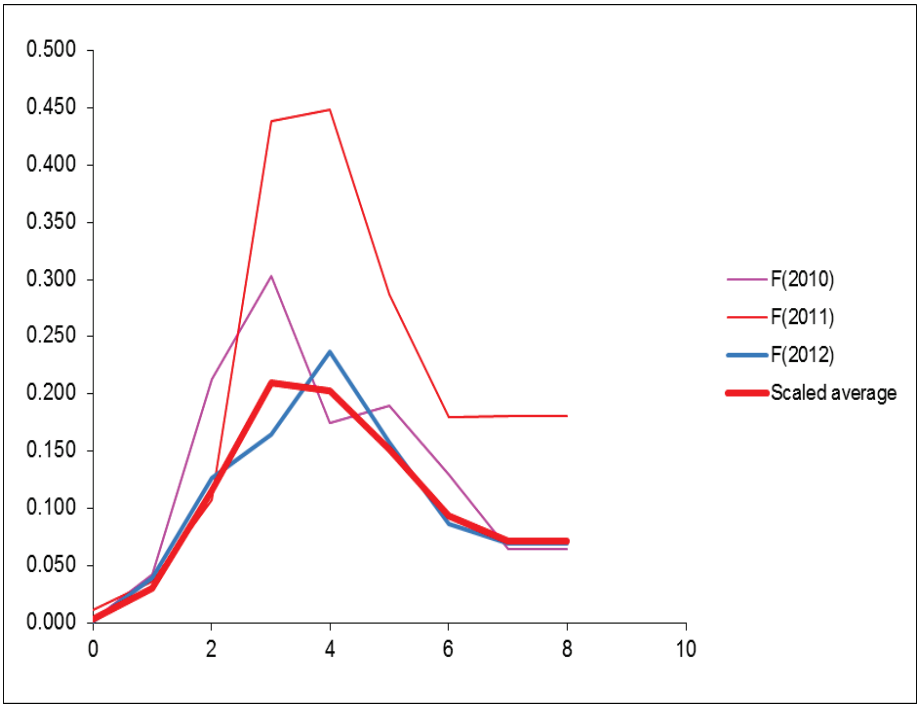


Figure 13.6.5. Haddock in Subarea IV and Division IIIa. Comparison of fishing mortality estimates for 2010-2012 with a three-year (2010-2012) mean exploitation pattern scaled to the mean level of the 2012 estimates.

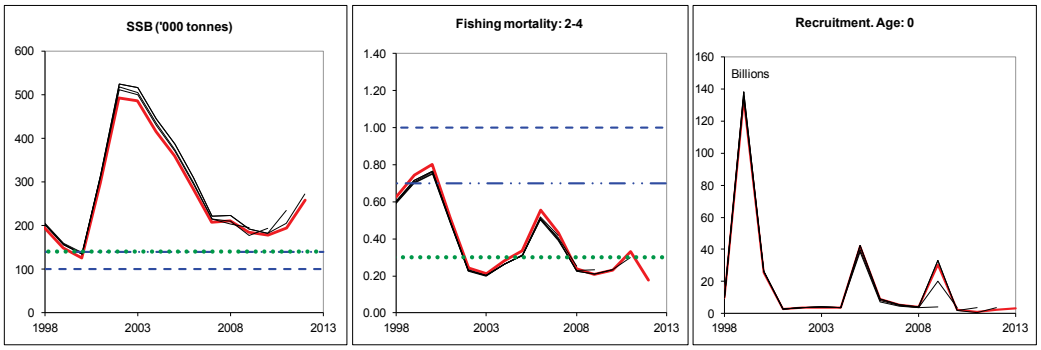


Figure 13.9.1. Haddock in Subarea IV and Division IIIa. Historical assessment quality plot.

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, apart from the catch multiplier now being estimated for the period 1993-2005 only.

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

Hemmer-Hansen and Wright (WD2, ICES-WGNSSK 2013 Annex 8) 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 14.17). 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.

A summary of other available information on stock definition can be found in the Stock Annex.

14.1.2 Ecosystem aspects

No new information was presented at the EG. 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), BT2 (mainly Netherlands), and TR2 (ICES-WKCOD, 2011; STECF, 2011). 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 metiers 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.

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 trialed 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 and 173 closures in 2010, 2011 and 2012, 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.

Changes in national fleet dynamics

The ICES WGFTFB 2013 report was not yet available. The latest report available is ICES-WGFTFB (2012). It should be noted that the information contained in the WGFTFB report does not cover fully all fleets engaged in North Sea fisheries; information was obtained from Scotland, France, Netherlands, Belgium, Sweden, Denmark and Norway.

A large demand for pulse trawling has developed within the Netherlands, with the number of vessels applying to fish under the 5% derogation far exceeding the number of licences available; this increased demand is driven by the fact that vessels not using pulse trawls are finding it difficult to get financial support from banks on economic (high fuel prices making beam trawling uneconomic) and ecological grounds (beam trawls are portrayed negatively). Furthermore, 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 added fishing time, due to faster hauling speed; this may result in changes in effort patterns and increased fishing time. A shift to Danish/Scottish seining has continued in a number of countries, also driven by high fuel prices. In Norway, the number of vessels has reduced due to movement of quota to newer and bigger vessels because of the renewal of the medium and larger sized seine net fleets; despite the reduction in number of vessels, this is likely to have caused an increase in capacity and effort.

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. The use of sorting grids continues to increase (e.g. in Sweden, aided by national legislation allocating 50% of the total *Nephrops* quota to grid vessels), and in some cases is becoming mandatory (e.g. in the Norway pout fishery from mid-2013). Extensive testing of new designs of trawl gear (e.g. the Flip-flap netting grid, or FFG) has also been carried out, with results showing a large and significant decrease in the number of the three main whitefish species retained by the FFG gear: reductions by weight of 73, 67 and 82% respectively for cad, haddock and whiting.

Fisheries Science Partnerships

Results from a series of ongoing collaborative studies were available to WGNSSK providing information on a number of species; details are listed below. The WG welcomes FSP studies of this format, 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. The WG regrets that some of the current surveys have now been terminated.

UK - North East Coast Cod Survey

The NE Coast cod survey (De Oliveira et al., 2013) is a designated time-series survey conducted since 2003 as part of the UK Fisheries Science Partnership (FSP). The objective of the survey series is to provide year-on-year comparative information on distribution, relative abundance and size/age composition of cod and whiting off the NE coast of England. The surveys also provide data on catches of other species important to the NE coast fishery, including haddock. The population of cod in the survey area has primarily comprised 1- and 2-year-olds, with some 3- and 4-year-olds. Older fish have been scarce due to offshore migration of mature fish. The relative strength of recent year classes of cod, as indicated by the time-series of FSP catch rates of 1-year-olds, has been similar to the trends given by recent ICES assessments for North Sea cod, but has not picked out the 2009 year class as being any larger than the surrounding year classes, and estimates the 2011 year class to be very weak; in contrast, the assessment indicates relatively stronger 2009 and 2011 year classes (almost the same size as the 2005 year class). Furthermore, overall catch rates for cod in the 2012 FSP survey were below average for the time series in terms of both total numbers (well below in this case) and total weight. However, it should be noted that this FSP survey only covers a small portion of the North Sea cod distribution area. A comparison of different seabed types indicates that for most years catches of cod are significantly greater on the hard ground, but that trends are similar between hard and soft ground.

Unfortunately, due to FSP project priorities having changed slightly in 2013/14, the North East cod FSP survey has been discontinued in lieu of other targets for the programme, so 2012 is the final year for this time series.

UK - North Sea Whitefish Survey

The North Sea whitefish survey is designed to provide a time-series of information on commercial vessel catch per unit effort from representative fishing grounds within the North Sea, with the eventual aim of providing a long-enough time series to be used to support the estimation of stock trends (Darby *et al*., 2013). The participating vessel uses a combination of traditional English fishing gears appropriate to hard and soft ground in order to provide information on comparative catch rates. The tows are distributed over sub-areas defined to provide information on catch rate, size/age composition and species catch composition from as many different locations as feasible, given time and cost constraints, within the area where the fishery takes place, and not necessarily at constant locations each year. The size of the whole catch is recorded, but detailed measurements are made of the catches of cod, whiting and haddock, and of plaice if resources permit. Thus far surveys have been held in 2009-2012.

Cod catch rates have varied between the hard ground catch rates being higher in 2009, soft ground catch rates in 2010 and similar rates on each ground type in 2011. The difference between ground types was constant across ages until 2012. In 2012, though, catches of cod at older ages were greater on soft ground, especially in the south, whereas in the north and at younger ages, catch rates were similar between ground types. Despite the substratum differences in catch rates, when averaged at an overall North Sea scale, the relative indices at age of cod, haddock and whiting abundance from the survey compare well with the ICES IBTSq3 survey data. However, the IBTS has greater selectivity at the youngest ages due to the smaller mesh size and therefore detects incoming year-class strength earlier than that of the North Sea Whitefish survey. Nevertheless, catches of older fish are more common and exhibit less noise in the North Sea Whitefish survey data than in the IBTSq3.

The results continue to demonstrate the value in developing a time-series for gadoids based on commercial vessels. The North Sea Whitefish time-series shows consistent agreement with the IBTS survey, but with higher, less noisy catch rates at the oldest ages. As such a time-series develops the results would allow differences in stock dynamics on hard and soft ground to be examined in detail and determination made of whether substratum type can affect survey estimates of stock abundance, especially as the stocks of cod and whiting rebuild under the current management regime, providing valuable input to the debate on the dynamics of the stocks and survey practices. Unfortunately, due to FSP project priorities having changed slightly in 2013/14, the North Sea Whitefish survey has been discontinued in lieu of other targets for the programme, so 2012 is the final year for this time series.

Denmark – RESOURCE Project

The Danish RESOURCE project represents the finalization of seven years of fishermen-scientists cooperation – a cooperation that was commenced on the initiative of the fishermen because they wanted to demonstrate that there are far more large Atlantic cod in the north-eastern North Sea than indicated by the catch rates obtained from the International Bottom trawl Survey (IBTS). This earlier initiative developed into the REX project, a predecessor of RESOURCE (Wieland *et al*. 2010). The RESOURCE project concentrates on the north-eastern North Sea, focusing on the importance of the geographical distribution of Atlantic cod at different scales (Beyer *et*

al., 2012). The project collects data from fishermen and scientists and assimilates knowledge on fishery practice, the geographical distribution of cod in the North Sea, and the vital mechanisms or processes in the sea (larval drift, growth, recruitment) that are important to explain the distribution dynamics. It uses the GeoPop statistical model to integrate data from trawl hauls (REX, RESOURCE, IBTS) in order to estimate the geographical distribution of cod by body size class, thus providing a possible way towards integrated stock assessments, combining space, time and fish size.

The project has demonstrated that, on a small geographical scale, it is difficult for the fisherman to obey the current RTC (real time closure) rules because the risk of catching small cod in a single haul is high, even if there are few small cod in the specific area. Furthermore, on a larger scale, data from REX/RESOURCE hauls give a more nuanced picture of the geographical distribution of cod in the REX area as compared to the rough image produced by exclusive use of IBTS data. Future fishermen-scientists' projects should be result-based and focus on ecosystem research. Increased process knowledge and real time REX data will ensure the necessary understanding of the factors controlling the annual recruitment to the North Sea cod stocks.

The North Sea Stock Survey

The North Sea Stock Survey (Napier 2012) was available to WGNSSK in order for fishers' perception of the state of the stock to be considered as part of the assessment process. The survey was carried out using a questionnaire circulated to North Sea fishermen in five countries; Belgium, Denmark, England, the Netherlands, and Scotland. Fishermen were asked to record their perceptions of changes in their economic circumstances and in the state of selected fish stocks from 2011 to 2012. A total of 220 completed questionnaires were returned in 2012, of which 184 were included in the analysis. The number of questionnaires returned was well below that in 2011, and the lowest since the start of the survey. Responses were fairly evenly distributed across all three size classes of vessels, although with a slightly greater proportion in the middle size class (15-24 m) and slightly fewer in the largest class (>24 m). Of the fishing gears, the otter trawl accounted for about one-third of responses, gill netsone-quarter, and beam trawls on fifth.

The spatial distribution of the change in the perceived abundance since 2001 is recorded by survey area in Figure 14.16. Overall, more than half of responses reported that cod were more abundant in 2012 than in 2011. The remainder were roughly evenly divided between reporting no change in abundance and lower abundance. Compared to 2011, the proportions of responses reporting more and less cod had increased, while fewer responses reported 'no change'. There was a clear north-south trend in perceptions of changes in the abundance of cod, with more responses reporting higher abundances in the central and north-western North Sea and Skagerrak (areas 1, 2, 3 & 8), and more reporting lower abundances in the south (areas 5 & 6b). More than a third of responses in areas 1 and 3 reported 'much more' cod, while the proportions reporting 'more' or 'much more' exceeded 80%. The cumulative index of perceptions of the abundance of cod continued to increase in all but the most southerly areas (Figure 14.16). Again the increases were greatest in the north and west, and the Skagerrak. The proportions reporting mostly large cod were greatest in the central, northern and western North Sea (areas 1, 2, 3 & 4), while the proportions reporting mostly small were greatest in the Kattegat (area 9) and southwestern areas (areas 4 & 5).

Just over half of responses reported no change in the level of discarding of cod, with the remainder evenly split between more and less discards. Higher levels of discards

were most frequently reported in the north and west (areas 1, 3 & 4), as well as the Kattegat (area 9), while lower levels of discards were most frequently reported in the south (areas 4, 5, 6a & 6b). About half of responses reported moderate levels of recruitment, while one third reported high levels. The proportions reporting low levels of recruitment were highest in the southern North Sea (areas 5 & 6b), while in most other areas (areas 1, 2, 3, 4, 7, 8 & 9) more than two-thirds of responses reported moderate or high levels of recruitment.

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
IIIa (Skagerrak)	3.3	2.9	3.2	4.1	4.8	3.8	3.8	3.8
IIa + IV	23.2	20.0	22.2	28.8	33.6	26.8	26.5	26.5
VIId				1.7	2.0	1.6	1.5	1.5

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 2010-2013, Council Regulations (EC) N°53/2010, N°57/2011, N°44/2012 and N°40/2013 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 for 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 metiers 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 in 2012.

The landings estimate for 2012 is 32.0 thousand tonnes, split as follows for the separate areas (thousand tonnes):

	TAC	Landings	Discards
IIIa-Skagerrak	3.8	4.3	2.0
IV	26.5	26.7	7.4
VIId	1.5	1.1	0.1
Total	32.2	32.0	9.6

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 and 2012 was performed in Intercatch, with the different nations providing information by quarter and métier. The provision of discard information has improved in 2011 and 2012, 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.

For cod in IV, IIIa-Skagerrak and VIId, ICES first raised concerns about the misreporting 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 up. 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, 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.

Landings in numbers at age for age groups 1-11+ and 1963-2012 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 Subarea IV (see section 2.1.6) and separately for the Skagerrak (Table 14.1). During the last five years, an average of 75% of the international landings in number were accounted for by juvenile cod aged 1-3; this averages rises to 90% when considering landings and discards combined. In 2012, age 1 cod comprised 41% of the total catch by number, age 2, 25% and age 3, 23%.

Discard numbers-at-age are shown in Table 14.2b. The proportions of the estimated total numbers discarded are plotted in Figure 14.1b and the proportion of the estimated discards for ages 1-4, in Figure 14.1c. Estimated proportion of total numbers caught that were discarded have varied between 35 and 55% from 1995 to 2005, but have shown an increase to above 70% since 2006, 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 55% in 2011, but increased again to 63% in 2012. Historically, the proportion of num-

bers discarded at age 1 have 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.. 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 to give 70% for age 2, 22% for age 3 and 7% for 4 year old cod. Note that these observations refer to numbers discarded, not weight.

Total catch numbers-at-age are shown in Table 14.2c. 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 2012. Data co-ordinators from each nation were tasked to input data for 2012 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 second year that Intercatch is used for this purpose for North Sea cod. The raising procedure was simplified compared to 2011, 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. Intercatch is discussed in section 1.2, and all results are available on WGNSSK sharepoint.Further work is ongoing on analysing the Intercatch data (cf ICES WGMIXFISH 2013).

14.2.2 Weight at age

Mean weight at age data for landings, discards and catch, are given in Tables 14.3a-c. 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

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).

Values for maturity are given in Table 14.5a, they are applied to all years and are unchanged from those used in recent assessments.

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 resulting 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 1976–2013. 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.

Quarter 3 international bottom-trawl survey (IBTS Q3): ages 0–6+, covering the period 1991–2012. 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. 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 catchabil-

ity/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. The proposed group, WGISDAA, met in early 2012 and 2013 but has not yet been able to address the catchability issues with the IBTS Q3 survey.

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 Reviews of last year's assessment

The North Sea Review Group were generally happy with the North Sea cod section of the report in 2012 (ICES-WGNSSK, 2012), and were satisfied that the assessment had been done as outlined in the Stock Annex.

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 IBTSQ1 survey, together with log-abundance curves and associated negative gradients for the age range 2-4. Similar plots are shown for the IBTSQ3 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 IBTSQ1 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 IBTSQ3 survey.

The SURBA survey analysis model was fitted to the survey data for the IBTSQ1. 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 –There is a high level of uncertainty in the model estimates, but the trend in recent years is a gradual decline in total mortality.

Recruitment –The IBTSQ1 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 2010-2013 data from the IBTS Q1 indicate that the 2009 and 2011 year classes may be the same level as the 2005 year class, but that the 2010 and 2012 year classes are weak.

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 may not be discarded to the same extent that earlier larger year classes (e.g. the 1996, 1999 and 2005 year classes) have been.

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. 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 starting from 1993, 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, as of 2006, 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 have developed a worrying retrospective pattern in F, which has become worse recently (see below). Two assessment runs are therefore presented, as follows:

a) A SAM SPALY run that estimates the catch multiplier for the period 1993-2012.

b) A SAM run that estimates the catch multiplier for the shortened period of 1993-2005.

Figures 14.9a-b compare these two assessment runs, with estimates from the SPALY run (a) superimposed (in light lines) on those from b for comparison. 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 b compared to a,

Normalised residual plots are show in Figures 14.10a-b for the SAM runs a (SPALY) and b (catch multiplier 1993-2005), indicating no serious model misspecification for either model run, although a likelihood ratio test (assuming $2(L_a - L_b) \sim \chi^2_{df=\dim_a - \dim_b}$, where $L_{a/b}$ represents the negative log-likelihood for run a/b) reveals a P value of 0.0002, implying a significant improvement in the model fit when estimating catch multipliers for 1993-2012 (the SPALY run a) compared to only estimating them for 1993-2005 (run b). However, we do not only consider the model fit itself, but also additional model performance diagnostics, such as retrospective patterns. Multi-year retrospective runs for SSB, Fbar (2-4), recruitment and the catch multiplier for SAM run a (SPALY) are shown in Figure 14.11a, indicating a general tendency to overestimate F, a tendency that has worsened (i.e. estimates from truncated datasets lying outside the confidence bounds for the full dataset) since the introduction in the 2012 assessment of M estimates from the most recent multispecies M key run. This retro-

spective pattern is coupled with estimates of the catch multiplier that are increasing and now significantly different 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 (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. A multi-year retrospective is repeated for SAM run b (catch multiplier 1993-2005; the catch multiplier plot is not shown because it ends in 2005), and shows a substantial improvement in retrospective pattern. Given the above concerns about the SAM SPALY run, SAM run b is 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 run b (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 14.10b and 14.11b 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 (the sum of 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, and possibly also the 2011 year class. The 2006, 2007, 2008 and 2010 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.

The North Sea Fishers' Survey (Figure 14.16) 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, 2009, and possibly also the 2011 year classes entering the fishery.

14.5 Recruitment estimates

Estimates of recruitment were sampled from the 1997-2011 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005, 2009 and 2011 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, but has not been repeated. 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}.

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. 5000 samples are generated from the estimated distribution of the final year's estimates. Those 5000 replicates are then simulated forward according to the model (assumptions given in the Stock Annex) and subject to different scenarios.

Two sets of forecasts are presented, the first associated with the SAM SPALY run, and the second with the SAM final assessment run (catch multiplier estimated for 1993-2005 only). Within each of these sets, several options are presented, each differing by the assumption made about fishing mortality in 2013, the intermediate year. These differing assumptions are reflected in Figure 14.15a for the SAM SPALY run, and Figure 14.15b for the SAM final run. In each case the first option (Basis A) assumes that F in 2012 follows the management plan procedure for setting F in the intermediate year, so it assumes there has been no cut in effort (derived by comparing effort allocations in Council Regulations (EC) N°44/2012 and N°40/2013) so that Fbar (2013) = Fbar (2012). The second option (Basis B) assumes that the TAC is adhered to in terms of landings in 2012. The third option (Basis C) assumes that there is a continuation of the F trend observed over 2007-2011; this third option is only presented for the SAM SPALY run because of the over-estimation of F, as observed in the retrospective pattern in F for this SAM model configuration. For each of these options, ten scenarios are considered as follows [note, $B_{trigger} = B_{pa}$]:

1) Management plan: either the Recovery Phase (paragraph 3 of Article 8 of EC 1342/2008) Fbar (2014) = 0.25×Fbar (2008), or the Longterm Phase apply-

ing the sliding rule (paragraph 4 of Article 8 of EC 1342/2008); in each case, ensure TAC (2014) is within 20% of TAC (2013)

2) MSY framework: Fbar (2014) = $F_{MSY} \times SSB_{2014}/B_{trigger}$

3) MSY transition rule: Fbar (2014) = min{0.2×Fbar (2010) + 0.8×($F_{MSY} \times SSB_{2014}/B_{trigger}$); F_{pa}}

4) Precautionary Approach: $SSB_{2015} = B_{pa}$

5) Zero catch: Fbar (2014) = 0

6) MSY: Fbar (2014) = F_{MSY}

7) Lower TAC constraint: Fbar (2014) such that TAC (2014) = 0.8×TAC (2013)

8) Upper TAC constraint: Fbar (2014) such that TAC (2014) = 1.2×TAC (2013)

9) Status quo – constant F: Fbar (2014) = Fbar (2013)

10) Status quo – constant TAC: Landings 2014 = TAC 2013

Forecasts for SAM SPALY run (Basis A-C) and associated scenarios are given in Table 14.12a, while those for the SAM final run (Basis A-B) and associated scenarios are given in Table 14.12b. Basis B for the SAM final run (Table 14.12b) is the preferred WG option.

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.

For the SAM SPALY run, applying the above-mentioned calculations (paragraph 3 for the Recovery Phase or paragraph 4 for the Longterm Phase) prior to application of the TAC constraint (paragraph 5 in each case) gives F_{2014} values of 0.16 for the Recovery Phase and 0.22 for the Longterm Phase, but since both of these F values lead to a greater than 20% decrease in TAC_{2014} relative to TAC_{2013} for each of Basis A-C in Table 14.12a, the TAC constraint is applied in both cases, leading to the Longterm Phase TAC not exceeding the Recovery Phase TAC for Basis A-C in Table 14.12a, implying that the management plan continues under the Recovery Phase for the SAM SPALY run, regardless of the intermediate year assumption of F.

For the SAM final run, the F_{2014} values are 0.16 for the Recovery Phase and 0.21 for the Longterm Phase prior to application of the TAC constraint. However, the Recovery Phase F does not lead to a greater than 20% decrease in TAC_{2014} relative to TAC_{2013} for either of Basis A or B in Table 14.12b, leading to the Longterm Phase TAC exceeding the Recovery Phase TAC for both of Basis A and B, in contrast to the SAM SPALY run. This implies that for the SAM final run, the management plan now enters the Longterm Phase for the first time, regardless of the intermediate year assumption of F.

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	SSB_{MP}	150 000 t	= $\mathbf{B}_{pa}$
	F_{MP}	0.4	Mortality rate when SSB > SSB_{MP}.
MSY Approach	MSY $B_{trigger}$	150 000 t	The default option of B_{pa}
	F_{MSY}	0.19	F_{max} 2010, within the range of fishing mortalities consistent with F_{MSY} (0.16–0.42).
Precautionary approach	B_{lim}	70 000 t	B_{loss} **(**~1995**)**
	B_{pa}	150 000 t	B_{pa} = Previous MBAL and signs of impaired recruitment below 150 000 t.
	F_{lim}	0.86	F_{lim} = F_{loss} (~1995).
	F_{pa}	0.65	F_{pa} = Approx. 5th percentile of F_{loss}, implying an equilibrium biomass > B_{pa}.

(unchanged since: 2011)

Yield and spawning biomass per Recruit F-reference points:

	Fish Mort Ages 2-4	Yield/R	SSB/R
Average 2007-2009	0.70	0.34	0.45
F_{max}	0.19	0.62	3.36
$F_{0.1}$	0.13	0.59	4.73
F_{med}	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 now estimated to be decreasing.

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

re-work 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 is declining more rapidly, and is now around the management plan target of 0.4, but still above F_{msy}.

The estimated CVs for observed catch-at-age 1, survey index-at-age 1 and the stock–recruitment relationship are all very large: 75%, 61% 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 abundance 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 0.10) 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 (0.85) 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 puts 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, SURBA) 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. The re-inclusion of the IBTS Q3 survey is envisaged in future once a detailed investigation is carried out; it is hoped that the ICES WG, WGISDAA, will be able to consider these matters at their next meeting.

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 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 the larger 2009 year class will start to mature and contribute to the spawning stock, and there are indications of a stronger 2011 year class as well.

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 year class appears to be weak. The 2011 year class appears to be stronger as well, but is still uncertain. Recent increases in the rate of discarding have been reversed, and there are encouraging indications that the 2009 year class is not being discarded to the same extent that earlier larger year classes were in the past (e.g. the 1996, 1999 and 2005 year classes).

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 just under a quarter of the total catch, 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 the stronger 2009 year class).

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 under-shooting 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 49% and 108% of the estimated total removals (average: 79%), indicating that the management system has not been effective in controlling the catches. 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 2012 being 96% of 1 year old (compared to 82% in 2011), 70% of 2 year old (66% in 2011), 22% of 3 year old (19% in 2011) and 7% of 4 year old cod (6% 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.

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, in 2007 it comprised 55%, in 2008 33%, in 2009 11% and in 2010 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. There are encouraging indications that the 2009 year

class is not being discarded to the same extent that earlier larger year classes were in the past (e.g. the 1996, 1999 and 2005 year classes).

The availability of discard rate estimates and age compositions has improved in 2011 and 2012.

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 2012 were 32.0 thousand tonnes and the estimated discards in 2012 were 9.6 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.

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Table 14.1 Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1993-2012 as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Belgium	3,374	2,648	4,827	3,458	4,642	5,799	3,882	3,304	2,470	2,616
Denmark	19,547	19,243	24,067	23,573	21,870	23,002	19,697	14,000	8,358	9,022
Faroe Islands	46	80	219	44	40	102	96	-	9	34
France	1,868	1,868	3,040	1,934	3,451	2,934	.	1,222	717	1,777
Germany	6,800	5,974	9,457	8,344	5,179	8,045	3,386	1,740	1,810	2,018
Greenland	.	.	.	.	.	.	.	.	.	.
Netherlands	10,220	6,512	11,199	9,271	11,807	14,676	9,068	5,995	3,574	4,707
Norway	8,742	7,707	7,111	5,869	5,814	5,823	7,432	6,410	4,369	5,217
Poland	-	-	-	18	31	25	19	18	18	39
Sweden	646	630	709	617	832	540	625	640	661	463
UK (E/W/NI)	14,940	13,941	14,991	15,930	13,413	17,745	10,344	6,543	4,087	3,112
UK (Scotland)	28,197	28,854	35,848	35,349	32,344	35,633	23,017	21,009	15,640	15,416
Total Nominal Catch	94,380	87,457	111,468	104,407	99,423	114,324	77,566	60,881	41,713	44,421
Unallocated landings	10,200	7,066	8,555	2,161	2,746	7,779	826	-1,114	-740	-121
WG estimate of total landings	**104,580**	**94,523**	**120,023**	**106,568**	**102,169**	**122,103**	**78,392**	**59,767**	**40,973**	**44,300**
Agreed TAC	**101,000**	**102,000**	**120,000**	**130,000**	**115,000**	**140,000**	**132,400**	**81,000**	**48,600**	**49,300**

Division VIId										
Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Belgium	157	228	377	321	310	239	172	110	93	51
Denmark	-	9	-	-	-	-	-	-	-	-
France	1,771	2,338	3,261	2,808	6,387	7,788	.	3,084	1,677	1,361
Netherlands	-	-	-	-	-	19	3	4	17	6
UK (E/W/NI)	530	312	336	414	478	618	454	385	249	145
UK (Scotland)	2	<0.5	<0.5	4	3	1	-	-	-	-
Total Nominal Catch	2,460	2,887	3,974	3,547	7,178	8,665	629	3,583	2,036	1,563
Unallocated landings	-28	-37	-10	-44	-135	-85	6,229	-1,258	-463	1,534
WG estimate of total landings	**2,432**	**2,850**	**3,964**	**3,503**	**7,043**	**8,580**	**6,858**	**2,325**	**1,573**	**3,097**

Division IIIa (Skagerrak)**										
Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Denmark	11,994	11,921	15,888	14,573	12,159	12,339	8,682	7,656	5,870	5,511
Germany	530	399	285	259	81	54	54	54	32	83
Norway	1,043	850	1,039	1,046	1,323	1,293	1,146	926	762	645
Sweden	2,575	1,834	2,483	1,986	2,173	1,900	1,909	1,293	1,035	897
Others	88	71	134	-	-	-	-	-	-	-
Norwegian coast *	909	760	846	748	911	976	788	624	846	.
Danish industrial by-catch *	511	666	749	676	205	97	62	99	687	.
Total Nominal Catch	16,230	15,075	19,829	17,864	15,736	15,586	11,791	9,929	7,699	7,136
Unallocated landings	-1,493	-1,814	-7,720	-1,615	-790	-255	-817	-652	-613	332
WG estimate of total landings	**14,737**	**13,261**	**12,109**	**16,249**	**14,946**	**15,331**	**10,974**	**9,277**	**7,086**	**7,468**
Agreed TAC	**15,000**	**15,500**	**20,000**	**23,000**	**16,100**	**20,000**	**19,000**	**11,600**	**7,000**	**7,100**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Nominal Catch	113,070	105,419	135,271	125,818	122,337	138,575	89,986	74,393	51,448	53,120
Unallocated landings	8,679	5,215	825	502	1,821	7,439	6,239	-3,024	-1,816	1,745
WG estimate of total landings	**121,749**	**110,634**	**136,096**	**126,320**	**124,158**	**146,014**	**96,225**	**71,369**	**49,632**	**54,865**

** 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	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Norwegian coast *	909	760	846	748	911	976	788	624	846	.
Danish industrial by-catch *	511	666	749	676	205	97	62	99	687	.
Total	**1,420**	**1,426**	**1,595**	**1,424**	**1,116**	**1,073**	**850**	**723**	**1,533**	**0**

Table 14.1 cont. Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1993-2012 as officially reported to ICES, and as used by the Working Group.

Sub-area IV										
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	1,482	1,627	1,722	1,309	1,009	894	946	666	653	846
Denmark	4,676	5,889	6,291	5,105	3,430	3,831	4,402	5,686	4,863	4,805
Faroe Islands	36	37	34	3	-	16	45	32	.	.
France	620	294	664	354	659	573	950	781	563	369
Germany	2,048	2,213	2,648	2,537	1,899	1,736	2,374	2,844	2,211	2,292
Greenland	.	.	35	23	17	17	11	.	.	.
Netherlands	2,305	1,726	1,660	1,585	1,523	1,896	2,649	2,657	1,928	1,951
Norway	4,417	3,223	2,900	2,749	3,057	4,128	4,234	4,496	4,898	4,423
Poland	35	-	-	-	1	2	3	.	2	.
Sweden	252	240	319	309	387	439	378	363	315	471
UK (E/W/NI)	2,213	1,890	1,270	1,491	1,587	1,546	2,384	2,553		
UK (Scotland)	7,852	6,650	4,936	6,857	6,511	7,185	9,052	11,567		
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	12,309	12,187
Others	.	.	.	786	.	.	.	.	.	.
Norwegian indust by-catch *	.	.	.	48	101	22	4	201	1	.
Danish industrial by-catch *	.	.	.	34	18	46	76	11	0	0
Total Nominal Catch	25,936	23,789	22,479	23,108	20,080	22,263	27,428	31,645	27,742	27,344
Unallocated landings	-89	-240	1,391	-1,012	-336	-68	-1,800	-345	-14	-686
WG estimate of total landings	**25,847**	**23,549**	**23,870**	**22,096**	**19,744**	**22,195**	**25,628**	**31,300**	**27,728**	**26,658**
Agreed TAC	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**	**26,842**	**26,475**

Division VIId										
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	54	47	51	80	84	154	73	57	56	38
Denmark	-	-	-	-	.	.	.	.	.	.
France	1,730	810	986	1,124	1,743	1,326	1,779	1,606	1,005	885
Netherlands	36	14	9	9	59	30	35	45	51	40
UK (E/W/NI)	121	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	n/a	126	99
Total Nominal Catch	1,941	974	1,230	1,481	2,073	1,661	2,024	1,836	1,238	1,061
Unallocated landings	-707	-167	-197	-353	-331	-307	-777	-44	-20	3
WG estimate of total landings	**1,234**	**807**	**1,033**	**1,128**	**1,742**	**1,354**	**1,247**	**1,792**	**1,218**	**1,064**
Agreed TAC							**1,678**	**1,955**	**1,564**	**1,543**

Division IIIa (Skagerrak)**										
Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Denmark	3,054	3,009	2,984	2,478	2,228	2,552	3,023	3,289	3,118	3,180
Germany	49	99	86	84	67	52	55	56	60	.
Norway	825	856	759	628	681	779	440	375	421	583
Sweden	510	495	488	372	370	365	459	458	518	.
Others	27	24	21	373	385	13	2	26	.	.
Norwegian coast *	.	720	759	524	494	498	342	369	342	467
Danish industrial by-catch *	.	10	18	9	.	-	1	0	0	0
Total Nominal Catch	4,465	4,483	4,338	3,935	3,731	3,761	3,979	4,204	4,117	3,763
Unallocated landings	-674	-696	-533	-569	-784	-463	-101	-116	-192	539
WG estimate of total landings	**3,791**	**3,787**	**3,805**	**3,366**	**2,947**	**3,298**	**3,878**	**4,089**	**3,925**	**4,302**
Agreed TAC	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**	**3,835**	**3,783**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined										
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total Nominal Catch	32,342	29,246	28,047	28,524	25,884	27,685	33,431	37,685	33,097	32,168
Unallocated landings	-1,470	-1,103	661	-1,934	-1,451	-838	-2,678	-505	-226	-145
WG estimate of total landings	**30,872**	**28,143**	**28,708**	**26,590**	**24,433**	**26,847**	**30,753**	**37,180**	**32,871**	**32,023**

** 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	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Norwegian coast *	.	720	759	524	494	498	342	369	342	467
Norwegian indust by-catch *	.	.	.	48	101	22	4	201	1	.
Danish industrial by-catch *	.	10	18	43	18	46	77	11	0	0
Total	**.**	**730**	**777**	**615**	**613**	**566**	**423**	**582**	**343**	**467**

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
1	1241	556	620	904	994	556
2	6852	3400	4403	5175	5218	2313
3	2443	4293	2763	4450	3830	5387
4	1532	1064	2693	1567	1492	1916
5	307	697	547	1281	602	626
6	114	170	245	238	579	239
7	39	70	52	87	68	161
8	36	30	29	19	25	21
9	6	21	20	9	5	6
10	1	4	7	5	10	5
+gp	0	3	2	3	2	1
TOTALNUM	12573	10307	11381	13737	12824	11233
TONSLAND	24433	26847	30753	37180	32871	32023
SOPCOF %	100	99	100	101	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
1	14622	8384	8600	9443	4391	12013
2	20183	9165	7020	6829	10166	5394
3	1506	7474	1435	1192	882	1535
4	371	149	586	52	98	139
5	49	21	34	22	11	5
6	25	13	16	0	7	2
7	0	0	8	0	1	1
8	2	3	0	0	1	0
9	0	0	0	0	0	0
10	0	0	2	0	0	0
+gp	0	0	0	0	0	0
TOTALNUM	36757	25210	17701	17538	15558	19089
TONSDISC	23636	21814	14022	9982	9485	9555
SOPCOF %	100	100	101	100	100	101

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
1	15862	8940	9220	10347	5385	12569
2	27035	12565	11423	12004	15383	7707
3	3949	11767	4198	5642	4713	6922
4	1903	1212	3280	1618	1590	2055
5	356	718	581	1303	613	631
6	139	183	261	238	586	241
7	39	71	60	87	69	162
8	38	33	29	19	26	21
9	6	21	20	9	5	6
10	1	4	9	5	10	6
+gp	0	3	2	3	2	1
TOTALNUM	49330	35517	29083	31275	28382	30322
TONSLAND	48069	48661	44775	47163	42357	41579
SOPCOF %	100	100	100	101	100	100

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
1	0.805	0.801	0.717	0.803	0.722	0.893
2	1.161	1.503	1.33	1.287	1.301	1.305
3	2.376	2.511	2.671	2.712	2.520	2.360
4	4.046	4.026	4.109	4.233	4.365	4.209
5	5.523	5.777	5.996	6.06	6.256	6.299
6	8.197	7.164	7.511	7.694	7.721	8.028
7	8.986	9.358	8.152	9.235	9.236	9.033
8	9.777	10.909	10.291	10.312	9.637	10.406
9	12.358	11.596	9.999	10.801	11.497	11.331
10	13.725	15.278	11.886	11.462	15.756	10.752
+gp	9.482	13.653	13.597	10.522	12.421	12.828

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
1	0.231	0.299	0.366	0.244	0.248	0.232
2	0.762	0.683	0.84	0.831	0.595	0.571
3	1.881	1.660	1.689	1.484	2.005	1.982
4	4.136	2.459	3.339	3.169	4.119	3.864
5	6.141	2.848	6.769	5.414	5.709	6.162
6	9.724	8.051	7.951	5.291	6.781	8.618
7	1.735	1.239	13.127	6.378	8.254	9.790
8	12.032	0.576	1.967	3.119	6.623	0.000
9	0.000	0.000	0.000	0.000	11.6	0.000
10	0.000	0.000	12.014	0.000	15.17	16.370
+gp	0.500	0.500	0.000	0.000	12.3576	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
1	0.276	0.330	0.390	0.293	0.335	0.261
2	0.863	0.904	1.029	1.028	0.835	0.792
3	2.187	1.971	2.335	2.453	2.424	2.276
4	4.064	3.834	3.972	4.199	4.349	4.185
5	5.607	5.692	6.041	6.049	6.245	6.298
6	8.467	7.228	7.538	7.692	7.710	8.032
7	8.917	9.321	8.795	9.234	9.216	9.036
8	9.902	9.879	10.212	10.311	9.495	10.406
9	12.358	11.596	9.999	10.801	11.499	11.331
10	13.725	15.278	11.915	11.462	15.754	10.979
+gp	8.154	13.295	13.597	10.522	12.421	12.828

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	32023	9555	41579

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						
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
2012*	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 and 2012 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 23 April 13

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IBTS_Q1_ext, 6 is a plusgroup

1983	2013						
1	1	0	0.25				
1	5						year
1	**5.696**	**17.403**	**2.997**	**2.050**	**0.793**	1.275	1983
1	**17.107**	**9.913**	**4.375**	**0.930**	**0.995**	0.820	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	**6.990**	**7.737**	**7.960**	**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**	**2.400**	**0.807**	**0.693**	0.356	1993
1	**14.856**	**4.510**	**3.015**	**0.860**	**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**	**2.670**	**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**	**0.410**	0.251	2001
1	**11.491**	**4.240**	**4.540**	**0.671**	**0.143**	0.230	2002
1	**0.756**	**4.168**	**1.301**	**1.415**	**0.480**	0.205	2003
1	**8.370**	**2.114**	**1.525**	**0.435**	**0.556**	0.268	2004
1	**2.723**	**3.283**	**0.940**	**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	**3.620**	**2.279**	**3.090**	**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**	0.210	2012
1	**2.757**	**5.776**	**1.929**	**1.643**	**0.881**	0.337	2013

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 = 114.708  Maximum gradient component = 0.0101676
```

The logarithm of the determinant of the hessian = 134.425

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	-10.852	0.11883	1																												
2	log survey q 2	-9.3928	0.05614	0.17	1																											
3	log survey q 3	-8.9109	0.05398	0.12	0.27	1																										
4	log survey q 4	-8.6623	0.05464	0.12	0.25	0.29	1																									
5	log survey q 5	-8.2862	0.05571	0.12	0.25	0.28	0.31	1																								
6	log sigF	-2.4104	0.14025	-0.1	-0.2	-0.2	-0.2	-0.2	1																							
7	log sigR	-0.6872	0.11386	0	-0	-0	-0	-0	-0	1																						
8	log sigN	-2.2675	0.17129	-0	-0	-0	-0.1	-0.1	-0.1	0.23	1																					
9	log sigC1	-0.2933	0.11324	-0	0.01	0.01	0.01	0.01	-0	-0.1	-0.1	1																				
10	log sigC2	-1.5353	0.16259	0.01	0.03	0.04	0.04	0.04	-0	-0.2	-0.3	0.16	1																			
11	log sigC3+	-2.4796	0.15799	0	0.01	0.02	0.03	0.03	-0	-0.1	-0.6	0.05	0.09	1																		
12	log sigS1	-0.4863	0.13569	0	0.03	0.03	0.04	0.04	-0	-0.1	-0.1	-0	0.02	0.05	1																	
13	log sigS2+	-1.3981	0.07572	0.05	0.09	0.11	0.12	0.13	-0.1	-0.1	-0.2	0.04	0.13	0.11	0.04	1																
14	rec_loga	1.8206	0.14274	-0.1	-0.1	-0	0.01	0.01	0	-0	0.01	0.02	0.03	-0	-0	-0	1															
15	rec_logb	-14.019	1.3474	-0	-0	0	0.01	0.01	-0	-0	0.01	0.03	0.04	-0	-0	-0	0.84	1														
16	rho	0.85263	0.07271	-0.1	-0.1	-0.1	-0.1	-0.2	0.41	-0	0.14	0.12	0.14	0.03	-0	-0.1	0.03	0.04	1													
17	log Cmult 93	-0.0835	0.09229	-0.1	-0.2	-0.2	-0.2	-0.2	0.06	-0	0.06	-0	-0	-0	-0	-0	-0	-0	0.06	1												
18	log Cmult 94	0.00393	0.10197	-0.1	-0.2	-0.2	-0.2	-0.2	0.06	-0	0.01	0.02	0	-0	-0	-0	-0	-0	0.06	0.43	1											
19	log Cmult 95	0.12991	0.10494	-0.1	-0.2	-0.2	-0.3	-0.3	0.11	0.02	0.01	0.01	0.04	-0	-0	-0	0	-0	0.09	0.22	0.47	1										
20	log Cmult 96	-0.034	0.10619	-0.1	-0.2	-0.3	-0.3	-0.3	0.15	0.04	0.08	-0	-0	-0.1	-0	-0.1	-0	-0	0.11	0.12	0.24	0.48	1									
21	log Cmult 97	-0.1463	0.10461	-0.1	-0.2	-0.2	-0.2	-0.2	0.08	0.05	0	-0	-0	0.01	-0	-0	0.01	0	0.05	0.07	0.13	0.24	0.47	1								
22	log Cmult 98	-0.3231	0.10497	-0.1	-0.2	-0.2	-0.3	-0.3	0.11	0.03	-0	-0	-0	-0	-0	-0.1	0	0	0.07	0.07	0.09	0.14	0.24	0.48	1							
23	log Cmult 99	-0.2308	0.10695	-0.1	-0.2	-0.3	-0.3	-0.3	0.18	0.03	0.07	-0	-0.1	-0	-0	-0.1	-0	-0	0.09	0.08	0.09	0.11	0.15	0.24	0.48	1						
24	log Cmult 00	-0.048	0.106	-0.1	-0.2	-0.3	-0.3	-0.3	0.15	0.01	0.01	-0	-0	0.01	-0	-0.1	-0	-0	0.07	0.09	0.1	0.11	0.12	0.14	0.24	0.48	1					
25	log Cmult 01	0.31213	0.10477	-0.1	-0.2	-0.2	-0.2	-0.2	0.03	0.02	-0	-0	0	0	-0	-0	0	-0	0.01	0.08	0.1	0.11	0.1	0.1	0.12	0.21	0.46	1				
26	log Cmult 02	0.14298	0.10677	-0.1	-0.2	-0.2	-0.3	-0.3	0.08	0.06	0.03	-0	-0.1	0.04	-0	-0.1	0	-0	0.03	0.09	0.11	0.12	0.12	0.11	0.1	0.14	0.24	0.47	1			
27	log Cmult 03	0.54225	0.10729	-0.1	-0.2	-0.3	-0.3	-0.3	0.17	0.03	0.03	0	0.02	-0	-0	-0.1	0.01	0.01	0.12	0.1	0.12	0.14	0.15	0.12	0.12	0.12	0.15	0.24	0.47	1		
28	log Cmult 04	0.17966	0.10538	-0.1	-0.2	-0.2	-0.2	-0.2	0.18	0.02	0.04	-0	-0	-0	-0	-0.1	0	-0	0.11	0.09	0.11	0.13	0.14	0.12	0.11	0.12	0.11	0.12	0.25	0.49	1	
29	log Cmult 05	0.15696	0.09555	-0.1	-0.2	-0.2	-0.2	-0.2	0.18	-0	0.02	-0	-0	0	-0	-0.1	-0	-0	0.11	0.07	0.09	0.11	0.12	0.1	0.1	0.11	0.09	0.07	0.12	0.24	0.46	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	0.116	0.448	0.514	0.471	0.448	0.479	0.479	0.478
1964	0.123	0.472	0.556	0.500	0.477	0.502	0.502	0.509
1965	0.130	0.497	0.597	0.529	0.503	0.518	0.518	0.541
1966	0.134	0.514	0.617	0.538	0.516	0.529	0.529	0.556
1967	0.147	0.565	0.676	0.585	0.569	0.578	0.578	0.609
1968	0.155	0.599	0.708	0.616	0.598	0.598	0.598	0.641
1969	0.151	0.585	0.680	0.592	0.579	0.574	0.574	0.619
1970	0.154	0.605	0.692	0.596	0.583	0.565	0.565	0.631
1971	0.173	0.690	0.769	0.661	0.644	0.623	0.623	0.707
1972	0.193	0.777	0.844	0.725	0.700	0.696	0.696	0.782
1973	0.187	0.761	0.805	0.696	0.668	0.661	0.661	0.754
1974	0.184	0.750	0.773	0.668	0.646	0.644	0.644	0.730
1975	0.195	0.800	0.816	0.699	0.678	0.674	0.674	0.772
1976	0.204	0.844	0.858	0.720	0.701	0.694	0.694	0.807
1977	0.203	0.833	0.850	0.698	0.696	0.684	0.684	0.794
1978	0.222	0.897	0.945	0.766	0.771	0.734	0.734	0.869
1979	0.203	0.800	0.876	0.700	0.695	0.656	0.656	0.792
1980	0.219	0.854	0.957	0.768	0.737	0.715	0.715	0.860
1981	0.225	0.868	0.992	0.799	0.744	0.737	0.737	0.886
1982	0.253	0.967	1.127	0.914	0.836	0.840	0.840	1.003
1983	0.248	0.947	1.103	0.910	0.823	0.828	0.828	0.987
1984	0.232	0.882	1.015	0.857	0.771	0.781	0.781	0.918
1985	0.223	0.848	0.965	0.833	0.742	0.755	0.755	0.882
1986	0.238	0.901	1.030	0.908	0.799	0.820	0.820	0.946
1987	0.236	0.898	1.020	0.916	0.796	0.827	0.827	0.945
1988	0.237	0.898	1.037	0.929	0.808	0.827	0.827	0.955
1989	0.244	0.923	1.063	0.967	0.844	0.859	0.859	0.984
1990	0.225	0.858	0.978	0.901	0.790	0.797	0.797	0.912
1991	0.231	0.873	0.999	0.933	0.825	0.844	0.844	0.935
1992	0.223	0.837	0.967	0.915	0.810	0.824	0.824	0.906
1993	0.222	0.828	0.978	0.921	0.819	0.830	0.830	0.909
1994	0.221	0.813	0.991	0.924	0.825	0.832	0.832	0.909
1995	0.224	0.824	1.030	0.949	0.857	0.854	0.854	0.934
1996	0.230	0.831	1.064	0.982	0.909	0.910	0.910	0.959
1997	0.229	0.808	1.058	0.998	0.930	0.919	0.919	0.955
1998	0.233	0.808	1.080	1.038	0.980	0.939	0.939	0.975
1999	0.241	0.814	1.115	1.092	1.040	1.002	1.002	1.007
2000	0.242	0.807	1.098	1.121	1.081	1.014	1.014	1.009
2001	0.231	0.764	1.028	1.079	1.045	0.985	0.985	0.957
2002	0.225	0.736	0.996	1.063	1.028	0.980	0.980	0.932
2003	0.223	0.733	0.981	1.058	1.024	0.975	0.975	0.924
2004	0.214	0.698	0.935	1.022	0.972	0.958	0.958	0.885
2005	0.200	0.651	0.867	0.951	0.919	0.914	0.914	0.823
2006	0.172	0.558	0.747	0.803	0.791	0.792	0.792	0.703
2007	0.151	0.490	0.664	0.701	0.694	0.698	0.698	0.618
2008	0.157	0.507	0.693	0.713	0.728	0.751	0.751	0.638
2009	0.149	0.478	0.652	0.678	0.694	0.730	0.730	0.603
2010	0.139	0.444	0.606	0.634	0.648	0.688	0.688	0.561
2011	0.117	0.373	0.502	0.534	0.546	0.58	0.58	0.470
2012	0.098	0.311	0.416	0.445	0.454	0.476	0.476	0.391

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	462314	193881	21405	10406	8674	3368	1673	701721
1964	845768	137310	53370	11691	5380	4715	2361	1060595
1965	1067681	244507	40905	23202	6426	2654	3187	1388562
1966	1375049	286645	69703	16756	9910	3376	2963	1764402
1967	1274418	357897	73865	29173	7974	4834	3337	1751498
1968	654744	321901	91217	28141	14346	3520	3616	1117485
1969	600189	155749	76420	33928	11366	6731	3167	887550
1970	1837653	145801	39895	32209	15329	4769	4093	2079749
1971	2385693	445521	35277	14973	15550	6794	4191	2907999
1972	587129	564107	94278	12269	6097	6710	5471	1276061
1973	873270	129314	111636	29555	4972	2513	4537	1155797
1974	806130	195048	25694	37012	11038	2159	3166	1080247
1975	1384708	179512	39656	9660	16275	4604	2282	1636697
1976	852561	313326	35954	13724	3955	6800	2767	1229087
1977	2113805	184610	55715	11189	5276	1736	4028	2376359
1978	1255444	476870	33024	18792	5225	2257	2270	1793882
1979	1428306	281250	85477	9336	7193	1791	1779	1815132
1980	2262543	311763	61821	25235	4034	2811	1690	2669897
1981	885582	492377	62007	17942	9162	1635	1824	1470529
1982	1388869	187213	95894	17077	6706	3775	1440	1700974
1983	800507	292728	34235	21341	5451	2435	1813	1158510
1984	1391649	172992	54666	8136	6823	2020	1582	1637868
1985	368060	305896	35596	15611	2915	2638	1381	732097
1986	1664441	83450	61206	10500	5718	1166	1637	1828118
1987	652783	386157	17670	15678	3240	2028	1043	1078599
1988	451802	153277	73792	5338	5046	1253	982	691490
1989	753889	106617	32112	17603	1833	1903	838	914795
1990	323515	179692	21245	7992	5112	643	945	539144
1991	353274	79063	33356	6071	2660	1943	691	477058
1992	741181	89232	16282	8884	2004	947	886	859416
1993	405956	192144	19274	5126	2859	754	638	626751
1994	869784	104193	38484	5503	1733	1008	492	1021197
1995	505852	231886	24319	10464	1771	642	520	775454
1996	365492	133920	43478	5854	3260	665	479	553148
1997	970921	99509	28368	9831	1924	1061	372	1111986
1998	154508	267801	22697	7134	2904	667	435	456146
1999	276786	40823	55437	5372	2021	851	412	381702
2000	499818	76496	10239	10783	1496	616	351	599799
2001	188528	143774	17956	2464	2504	368	302	355896
2002	232118	53316	33725	4611	698	684	202	325354
2003	106404	64667	14423	8045	1295	208	244	195286
2004	173685	30152	14615	3665	2234	334	152	224837
2005	117243	48582	7641	3450	1007	768	144	178835
2006	304066	33256	12616	2141	959	309	287	353634
2007	127262	92042	9764	3881	826	333	203	234311
2008	153277	37873	27392	2969	1505	364	250	223630
2009	163571	46166	11148	7600	1232	550	244	230511
2010	249197	50111	14451	3738	2985	502	281	321265
2011	134592	77265	15772	4420	1573	1314	291	235227
2012	253723	42531	26397	6316	1960	715	629	332271
2013	246718	81064	15584	10617	3287	1020	684	358974

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	30989	49871	7752	3568	2859	1172	582
1964	59059	36596	20457	4203	1866	1702	852
1965	77497	67609	16489	8709	2320	981	1178
1966	101296	81040	28730	6369	3649	1268	1113
1967	101407	108727	32416	11803	3165	1943	1341
1968	54334	102058	41246	11844	5908	1451	1490
1969	48267	48494	33513	13866	4572	2688	1265
1970	150091	46607	17697	13225	6200	1883	1616
1971	217119	157692	16817	6634	6760	2886	1781
1972	59024	217858	47830	5798	2815	3084	2515
1973	85460	49331	54819	13579	2221	1114	2011
1974	77482	73843	12289	16522	4811	939	1377
1975	140547	71346	19671	4456	7346	2069	1025
1976	90219	129599	18415	6462	1828	3120	1270
1977	221483	75872	28365	5155	2425	788	1829
1978	142529	206902	17957	9234	2578	1076	1083
1979	149059	113052	44267	4308	3302	790	784
1980	253749	131597	33820	12413	1930	1317	791
1981	101600	210744	34617	9062	4413	782	873
1982	177637	86388	57624	9412	3492	1972	752
1983	101124	133626	20300	11723	2808	1259	938
1984	166192	75584	30863	4302	3367	1005	787
1985	42625	130431	19486	8101	1401	1283	672
1986	206365	37172	34843	5760	2890	599	841
1987	81064	171888	10013	8643	1633	1048	539
1988	56715	68282	42260	2970	2569	648	508
1989	97822	48407	18658	10037	960	1008	444
1990	39423	77699	11753	4362	2563	325	477
1991	44298	34558	18692	3386	1373	1018	362
1992	90454	37904	8935	4894	1022	488	457
1993	49593	81016	10634	2834	1468	391	331
1994	105905	43443	21352	3049	894	523	255
1995	62818	97655	13748	5893	937	339	274
1996	46705	56903	24939	3362	1791	365	263
1997	124057	41544	16135	5698	1072	587	206
1998	20175	112151	12973	4228	1671	374	244
1999	37448	17225	32061	3275	1205	496	240
2000	68105	32157	5827	6662	912	362	206
2001	24691	58221	9760	1488	1496	212	174
2002	29801	21016	17871	2758	413	393	116
2003	13554	25387	7526	4795	765	119	140
2004	21258	11411	7363	2139	1279	190	86
2005	13487	17435	3651	1925	556	423	79
2006	30324	10587	5428	1072	482	155	144
2007	11258	26436	3857	1769	379	153	93
2008	14012	11165	11138	1370	713	176	121
2009	14245	12987	4334	3385	565	262	116
2010	20335	13282	5321	1585	1304	229	128
2011	9332	17687	5020	1648	606	529	117
2012	14802	8333	7231	2043	653	248	218

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 unallocated mortality) and average fishing mortality for ages 2 to 4 (Fbar 2-4).

Year	Recruits age 1 ('000)	Low	High	TSB (tons)	Low	High	SSB (tons)	Low	High	Total removals (tons)	Low	High	Fbar 2-4	Low	High
1963	462314	341847	625233	515555	459021	579052	153584	138426	170400	123995	110359	139316	0.478	0.423	0.540
1964	845768	631378	1132958	686252	596874	789013	165877	150710	182570	152207	137254	168791	0.510	0.456	0.570
1965	1067681	801596	1422093	863717	759557	982160	205048	187312	224463	202805	181349	226800	0.541	0.486	0.603
1966	1375049	1031908	1832295	1050734	920787	1199021	228205	209534	248540	247954	222350	276508	0.556	0.501	0.618
1967	1274418	954497	1701567	1137109	1003638	1288331	251954	231929	273707	299240	267480	334770	0.609	0.549	0.675
1968	654744	486708	880795	944112	854044	1043678	262236	241704	284512	301342	272527	333203	0.641	0.578	0.710
1969	600189	447817	804406	802109	719870	893743	258849	238193	281296	237994	217823	260033	0.619	0.558	0.686
1970	1837653	1374637	2456627	1333077	1111666	1598586	274581	252399	298712	265402	233531	301622	0.631	0.571	0.698
1971	2385693	1782808	3192453	1467396	1249208	1723694	276786	255329	300046	353628	307662	406461	0.707	0.642	0.779
1972	587129	438441	786242	980679	877366	1096156	240867	222499	260751	367324	322877	417889	0.782	0.709	0.862
1973	873270	653188	1167506	798109	709441	897859	212140	196331	229221	259367	236091	284938	0.754	0.684	0.831
1974	806130	602595	1078412	753135	672092	843951	232118	213691	252133	238948	214972	265598	0.730	0.663	0.805
1975	1384708	1023665	1873090	861129	738351	1004325	213203	196599	231210	238470	212546	267556	0.772	0.702	0.849
1976	852561	628556	1156397	660664	585848	745033	182773	169032	197631	238709	209201	272379	0.807	0.732	0.889
1977	2113805	1564223	2856478	1012568	836996	1224969	160813	149180	173355	243531	210119	282256	0.794	0.721	0.874
1978	1255444	933877	1687738	1119060	952817	1314310	160332	149265	172219	327420	278281	385236	0.870	0.791	0.956
1979	1428306	1065079	1915406	1000490	871785	1148195	166375	154934	178661	308970	272725	350033	0.792	0.720	0.870
1980	2262543	1679220	3048499	1169398	995619	1373510	181861	169326	195325	339083	295262	389407	0.860	0.785	0.941
1981	885582	660333	1187665	987567	871234	1119434	194269	181306	208160	360411	314500	413024	0.886	0.811	0.968
1982	1388869	1046331	1843543	1011556	872736	1172457	187400	175447	200167	337729	299556	380767	1.003	0.919	1.094
1983	800507	607022	1055663	802109	702407	915964	152360	142415	162999	280127	246083	318882	0.986	0.905	1.075
1984	1391649	1053407	1838499	809361	694435	943306	130092	121766	138988	241832	213396	274058	0.918	0.841	1.002
1985	368060	276675	489627	557936	499806	622827	125116	117015	133779	220356	193643	250755	0.882	0.807	0.964
1986	1664441	1257857	2202448	764517	637800	916411	114577	107311	122335	205253	178758	235675	0.946	0.868	1.031
1987	652783	495875	859340	724328	629659	833231	107152	100212	114571	244263	209285	285086	0.945	0.867	1.029
1988	451802	343190	594788	539825	477829	609864	99012	92658	105803	197008	176590	219787	0.955	0.877	1.039
1989	753889	567559	1001390	528607	453023	616801	92689	86519	99299	168215	148765	190208	0.984	0.903	1.073
1990	323515	245826	425755	369904	328540	416477	78433	73296	83930	133653	118034	151338	0.913	0.835	0.997
1991	353274	268219	465301	338405	298513	383629	71898	67453	76636	119134	107055	132575	0.935	0.858	1.019
1992	741181	562485	976646	487966	411541	578582	68186	63860	72806	131268	114292	150767	0.906	0.831	0.988
1993	405956	308680	533887	397520	350553	450780	63704	59802	67860	140084	122156	160643	0.909	0.834	0.991
1994	869784	652587	1159269	482145	409686	567419	65644	61628	69921	140365	123682	159298	0.909	0.834	0.991
1995	505852	384793	664998	513497	446169	590985	73644	68920	78692	169906	147378	195877	0.934	0.857	1.019
1996	365492	277640	481143	416649	368731	470795	72042	67620	76752	151146	134991	169234	0.959	0.881	1.044
1997	970921	732750	1286505	576655	478742	694593	68050	63861	72514	150693	129780	174976	0.955	0.879	1.038
1998	154508	116201	205442	313953	277147	355648	55882	52382	59617	128669	111187	148900	0.975	0.898	1.059
1999	276786	209592	365521	234920	209045	263998	51380	48136	54842	93153	84284	102956	1.007	0.927	1.095
2000	499818	379542	658210	313953	266634	369671	45297	42205	48616	93995	81509	108394	1.009	0.929	1.095
2001	188528	141303	251536	224134	198765	252742	37609	35272	40101	82372	72674	93364	0.957	0.882	1.039
2002	232118	174972	307928	241349	211259	275725	38561	36101	41189	80580	71782	90456	0.932	0.856	1.014
2003	106404	80710	140278	136216	123323	150457	33323	31018	35799	55826	50180	62108	0.924	0.850	1.004
2004	173685	131940	228639	131268	115058	149763	28254	26425	30210	43002	38729	47746	0.885	0.812	0.965
2005	117243	89332	153873	124244	110561	139620	25566	23871	27380	41357	36789	46493	0.823	0.752	0.900
2006	304066	231339	399656	134323	116497	154875	21844	20383	23410	34406	30634	38643	0.703	0.640	0.772
2007	127262	97071	166842	161135	142857	181753	27778	25755	29960	45890	40113	52499	0.618	0.559	0.684
2008	153277	116751	201229	163898	146958	182791	34201	31518	37112	48485	43934	53506	0.638	0.576	0.706
2009	163571	124273	215294	181498	160916	204713	40619	37160	44401	48972	44090	54394	0.603	0.539	0.674
2010	249197	187670	330896	200386	175292	229072	43261	38954	48044	50212	45172	55813	0.562	0.494	0.639
2011	134592	97320	186137	189852	165150	218248	45890	40045	52588	46258	41581	51462	0.470	0.397	0.555
2012	253723	164266	391899	210449	174710	253499	54776	45785	65531	43608	39182	48534	0.391	0.312	0.489
2013							71970	56423	91799						

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	13265	123995		123995
1964	139246	13001	152207		152207
1965	181680	21007	202805		202805
1966	216209	31698	247954		247954
1967	265402	33624	299240		299240
1968	280408	21051	301342		301342
1969	226160	11967	237994		237994
1970	241832	23671	265402		265402
1971	292436	61636	353628		353628
1972	332036	35066	367324		367324
1973	234920	24588	259367		259367
1974	214272	24662	238948		238948
1975	206282	32241	238470		238470
1976	200988	37571	238709		238709
1977	180232	63007	243531		243531
1978	287506	39935	327420		327420
1979	268069	41069	308970		308970
1980	272665	66171	339083		339083
1981	322546	38025	360411		360411
1982	297152	40579	337729		337729
1983	254740	25413	280127		280127
1984	196222	45707	241832		241832
1985	198392	22049	220356		220356
1986	160653	44623	205253		205253
1987	214915	29378	244263		244263
1988	184241	12702	197008		197008
1989	135673	32630	168215		168215
1990	112420	21303	133653		133653
1991	104715	14459	119134		119134
1992	105030	26160	131268		131268
1993	126308	25990	152280	0.92	140084
1994	104513	35280	139814	1.00	140365
1995	122038	27149	149207	1.14	169906
1996	134859	21431	156370	0.97	151146
1997	132102	42376	174439	0.86	150693
1998	137192	40584	177751	0.72	128669
1999	100493	16869	117341	0.79	93153
2000	78356	20283	98619	0.95	93995
2001	47423	12856	60287	1.37	82372
2002	62381	7533	69844	1.15	80580
2003	27248	5188	32460	1.72	55826
2004	28864	7040	35930	1.20	43002
2005	29350	5980	35350	1.17	41357
2006	26213	8206	34406		34406
2007	23647	22248	45890		45890
2008	26662	21812	48485		48485
2009	32435	16564	48972		48972
2010	37421	12755	50212		50212
2011	34996	11275	46258		46258
2012	33223	10385	43608		43608

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	0.92	0.76	1.11
1994	1.00	0.82	1.23
1995	1.14	0.92	1.40
1996	0.97	0.78	1.20
1997	0.86	0.70	1.06
1998	0.72	0.59	0.89
1999	0.79	0.64	0.98
2000	0.95	0.77	1.18
2001	1.37	1.11	1.68
2002	1.15	0.93	1.43
2003	1.72	1.39	2.13
2004	1.20	0.97	1.48
2005	1.17	0.97	1.42

Table 14.12a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch options based on the SAM SPALY run. Units are '000t (SSB, landings, discards, unaccounted) or millions (recruitment). [See Figure 14.15a for intermediate year F assumptions.]

Basis A

Management Plan assumption: F(2013) = F(2012) =	**0.54**
Recruitment resampled from 1998-2012 =	**204**
SSB(2014) =	**82.5**
HC landings (2013) =	**39.6**
Discards (2013) =	**15.2**
Unallocated (2013) =	**24.9**

Rationale	Catch (2014)	Landings (2014)	Discards (2014)	Unalloc. (2014)	Basis	Ftotal (2014)	F land (2014)	F disc (2014)	F unal (2014)	SSB (2015)	%SSB change	%TAC change
Management Plan	49.5	25.4	8.6	15.4	F08*0.25 with TAC constr	0.28	0.14	0.06	0.09	115.8	40	-20
MSY approach	19.9	10.3	3.4	6.2	FMSY *SSB2014/Btrigger	0.10	0.05	0.02	0.03	138.9	68	-68
MSY transition	36.0	18.5	6.2	11.2	Transition rule	0.20	0.10	0.04	0.06	126.3	53	-42
Precautionary Approach	6.0	3.1	1.0	1.9	SSB2015=Bpa	0.03	0.01	0.01	0.01	150.0	82	-90
Zero Catch	0.0	0.0	0.0	0.0	F=0	0.00	0.00	0.00	0.00	155.0	88	-100
MSY	35.0	18.0	6.0	10.9	FMSY	0.19	0.10	0.03	0.06	127.1	54	-43
TAC constraint	49.5	25.4	8.6	15.4	TAC2013-20%	0.28	0.14	0.06	0.09	115.8	40	-20
TAC constraint	74.5	38.1	13.2	23.3	TAC2013+20%	0.45	0.22	0.09	0.14	96.3	17	20
Status quo	85.4	43.5	15.2	26.6	Fsq	0.54	0.27	0.10	0.17	88.0	7	37
Status quo	62.0	31.8	10.9	19.4	Constant TAC	0.36	0.18	0.07	0.11	105.8	28	0

Basis B

Assume F(2013) so that HC landings (2013) = TAC(2013) =	**0.41**
Recruitment resampled from 1998-2012 =	**204**
SSB(2014) =	**94.7**
HC landings (2013) =	**31.8**
Discards (2013) =	**11.8**
Unallocated (2013) =	**19.8**

Rationale	Catch (2014)	Landings (2014)	Discards (2014)	Unalloc. (2014)	Basis	Ftotal (2014)	F land (2014)	F disc (2014)	F unal (2014)	SSB (2015)	%SSB change	%TAC change
Management Plan	48.6	25.5	8.0	15.2	F08*0.25 with TAC constr	0.24	0.12	0.05	0.07	133.6	41	-20
MSY approach	25.2	13.3	4.1	7.9	FMSY *SSB2014/Btrigger	0.12	0.06	0.02	0.04	152.8	61	-58
MSY transition	42.2	22.1	6.9	13.2	Transition rule	0.21	0.10	0.04	0.07	138.7	47	-30
Precautionary Approach	28.6	15.1	4.6	8.9	SSB2015=Bpa	0.14	0.07	0.03	0.04	150.0	58	-53
Zero Catch	0.0	0.0	0.0	0.0	F=0	0.00	0.00	0.00	0.00	173.7	83	-100
MSY	38.7	20.3	6.3	12.1	FMSY	0.19	0.10	0.03	0.06	141.6	50	-36
TAC constraint	48.6	25.5	8.0	15.2	TAC2013-20%	0.24	0.12	0.05	0.07	133.6	41	-20
TAC constraint	73.4	38.2	12.3	22.9	TAC2013+20%	0.39	0.19	0.08	0.12	114.3	21	20
Status quo	75.4	39.2	12.6	23.5	Fsq	0.41	0.20	0.08	0.13	112.8	19	23
Status quo	60.9	31.8	10.1	19.0	Constant TAC	0.32	0.16	0.06	0.10	124.2	31	0

Basis C

Assume F(2013) follows trend: F(2007) to F(2011)	**0.47**
Recruitment resampled from 1998-2012 =	**204**
SSB(2014) =	**88.7**
HC landings (2013) =	**35.6**
Discards (2013) =	**13.4**
Unallocated (2013) =	**22.2**

Rationale	Catch (2014)	Landings (2014)	Discards (2014)	Unalloc. (2014)	Basis	Ftotal (2014)	F land (2014)	F disc (2014)	F unal (2014)	SSB (2015)	%SSB change	%TAC change
Management Plan	48.9	25.4	8.3	15.3	F08*0.25 with TAC constr	0.26	0.13	0.05	0.08	125.3	41	-20
MSY approach	22.5	11.8	3.7	7.0	FMSY *SSB2014/Btrigger	0.11	0.06	0.02	0.03	146.0	65	-63
MSY transition	39.0	20.3	6.5	12.2	Transition rule	0.20	0.10	0.04	0.06	133.0	50	-36
Precautionary Approach	17.7	9.3	2.9	5.5	SSB2015=Bpa	0.09	0.04	0.02	0.03	150.0	69	-71
Zero Catch	0.0	0.0	0.0	0.0	F=0	0.00	0.00	0.00	0.00	164.5	86	-100
MSY	36.9	19.2	6.2	11.5	FMSY	0.19	0.10	0.03	0.06	134.6	52	-40
TAC constraint	48.9	25.4	8.3	15.3	TAC2013-20%	0.26	0.13	0.05	0.08	125.3	41	-20
TAC constraint	74.1	38.2	12.8	23.1	TAC2013+20%	0.42	0.21	0.08	0.13	105.5	19	20
Status quo	80.6	41.5	13.9	25.1	Fsq	0.47	0.23	0.10	0.15	100.4	13	31
Status quo	61.5	31.8	10.5	19.2	Constant TAC	0.34	0.17	0.07	0.11	115.2	30	0

Table 14.12b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch options based on the SAM final run. Units are '000t (SSB, landings, discards) or millions (recruitment). [See Figure 14.15b for intermediate year F assumptions.]

Basis A

Management Plan assumption: F(2013) = F(2012) =	**0.39**
Recruitment resampled from 1998-2012 =	**174**
SSB(2014) =	**87.8**
HC landings (2013) =	**40.9**
Discards (2013) =	**14.8**

Rationale	Catch (2014)	Landings (2014)	Discards (2014)	Basis	Ftotal (2014)	F land (2014)	F disc (2014)	SSB (2015)	%SSB change	%TAC change
Management Plan	37.5	28.8	8.7	Longterm phase slide rule	0.21	0.15	0.06	127.4	45	-9
MSY approach	21.0	16.2	4.8	FMSY *SSB2014/Btrigger	0.11	0.08	0.03	141.2	61	-49
MSY transition	36.5	28.1	8.5	Transition rule	0.20	0.14	0.06	128.3	46	-12
Precautionary Approach	10.1	7.8	2.3	SSB2015=Bpa	0.05	0.04	0.01	150.0	71	-76
Zero Catch	0.0	0.0	0.0	F=0	0.00	0.00	0.00	158.4	80	-100
MSY	34.7	26.7	8.0	FMSY	0.19	0.13	0.06	129.8	48	-16
TAC constraint	33.0	25.4	7.6	TAC2013-20%	0.18	0.13	0.05	131.1	49	-20
TAC constraint	49.7	38.1	11.6	TAC2013+20%	0.28	0.20	0.08	117.3	34	20
Status quo	65.7	50.2	15.5	Fsq	0.39	0.28	0.11	104.2	19	58
Status quo	41.4	31.8	9.6	Constant TAC	0.23	0.16	0.07	124.1	41	0

Basis B

Assume F(2013) so that HC landings (2013) = TAC(2013) =	**0.29**
Recruitment resampled from 1998-2012 =	**174**
SSB(2014) =	**97.8**
HC landings (2013) =	**31.8**
Discards (2013) =	**11.3**

Rationale	Catch (2014)	Landings (2014)	Discards (2014)	Basis	Ftotal (2014)	F land (2014)	F disc (2014)	SSB (2015)	%SSB change	%TAC change
Management Plan	40.6	31.6	9.0	Longterm phase slide rule	0.21	0.15	0.06	139.3	42	-1
MSY approach	25.3	19.8	5.5	FMSY *SSB2014/Btrigger	0.12	0.09	0.03	152.1	56	-38
MSY transition	41.3	32.2	9.1	Transition rule	0.21	0.15	0.06	138.7	42	1
Precautionary Approach	27.7	21.7	6.1	SSB2015=Bpa	0.14	0.10	0.04	150.0	53	-32
Zero Catch	0.0	0.0	0.0	F=0	0.00	0.00	0.00	173.2	77	-100
MSY	37.6	29.3	8.3	FMSY	0.19	0.13	0.06	141.9	45	-8
TAC constraint	32.4	25.3	7.1	TAC2013-20%	0.16	0.12	0.04	146.2	49	-20
TAC constraint	49.2	38.2	11.0	TAC2013+20%	0.26	0.18	0.08	132.1	35	20
Status quo	55.1	42.7	12.4	Fsq	0.29	0.21	0.08	127.2	30	34
Status quo	40.8	31.8	9.0	Constant TAC	0.21	0.15	0.06	139.1	42	0

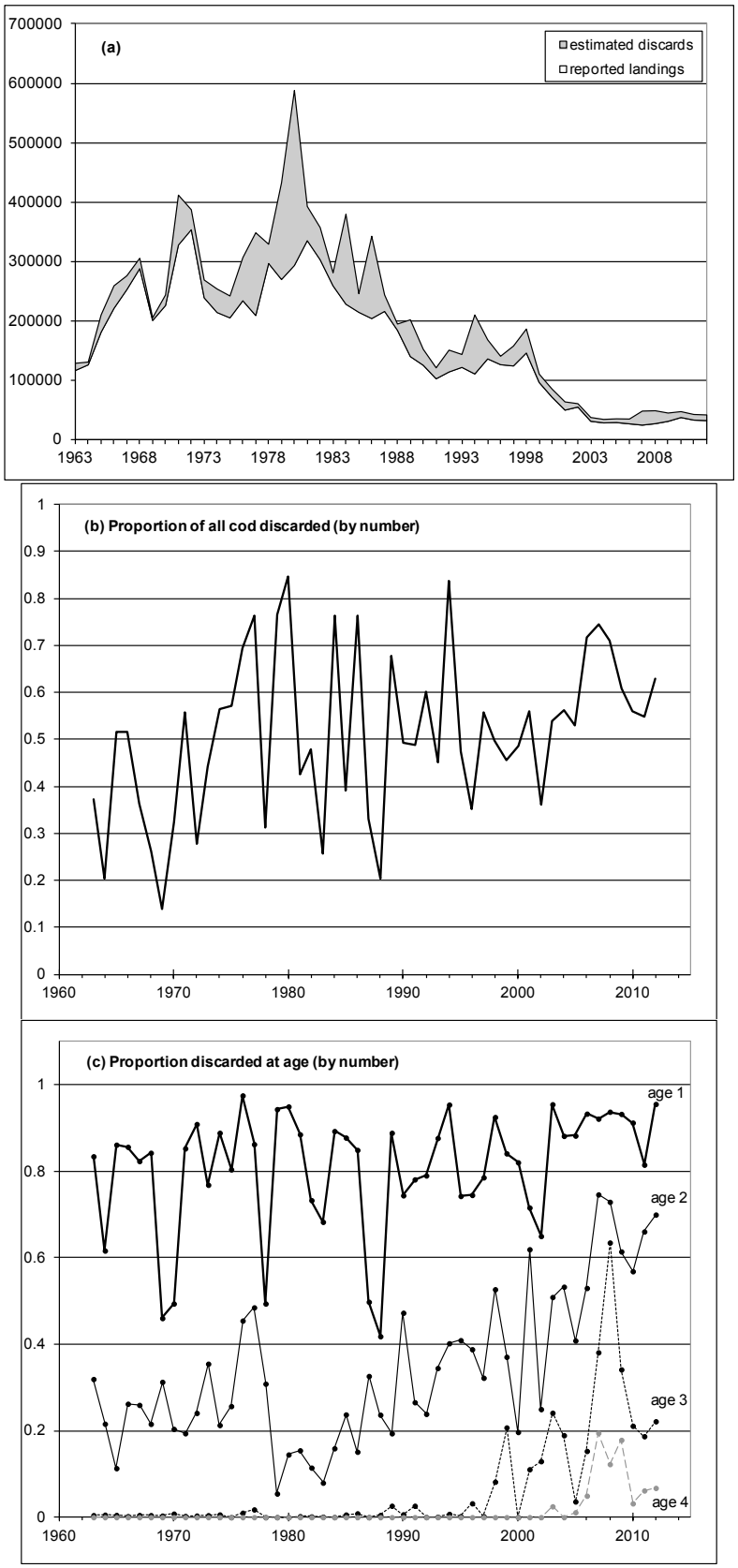


Figure 14.1 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: (a) stacked area plot of reported landings and estimated discards (in tons); (b) proportion of total numbers caught that are discarded; and (c) proportion of total numbers caught at age that are discarded

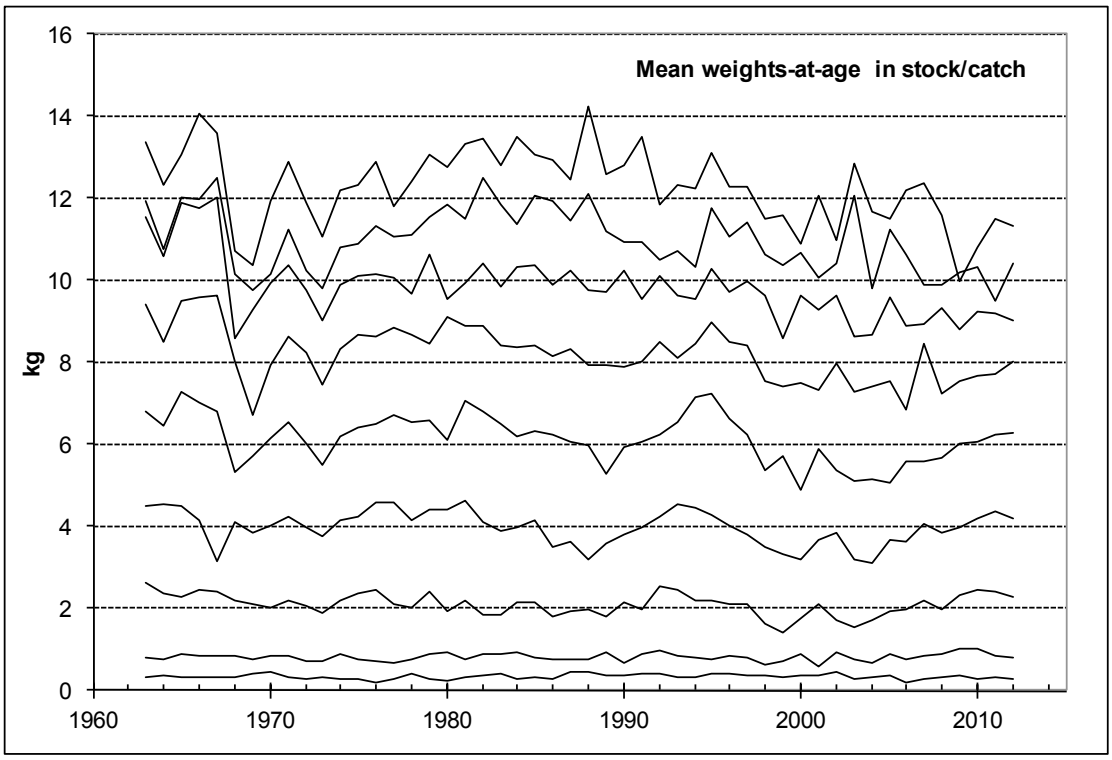


Figure 14.2 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: Mean weight at age in the catch for ages 1-9.

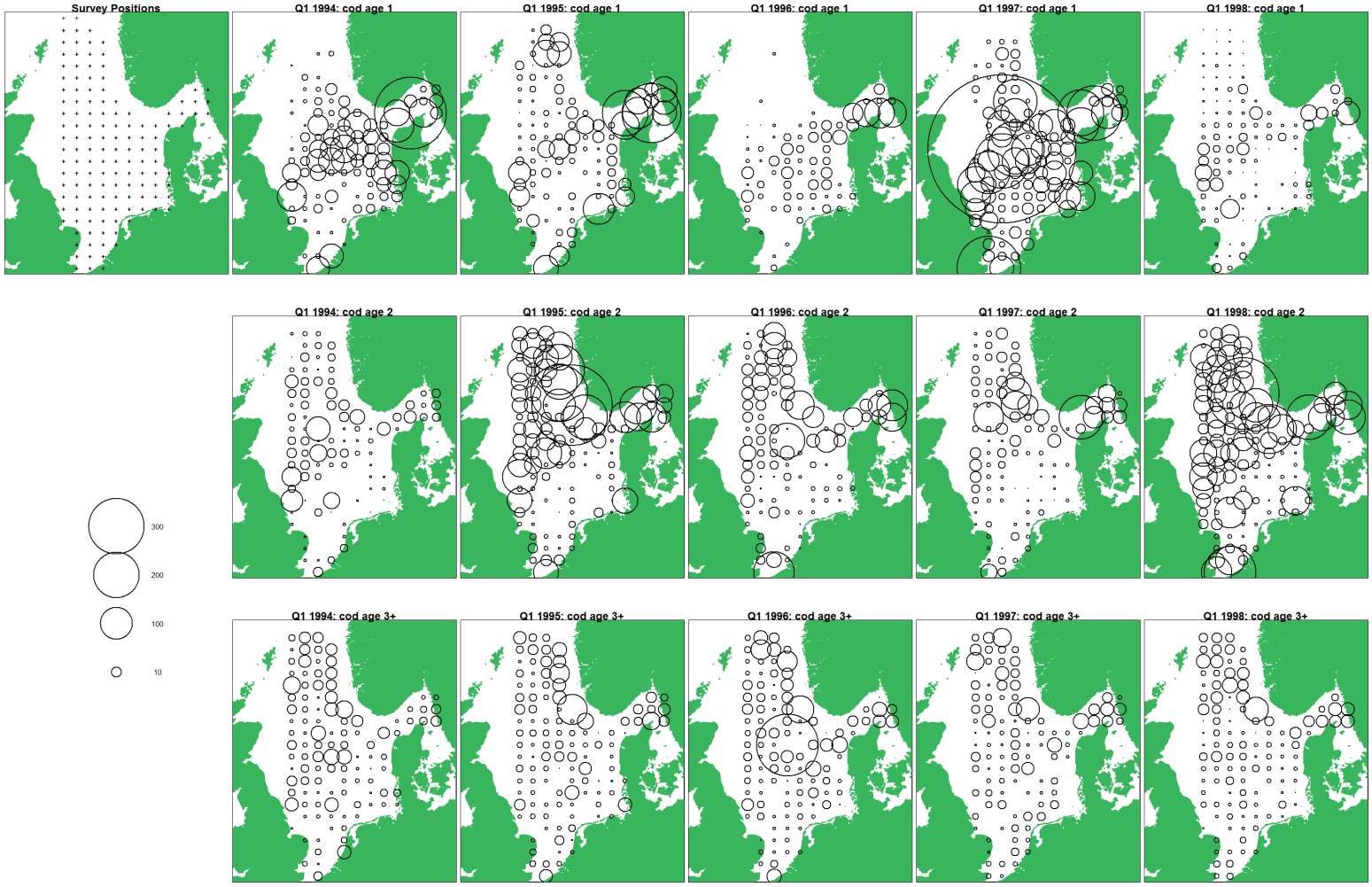


Figure 14.3a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1994-2013 in the North Sea.



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 1994-2013 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 1994-2013 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 1994-2013 in the North Sea.

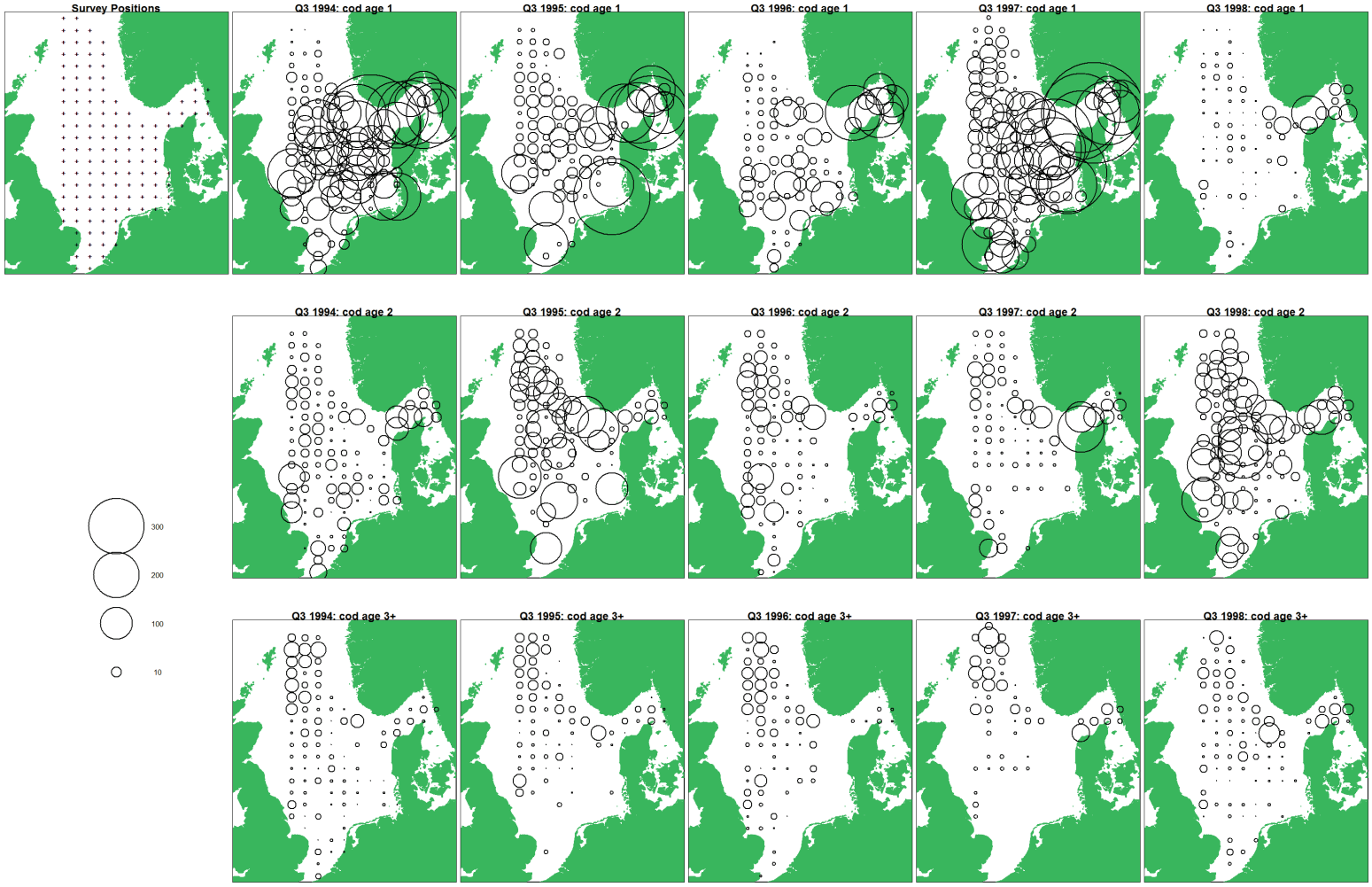


Figure 14.3b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1994-2012 in the North Sea.

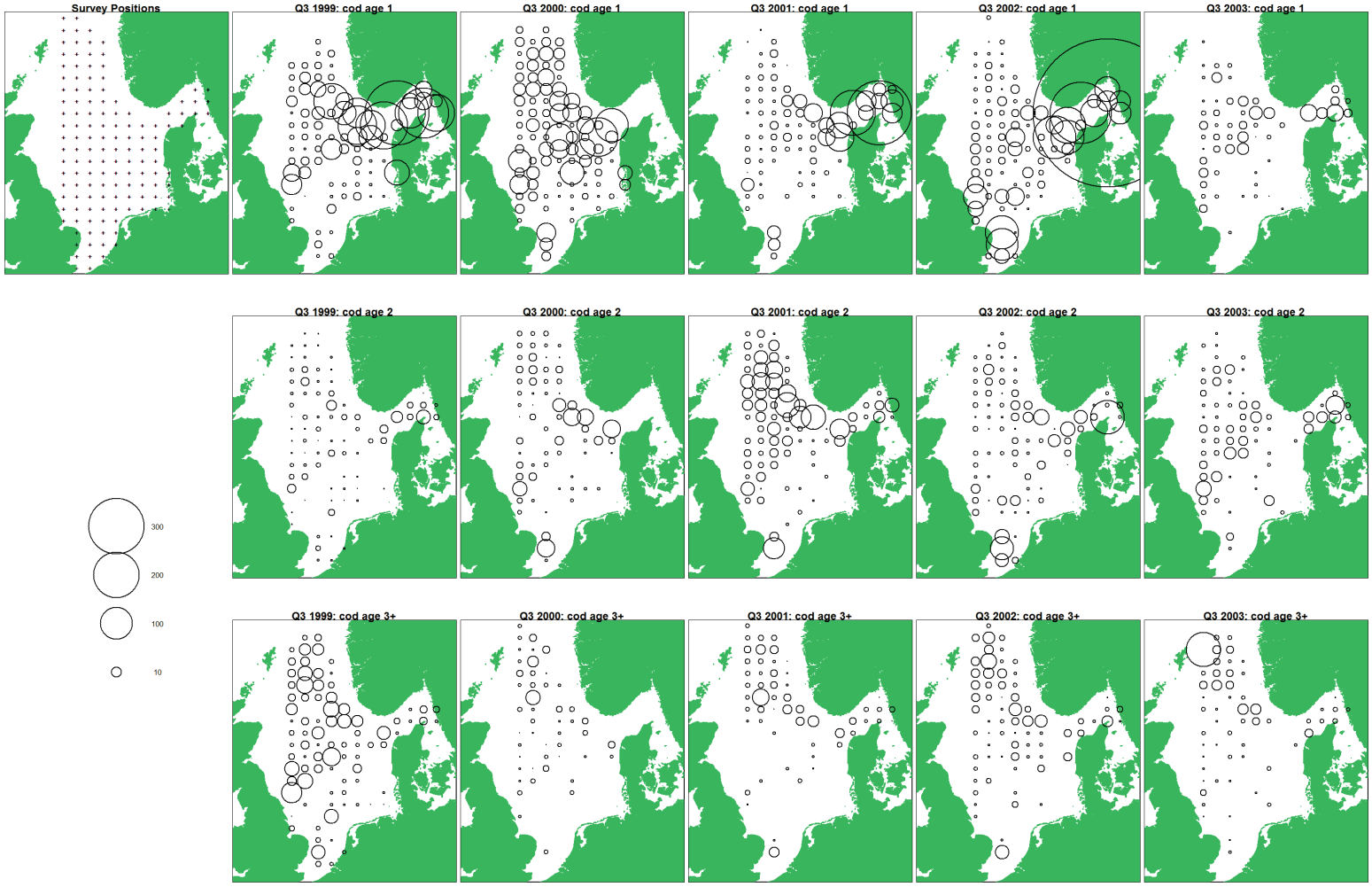


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1994-2012 in the North Sea.

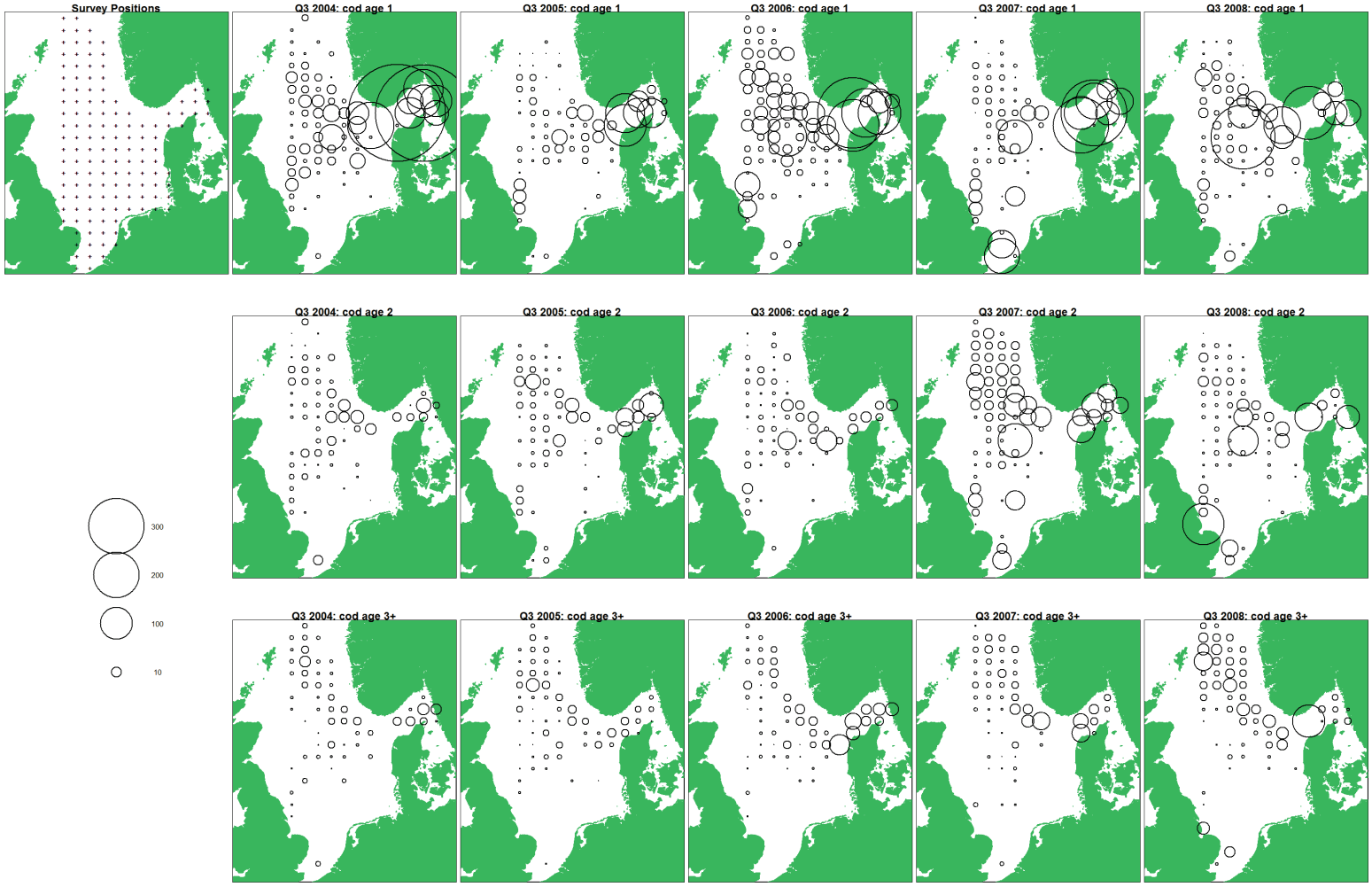


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1994-2012 in the North Sea.

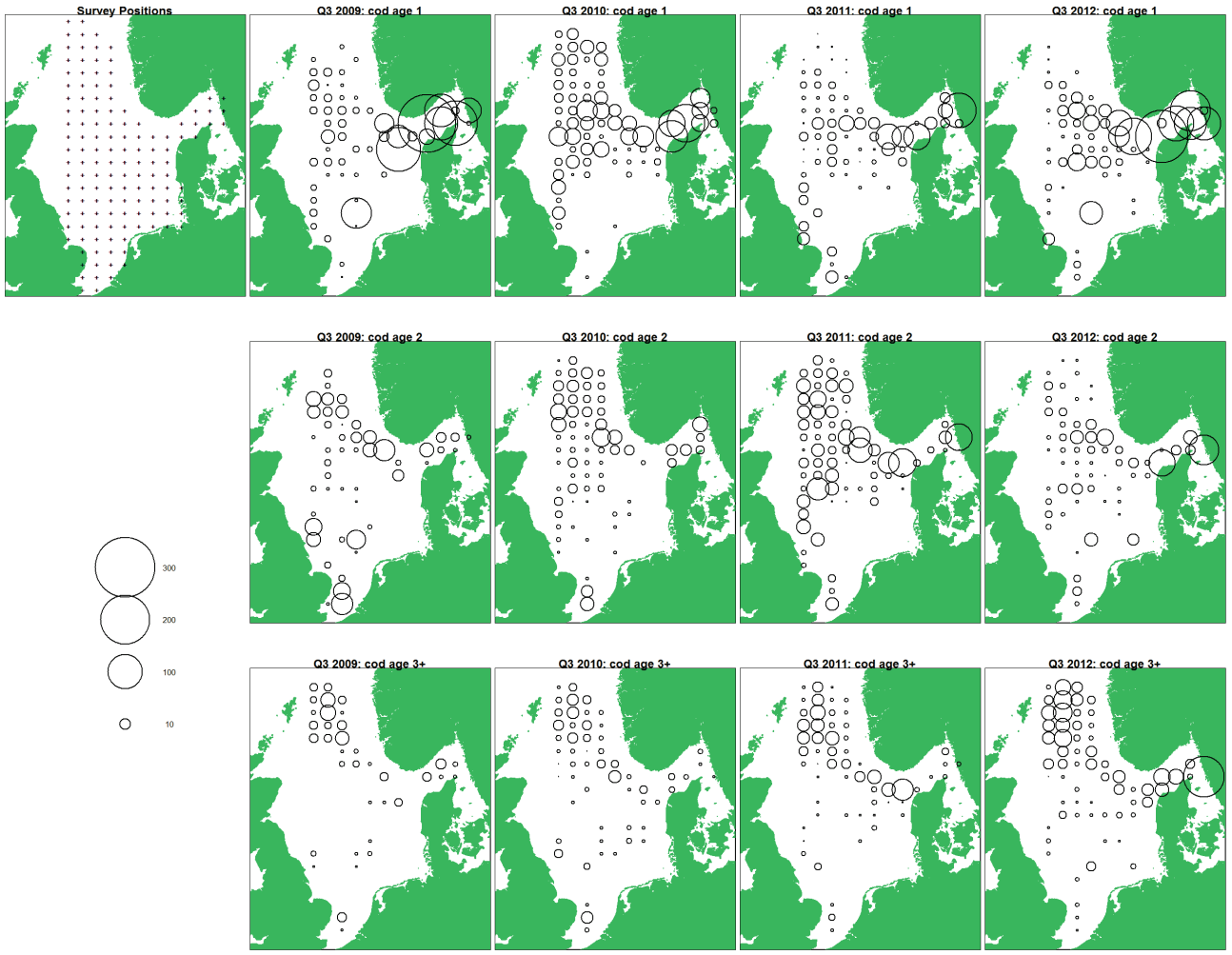


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1994-2012 in the North Sea.

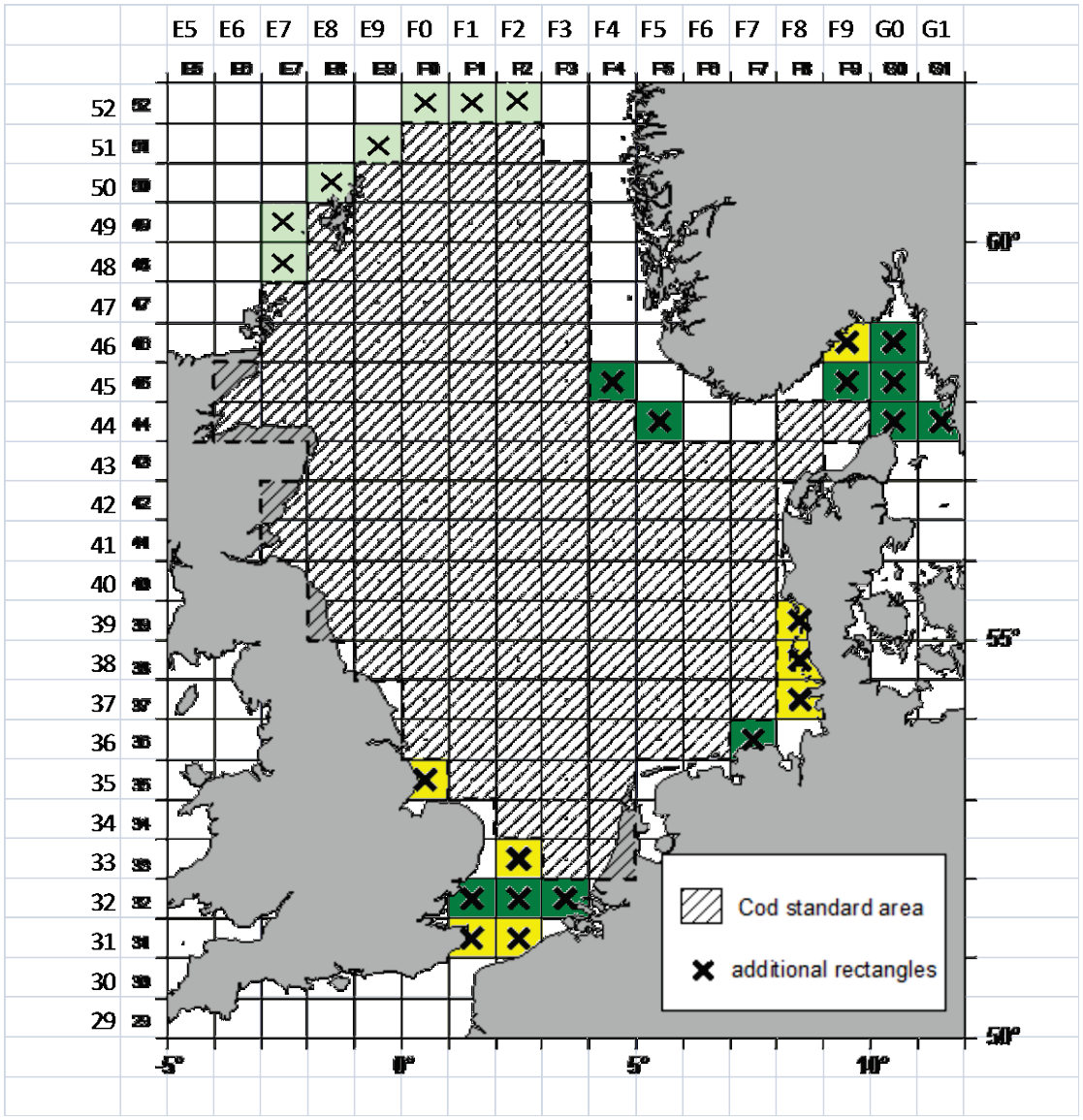


Figure 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Extension of cod standard area used for the revision of IBTS indices. Crosses indicate suggested extensions to the survey (ICES-WKROUND, 2009; ICES-WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate 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).

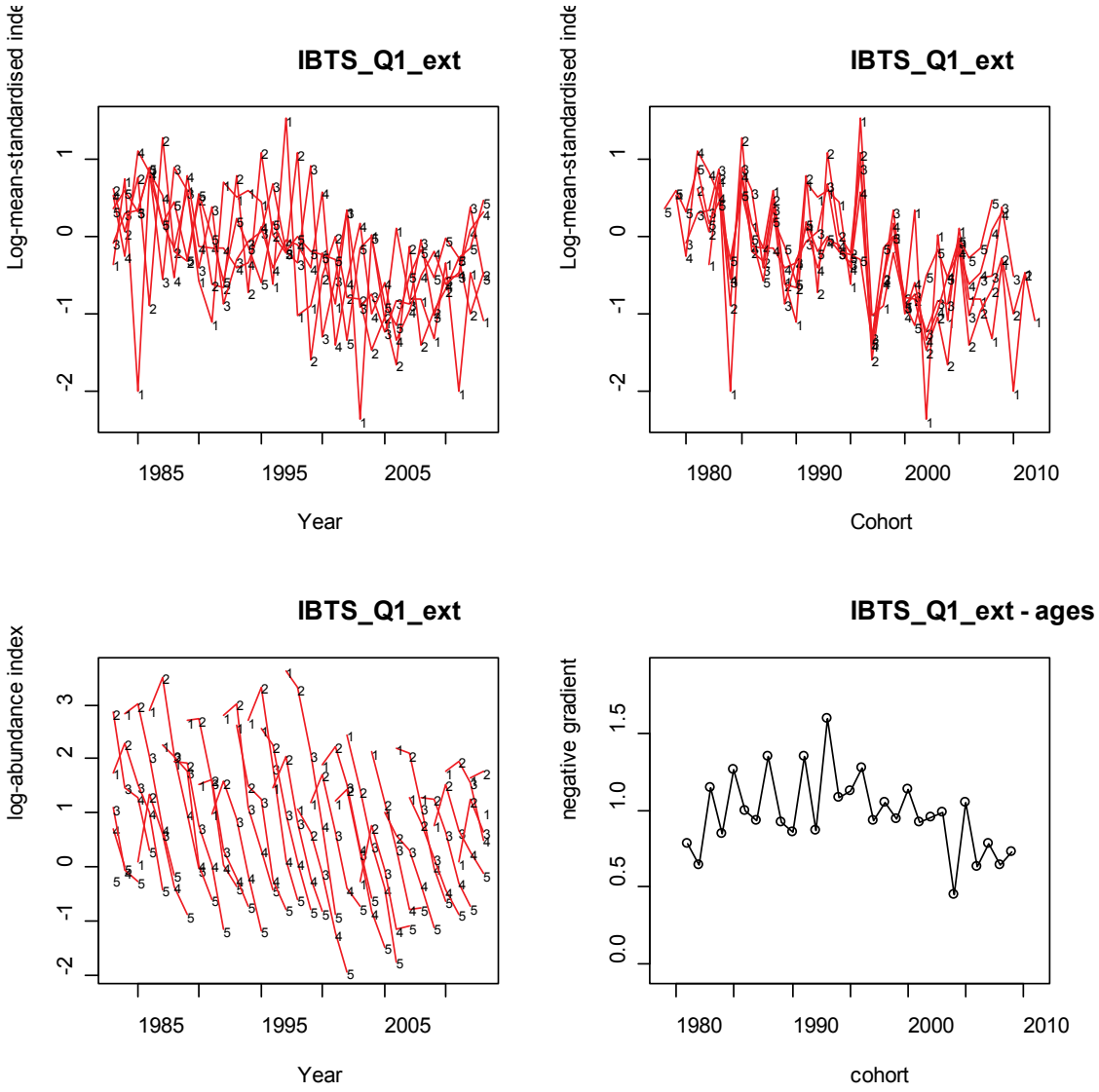


Figure 14.4a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ1 extended area groundfish survey.

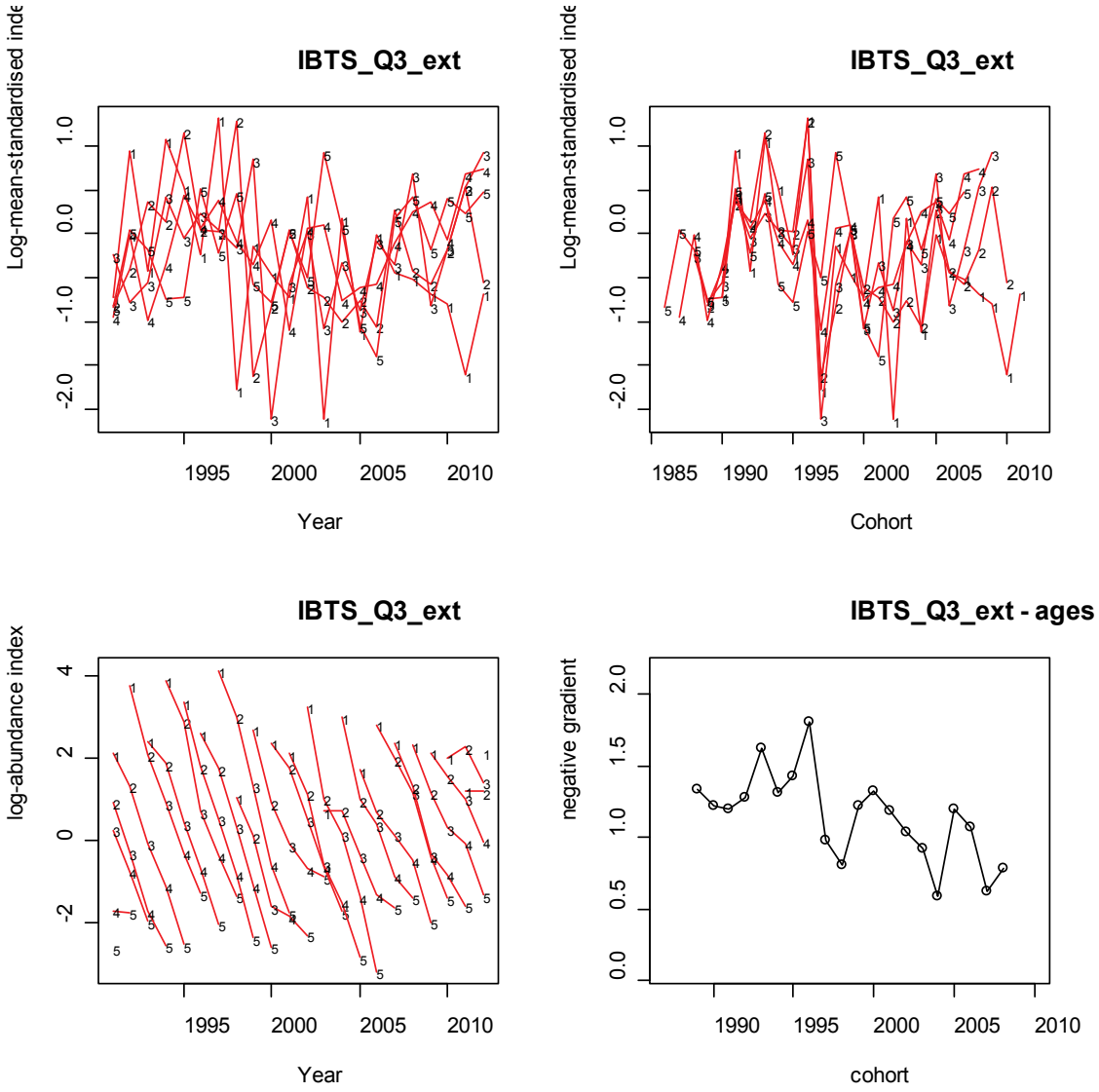


Figure 14.4b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ3 extended area groundfish survey.

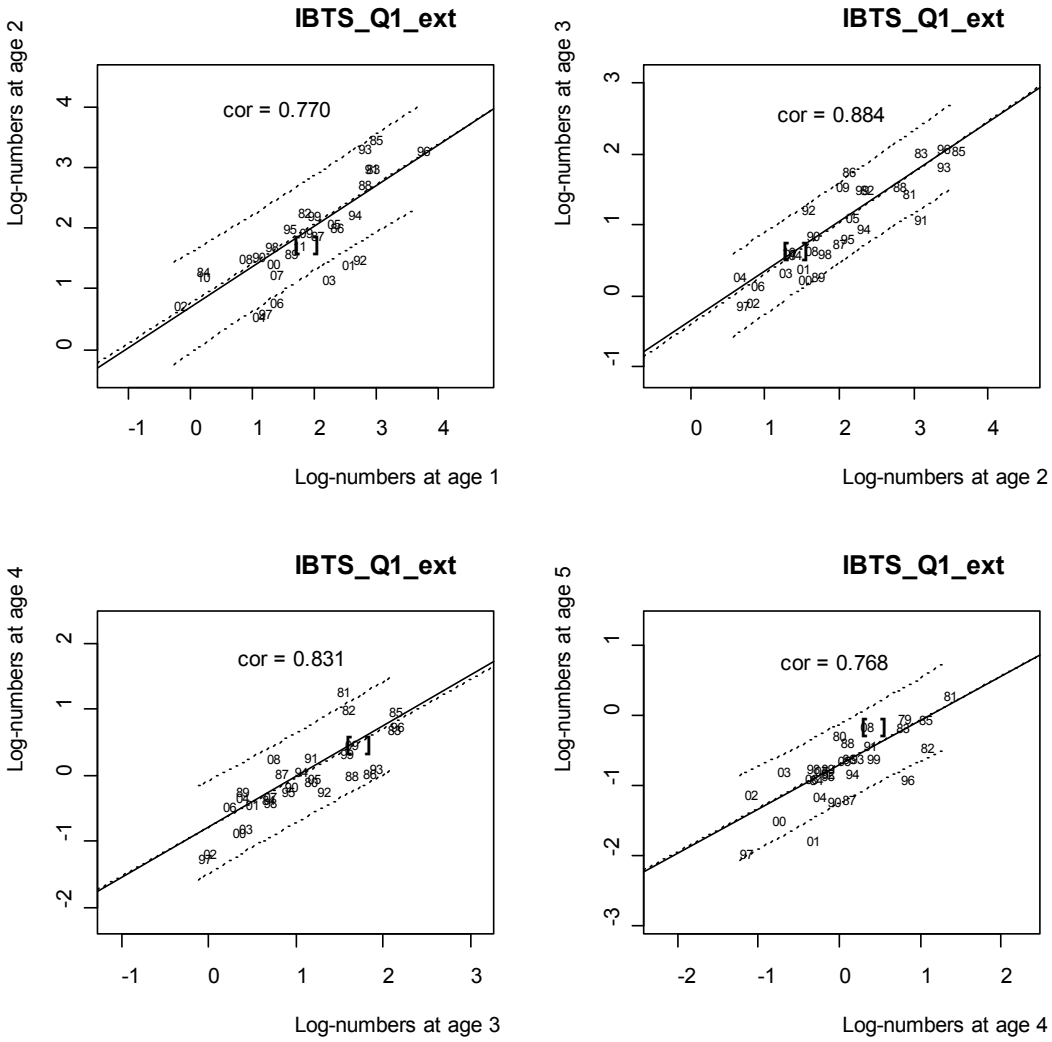


Figure 14.5a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ1 for the period 1983-2013. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

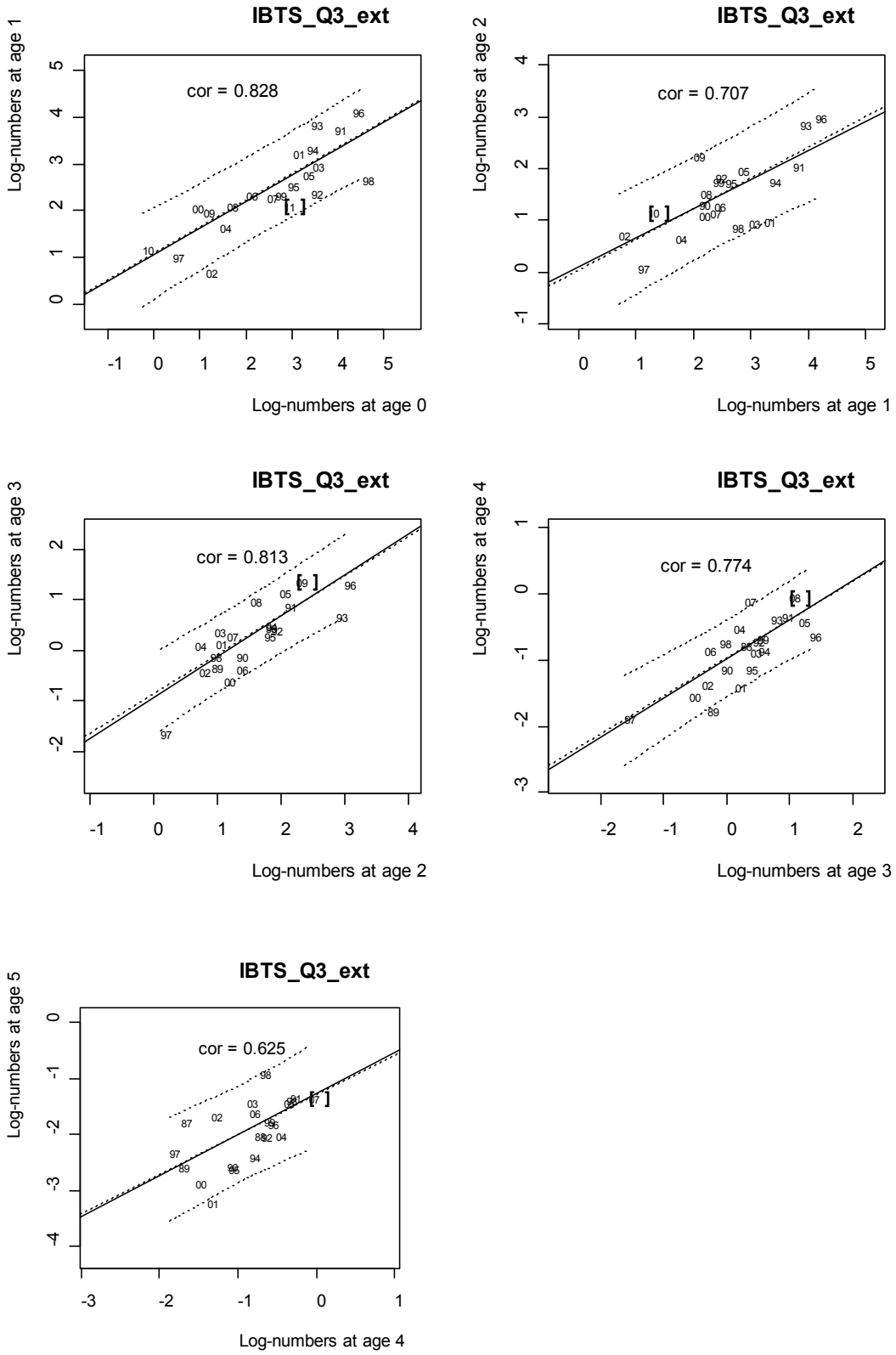


Figure 14.5b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ3 for the period 1991-2012. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

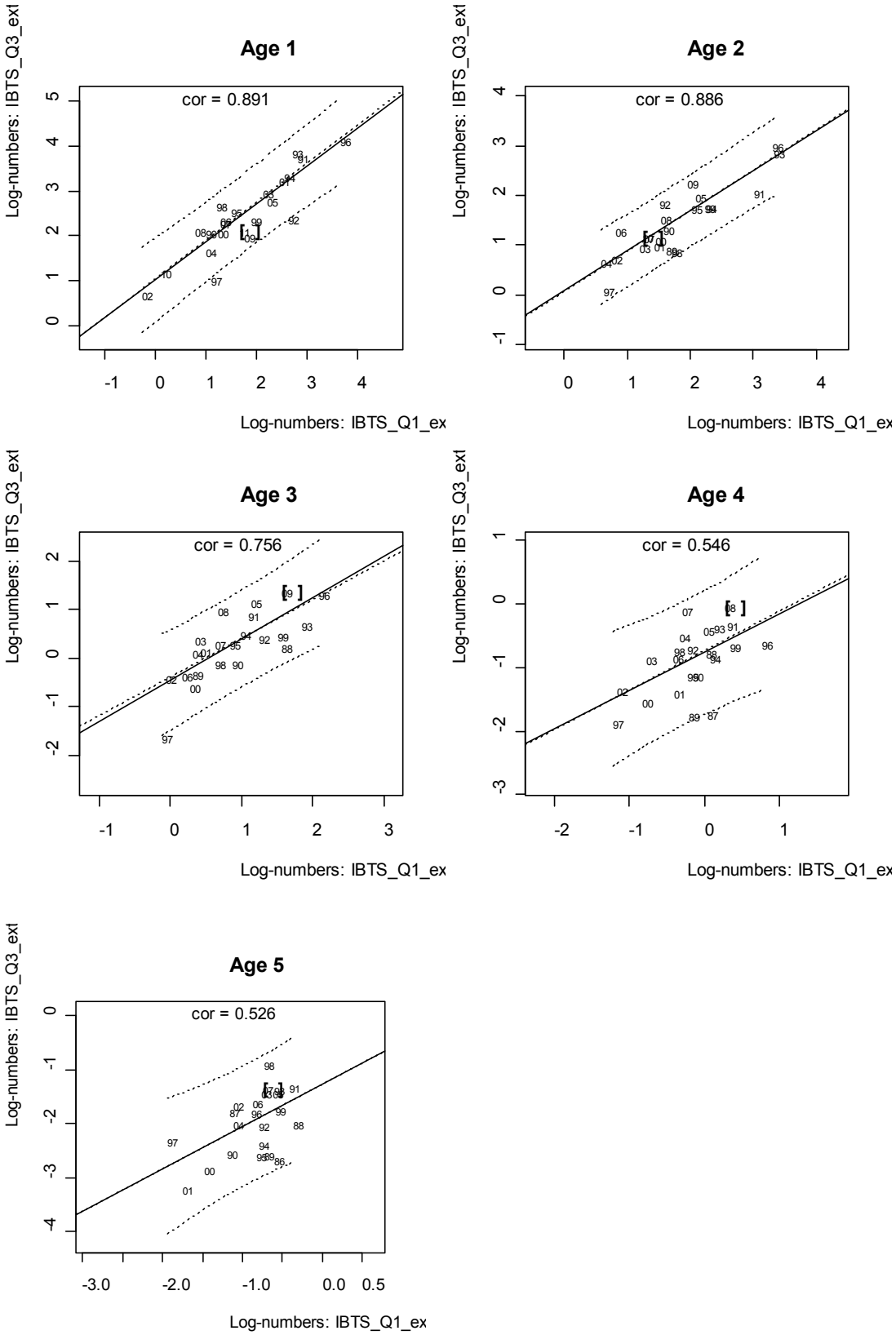


Figure 14.5c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Between-survey correlations for IBTSQ1 and Q3 surveys for the period 1991-2012. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear 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.

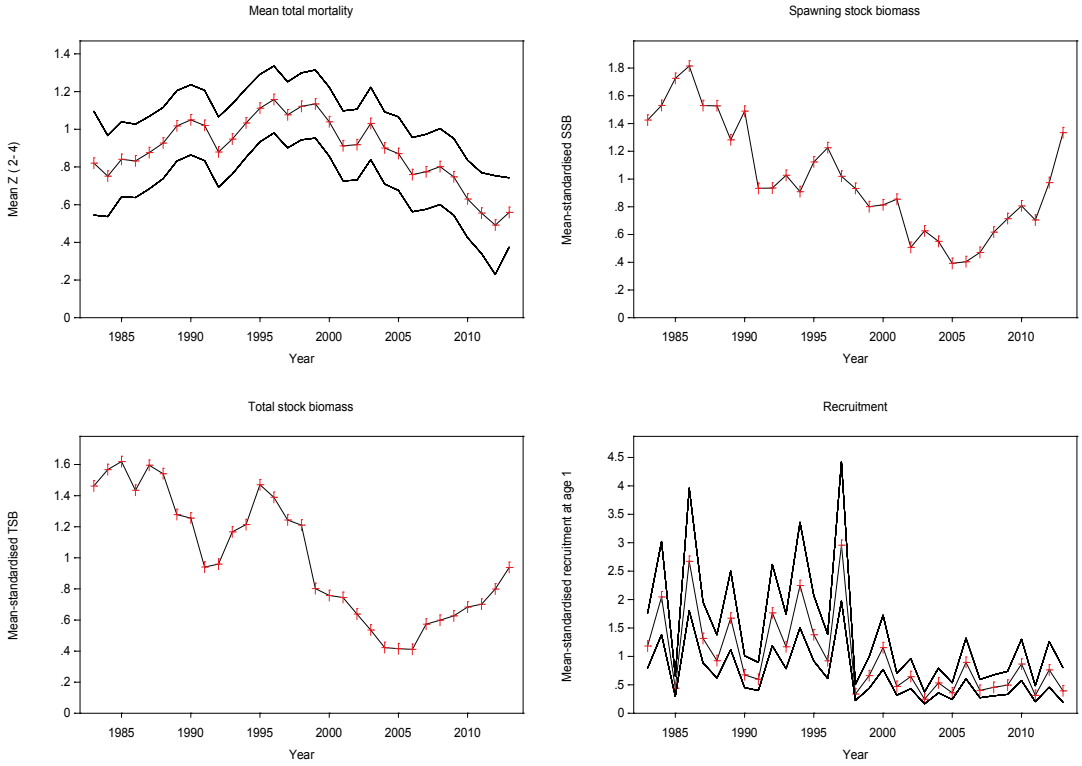


Figure 14.6 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Surba summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for the IBTSQ1 survey. The smoothing parameter λ is set to 2, and reference age at 3. Broken lines are 95% confidence bounds.

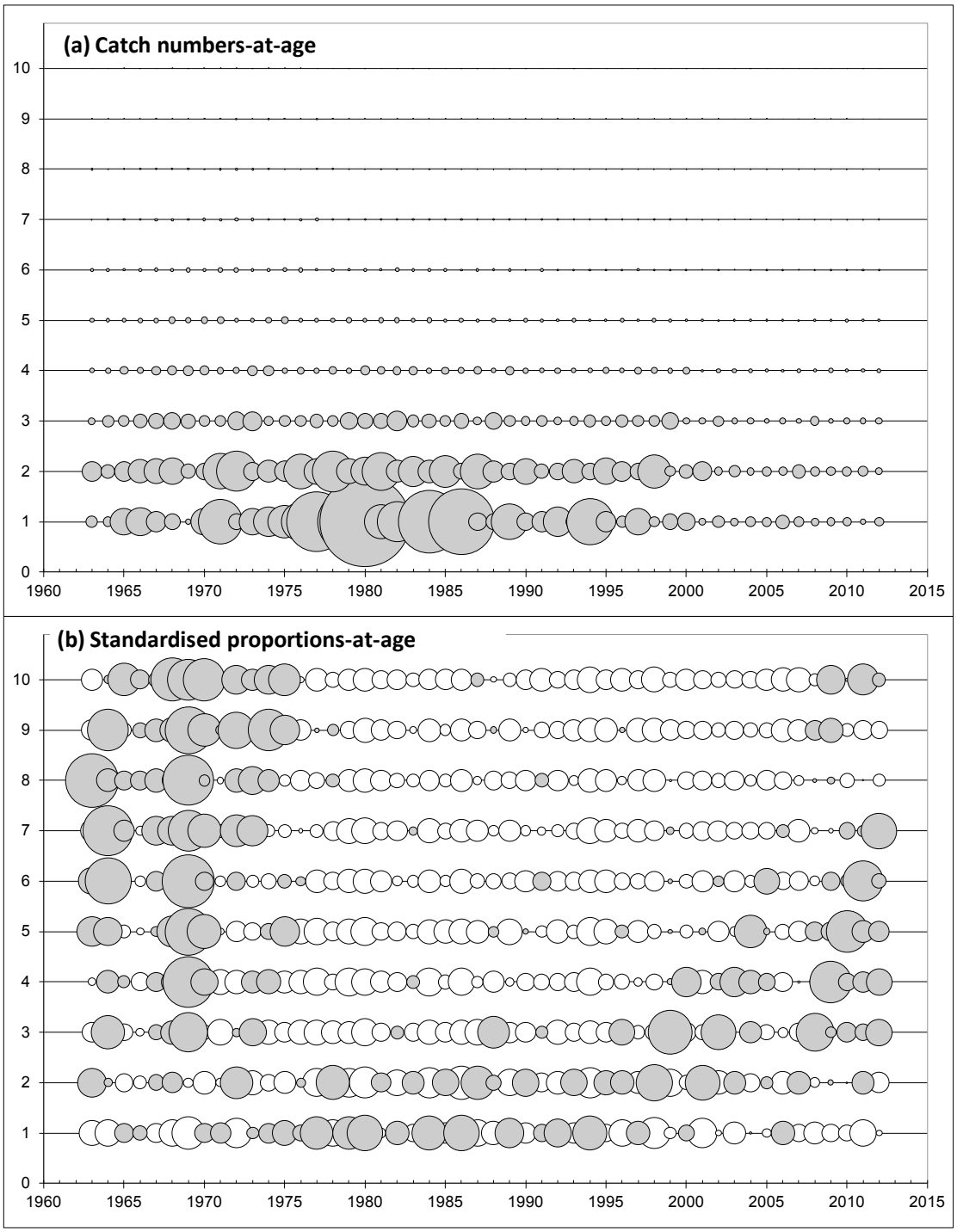


Figure 14.7 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

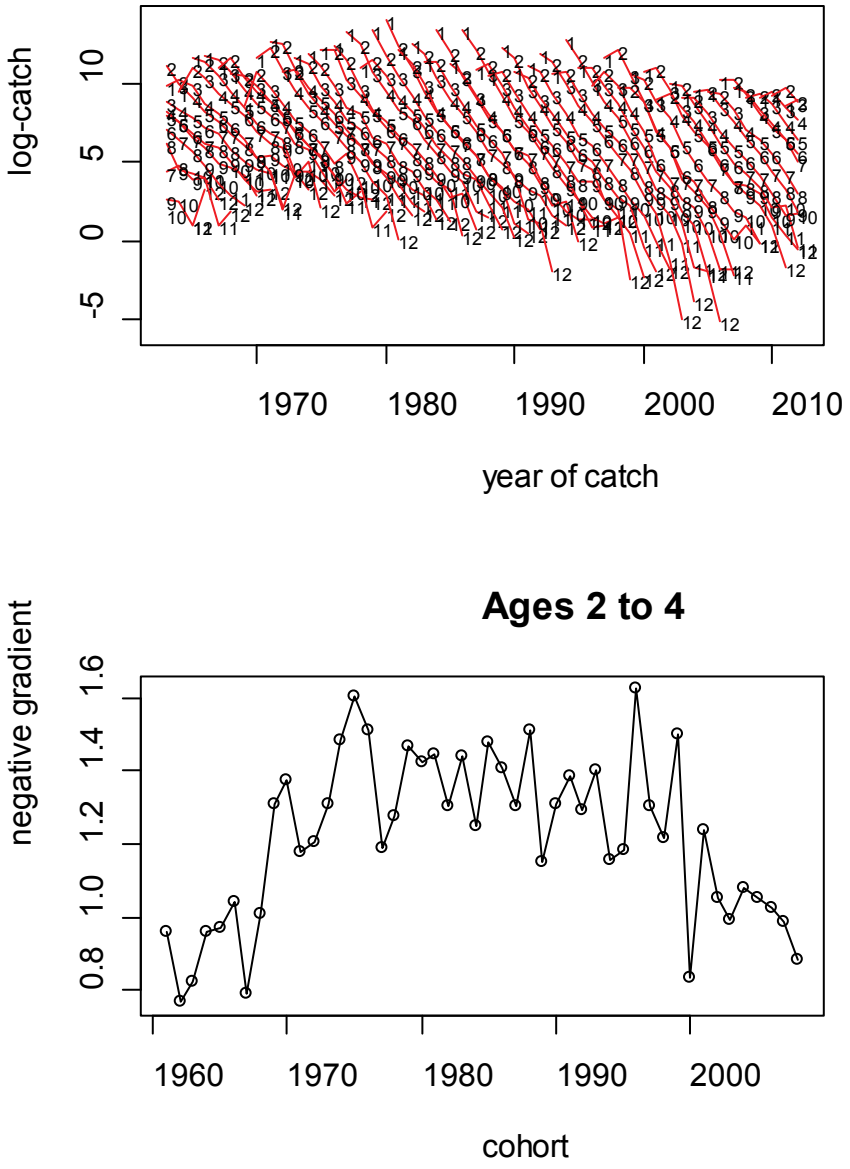
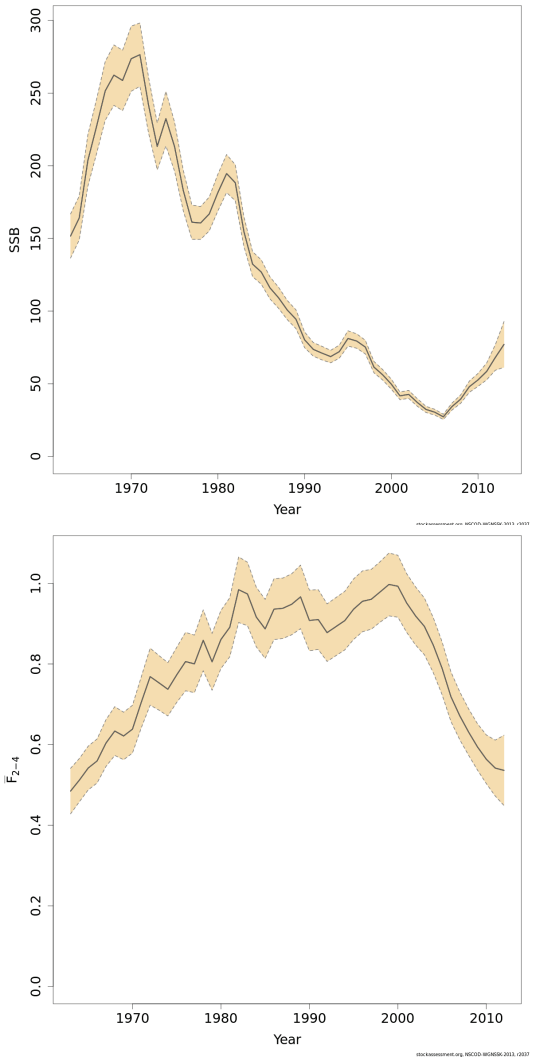


Figure 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2-4.


SSB
0
50
100
150
200
250
300
1970
1980
1990
2000
2010
Year
F_{2-4}
0.0
0.2
0.4
0.6
0.8
1.0
1970
1980
1990
2000
2010
Year

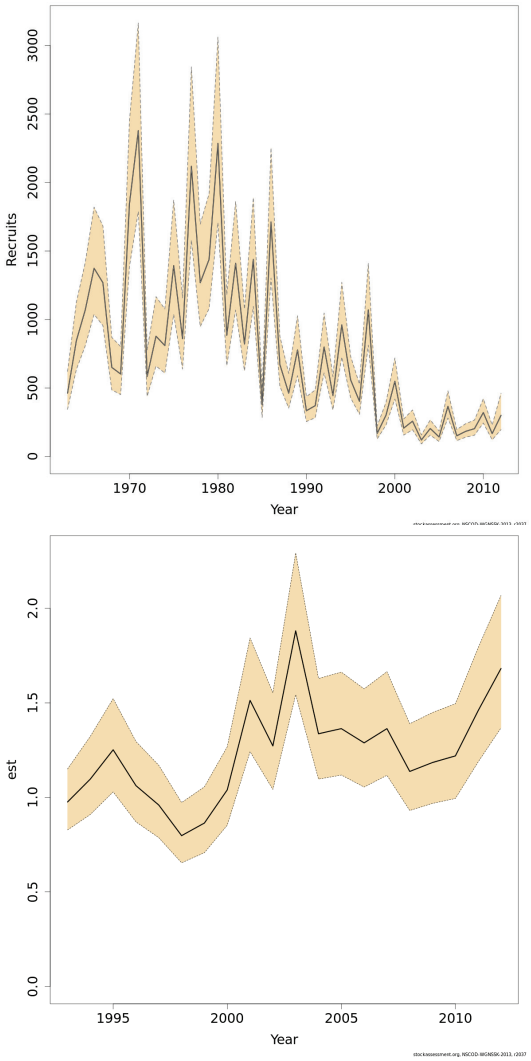
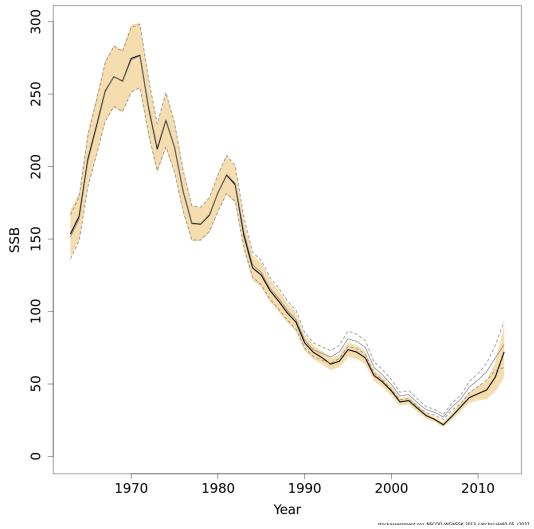
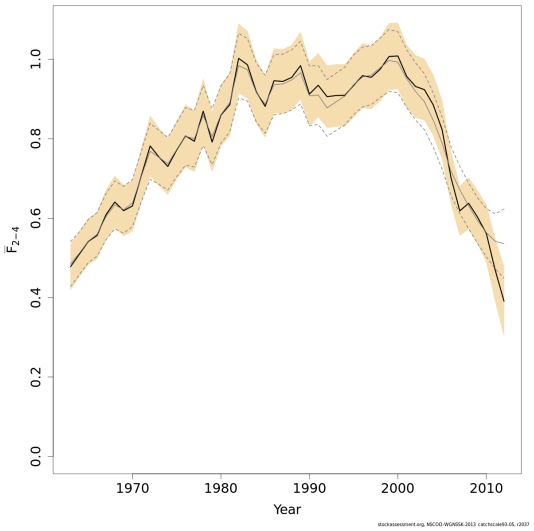


Figure 14.9a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM SPALY run (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The catch multiplier is estimated for all years from 1993 onwards.


SSB
0
50
100
150
200
250
300
1970
1980
1990
2000
2010
Year


F_{2-4}
0.0
0.2
0.4
0.6
0.8
1.0
1970
1980
1990
2000
2010
Year

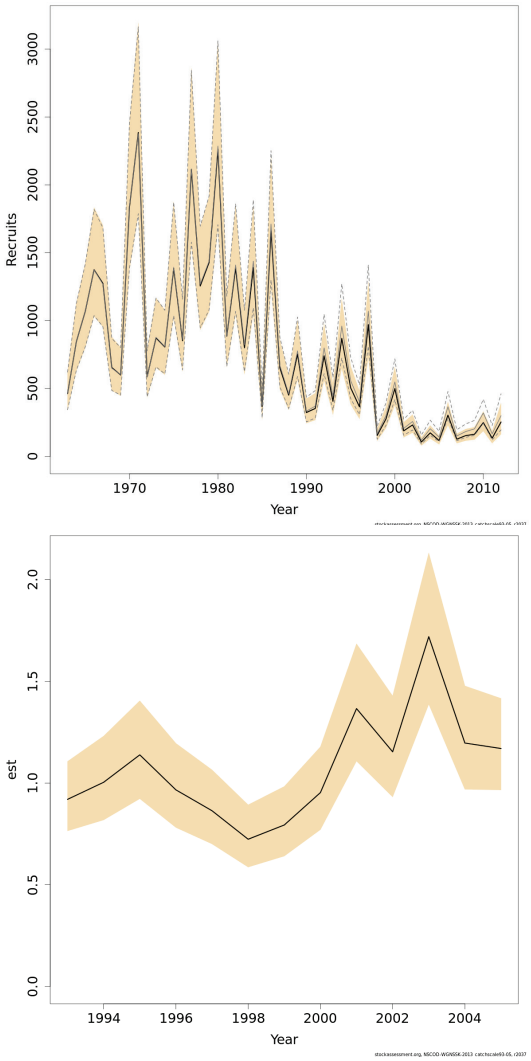


Figure 14.9b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from an alternative SAM run with the catch multiplier estimated for years 1993-2005 only (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals). The SPALY run is plotted in light grey for the SSB, F and recruitment plots for comparison.

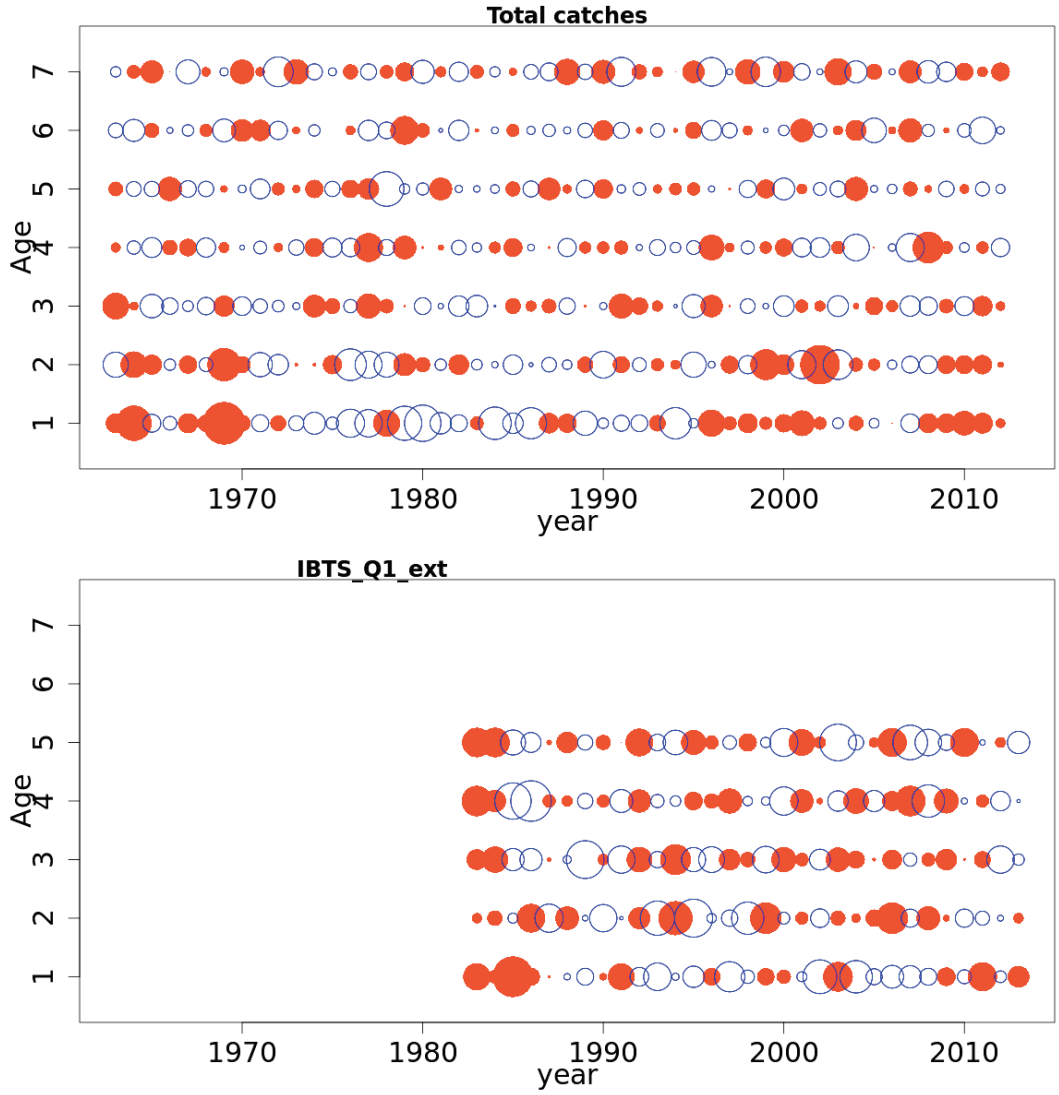


Figure 14.10a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the SAM SPALY run, for total catch and IBTSQ1. Empty circles indicate a positive residual and filled circles negative residual.

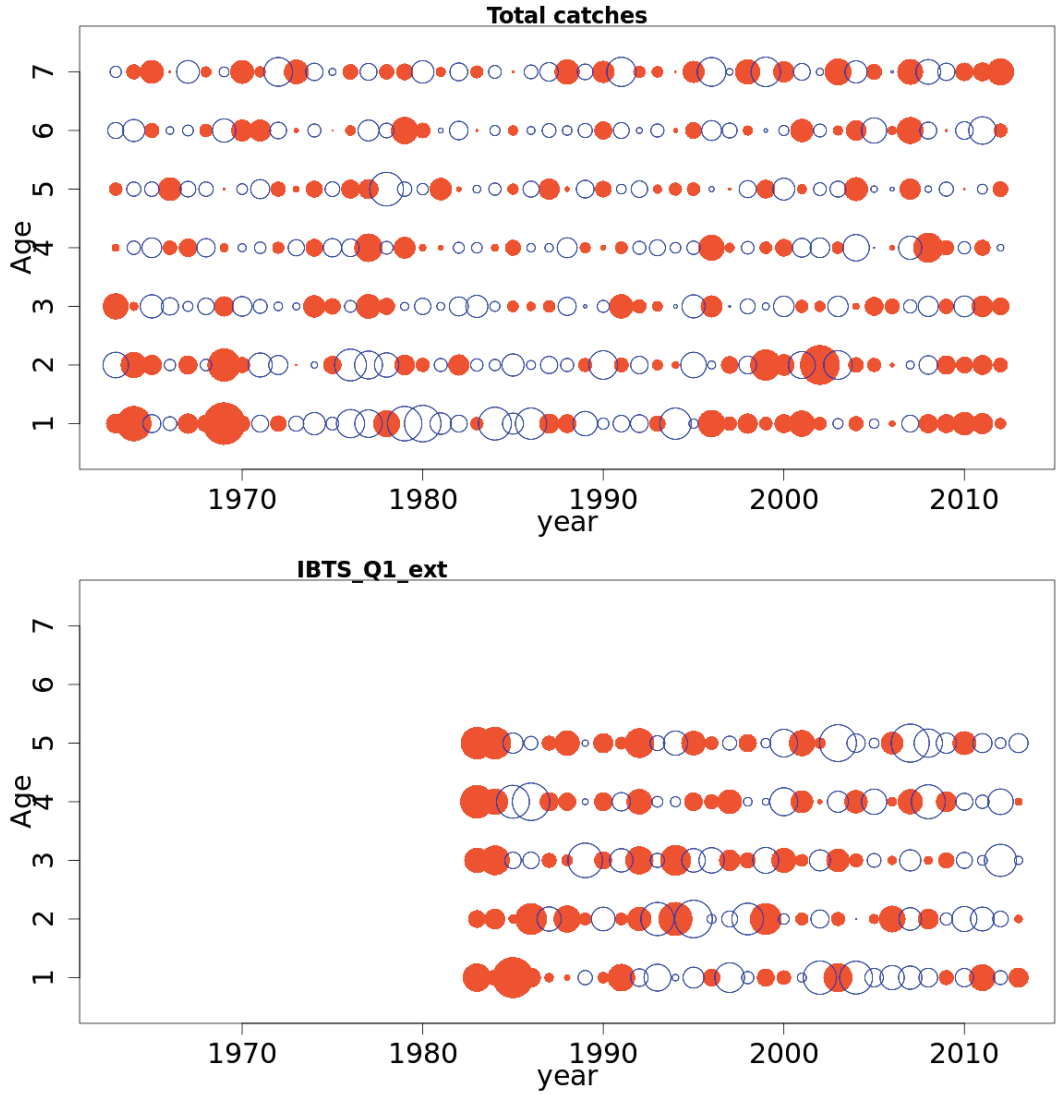


Figure 14.10b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the alternative SAM run (catch multiplier estimated for 1993-2005 only), for total catch and IBTSQ1. Empty circles indicate a positive residual and filled circles negative residual.

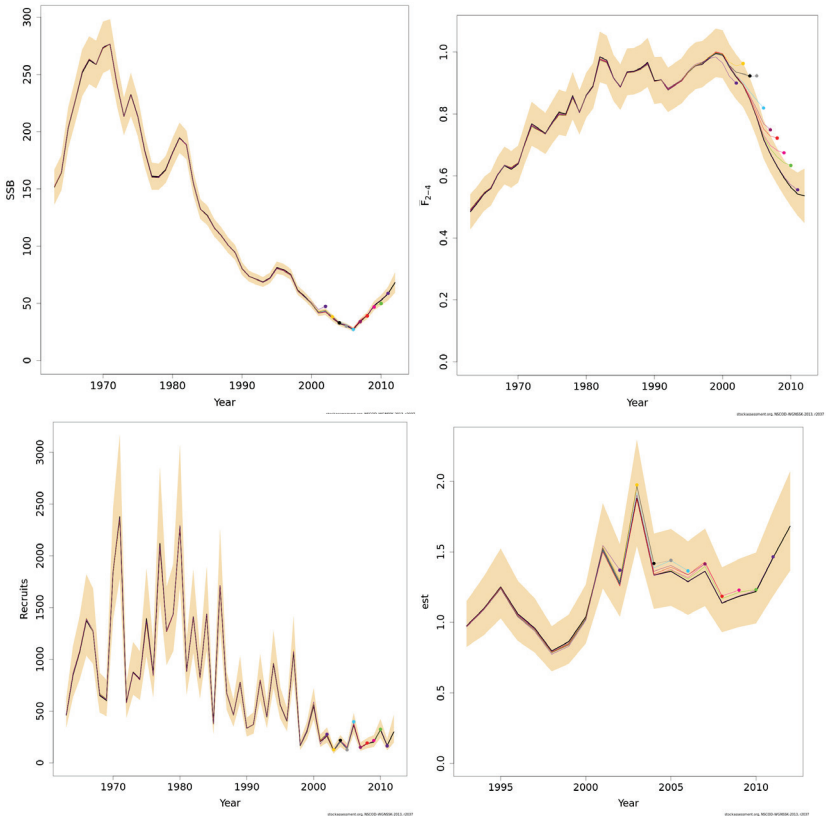


Figure 14.11a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Retrospective estimates (10 years) from the SAM SPALY run. Estimated yearly SSB (top-left), average fishing motality (top-right), recruitment age 1 (bottom-left) and catch multiplier (bottom-right), together with corresponding point-wise 95% confidence intervals.

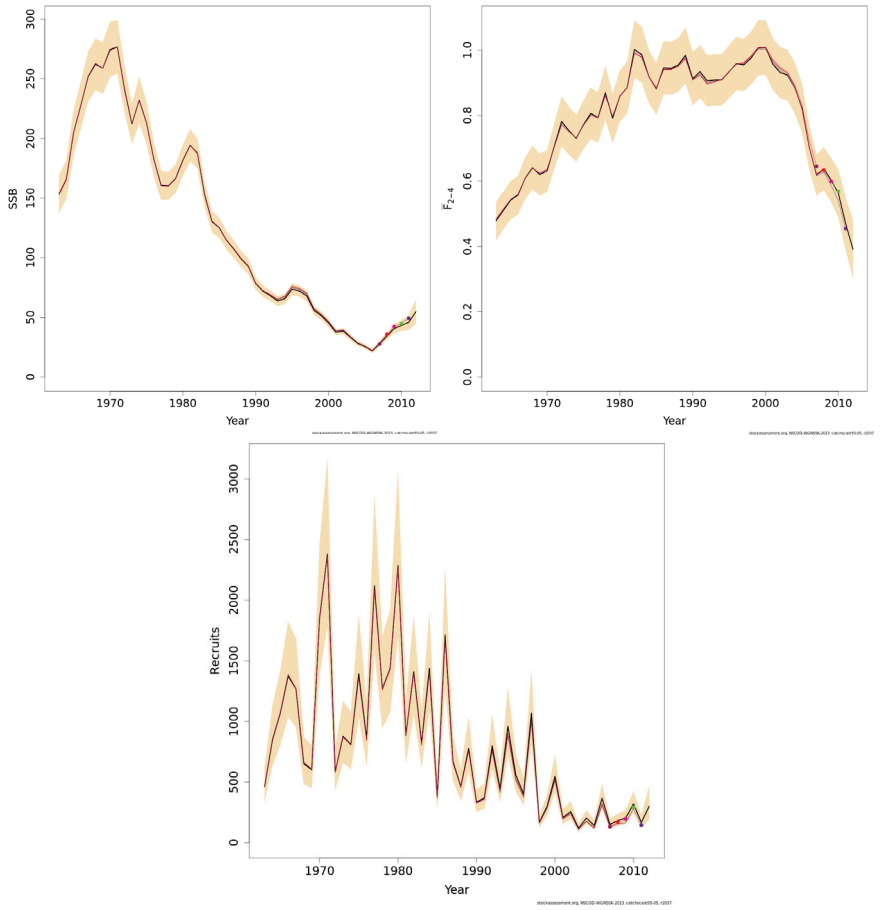


Figure 14.11b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Retrospective estimates (10 years) from the alternative SAM run (catch multiplier estimated for 1993-2005 only). Estimated yearly SSB (top-left), average fishing motality (top-right), and recruitment age 1 (bottom-left), together with corresponding point-wise 95% confidence intervals.

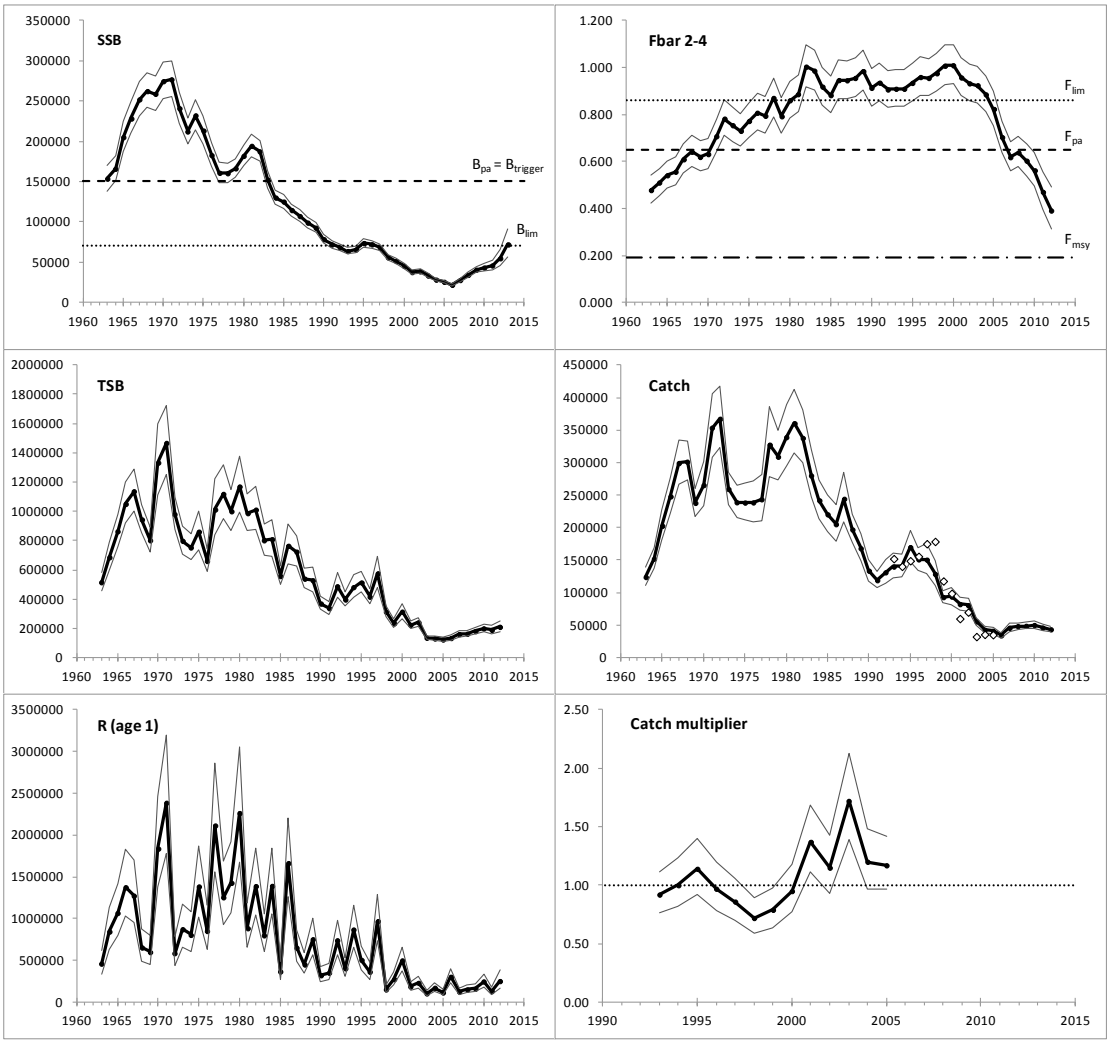


Figure 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Clockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2-4 (F(2-4)), 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.

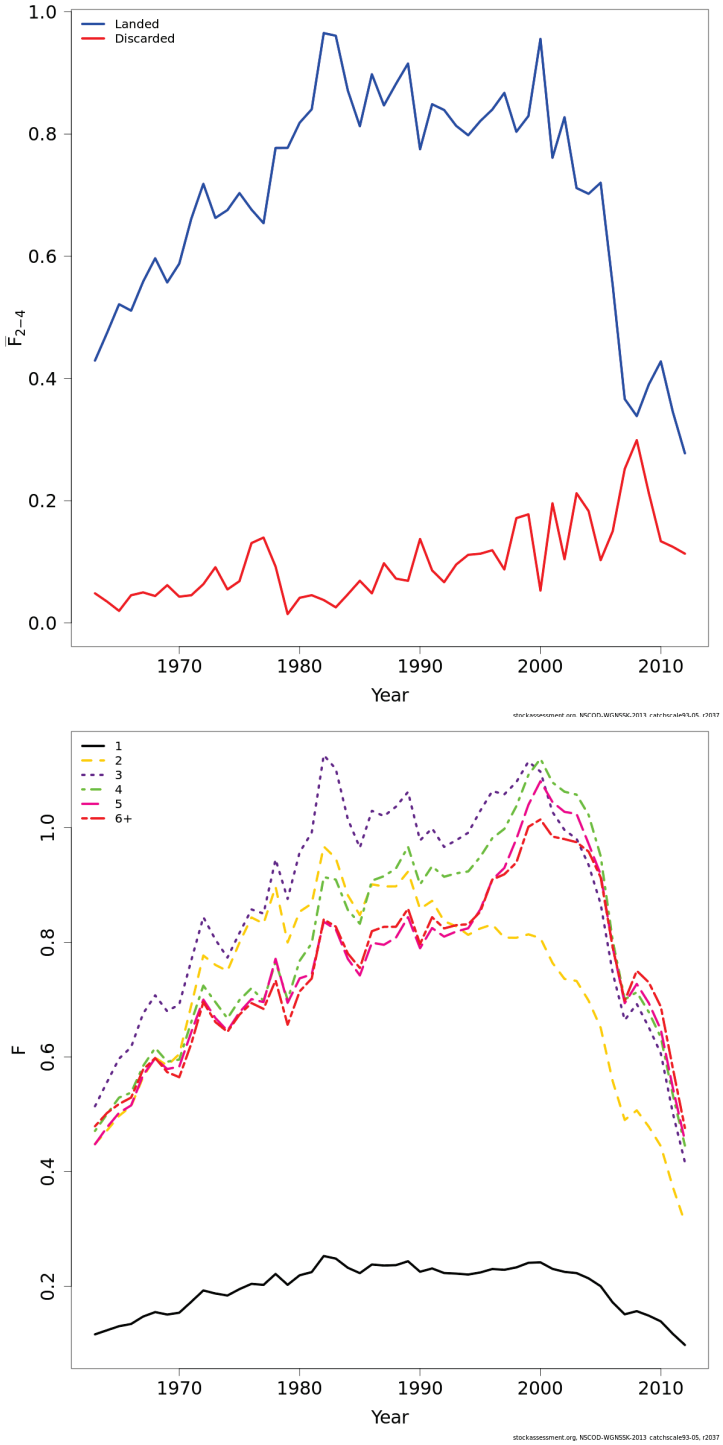


Figure 14.13 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM final run estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2-4 (shown in Figure 14.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

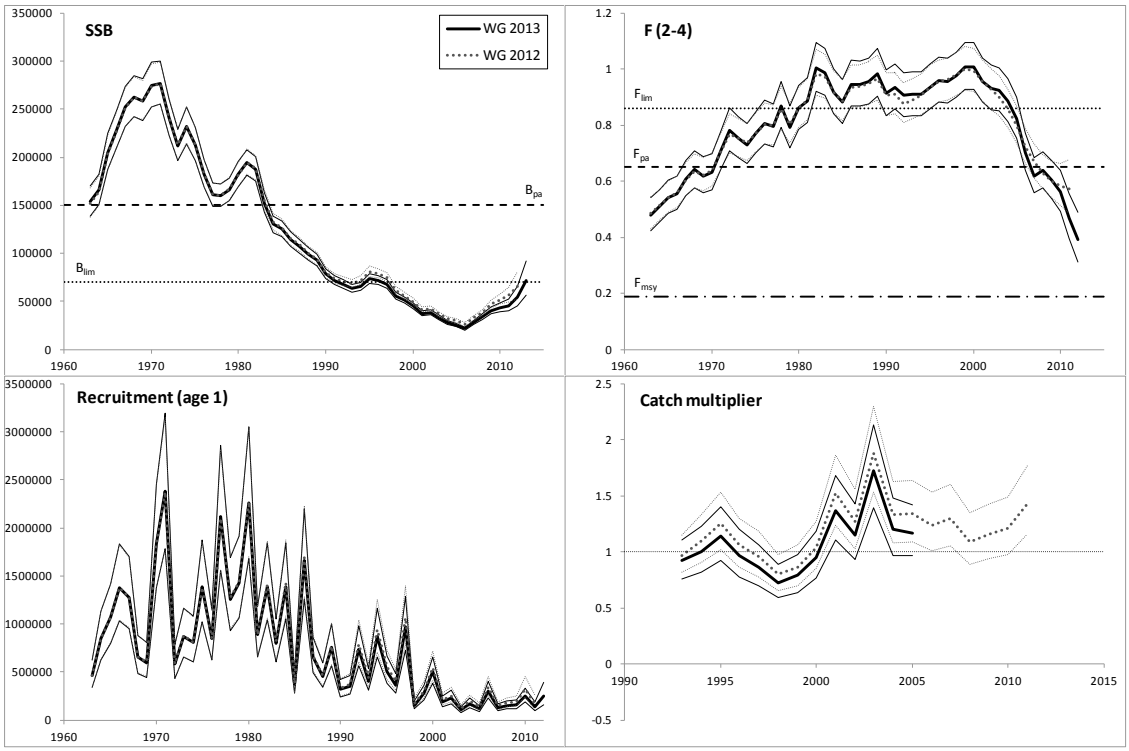
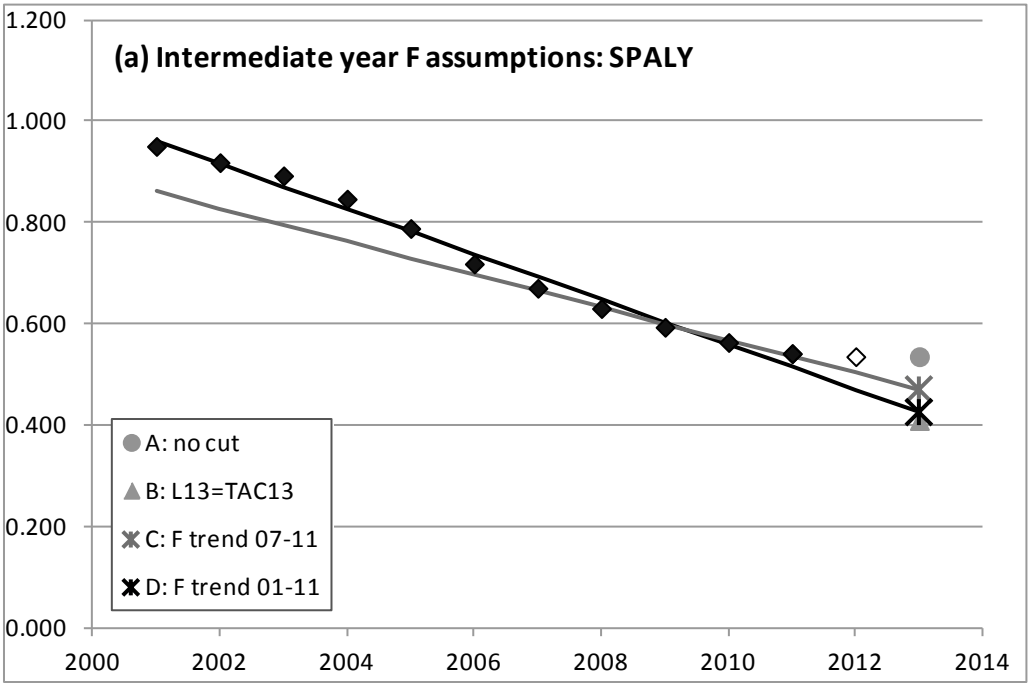


Figure 14.14 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Comparison of final SAM assessment for 2013 (estimating the catch multiplier for 1993-2005 only) with the final SAM assessment for 2012 (estimating the catch multiplier from 1993 onwards). Plots are as described in Figure 14.12.



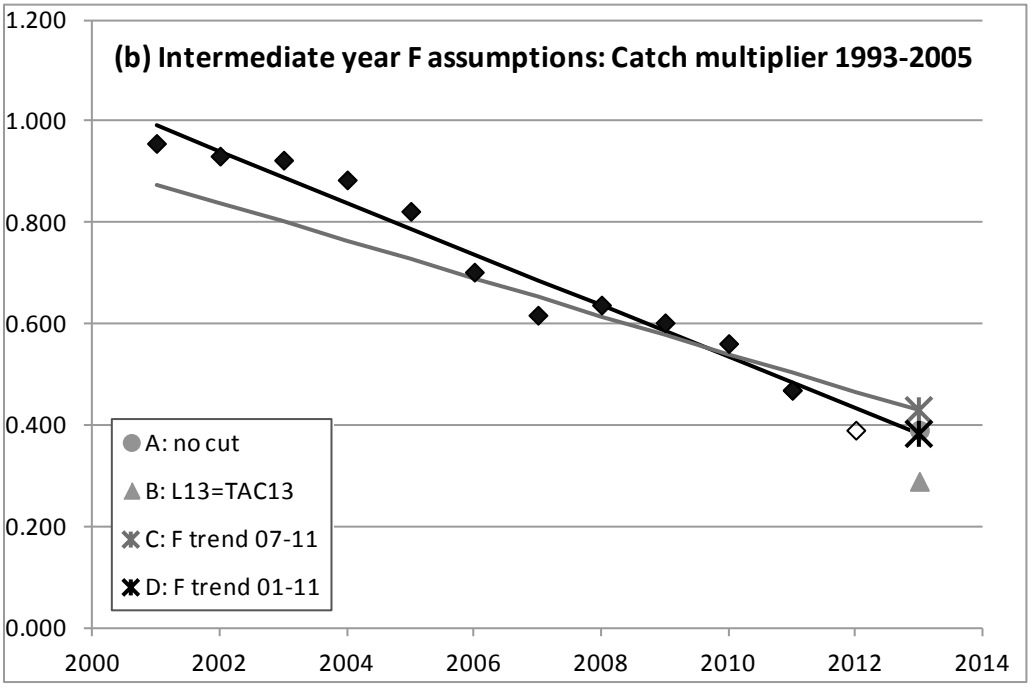


Figure 14.15 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Intermediate year F(2-4) options (relative to F in 2012) for the stochastic projections, corresponding to the Catch Options table (Table 14.12a) associated with (a) the SAM SPALY run and (b) the SAM final run (catch multiplier estimated for 1993-2005 only). A: no cut in F; B: Landings in 2013 correspond to the TAC set for 2013; C: extrapolate from the trend in F over 2007-2011; D: extrapolate from the trend in F over 2001-2011. For (a) options A-C are presented, while for (b) only options A and B are presented (see text for details). Option D was similar to others, and was therefore not considered further.

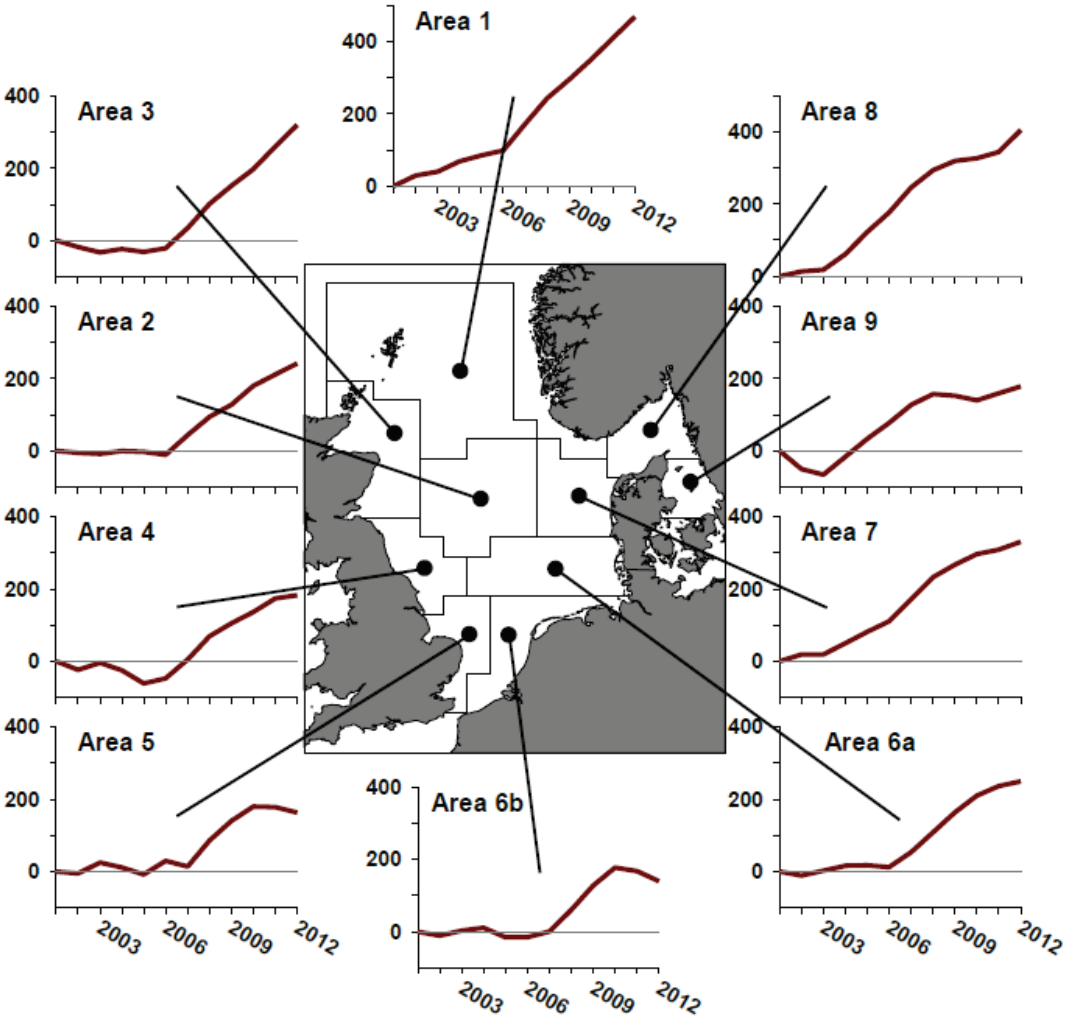


Figure 14.16 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. The North Sea Stock Survey fishers perception of the change abundance of North Sea cod since 2003 (Napier 2012).

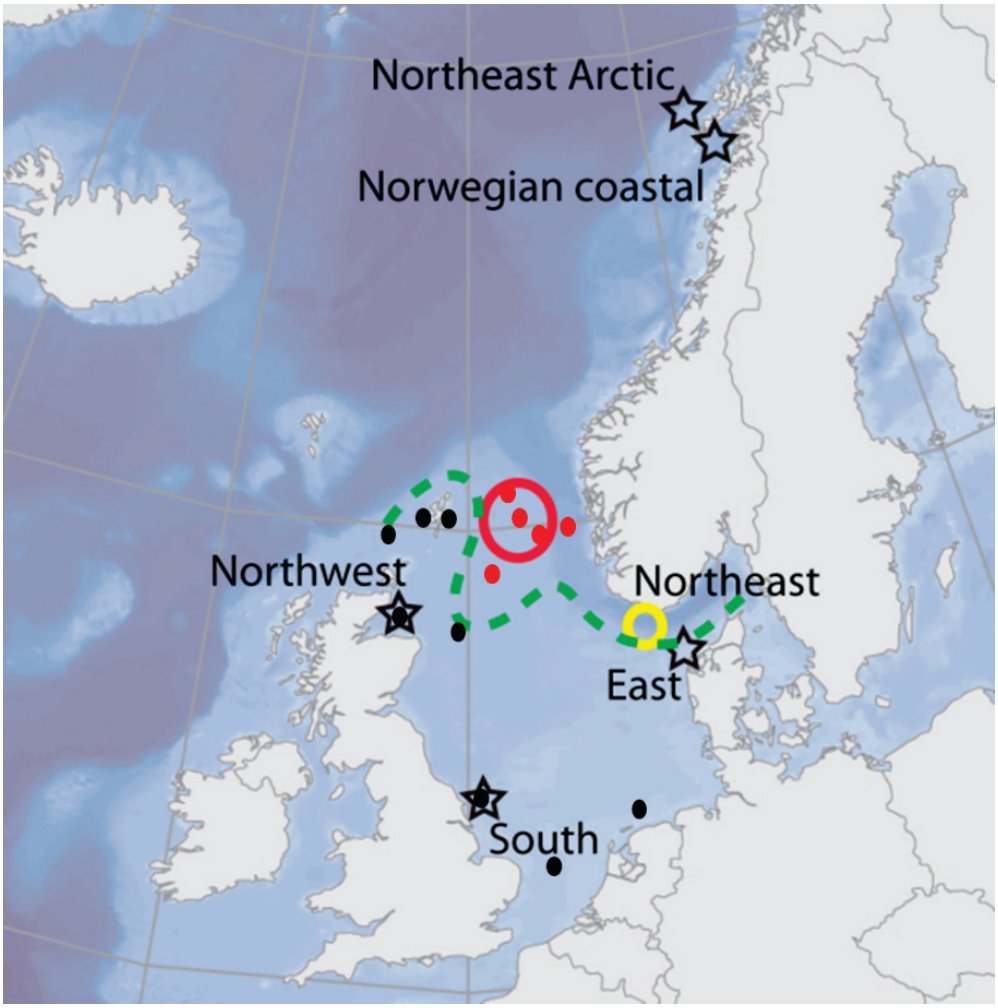


Figure 14.17 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Location of samples analysed for genetic variation. Red circle shows Viking Bank where Nielsen *et al*. (2009) identified a genetically unique population. Yellow circle represents the divergent population identified in Poulsen *et al*. (2011) and in the review by Hemmer-Hansen and Wright (WD ##). 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).

15 Pollack in the North Sea and Skagerrak (Subarea IV and Division IIIa)

15.1 General

15.1.1 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 35 cm, at 3 years of age and growth after age 3 is about 7 cm per year. Feeding is mainly on fish, and incidentally on crustaceans and cephalopods.

15.1.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012a) 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.

15.1.3 ICES Advice of 2013

The information in this section is taken from the Advice summary sheet 2013, section 6.4.20.

Advice for 2013 and 2014

The 2012 advice for this stock is biennial and valid for 2013 and 2014 (see ICES, 2012b): *Based on the ICES approach for data limited stocks, ICES advises that in Subarea IV catches should be no more than 1300 tonnes. In Division IIIa, there should be no directed fisheries and bycatch and discards should be minimised.*

The following information has been taken from ICES Advice 2012, section 6.4.32 (ICES, 2012b).

ICES approach to data limited stocks

For data limited stocks without information on abundance or exploitation ICES considers that a precautionary reduction of catches should be implemented, unless there is ancillary information clearly indicating that the current exploitation is appropriate for the stock.

For Pollack in this area two situations occur: for Subarea IV, insufficient information is available on abundance or exploitation. This implies that catches should decrease by 20% in relation to the last three years average catch, corresponding to catches of no more than 1300 t.

For Division IIIa, the abundance is estimated to be at the lowest in the time series. This implies that there should be no directed fisheries and bycatch and discards should be minimised in this Division.

15.2 Management

For IV and IIIa there are no formal TACs for pollack, but catches of pollack are 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.

15.3 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 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. However, trends in landings may not accurately reflect trends in stock abundance.

Landings by country for the years 1977–2012 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 between 1977 and 2012. Two periods with high landings at the end of the 1970s and beginning of the 1990s are visible. Since then, landings have declined in Division IIIa, but have remained fairly stable at approximately 400–500 t since 2000. Likewise in Subarea IV, landings have generally declined since the mid 1990s, with landings in 2012 being the lowest observed since 1977.

Swedish fishers targeted pollack from the 1940s until mid-1980s when landings sometimes amounted to over 1000 t. From the 1980s, pollack started to decline and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast. Currently, 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 64%, 12%, and 8% of the catches, respectively. In 2012, 90% of the landings were caught with gillnet and shrimp (*Pandalus*) trawls in Division IIIa; in Subarea IV, 67% of the catches were made with gillnets and 11% 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 included in the first step of the discard ban in the Skagerrak (Division IIIa) from 1 January 2013, which includes all fisheries except those using pots and traps.

Pollack is also often caught in recreational fisheries, but no data about these catches are known to the working group.

15.4 Survey data / recruit series

Pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat, catches were much higher in the 1970s. They are distributed mainly over the northwestern North Sea (along the Norwegian Deep) and into the Skagerrak-Kattegat (Figure 15.2). Time series of abundance (average number per hour) in the IBTS surveys are shown for Subarea IV and Division IIIa separately, for quarter 1 (from 1977 onwards) and quarter 3 (from 1991 onwards) (Figure 15.3). The catches are

small, and rather irregular, and although no strong patterns emerge in IV and IIIa, a declining trend in pollack abundance is detectable, especially in quarter 1 (Figure 15.3).

15.4.1 Biological sampling

Some biological data has been collected in Subarea IV and Division IIIa by Norway in the most recent years, but the data have not yet been processed.

15.4.2 Analysis of stock trends

For Division IIIa (Skagerrak and Kattegat), the trends in landings, supported by the IBTS survey trends, indicate a decline in the stock. Cardinale et al. (2012) analysed the spatial distribution and stock trends for the period 1906–2007, based on surveys and commercial catches, and showed a similar decline for the Skagerrak and Kattegat (Figure 15.4). The stock biomass of pollack is suggested to increase from 1940 to reach a peak in the late 1950s. Since then the biomass has shown a decrease to reach the current low level around 2000. In routine surveys, Pollack is caught in highly variable numbers, and trawl surveys are probably not very well suited for monitoring of this species.

The sum of evidence points to a substantial decline of pollack in the Skagerrak, and although no similar trend is seen in the North Sea, landings in 2012 were the lowest observed since 1977.

15.4.3 Data requirements

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 the Norwegian biological data from commercial catches should be processed.

15.5 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 2012a. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

ICES. 2012b. Pollack in Subarea IV and Division IIIa. *In* Report of the ICES Advisory Committee, 2012. ICES Advice, 2012. Book 6, Section 6.4.32.

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

Table 15.2. Pollack. Landings by country in Subarea IV as officially reported to ICES.

	ICES Subarea IV										
	Belgiu.	Denmark	Faeroe.	France	German.	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	299		NA	73	0	743		63	481	1671
2012	17	123		3	83	1	430		42	443	1140

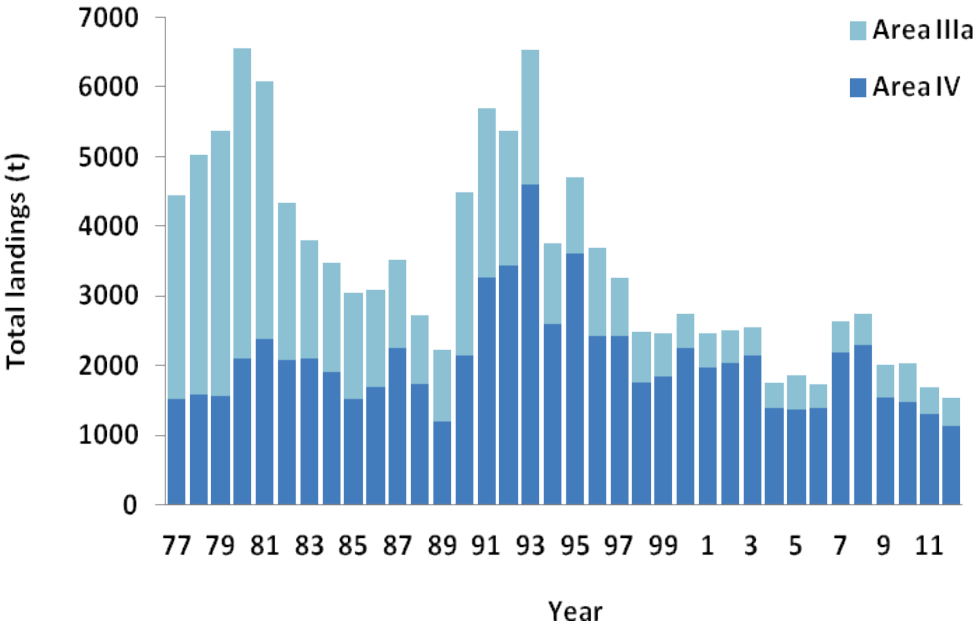


Figure 15.1. Pollack in Division IIIa and Subarea IV. Total landings of pollack as officially reported to ICES.

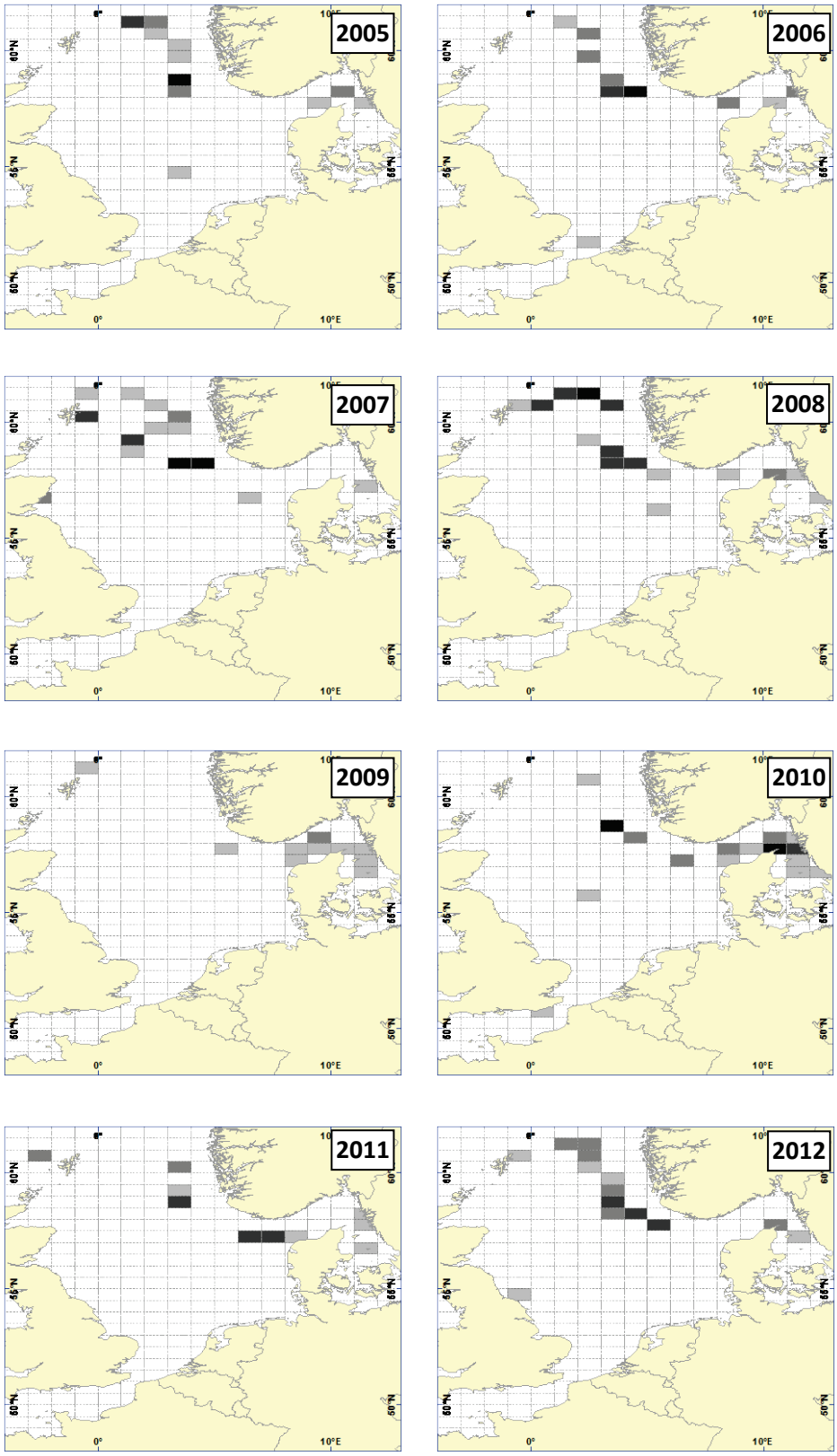


Figure 15.2. Pollack in Division IIIa and Subarea IV. Distribution of pollack based on NS-IBTS data (in DATRAS) for both quarters 1 and 3, expressed as average number per hour caught in the GOV-trawl.

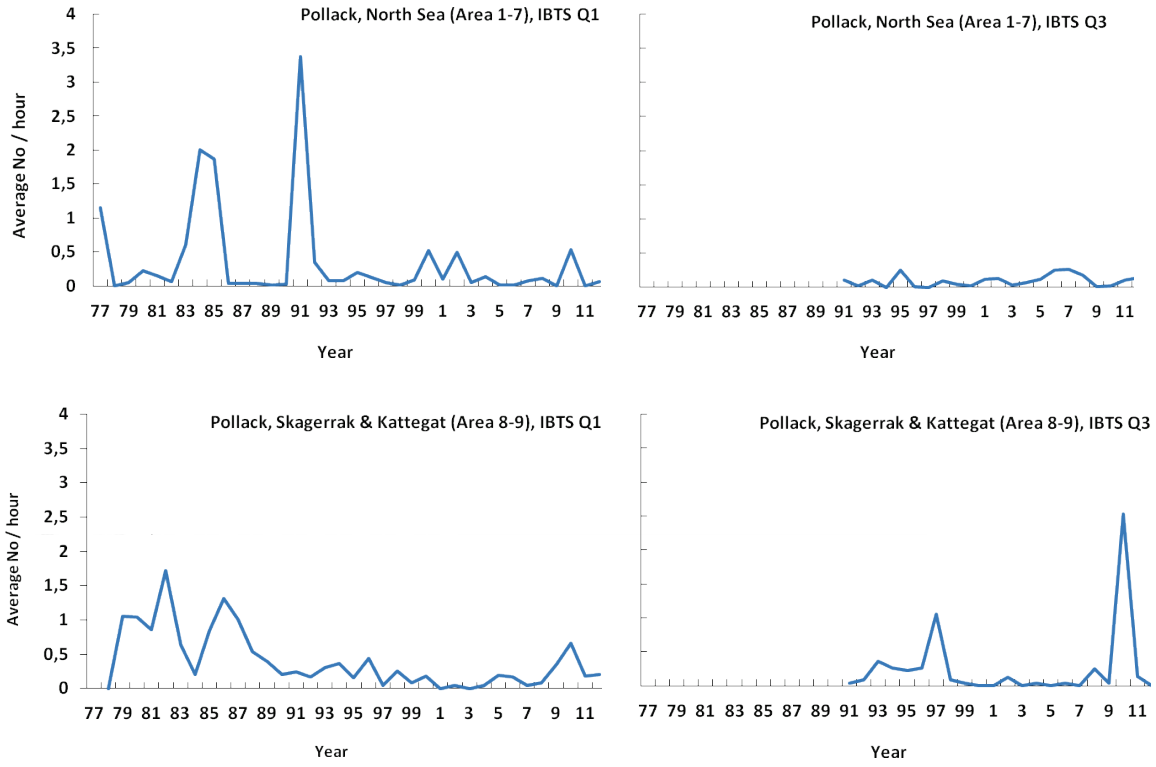


Figure 15.3. Pollack in Subarea IV and Division IIIa. Time series of abundance of pollack in the IBTS survey in the North Sea (roundfish areas 1-7) and in Skagerrak/Kattegat (roundfish areas 8 and 9), shown as number caught per hour with the GOV-trawl. Data from Datras.

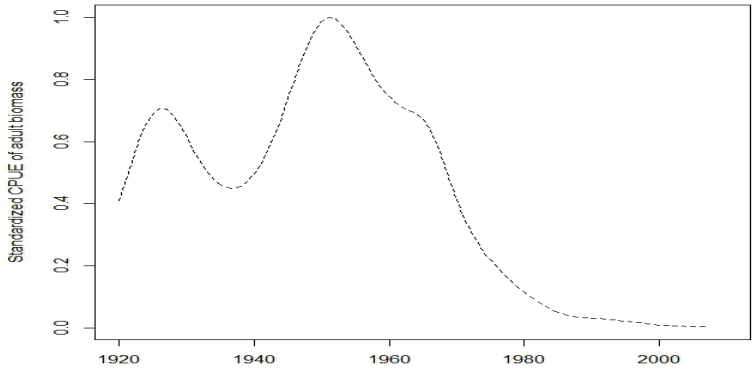


Figure 15.4. Pollack in Subarea IV and Division IIIa. Biomass trend of pollack in Division IIIa since 1920 (modified from Cardinale *et al.* 2012).

16 Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)

16.1 General biology

The existing knowledge of grey gurnard general biology is available in the stock annex. The here provided information is from the WGNEW 2012 report (ICES, 2012) complemented with a section on ecosystem considerations specific to the North Sea ecoregion.

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.

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.

16.2 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).

16.3 Management regulations

There is no minimum landing size for this species and there is no TAC.

16.4 Fisheries data

16.4.1 Historical landings

Historically, grey gurnard is taken as a by-catch 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 larger part of the catch appears to be discarded (see also stock Annex). Owing to the low commercial value of this species, landings data will usually not reflect the actual catches very well.

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. However, in recent years the official statistics seem to improve gradually. Since the early 1980s specific landings data for grey gurnard are available from the catch statistics. Before, these data occurred only sporadically in the statistics (Figure 16). Exceptionally high annual landings were reported during the late 1980s to early 1990s with a maximum of 46 598 t in 1987 (Table 16.1) because of Danish landings for reduction purposes (Figure 16.1a). After this peak the Danish landings dropped again to a low level. Recent international landings have been low at around 300 to 500 t per year. The average 2000-2012 is at 356 t (Figure 16.1b).

16.4.2 Discards

In Table 16.2 the numbers per hour of discarded grey gurnard in Dutch bottom-trawl fisheries in North Sea and Eastern Channel are shown for 2006-2010. The rates are highly variable.

16.5 Survey data / recruit series

For the North Sea and Skagerrak/Kattegat, data are available from the International Bottom Trawl survey. The IBTS-Q1 and 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 16.3 and 16.4). 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 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).

A time series of abundance index of grey gurnard in the IBTS-Q1 survey has shown a strong increase pattern from the beginning of 90's (Figure 16.5).

IBTS-Q3 series shows the same strong increase of the index during the 90's and stabilized at high level since then (figure 16.6).

The length distributions index presented in the WGNEW2010 Report have not been updated and are now in the stock annex. They showed that a bi modal structure occured in Skagerrak and Kattegat (IIIa) which was not observed in North Sea where smaller fish were only found in relatively small numbers.

16.6 Biological sampling

Biological data for this species are still scarce (see also the stock annex). In North Sea, individual data have been collected during the 2010 IBTS-Q1 survey.

An ALK from otoliths collected 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 16.7).

A maturity length key of Grey gurnard sampled shows that above 19-20 cm almost all the individuals can be considered mature (Figure 16.8). The sampling was not carried out during the spawning which takes place in spring and summer.

Both of these two datasets suggest that grey gurnard is early maturing in North Sea and a certain proportion of fish at age 1 are mature.

16.7 Population biological parameters and other research

The information delivered at the WGNEW 2010 is now in the stock annex.

16.8 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.

The time series based on catches from the IBTS survey in the North Sea and in Skagerrak-Kattegat both show an increase since the late 1980s

16.9 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 and also because there is some indication that this species is highly discarded.

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.

Availability of the time series of UK (Scotland) and Irish surveys abundance index of grey gurnard should give more information on the population in areas covered by these surveys. For a better understanding of this species an increase in our knowledge of biological parameters is required.

From the information presented here, it can be concluded that grey gurnard is currently of very limited commercial interest excepted in North Sea.

In the context of ecosystem considerations, it would be useful to obtain more information on age composition of the stock and its diet composition.

16.10 Ecosystem considerations

Grey gurnard is considered a predator on a number of commercially important demersal stocks (cod, whiting, haddock, sandeel, Norway pout) in the North Sea (ICES, 2011; WGSAM). The steep increase in abundance of the 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. 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.

16.11 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.

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.

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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 in area IIIa, IV, and VIId 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	56	3	9	475	2	0	98

Table 16.2. Grey gurnard. Discards per hour of grey gurnard by different metiers in the Netherlands.

Numbers per hour of discarded non-target fish species in Dutch bottom-trawl fisheries

Métier	**TBB_DEF**	**TBB_DEF***	**TBB_DEF**	**OTB_MCD**	**OTB_DEF**	**OTB_DEF**
Mesh size/hp power 7	**0-99**	**70-99**	**100-119**	**70-99**	**70-99**	**100-119**
2006 Grey gurnard	68.3				92	
2007 Grey gurnard	60.2					
2008 Grey gurnard	34.3					
2009 Grey gurnard	55	17	37	111	77	15
2010 Grey gurnard	81	10	109	47	52	110

*≤300 hp segment

Table 16.3. Grey gurnard abundance indices (n/hour) from IBTS Q1 and Q3 survey.

Year	IBTS_Q1	IBTS_Q3
1965	0.0	
1966	0.0	
1967	27.7	
1968	142.4	
1969	27.1	
1970	25.5	
1971	6.7	
1972	1.3	
1973	14.2	
1974	65.0	
1975	35.8	
1976	85.9	
1977	9.4	
1978	42.6	
1979	3.3	
1980	8.8	
1981	9.4	
1982	57.8	
1983	47.6	
1984	51.6	
1985	28.6	
1986	77.8	
1987	41.7	
1988	19.2	
1989	65.6	
1990	97.9	
1991	95.1	85.8
1992	118.7	107.0
1993	114.3	74.2
1994	102.1	110.7
1995	122.3	79.6
1996	192.8	127.3
1997	139.6	98.0
1998	178.5	168.7
1999	258.6	205.8
2000	265.2	158.8
2001	187.8	234.5
2002	230.2	167.8
2003	213.8	167.6
2004	263.8	138.6
2005	270.9	193.2
2006	241.7	176.0
2007	305.6	223.9
2008	292.1	219.9
2009	209.1	216.2
2010	269.9	193.6
2011	269.9	216.1
2012	327.2	200.3
2013	151.4	

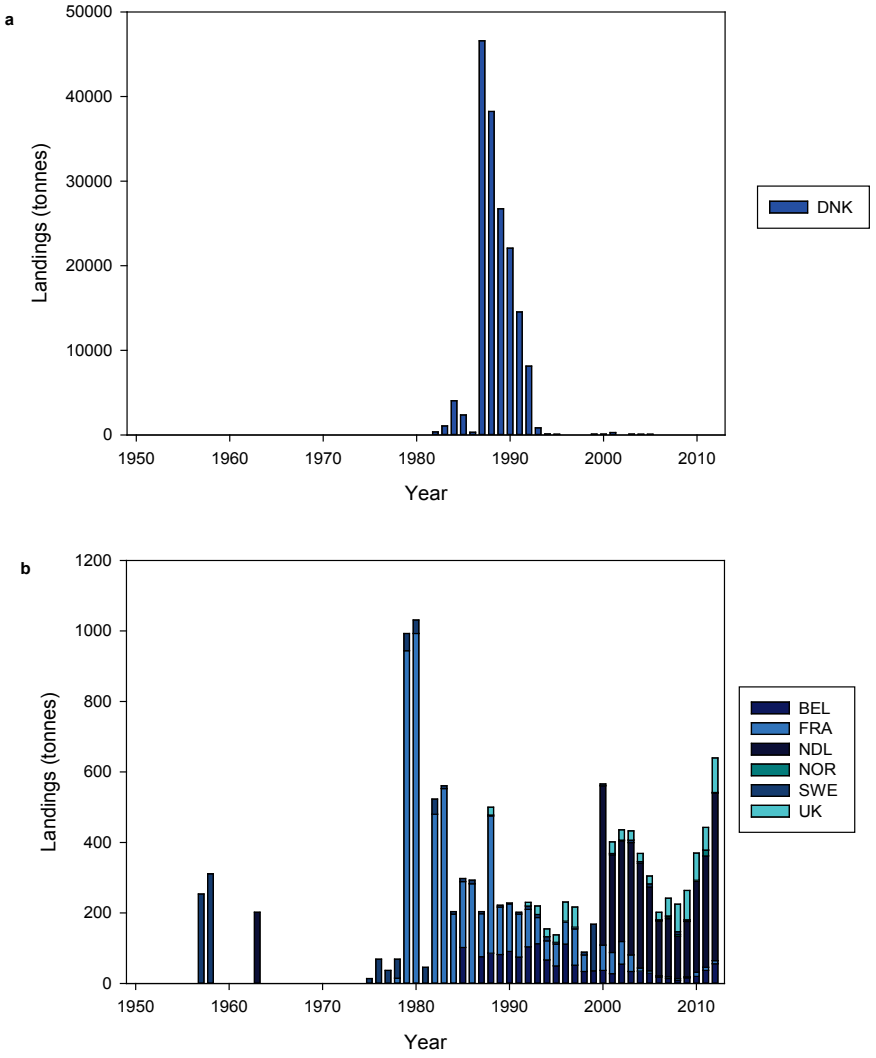


Figure 16.1. Grey gurnard. Official catches of grey gurnard reported at ICES from 1950 to 2012 in areas IV, IIIa, and VIId. (a) Denmark only, (b) all other relevant countries.

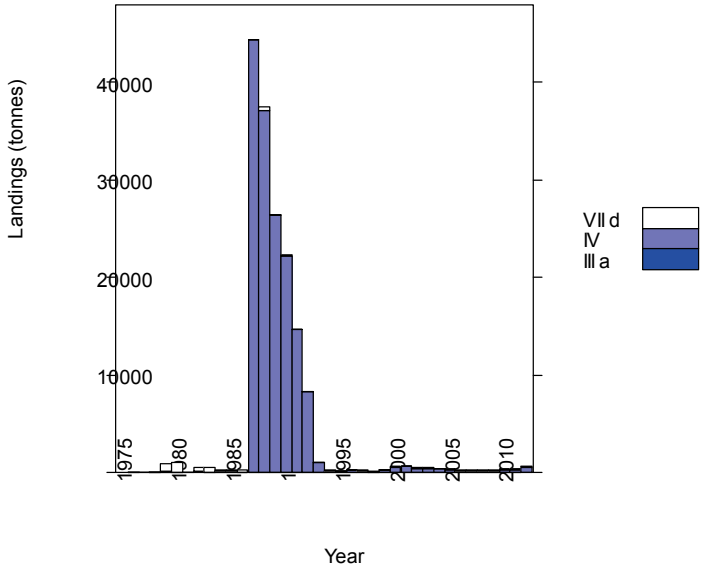


Figure 16.2. Grey gurnard. Official catches of grey gurnard reported at ICES from 1950 to 2012 in the main areas.

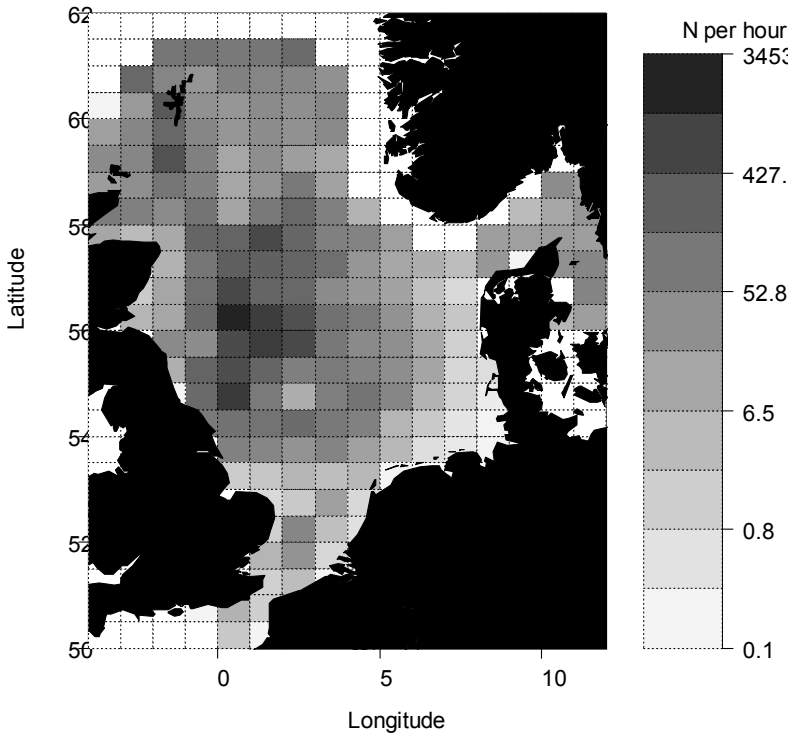


Figure 16.3. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q1 survey (all years) .

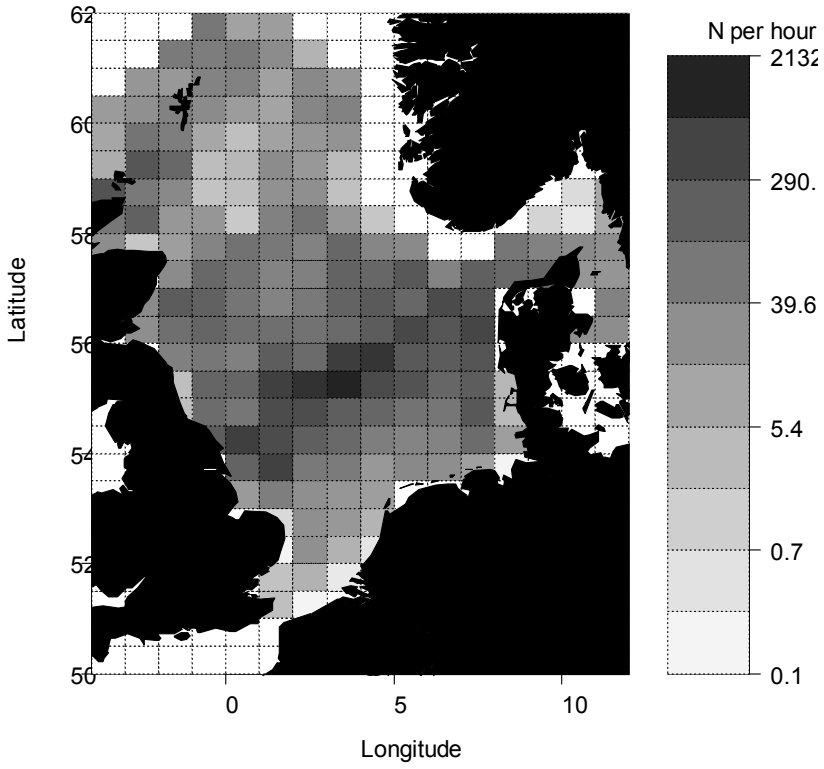


Figure 16.4. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q3 survey (all years).

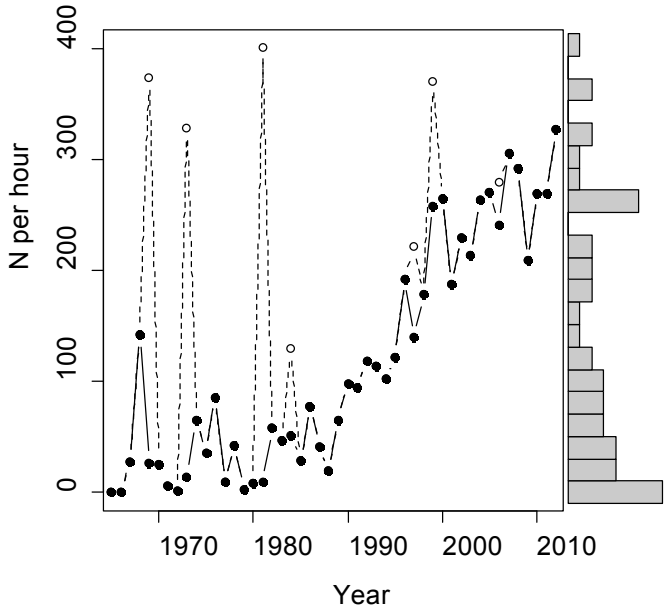


Figure 16.5. Grey gurnard. Abundance index of grey gurnard from IBTS-Q1 survey time series. The plain line excludes the exceptionally high abundance observed occasionally in a single rectangle by shoal behaviour as proposed in Heessen and Daan (1996). Histogram along the left y-axis indicates number of observations in this abundance range.

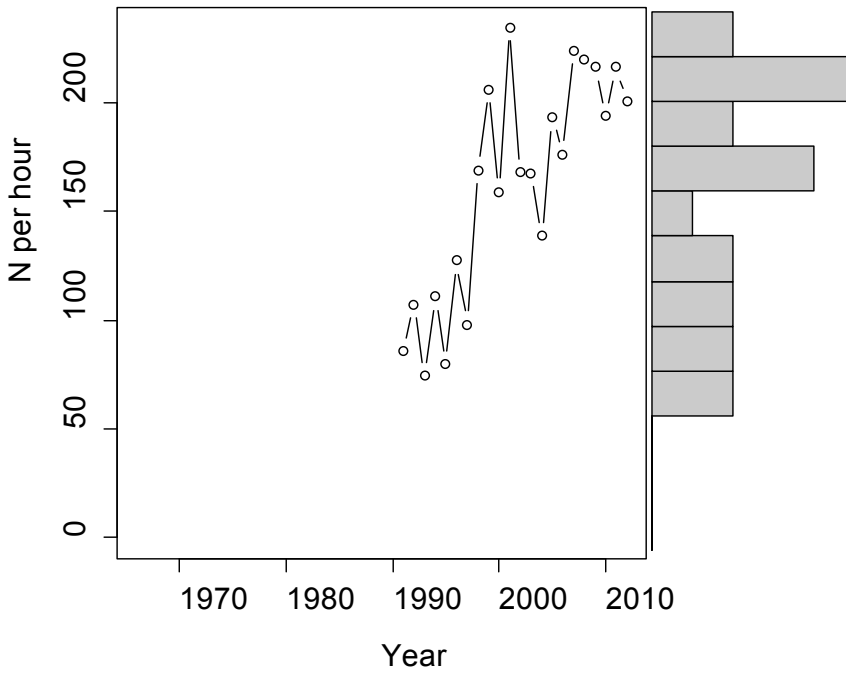


Figure 16.6. Grey gurnard. Abundance index of grey gurnard from IBTS-Q3 survey time series. Histogram along the left y-axis indicates number of observations in this abundance range.

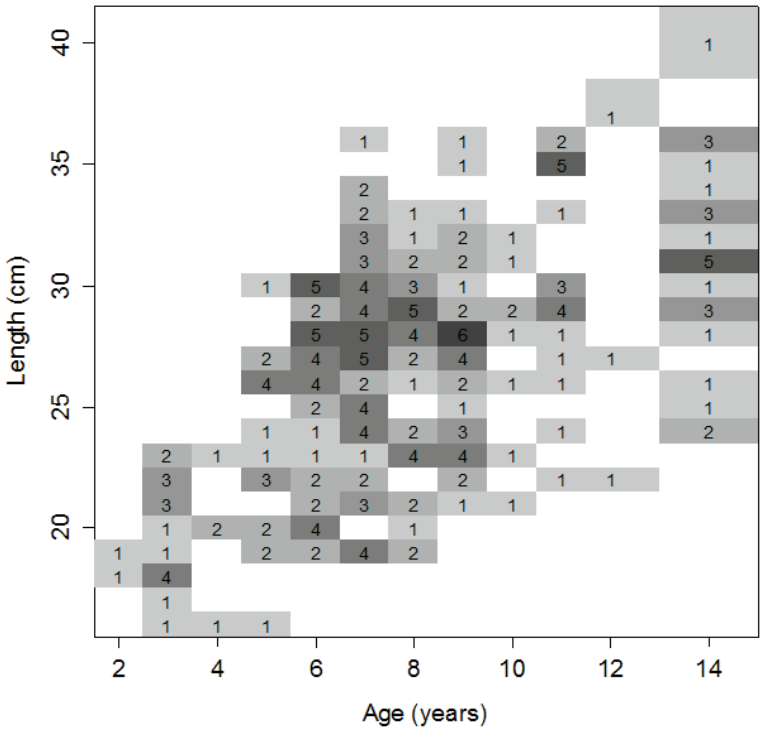


Figure 16.7. Grey gurnard. ALK from otoliths of Grey gurnard collected during 2010 IBTS-Q1 survey.

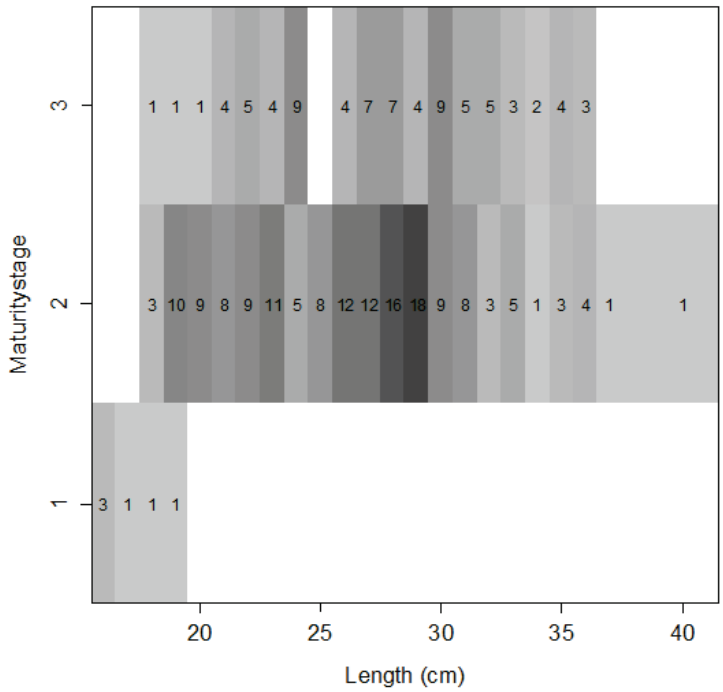


Figure 16.8. Maturity length key of Grey gurnard sampled during IBTS-Q1 surveys.

17 Striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern English Channel) and IIIa (Skagerrak–Kattegat)

17.1 General

17.2 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)).

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.

17.2.1 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.

17.2.2 ICES advice

2012 advice: This is the first time ICES has provided advice for striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern English Channel) and IIIa (Skagerrak–Kattegat). Based on the ICES approach for data-limited stocks, ICES advises that catches should be no more than 1700 tonnes.

17.2.3 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.

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.

17.3 Data available

17.3.1 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.

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.

17.3.2 Age compositions

Only partial age composition was available to the working group for years 2004 to 2008. Figure 17.2.2.1 shows that most of the catches made during this period were made on ages 1 and 2.

17.4 Data analyses

17.4.1 Exploratory survey-based analyses

The Channel Ground Fish Survey (CGFS) survey and the IBTS-Q3 surveys provide abundance indices-at-age. The stock is mainly fished in the eastern English Channel (Division VIId) and southern North Sea. Biomass estimates from Divison VIId (fig. 17.1.4.1) show high variability and indicate a considerable decrease in the last three years. Abundance in the North Sea (fig. 17.4.1.2) has also been low in recent years. The average of the stock size indicator (relative biomass) in the last two years (2011–2012) is 69% lower than the average of the three previous years (2008–2010).Figure 17.4.3 shows that age class in the catches during the CGFS survey are clearly dominated by young age classes.

17.4.2 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 2013 and 2014. The advice is reopened given the very low biomass and abundance indices in the last years, the high decrease of commercial landings in the last years, and because there are directed fisheries.

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	431	0	14	445
1993	0	0	516	0	18	534
1994	0	0	308	0	14	322
1995	0	0	2016	0	63	2079
1996	0	1	1785	1	36	1824
1997	0	1	731	0	48	781
1998	0	1	2598	0	97	2697
1999[1)]	0	2	0	0	70	74
2000	0	2	2590	235	93	2922
2001	0	5	1417	533	142	2102
2002	0	12	1346	326	82	1778
2003	17	0	2750	396	115	3278
2004	22	0	3618	804	91	4535
2005	19	0	1595	600	81	2295
2006	12	0	1029	293	69	1403
2007	13	0	3475	906	161	4555
2008	15	0	3249	873	313	4450
2009	13	0	736	562	260	1571
2010	62	0	879	567	311	1819
2011	83	0	576	540	239	1438
2012[2)]	40[2)]	0	214[2)]	378[2)]	87[2)]	719[2)]

[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	45
1988	7	0	33	40
1989	5	0	37	42
1990	33	0	504	537
1991	26	0	193	219
1992	30	0	415	445
1993	63	0	471	534
1994	58	0	264	322
1995	527	0	1552	2079
1996	264	0	1559	1823
1997	139	0	641	780
1998	389	0	2307	2696
1999[1)]	35	0	37	72
2000	882	0	2038	2920
2001	800	0	1297	2097
2002	617	0	1149	1766
2003	809	0	2469	3278
2004	910	0	3625	4535
2005	702	0	1593	2295
2006	320	0	1083	1403
2007	773	0	3782	4555
2008	914	0	3536	4450
2009	454	0	1117	1571
2010	350	0	1469	1819
2011	303	0	1135	1438
2012[2)]	179[2)]	-	540[2)]	719[2)]

[1)] No data reported by France in 1999.

[2)] ICES estimates.

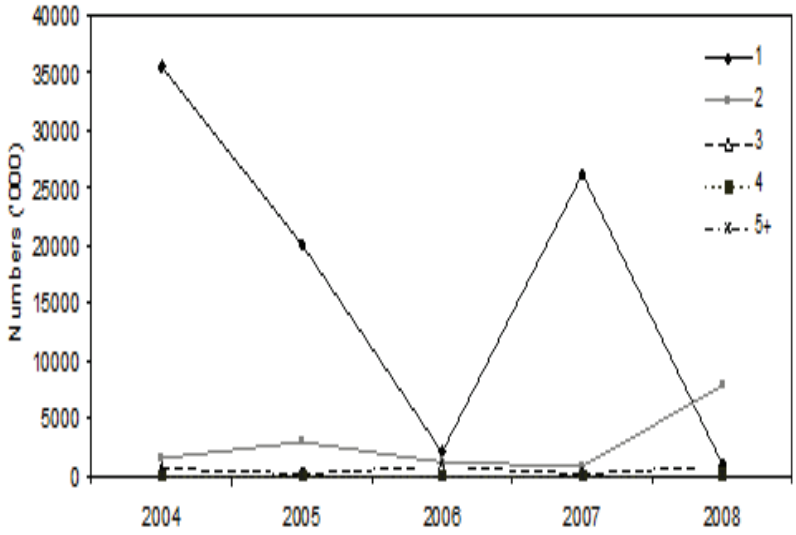


Figure 17.2.2.1 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Age composition of French landings in Divisions VIId and IVc (Eastern English Channel and Southern North Sea).

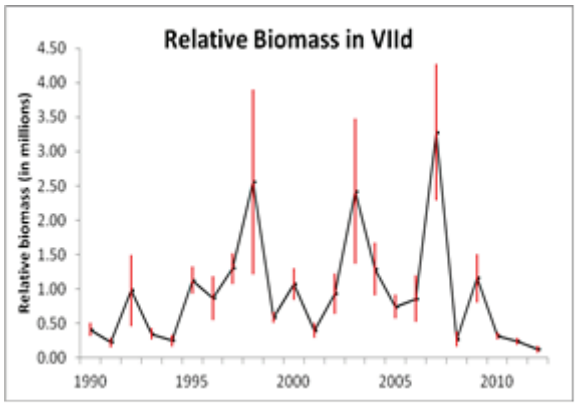


Figure 17.4.1.1 Relative biomass from CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

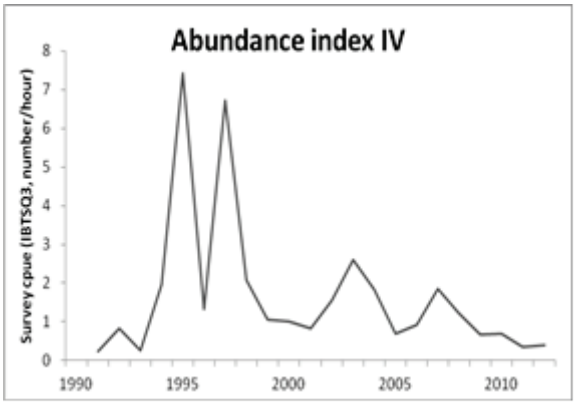


Figure 17.4.1.2 Abundance in Subarea IV (Q3) from IBTS-Q3

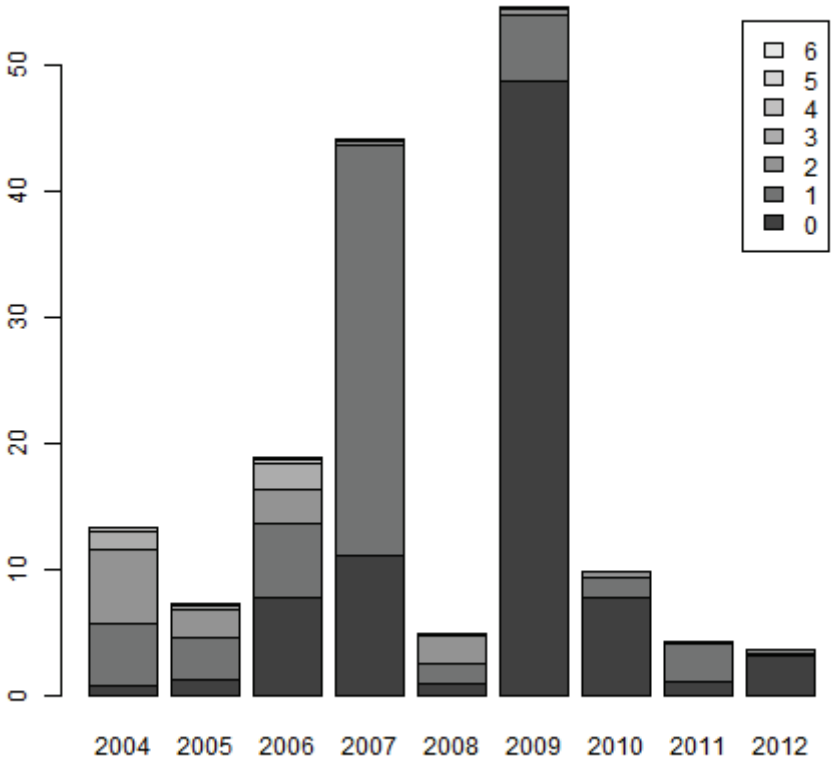


Figure 17.4.1.3 Number of individuals per hour trawled during CGFS (Channel Ground Fish Survey) in Division VIId (Q4)

18 Turbot in Subarea IV

This report presents the stock assessment carried out for turbot in Subarea IV in 2013. More details on the data used, assumptions made and the assessment model can be found in the stock annex.

18.1 General

Turbot (*Psetta 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. Additionally, it was not decided at IBPNEW exactly how the results of the assessment should be used for providing advice (i.e. short term forecast settings, reference points etc.).

At WGNSSK it was decided to categorise turbot as a 'Category 2' stock under the ICES data-limited stocks (DLS) framework (ICES, 2013). 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 2013

The information in this section is taken from the ICES advice sheet 2012, section 6.4.26. Given that turbot in subarea IV has not previously had a quantitative stock assessment, previously ICES has provided qualitative advice for this stock.

Advice for 2013:

The 2011 advice for the stock was biennial, i.e. valid for two years. On the basis of precautionary considerations it was advised that catches should not increase in 2012 or 2013.

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 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

For WGNSSK 2013, InterCatch was not used for the North Sea turbot stock (see text table below).

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.
Tur-nsea (Turbot in area IV)	'Not used'	Was not included int the North Sea/MIXFISH data call. All data required for the benchmark assessment where available elsewhere.	-	Turbot will be added to Intercatch in 2014

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 2014.

Figure 18.2.1 shows the trend in total landings over time and Figure 18.2.2 shows the breakdown of landings by country for 2012 (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 by-catch species, this indicates that abundance of turbot has likely increased over this period.

Age structure of the landings since 2004 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. These age structures are raised to total Dutch landings by quarter. The total Dutch landings are subsequently raised to the total international landings per year. Landings at age are presented in Table 18.2.1 and Figure 18.2.3. There is a notable increase in the amount of age 1 and 2 turbot landed since 2002. This corresponds to a decrease in minimum market size for turbot in the Netherlands. The 2005 year class (age 1 in 2006) contributed the largest catches of age 1 and age 2 fish of the whole time series. Since then there have been no notably large year classes observed in the landings data.

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 indi-

cates 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 18.2.4).

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 in the other two indices.

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 (Figure 18.2.5). 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 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. 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 ma-

turity 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).

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. This will be examined further in advance of WGNSSK 2014.

18.3.1 Model settings

The assessment model was conducted using the settings given below. This is the first year that this assessment has been conducted at WGNSSK.

Assessment settings used in the final assessment

Year:	2013
First tuning year	1975
Last data year	2012
Ages	1-9
Plus group	No
Total Landings	Not used
Landings at age	1975-1978, 1981-1990, 1998, 2000-2012
Discards	Not used (assumed 0)
Abundance indices	BTS-Isis 1985–2012 SNS 1975–2002, 2004-2012 NL-BT2 LPUE 2002–2012
Selectivity at age splines	4 knots, 1975-2001 and 2002-2012
Annual F spline	5 knots, 1975-2012
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.

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. 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.

Estimates of total landings from various sources are presented in Figure 18.3.3. Official landings (not inputted directly into the assessment model) can be 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 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. 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 2012, lower than the long term geometric mean (0.54). The SSB in 2012 was estimated to be 4 277t, increasing to 5 090t in 2013. Both years are lower than the long term geometric mean (5 621t). The estimated recruitment (age 1) for 2012 is the lowest 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. 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 five 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 overestimate SSB and underestimate F. 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 (Figure 18.5.1), F_{max}, estimated for the yield per recruit curve (Figure 18.5.2), is proposed as a proxy for F_{MSY}. From the MCMC analyses done in IBPNEW a distribution of the value of F_{max} was

derived (Figure 18.5.2). This distribution is recommended as a reasonable range for the F_{MSY} proxy.

Biological reference points for turbot in Subarea IV

	Type	Value	Technical basis
MSY Approach	**MSY $B_{trigger}$**	Undefined	
	F_{MSY}	0.34 (range: 0.31-0.37)	F_{max} as proxy for F_{MSY}
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 2013). 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 (2013) are taken for the assessment model outputs. Recruitment in 2012 is considered to be poorly estimated by the model. Hence recruitment values for 2012-2015 are all assumed to be the long term geometric mean (4.4 million). It is estimated that between 35 and 45% of the predicted catch for the TAC year (2014) 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. This implies an F of 0.34 in 2013, corresponding to landings of 2914t, leading to an SSB of 6205t at the start of the TAC year (2014).

The resulting F in 2014 and SSB in 2015 for different values of TAC for 2014 are plotted in Figure 18.6.1. The TACs, associated Fs and resultant SSBs when applying F_{MSY} or the ICES transition to F_{MSY} (equation 1) are presented in Table 18.6.1.

$$F_{MSY-trans} = (1-\omega)F_{SQ} + \omega F_{MSY} \quad (1)$$

Where: ω=0.8, F_{SQ}= the most recent F estimate (=F_{2012}) and F_{MSY} = F_{max}

Since F is currently above F_{MSY}, it is recommended to apply the transition to F_{MSY}. This would imply that fishing mortality should be reduced to 0.38 based on (F2010*0.2)+(FMSY*0.8) = (0.53 *0.2) + (0.34 *0.8) = 0.38. This will result in landings of 3247t in 2014. This is expected to lead to an increase in SSB of 8% from 2014 to 2015.

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 depend-

ing 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 smlaller turbot, 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.

18.8 Future work

Since this is the first year that a full quantitative assessment has been conducted for turbot, there is still work to be done to address potential sources of bias and uncertainty in the assessment model. In 2013 turbot has been 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 2014. 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. Test alternative versions of the objective function (e.g. weighting of data sources, inclusion of total landings etc.)

6. Examination of the functional form of the selectivity curve(s)

7. Test different numbers (or locations) of knots in the annual exploitation spline

18.9 References

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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.

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Table 18.2.1 Turbot in Subarea IV: Landings at age estimates (abundance) 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

Table 18.2.2 Turbot in Subarea IV: 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

Table 18.2.2 cont. Turbot in Subarea IV: 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

Table 18.2.2 cont. Turbot in Subarea IV: 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

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	0.68	1.16	1.92	2.72	3.71	4.54	5.15	5.81
Catch weight at age (kg)	0.5	0.78	1.25	2	2.92	3.89	4.71	5.43	6.13
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 from the assessment model.

N@A	1	2	3	4	5	6	7	8	9
1975	4047	4236	2591	770	434	384	286	176	142
1976	8607	3313	3055	1367	402	249	241	158	97
1977	11738	7046	2383	1597	707	229	155	132	87
1978	4704	9608	5050	1230	816	398	142	84	72
1979	2938	3851	6857	2569	619	454	244	76	45
1980	3297	2405	2734	3428	1270	340	276	129	40
1981	2535	2698	1698	1340	1660	686	204	143	67
1982	4318	2075	1893	814	634	881	406	103	72
1983	7022	3535	1445	885	375	330	513	201	51
1984	5461	5747	2443	658	397	191	189	249	98
1985	2641	4470	3939	1080	287	197	108	89	118
1986	3705	2162	3037	1690	457	139	109	50	41
1987	5900	3033	1456	1263	692	216	76	49	22
1988	4473	4829	2023	586	500	319	115	33	21
1989	5624	3661	3192	789	225	225	167	49	14
1990	6840	4603	2398	1206	293	98	115	68	20
1991	5375	5598	2988	879	434	125	49	46	27
1992	5707	4399	3605	1065	307	181	62	19	18
1993	5756	4671	2812	1252	362	126	88	24	7
1994	5154	4711	2967	956	417	146	60	33	9
1995	8355	4218	2978	992	313	165	69	22	12
1996	4037	6838	2658	985	321	123	78	25	8
1997	3309	3304	4302	874	317	126	58	28	9
1998	3598	2708	2079	1414	281	124	59	21	10
1999	1953	2945	1706	686	457	110	59	22	8
2000	3481	1598	1860	569	224	181	52	21	8
2001	2591	2849	1014	629	189	90	87	19	8
2002	5440	2120	1817	349	213	77	43	33	7
2003	4980	4255	730	640	121	88	38	17	13
2004	5844	3900	1504	264	227	51	44	15	7
2005	4657	4585	1420	559	96	98	26	18	6
2006	7995	3659	1722	544	211	43	51	11	7
2007	5319	6293	1421	682	212	96	22	22	5
2008	2631	4194	2529	582	275	99	51	10	10
2009	3451	2078	1747	1072	243	132	54	23	5
2010	5022	2732	897	767	464	120	74	25	11
2011	6090	3983	1222	408	344	236	69	36	12
2012	760	4839	1847	575	189	180	138	34	18

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	0.44	0.45	0.36	0.27	0.39	0.39	0.39
1976	0.00	0.13	0.45	0.46	0.36	0.27	0.40	0.40	0.40
1977	0.00	0.13	0.46	0.47	0.37	0.28	0.41	0.41	0.41
1978	0.00	0.14	0.48	0.49	0.39	0.29	0.42	0.42	0.42
1979	0.00	0.14	0.49	0.50	0.40	0.30	0.44	0.44	0.44
1980	0.00	0.15	0.51	0.53	0.42	0.31	0.46	0.46	0.46
1981	0.00	0.15	0.54	0.55	0.43	0.32	0.48	0.48	0.48
1982	0.00	0.16	0.56	0.57	0.45	0.34	0.50	0.50	0.50
1983	0.00	0.17	0.59	0.60	0.48	0.36	0.52	0.52	0.52
1984	0.00	0.18	0.62	0.63	0.50	0.37	0.55	0.55	0.55
1985	0.00	0.19	0.65	0.66	0.52	0.39	0.58	0.58	0.58
1986	0.00	0.20	0.68	0.69	0.55	0.41	0.61	0.61	0.61
1987	0.00	0.20	0.71	0.73	0.57	0.43	0.63	0.63	0.63
1988	0.00	0.21	0.74	0.76	0.60	0.45	0.66	0.66	0.66
1989	0.00	0.22	0.77	0.79	0.63	0.47	0.69	0.69	0.69
1990	0.00	0.23	0.80	0.82	0.65	0.49	0.72	0.72	0.72
1991	0.00	0.24	0.83	0.85	0.67	0.50	0.74	0.74	0.74
1992	0.00	0.25	0.86	0.88	0.69	0.52	0.77	0.77	0.77
1993	0.00	0.25	0.88	0.90	0.71	0.53	0.78	0.78	0.78
1994	0.00	0.26	0.90	0.92	0.73	0.54	0.80	0.80	0.80
1995	0.00	0.26	0.91	0.93	0.73	0.55	0.81	0.81	0.81
1996	0.00	0.26	0.91	0.93	0.74	0.55	0.81	0.81	0.81
1997	0.00	0.26	0.91	0.93	0.74	0.55	0.82	0.82	0.82
1998	0.00	0.26	0.91	0.93	0.74	0.55	0.81	0.81	0.81
1999	0.00	0.26	0.90	0.92	0.73	0.54	0.80	0.80	0.80
2000	0.00	0.26	0.88	0.90	0.72	0.54	0.79	0.79	0.79
2001	0.00	0.25	0.87	0.89	0.70	0.52	0.77	0.77	0.77
2002	0.05	0.87	0.84	0.86	0.68	0.51	0.75	0.75	0.75
2003	0.04	0.84	0.82	0.84	0.66	0.50	0.73	0.73	0.73
2004	0.04	0.81	0.79	0.81	0.64	0.48	0.71	0.71	0.71
2005	0.04	0.78	0.76	0.78	0.61	0.46	0.68	0.68	0.68
2006	0.04	0.75	0.73	0.74	0.59	0.44	0.65	0.65	0.65
2007	0.04	0.71	0.69	0.71	0.56	0.42	0.62	0.62	0.62
2008	0.04	0.68	0.66	0.67	0.53	0.40	0.59	0.59	0.59
2009	0.03	0.64	0.62	0.64	0.51	0.38	0.56	0.56	0.56
2010	0.03	0.60	0.59	0.60	0.48	0.36	0.53	0.53	0.53
2011	0.03	0.57	0.55	0.57	0.45	0.34	0.49	0.49	0.49
2012	0.03	0.53	0.52	0.53	0.42	0.31	0.46	0.46	0.46

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	4047	16116	8567	4588	3524	0.33	0.28
1976	8607	19539	8739	4814	3783	0.33	0.25
1977	11738	24320	9064	4484	4119	0.34	0.18
1978	4704	23566	10449	5034	5466	0.35	0.21
1979	2938	22899	13661	6364	6831	0.37	0.28
1980	3297	20791	14672	5485	6277	0.38	0.26
1981	2535	17438	12552	4755	5090	0.40	0.27
1982	4318	16282	10361	4453	4365	0.42	0.27
1983	7022	17096	8409	4575	4014	0.44	0.27
1984	5461	16705	7184	5297	4240	0.46	0.32
1985	2641	14861	7384	6188	4870	0.48	0.42
1986	3705	13839	7546	5263	4646	0.51	0.38
1987	5900	14125	6586	4271	3844	0.53	0.30
1988	4473	13559	5662	4041	3840	0.55	0.30
1989	5624	14569	5810	4927	4382	0.58	0.34
1990	6840	15645	5783	5750	4436	0.60	0.37
1991	5375	15363	5648	6340	4772	0.62	0.41
1992	5707	15601	6017	5933	5135	0.64	0.38
1993	5756	15289	5959	5546	4972	0.66	0.36
1994	5154	14618	5659	5244	4890	0.67	0.36
1995	8355	16626	5513	4671	4787	0.68	0.28
1996	4037	14595	5294	3644	4973	0.68	0.25
1997	3309	13254	5820	3382	5363	0.68	0.26
1998	3598	11400	5447	3086	4256	0.68	0.27
1999	1953	8878	4337	3187	3420	0.67	0.36
2000	3481	8693	3771	4025	2914	0.66	0.46
2001	2591	7702	3164	4100	2465	0.65	0.53
2002	5440	9680	2956	3749	3149	0.75	0.39
2003	4980	9789	2666	3374	3409	0.73	0.34
2004	5844	10525	2528	3317	3382	0.71	0.32
2005	4657	10293	2788	3195	3644	0.68	0.31
2006	7995	12745	3090	2976	3514	0.65	0.23
2007	5319	12503	3361	3509	4295	0.62	0.28
2008	2631	10383	4008	3005	3998	0.59	0.29
2009	3451	9698	4507	3089	3172	0.56	0.32
2010	5022	10475	4199	2692	2851	0.53	0.26
2011	6090	11976	3896	2807	3012	0.49	0.23
2012	760	9212	4277	2914	3391	0.46	0.32
Geo. Mean	4418	13656	5621	4184	4096	0.54	0.31

Table 18.6.1. Turbot in Subarea IV. Management options for 2014 and their effects on the stock.

Landings (2013) = Landings (2012) = 2914t; SSB (2014) =6205t; R (2013/14) = 4418000 = GM(1957–2012)

Rationale	TAC (2014)	Basis	F Total (2014)	SSB (2015)	%SSB change	%TAC change
MSY transition	3246.75	$(F_{2010}*0.2)+(F_{MSY}*0.8)$	0.38	6703.66	+8	+11
MSY framework	2978.26	F_{MSY} ($=F_{max}$)	0.34	6971.03	+12	+2

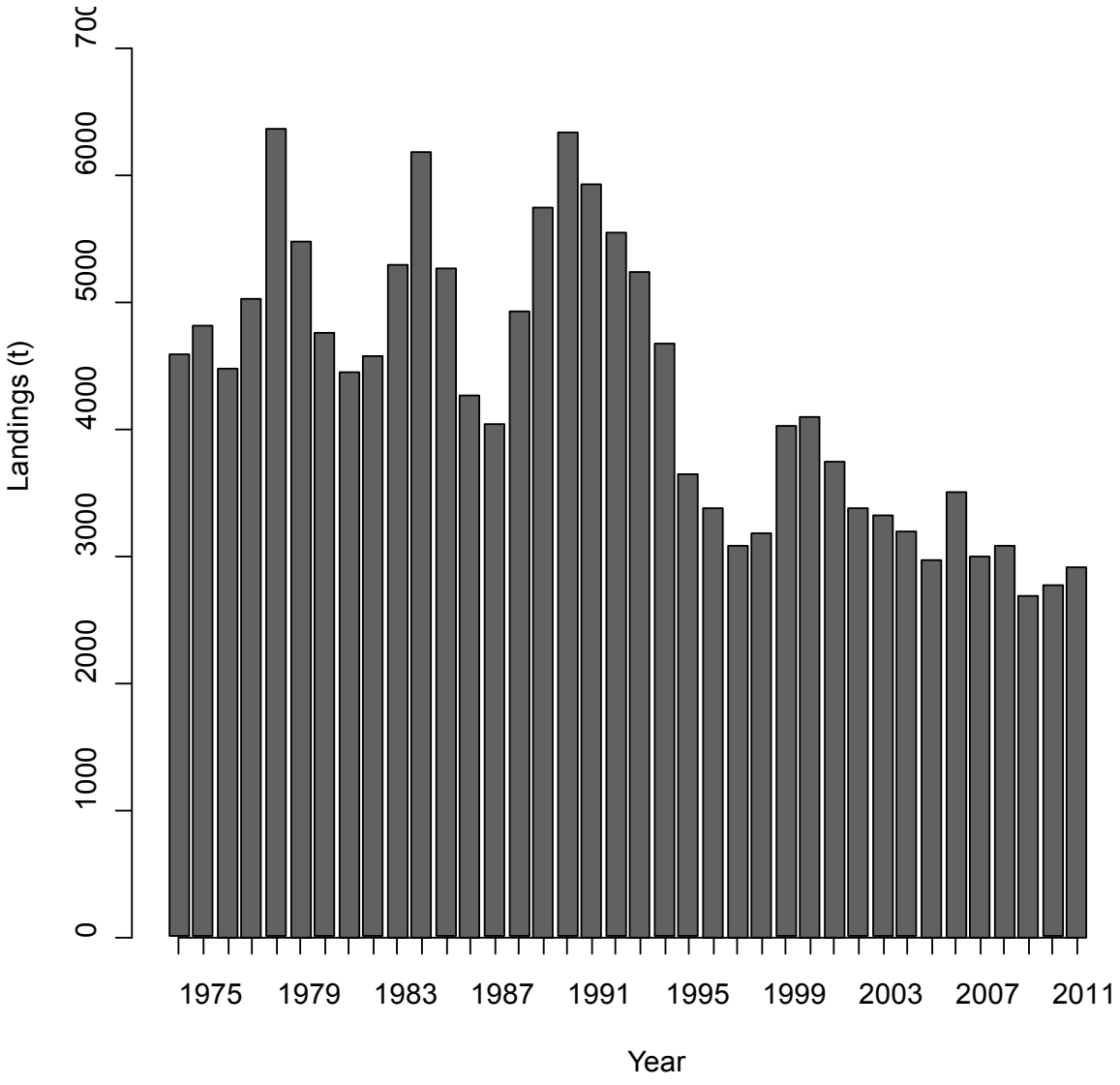


Figure 18.2.1. Turbot in Subarea IV. Total landings 1957-2012 (from the ICES database of official landings).

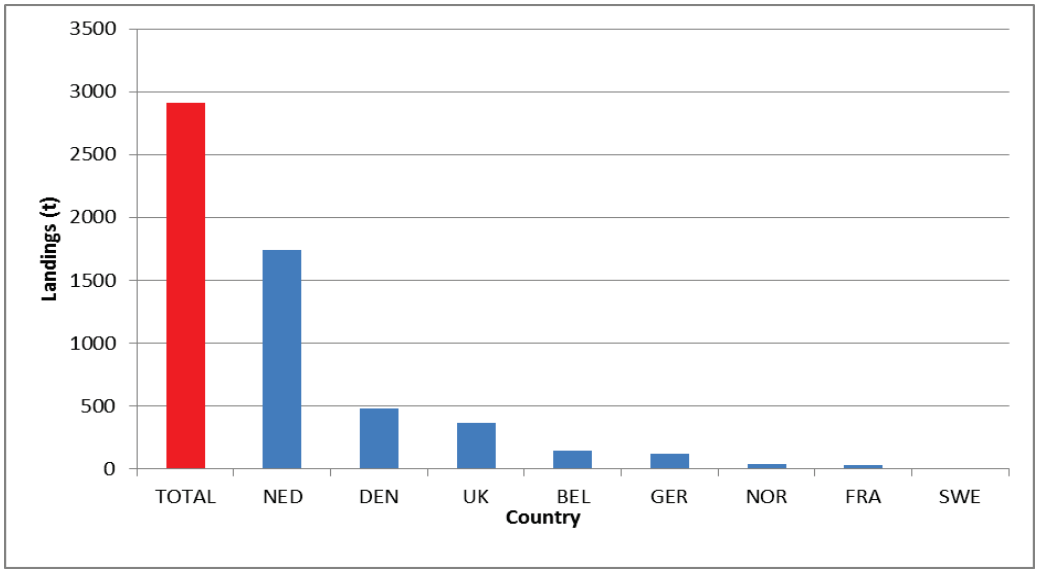


Figure 18.2.2. Turbot in Subarea IV. Landings by country in 2012 (from the ICES database of official landings).

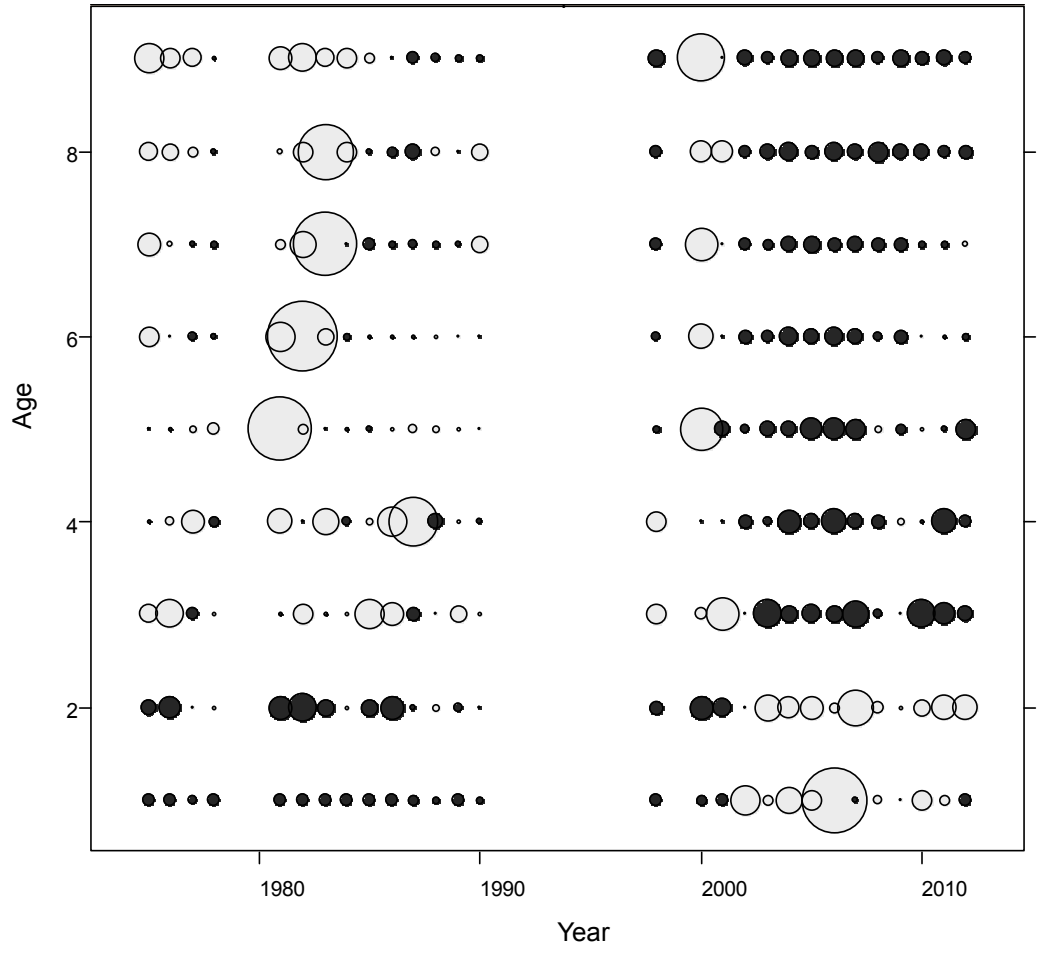


Figure 18.2.3. Turbot in Subarea IV. Age standardised landings at age 1957-2012. The size of the bubble indicates the size of the deviation from average landings, grey bubbles indicate above average values for a given age, black bubbles indicate below average values for a given age.

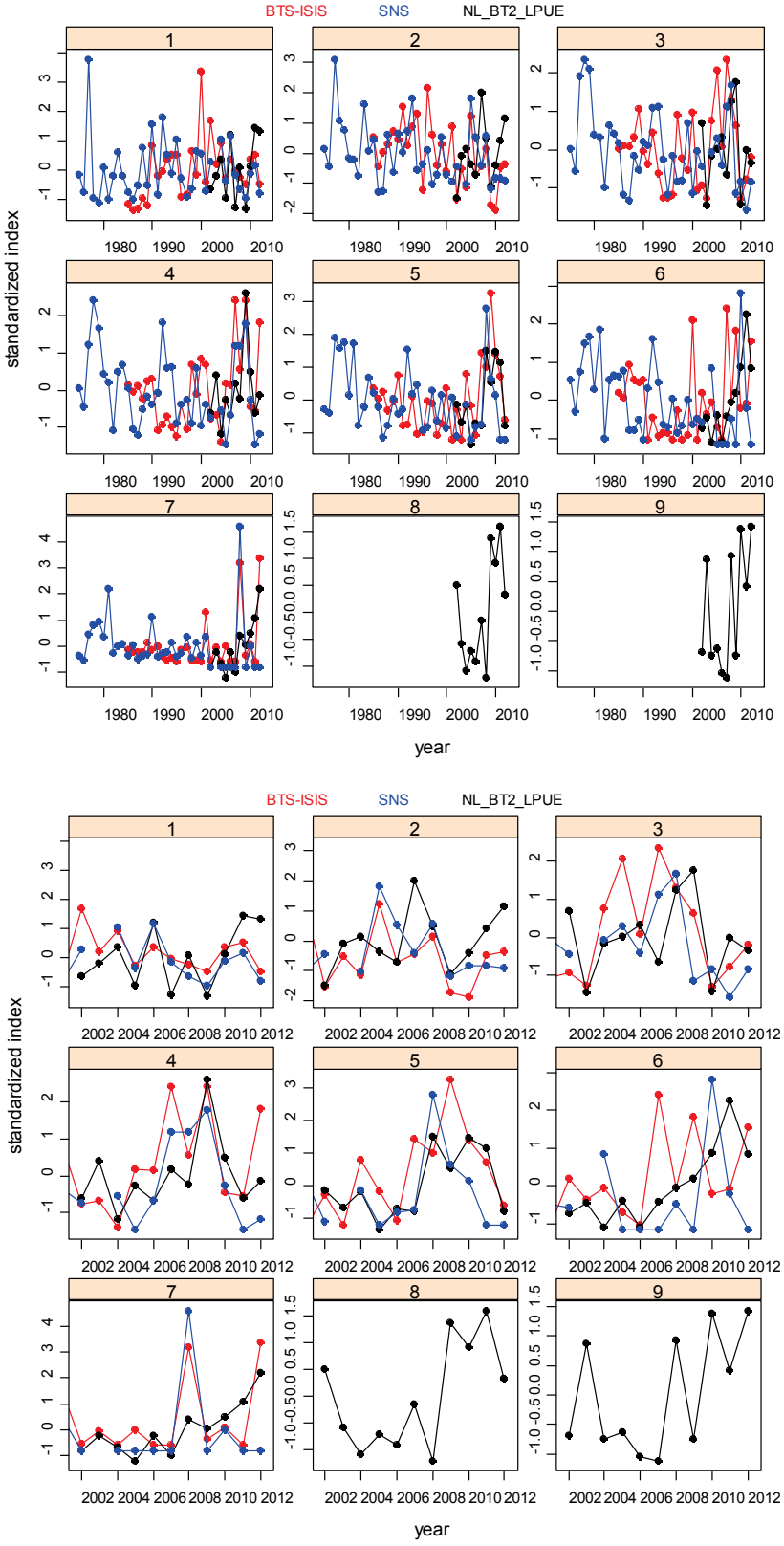


Figure 18.2.4 Turbot in Subarea IV. Time series of the standardized indices for ages 1 to 9 from the three tuning fleets used in the assessment: BTS-ISIS (red), SNS (blue) and NL beam trawl LPUE (black). All years (top) and recent period (2002 onwards, bottom).

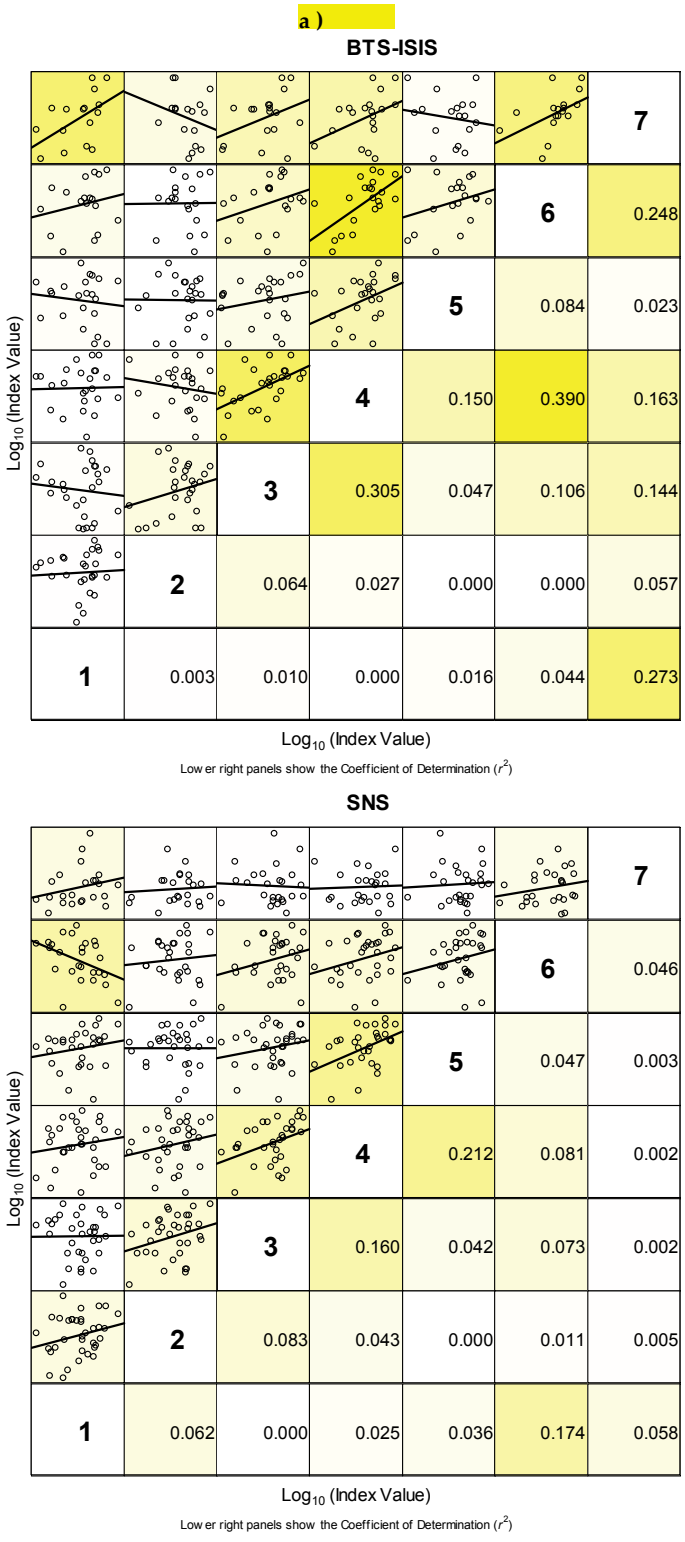


Figure 18.2.5 Turbot in Subarea IV. Internal consistency of the three tuning indices used in the assessment. : BTS-ISIS (top), SNS (bottom) and NL beam trawl LPUE (next page).

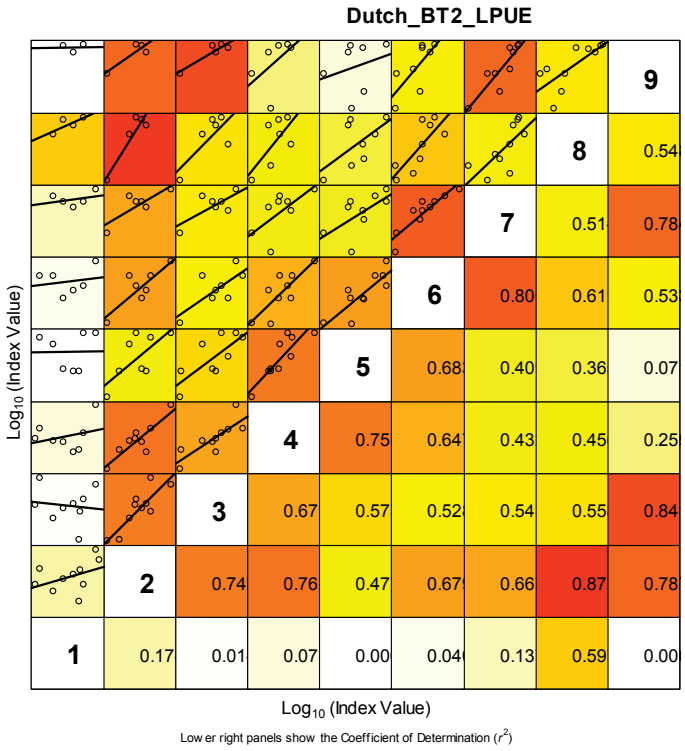


Figure 18.2.5 cont. Turbot in Subarea IV. Internal consistency of the three tuning indices used in the assessment. : BTS-ISIS, SNS (previous page) and NL beam trawl LPUE.

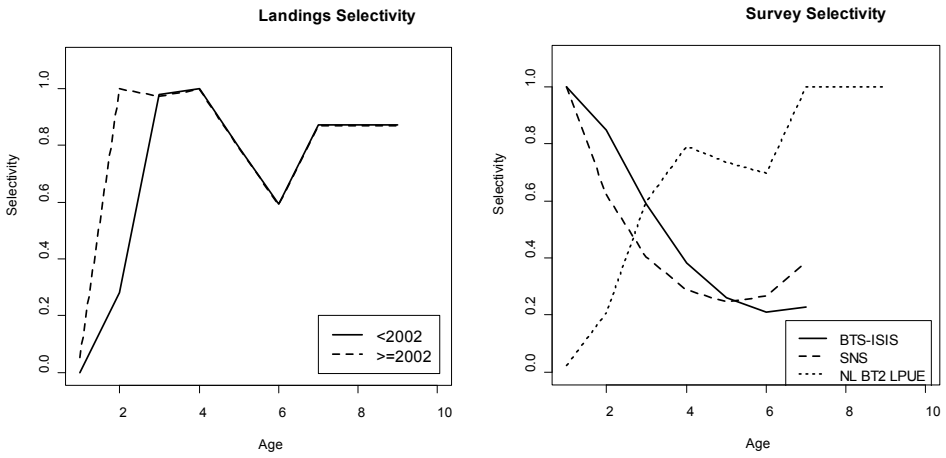


Figure 18.3.1. Turbot in Subarea IV. Model estimated selectivity at age curves for the landings at age (two periods; left) and the three tuning indices used in the assessment (BTS-ISIS, SNS and NL beam trawl LPUE, right).

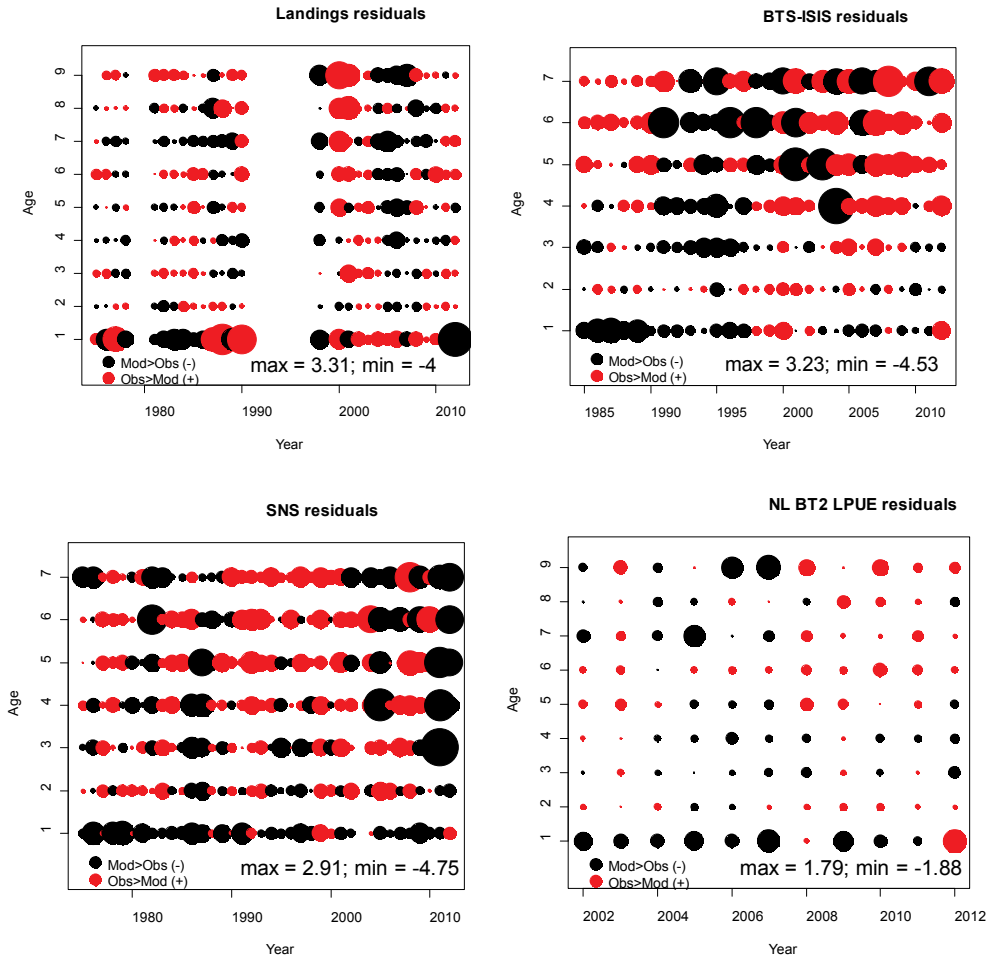


Figure 18.3.2. Turbot in Subarea IV. Log catchability residuals for the landings (top left) and the three tuning fleets: BTS-ISIS (top right), SNS (bottom left) and NL beam trawl LPUE (Bottom right). Black bubbles indicate that the model estimates higher values than observed, red bubbles indicate that the model estimates lower values than observed. Scales are comparable across plots and minimum and maximum values for each series are provided.

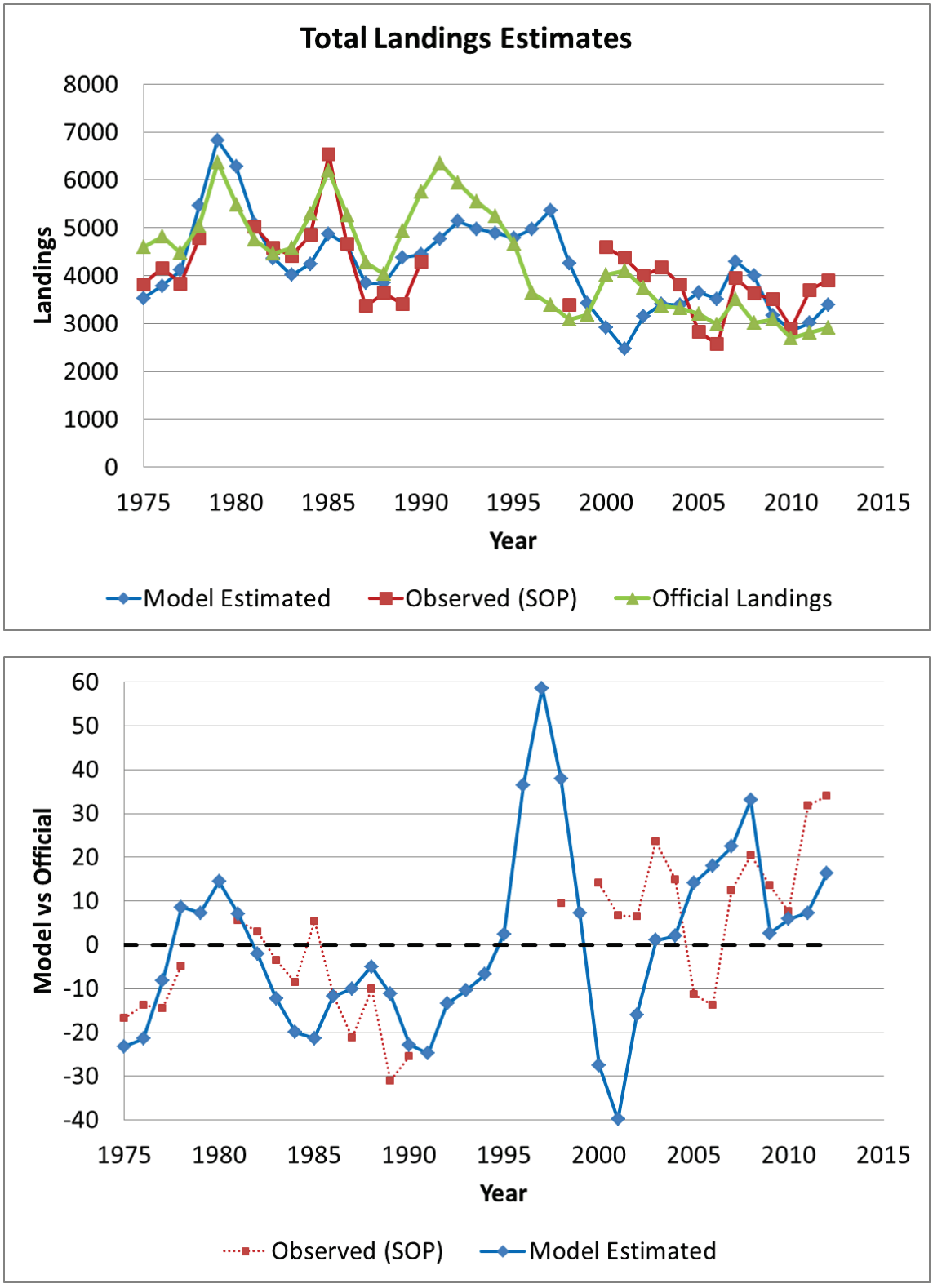


Figure 18.3.3. Turbot in Subarea IV. Top: Estimates of total landings from various sources: official landings (green triangles), sum of products (SOP) from landings at age inputted into the model (red squares) and model estimated values (blue circles). Bottom: Model input and output values compared to the official estimates (percentage differences).

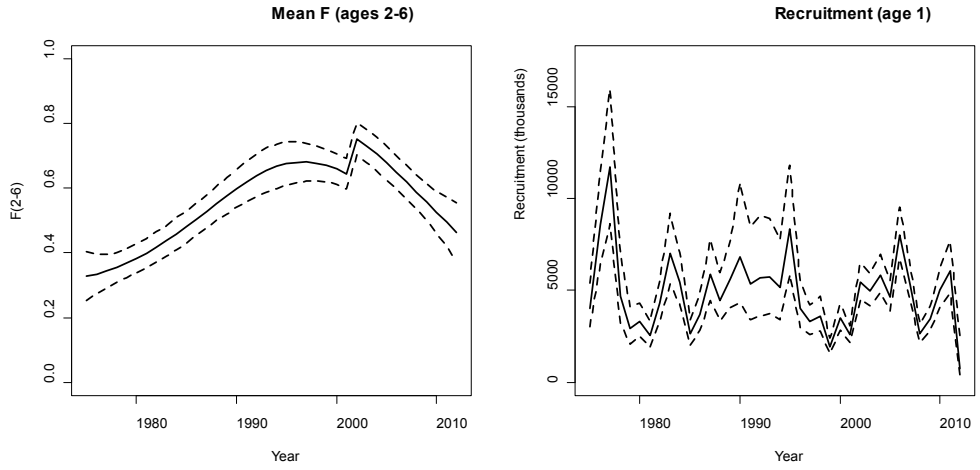


Figure 18.4.1 Turbot in Subarea IV. Key metrics from the assessment model results: spawner stock biomass (top left), fishing mortality (top right) and recruitment (bottom). The best estimate (solid line) and 95% confidence limits (dashed lines) are plotted.

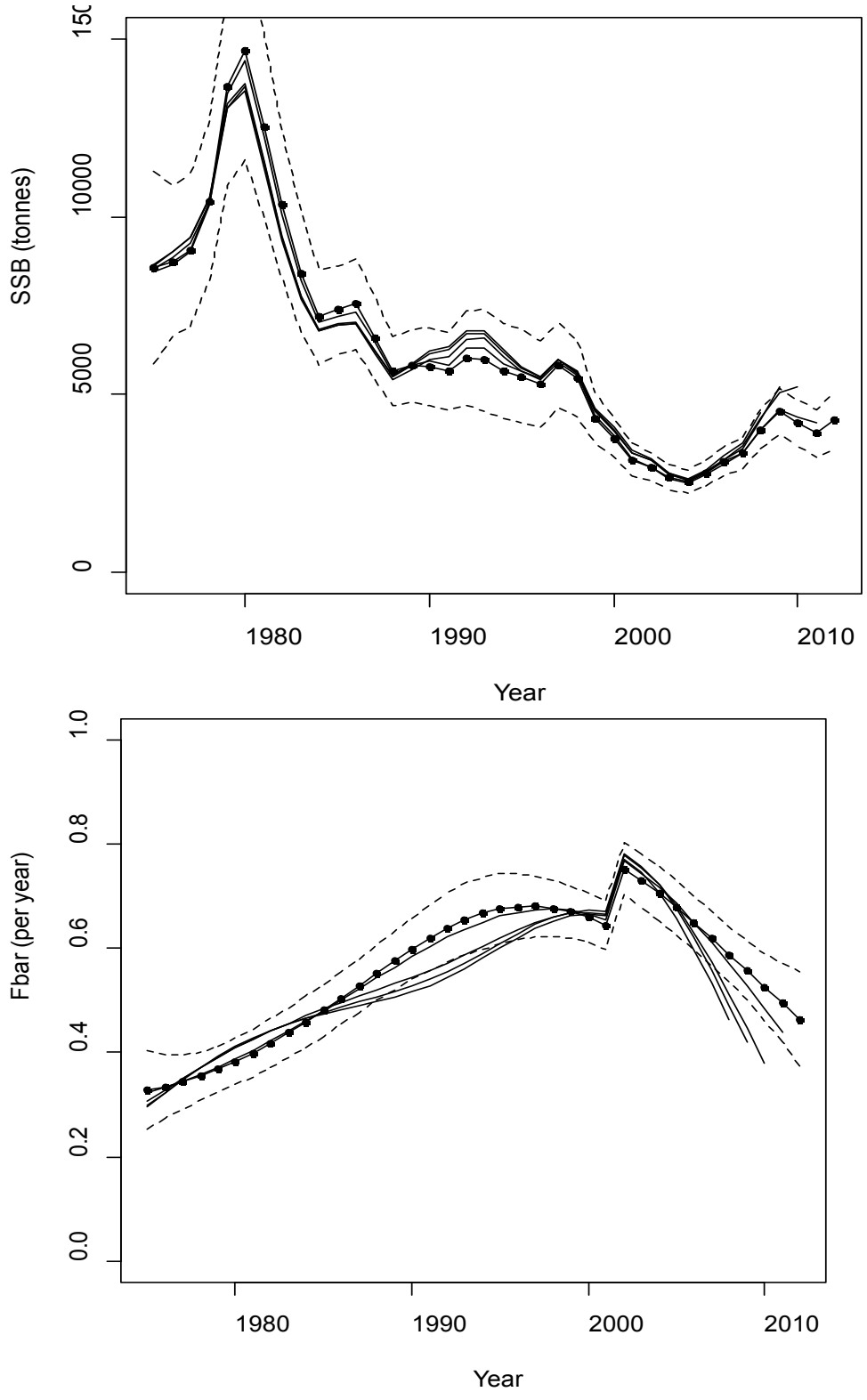


Figure 18.4.2 Turbot in Subarea IV. Retrospective analysis of the key metrics from the assessment model results: spawner stock biomass (top), fishing mortality (bottom) and recruitment (next page). The current assessment (line with points), uncertain bounds from the current assessment (dashed lines) and five retrospective 'peels' (plain lines) are shown.

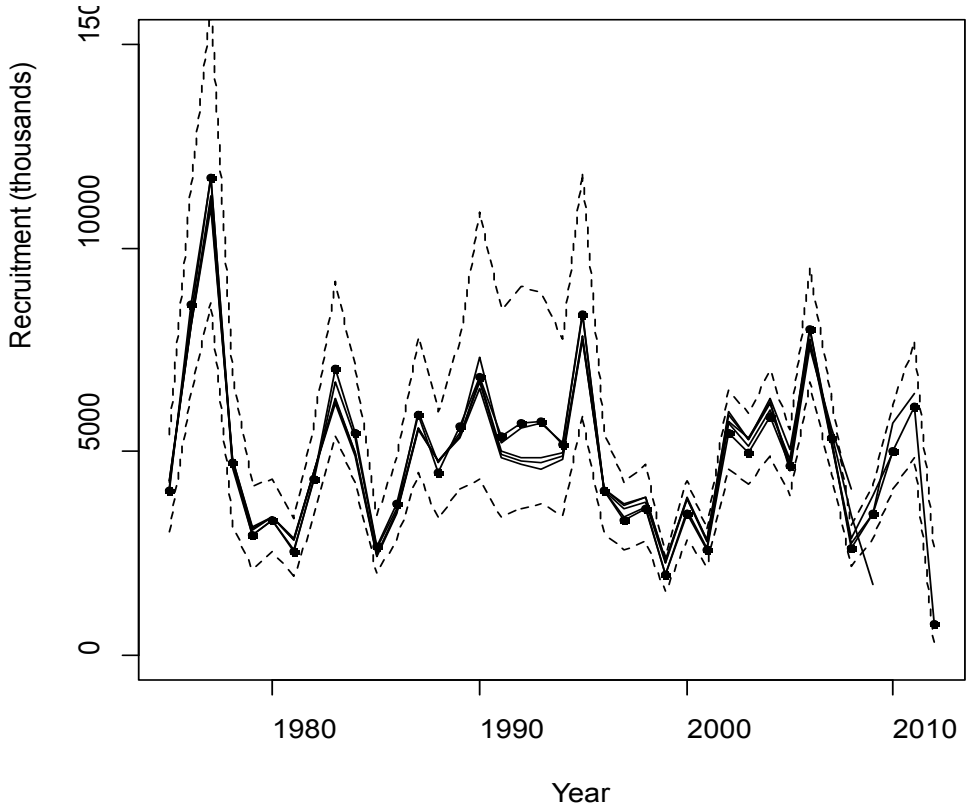


Figure 18.4.2. cont. Turbot in Subarea IV. Retrospective analysis of the key metrics from the assessment model results: spawner stock biomass, fishing mortality (previous page) and recruitment. The current assessment (line with points), uncertain bounds from the current assessment (dashed lines) and five retrospective 'peels' (plain lines) are shown.

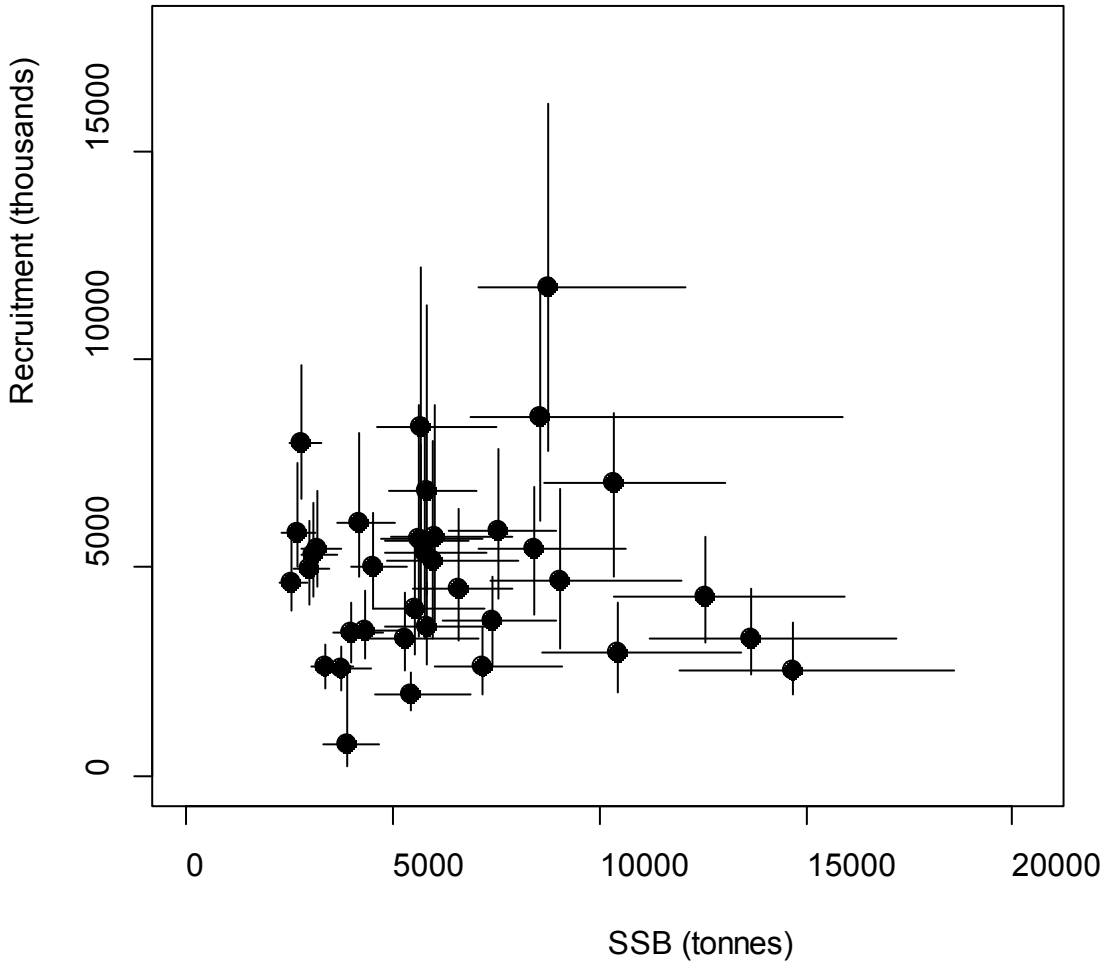


Figure 18.5.1. Turbot in Subarea IV. Stock-recruitment plot from the assessment model results, including uncertainty in SSB and recruitment estimation.

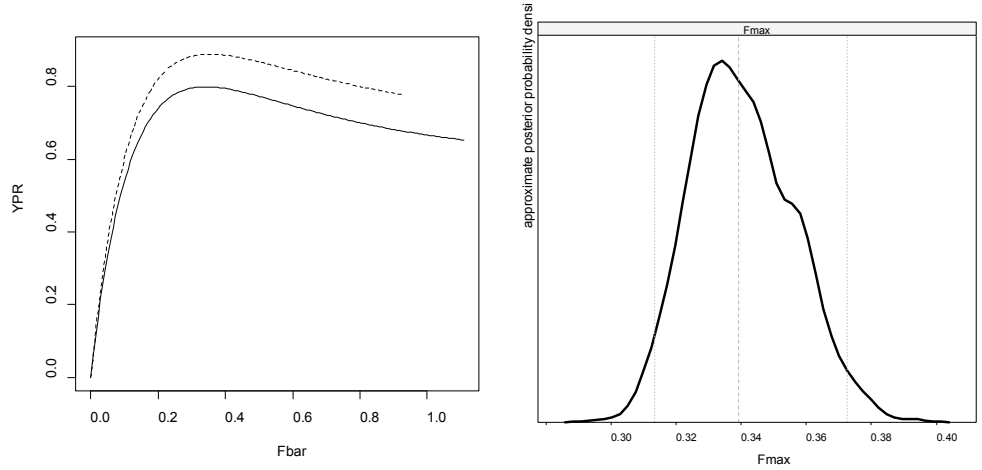


Figure 18.5.2 Turbot in Subarea IV. Left: Yield per recruit curves assuming the selectivity pattern prior to 2002 (dashed line) and assuming the selectivity pattern for 2002-present (solid line). Right: The probability distribution of the value of Fmax from MCMC analyses (ICES 2012a).

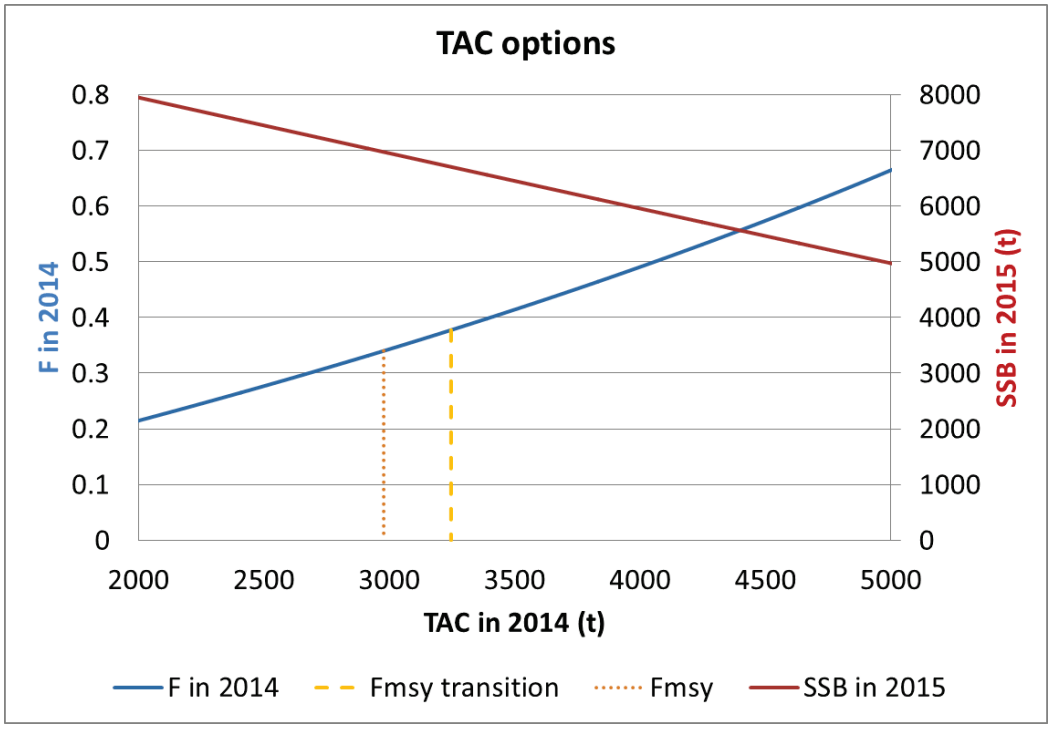


Figure 18.6.1 Turbot in Subarea IV. The impact of the chosen TAC in 2014 on the expected F in 2014 (blue, left axis) and resultant SSB in 2015 (red, right axis). The yellow lines indicate the TACs that would result from applying either F_{MSY} or the transition to F_{MSY} in 2014.

19 WGNEW Stocks

During the WGNEW meeting in March 2013, advice sheets were drafted for several flatfish stocks relevant for the WGNSSK 2013 (Table 19.1). All of these stocks were classified as category 3 stocks following the guidelines of the ICES Data Limited Stocks methodological document (draft version 2012).

For all of the WGNEW stocks, official landings data by area and country and different survey abundance indices were available. Dab (*Limanda limanda*), flounder (*Platichthys flesus*), lemon sole (*Microstomus kitt*) and witch flounder (*Glyptocephalus cynoglossus*) landings decreased in the recent decade due to a reduction of fishing effort. A similar trend was observed for turbot (*Psetta maximus*) in IIIa, but in this case landings in 2012 sharply increased. The landings of brill (*Scophthalmus rhombus*) were more or less stable over the last decade. Landings for turbot and brill seem to be a good proxy for catches as these species are valuable bycatch species and therefore discard rates are assumed to be negligible. This is in contrast to dab and flounder for which discard rates are known to be very high and variable. However, in the latter case discards were not quantified yet, because more data compilation is needed for this task.

Due to high variability in all available survey abundance indices, it was decided to fit smoother functions (R *lowess* function with f=0.5) to detect stock trends for dab, flounder, lemon sole, witch flounder, and turbot in IIIa (Figure 19.1).

Dab abundance index (Figure 19.1.a) increased since the mid-eighties and fluctuated with high variability on a relatively high level during the last two decades. The fitted smoother function indicates a slight increase in stock trend for the last decade. As there are quite a lot dab data available, age readings as well as discard rates, it was decided to include dab into the official data call in 2014. A comprehensive data compilation is needed to raise discards and to estimate total catch.

A similar trend was observed for flounder in Subarea IV (Fig. 19.1.b) with two peaks in abundance in the late eighties/early nineties followed by a decrease until 2002. Since then, flounder abundance index increased again and is relatively stable for the most recent years. The smoother function indicates a slight increase in abundance in recent years. It was decided to include flounder into the official data call in 2014.

For lemon sole, the available survey information indicates that mature biomass is variable without trend and has been at a high level in recent years (Figure 19.1.c). However, the smoother function indicates a slight decreasing trend in stock abundance for the last decade.

Abundance indices for witch flounder show a declining trend since the peak observed in 2000, followed by an increase in the most recent years (Figure 19.1.d). For witch flounder an exploratory XSA was performed in Division IIIa which indicate that fishing mortality is above potential F_{MSY} proxies for this stock (ICES WGNEW, 2013).

For turbot in Divison IIIa the survey based abundance index is highly variable, but with a declining trend in the smoother function (Figure 19.1.e). Additional information from historical survey data were used for turbot to estimate relative biomass taking into account assumptions about technology creep (Cardinale et al. 2009). This recent analysis has shown that turbot biomass in IIIa might have declined quite substantially and is on a stable but low level for recent years.

In the case of brill (Sub area IV) catch per unit effort from surveys was too low and variable to derive any reliable stock trend. Therefore, an additional index based on landings per unit effort from the Dutch beam trawl fleet was estimated which indicates an increasing stock trend.

Table 19.1: WGNEW stocks relevant for WGNSSK 2013

FISH STOCK	STOCK NAME	STOCK COORDINATOR
bll-nsea	Brill in Subarea IV and Divisions IIIa and VIId, e	Belgium (Kelle Moreau)
dab-nsea	Dab in Subarea IV and Division IIIa	Germany (Holger Haslob)
fle-nsea	Flounder in Subarea IV and Division IIIa	Netherlands (Tessa van der Hammen)
lem-nsea	Lemon sole in Subarea IV and Division IIIa and VIId	United Kingdom (Bill Lart)
wit-nsea	Witch in Subarea IV, Division IIIa and VIId	Sweden (Francesca Vitale)
tur-kask	Turbot in Division IIIa	Sweden (Francesca Vitale)

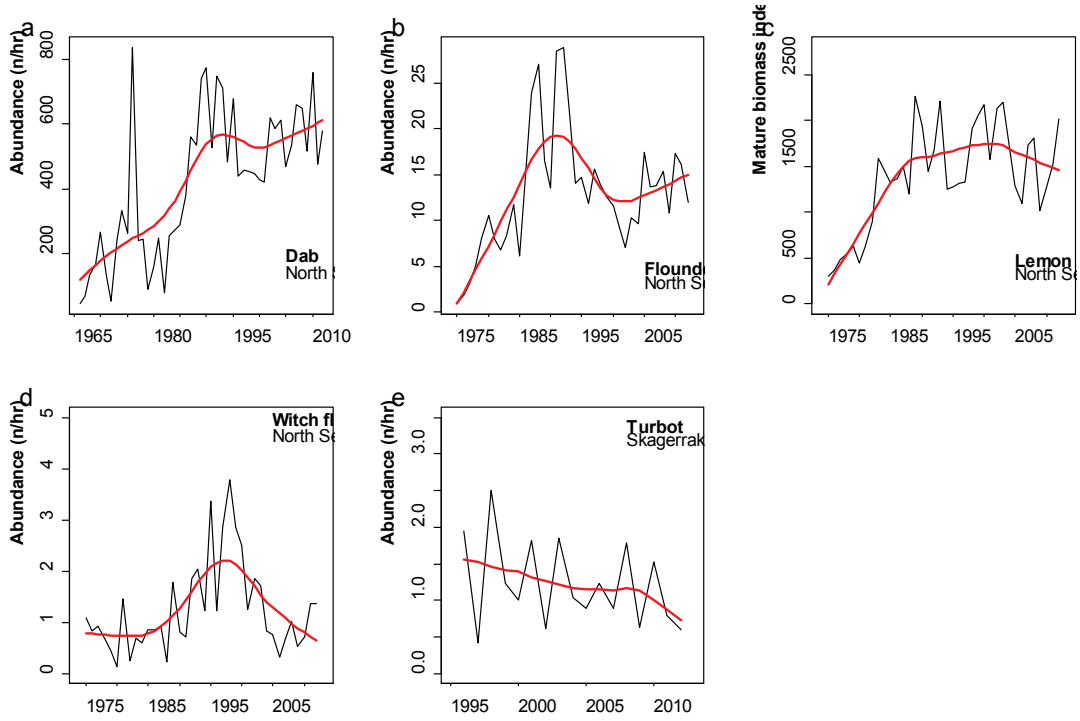


Figure 19.1 Smoother functions fitted to abundance indices. (a) Dab IBTS q1 in Subarea IV, (b) flounder IBTS q1 in Subarea IV and Division IIIa, (c) lemon sole IBTS q1 in Subarea IV, (d) witch flounder IBTS q1 in Subarea IV, (e) turbot BITS q1 in Division IIIa. All smoother functions were created with the R function *lowess* with f=0.5.

20 EU Norway requests

20.1 EU request on changing the TAC year for Norway pout in the North Sea

Request

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 the light of this, ICES is asked to again evaluate a management strategy based on the existing ICES escapement strategy, but where the TAC year is changed to 1 November – 31 October rather than 1 January – 31 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.

The evaluation

Preliminary results were presented at the WG (Vinther and Nielsen, 2013). The analysis was based on settings very similar to the ICES assessment from September 2012, with a quarterly time-step, but was implemented with a different assessment model (SMS) which allows uncertainty in the outputs to be quantified. This leads to only minor differences with the ICES assessment. The internal SMS population structure is used to project the population forward, under application of different management strategies. Forward simulations use historical averages of weights-at-age and exploitation patterns by age and quarter. Future recruitments are generated stochastically around a hockey-stick, with inflection point at B_{lim}, fit to the historically observed stock–recruitment values. The stochastic distribution is Normal (in logarithmic scale), constrained to deliver values within 2 standard deviations, to better match the observed recruitments. Assessment errors were included in the MSE loop by generating a perceived population stochastically around the true population. The simulations start in 2013 and no implementation error was assumed. However, when catching the TAC would lead to an annual F in excess of 0.6 (split into F = 0.28 for the quarter 4 of the year and F = 0.32 for quarters 1–3), this value is imposed as an F ceiling and the full TAC is not taken. The situation where a ceiling on F is imposed directly as part of the harvest control rule, instead of on the realized F, was also tested.

The MSE uses quarterly time steps which do not align with the suggested TAC year, 1 November–31 October. It was not possible to change the quarterly time steps used by the software so the implemented TAC year in the simulations was actually 1 October–30 September.

The evaluation concluded that an escapement strategy based on an escapement biomass of 150 kt, modified to include a minimum TAC higher than zero and a ceiling on the TAC, and with a TAC year from 1 November to 31 October, is in accordance with the precautionary approach and leads to sustainable yields, under the following conditions:

The minimum TAC should not exceed 20 kt. The harvest control rule requires a ceiling on F (to be applied when the TAC is set higher than the minimum TAC) in order to be precautionary. If the ceiling for the TAC is set at 200 kt, then the ceiling on F should be no higher than 0.6. If the ceiling for the TAC is set at 100 kt, then the ceiling on F should be no higher than 0.8.

Moving the TAC year to 1 November–31 October, based on annual advice in October, is considered to have limited influence on long-term yield, stock sizes, and probability of low stock biomass.

Source:

ICES. 2013. EU request on changing the TAC year for Norway pout in the North Sea. Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.3.5.1.

Vinther, M., and Nielsen, J. R. 2013. Evaluations of management strategies for Norway pout in the North Sea and Skagerrak. ICES CM 2013/ACOM: 66.

20.2 EU request on interannual quota flexibility for plaice in the North Sea

Request

The EU long term management plan for plaice and sole in the North Sea has been in force since 2007 (Regulation (EC) No 676/2007). It was envisaged that this plan would be revised once both stocks had been brought within precautionary limits for two consecutive years, but it was decided to maintain the existing harvest control rules pending consultations with Norway for an agreed EU-Norway management plan for plaice, or for a jointly agreed mixed fisheries plan for the North Sea. As an interim measure, the Commission has nevertheless proposed that fishing effort on sole and plaice can be maintained at its 2012 level.

In order to explore possible options for further changes to the existing plan, ICES is requested to evaluate the impact of an inter-annual quota flexibility of +/-10% (for plaice only) on the performance of the plan with respect to long term yield and risk. For the purpose of this exercise, ICES should assume that the fishing effort ceiling for the sole and plaice fisheries will be maintained at its 2012 level.

The evaluation

The basis for the evaluation was presented at the WG. The evaluation (Brunel and Miller, 2013) concluded that the multiannual management plan is robust to inclusion of interannual quota flexibility in terms of the probability of the stock biomass falling below B_{lim}, and without substantial changes in average yield. This conclusion is conditional on the interannual quota flexibility being suspended when the stock is estimated to be outside safe biological limits.

Sources

Brunel, T., and Miller, D. C. M. 2013. An Evaluation of the Impact of Interannual Quota Flexibility (Banking and Borrowing) on the Performance of the North Sea Flatfish Long-Term Management Plan. ICES CM 2013/ACOM:64.

ICES.2013. EU request on interannual quota flexibility for plaice in the North Sea. Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.3.5.3

20.3 EU request on interannual quota flexibility for saithe in the North Sea

Request

In 2012, the EU and Norway submitted the following request ICES to evaluate a number of options for revising the jointly agreed long term management plan for saithe.

"In accordance with point 5.3.3 of the Agreed record of Fisheries Consultations between Norway and the European Union for 2012, signed on 2 December 2011, it was agreed to convene a seminar on long term management plans. The objective of this seminar was to establish the basis for further developing long-term management plans for joint stocks.

Based on the most recent assessment of the stock of saithe in ICES Subarea IV, Division IIIa and Subarea VI, ICES is requested to conduct an evaluation, by 1 October 2012, of the current harvest control rule with the following variations:

1. *Applying the current management plan unchanged.*
2. *Applying the harvest control rule with no TAC stability mechanism.*
3. *Applying the HCR with the following stability mechanisms when the SSB is above Blim:*
    a) *Setting a TAC in the TAC year based on the average of the projected TACs at target F over three years starting with the TAC year.*
    b) *Setting the TAC to be the average of the current TAC and the TAC that would result from the application of the HCR for the TAC year.*
    c) *Applying a TAC constraint of +/- 15%, but where the resulting fishing mortality is not allowed to deviate by more than 15%, 20% or 25% from the target F.*
4. *Applying the HCR with the above mentioned stability mechanisms, but applying them only when the stock is above Bpa.*
5. *Allowing an inter-annual quota flexibility of +/- 10%*

ICES delivered its response in November 2012, but due to time constraints did not evaluate the impact of an inter-annual quota flexibility of +/- 10%. ICES is therefore requested to complete its evaluations with the inclusion of inter-annual quota flexibility.

The evaluation

The basis for the evaluation was presented at the WG. The evaluation concluded that the evaluated harvest control rules are robust to the inclusion of interannual quota flexibility in terms of the probability of the stock biomass falling below Blim, and without substantial changes in average yield. This conclusion is conditional on the interannual quota flexibility being suspended when the stock is estimated to be outside safe biological limits. ICES repeats its 2012 advice that the management plan should be re-evaluated no later than 2016.

Sources

De Oliveira, J. 2013. Evaluation of a banking and borrowing scheme for saithe – Addendum to De Oliveira *et al.* (2012) "North Sea saithe management strategy evaluation". ICES CM 2013/ACOM:65

ICES 2013. EU request on interannual quota flexibility for saithe in the North Sea. . Report of the ICES Advisory Committee, 2013. ICES Advice, 2013. Book 6, Section 6.3.5.4.

20.4 Joint EU-Norway request on the impact of a discard ban and new technical measures in Skagerrak

NB – this request was withdrawn after the working group

Request

The European Union and Norway have agreed that a discard ban should be implemented in the Skagerrak (Division III a N) from 1 January 2013. However the legislative process implementing the ban in the waters of the Union will only be finalized during the course of 2013. Therefore the ban would apply in the Union's waters from 1st of January 2014.

It has also been agreed that new technical measures should be implemented from 01 January 2013. These measures will be applicable in the Union's waters of the Skagerrak from 1st of February 2013.

The technical measures to be implemented are:

a) Pandalus fisheries

1. *No change to the current cod end minimum size of 35 mm.*
2. *Mandatory use of a sorting grid with a maximum bar spacing of 19mm.*
3. *Allowing use of a fish retention device provided that there are adequate fishing opportunities to cover by-catch and that the retention device is:*
    a. *Constructed with a top panel of a minimum mesh size of 120 mm square mesh;*
    b. *A minimum of 3 metres in length.*
    c. *At least as wide as the width of the sorting grid.*

b) Directed Nephrops fisheries

Mandatory use of sorting grid (35mm bar spacing) together with a square mesh cod end with a minimum mesh size of 70 mm.

c) Mixed demersal trawl and seine and Mixed Nephrops/demersal fisheries

1. *The basic cod end minimum mesh size for these fisheries should be 120 mm diamond mesh.*
2. *Allowing a derogation with the use of a 90 mm cod end together with a square mesh panel of 140 mm or a diamond mesh panel of 270 mm where in both cases the panel is:*
    a. *A minimum of 3 metres in length.*
    b. *The panel should be positioned no more than 4 metres from the cod line.*
    c. *Be the full width of the top sheet of the trawl (i.e. from selvedge to selvedge): and*

d. *In the case of the diamond mesh, the panel be placed in a four panel section and mounted with a joining ration of 3 meshes of 90 mm to 1 mesh of 270 mm.*

The European Union and Norway have agreed that, for those species (stocks) where a discard ban is implemented, all catches should be accounted against the quotas concerned. This means that the quota set for the stocks concerned should reflect the total catch and not only the landings.

In addition to the implementation of a discard ban for cod, haddock, whiting, saithe, herring, mackerel, Pandalus borealis, sprat, hake, ling, monkfish, pollack, blue ling, tusk and grenadier, a decrease in the EU minimum landing size for Nephrops is envisaged.

ICES is requested to advise on:

1. *Estimate the impact of the technical measures in 2013 and discard ban to be implemented in 2014, on the total catch (i.e. landings and fish that would have been discarded in the absence of a discard ban) of cod, haddock, whiting, saithe, herring, mackerel, Pandalus borealis, sprat, hake, ling, blue ling, tusk and grenadier in the Skagerrak. Discard rate changes over time should be presented in weight where possible.*

The proportions of the EU catches of Nephrops in the Skagerrak above and below minimum landing size in 2012, and would be expected in 2013, if the above mentioned technical measures are implemented and the EU minimum landing size was i) unchanged or ii) 110 mm or iii) 100, or iv) 85 mm.

Evaluation

Preliminary ideas on how to answer the request were discussed in the group.

For *Nephrops*, the idea is to compile the selectivity parameters from the newly legislated 70 mm square mesh codends and the different Seltra trawls (90 mm diamond mesh). Applying the new selectivity properties from the suggested *Nephrops* trawls on recent *Nephrops* size distributions makes it possible to estimate the new discard rates.

Further work is needed to plan the full evaluation.

Annex 1 – List of Participants

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

24 - 30 April 2013

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Annex 2 Update Forecasts and Assessments

2.1 Summary

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak [WGNSSK] (Chair: Clara Ulrich, DK) 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 2013 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.

A major update in 2013 is that 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 both whiting in North Sea and Eastern Channel, and *Nephrops* FU6 (Farn Deeps). For whiting, updated advice would imply a 10% reduction in the TAC for Subarea IV, compared with a 2% reduction in the ICES advice presented in June. For *Nephrops* FU6, the new advice would be 13% lower than the advice presented in June.

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 Division IIIa

2.3.1 New survey information

The new data available for a potential autumn forecast are the third-quarter groundfish surveys carried out by Scotland (ScoGFS) and England (EngGFS), and the international third-quarter IBTS survey (IBTS Q3). The latter is not used in the haddock assessment or forecast, and is not considered further here. The full available dataset for the ScoGFS and EngGFS 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 2013), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008). At the time of writing, a new ICES workshop (WKUP) is being planned to reconsider how updates of assessments and advice should be conducted, but as this is due to meet in November 2013 the approach defined by AGCREFA is continued here.

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 (2013) 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 2013 year-class at age 0	
Log WAP from RCT3 (R)	7.77
Log of recruitment assumed in spring (A)	8.04
Int SE of log WAP (S)	0.31
Distance D $\left(D = \frac{R - A}{S}\right)$	**-0.85**

Conclusions from protocol

As the distance -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea haddock should not be reopened.** The autumn indices suggest that the size of the incoming year-class is slightly smaller (but not significant so) than what had been assumed in the forecast produced by WGNSSK in May 2013.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2013). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2013/ACOM:13.

Table 2.3.1. Haddock in Sub-Area IV and Division IIIa. Indices from the third-quarter English (EngGFS) and Scottish (ScoGFS) groundfish survey series. New data from autumn 2013 are highlighted.

EngGFS							
1992	2013						
1	1	0.5	0.75				
0	6						
100	246.059	58.746	29.133	1.742	0.146	0.037	0.251
100	40.336	73.145	17.435	4.951	0.176	0.048	0.000
100	279.344	23.990	26.992	2.511	0.894	0.058	0.003
100	53.435	113.775	13.223	11.032	0.827	0.275	0.021
100	61.301	26.747	43.044	3.603	2.052	0.207	0.088
100	40.653	45.346	12.608	19.968	0.719	0.718	0.067
100	15.747	26.497	16.778	4.079	4.141	0.226	0.141
100	626.610	16.551	8.404	3.663	1.258	1.201	0.040
100	92.139	249.813	4.528	1.634	0.740	0.336	0.350
100	1.097	28.622	96.498	3.039	0.828	0.350	0.135
100	2.721	3.954	22.559	60.583	0.542	0.097	0.153
100	3.199	6.015	1.247	13.967	45.079	0.719	0.026
100	3.398	6.599	3.864	0.448	6.836	17.406	0.217
100	122.383	9.740	5.992	2.584	1.249	6.617	3.654
100	12.838	54.403	3.226	1.137	0.426	0.148	0.861
100	8.463	10.628	43.401	1.402	0.624	0.092	0.078
100	2.613	6.494	5.801	18.534	0.727	0.266	0.137
100	28.978	5.532	6.781	4.636	7.147	0.108	0.099
100	3.065	46.229	2.959	2.103	2.175	3.716	0.284
100	0.549	2.792	32.592	1.785	1.396	1.168	3.147
100	4.004	1.355	2.630	16.465	0.511	0.416	0.762
100	2.064	3.346	0.846	0.940	8.749	0.257	0.282

ScoGFS							
1998	2013						
1	1	0.5	0.75				
0	6						
100	3280	6349	1924	490	511	24	18
100	66067	1907	1141	688	197	164	6
100	11902	30611	460	221	130	73	27
100	79	3790	11352	179	65	40	18
100	2149	675	2632	6931	70	37	18
100	2159	1172	307	2092	4344	22	17
100	1729	1198	547	101	819	1420	9
100	19708	761	657	153	112	347	483
100	2280	7275	272	158	33	14	73
100	1119	1810	5527	117	57	11	5
100	1885	733	1002	2424	28	24	6
100	9015	877	547	469	1185	37	8
100	115	8328	680	297	303	811	4
100	317	252	5192	284	127	101	284
100	580	69	270	1766	66	47	41
100	272	1020	225	163	1387	28	28

Table 2.3.2. Haddock in Sub-Area IV and Division IIIa. RCT3 input file. Data from surveys in autumn 2013 are highlighted.

YEARCLASS	RECRUITMENT	IBTS1	IBTS2	EGFS0	EGFS1	EGFS2	SGFS0	SGFS1	SGFS2
1981	32573.237	NA	403.079	NA	NA	NA	NA	NA	NA
1982	20481.167	302.278	221.275	NA	NA	NA	NA	NA	NA
1983	66907.115	1072.285	833.257	NA	NA	NA	NA	NA	NA
1984	17177.582	230.968	266.912	NA	NA	NA	NA	NA	NA
1985	23909.178	573.023	328.062	NA	NA	NA	NA	NA	NA
1986	48938.701	912.559	677.641	NA	NA	NA	NA	NA	NA
1987	4142.071	101.691	98.091	NA	NA	NA	NA	NA	NA
1988	8335.95	219.705	139.114	NA	NA	NA	NA	NA	NA
1989	8599.596	217.448	134.076	NA	NA	NA	NA	NA	NA
1990	28285.263	680.231	331.044	NA	NA	29.133	NA	NA	NA
1991	27405.41	1141.396	519.521	NA	58.746	17.435	NA	NA	NA
1992	41659.387	1242.121	491.051	246.059	73.145	26.992	NA	NA	NA
1993	13021.649	227.919	201.069	40.336	23.99	13.223	NA	NA	NA
1994	55427.392	1355.485	813.268	279.344	113.775	43.044	NA	NA	NA
1995	13954.774	267.411	353.882	53.435	26.747	12.608	NA	NA	NA
1996	21227.007	849.943	420.926	61.301	45.346	16.778	NA	NA	1924
1997	12600.705	357.597	222.907	40.653	26.497	8.404	NA	6349	1141
1998	9874.593	211.139	96.075	15.747	16.551	4.528	3280	1907	460
1999	133501.618	3482.017	2255.213	626.61	249.813	96.498	66067	30611	11352
2000	25617.352	894.651	473.628	92.139	28.622	22.559	11902	3790	2632
2001	2728.46	57.312	39.267	1.097	3.954	1.247	79	675	307
2002	3585.892	89.991	79.617	2.721	6.015	3.864	2149	1172	547
2003	3749.453	71.877	60.982	3.199	6.599	5.992	2159	1198	657
2004	3608.535	69.697	38.742	3.398	9.74	3.226	1729	761	272
2005	42003.728	766.995	304.067	122.383	54.403	43.401	19708	7275	5527
2006	9049.36	66.313	106.461	12.838	10.628	5.801	2280	1810	1002
2007	5523.197	60.047	139.651	8.463	6.494	6.781	1119	733	547
2008	4090.983	74.725	71.685	2.613	5.532	2.959	1885	877	680
2009	30449.019	686.401	772.907	28.978	46.229	32.592	9015	8328	5192
2010	2173.968	46.375	55.952	3.065	2.792	2.63	115	252	270
2011	NA	14.468	23.398	0.549	1.355	0.846	317	69	225
2012	NA	58.261	NA	4.004	3.346	NA	580	1020	NA
2013	NA	NA	NA	2.064	NA	NA	272	NA	NA

Table 2.3.3. Haddock in Sub-Area IV and Division IIIa. RCT3 output file.

```
Analysis by RCT3 ver4.0

Haddock

Data for 8 surveys over 33 years : 1981 - 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
    ibts1 0.9369     4.210 0.3378  0.9127 29      NA         NA      NA          NA
    ibts2 1.1056     3.586 0.3366  0.9121 30      NA         NA      NA          NA
    egfs0 0.6513     7.372 0.3219  0.9324 19  0.7247      7.844   0.364      0.8299
    egfs1 0.9634     6.515 0.2353  0.9616 20      NA         NA      NA          NA
    egfs2 1.0466     6.972 0.3357  0.9228 21      NA         NA      NA          NA
    sgfs0 0.7610     3.146 0.6762  0.7906 13  5.6049      7.412   0.804      0.1701
    sgfs1 0.9872     1.619 0.3980  0.9094 14      NA         NA      NA          NA
    sgfs2 1.0588     1.803 0.3841  0.9115 15      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 30      NA      9.576   1.065      0.0000

               WAP logWAP int.se
yearclass:2013 2369   7.77 0.3166
```

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) and the autumn Norwegian acoustic survey (NORACU). The full 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 2013 data for age 3.

```
IBTS-Q3
   1991   2013
      1      1    0.5   0.75
      3      5
      1  1.946  0.402  0.064
      1  1.077   2.76  0.516
      1  7.965  2.781  1.129
      1  1.117  1.615  0.893
      1 13.959  2.501  1.559
      1  3.825  6.533  1.112
      1  3.756  3.351  7.461
      1  1.027  3.921  1.333
      1    2.1  2.019  2.949
      1  3.479  8.836  1.081
      1 21.496  6.173  3.937
      1 10.748 18.974  1.327
      1 19.272 23.802 13.402
      1  4.979  6.896  3.158
      1  8.893   6.87  4.994
      1 10.636  29.82  2.934
      1 34.018  5.594 11.763
      1  3.467   5.86  1.122
      1  1.346  1.703  0.568
      1  1.365  0.962  0.465
      1  4.541  8.496  1.067
      1 11.106  2.521  2.799
      1 12.047 16.964  0.972
```

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 2013). 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     20      2
   1991 104109   -11  1.117
   1992 228903 56244 13.959
   1993 113491 21480  3.825
   1994 164641 22585  3.756
   1995  71510 15180  1.027
   1996 143682 16933    2.1
   1997  96723 34551  3.479
   1998 228431 72108 21.496
   1999 194694 82501 10.748
   2000 129410 67774 19.272
   2001 100905 34153  4.979
   2002 191674 48446  8.893
   2003  64356 18909 10.636
   2004 113814 77958 34.018
   2005  68029  7122  3.467
   2006  54114   -11  1.346
   2007 128045 34953  1.365
   2008  61662 18118  4.541
   2009  37432  3232 11.106
   2010    -11 10023 12.047
NORACU
IBTS Q3
```

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 2013.txt
RCT3 input for D calculations for  Saithe in Subareas IV, VI and Division IIIa
Data for 2 surveys over 20 years :  1991 - 2010

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.

Year-class = 2010

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

  NORACU   0.63   5.14   0.36  0.715     17   9.21   10.92    0.428    0.603
  IBTSq3   2.36   6.72   2.08  0.069     19   2.57   12.79    2.415    0.019

                                       VPA Mean =   11.46    0.540    0.378

 Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class     Average      WAP     Std     Std    Ratio             VPA
          Prediction           Error   Error

 2010 70097.000000     11.16    0.33    0.25     0.55
```

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)	11.16
Log of recruitment assumed in spring (A)	11.67
Int SE of log WAP (S)	0.33
Distance $D = (R - A)/S$	-1.54

2.4. Conclusions from protocol

The RCT3 analysis estimate of D was -1.54, indicating recruitment was less than expected from the spring assumptions and, following the AGCREFA protocol, the advice should normally be reopened. However, since the advice for saithe from spring was already constrained by the -15% change in TAC, a lower recruitment would not decrease the advice any further down. The advice for saithe would only have been reopened and updated if the distance (D) estimated for age 3 would have been significantly positive ($D > 1.0$).

An RCT3 analysis for age 4 was also explored and indicated contradictory results; the D estimate indicated the age 4 2009 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, the signal from the IBTS Q3 survey was not in agreement with that from the NORACU survey, 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 un-

clear 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 (2013). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2013/ACOM:13.

2.5 Whiting in Subarea IV and VIID

2.5.1 New survey information

The new data available for a potential autumn forecast are the third-quarter groundfish surveys carried out by Scotland (ScoGFS) and England (EngGFS), and the international third-quarter IBTS survey (IBTS Q3). The first two of these are not used in the whiting assessment or forecast, and are not considered further here. 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 2013), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008). At the time of writing, a new ICES workshop (WKUP) is being planned to reconsider how updates of assessments and advice should be conducted, but as this is due to meet in November 2013 the approach defined by AGCREFA is continued here.

During data collation for the application of the update protocol, it became clear that the RCT3 analysis for estimating the strength at age 1 of the 2012 year-class had been carried out incorrectly at the May meeting of WGNSSK. Specifically, the IBTS Q1 data had been erroneously shifted backwards one year (so that the survey index for the 1990 year class at age 1 was used in the analysis for the 1989 yearclass at age 1, and so on). This mistake has been corrected in the RCT3 input data collated for the October analysis. It is also of interest to determine whether the decision to revise the forecast or not would have been different had the correct dataset been used in May, so the following summarises the results of (and comparisons between) RCT3 runs based on three datasets: *May*, *May corrected*, and *October*.

RCT3 analysis

Based on the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), three RCT3 analyses were run to provide an estimate of the abundance of the incoming (2012) year-class at age 1. The RCT3 input and output files for the *October* run are given in Tables 2.5.2 and 2.5.3.

Update protocol calculations

The outcome of the application of the protocol was as follows. Comparing the *May* and *October* datasets, we see that:

Calculations for 2012 year-class at age 1	
Log WAP from RCT3 *October* (R)	13.93
Log WAP from RCT3 May (A)	14.58
Int SE of log WAP from RCT3 *October* (S)	0.1767
Distance D $\left(D = \frac{R-A}{S}\right)$	**-3.68**

Comparing the *May corrected* and *October* datasets, we see that:

Calculations for 2012 year-class at age 1	
Log WAP from RCT3 *October* (R)	13.93
Log WAP from RCT3 *May corrected* (A)	14.14
Int SE of log WAP from RCT3 *October* (S)	0.1767
Distance D $\left(D = \frac{R-A}{S}\right)$	**-1.19**

Conclusions from protocol

For both comparisons, the distance D < -1.0. For the *May-October* comparison, this is mostly because the IBTS Q1 data was incorrectly backshifted by one year. This meant that the forecast for the 2012 year-class at age 1 was largely dependent on the IBTS Q3 age-0 index value from 2012, and in this case this led to a positive bias in the 2012 year-class forecast. It should also be noted that the IBTS Q3 index for age-1 in 2013 is less than the regression model predicted. The latter factor is the reason for the reduced prediction in the *May corrected-October* comparison, although this is only included here for information as the ICES advice presented in July was based on the *May* dataset.

Given that the distance D < -1.0, the protocol concludes that **the advisory process for North Sea whiting should be reopened.** The autumn indices suggest that the size of the incoming year-class is smaller than what had been assumed in the forecast produced by WGNSSK in May 2013. This conclusion would still have been reached if the correct dataset had been used in the May forecast.

Revised forecast

The updated RCT3 analysis presented above indicated that the estimate of the 2012 yearclass at age 1 (in 2013) in the forecast should be reduced to 1119 million (compared with 2140 million used in the *May* dataset). This new value was used in a short-term forecast which was otherwise unchanged (see ICES-WGNSSK 2013 for details).

Input data for short-term forecasts is given in Table 2.5.4, while the output is summarised in the management options in Table 2.5.5. Assuming mean F_{2013} to equal mean F_{2012} results in human consumption landings in 2013 of 17282 t from a total catch of 25343 t, giving an SSB in 2014 of 234337 t (a decrease from the 2013 value of 271882 t). Carrying the same fishing mortality forward into 2014 (the status quo F option) would result in landings of 15649 t out of total catches of 23473 t, and would result in

an SSB of 298971 t in 2015 (an increase of 28%). Applying the proposed target F (0.225) from the management plan to the stock in 2014 would generate landings of 22370 t out of total catches of 33249 t, and result in an SSB of 290907 t in 2015 (a 24% increase). The revised landings forecast for 2014 indicates a 10% reduction in the TAC for Subarea IV, compared with a 2% reduction in the ICES advice presented in July.

References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2013). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2013/ACOM:13.

Table 2.5.1. Whiting in Sub-Area IV and Division VIId. Indices from the third-quarter IBTS groundfish survey series. New data from autumn 2013 are highlighted.

	0	1	2	3	4	5	6
1991	536.99	703.368	158.594	79.024	14.568	5.183	1.018
1992	1379.459	600.867	296.1	72.451	57.498	10.273	6.212
1993	919.193	638.722	177.377	66.118	14.711	15.904	3.039
1994	610.743	677.645	219.541	74.71	19.506	4.722	3.16
1995	729.246	619.786	291.18	107.195	21.512	6.013	3.464
1996	316.501	545.708	278.218	129.356	34.003	6.893	4.1
1997	2062.67	332.968	180.681	108.985	28.006	10.711	4.245
1998	2631.69	330.6	150.205	52.766	31.01	11.179	4.695
1999	2498.55	1203.503	190.645	53.932	24.452	9.529	4.179
2000	1968.07	941.658	326.943	64.113	13.625	6.532	4.873
2001	3031.442	645.003	282.32	94.854	19.281	4.315	7.508
2002	264.063	732.137	237.372	125.148	33.96	5.275	2.76
2003	363.406	246.155	302.054	134.824	66.058	16.452	4.663
2004	1012.818	188.577	49.05	75.85	48.675	32.286	14.398
2005	162.592	179.5	70.531	27.609	45.385	29.211	33.929
2006	201.578	172.79	84.975	31.91	13.207	22.853	25.343
2007	821.741	95.645	64.042	37.929	11.604	8.459	20.846
2008	765.057	362.658	68.92	30.973	13.817	4.103	14.82
2009	593.814	585.543	384.805	40.992	12.296	8.038	6.81
2010	509.938	223.603	146.61	56.47	13.118	6.343	7.961
2011	246.898	445.203	143.796	46.864	16.001	6.884	4.652
2012	307.402	258.453	194.624	57.376	19.993	10.564	5.35
2013	268.29	51.63	61.033	48.836	11.058	4.243	1.55

Table 2.5.2. Whiting in Sub-Area IV and Division VIId. RCT3 input file for the *October* run. Data from surveys in autumn 2013 are highlighted.

YEARCLASS	VPA	IBTSQ11	IBTSQ12	IBTSQ30	IBTSQ31	IBTSQ32
1989	5589678	518.936	686.445	-11	-11	158.594
1990	5728263	1007.621	665.714	-11	703.368	296.1
1991	5462339	907.297	522.811	536.99	600.867	177.377
1992	6398115	1075.624	627.406	1379.459	638.722	219.541
1993	6069489	721.709	448.484	919.193	677.645	291.18
1994	5528000	678.59	485.968	610.743	619.786	278.218
1995	3899647	502.361	342.212	729.246	545.708	180.681
1996	2980408	287.733	160.695	316.501	332.968	150.205
1997	4150333	543.117	305.445	2062.67	330.6	190.645
1998	6933390	676.27	460.697	2631.69	1203.503	326.943
1999	8465955	741.49	598.388	2498.55	941.658	282.32
2000	6635602	648.649	343.308	1968.07	645.003	237.372
2001	5725704	557.353	296.422	3031.442	732.137	302.054
2002	1863855	131.035	89.604	264.063	246.155	49.05
2003	1929401	184.472	50.037	363.406	188.577	70.531
2004	2524939	142.047	125.26	1012.818	179.5	84.975
2005	2450362	184.564	150.441	162.592	172.79	64.042
2006	2202521	64.588	205.862	201.578	95.645	68.92
2007	4141709	268.484	295.618	821.741	362.658	384.805
2008	3444175	211.006	225.541	765.057	585.543	146.61
2009	3193385	326.994	336.844	593.814	223.603	143.796
2010	4175681	184.287	578.418	509.938	445.203	194.624
2011	-11	230.452	156.38	246.898	258.453	61.033
2012	-11	49.468	-11	307.402	51.63	-11
2013	-11	-11	-11	268.29	-11	-11

Table 2.5.3. Whiting in Sub-Area IV and Division VIId. RCT3 output file for the *October* run.

```
Analysis 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:2012
index   slope   int     se      rsquare n       pred    se.pred WAP.weights
IBTSq11 0.6614  11.31   0.2539  0.7628  22      3.901   13.89   0.3126  0.3797
IBTSq12 0.7355  11.04   0.2632  0.7496  22      NA      NA      NA      NA
IBTSq30 0.6746  10.73   0.3754  0.608   20      5.728   14.59   0.4166  0.2138
IBTSq31 0.7697  10.58   0.2302  0.801   21      3.944   13.61   0.3022  0.4064
IBTSq32 0.8512  10.87   0.2445  0.7762  22      NA      NA      NA      NA
VPAMean NA      NA      NA      NA      22      NA      15.24   0.4444  0

                WAP     logWAP  int.se
yearclass:2012 1119366 13.93   0.1767
```

Table 2.5.4. Whiting in Sub-Area IV and Division VIId. Short-term forecast inputs.

```
MFDP version 1a
Run: oct01
Time and date: 10:43 09/10/2013
Fbar age range (Total) : 2-6
Fbar age range Fleet 1 : 2-6
Fbar age range Fleet 2 : 2-6


2013
Age     N       M       Mat     PF      PM      SWt
1       1119366 1.57451 0.11    0       0       0.086523
2       485450.4636     0.88681 0.92    0       0       0.193188
3       331264.6577     0.58451 1       0       0       0.279172
4       111405.0066     0.558   1       0       0       0.385106
5       51566.42876     0.55171 1       0       0       0.398129
6       34326.37892     0.55108 1       0       0       0.413145
7       7925.453202     0.56214 1       0       0       0.420868
8       3285.107176     0.58727 1       0       0       0.462072

Catch
Age     Sel     CWt     DSel    DCWt
1       0.002669833     0.13516 0.013553704     0.07643
2       0.041795324     0.2364  0.053112472     0.15814
3       0.072072495     0.33693 0.047770541     0.19522
4       0.105552442     0.46777 0.047662215     0.22971
5       0.108803094     0.44326 0.037784092     0.27936
6       0.152512307     0.50109 0.078772712     0.24023
7       0.191535314     0.47834 0.076556108     0.28035
8       0.220129654     0.49815 0.048090395     0.34433

IBC
Age     Sel     CWt
1       0.002   0.08652
2       0.003   0.19319
3       0.004   0.27917
4       0.006   0.38511
5       0.003   0.39813
6       0.003   0.41314
7       0.004   0.42087
8       0.003   0.46207
```

Table 2.5.4. Whiting in Sub-Area IV and Division VIId. Short-term forecast inputs (cont).

```
2014
Age     N       M       Mat     PF      PM      SWt
1       4139101.341     1.57451 0.11    0       0       0.086523
2       .       0.88681 0.92    0       0       0.193188
3       .       0.58451 1       0       0       0.279172
4       .       0.558   1       0       0       0.385106
5       .       0.55171 1       0       0       0.398129
6       .       0.55108 1       0       0       0.413145
7       .       0.56214 1       0       0       0.420868
8       .       0.58727 1       0       0       0.462072

Catch
Age     Sel     CWt     DSel    DCWt
1       0.002669833     0.13516 0.013553704     0.07643
2       0.041795324     0.2364  0.053112472     0.15814
3       0.072072495     0.33693 0.047770541     0.19522
4       0.105552442     0.46777 0.047662215     0.22971
5       0.108803094     0.44326 0.037784092     0.27936
6       0.152512307     0.50109 0.078772712     0.24023
7       0.191535314     0.47834 0.076556108     0.28035
8       0.220129654     0.49815 0.048090395     0.34433

IBC
Age     Sel     CWt
1       0.002   0.08652
2       0.003   0.19319
3       0.004   0.27917
4       0.006   0.38511
5       0.003   0.39813
6       0.003   0.41314
7       0.004   0.42087
8       0.003   0.46207


2015
Age     N       M       Mat     PF      PM      SWt
1       4139101.341     1.57451 0.11    0       0       0.086523
2       .       0.88681 0.92    0       0       0.193188
3       .       0.58451 1       0       0       0.279172
4       .       0.558   1       0       0       0.385106
5       .       0.55171 1       0       0       0.398129
6       .       0.55108 1       0       0       0.413145
7       .       0.56214 1       0       0       0.420868
8       .       0.58727 1       0       0       0.462072

Catch
Age     Sel     CWt     DSel    DCWt
1       0.002669833     0.13516 0.013553704     0.07643
2       0.041795324     0.2364  0.053112472     0.15814
3       0.072072495     0.33693 0.047770541     0.19522
4       0.105552442     0.46777 0.047662215     0.22971
5       0.108803094     0.44326 0.037784092     0.27936
6       0.152512307     0.50109 0.078772712     0.24023
7       0.191535314     0.47834 0.076556108     0.28035
8       0.220129654     0.49815 0.048090395     0.34433

IBC
Age     Sel     CWt
1       0.002   0.08652
2       0.003   0.19319
3       0.004   0.27917
4       0.006   0.38511
5       0.003   0.39813
6       0.003   0.41314
7       0.004   0.42087
8       0.003   0.46207

Input units are thousands and kg - output in tonnes
```

Table 2.5.5. Whiting in Sub-Area IV and Division VIId. Draft advice table.

Basis: F(2013) = status quo F = 0.153; SSB (2013) = 272; TAC IV (2013) = 18.932; HC landings (2013) = 17.282; Discards (2013) = 7.251; IBC (2013) = 0.810; Recruitment (2013) = revised RCT3 forecast = 1119 million.

Rationale	Total catch 2014	Total Landings IV+VIId 2014	Total Discards 2014	Total IBC 2014	Landings IV 2014	Landings VIId 2014	Basis	Total F 2014	F(landings) 2014	F(disc) 2014	F(IBC) 2014	SSB	% SSB change	% TAC change
Precautionary considera-tions	33.249	22.370	9.949	0.929	16.982	5.389	MP F rescaled (0.75 x 0.3)	0.225	0.143	0.079	0.004	290.907	24%	-10%
Management plan	42.373	28.680	12.780	0.912	21.772	6.909	15% TAC increase (IV)	0.289	0.184	0.101	0.004	283.345	21%	15%
IBC only	0.988	0.000	0.000	0.988	0.000	0.000	F = 0	0.004	0.000	0.000	0.004	317.701	36%	-100%
Other options	17.710	11.628	5.125	0.958	8.827	2.801	0.75 * F(2013)	0.116	0.072	0.040	0.004	303.782	30%	-53%
	28.309	18.955	8.416	0.938	14.389	4.566	1.25 * F(2013)	0.190	0.120	0.066	0.004	295.000	26%	-24%
	31.553	21.199	9.422	0.932	16.092	5.106	15% TAC decrease (IV)	0.213	0.135	0.074	0.004	292.312	25%	-15%
	23.473	15.649	6.877	0.947	11.879	3.770	F(2013)	0.153	0.096	0.053	0.004	298.971	28%	-37%
	36.963	24.939	11.101	0.922	18.932	6.007	Rollover TAC	0.251	0.159	0.088	0.004	287.828	23%	0%
	43.907	29.739	13.259	0.909	22.576	7.164	MP F target	0.300	0.191	0.105	0.004	282.076	20%	19%

Units: 000 tonnes.

Under the assumption that effort is linearly related to fishing mortality

Total human consumption landings are assumed to be split 76% (Subarea IV), 24% (Division VIId).

[1)] SSB 2015 relative to SSB 2014.

[2)] Landings IV 2014 relative to TAC IV 2013

2.6 North Sea plaice

2.6.1 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.

2.6.2 RCT3 Analysis

The RCT3 analysis on the BTS 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 CM 2008/ACOM:60). 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 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.

2.6.3 Update protocol calculations and conclusions

The outcomes from the RCT3 analyses for the two ages are presented in table 2.6.2. Given that the 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).

For age 1, the D value for this age indicates 0.89, a positive signal, but not significantly different from spring assumptions (i.e. <1). For age 2 the D value=0.40 indicating a, positive signal, but not significantly different from spring assumptions.

Because both D values are between -1 and 1, the spring assessment does not need to be updated and there is no requirement to reopen the advice.

Table 2.6.1 North Sea plaice RCT3 input data

PLAICE	NORTHSEA	AGE1	PLAICE	NORTHSEA	AGE2
6	40 2		6	40 2	
1973	1132775	-11	1973	822021	-11
1974	864859	-11	1974	548602	-11
1975	693092	-11	1975	449542	-11
1976	989338	-11	1976	648015	-11
1977	914118	-11	1977	610233	-11
1978	895153	-11	1978	529846	-11
1979	1133652	-11	1979	809508	-11
1980	868626	-11	1980	658124	-11
1981	2035162	-11	1981	1447072	-11
1982	1312130	-11	1982	937458	-11
1983	1263687	-11	1983	847805	173.9
1984	1853892	136.8	1984	1291741	131.7
1985	4775439	667.4	1985	3256552	764.2
1986	1970104	225.8	1986	1438737	147
1987	1776234	680.2	1987	1275608	319.3
1988	1189264	467.9	1988	872002	146.1
1989	1039262	185.3	1989	800662	159.4
1990	918015	291.4	1990	655070	174.5
1991	781976	360.9	1991	572330	283.4
1992	532656	189	1992	387004	77.1
1993	445836	193.3	1993	342990	40.6
1994	1167369	265.6	1994	935840	206.9
1995	1296449	310.3	1995	1066201	59.2
1996	2160323	1046.8	1996	1831514	402.7
1997	777736	347.6	1997	604098	121.6
1998	845152	293.3	1998	643092	69.3
1999	987140	267.5	1999	792274	72.2
2000	544499	206.5	2000	459528	44.5
2001	1729930	519.2	2001	1269420	159.1
2002	528876	132.8	2002	413472	39.6
2003	1270058	233.7	2003	927104	66.2
2004	770698	163	2004	605542	36.4
2005	937388	128.6	2005	638099	67.2
2006	1168187	312	2006	982324	120.7
2007	1014800	221.6	2007	789129	105.2
2008	150193	409	2008	196121	84.3
2009	-11	261	2009	-11	148.2
2010	-11	486	2010	-11	191.5
2011	-11	241.8	2011	-11	113.2
2012	-11	449.8	2012	-11	-11
BTS1			BTS2		

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 : 1973 - 2012
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
     BTS1 3.192    -4.211 1.609  0.1482 25   6.109      15.29  1.7360
0.09607
 VPA Mean    NA        NA    NA      NA 36      NA      13.84  0.5659
0.90393

                   WAP logWAP int.se
yearclass:2012 1172904  13.97 0.5381

Spring assumption for age 1: 930070; log(930070) = 13.74

Plaice age 1 D = (15.29 - 13.74)/ 1.7360  =  0.89, positive signal, but not
different from spring assumptions.
```

D calculation North Sea plaice age 2

```
Analysis by RCT3 ver4.0
Data for 1 surveys over 40 years : 1973 - 2012
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:2011
    index slope intercept     se rsquare  n indices prediction se.pred
WAP.weights
     BTS2 1.108     8.309 0.6227  0.4685 26   4.729      13.55  0.6605
0.3785
 VPA Mean    NA        NA     NA      NA 36      NA      13.54  0.5154
0.6215

                  WAP logWAP int.se
yearclass:2011 761653  13.54 0.4063

Spring assumption for age 1: 590490; log(590490) = 13.29

Plaice age 2 D= (13.55 - 13.29)/0.6605 =  0.40, positive signal, but no differ-
ent from spring assumptions.
```

2.7 North Sea sole

2.7.1 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS). The BTS 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

2.7.2 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 CM 2008/ACOM:60). 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 including the assessment estimates for the two ages are presented in Table 2.7.1. 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.

2.7.3 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 2.7.2. For age 1, the D value for this age is 0.19, which represents a positive signal which is not different from spring assumptions. As this value is between -1 and 1. For age 2 the D value is 0.048 indicating a positive signal which is not different from spring assumptions. Hence, the spring assessment does not need to be updated and there is no requirement to reopen the advice.

Table 2.7.1 North Sea sole RCT3 input data

```
Sole   NorthSea      Age1
1      40     2
1973   111571 -11
1974   41341  -11
1975   114354 -11
1976   141807 -11
1977   47993  -11
1978   11840  -11
1979   153486 -11
1980   149544 -11
1981   152556 -11
1982   140856 -11
1983   70394  -11
1984   81523  7.03
1985   158271 7.17
1986   71930  6.97
1987   452837 83.11
1988   106703 9.01
1989   174849 37.84
1990   69567  4.03
1991   349071 81.63
1992   68424  6.35
1993   56389  7.66
1994   94962  28.13
1995   48824  3.98
1996   267465 169.34
1997   112053 17.11
1998   80949  11.96
1999   121643 14.59
2000   62656  8
2001   183935 20.99
2002   81546  10.51
2003   43974  4.19
2004   48353  5.53
2005   203831 17.09
2006   54421  7.5
2007   69705  15.25
2008   98360  15.95
2009   -11    54.8
2010   -11    26.2
2011   -11    5.1
2012   -11    6.8
BTS1

Sole   NorthSea      Age2
1      40     2
1973   100859 -11
1974   37153  -11
1975   102460 -11
1976   126620 -11
1977   43401  -11
1978   10704  -11
1979   138261 -11
1980   134901 -11
1981   135473 -11
1982   127080 -11
1983   63513  -11
1984   73610  -11
1985   142856 7.121
1986   64996  5.183
1987   409734 12.548
1988   96439  12.512
1989   157397 68.084
1990   62835  24.487
1991   314934 28.841
1992   61862  22.284
```

```
1993   50348  42.345
1994   81392  7.121
1995   44016  8.458
1996   240515 7.634
1997   101160 4.919
1998   72976  27.422
1999   107852 18.363
2000   55878  6.144
2001   165436 9.963
2002   72790  4.182
2003   39298  9.947
2004   42676  4.354
2005   177768 3.395
2006   48942  2.332
2007   61208  19.504
2008   87449  9.062
2009   -11    4.999
2010   -11    10.707
2011   -11    17.387
BTS2
```

Table 2.7.2 North Sea sole RCT3 analysis and D value with the new survey

North Sea sole age 1: D calculation

```
Analysis by RCT3 ver4.0

Sole

Data for 1 surveys over 40 years : 1973 - 2012
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:2010
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS1 0.7507      9.59 0.3863  0.7354 25   3.266      12.04  0.4147        0.73

yearclass:2011
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS1 0.7507      9.59 0.3863  0.7354 25   1.629      10.81  0.4185      0.7264

yearclass:2012
    index  slope intercept     se rsquare  n indices prediction se.pred WAP.weights
     BTS1 0.7507      9.59 0.3863  0.7354 25   1.923      11.03  0.4144      0.7303

                 WAP logWAP int.se
yearclass:2012  69683  11.15 0.3542


Sole age 1 D = (11.15 - log(64976))/ 0.3542 =  0.1926221, positive signal, but
not different from spring assumptions (-1 < D < 1).
```

D calculation North Sea sole age 2

```
Analysis by RCT3 ver4.0

Sole

Data for 1 surveys over 40 years : 1973 - 2012
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:2011
    index slope intercept    se rsquare  n indices prediction se.pred WAP.weights
     BTS2 4.859  -0.07177 4.145 0.02464 24   2.856      13.80  4.4498     0.02294
 VPA Mean    NA        NA    NA      NA 36      NA      11.36  0.6819     0.97706

yearclass:2012
    index slope intercept    se rsquare  n indices prediction se.pred WAP.weights
     BTS2 4.859  -0.07177 4.145 0.02464 24   2.902      14.03  4.4558     0.02288
 VPA Mean    NA        NA    NA      NA 36      NA      11.36  0.6819     0.97712

                WAP logWAP int.se
yearclass:2011 90937  11.42  0.674
yearclass:2012 91393  11.42  0.674

Sole age 2 D = (11.42 - log(88211))/ 0.674 positive signal, but not different
from spring assumptions.
```

2.8 North Sea *Nephrops*

Farn Deeps

The latest UWTV survey of the Farn Deeps survey was carried out between 8th-16th June 2013. Al standard protocols and procedures were followed. The only change to the program was a shift of 4 months from October to June. This move in survey time was discussed in the Benchmark meeting in February 2013.

- Poor weather and low visibility caused by *Nephrops* trawling activity had plagued the survey in the previous two years. Quality control processes are in place to minimise the effects of poor visibility, but the number of stations with useable footage reduces with lower visibility.
    - The weather in June 2013 was particularly good and the lack of *Nephrops* trawling activity at this time of year delivered excellent footage, the best obtained to date. All stations were completed and, although not directly quantifiable, there is a greater feeling of confidence in the survey results as a result of the improved footage.
- 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 noted that many surveys which are considered single series have endured changes such as new vessels and different participants all of which may induce changes in catchability. The various TV surveys for *Nephrops* take place over a range of months, but the results are all used as proxies for stock status the following year. The 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.

The 2013 TV survey results were 706 million. The values used in the June Advice Sheet came from the 2012 survey and were 758 million with a 95% CV of 13 million. The 2013 value is therefore significantly different (the ACOM test specifies 1 SD, this is well past 2 SD) and therefore the advice for FU6 should be reopened.

It must be underlined that the current way of producing advice for *Nephrops* stocks in the context of future discards ban and survival conditions is still under debate and scrutiny, and some updates might be brought next year after further work.

Table 1. Survey results for *Nephrops* in FU6.

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 2. Revised Advice table

Basis: $F_{2010-2012}$ = average harvest rate over 2008–2010 = 12.3 %; Bias-corrected survey index (2014=2013.) = 706 million; Mean weight in landings (2010–2012) = 25.56 g; Mean weight in discards (2010–2012) = 11.10g,

Basis	Total Catches*	Landings	Dead Discards**	Surviving Discards**	Harvest Rate
	L+DD+SD	L	DD	SD	for L+DD
	323	283	34	6	2%
	646	567	67	11	4%
MSY approach	1078	947	112	19	6.68%
MSY Transition	1169	1026	122	21	7.24%
FMSY	1310	1151	137	23	8.12%
	1453	1275	151	26	9%
	1775	1559	185	31	11%
	1937	1700	202	34	12%
F 2010-2012	1985	1743	207	35	12.30%
	2421	2126	252	43	15%
	3228	2834	336	57	20%

Weights in tonnes.

* Total catches are the landings including dead and surviving discards

** Total discard rate is assumed to be 24.34% of the catches (in number, last 3 years average, 2010–2012), discard survival is assumed 15% (ICES, 2013c).

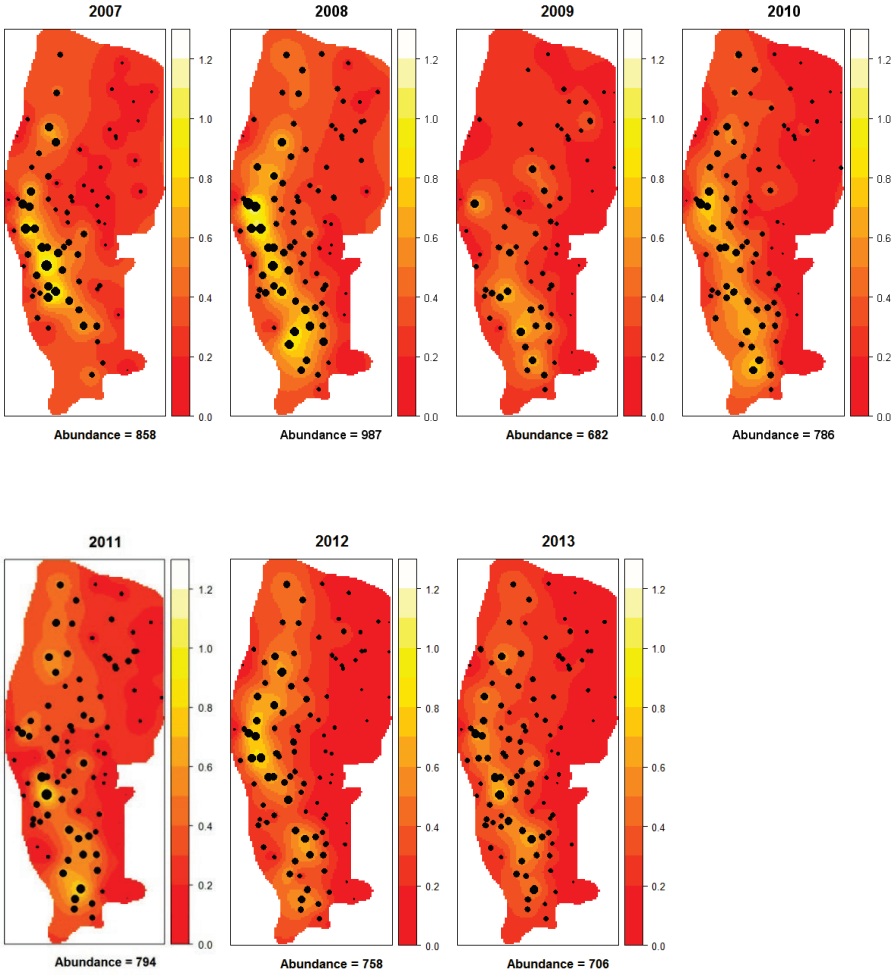


Figure 1: Survey results

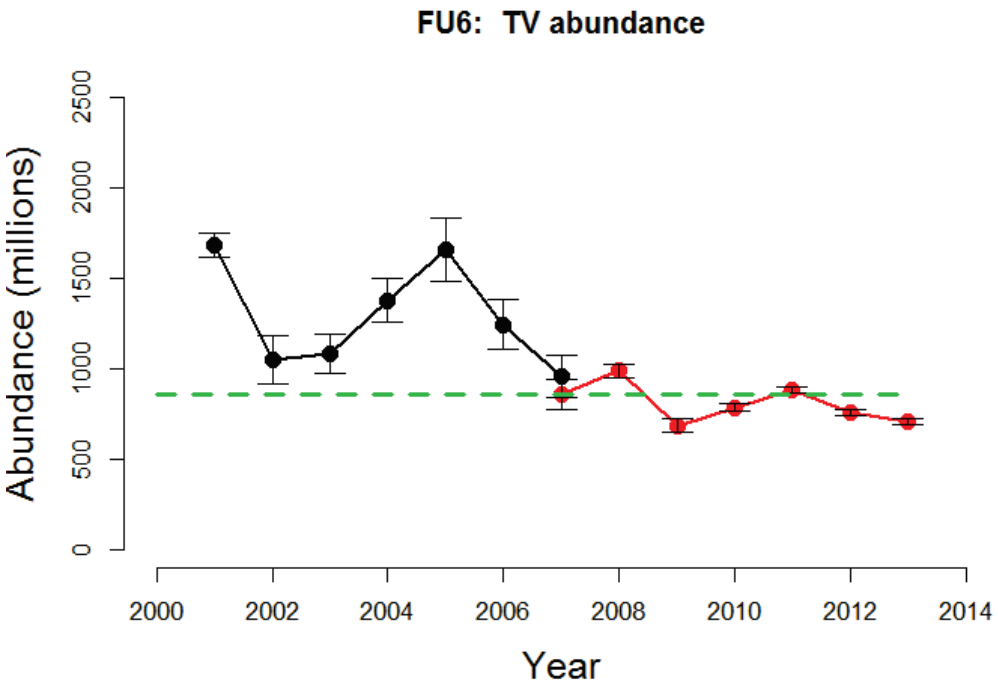


Figure 2. TV survey abundance time series

Fladen (FU7)

The most recent UWTV survey for this stock was carried out in June 2013. 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 2013 advice and based on the 2012 survey is 2748 million (Table 2.8.3 and Figure 2.8.3). The estimate from the 2013 summer survey is 2902 million with a 95 % CI of 335 million. The 2012 value is within 1 SD of the new 2013 abundance estimate and therefore the advice for FU7 should not be reopened.

Table 2.8.3. ***Nephrops*****, Fladen (FU 7): Results of the 1992-2013 TV surveys (bias-adjusted).**

Year	Stations	Abundance millions	Mean density burrows/m²	95% confidence interval 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

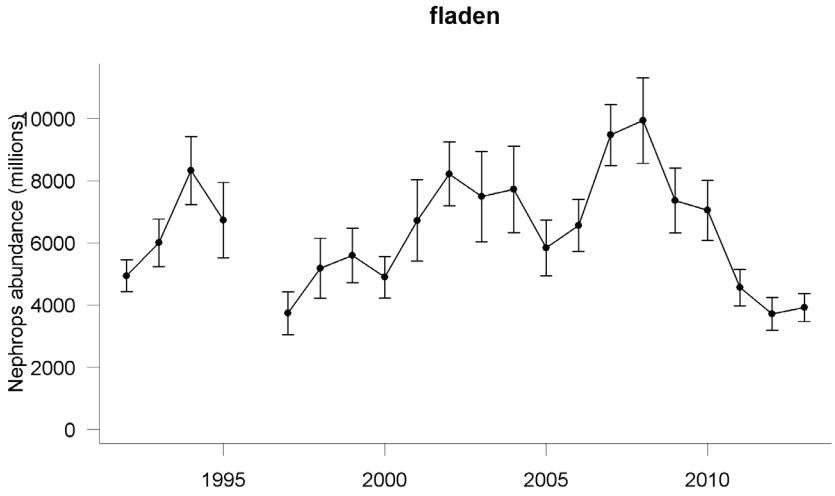


Figure 2.8.3. *Nephrops*, Fladen (FU 7): Results of the 1992-2013 TV surveys (not bias-adjusted).

Firth of Forth (FU8) and Moray Firth (FU9)

The UWTV surveys for these two FUs take place later in the summer (end Aug) 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.

2.9 References

ICES-AGCREFA (2008). Report of the Ad hoc Group on Criteria for Reopening Fisheries Advice (AGCREFA). ICES CM 2008/ACOM:60.

ICES-WGNSSK (2011). Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak. ICES CM 2011/ACOM:13.

ICES-WKBENCH, 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks. ICES CM 2011/ACOM:38

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Stock Annex: FU32 Norwegian Deep **947**

Stock Annex: FU6, Farn Deeps **957**

Stock Annex: FU7, Fladen Ground **966**

Stock Annex: FU8, Firth of Forth **975**

Stock Annex: FU9, Moray Firth **984**

Stock Annex Noup *Nephrops* (FU 10) **995**

Stock Annex WGNSSK – Norway pout **1001**

Stock Annex: Plaice IIIa **1061**

Stock Annex: Plaice in area IV **1075**

Stock Annex Plaice in Division VIId **1086**

Stock Annex Pollack in Subarea IV and Division IIIa **1113**

Stock Annex - Sole in Division VIId **1117**

Stock Annex - Grey Gurnard **1126**

Annex 03 – Stock Annexes – Part 1

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 ºN.

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.

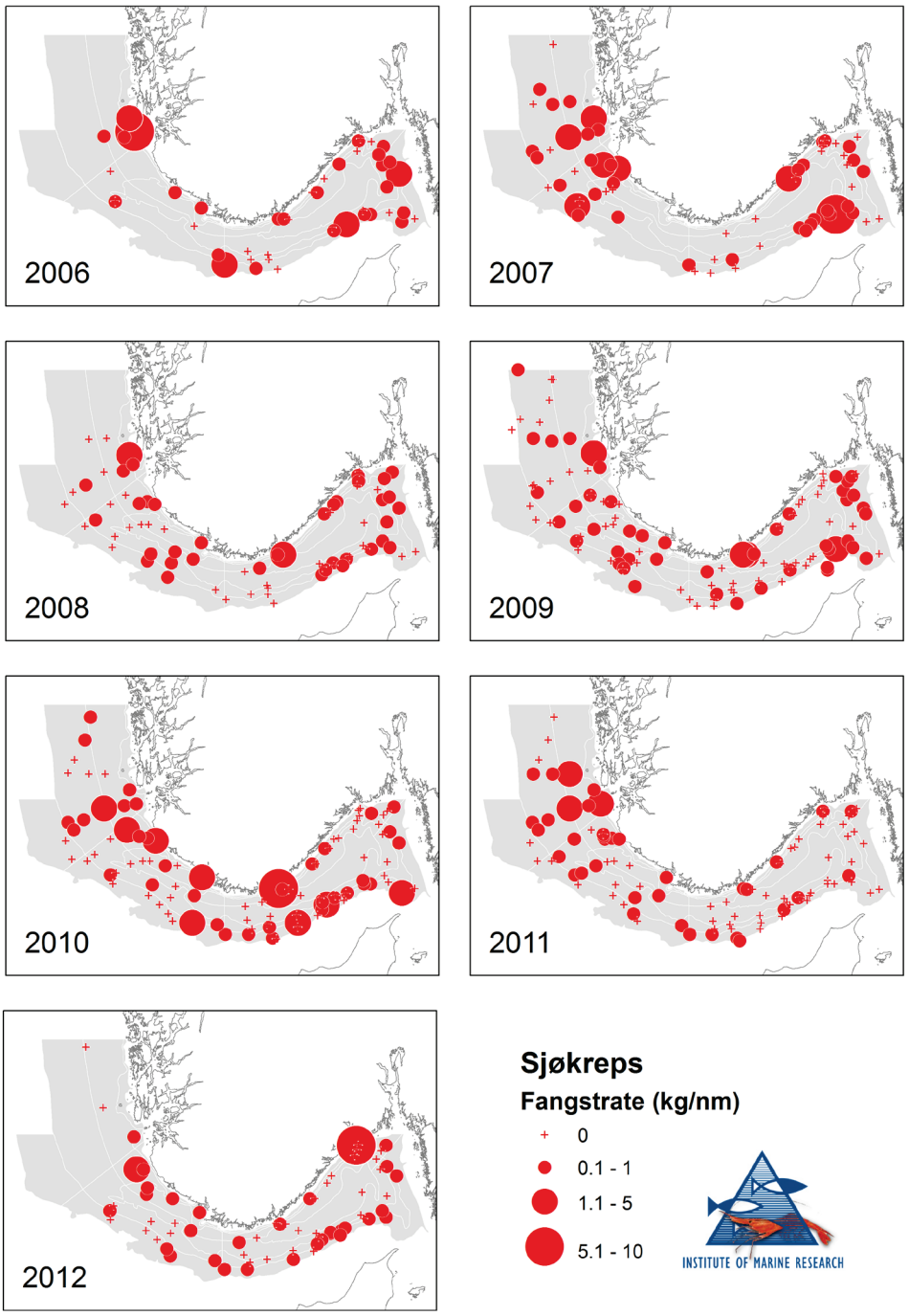


Figure A1-1. *Nephrops* Norwegian Deep (FU 32). Catches (kg/nm trawled) from the Norwegian shrimp survey, January-February 2006-2012.

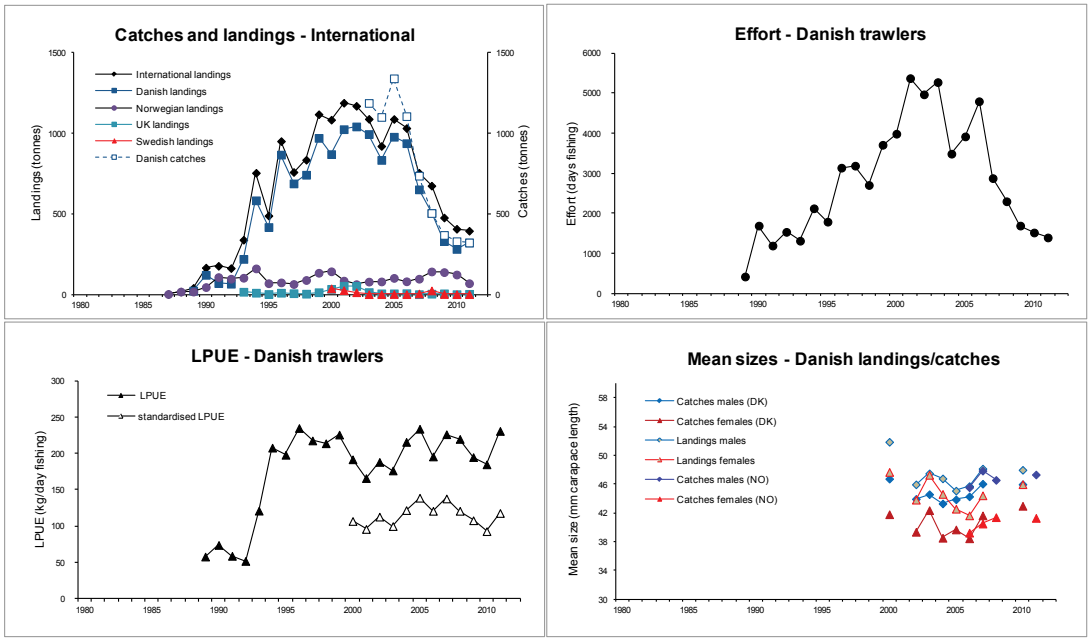


Figure. A2-1. *Nephrops* **Norwegian Deep (FU 32). Long term landings, Danish effort, Danish LPUE and Danish mean sizes of catches and landings.**

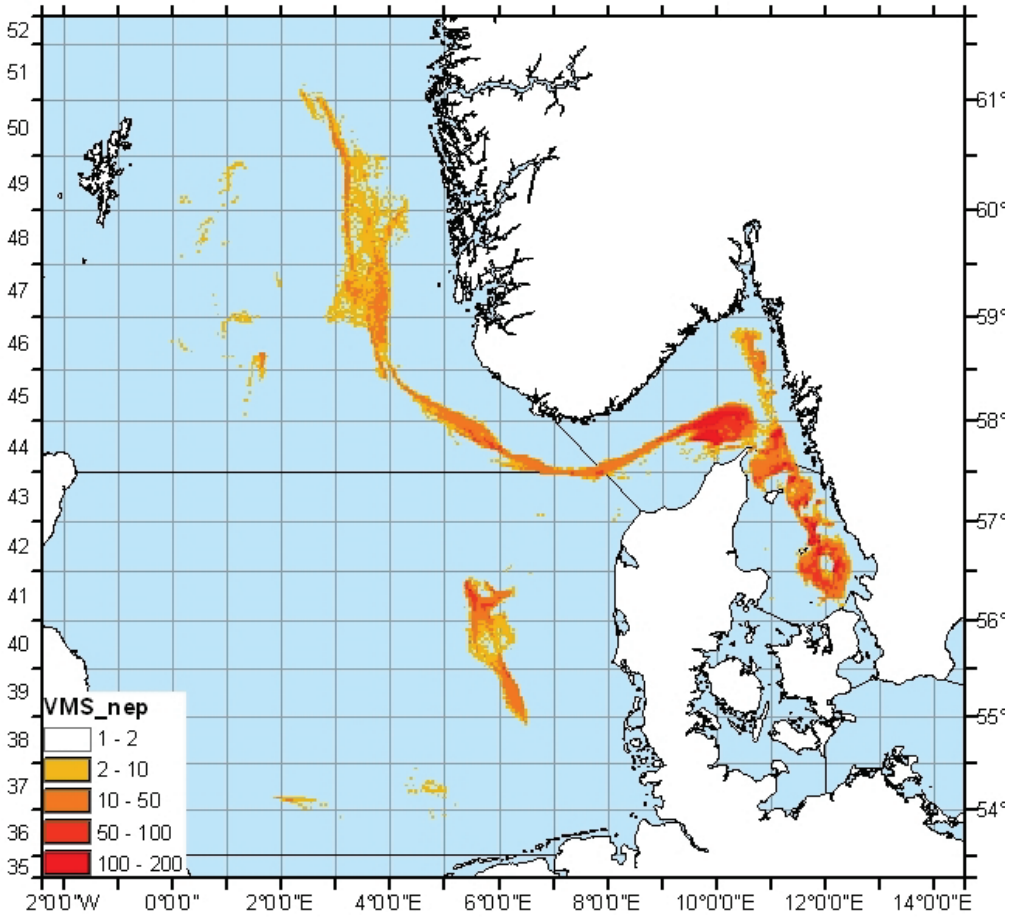


Figure A2-2. ***Nephrops*** **Norwegian Deep (FU 32). VMS data showing the spatial distribution of the Danish and Swedish fleet fishing for** ***Nephrops*** **in Skagerrak, Kattegat, and the North Sea. The Swedish vessels are mainly fishing in Kattegat and the northeastern part of Skagerrak.**

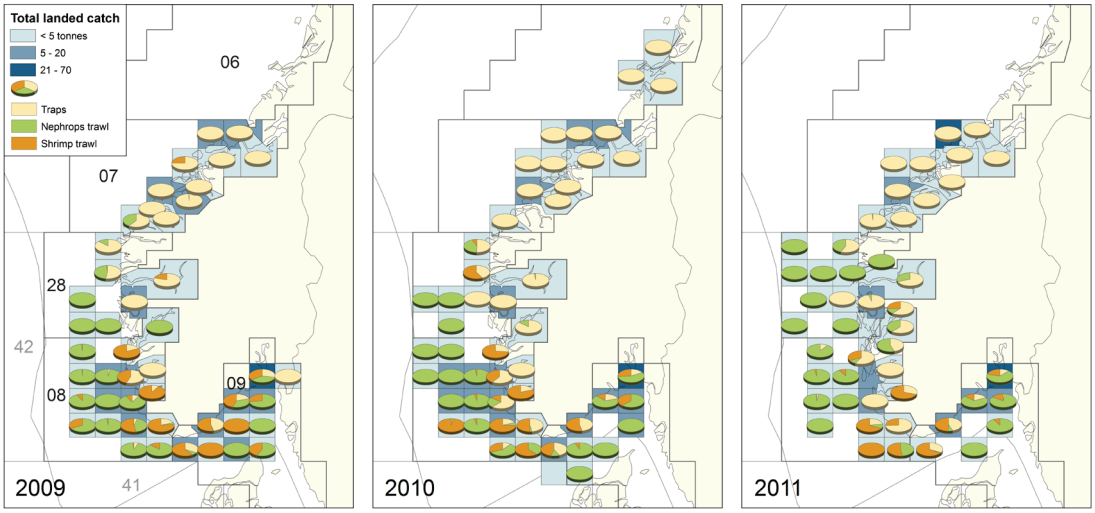


Figure A2-3. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings per gear type and ICES statistical rectangle in 2009-2011. The numbers are area codes from the Norwegian Directorate of Fisheries, where 08 refers to FU 32 south of 60 °N, and 28 refers to FU 32 north of 60 °N. Data from the Norwegian Directorate of Fisheries.**

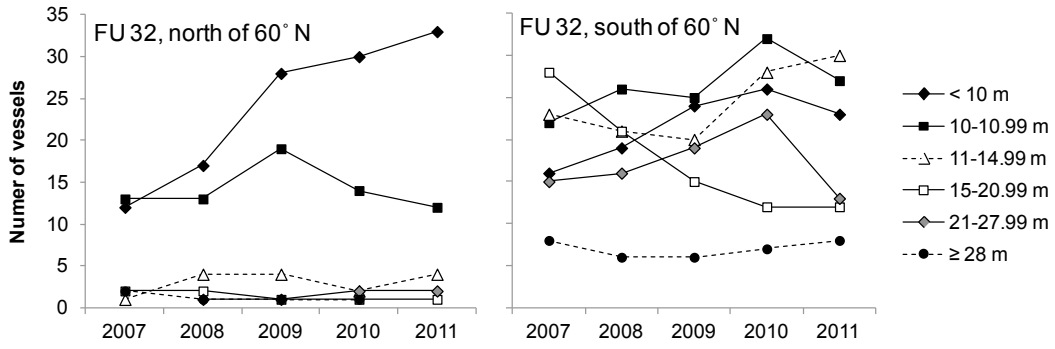


Figure A2-4. ***Nephrops*** **Norwegian Deep (FU 32). The Norwegian fleet landing** ***Nephrops,*** **per length group in 2007-2011, north and south of 60 °N. Data from the Norwegian Directorate of Fisheries.**

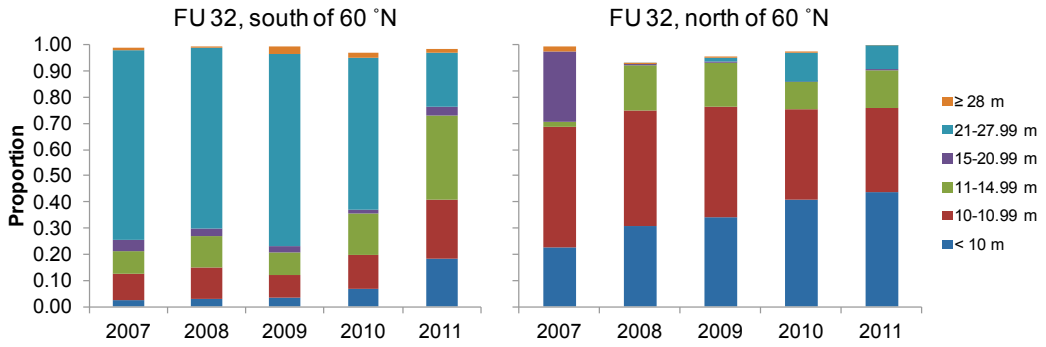


Figure A2-5. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings (proportion) in 2007-2011 per vessel length group, north and south of 60 °N. Not all columns add up to one due to lack of lengths for some vessels. Data from the Norwegian Directorate of Fisheries.**

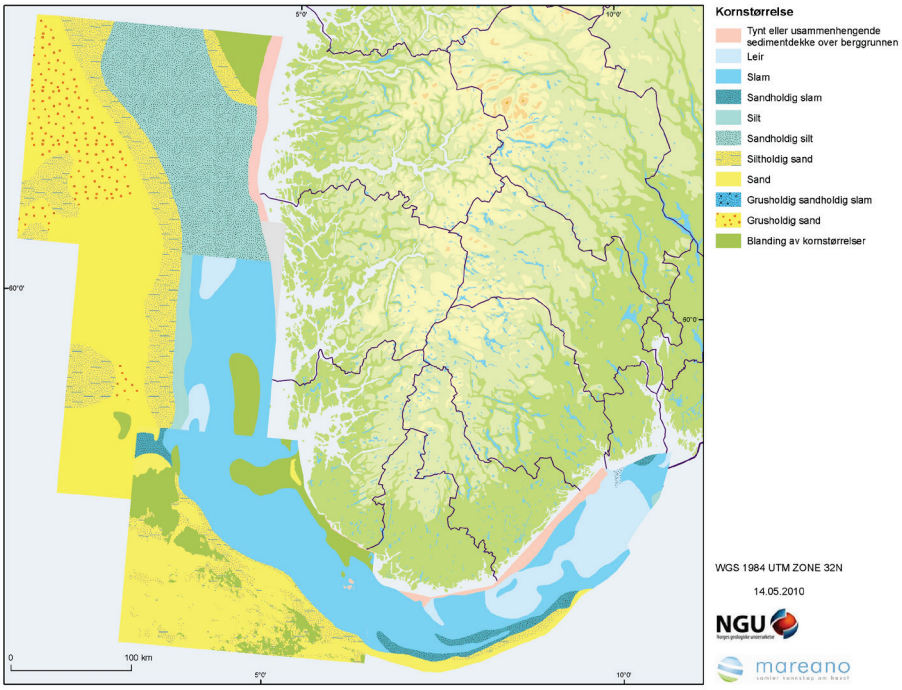


Figure A3-1. Sediment map of the Norwegian Deep and Skagerrak. Map from www.mareano.no.

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

A. 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 lead-

ing 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.

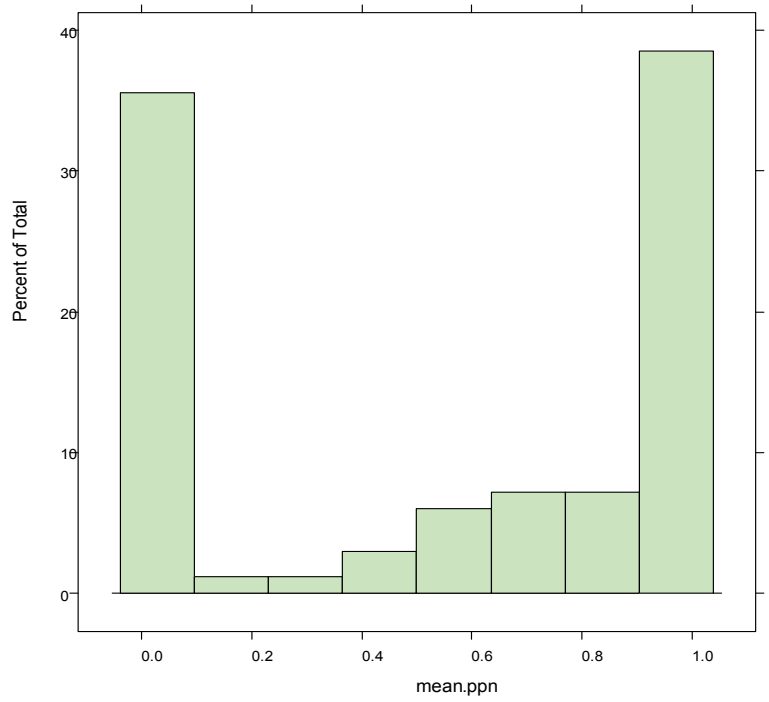


Figure B.1.1. Farn Deeps (FU 6): Histogram of proportion individuals <26mm discarded.

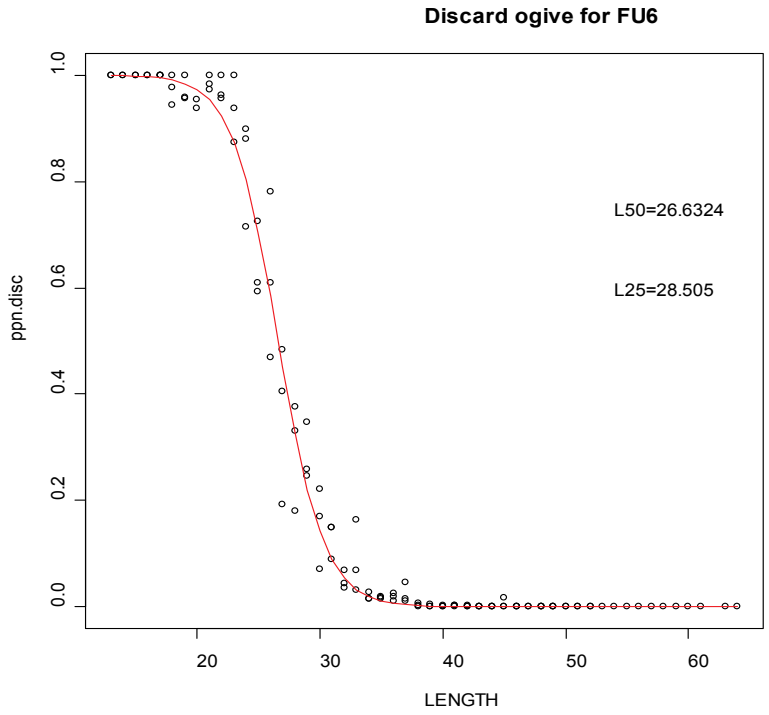


Figure B.1.2. Farn Deeps (FU 6): Discard ogive selected for FU6 *Nephrops*, trip level data pooled to year 2002-2007

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:

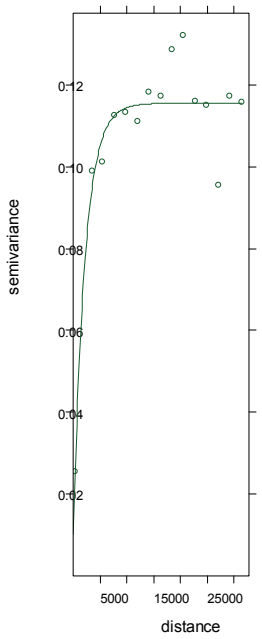
Underwater TV survey: years 1996 – present. Surveys have been conducted in Spring and/or Autumn each year but only consistently in Autumn from 2001. In 2008 there was an historical revision of burrow density estimates from the TV survey. Previous estimates of burrow density had assumed that station density 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 get-

ting 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 km² 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
	M	0.14	0.10	9.4	41.7	48.9	44.7
$F_{0.1}$	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
	M	0.27	0.19	15.4	25.8	33.1	28.9
F_{max}	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
	M	0.19	0.14	11.7	34.5	41.9	37.6
$F_{35\%SpR}$	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
	M	0.14	0.09	9.5	40.3	47.6	43.3
$F_{0.1}$	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
	M	0.28	0.18	16.2	23.6	30.8	26.5
F_{max}	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
	M	0.18	0.11	11.4	34.5	41.9	37.6
$F_{35\%SpR}$	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

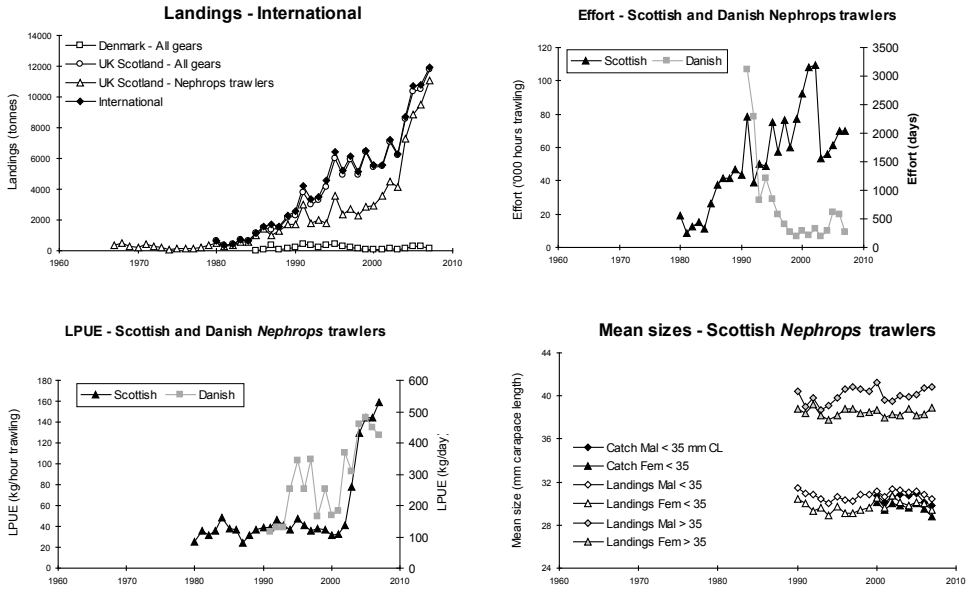


Figure B1-1. *Nephrops*, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.

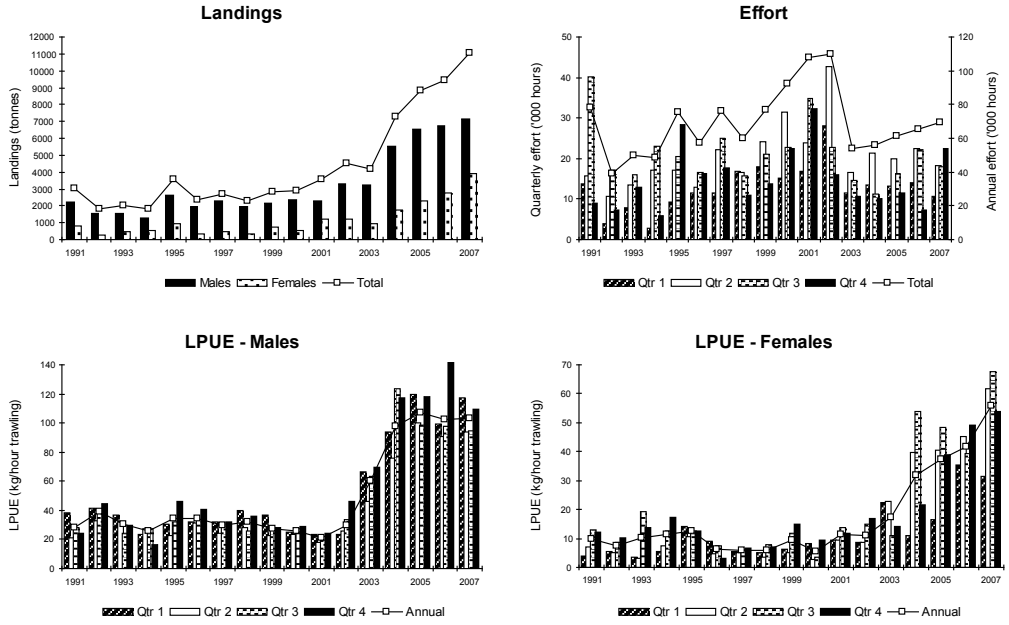


Figure B1-2. ***Nephrops*****, Fladen (FU 7), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

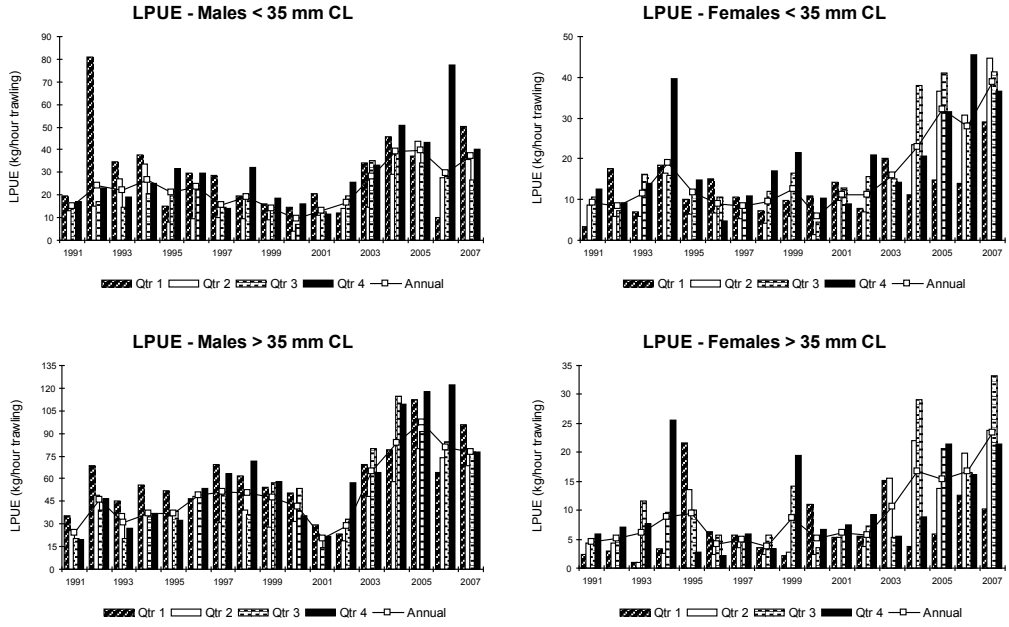


Figure B1-3. ***Nephrops*****, Fladen (FU 7), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

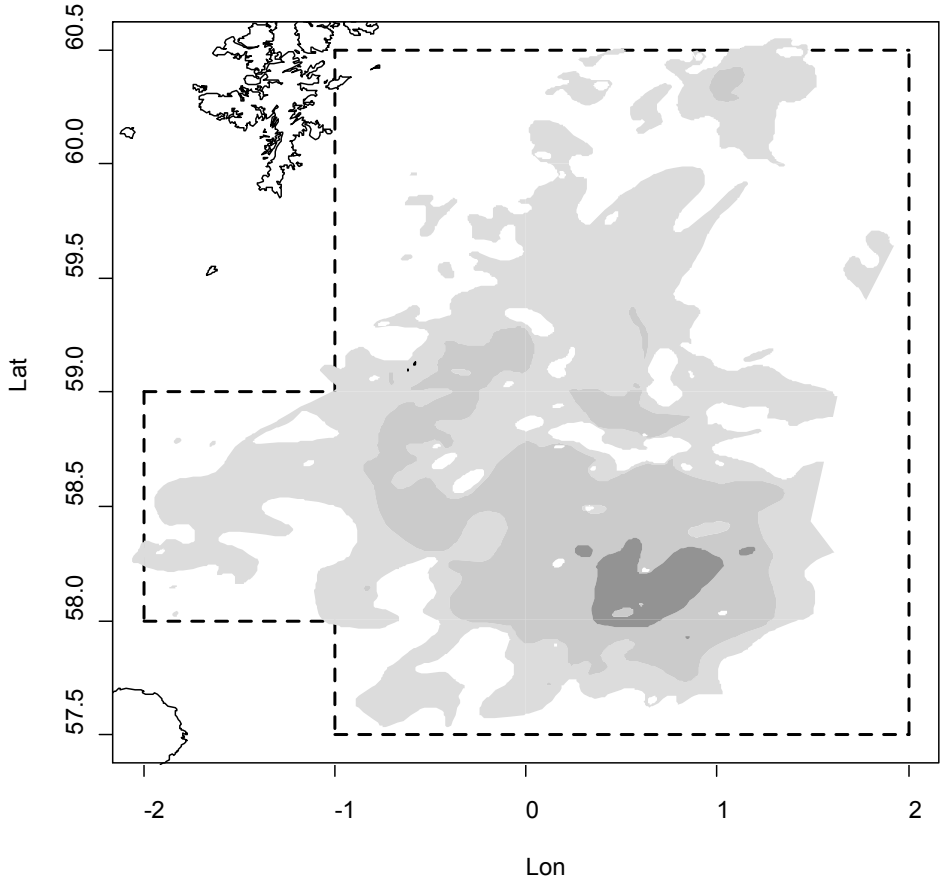


Figure B3–4. Distribution of *Nephrops* sediments in the Fladen Ground (FU 7). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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
	M	0.13	0.06	7.5	42.3	64.5	51.7
$F_{0.1}$	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
	M	0.24	0.11	12.3	26.9	49.5	36.5
F_{max}	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
	M	0.18	0.08	9.7	34.1	57.0	43.8
$F_{35\%SpR}$	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
	M	0.14	0.06	7.7	40.8	62.3	49.9
$F_{0.1}$	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
	M	0.25	0.11	12.7	25.3	46.8	34.4
F_{max}	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
	M	0.17	0.07	9.4	34.6	56.6	43.9
$F_{35\%SpR}$	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

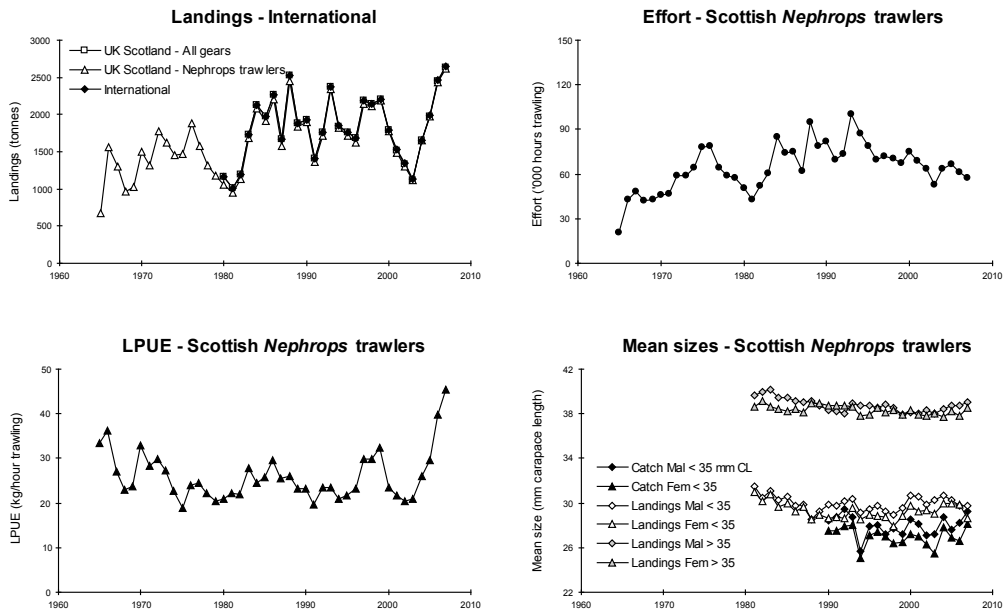


Figure B1-1. *Nephrops*, Firth of Forth (FU 8), Long term landings, effort, LPUE and mean sizes.

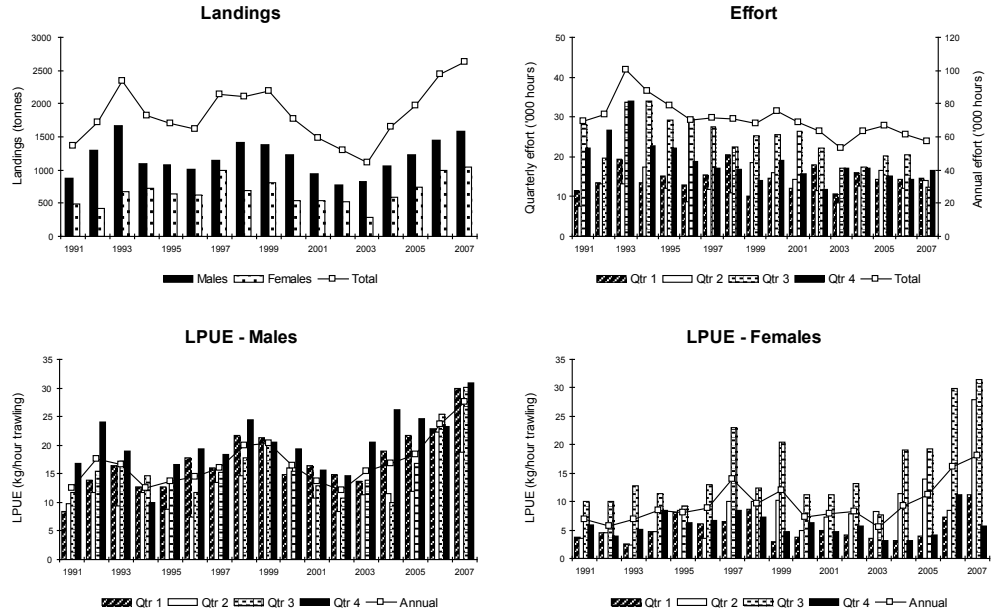


Figure B1-2. *Nephrops*, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

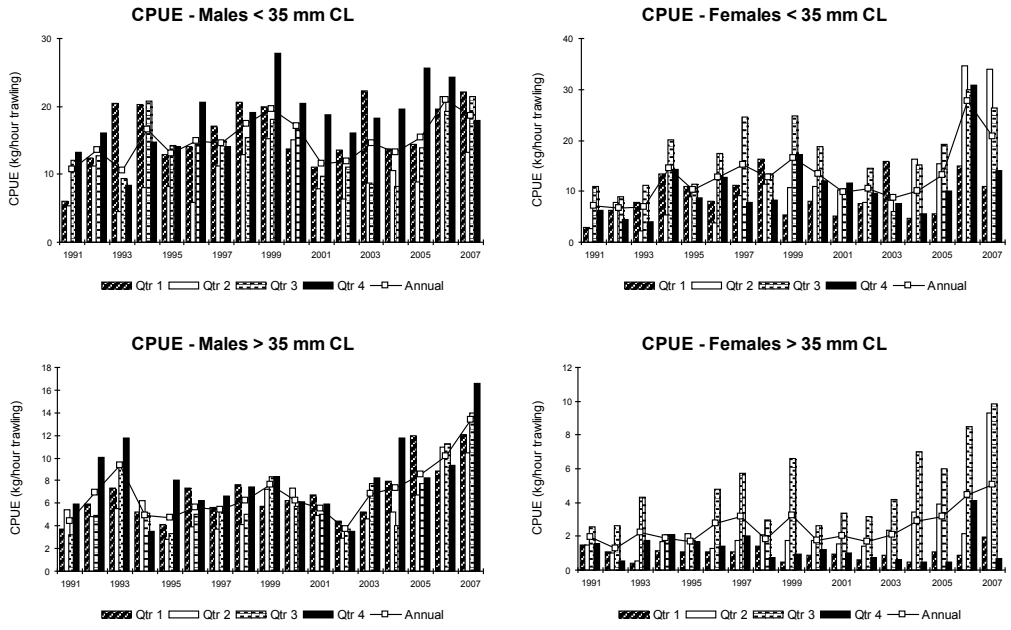


Figure B1-3. *Nephrops*, Firth of Forth (FU 8), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.

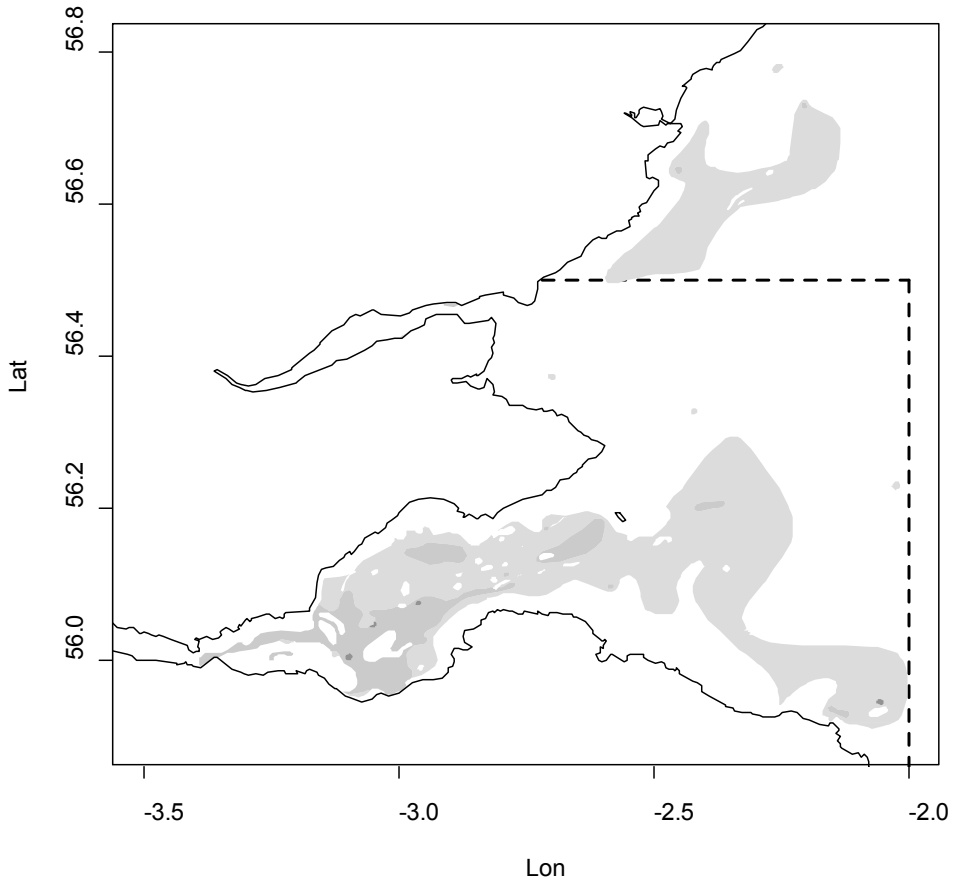


Figure B3–1. Distribution of *Nephrops* sediments in the Firth of Forth (FU 8). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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	F	HR (%)	SPR (%) M	F	T
$F_{0.1}$	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
F_{max}	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
$F_{35\%SpR}$	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	F	HR (%)	SPR (%) M	F	T
$F_{0.1}$	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
F_{max}	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
$F_{35\%SpR}$	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

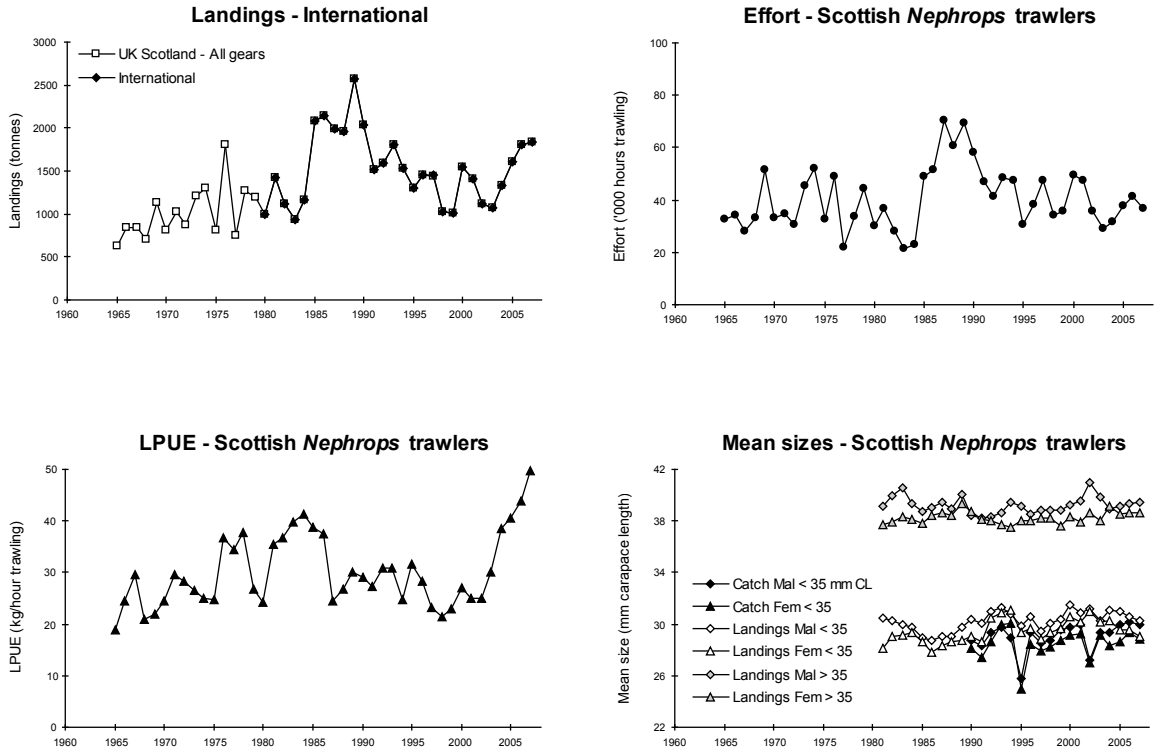


Figure B1-1. ***Nephrops*****, Moray Firth (FU 9), Long term landings, effort, LPUE and mean sizes.**

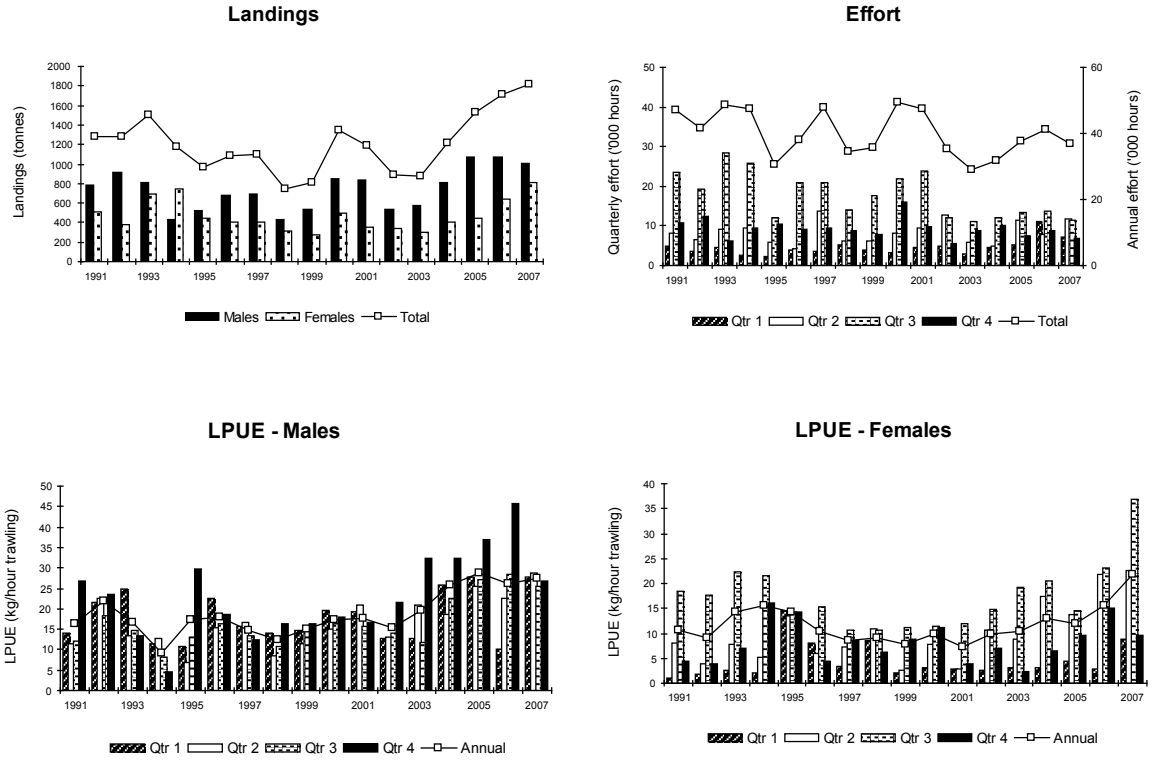


Figure B1-2. ***Nephrops*****, Moray Firth (FU 9), Landings, effort and unstandardised LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

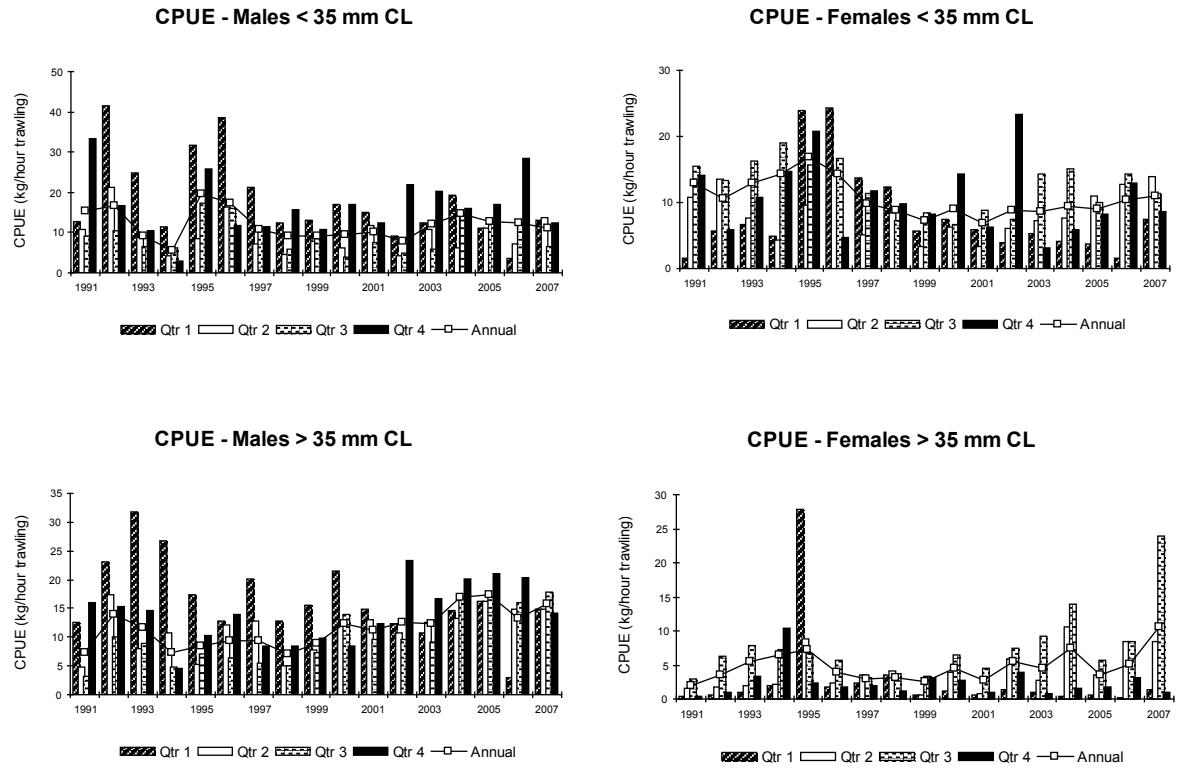


Figure B1-3. ***Nephrops*****, Moray Firth (FU 9), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

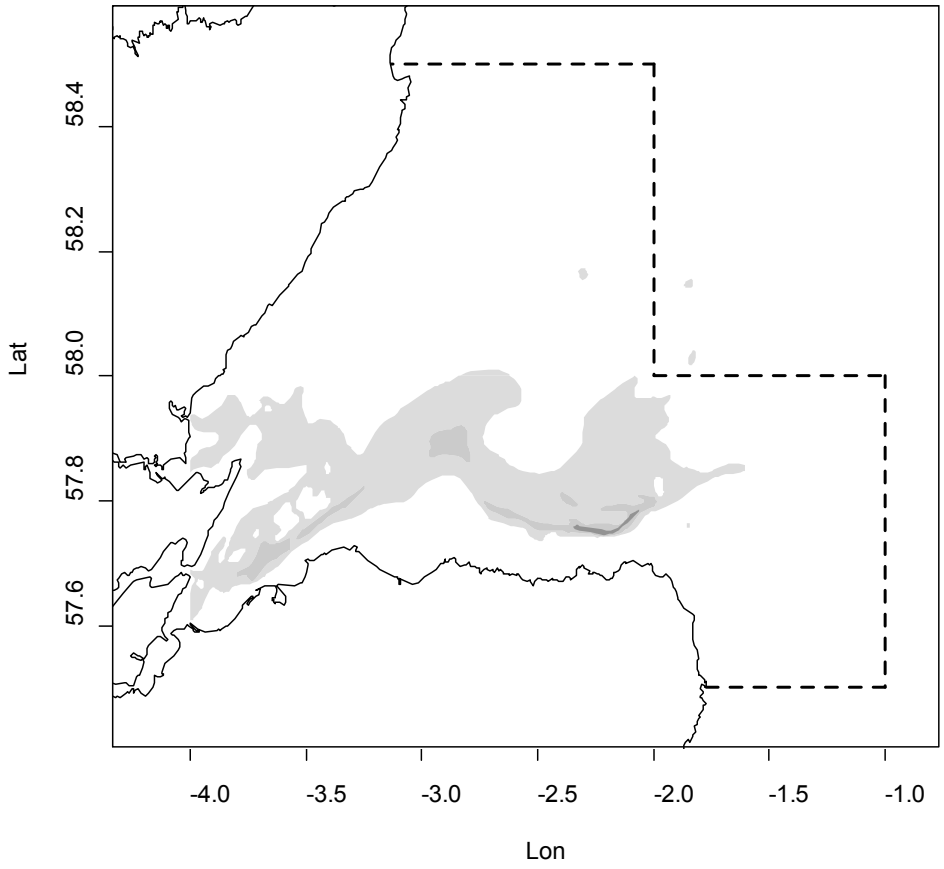


Figure B3–1. Distribution of *Nephrops* sediments in the Moray Firth (FU 9). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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 repre-

sented 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	-

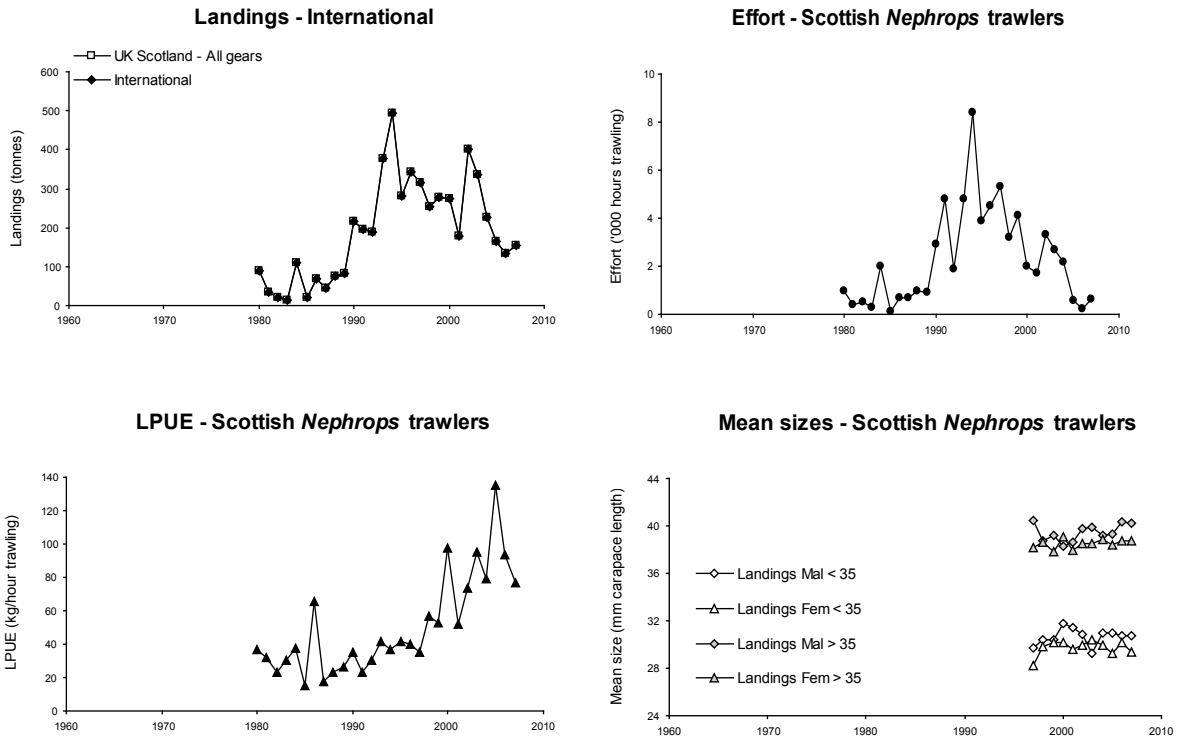


Figure 3.4.1.11 *Nephrops*, Noup (FU 10), Long term landings, effort, LPUE and mean sizes.

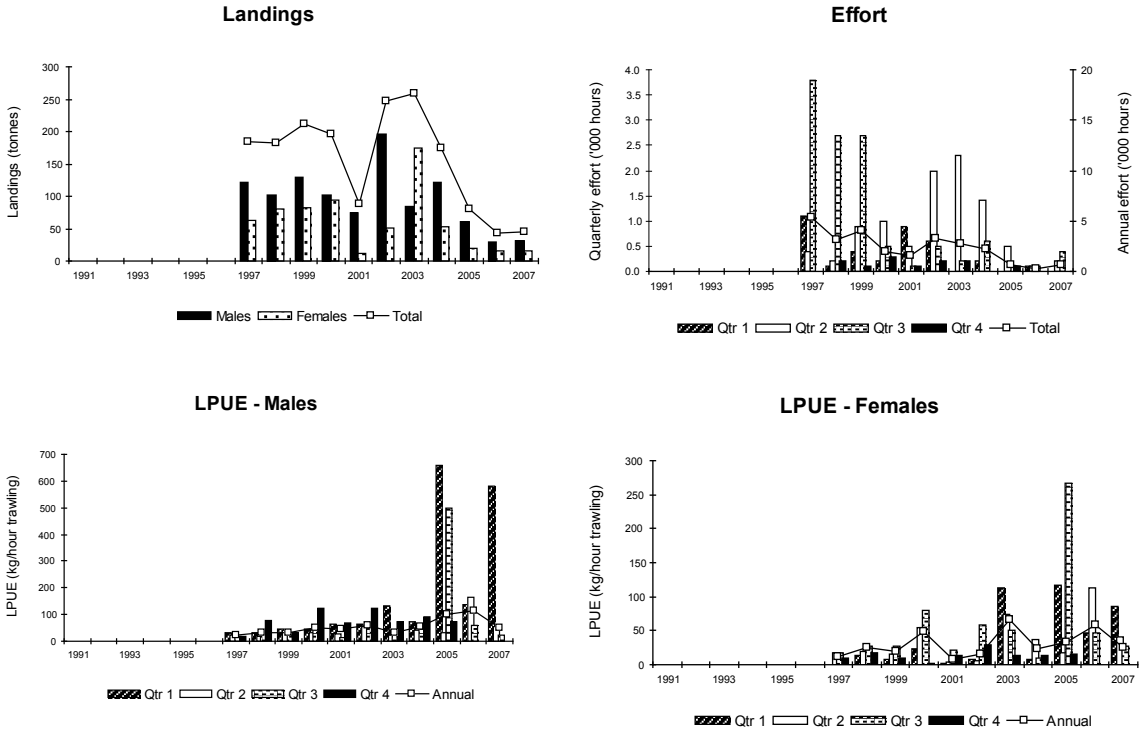


Figure 3.4.1.12 *Nephrops*, Noup (FU 10), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

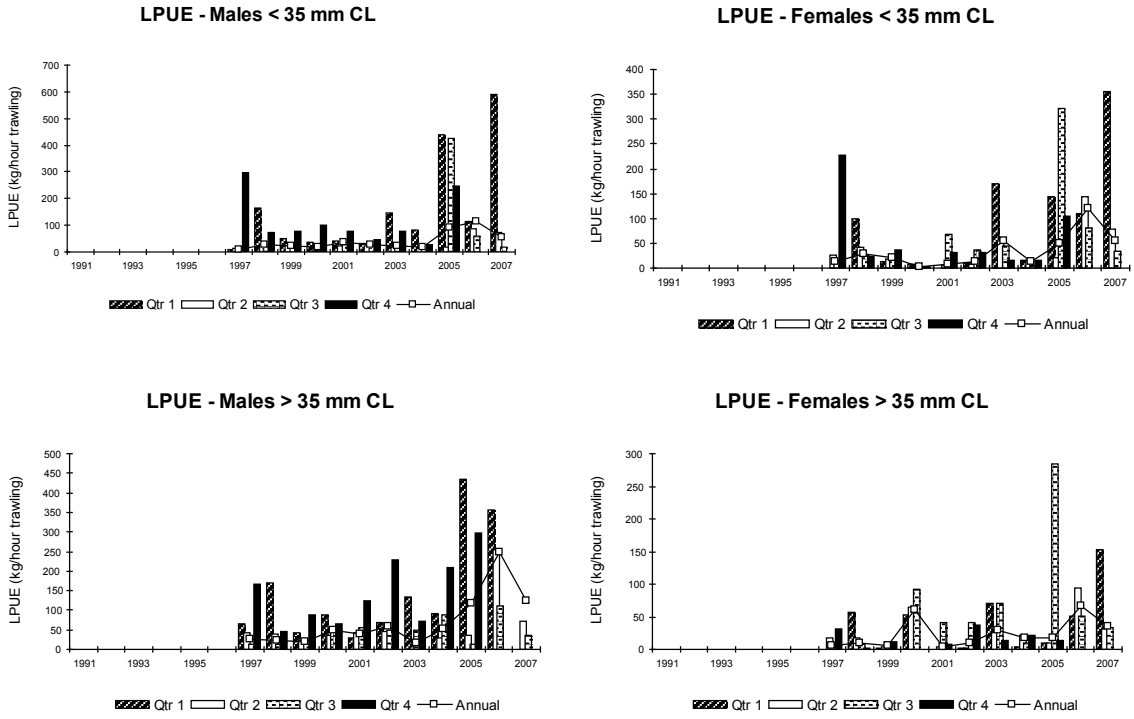


Figure 3.4.1.13 ***Nephrops*****, Noup (FU 10), LPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

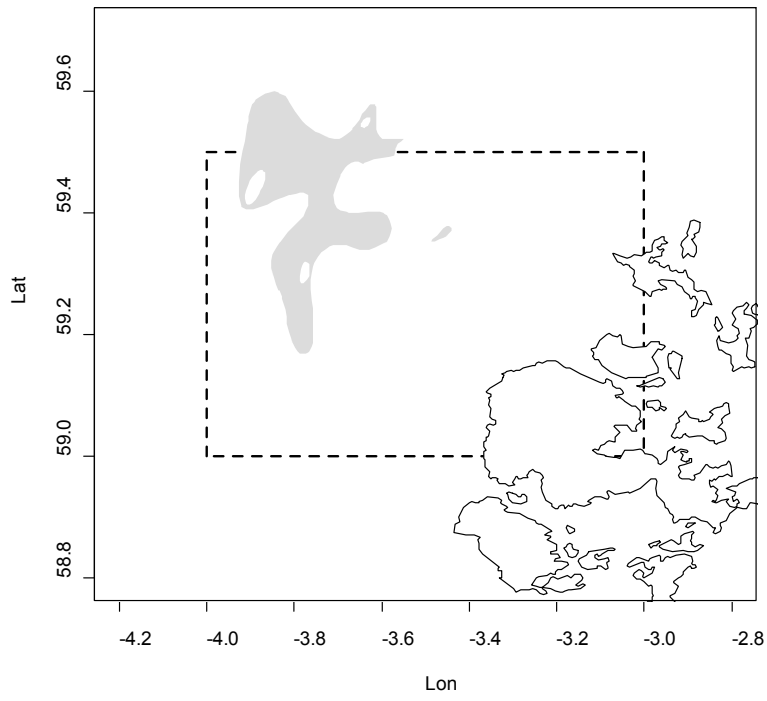


Figure B3–1. Distribution of ***Nephrops*** **sediments in Noup (FU 10). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.**

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.

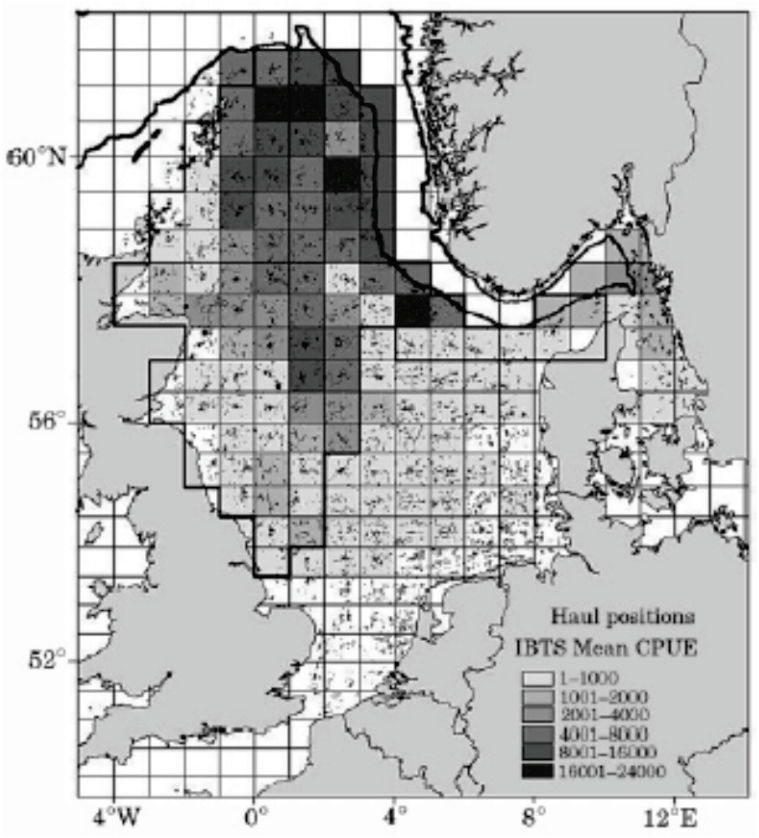


Figure 1 Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al*., 2002b].

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**.

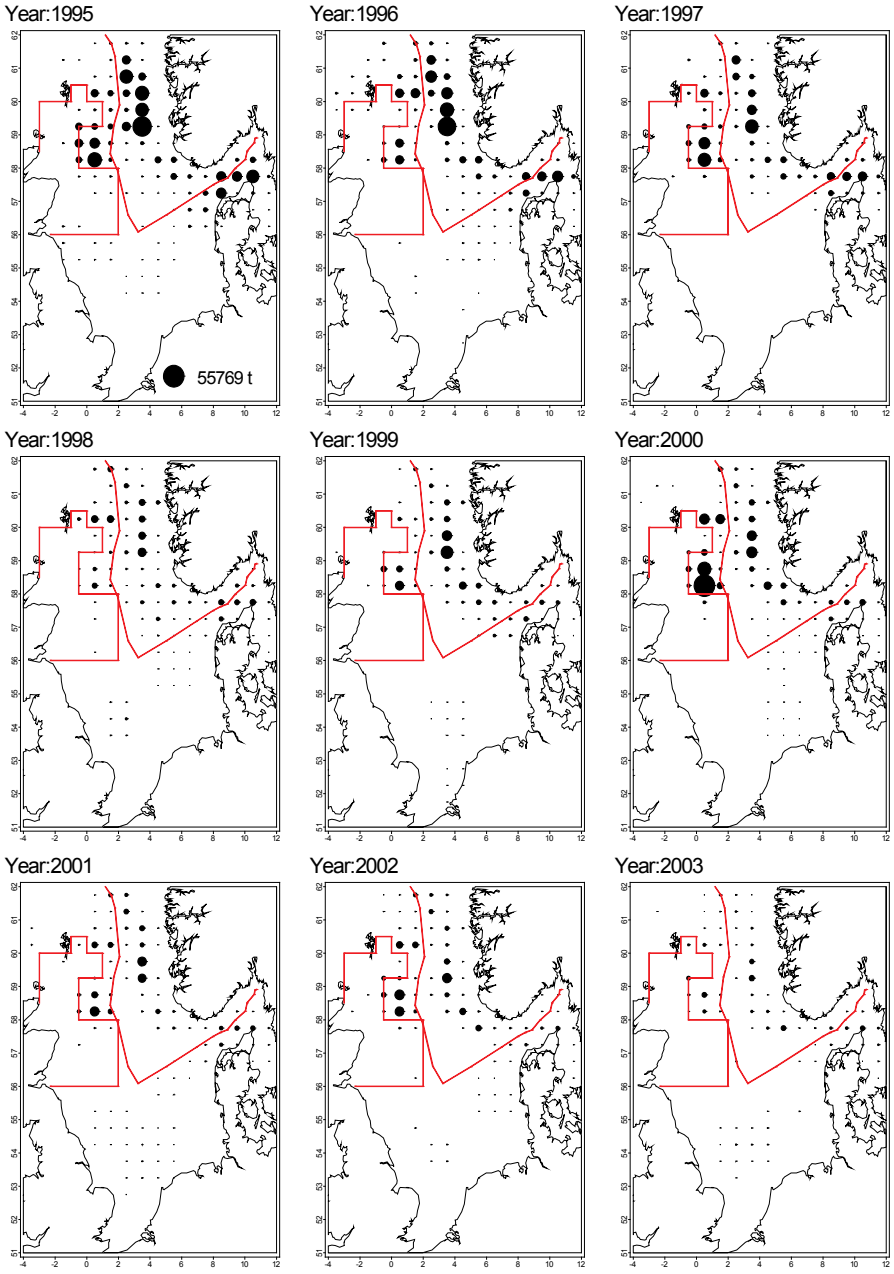


Figure 2. Landings of Norway pout by year and ICES rectangles for the period 1995-2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map.

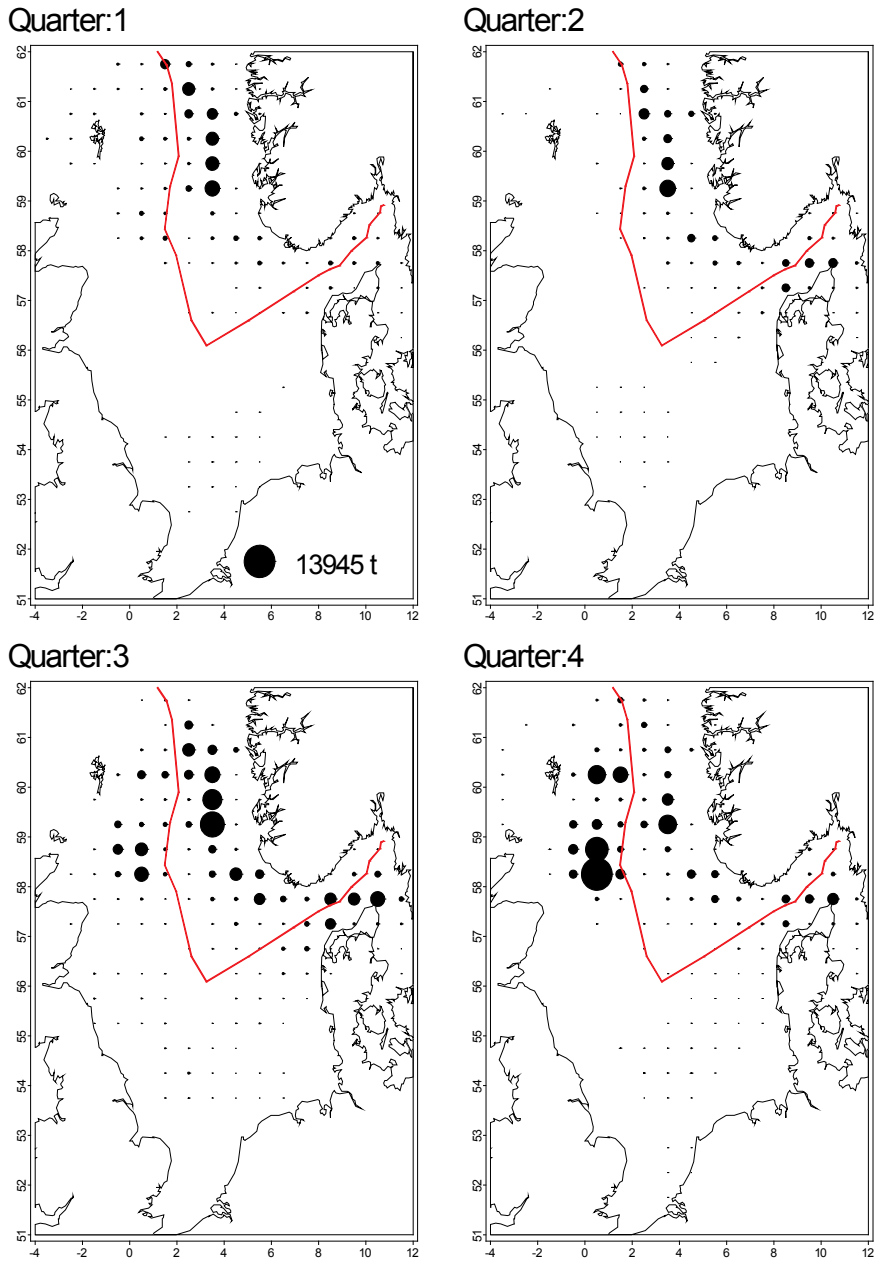


Figure 3. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994-2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map

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 Log-book 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 in-

dustrial 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 multi-species 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 assess-

ment 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.

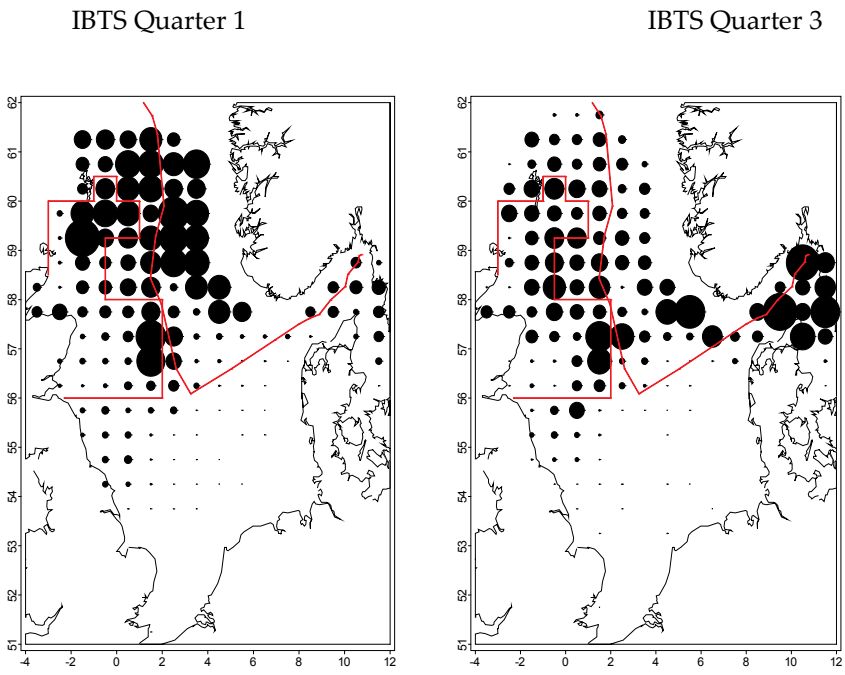


Figure 4 IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps 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 ar-

ea. 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 pro-

cedure 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:                                                          No
plus group in SMS (4+-group in SXSA)
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	Fa_0
Age 1	Fa_1
Age 2	Fa_2
Age 3	Fa_3

$F(q)$:

	Q1	q2	q3	q4
Age 0	0.0	0.0	Fq	0.25
Age 1	$Fq_{1,1}$	$Fq_{1,2}$	$Fq_{1,3}$	0.25
Age 2	$Fq_{2,1}$	$Fq_{2,2}$	$Fq_{1,3}$	0.25
Age 3	$Fq_{3,1}$	$Fq_{3,2}$	$Fq_{3,3}$	0.25

$F(y)$:

Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	…
1	Fy_2	Fy_3	Fy_4	Fy_5	Fy_6	Fy_7	Fy_8	Fy_9	….

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 Approach	MSY $B_{escapement}$	150 000 t	= B_{pa}
	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	90 000 t	B_{lim} = B_{loss}, the lowest observed biomass in the 1980s
	B_{pa}	150 000 t	= B_{lim} $e^{0.3*1.65}$
	F_{lim}	Undefined	None advised
	F_{pa}	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

$$B_{pa} = B_{lim}\, e^{0.3*1.65} \quad (SD).$$

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:
B_{lim} is 90 000 t	B_{pa} be established at 150 000 t. Below this value the probability of below average recruitment increases.
Note:	

Technical basis:

$B_{lim} = B_{loss}$ = 90 000 t.	$B_{pa} = B_{lim}\, e^{0.3-0.4*1.65}$ (SD).
F_{lim} None advised.	F_{pa} 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

$B_{pa} = B_{lim}\, e^{0.3-0.4*1.65}$ (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 an-

swer. 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 over-fishing 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	50000[1]	17660	in 'others'
2001	1020000	150000	211200	50000[1]	14130	in 'others'
2002	918000	150000	198000	50000[1]	10500	in 'others'
2003	918000	131000	198000	50000[1]	7000	in 'others'
2004	826200	131000	198000	50000[1]	7000	in 'others'
2005	660960	10000	0	5000[2]	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	800[1]	5400	11000
2001	6400	51000	240000	800[1]	5400	11000
2002	4770	58000	150000	800[1]	5400	11000
2003	3180	50267	130000	800[1]	5400	11000
2004	3180	50267	137000	800[1]	5400	11000
2005	4686	42727	137000	800[1]	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.

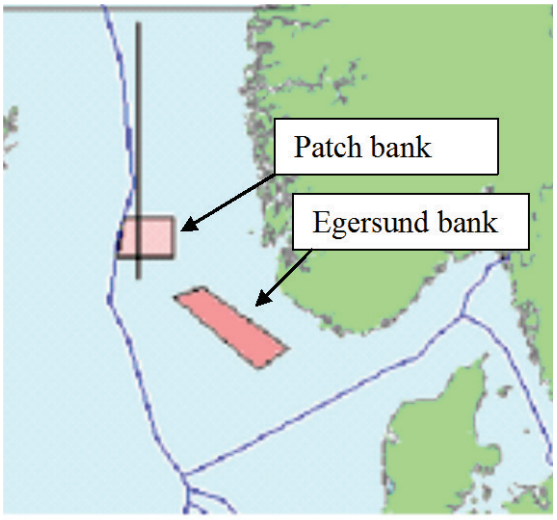
ACFM recommended that effort in 2005 should not exceed 40 % of the effort in 2004. Based upon this advice, the sandeel season in the Norwegian economic zone was further shortened in 2005. The sandeel season, defined as the period when smaller mesh size than 16 mm can be used, was 8 months (March – October) 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 regula-

tion 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.

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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 reduc-

tion 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.

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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 by-catch 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

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Figure 1. Location for the IBTS (open dots) and KASU stations (black dots).

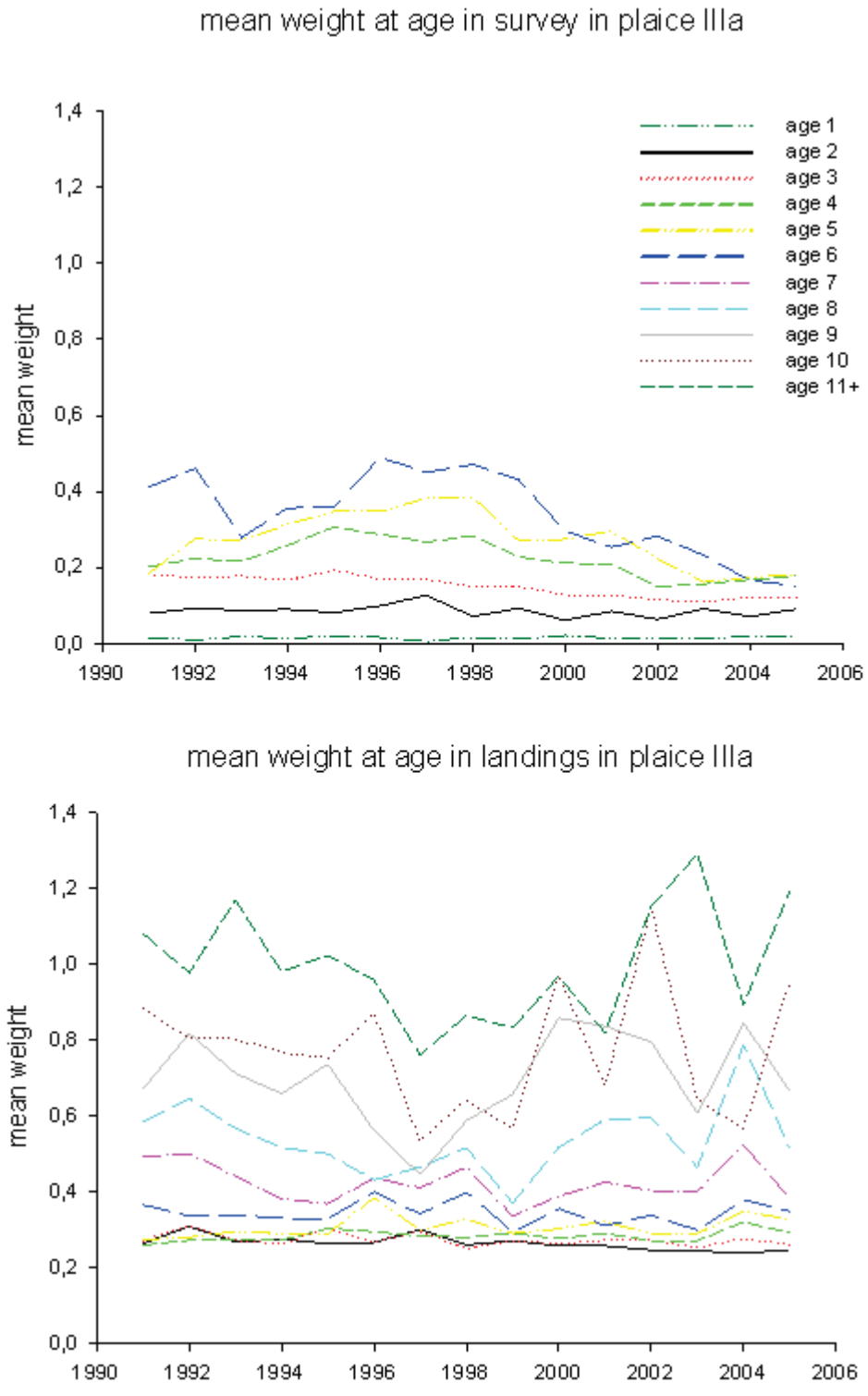


Figure 2: Mean weight at age from IBTS and commercial fleets in IIIa between 1991-2005.

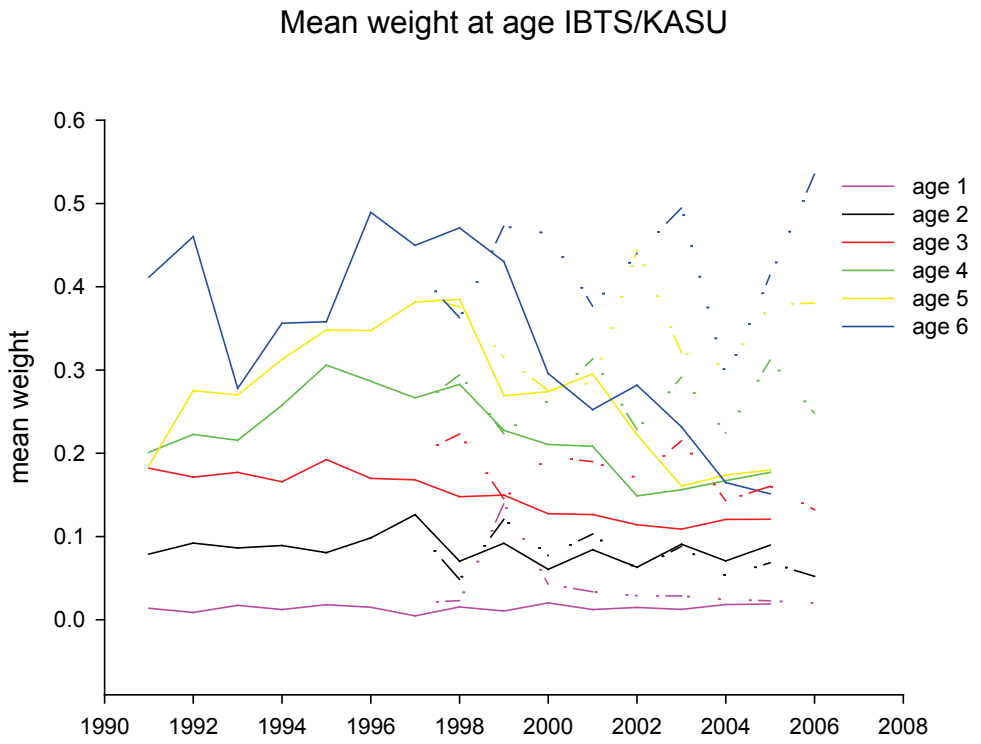


Figure 3. Comparison between IBTS q1 in area IIIa (solid line) 1991-2005 and KASU q1 in IIIa+22 (dotted line) 1996-2006 in area IIIa.

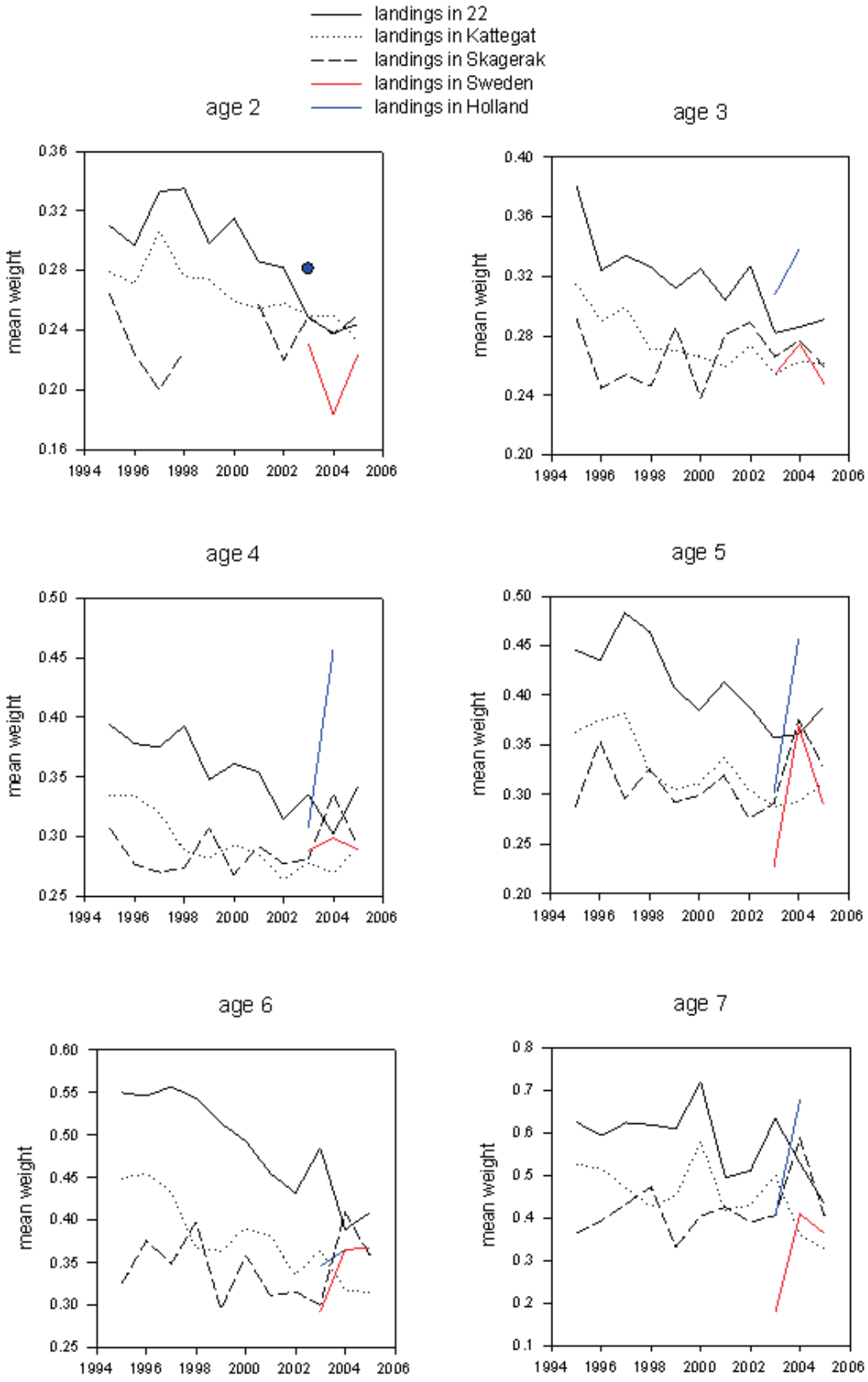


Figure 4: Mean weight at age 2-7 from 5 different commercial fleets.

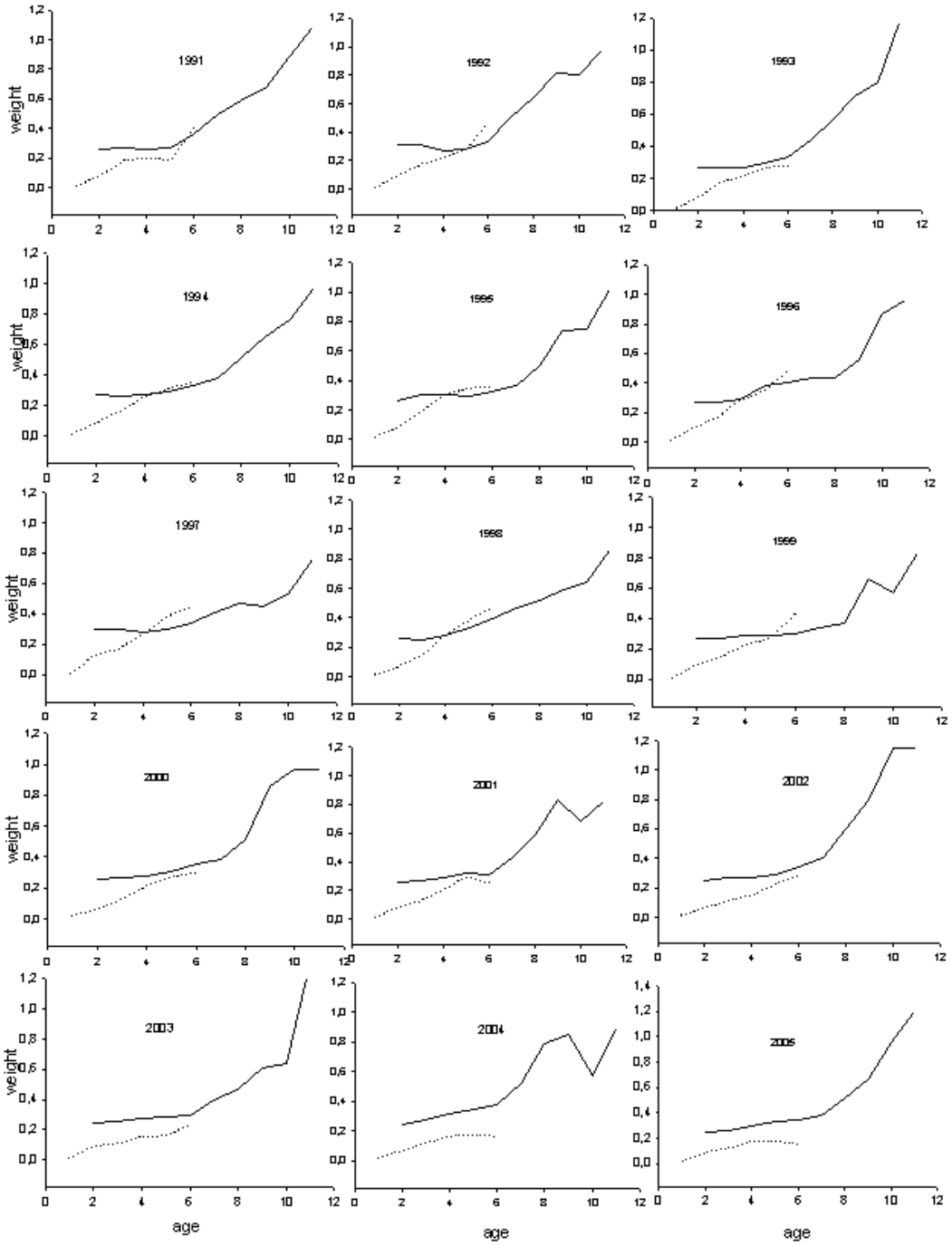


Figure 5. Comparison of mean weight at age between the IBTS survey (dottet line) and commercial samples (solid line) in IIIa in the years 1991-2005

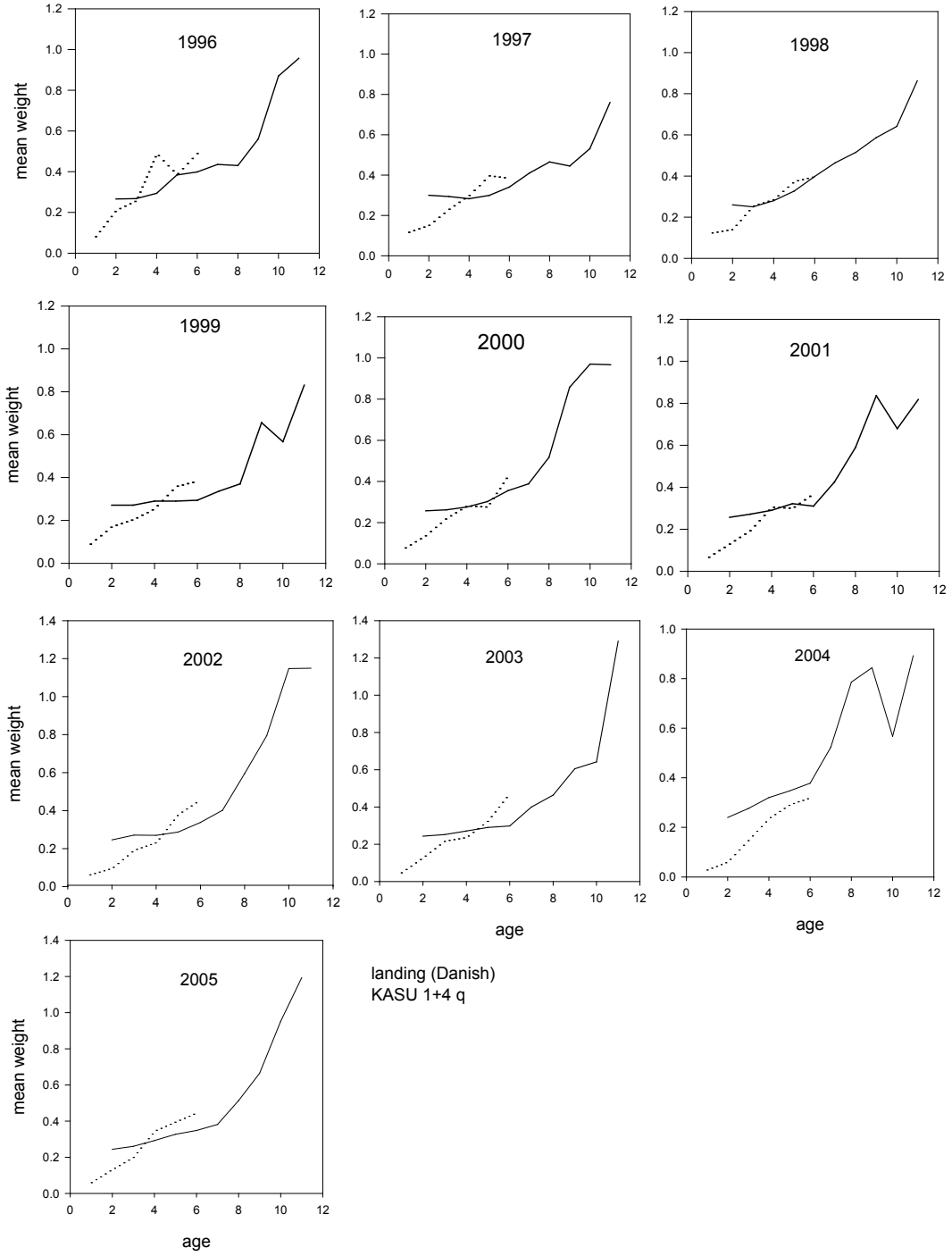


Figure 6. Comparison of mean weight at age between the KASU survey 1+ 4 q (dottet line) and commercial samples (solid line) in IIIa in the years 1996-2005

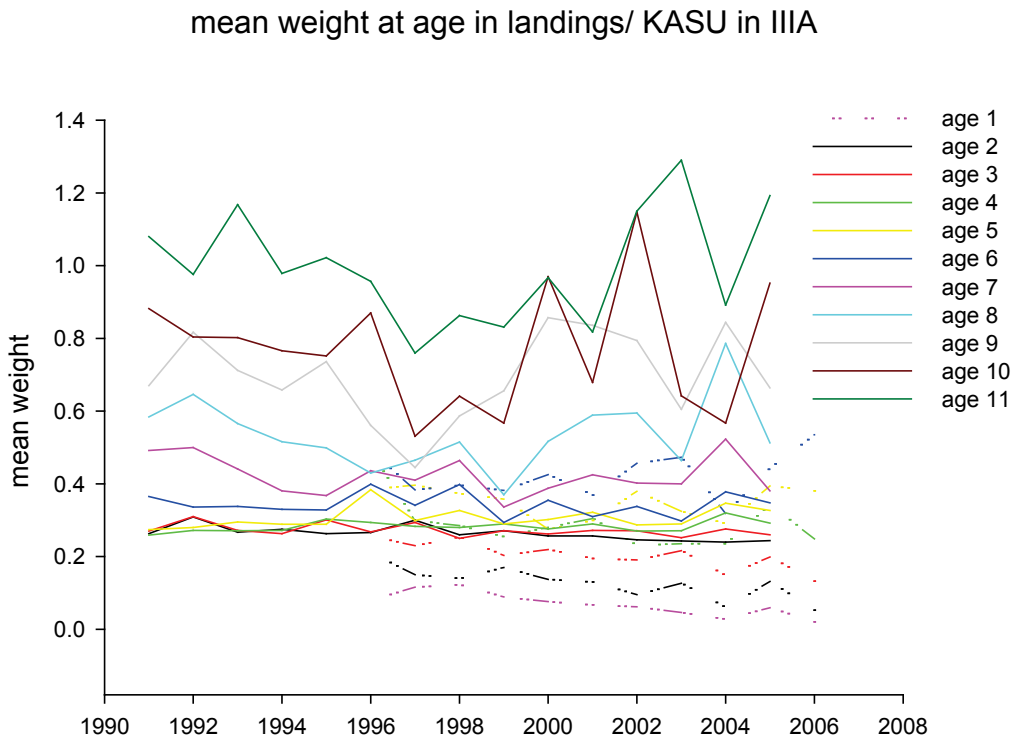


Figure 7. Mean weight at age in KASU 1+4 q and commercial landings from the Danish fleet.

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 in-

stances, 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 II_a). 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 ef-

fect 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 $\mathbf{B}_{lim}$ be set at 160 000 t and that $\mathbf{B}_{pa}$ 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 5^{th} 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. 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	B_{lim}	160 000 t	B_{loss} = 160 000 t, the lowest observed biomass in 1997 as assessed in 2004.
	B_{pa}	230 000 t	Approximately 1.4 B_{lim}.
	F_{lim}	0.74	F_{loss} for ages 2–6.
	F_{pa}	0.60	5th percentile of F_{loss} (0.6) and implies that B_{eq}>$B_{pa1)}$ and a 50% probability that SSB_{MT} ~ B_{pa}.
Targets	F_{mgt}	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

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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)
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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.

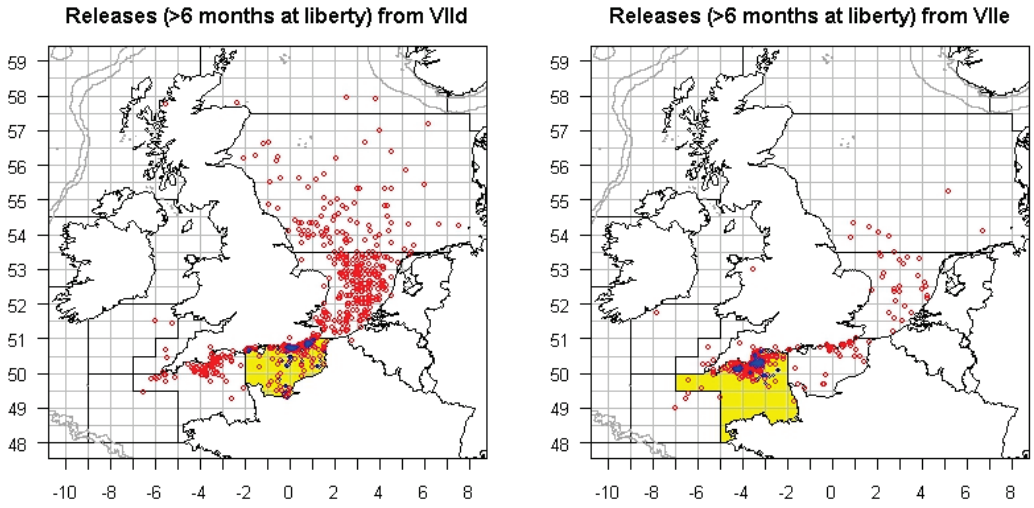


Figure 1 : Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

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 log-books 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 log-books. 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. Alt-

hough 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

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ANNEX 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



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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.

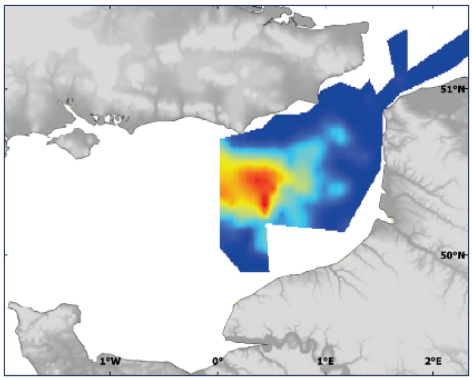
Life history parameters - Maximum length 100 cm; common length 25-45 cm; minimum landing size 22 cm except in Skaggerak and Kattegat 27 cm (EU); maximum lifespan 50 years; age and length at maturity 2-7 years and 18-35 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 71.65 cm, growth rate 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).

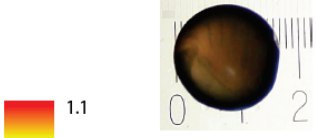
Environment - This bentho-demersal species prefers to live on sand but also on gravely or muddy substrates, from the coast to 200 m in depth. The species is found in marine to brackish temperate waters.

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)

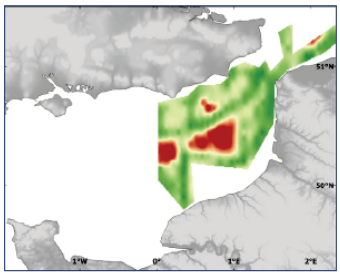




stade 1
stage 1

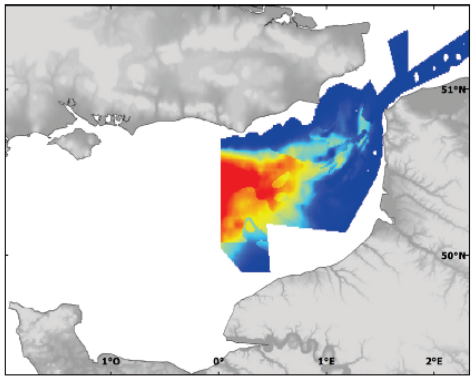
1.1
0
log (x+1),
x = nbr. ind.
/ 20 m³

Erreur de krigeage
Kriging error



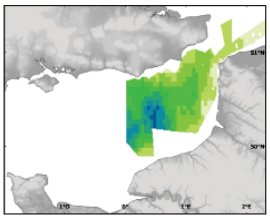
élevé/*high*
faible/*low*

Habitat préférentiel en janvier (GLM)
Preferential habitat in January (GLM)



élevé/*high*
faible/*low*
1
0.6
0.4
0.3
0.25
0.2
0.15
0.1
0.05
0.01
0

Erreur du modèle / *Model error*



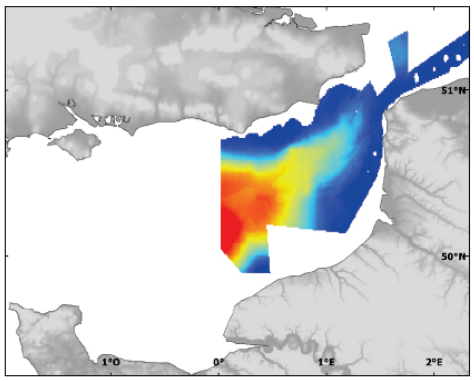
DEP	+2
STR	-
TMP	+
SAL	
CHL	+
SED	

0/1 GLM

DEP	
STR	
TMP	2
SAL	
CHL	
SED	CS M - G - FS - P

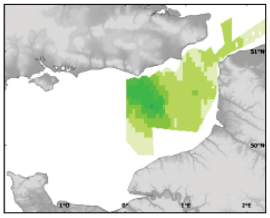
+ GLM

Habitat potentiel en janvier (RQ)
Potential habitat in January (RQ)



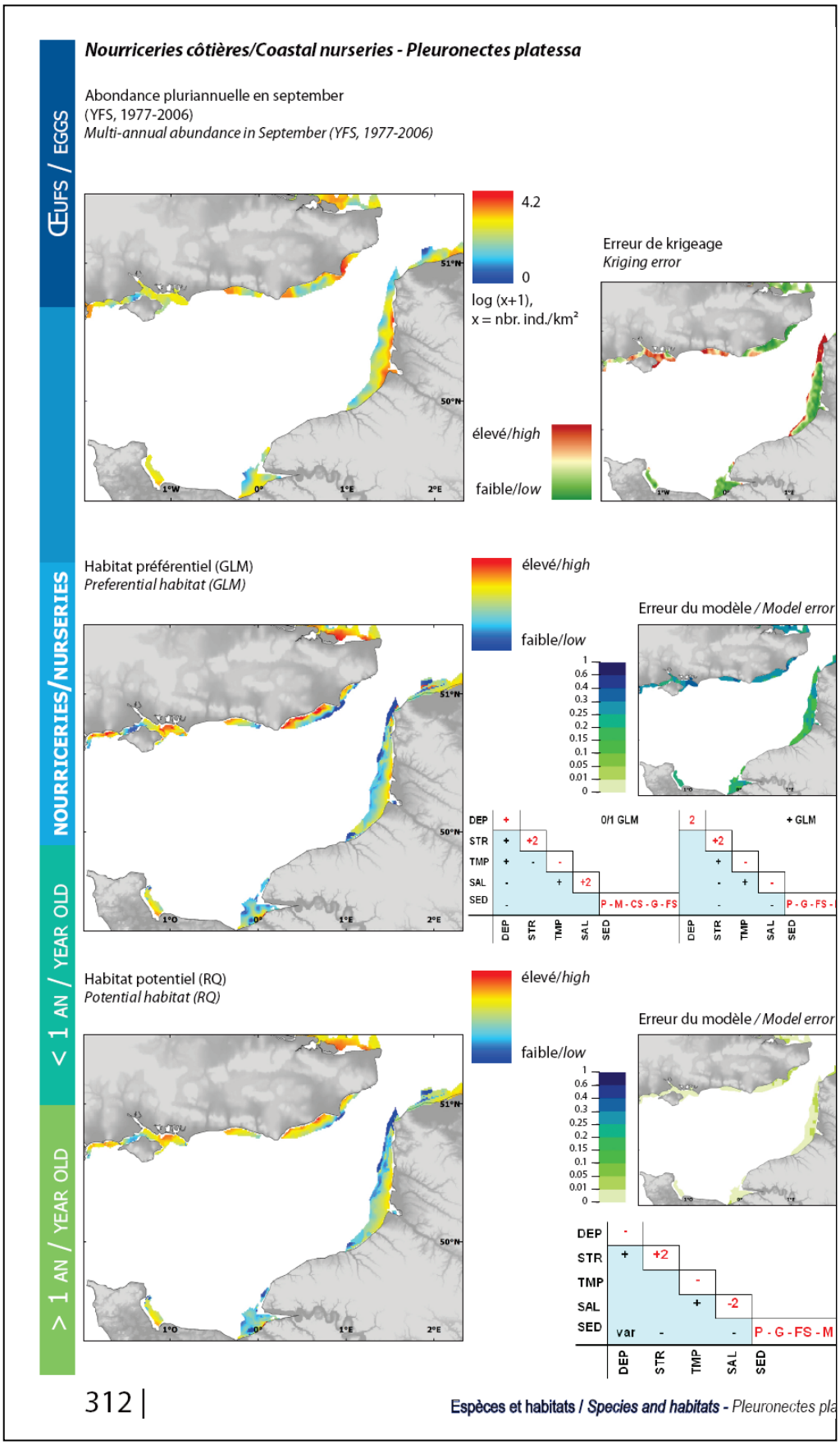
élevé/*high*
faible/*low*
1
0.6
0.4
0.3
0.25
0.2
0.15
0.1
0.05
0.01
0

Erreur du modèle / *Model error*



DEP	+2
STR	-2
TMP	-2
SAL	-2
CHL	+2
SED	CS M - FS - G - P

Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*


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 error
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
P - M - CS - G - FS
P - G - FS -
Habitat potentiel (RQ)
Potential habitat (RQ)
élevé/high
faible/low
Erreur du modèle / Model error
var
P - G - FS - M
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

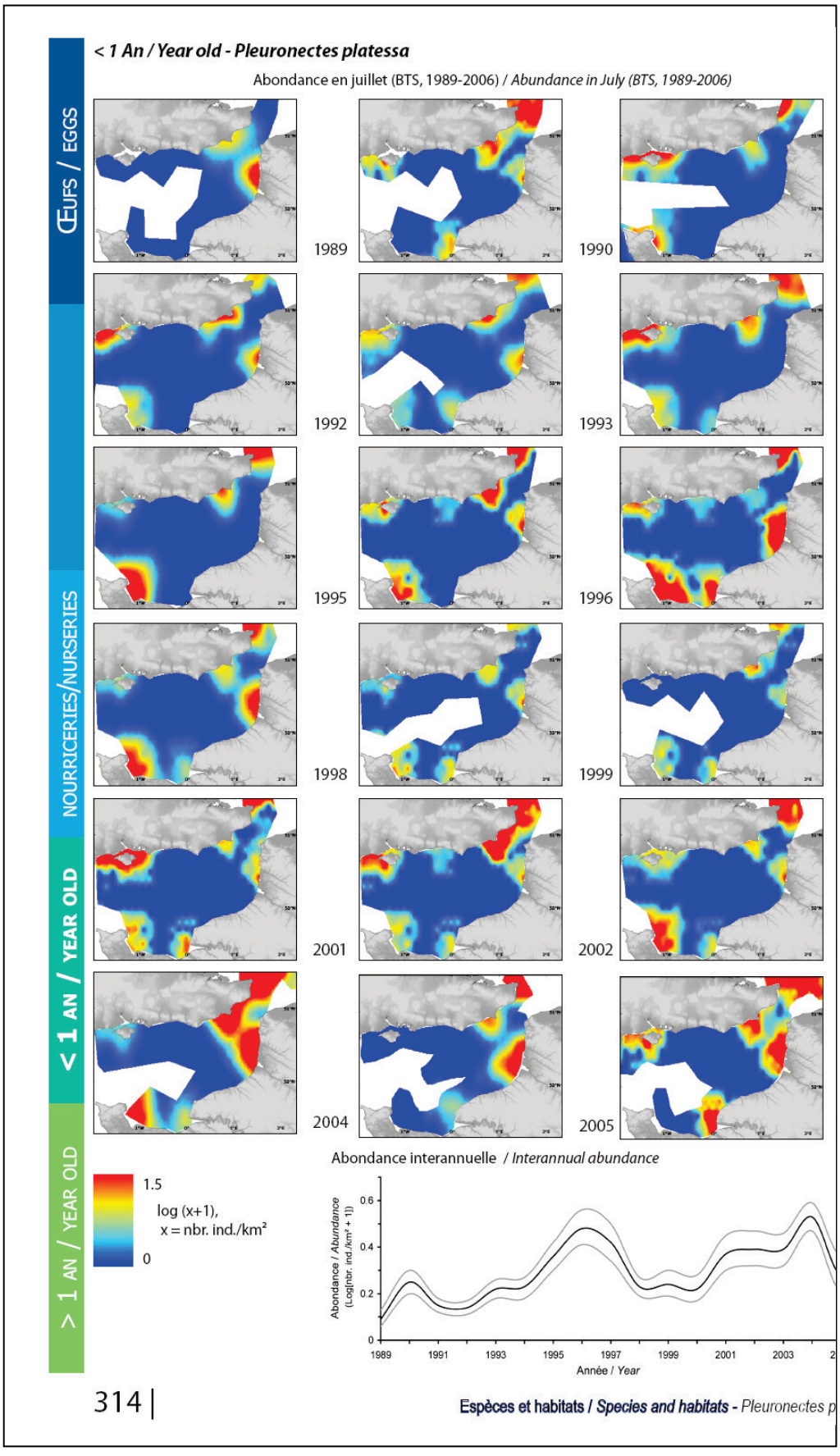
The multi-annual abundance map from the YFS surveys (September) indicates a very coastal spatial distribution of plaice across the sampled area, with some high abundance areas in front of the Bays of Somme, Canche, Authie and Rye. The potential and preferential habitat models are very similar and agree 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.

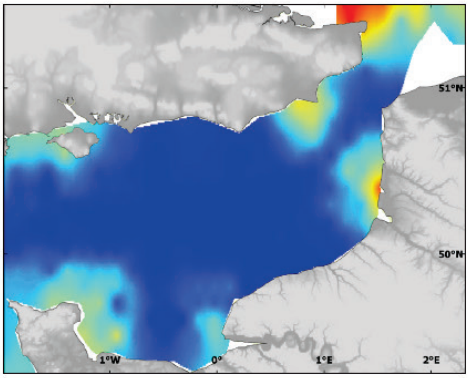
In October, the distribution of young plaice was more spatially restricted than in July, and seemed to be concentrated the Bays of Somme, Canche, Authie and Seine. Some young individuals were also found around the Cherbourg Peninsula. Occurrence areas of young plaice did not change a lot between July and October. The kriging error was more important in the north-west of the study area, where observa-


ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
< 1 An / Year old - Pleuronectes platessa
Abondance en juillet (BTS, 1989-2006) / Abundance in July (BTS, 1989-2006)
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))
0.6
0.4
0.2
0
1989
1991
1993
1995
1997
1999
2001
2003
Année / Year
314 |
Espèces et habitats / Species and habitats - Pleuronectes p

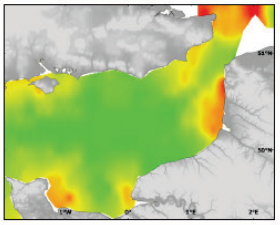
< 1 An / Year old - Pleuronectes platessa

Abondance moyenne en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)



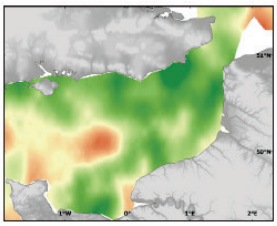


Ecart-type / *Standard deviation*



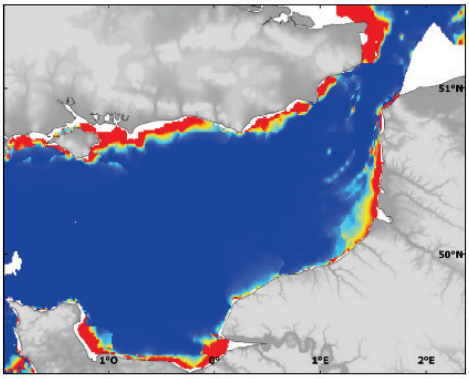
élevé/*high*
faible/*low*

Erreur de krigeage / *Kriging error*



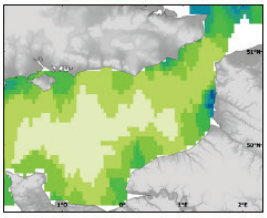
élevé/*high*
faible/*low*

Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)

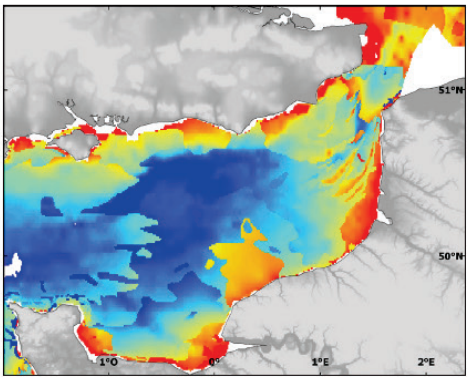


élevé/*high*
faible/*low*

Erreur du modèle / *Model error*

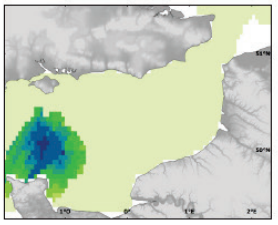


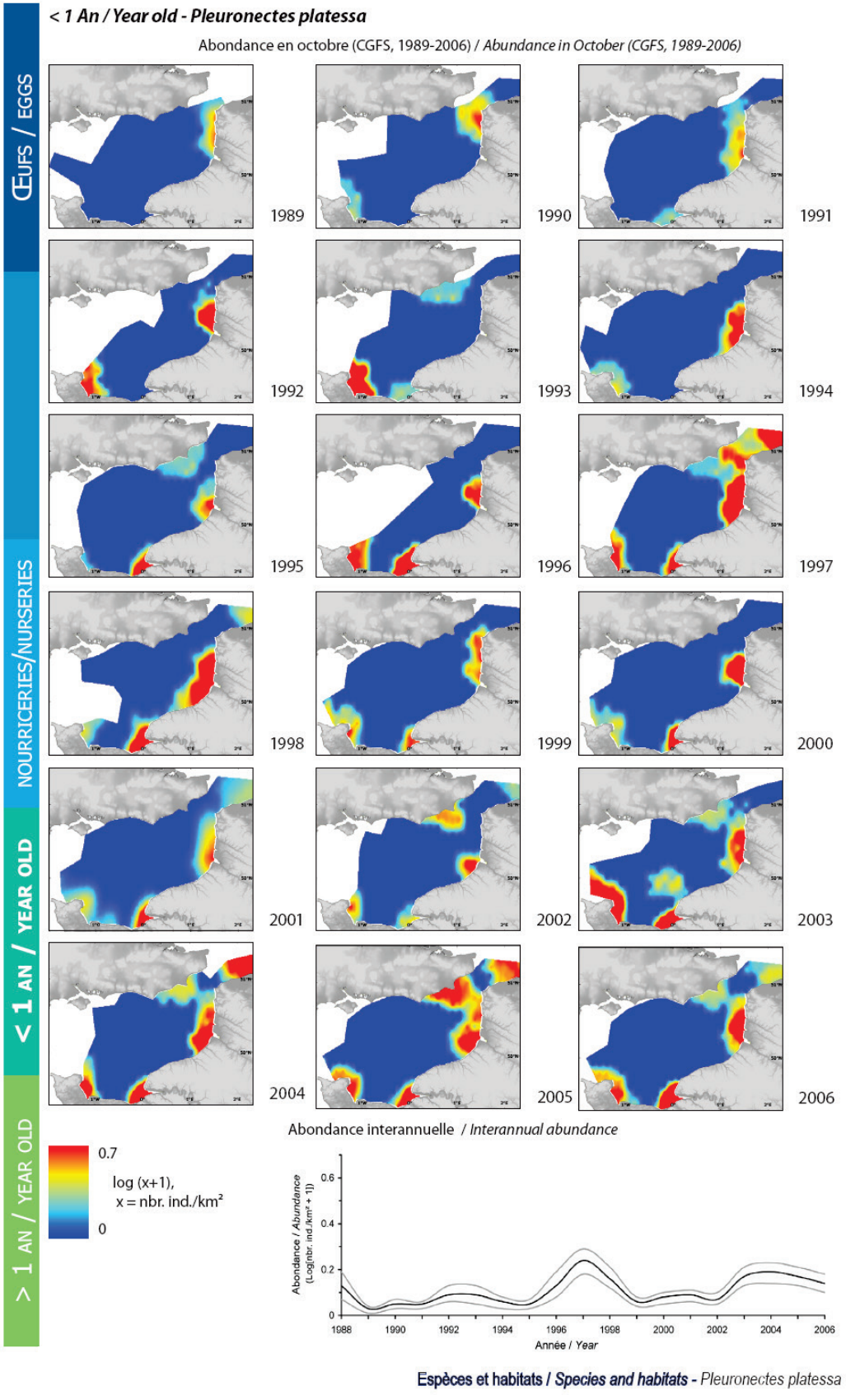
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)



élevé/*high*
faible/*low*

Erreur du modèle / *Model error*



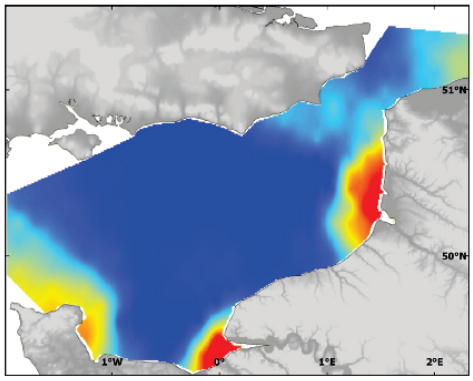


Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

< 1 An / Year old - Pleuronectes platessa

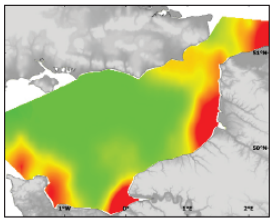
Abondance moyenne
en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)



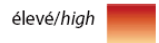


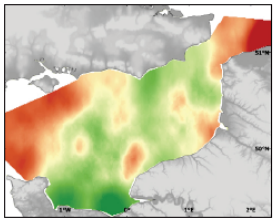


Ecart-type / *Standard deviation*

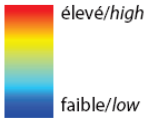


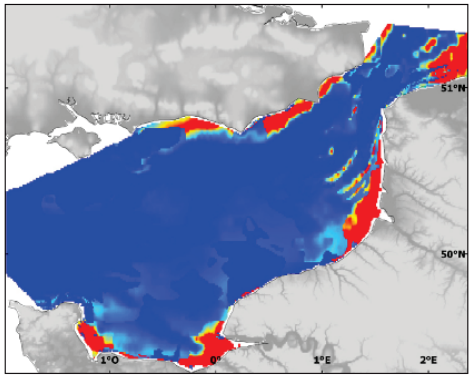
Erreur de krigeage / *Kriging error*



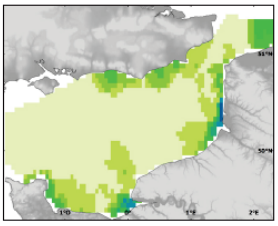


Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)

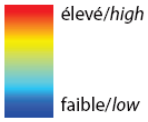


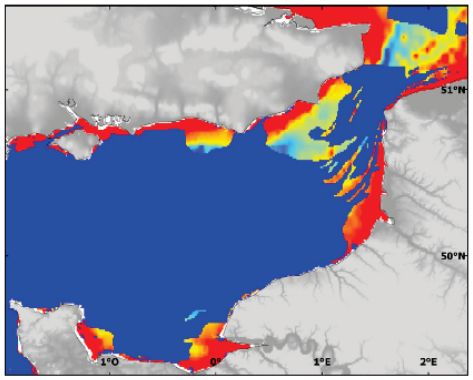


Erreur du modèle / *Model error*

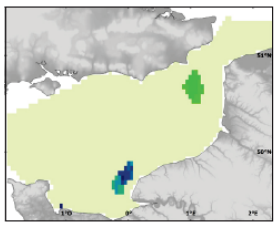


Habitat potentiel enoctobre (RQ)
Potential habitat in October (RQ)





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.

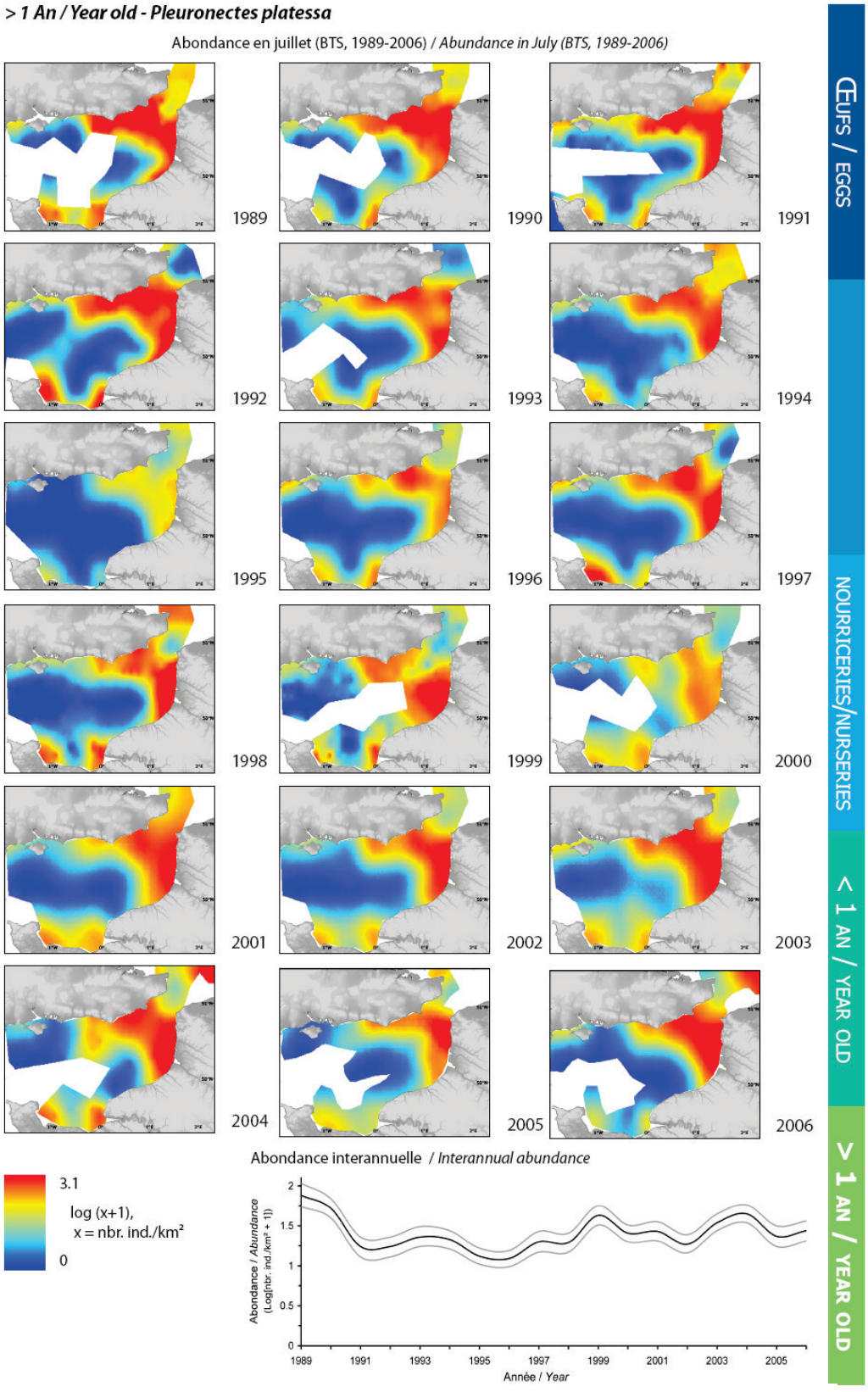
tions were more sparse. As in July, the preferential habitat model strongly favoured coastal areas close to estuaries, which this time agrees with the survey data. The potential habitat model resembles the preferential habitat model but exhibits a more dispersed offshore spatial distribution in the Dover Strait as well as in the southern North Sea.

> 1 year old

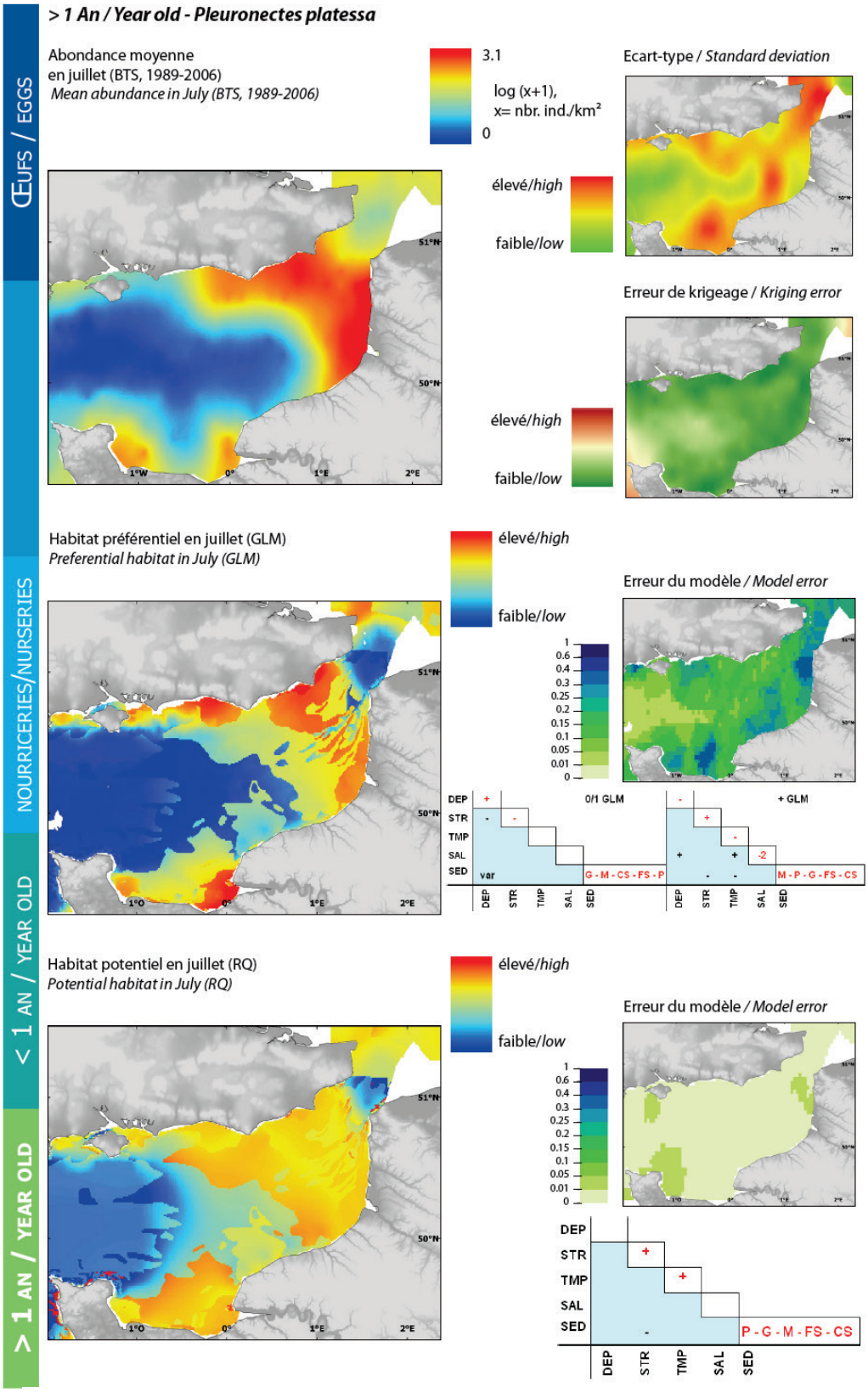
Older than one year individuals (length > 18.1 cm) were found in the same areas as younger ones but had a more offshore distribution pattern.

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.

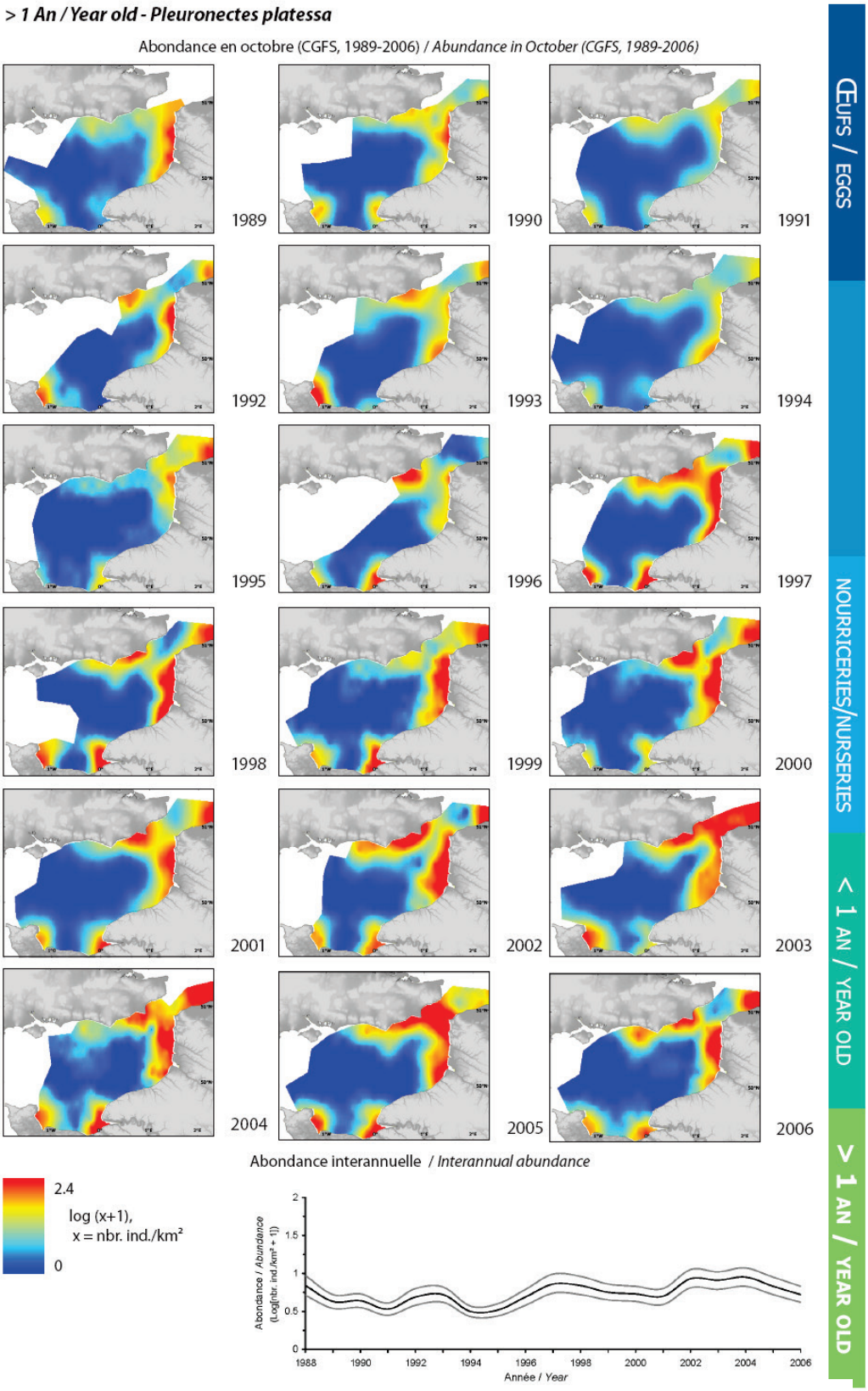
In October, the distribution pattern seemed to contract along the coasts. Many individuals were found along the Opale and Belgium coasts and around Dungeness. Some patches occured in the Bays of Seine and Veys. The kriging error was again associated with more sparse observations. The preferential and 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.



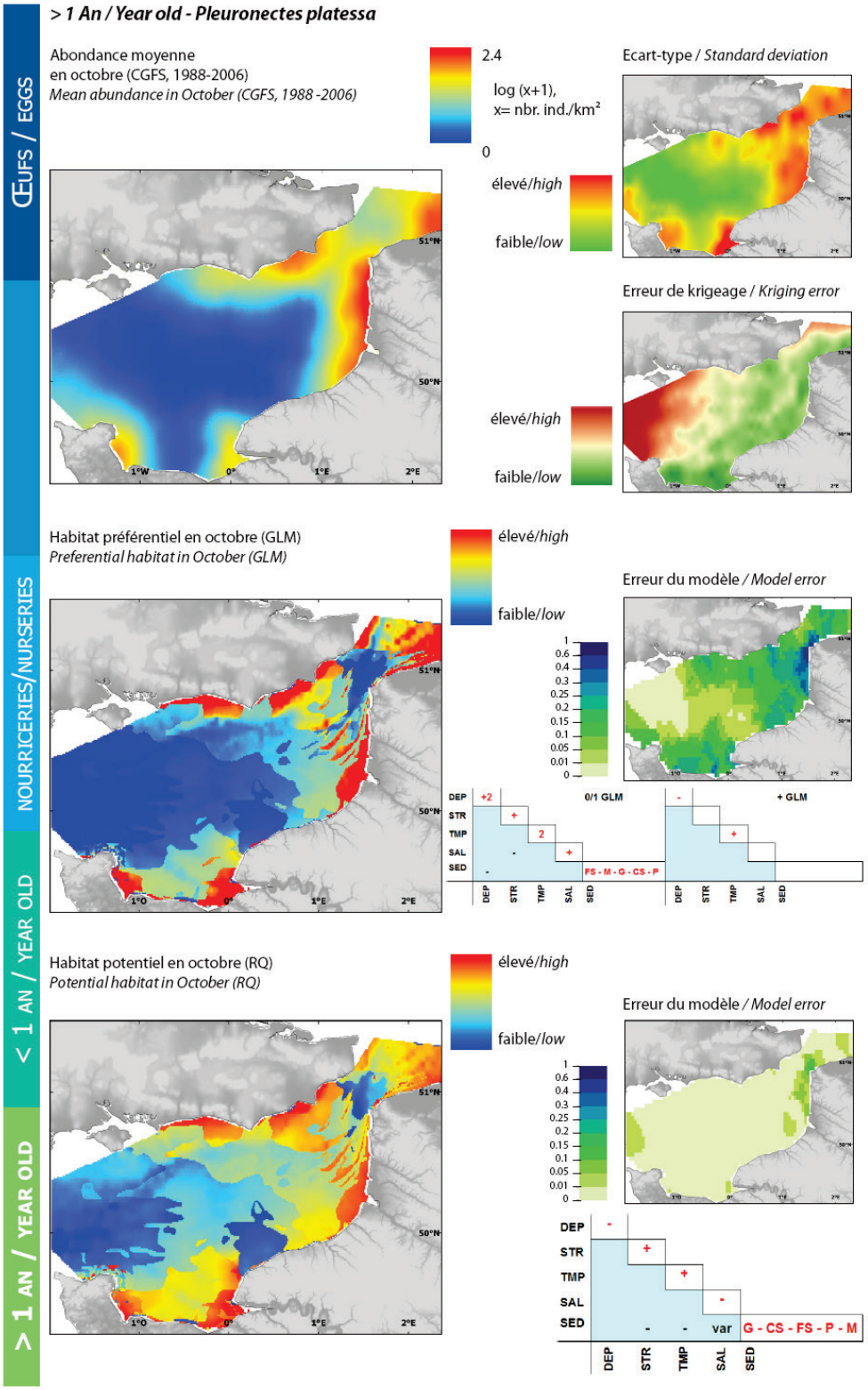
Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*



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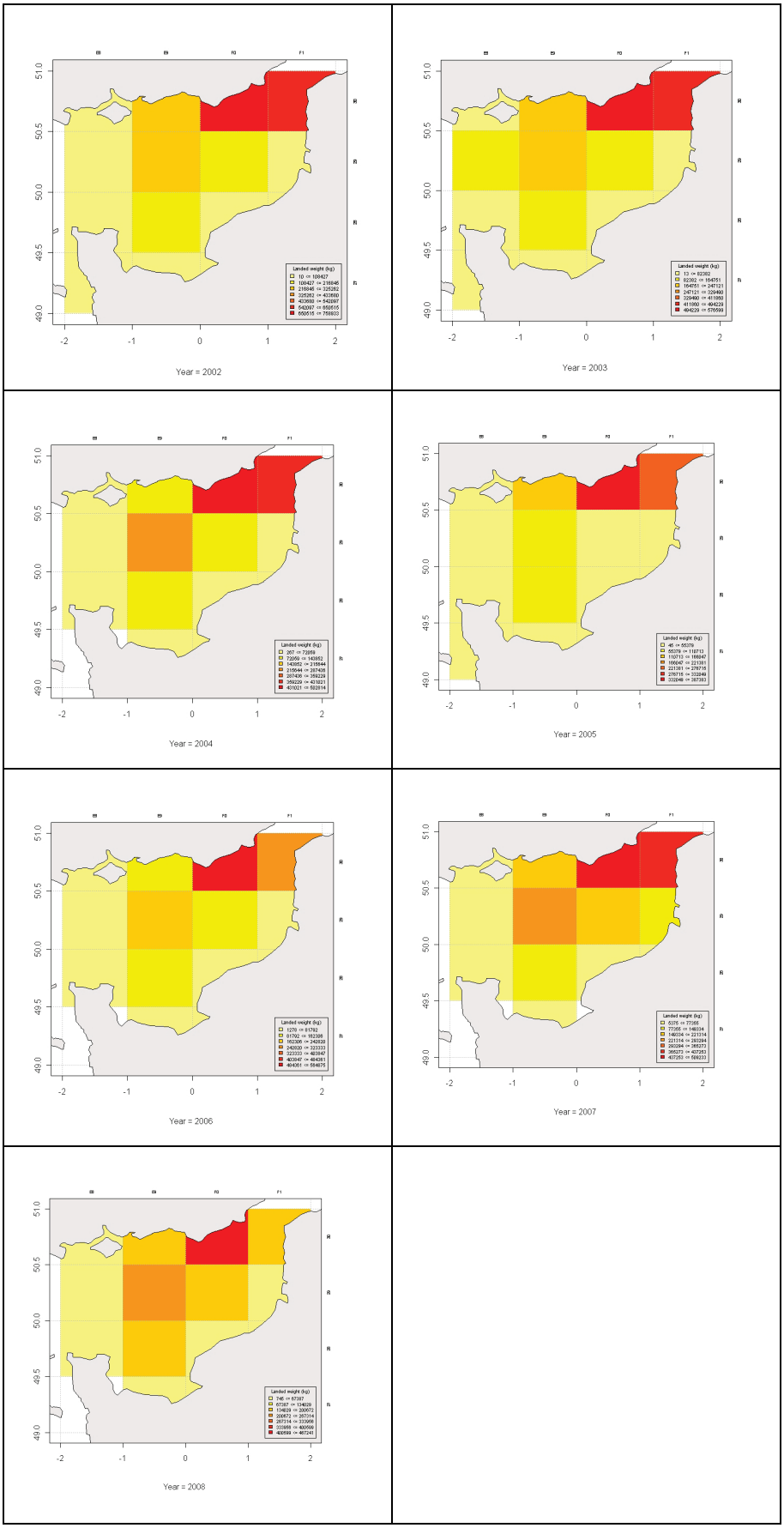


Figure . Plaice in VIId. - International landings from 2002 to 2008.

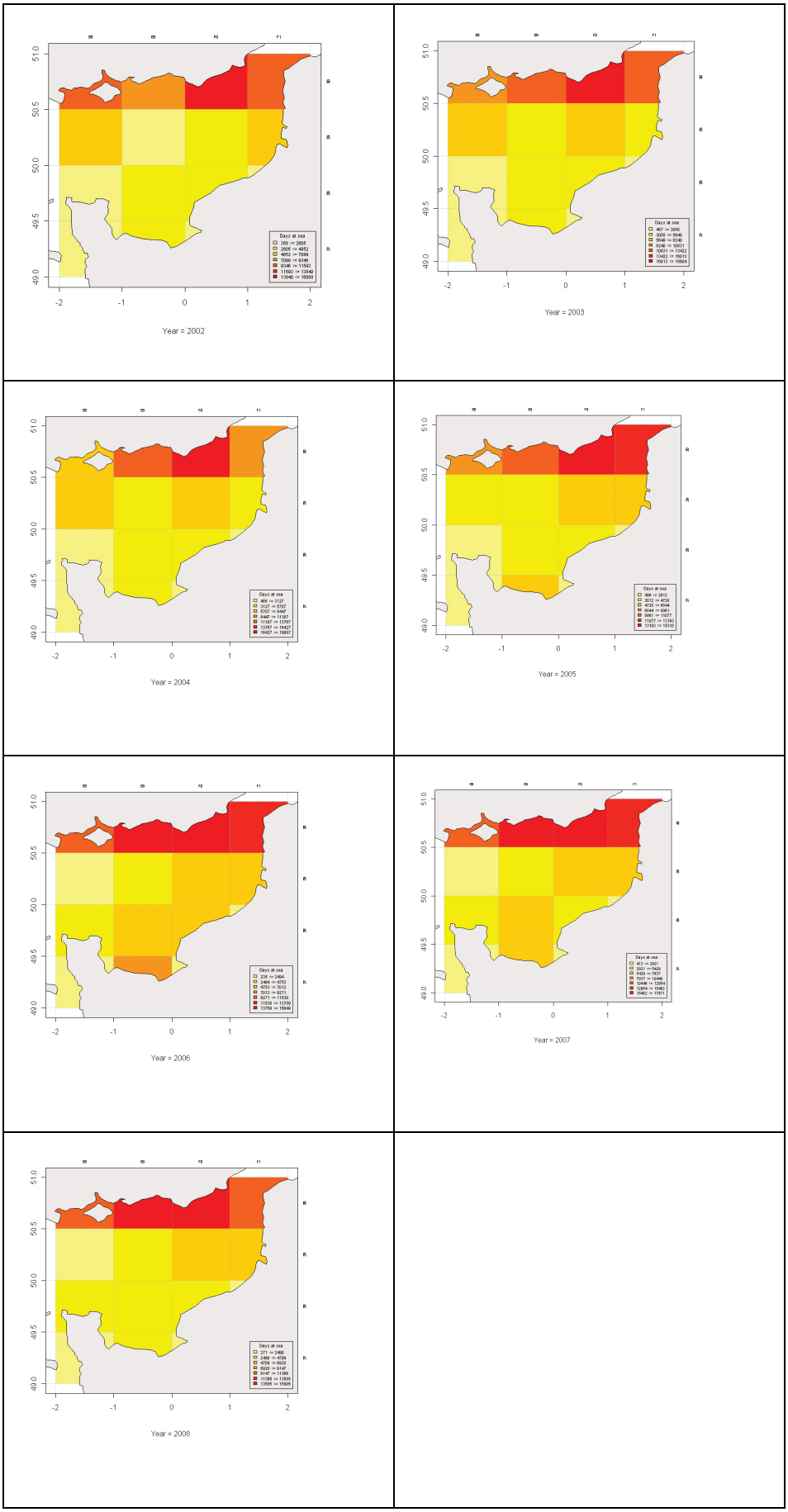


Figure Plaice in VIId - International effort in days at sea from 2002 to 2008.

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

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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

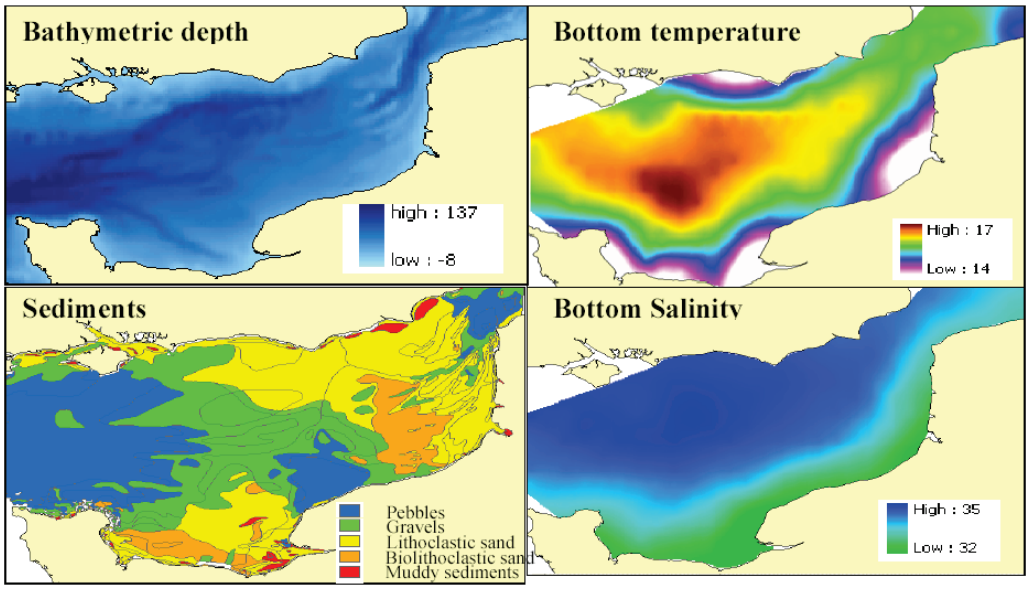


Figure 1. Eastern English Channel physical and hydrological features: Bathymetric depth and simplified sediment types representation. Survey bottom temperature and bottom salinity (averaged for 1997 to 2003) obtained by Kriging. (in Vaz *et al.*, 2004).

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.

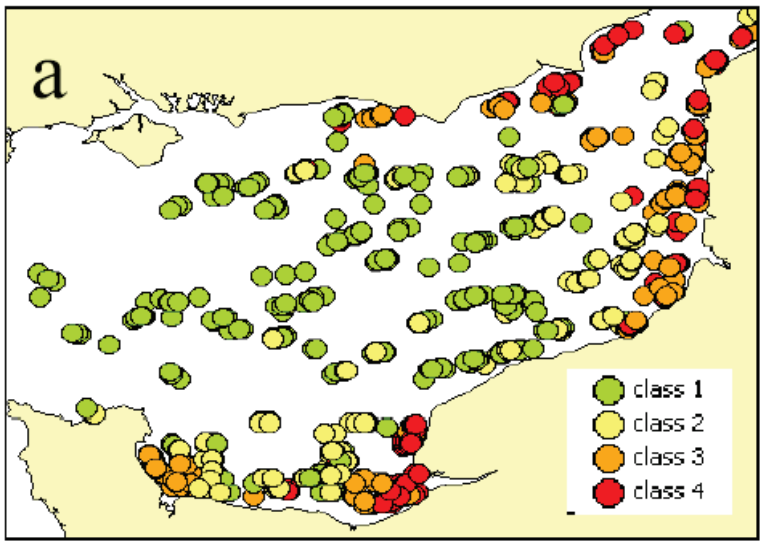


Figure 2. Spatial distribution of Fish Subcommunities in the Eastern Channel from 1988 to 2003. Observed assemblage type at each station, These illustrate the gradation from open sea community to coastal and estuarine communities (In Vaz *et al.*, 2004).

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 pro-

vided. 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\eximport\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.

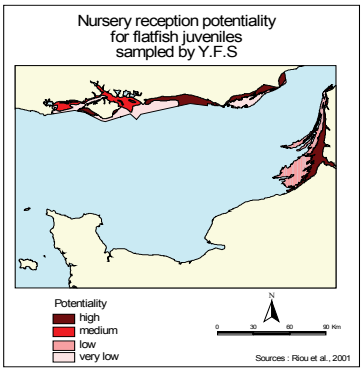
B.3 Surveys

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 (Km^2)	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 $B_{trigger}$	8000 t	Bpa
	F_{MSY}	0.29	Stochastic simulations assuming smooth hockey stick relationship

(unchanged since 1998)

H. Other issues

None.

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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	

A. 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 in-Figure 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.

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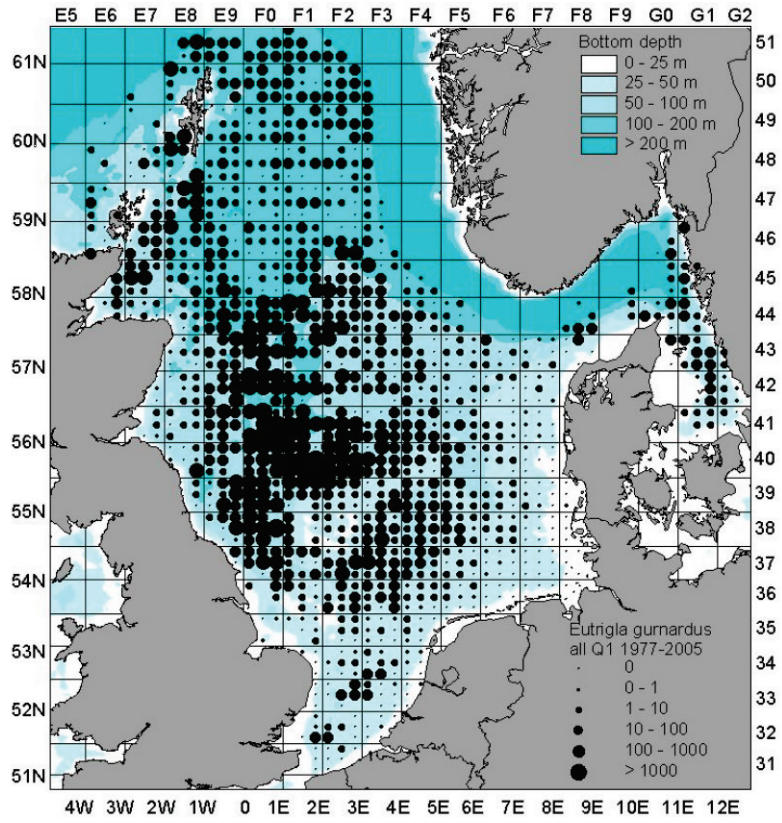


Figure 1. Average annual catch (number per fishing hour for all length classes combined) for grey gurnard in the quarter 1 IBTS survey, 1977–2005 (ICES-FishMap).

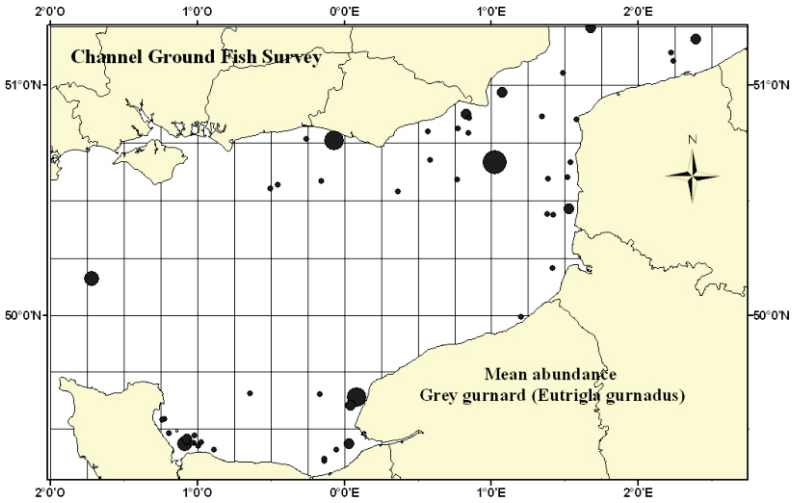


Figure.2. Distribution of grey gurnard in the eastern Channel. CGFS survey 1988–2004

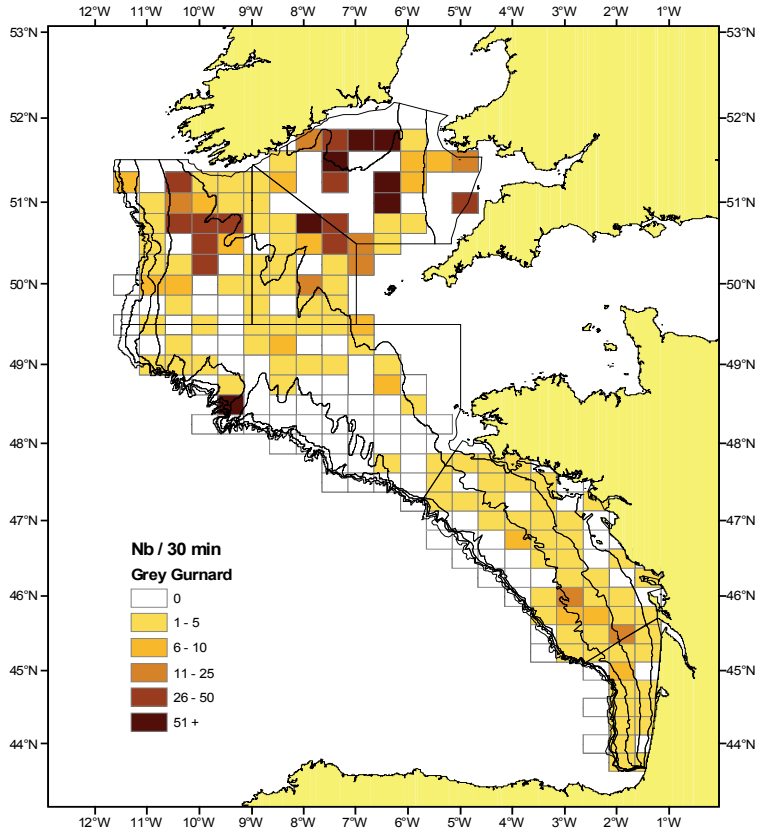


Figure.3. Distribution of grey gurnard in the Celtic Sea and the Bay of Biscay. EVHOE survey, 1997–2004.

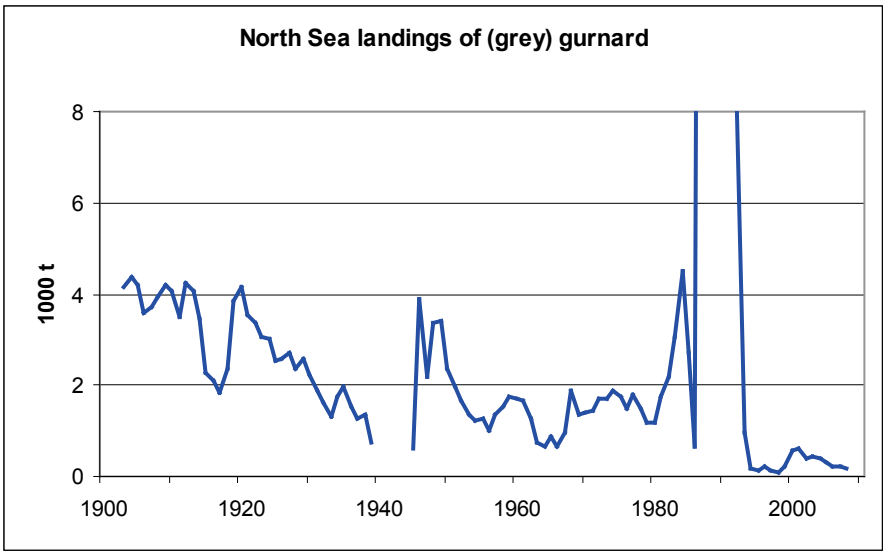


Figure.4. Total international landings of gurnards from the North Sea, probably most of the landings consisted of grey gurnard. See text for further explanation.

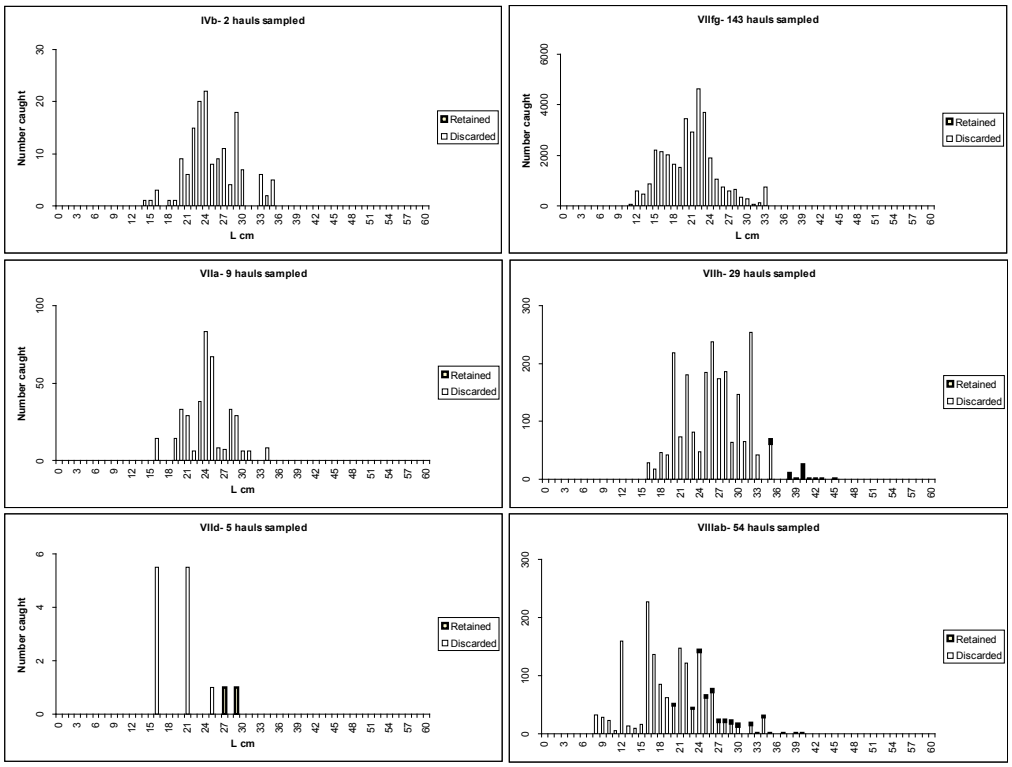


Figure 5 Length composition of French catches of grey gurnard in 2005.

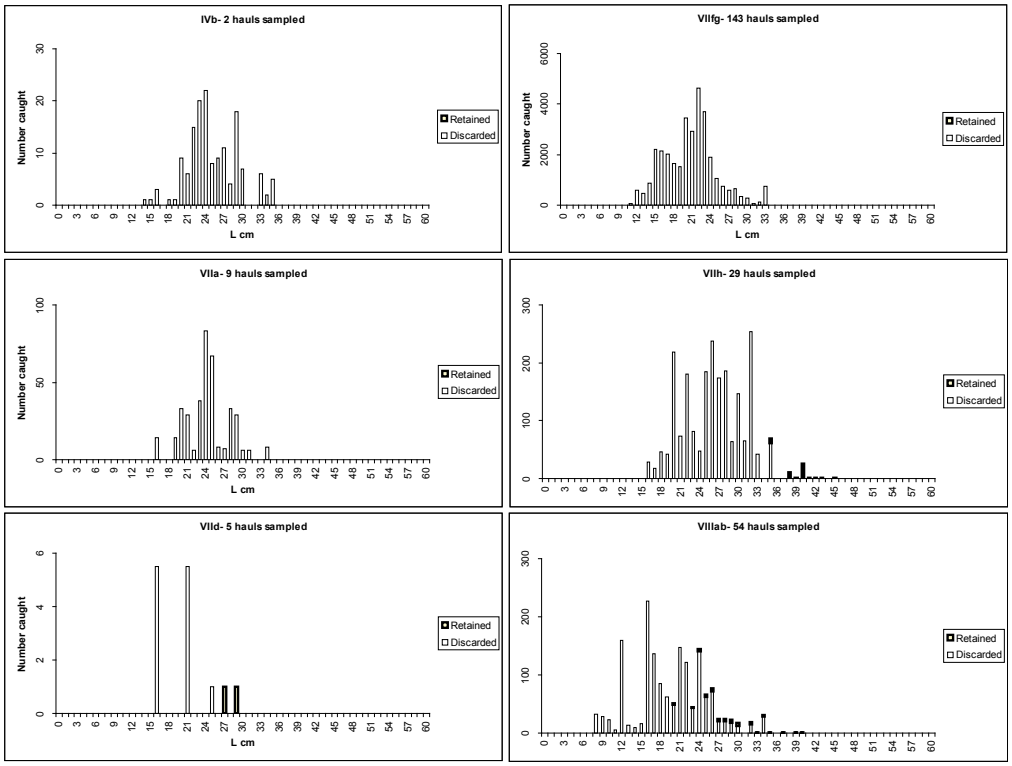


Figure.6 Length composition of French catches of grey gurnard in 2006.

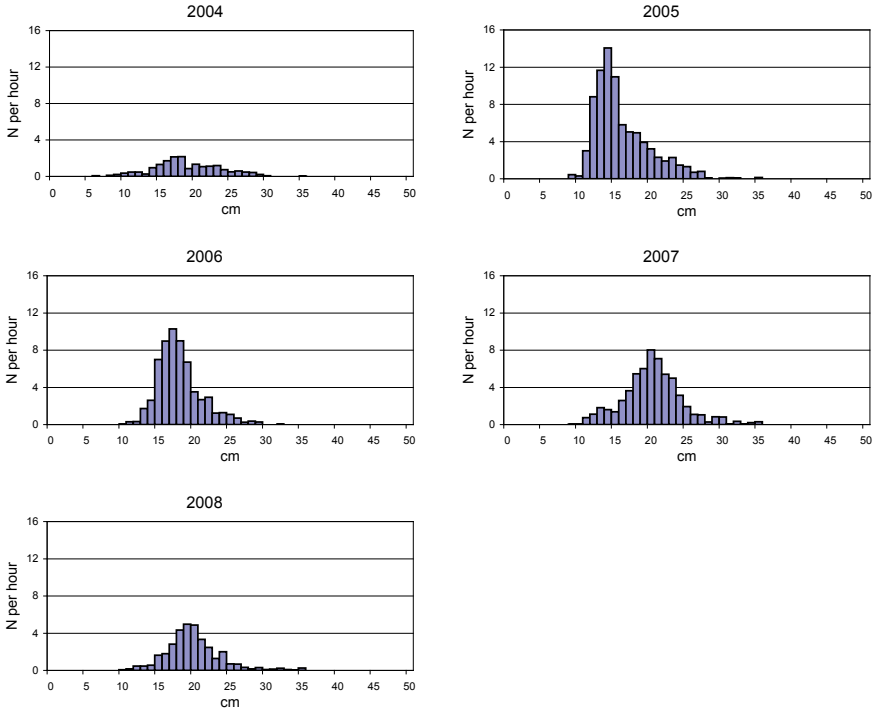


Figure.7 Grey gurnard: number at length discarded per fishing hour by the Dutch beam trawl fishery in the years 2004 to 2008.

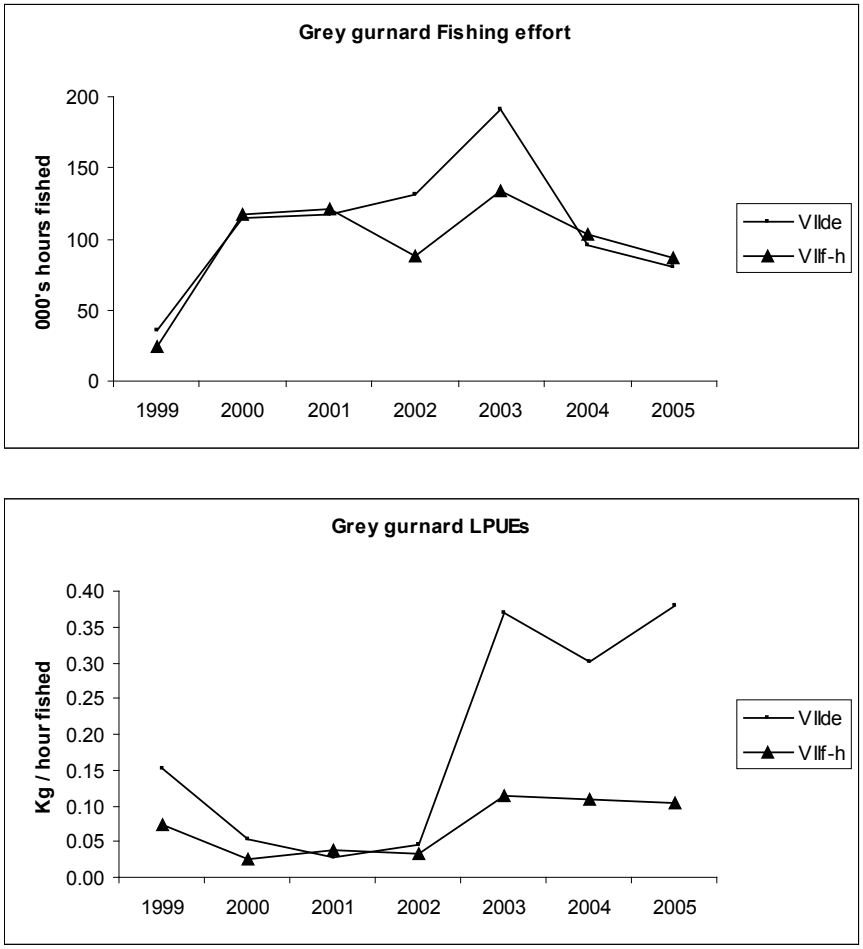


Figure 8. Effort and landings per unit of effort for French single otter trawlers for areas VIId,e and VIIf–h for the years 1999 to 2005.

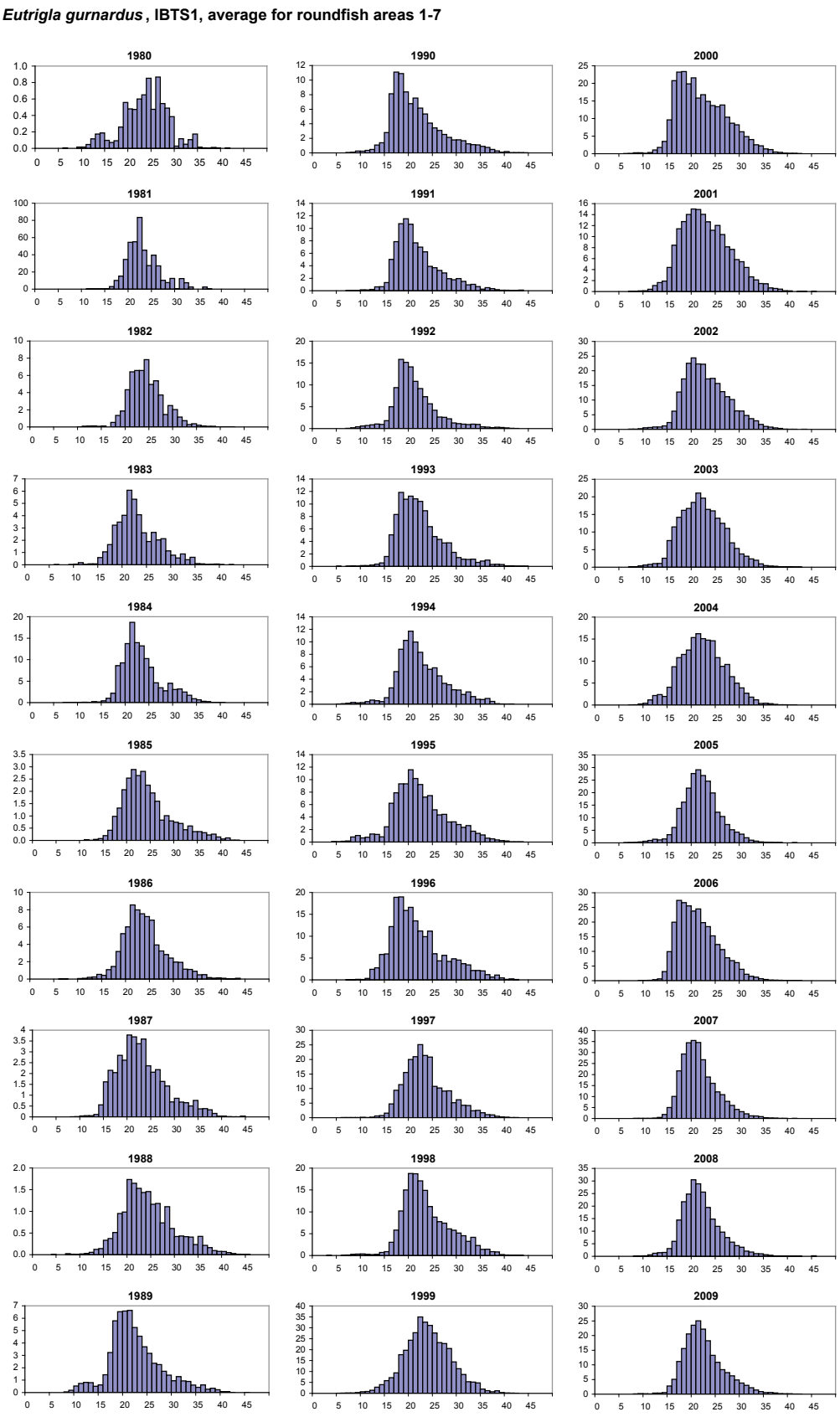


Figure 9 Grey gurnard in IV: number at length during the quarter 1 IBTS survey.

***Eutrigla gurnardus*, IBTS1, average for roundfish areas 8 and 9**

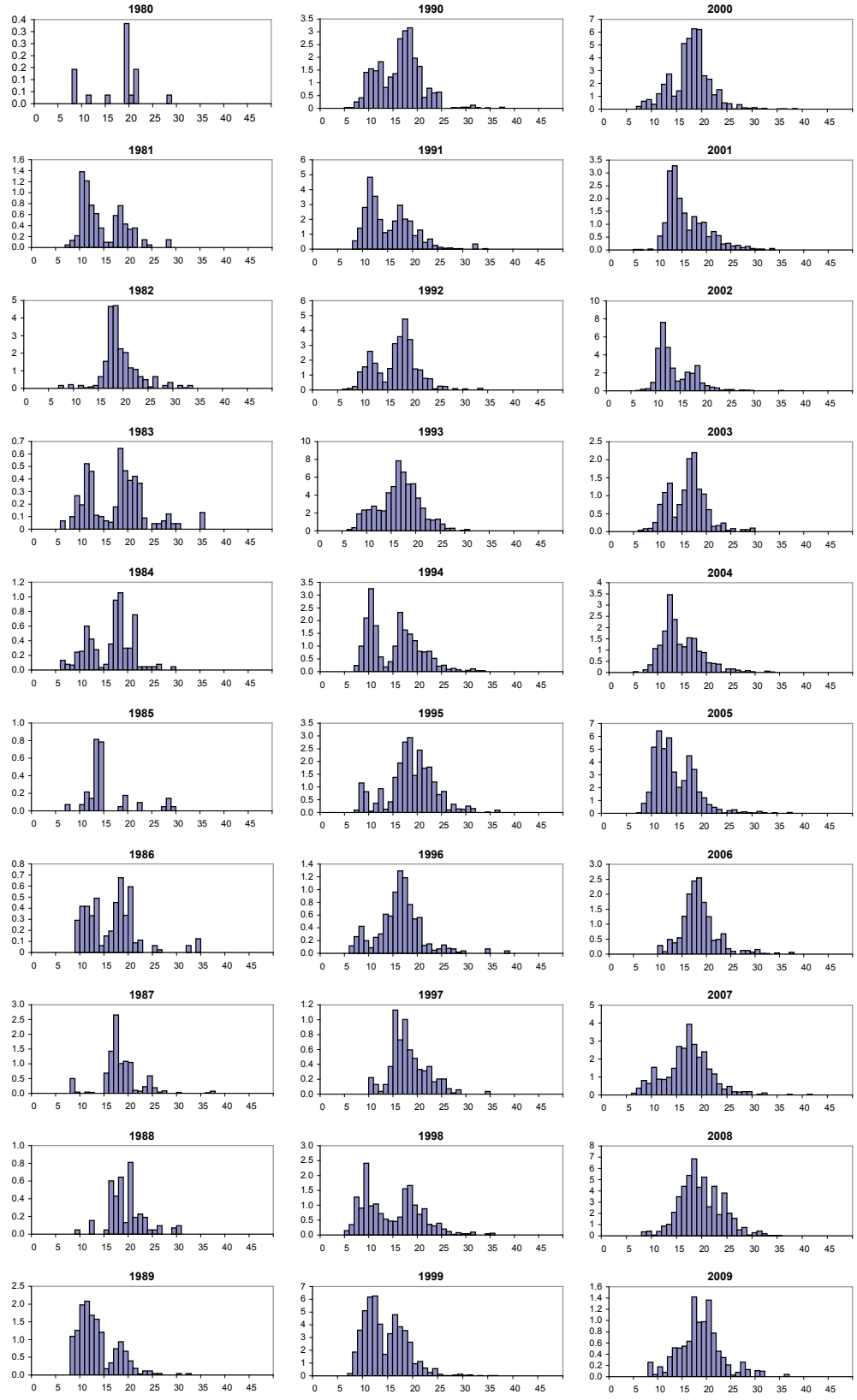


Figure 10 Grey gurnard in IIIa: number at length during the quarter 1 IBTS survey.

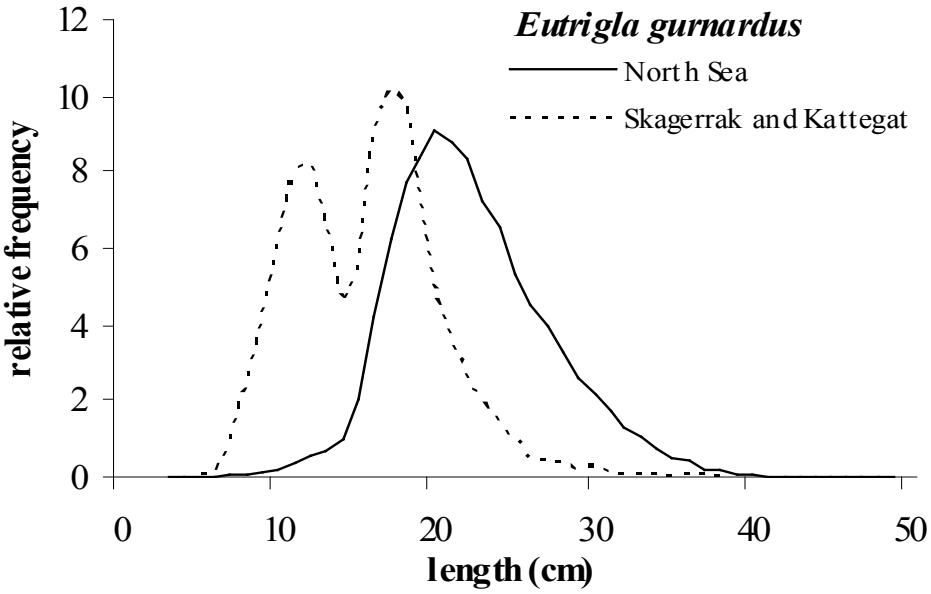


Figure 11. Length frequency distribution of *E. gurnardus* based on the quarter 1 IBTS, 1985–2005 in the North Sea and in Skagerrak/Kattegat. (ICES-FishMap).

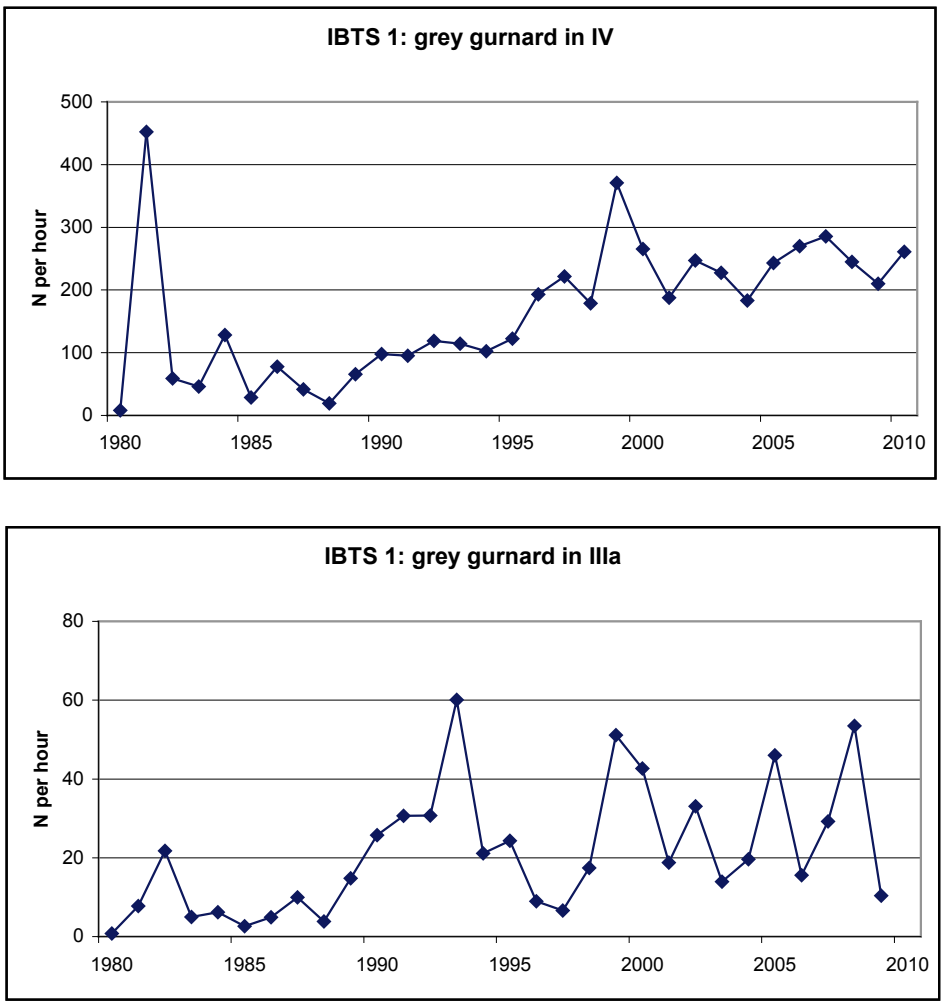


Figure 12. Average catch rate (number per hour for all length classes combined) of grey gurnard in the North Sea (upper panel) and in Skagerrak and Kattegat (lower panel), based on quarter 1 IBTS.

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

Annex 3 Part 2 1146

Stock Annex: Striped Red Mullet in Divisions IIIa, VIId and Subarea IV 1146

Stock Annex - North Sea Sole 1166

Stock Annex – Whiting IIIa 1174

Stock annex: Haddock in Subarea IV and Division IIIa(N) 1177

Stock Annex – Cod in 347d 1190

Stock Annex Saithe in Subarea IV (North Sea) 1217

Stock Annex–Sandeel in IV 1226

Stock Annex–Sandeel in IV 1264

Stock Annex - Turbot in ICES Subarea IV (North Sea) 1277

Stock Annex: Turbot in IIIa 1291

Stock Annex Whiting in 47d 1299

Annex 3 Part 2

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 1).

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 be-

tween 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

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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.

Year	Length		Age		Maturity		Individual weight	
	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

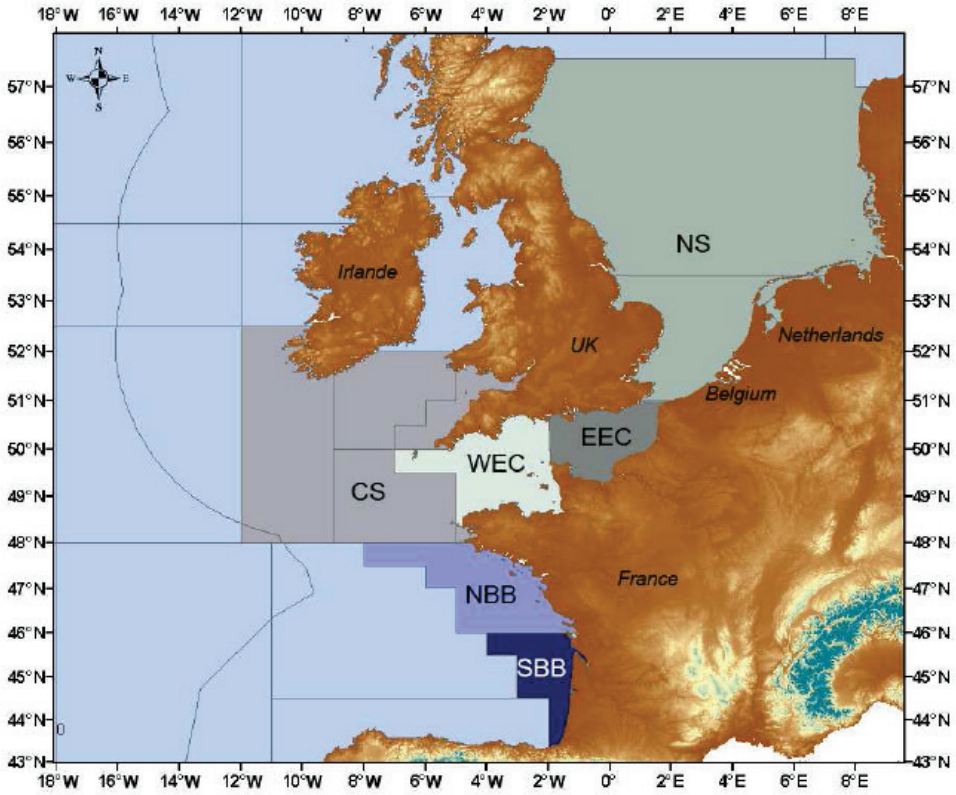


Figure 1. Striped red mullet. Map divided into 6 geographic sectors.

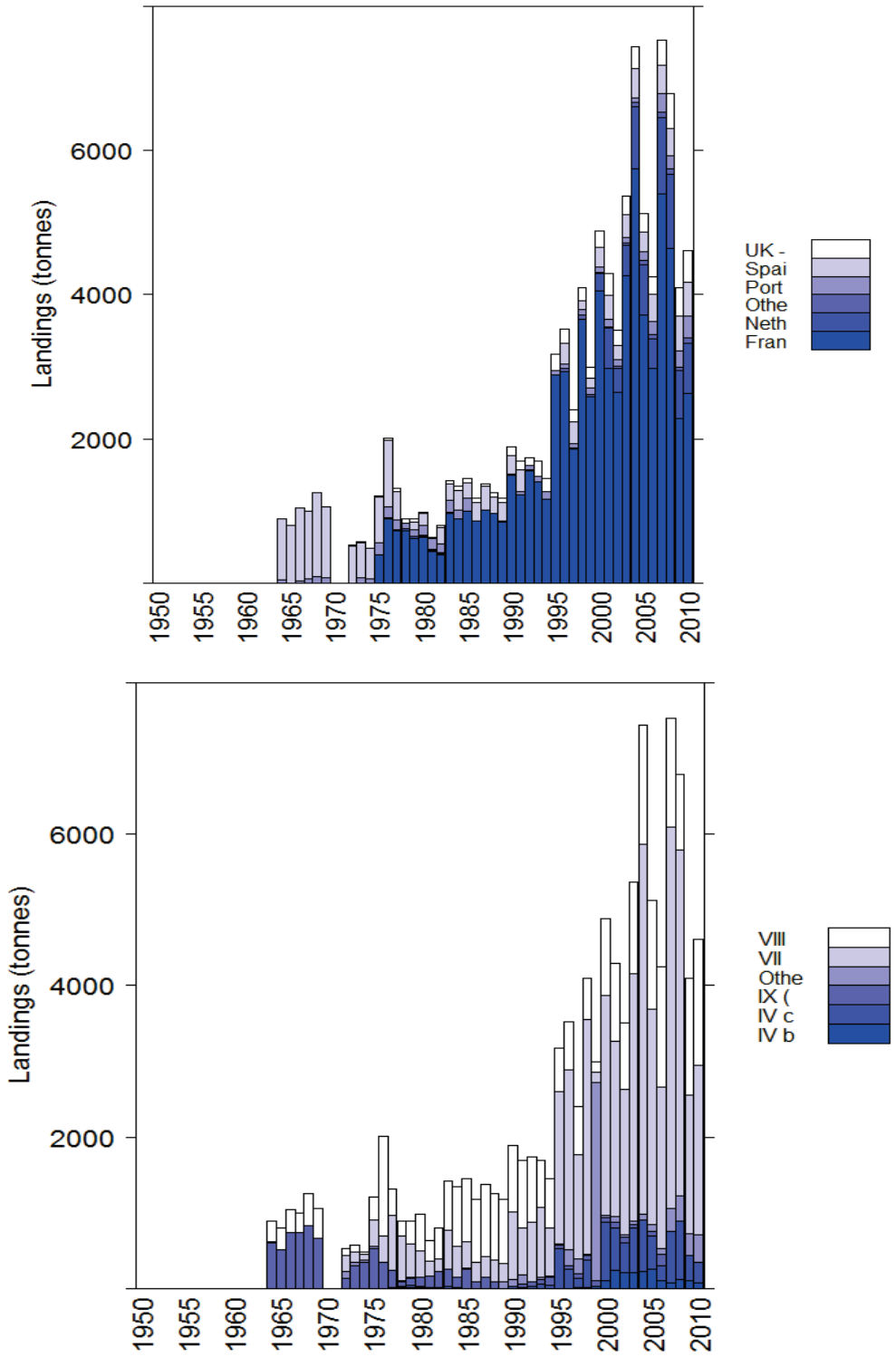


Figure 2. Striped red mullet. Landings per country (top panel) and per ICES area (bottom panel). As officially reported.

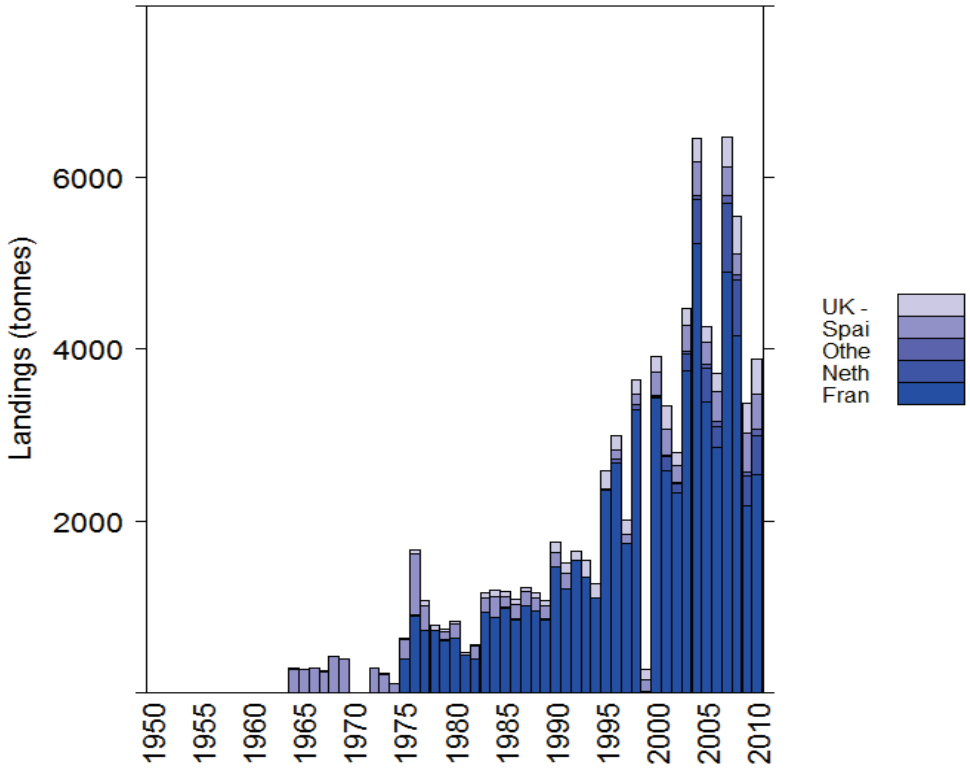


Figure 3. Striped red mullet. Landings in ICES area VIId by country. As officially reported.

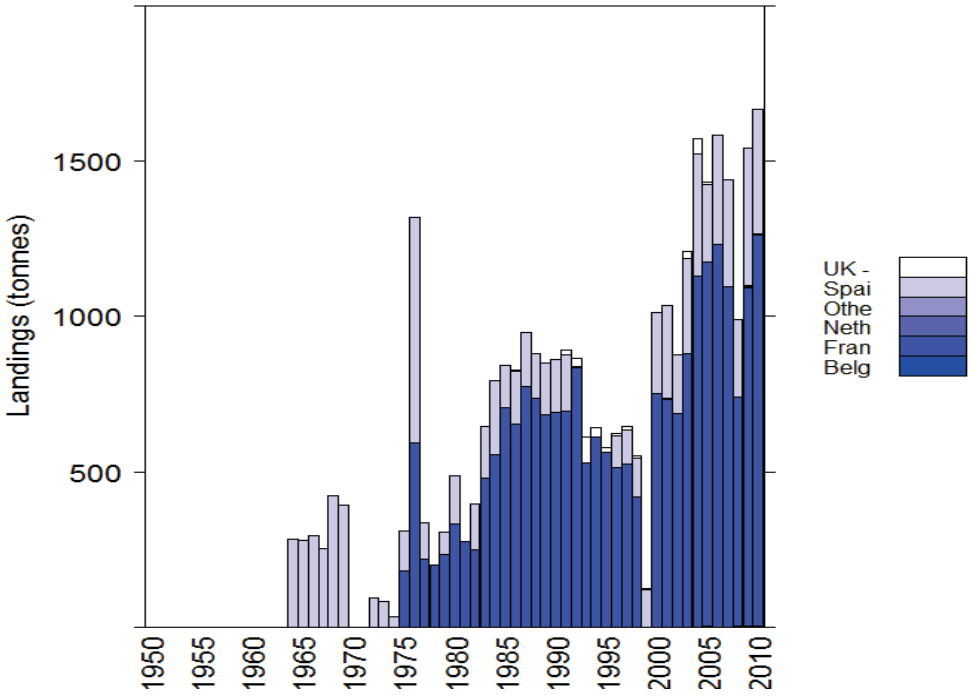


Figure 4. Striped red mullet. Landings in ICES area VIII by countriy. As officially reported.

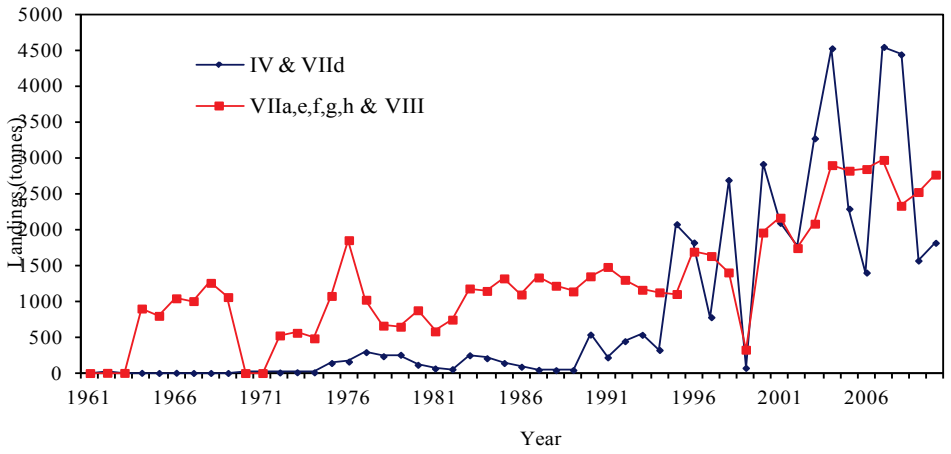


Figure 5. Striped red mullet. Landings from 1960 to 2010 in the north zone (ICES areas : VIId and IV) and in the south zone (ICES areas : VIIa,d,g,h, j & VIII). As officially reported.

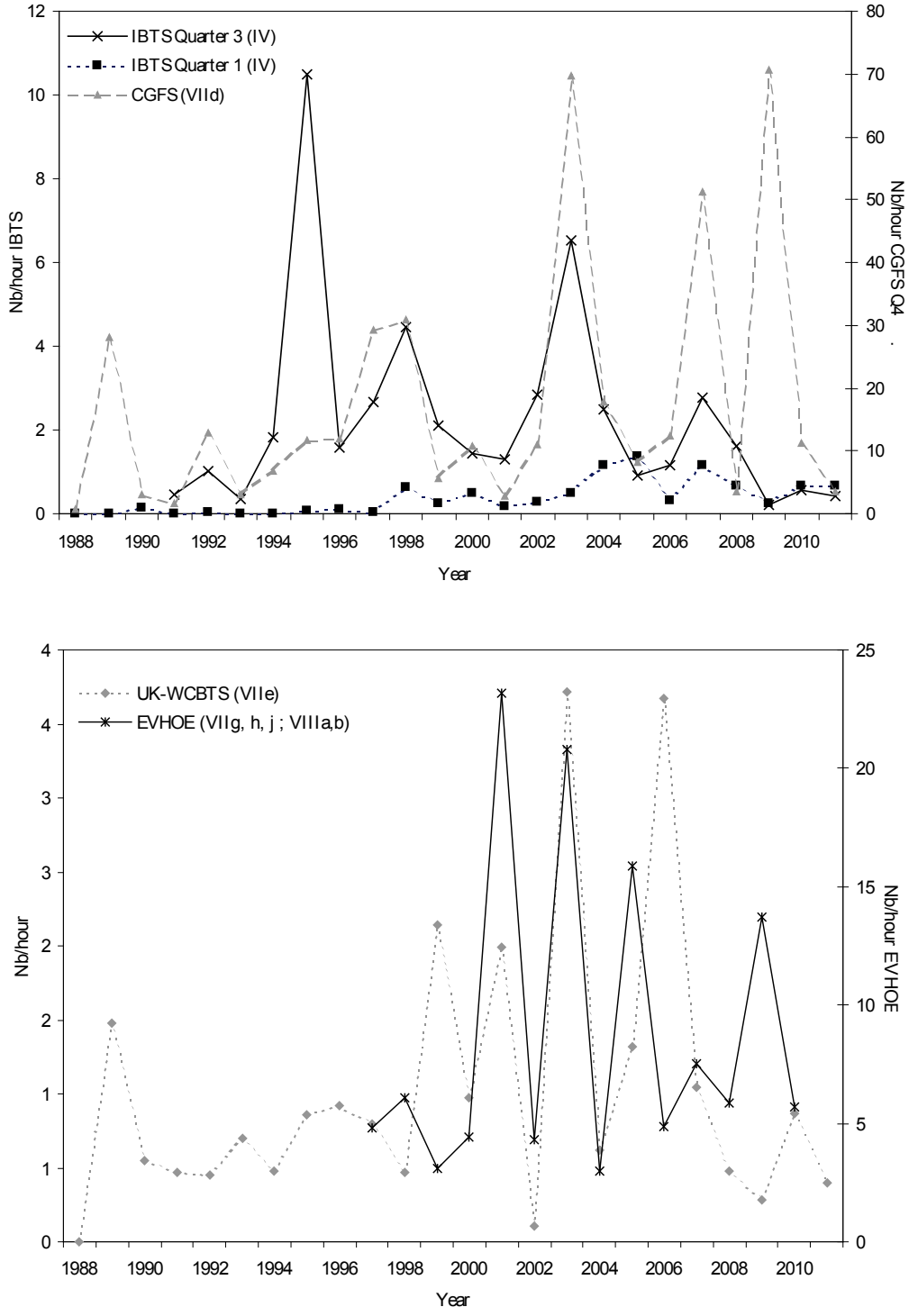
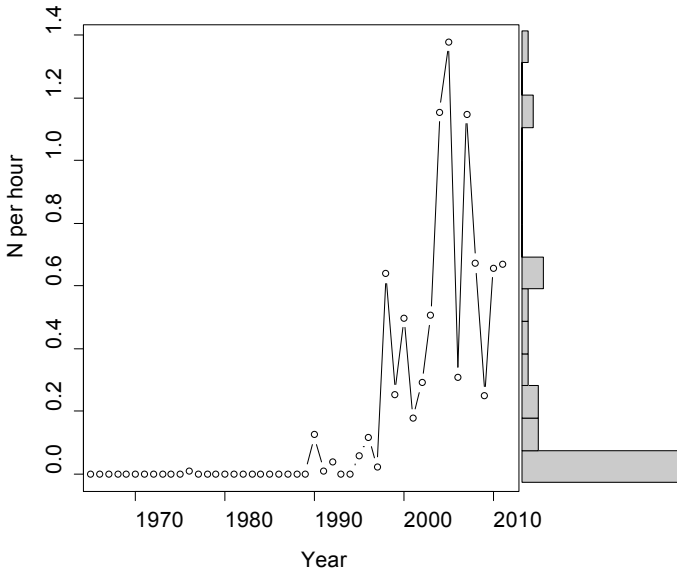
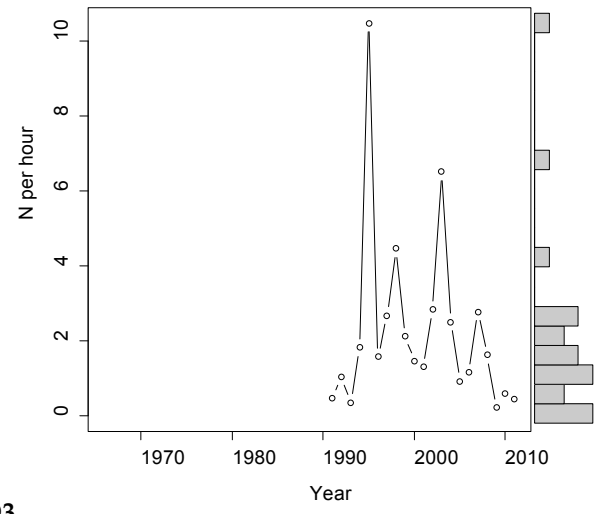


Figure 6. Striped red mullet. Time series of abundance (Nb/hour) of striped red mullet base on Surveys (International Bottom Trawl Survey (IBTS, IV), Channel Ground Fish Survey (FR-CGFS, VIId), UK-WCBTS (VIIe), EVHOE-WIBTS survey (VIIg, h, j ; VIIIa,b) from 1988 to 2011.

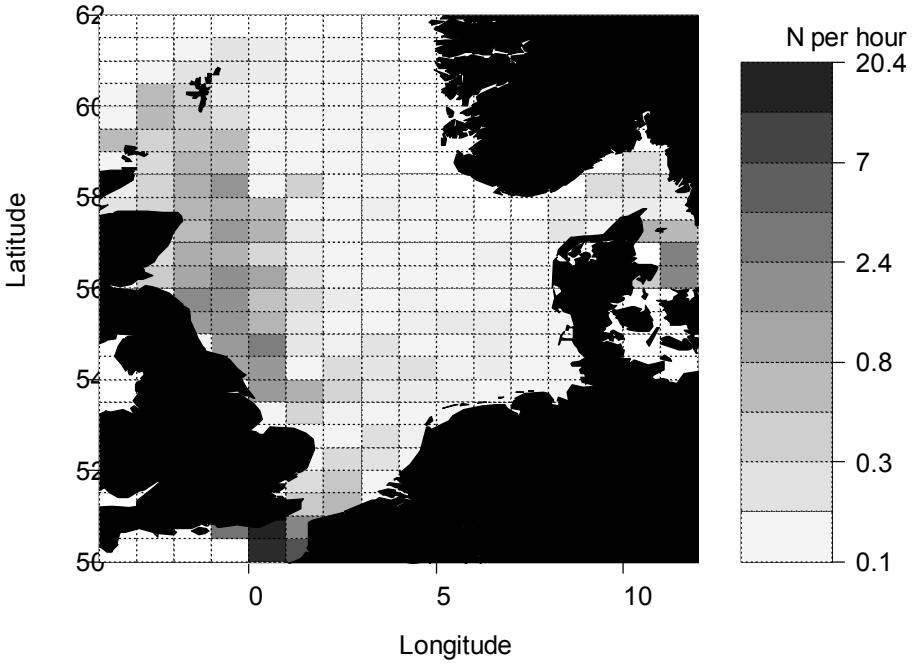


IBTS Q1

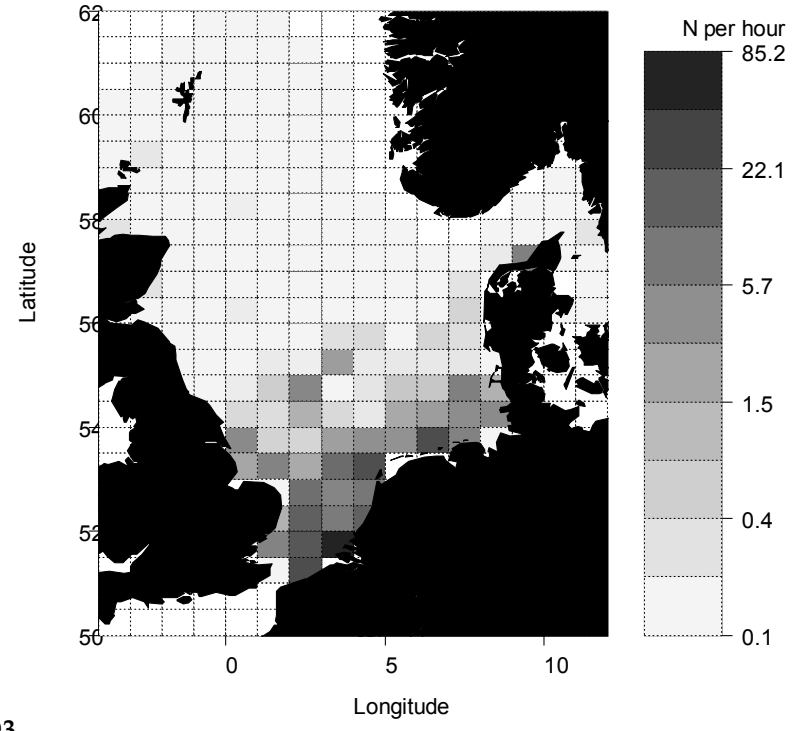


IBTS Q3

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).

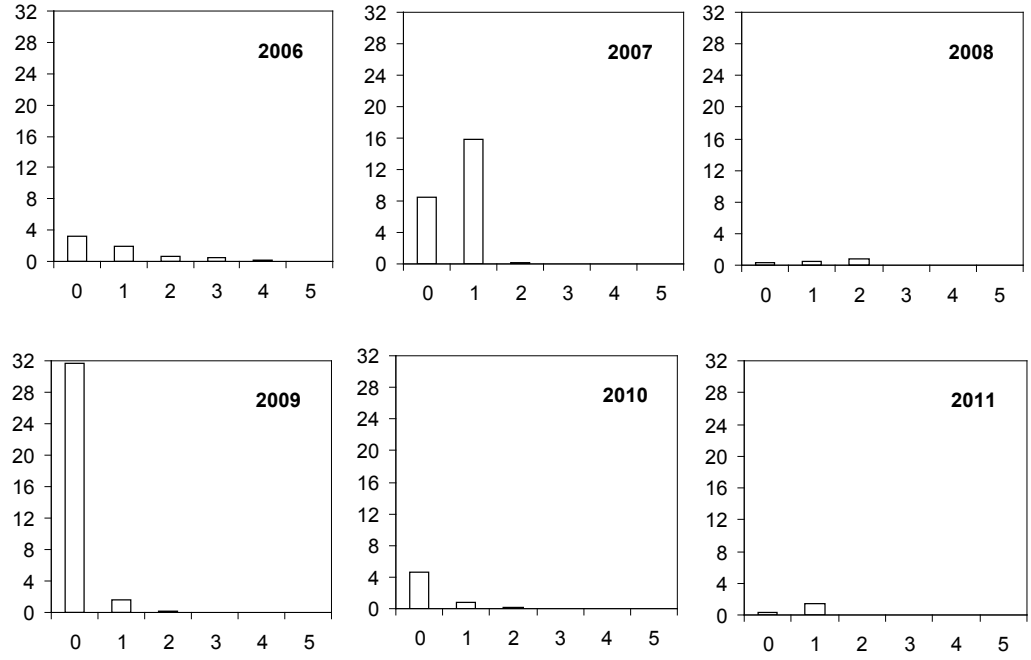


Figure 9. Striped red mullet. Abundance indices (Nb/30 min Trawl) of striped red mullet per age class (Length, cm.) during FR-CGFS from 2006 to 2011.

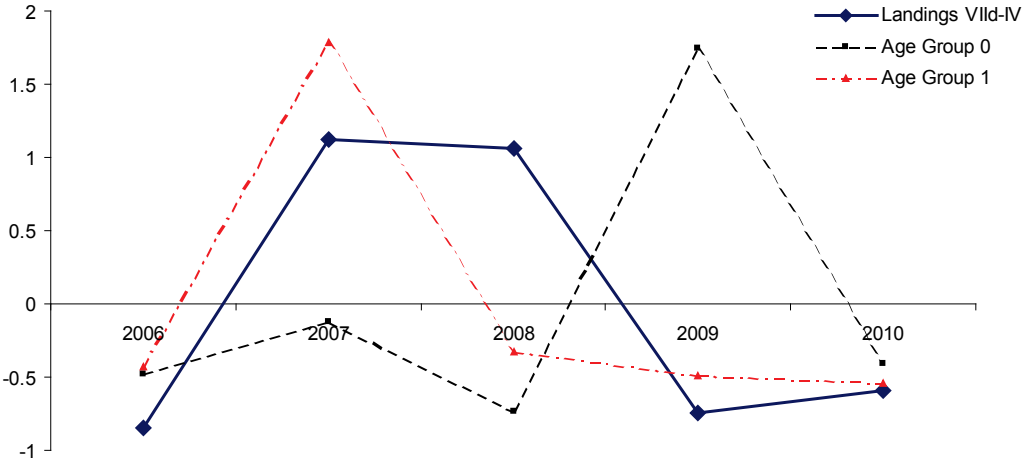


Figure 10. Striped red mullet. Mean standardised of Abundance indices base on CGFS survey (ICES Subarea VIId) from 2006 to 2010 per age class and total landings (ICES Subareas VIId-IV) of striped red mullet.

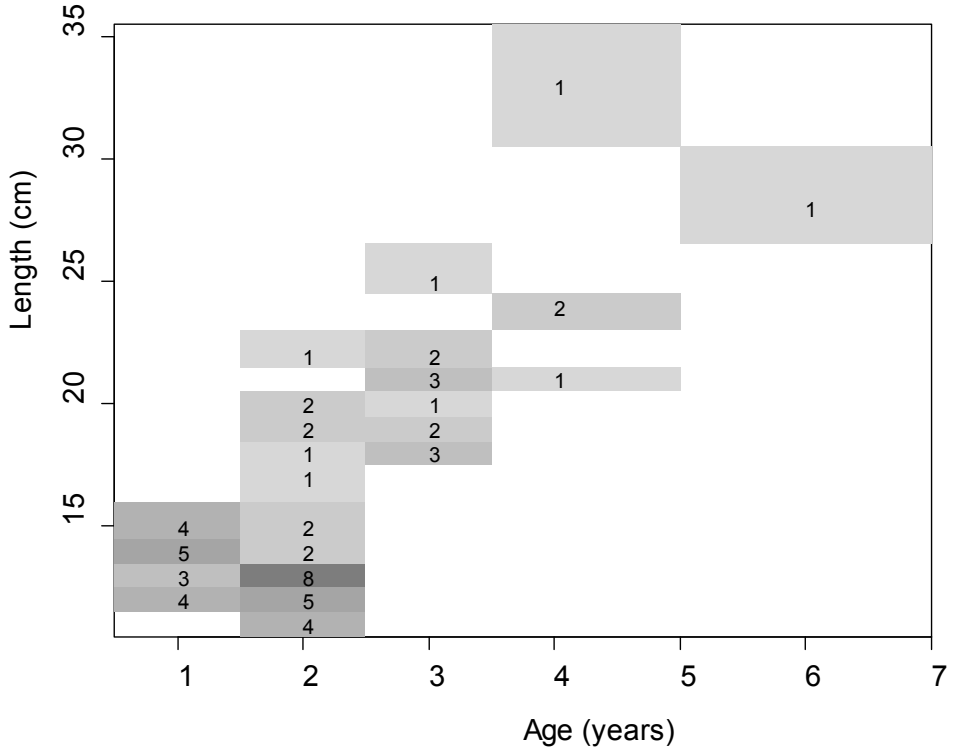


Figure 11. Striped red mullet. Age Length Key of striped red mullet in the north Sea during the IBTS-Q1 survey.

ANNEX 1 – ELEMENTS OF BIOLOGY ON PLAICE 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



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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.

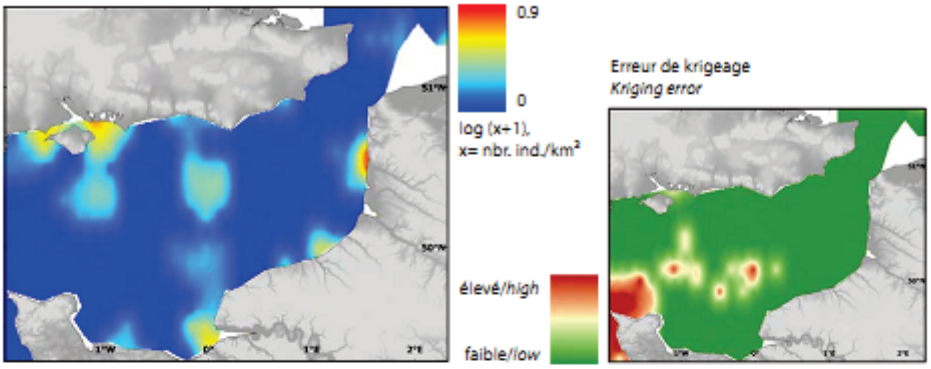
Life history parameters - Maximum length 42 cm; common length 15-35 cm; minimum landing size 19 cm (EU); maximum lifespan 11 years; age and length at maturity 1-2 years and 16-19 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 51.35 cm, growth rate k = 0.186 $year^{-1}$, theoretical age t_0 = -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.

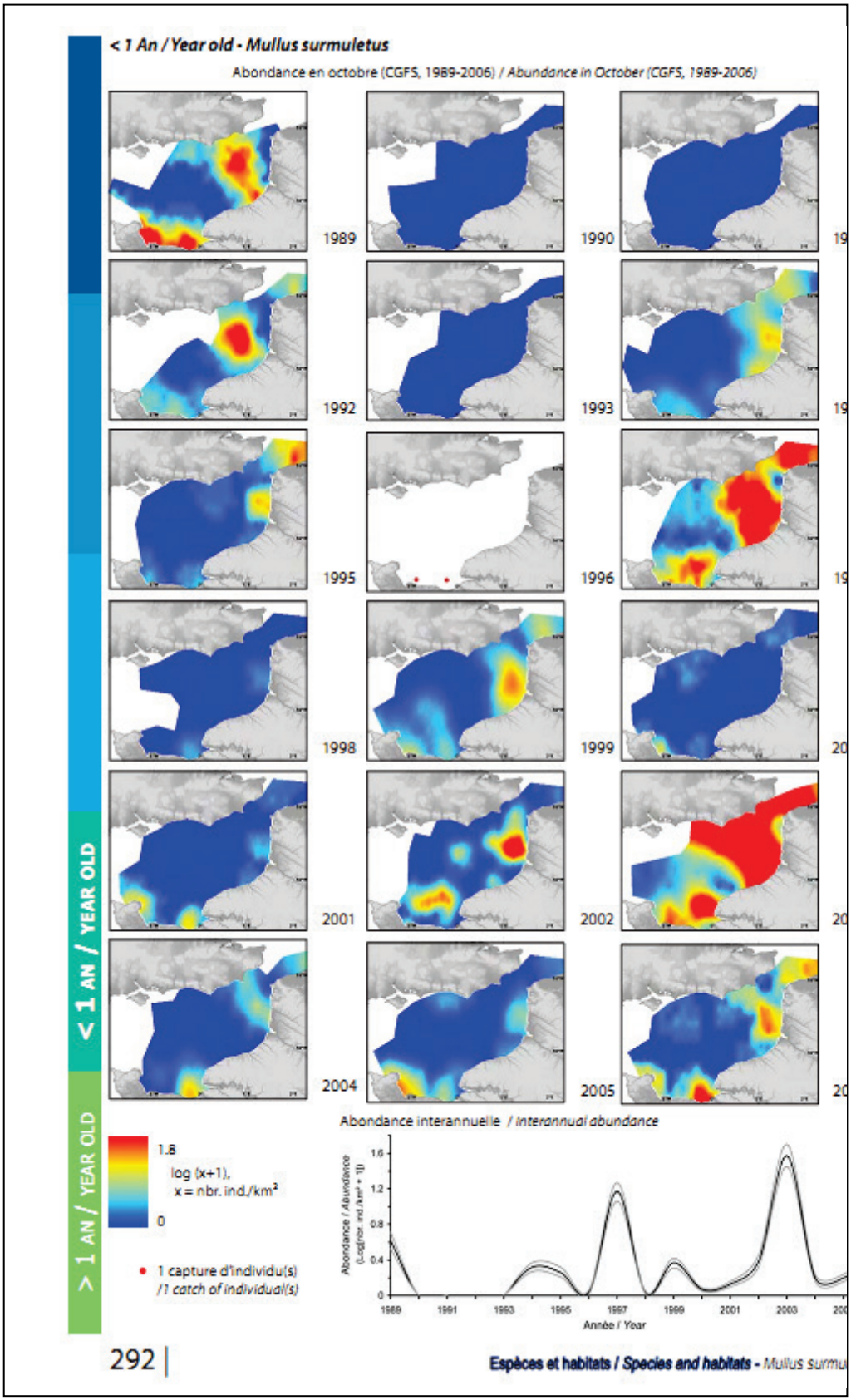
Red mullet less than 17.3 cm in length were considered as being less than one year old, and the distribution patterns and habitats (in October) were defined separately for young and older individuals. Red mullets are not representatively sampled by the beam trawl used during the July BTS survey; as a 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.

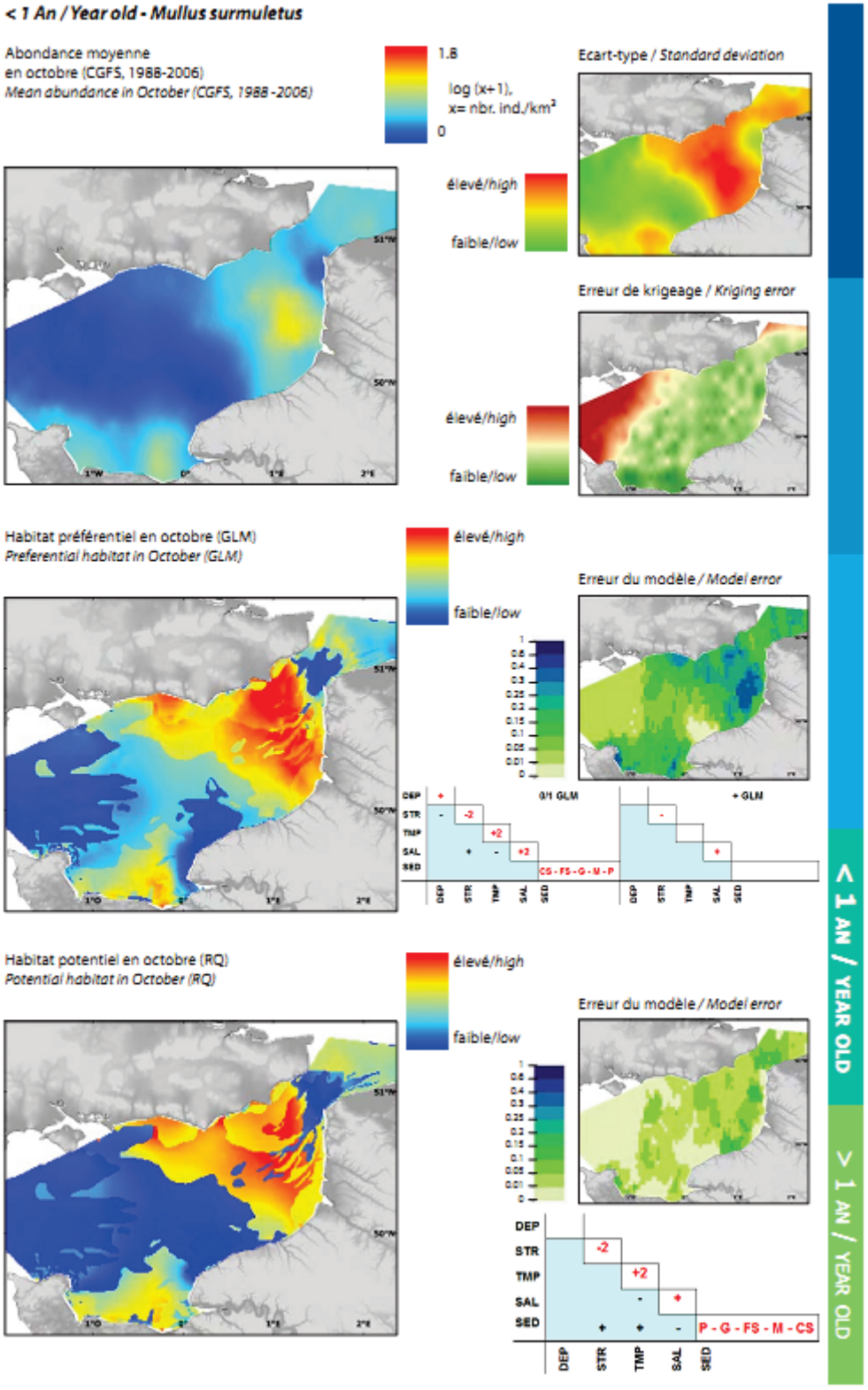
< 1 year old

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

> 1 AN / YEAR OLD


< 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 abundance
Abondance / Abundance
Année / Year
292
Espèces et habitats / Species and habitats - Mullus surmu



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.

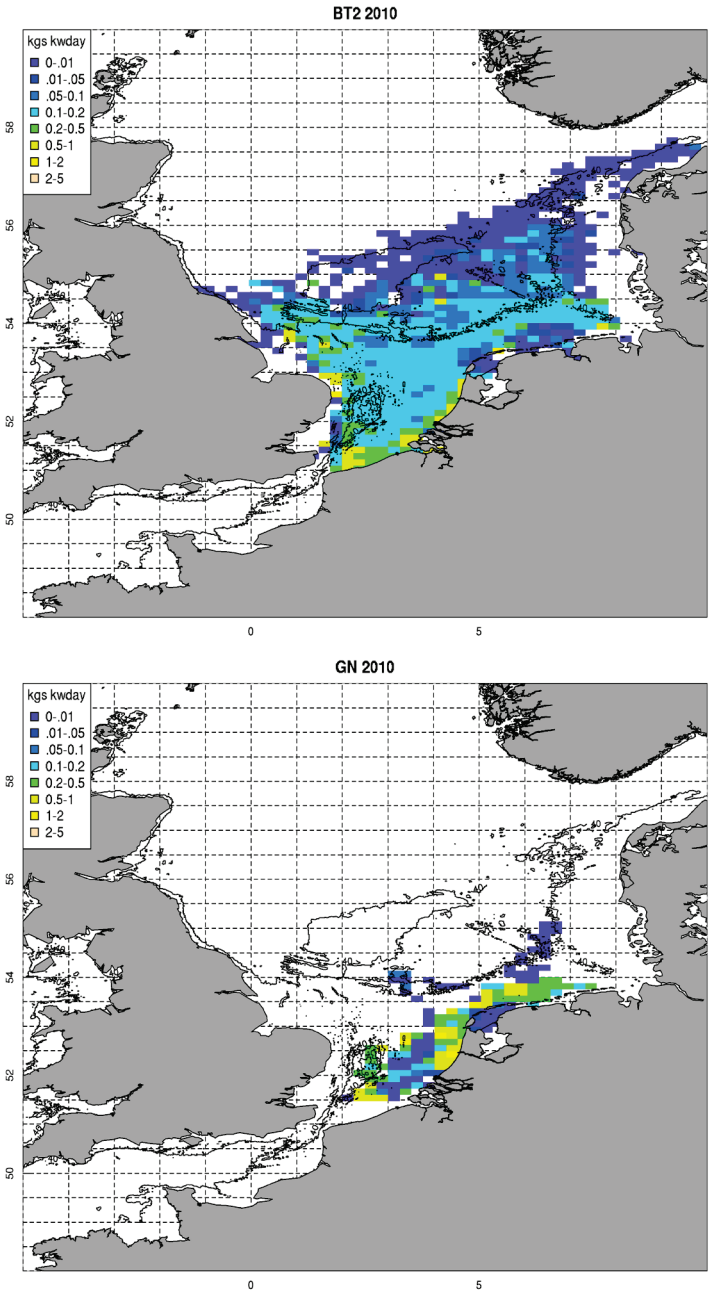


Figure 1. Landing rates (kgs kwday-1) in 2010 by Dutch flagged BT2 (beam trawlers working 80-89mm mesh, top) and GN (gillnetters, bottom). Data are based on combining VMS and logbook data. 40m depth contour also added.

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 II_a). 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 temporal 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 coincide, 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 Sur-

vey) 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 1970[1]-assessment year 1-4 NL-beam trawl index 1997-assessment year 2-9
Plus group	10
First tuning year	1970[1]
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 $\mathbf{B_{lim}}$= $\mathbf{B_{loss}}$= 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. 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	B_{lim}	25,000 t	B_{loss}
	B_{pa}	35,000 t	B_{pa}1.4 *B_{lim}
	F_{lim}	Not defined	
	F_{pa}	0.40	F_{pa} = 0.4 implies $B_{eq} > B_{pa}$ and $P(SSB_{MT} < B_{pa}) < 10\%$.
Targets	F_{mgt}	0.2	EU management plan

(unchanged since 1998, target added in 2008)

H. Other Issues

None identified

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Stock Annex – Whiting IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Whiting IIIa
Working Group:	WGNSSK
Date:	April 2013
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, thus giving a support for a stock separation between the North Sea and IIIa.

A.2. Fishery

The total landings of whiting from IIIa have declined from over 20 000 tonnes in the 1980s (>40 000 tonnes in single years) to 63 tonnes in 2012, 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.

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).

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.

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Stock annex: Haddock in Subarea IV and Division IIIa(N)

Stock specific documentation of the standard assessment procedures used by ICES.

Stock:	Haddock in Subarea IV and Division IIIaN (Skagerrak)
Working Group:	ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Date:	May 2009
Author:	Coby Needle
Revisions:	Coby Needle [WKBENCH], January-February 2011
	Coby Needle [WGNSSK], May 2011

A. General

A.1. Stock definition

Haddock in Subarea IV and Division IIIaN (Skagerrak) occupy the northern and central North Sea and Skagerrak and are possibly linked to the Division VIa stock on the West of Scotland. Haddock in this area are seldom found below 300 m (although Rockall 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.

A.2. Fishery

Most of the information presented below pertains to the Scottish demersal whitefish fleet, which is provided with the bulk of the available quota and consequently takes the largest proportion of the haddock stock. This fleet is not just confined to the North Sea, as vessels will sometimes operate in Divisions VIa (off the west coast of Scotland) and VIb (Rockall): it is also a multi-species fishery that lands a number of species other than haddock.

A.2.1. Management plans

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:

Every effort shall be made to maintain a minimum level of Spawning Stock Biomass greater than 100,000 tonnes (Blim).

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).

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.

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.*

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.

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.

In the event that ICES advices 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.

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).

Further technical conservation measures

EU technical regulations in force are contained in Council Regulation (EC) 850/98 and its amendments. This regulation prescribes the minimum target species composition for different mesh size ranges. In 2001, haddock in the whole of NEAFC region 2 were a legitimate target species for towed gears with a minimum codend mesh size of 100 mm. As part of the cod recovery measures, the EU and Norway introduced additional technical measures from 1 January 2002 (EC 2056/2001). The basic minimum mesh size for towed gears for cod from 2002 was 120 mm, although in a transitional arrangement running until 31 December 2002 vessels were allowed to exploit cod with 110-mm codends provided that the trawl was fitted with a 90-mm square mesh panel and the catch composition of cod retained on board was not greater than 30% by weight of the total catch. From 1 January 2003, the basic minimum mesh size for towed gears for cod was 120 mm. The minimum mesh size for vessels targeting haddock in Norwegian waters is also 120 mm.

At the December Council 2006 (EC 41/2006), additional derogations were introduced to allow additional days fishing in the smaller mesh (90 mm) trawl fishery where vessels fitted a square mesh window close to the cod end to allow for improved selectivity of these gears (and hence the possibility of lower haddock discards). The change in mesh size was expected to shift exploitation patterns to older ages and increase the

weight-at-age for retained fish from younger age classes. Improvements in the exploitation pattern were not immediately observed, however, and it was not possible to determine if this was due to confounding effects from other fleet segments.

Effort restrictions in the EC were introduced in 2003 (EC 2341/2002, Annex XVII, amended in EC 671/2003). Effort restriction measures were revised for 2005 (EC 27/2005, Annex IV). Effort regulations for 2008 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) are intended to lead to 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.

	Area			Max days at sea		
Description of gear and special condition (if applicable)	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**

In early 2008, a one-net rule was introduced in Scotland as part of the new conservation credits scheme (Section 13.1.4). 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).

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-

card 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 informed 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) and 2011 (59 closures by 16th May). 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 abundance 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". As of February 2011, evaluations of the progress of this scheme and its effect on the fishery and stocks are underway. 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.

Fleet changes and development

The number of Scottish-based vessels (over 10 m) in the demersal sector was reduced by approximately one third (98 vessels) during 2002, the bulk of this being due to vessels accepting decommissioning. Although the decommissioning scheme encompassed all vessel types and sizes, the vessels eventually decommissioned included a significant number of older boats and those with track record of catching cod. Amongst the remaining vessels there has been a reduction in the segment operating seine net or pair seine. The observed shift towards pair trawling from single-vessel seine and trawls in the early 2000's may have implied an increase in catchability, but the decommissioning rounds in 2002 and 2003 included a slightly higher proportion of pair trawlers, resulting in no real overall change in fleet composition.

The number of Scottish based vessels (over 10 m) in the demersal sector was reduced by 67 in a further decommissioning round in 2004. More recently, increased fuel prices have resulted in a shift from twin trawl to single trawl and pair seine/trawl by many boats in the Scottish demersal mixed fishery sector (ICES-WGFTFB 2006). The observed shift towards pair trawling from single seine may be explained by a standardization of reporting and recording of gear types. Vessels previously participating in the seine net class may have included vessels operating pair seine whereas this classification is now recorded as pair trawl.

In 2005, there was an expansion in the squid fishery in the Moray Firth area resulting from increased effort from smaller (<10m) vessels, and from a number of larger vessels that had switched from demersal fisheries for haddock and cod, to squid fisheries, in order to avoid days-at-sea restrictions (ICES-WGFTFB 2006). The mesh regulation for squid fishing is 40 mm codend, which could lead to bycatch/discard of young haddock and cod. In 2006 and 2007, the squid fishery declined: vessels that shifted away from squid targeted *Nephrops* instead. However, the potential remains for high bycatches of young gadoids in the future, given the small mesh size used.

During 2008, a number of Scottish vessels switched focus to the Rockall area to take advantage of the increased quota there. The economic benefit of being able to land more haddock outweighed the costs involved in steaming to Rockall in a climate of increased fuel prices. This fishery is very dependent on good weather, however, and is not a consistent feature. At the same time, several vessels switched from whitefish fishing in Division VIa to *Nephrops* exploitation in Subarea IV using 80-mm gear (ICES-WGFTFB 2008). This may have implications for haddock bycatch in the *Nephrops* fishery, although (under the stipulations of the Scottish conservations credits scheme; see above), nets in the 80mm range will had to have a 110mm square mesh panel installed from July 2008. Compliance was close to 100% during 2008. Trials suggested that this square-mesh panel increased the 50% selection length (L_{50}) for haddock by around 30%, which implied increased escapement of young haddock from the *Nephrops* fishery.

Also during 2008, a number of Scottish vessels moved from twin to single trawls, and there was also an increase in the use of pair trawl/seine. Some high-powered whitefish vessels switched to *Nephrops* and were targeting North Sea grounds with double bag trawls. This was very much driven by fuel costs, and may have had implications for reduced LPUE and increases in discarding.

Analysis of fishing effort trends in the major fleets exploiting North Sea cod indicates that fishing effort in those fleets has been decreasing since the mid-1990s due to a combination of decommissioning and days-at-sea regulations (STECF-SGRST-05-01 & 04, 2005). The decrease in effort is most pronounced in the years 2002 and beyond.

Information presented to ICES in 2008 noted that the UK large mesh demersal trawl fleet category (>100 mm, 4A) has been reduced by decommissioning and days-at-sea regulations to 40% of the levels recorded in the EU reference year of 2001. There was a movement into the 70–90 mm sector to increase days at sea in 2002 and 2003, but the level of effort stabilised in 2004. The effort of the combined trawl gears has shown a continued decrease of 36% overall, from the EU reference year of 2001 (STECF-SGRST-05-01 & 04, 2005).

A.3. Ecosystem aspects

The North Sea 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 an important prey species, mainly for saithe and other gadoids

B. Data

B.1. Commercial catch

Age compositions

Three components of the North Sea haddock catch are considered: landings for human consumption, discards and industrial bycatch. The sources of information on these components were as follows (for the 2010 assessment):

		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 columns indicate the following: Y = provided to the WG, NP = not provided to the WG, and NR = not requested. In the SA 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.

Data exploration

The standard plots used in exploratory data analysis of North Sea haddock catch data include:

1) Time-series of proportion of total catch discarded by age.

2) Log catch curves by cohort (total catch).

3) Negative gradients of log catches per cohort, averaged over mean *F* ages (total catch).

4) Bivariate correlations by cohort (total catch), with fitted regression lines. That is, catch numbers at age 0 are plotted against catch numbers at age 1 for each cohort, then age 0 against age 2, and so on for all age combinations.

5) Results of a separable VPA analysis, generated using either the Lowestoft VPA implementation (Darby and Flatman 1994) or the FLR equivalent.

B.2. Biological Information

Weight at age

Weights-at-age data are provided for the stock, total catch, landings, discards and human consumption. Values are derived from length sampling carried out by Denmark, Germany, Norway, Sweden and the UK (see table above), to which fixed weight-length relationships are then applied. Weights-at-age are also collected on the IBTS surveys, but these are not yet used directly in the assessment.

Maturity and natural mortality

The growth dynamics of haddock in the North Sea have changed considerably over time. WKBENCH (ICES-WKBENCH 2011) demonstrated that haddock are now growing more quickly when young but reaching a shorter eventual length than used to be the case. At the same time, survey-based sampling indicates that the maturation age has reduced, with the proportion mature of age-2 fish increasing from around 35% in the early 1970s to around 80% now. However, estimation of the effect of increasing maturity and changing growth on reproductive potential is not straightforward, as fecundity has also changed through time (see comments in ICES-WKBENCH 2011, and the section on "Biological Reference Points" below). The conclusion from WKBENCH was that:

- "WKBENCH recommends that refined maturity estimates should be developed before the next WGNSSK meeting in May 2011 and used in subsequent update assessments."

WKBENCH also considered the issue of natural mortality *M*, which previously had been assumed to be fixed through time. Annual estimates of natural mortality are available from key runs of the SMS model, as reported by the ICES Working Group on Multispecies Assessment Methods (e.g. ICES-WGSAM 2008). The last key run was conducted in 2007, so estimates are constant for 2007-2009. In addition, it should be emphasised that the last year of comprehensive stomach-data collection was 1991, so the food-web definitions on which SMS runs are based are likely to be out of date to a certain extent. The effects of these time-varying estimates of natural mortality on both XSA and SAM assessment model runs were explored by WKBENCH. The new estimates are quite different from the fixed values used previously, with *M* for age-0 being lower and for ages 2 and above being higher, and that this is likely to have a substantial impact on assessments. The subsequent recommendation was:

- "WKBENCH recommends that time-varying natural mortality estimates from WGSAM should be used in the subsequent update assessments."

Finally, WKBENCH carried out interim test assessments using the new estimates of maturity and natural mortality, and also produced interim estimates of corresponding biological reference points (which are considerably different to before). These need to be revisited before they can be considered as the basis for advice (see the section on "Biological Reference Points" below).

Recruitment

Recruitment to the North Sea haddock stock is very sporadic, and is characterised by occasional large year classes interspersed by several years of poor recruitment. The reasons for this are unknown. It is likely (see ICES-WKBENCH 2011) that larval haddock spawned to the West of Scotland (Division VIa) settle as demersal juveniles in the northern North Sea, before (possibly) returning west to spawn subsequently.

B.3. Surveys

Five survey series are used in the assessment of North Sea haddock. The survey data used in the 2010 assessment are summarised below:

Country	Fleet	Quarter	Code	Year range	Age range available	Age range used
Scotland	Groundfish survey	Q3	ScoGFS Aberdeen Q3	1982-1997	0-8	0-7
	Groundfish survey	Q3	ScoGFS Q3 GOV	1998-2009	0-8	0-7
England	Groundfish survey	Q3	EngGFS Q3 GRT	1977-1991	0-10+	0-7
	Groundfish survey	Q3	EngGFS Q3 GOV	1992-2009	0-10+	0-7
International	Groundfish survey	Q1	IBTS Q1 (backshifted)	1982-2010	1-5+	1-4

The Scottish and English groundfish survey time-series are both split, to reflect changes in the vessel and gear used which are thought to have substantially affected survey catchability. The collated IBTS Q3 time-series, to which both ScoGFS Q3 and EngGFS Q3 contribute, is also available for the assessment but has not been used to date: the principal reason is that it was historically not available in time for the assessment working group meeting in September, but it also has a shorter time series.

Data exploration

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 SURBA model fits (Needle 2003). These give estimated mean Z, relative SSB and relative recruitment trends, along with confidence intervals.

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.

B.5. Other relevant data

No other relevant data have been used in the assessment to date.

C. Historical stock development

Model used as a basis for advice

The advice is based on assessments carried out using the XSA model (Shepherd 1992, Darby and Flatman 1994) implemented as the FLXSA module of the FLR library of the R statistical package. WKBENCH recommended that exploratory runs of both the SAM (ICES-WGCOD 2011) and SURBA (Needle 2003) also be carried out each year to confirm (or otherwise) the indications of stock dynamics from the update XSA run.

Model Options chosen

XSA / FLXSA model settings used in the WGs from 2007 to 2011 were as follows (* = backshifted):

ASSESSMENT YEAR		2007	2008	2009	2010	2011
Model		XSA	FLXSA	FLXSA	FLXSA	FLXSA
q plateau		6	6	6	6	6
F shrinkage		2.0	2.0	2.0	2.0	2.0
Power model ages		None	Age 0	Age 0	Agew 0	None
Plus-group		8	8	8	8	8
Tuning fleet year ranges	EngGFS Q3	77-91; 92-06	77-91; 92-07	77-91; 92-08	77-91; 92-09	77-91; 92-10
	ScoGFS Q3	82-97; 98-06	82-97; 98-07	82-97; 98-08	82-97; 98-09	82-97; 98-10
	IBTS Q1*	82-06	82-07	82-08	82-09	82-10
Tuning fleet age ranges	EngGFS Q3	0-7				
	ScoGFS Q3	0-7				
	IBTS Q1*	0-4				

Note that the earlier XSA assessment did not use a power model on any ages. Due to a coding error, the FLXSA implementation used from 2008-2010 included a power model assumption for age-0. This was noted and corrected at the 2011 WG meeting.

D. Short-term projection

Initial stock size

Deterministic starting populations taken from VPA survivors.

Maturity

Average of final three years of assessment data.

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

Jaworski (2011) applied twenty different growth forecasting methods in a hindcast analysis, in which weights-at-age forecasts from 12 years ago were compared with the observed outcomes. The test statistics were the ratio of forecast to observed weights, and the variance of the forecast. There was a general tendency to overestimate weights in forecasts, while the most beneficial model, in terms of both test statistics, was a simple cohort-based linear model.

Jaworski's analysis provided an extensive hindcast testing procedure of a wide variety of methods for forecasting weights-at-age in North Sea haddock, and explored the issue in far more depth and breadth than had previously been possible. His conclusion on the method that generates the estimate with the least bias and variance appears to be robust and has been extensively peer-reviewed. Therefore, WKBENCH recommended that weights-at-age for North Sea haddock forecasts be modelled using a linear cohort-based approach. 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 be generated for these cohorts). This procedures is applied separately for each catch component (catch/stock, landings, discard), except for industrial bycatch for which 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. A future benchmark should consider the use of weights-at-age measured during research-vessel surveys for stock weights.

Exploitation pattern

Fishing mortalities for forecasts are taken to be a three-year average scaled to the final year. WGNSSK in 2010 concluded that fishing mortality in 2010 was likely to be at a similar level to that estimated for 2009, and used a scaled average to reduce the effect of uncertainty in that 2009 estimate.

Intermediate year assumptions

The available haddock quota has generally not been fully utilized in the past, and a TAC constraint on the forecast has not been thought to be necessary. However, uptake has started to increase, and in 2010 it was observed that segments of the Scottish demersal fleet did exhaust their quota (probably due to further restrictions in cod catching). Therefore, in future assessments it will be necessary to reconsider the question of whether a TAC-constrained forecast is required.

Stock recruitment model used

North Sea haddock shows no detectable influence of stock size on subsequent recruitment. In addition, there are no observed indications of incoming year class strength available to WGNSSK. The ScoGFS and EngGFS Q3 survey indices are not yet available at the time of the assessment meeting. The IBTS Q1 indices are available, but do not include age-0 recruiting fish as these are too small to be caught (or are

not yet hatched) when the survey takes place. For this reason, recruitment estimates of the incoming year class are based on a mean of previous recruitment.

In the past, a strong haddock year class has generally been followed by a sequence of low recruitments. In order to take this feature into account, the geometric mean of the five lowest recruitment values over the period from 1994 to $y - 3$ (where y is the year of the assessment WG) has been assumed for recruitment in the years y, $y + 1$ and $y + 2$. Recruitment estimates for years $y - 2$ and $y - 1$ are not included in this calculation, because the most recent two XSA estimates of recruitment are thought to be relatively uncertain.

Procedures used for splitting projected catches

Three-year average of catch component ratios.

E. Medium-term projections

Medium-term projections, in the sense of biological simulations assuming fixed mortality, are no longer carried out for this stock on an annual basis. However, management simulations are regularly performed to evaluate management plan proposals, and these are similar in some ways to medium-term projections (see Section A.2.1 above).

F. Long-term projections

Yield and spawning-stock-biomass per recruit analyses are carried out for this stock as part of the annual assessment process. The MFYPR software is used for this purpose.

G. Biological reference points

The Precautionary Approach reference points for cod in IV, IIIa (Skagerrak) and VIId have been unchanged since 2007. They are:

	TYPE	VALUE	TECHNICAL BASIS
Precautionary approach	B(lim)	100 000 tonnes	Smoothed B(loss)
	B(pa)	140 000 tonnes	B(pa) = 1.4 * B(lim) (*)
	F(lim)	1.0	F(lim) = 1.4 * F(pa) (*)
	F(pa)	0.7	10% probability that SSB(MT) < B(pa)
Targets	F(HCR)	0.3	Based on HCR simulations and agreed in the management plan

***The multiplier of 1.4 is derived from $\exp(\sigma^2)$, where $\sigma^2 \sim 0.34$ is intended to reflect the variability of the time-series concerned (B or F).**

In its report of January 2011, WKBENCH recommended that the biological reference points for North Sea haddock be revised in time for the 2011 advisory round: "If the proposed new assessment (with time-varying natural mortality and maturity estimates) is accepted for use in subsequent updates, WKBENCH recommends that biomass and fishing mortality reference points and management strategy evaluations be revisited and potentially updated." The use of revised maturity values without due consideration of concomitant changes in fecundity and reproductive potential could result in misleading advice, and WKBENCH concluded that reference points based on reproductive potential would probably serve the advisory process best.

Yield and spawning biomass per recruit reference points

The estimation of MSY and F_{msy} was first carried out by WGNSSK in 2010. A total of nine estimates were provided, each with associated confidence limits. The principal model used was an equilibrium age-structured model, described below: analyses were also conducted using an ADMB implementation and FLR modules, but these are widely available and are not further described here.

This implementation was developed in the Marine Laboratory, Aberdeen, and is coded in R. It was used to generate F_{msy} estimates for the WKFRAME meeting (ICES-WKFRAME 2010), and the following text is adopted from that report.

F_{msy}, B_{msy} and MSY can be calculated for any given stock, using a combination of fitted stock-recruit, yield-per-recruit and SSB-per-recruit curves. The estimation proceeds as follows:

1. Draw a stock-recruit plot: that is, a curve illustrating the fitted relationship between recruitment *R* and spawning-stock biomass *S*. Denote this curve by $R = \mathbf{G}(S)$.
2. Draw a second plot, containing both yield-per-recruit and spawner-per-recruit curves. Denote these by $Y/R = \mathbf{H}(F)$ and $S/R = \mathbf{I}(F)$.
3. For any given *F* (say, F'), the corresponding point on the spawner-per-recruit curve is given by $S'/R' = \mathbf{I}(F')$.
4. Take the reciprocal, so that $R'/S' = 1/\mathbf{I}(F')$. This denotes the *slope* of a straight line on the stock-recruit plot, that passes through the origin and cuts the curve at $(S', \mathbf{G}(S')) = (S', R')$. Hence such a line on a stock-recruit plot does not specify directly a particular fishing mortality rate, but the reciprocal of its slope does.
5. Iterate through multipliers $E_i \in [0.0, 2.0]$, and hence fishing mortalities (since $F_i = E_i \times F_{sq}$). For any E_i, $R_i/S_i = 1/\mathbf{I}(F_i) = 1/\mathbf{I}(E_i \times F_{sq})$. This is the slope of the line on the stock-recruit plot that intersects the stock-recruit curve at (S_i, R_i).
6. The yield-pre-recruit curve is written as $Y/R = \mathbf{H}(F)$. From this we can obtain yield $Y = R \times \mathbf{H}(F)$. For a given E_i, $Y_i = R_i \times \mathbf{H}(F_i) = R_i \times \mathbf{H}(E_i \times F_{sq})$. Plotting these for all *i* gives the yield curve $Y = \mathbf{J}(F)$, for which we can obtain F_{msy} by maximising:

$$F_{msy} = F \text{ such that } \frac{dY}{dF} = 0.$$

7. Note that the same procedure can be carried out for spawning biomass, so we can plot yield *Y* against spawner biomass *S* to estimate at what biomass yield is maximised.

The calculation is repeated for 1000 bootstrapped stock-recruit curves, which are obtained by sampling from a multivariate normal distribution determined by the variance-covariance matrix of the estimated stock-recruit model parameters,

The assumed form of the underlying stock-recruit curve is very influential in the derivation of F_{msy} estimates, but is also very difficult to determine for North Sea haddock. The main drawback of this particular implementation is that it only includes the Ricker stock-recruit model so far, and thus does not permit evaluation of the sensitivity of F_{msy} estimates to stock-recruit assumptions. It also does not y*et al*low for

annual variation in biological parameters such as growth and maturity. On the other hand, it does carry out retrospective F_{msy} estimation automatically.

H. Other issues

No other issues.

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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 tempera-

tures 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 spatial-

ly 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 recolonize 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 re-

late 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 implemen-

tation 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 ob-

tained 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 misreporting 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 northernmost 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:

$$\vartheta = (Q_{a=1,2,3,4,5}^{(s=1)}, \sigma_R^2, \sigma_S^2, \sigma_F^2, \sigma_{\circ,a=1,2,3^+}^2, \sigma_{s=1,a=1,2^+}^2,$$

$$\tau_{1993}, \tau_{1994}, \ldots, \tau_{2009}, \alpha, \beta, \rho)$$

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	B_{lim}	70 000 t	B_{loss} (~1995)
	B_{pa}	150 000 t	B_{pa} = Previous MBAL and signs of impaired recruitment below 150 000 t.
	F_{lim}	0.86	$F_{lim} = F_{loss}$ (~1995)
	F_{pa}	0.65	F_{pa} = Approx. 5th percentile of F_{loss}, implying an equilibrium biomass > B_{pa}.
Targets	F_y	0.4	EU/Norway agreement December 2009

Unchanged since 1998

Yield and spawning biomass per Recruit F-reference points:

	Fish Mort Ages 2-4	Yield/R	SSB/R
Average last 3 years	0.70	0.34	0.45
F_{max}	0.19	0.62	3.36
$F_{0.1}$	0.13	0.59	4.73
F_{med}	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.

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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.

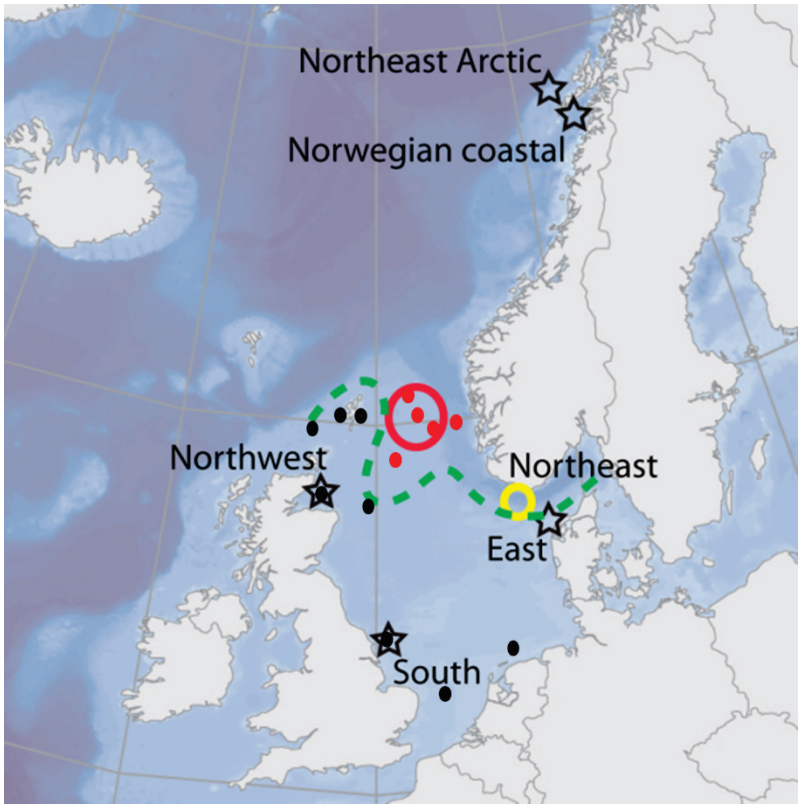


Figure 1. Location of samples analysed for genetic variation. Red circle shows Viking Bank where Nielsen *et al.* (2009) identified a genetically unique population. Yellow circle represents the divergent population identified in Poulsen *et al.* (2011) and in this document. Dots represent sample locations 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 as-

sessment. 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 Approach	MSY $B_{trigger}$	200 000 t	Default value B_{pa}
	F_{MSY}	0.30	Stochastic simulation using hockey-stick stock-recruitment
Precautionary approach	B_{lim}	106 000 t	B_{loss} = 106 000 t (estimated in 1998).
	B_{pa}	200 000 t	affords a high probability of maintaining SSB above B_{lim}
	F_{lim}	0.6	F_{loss} the fishing mortality estimated to lead to stock falling below B_{lim} in the long term.
	F_{pa}	0.4	implies that $B_{eq} > B_{pa}$ and $P(SSB_{MT} < B_{pa}) < 10\%$.

Precautionary reference points were derived in 2006 and are:

$\mathbf{F}_{0.1}$	0.10	$\mathbf{F}_{lim}$	0.60
$\mathbf{F}_{max}$	0.22	$\mathbf{F}_{pa}$	0.40
$\mathbf{F}_{med}$	0.35	$\mathbf{B}_{lim}$	106 000 t
$\mathbf{F}_{high}$	>0.49	$\mathbf{B}_{pa}$	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,	no change	Uncertain, no	IBTS Q3 (age: 3-

	1992 onwards)		Norwegian effort	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.

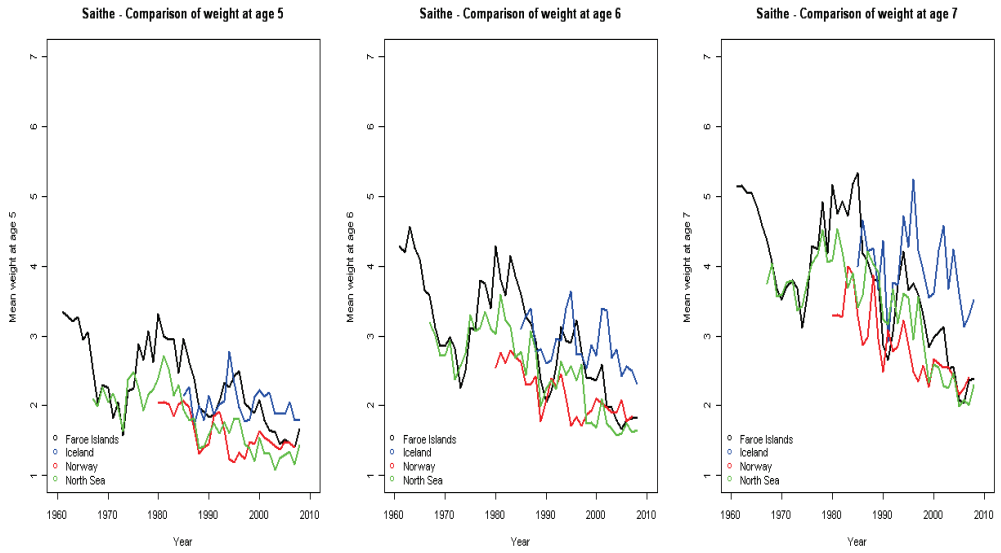


Figure 1. Weight at age by stock: The reduction of weight at age seems to be of importance for three out of four stocks, while one (Icelandic) does not show the same decline. (i Homrum, E. 2011, in prep).

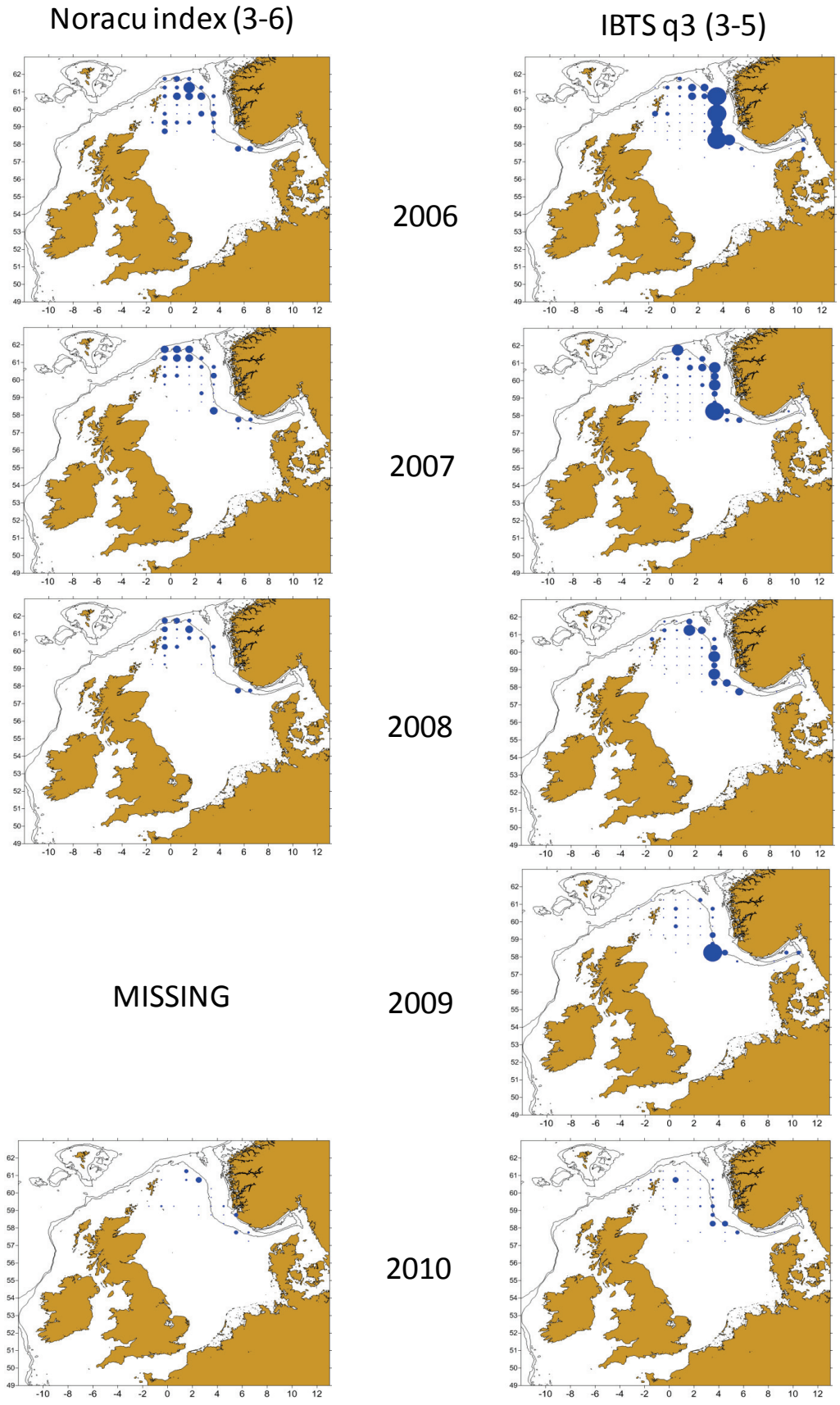


Figure 2. NORACU (left column) and IBTS Q3 (right column) indexes from 2006 to 2010

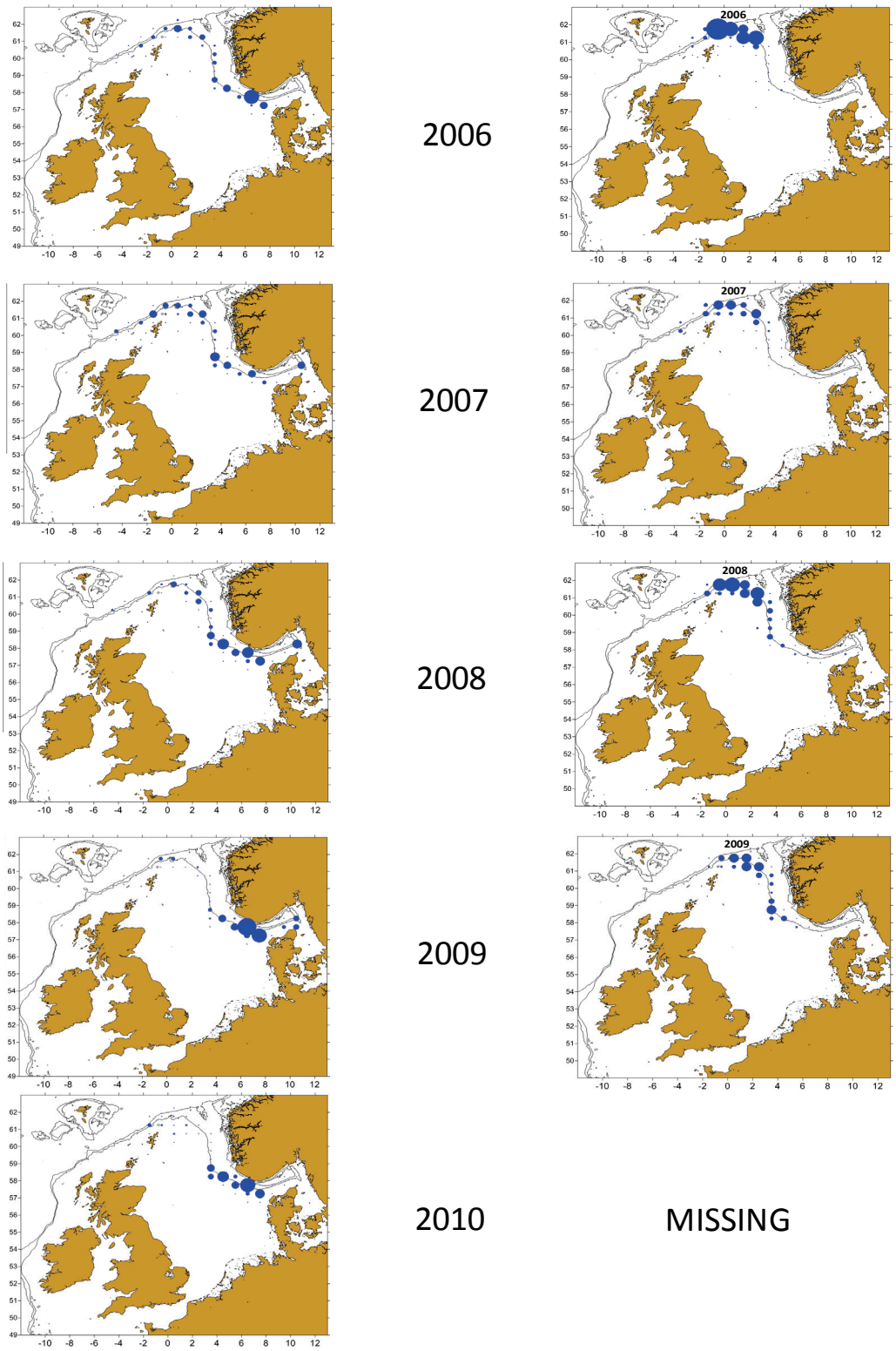


Figure 3. Spatial distribution of the catches for the GEROTR (left column) and NORTRL (right column) indexes from 2006 to 2010.

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)).

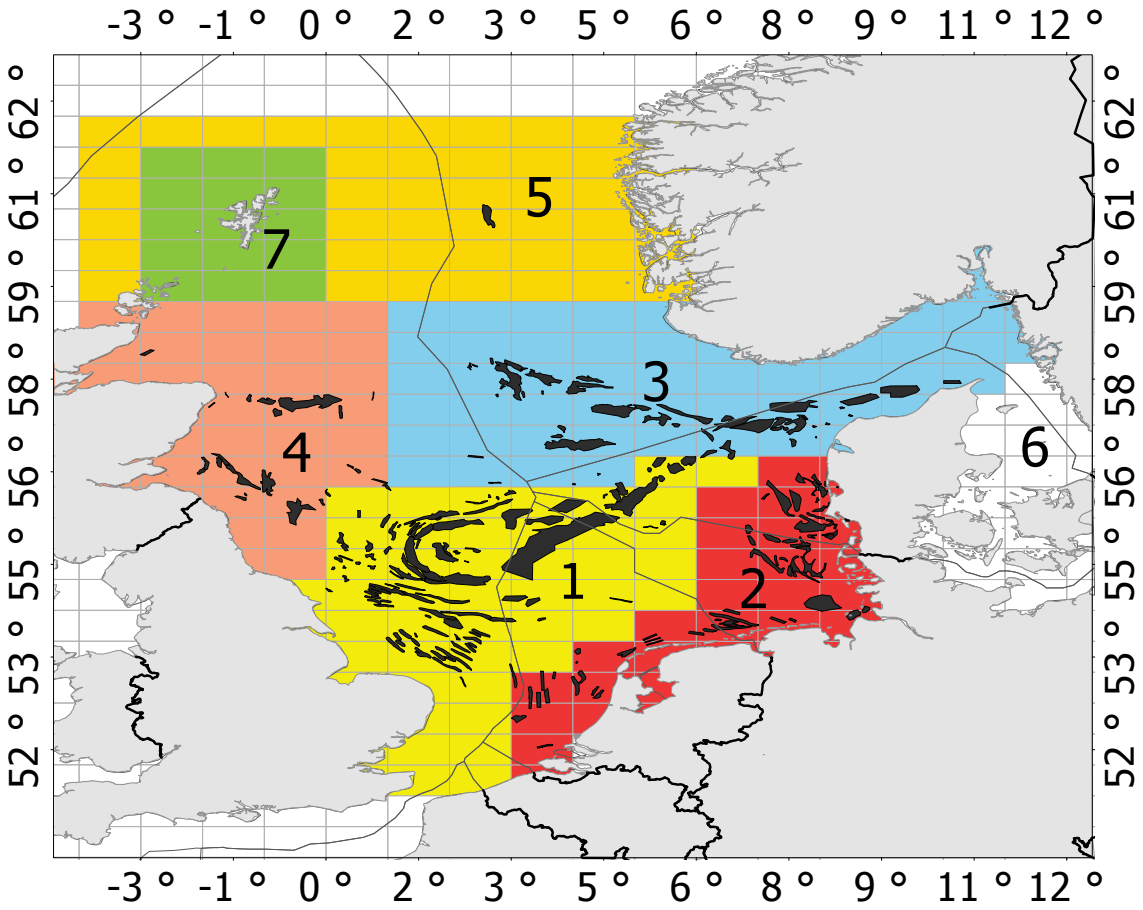


Figure 4. 2. Sandeel fishing banks (black areas), EEZ borders, and assessment areas: eastern area (red), northern area (blue), southern area (yellow), western area (dark orange), Shetland area (green) and Viking bank area (light orange).

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.

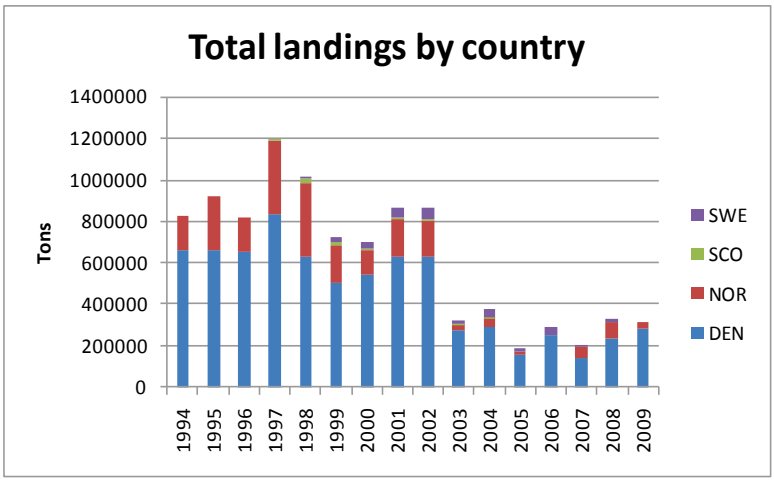


Figure 3.2.

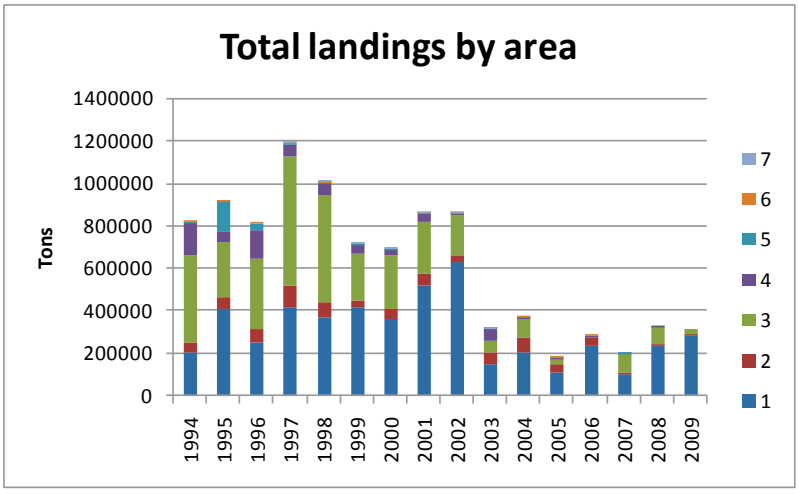


Figure 3.3.

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).

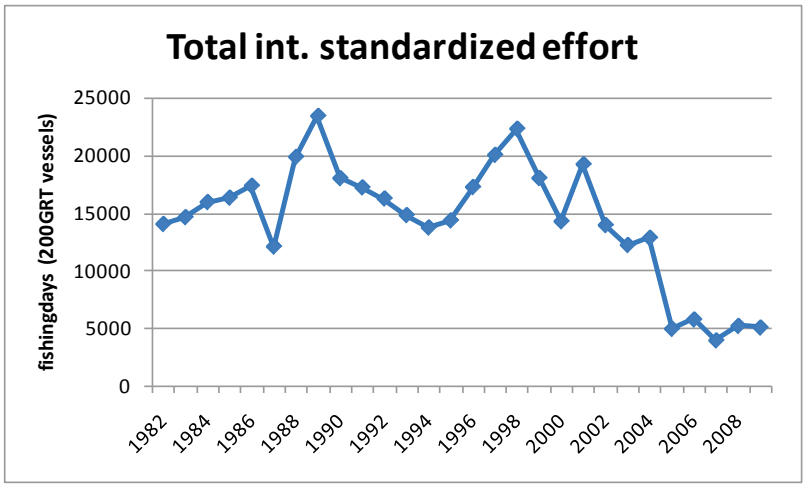


Figure 3.4.

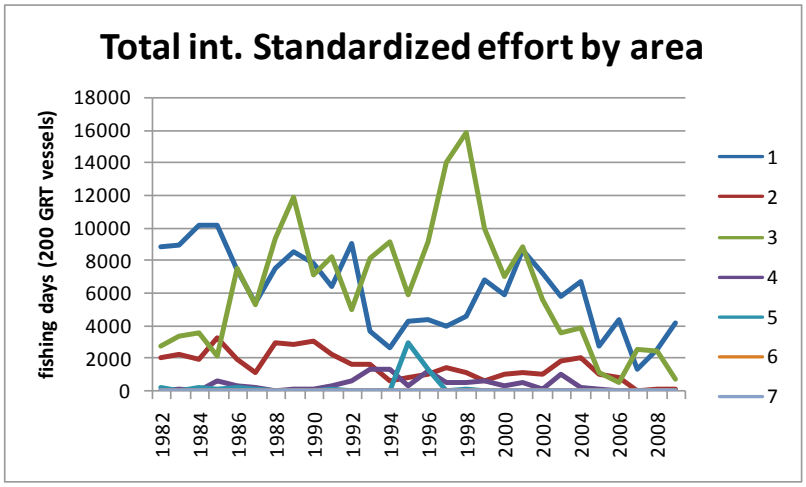


Figure 3.5.

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 sea-

birds 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.

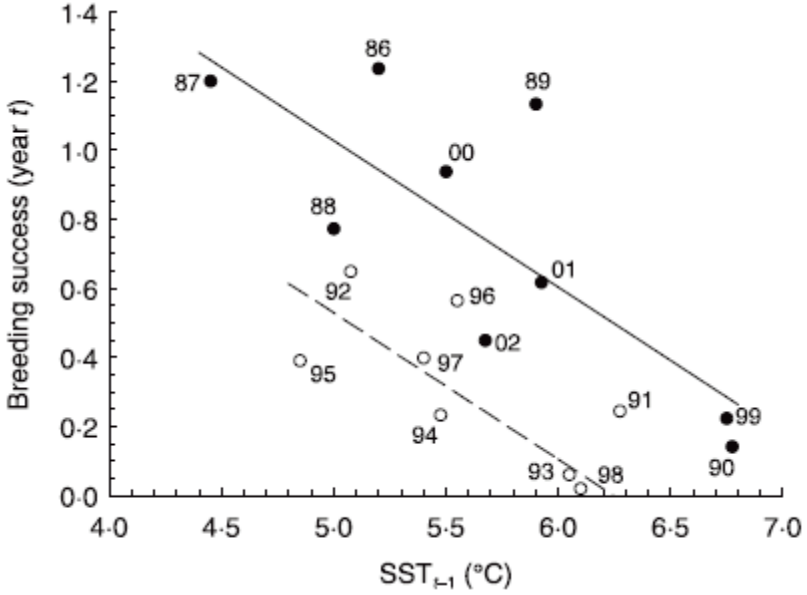


Figure 3.1a. Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Bankie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years. From Frederiksen *et al.*, 2004.

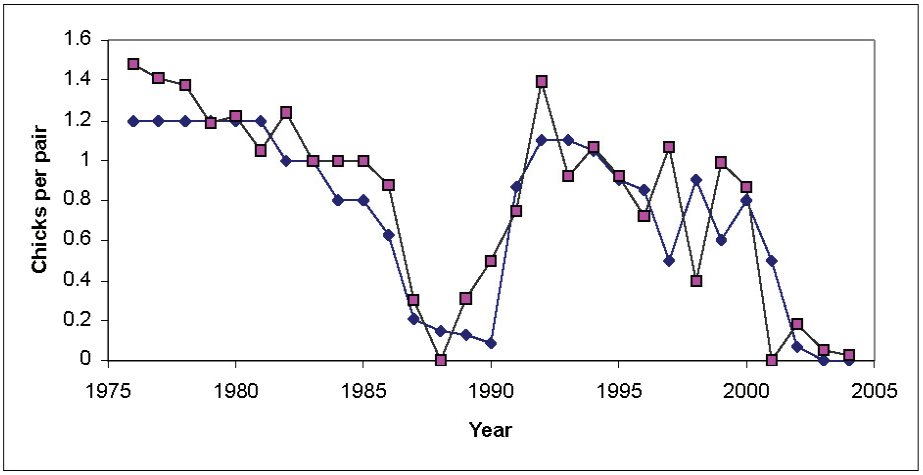


Figure 3.1b. Breeding success of black-legged kittiwakes (pink) and Arctic skuas (blue) at Foula, Shetland, during 1976–2004, showing a close correlation between the success of the two species in this time-series, and periods of particularly low success in 1987–1990 and in 2001–2004.

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.

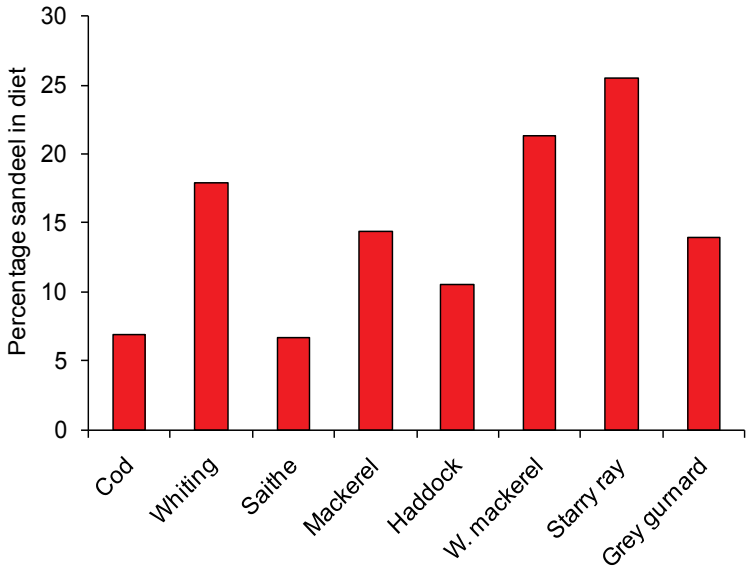


Figure 3.3b. Proportion of the diet consisting of sandeel for different predatory fish (ICES 1997).

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 re-

search 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).

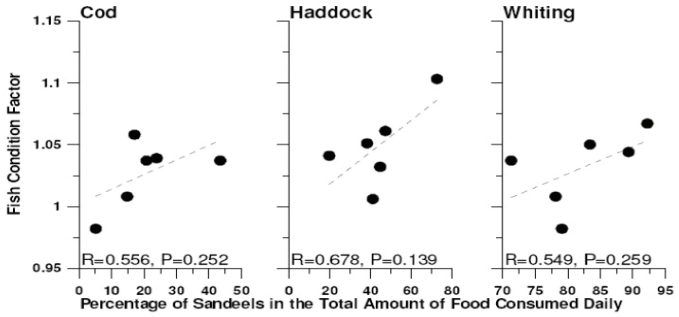


Figure 3.3c. Relationship between the body condition of gadoid predators in the Firth of Forth, and the quantity of sandeels consumed (from Greenstreet *et al.*, 2006).

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:

6) 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 kitti-

wake 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.

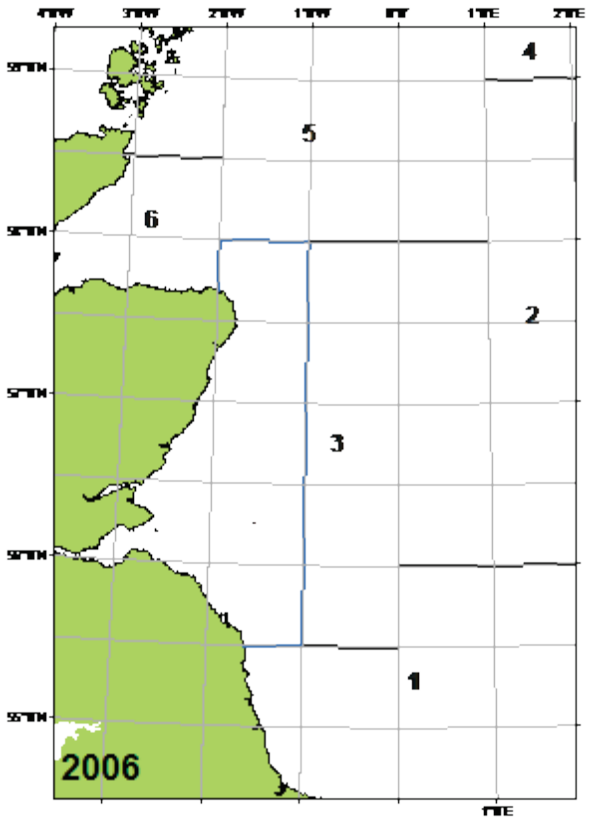


Figure 4. Chart showing the closed area (blue line).

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 Northeast 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/Asssess: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.

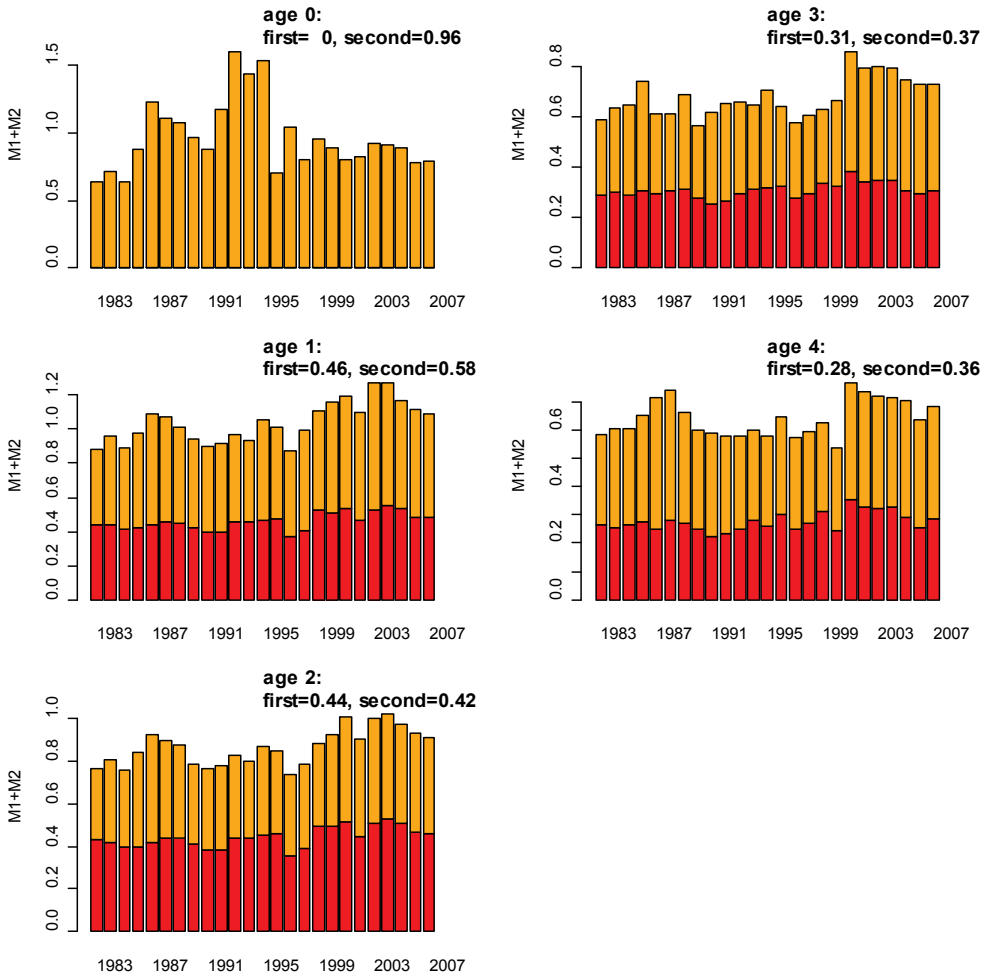


Figure 3.5. Natural mortalities of sandeel by half year. Mean values (1982–2007) for first and second half year are presented in the headings.

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:

$$\overline{CPUE}_a = \frac{\sum_{sq} \overline{CPUE}_{a,sq}}{n_{a,sq}} \quad \textbf{(1)}$$

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 assess-

ment 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
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 (B_{lim})	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

Option	Area 1	Area 2	Area 3
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	B_{lim}	SSB CV	B_{pa}
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.

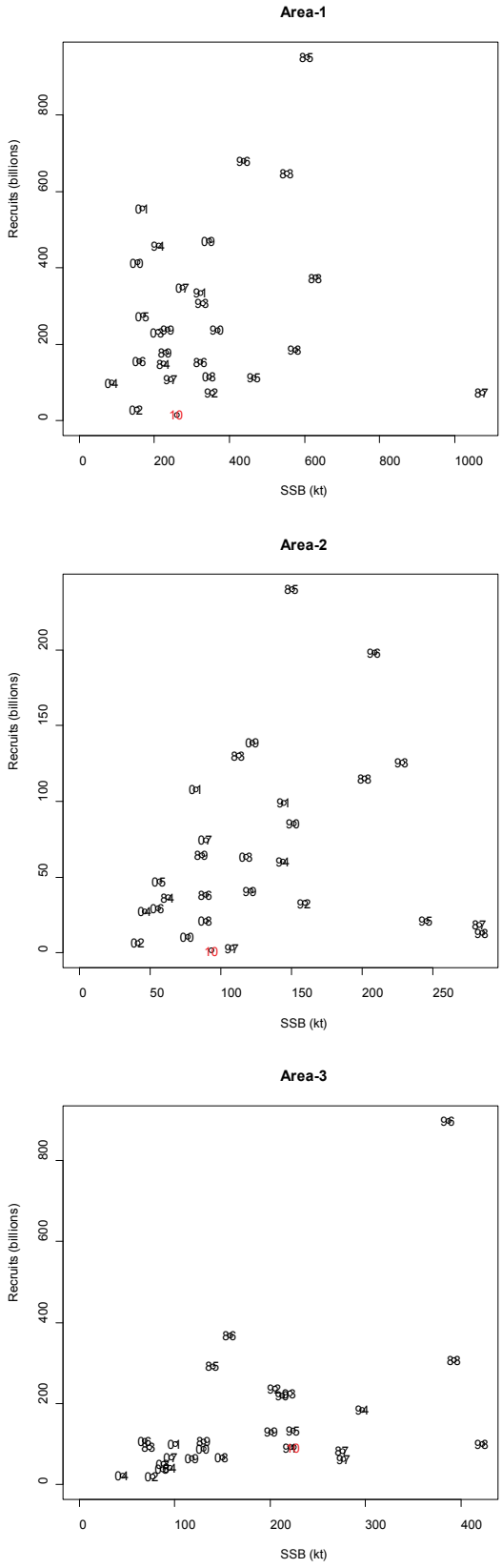


Figure 4. Stock–recruitment relationship in areas 1 to 3. Note that the recruit estimate for 2010 is based on very little input data and is therefore highly unreliable.

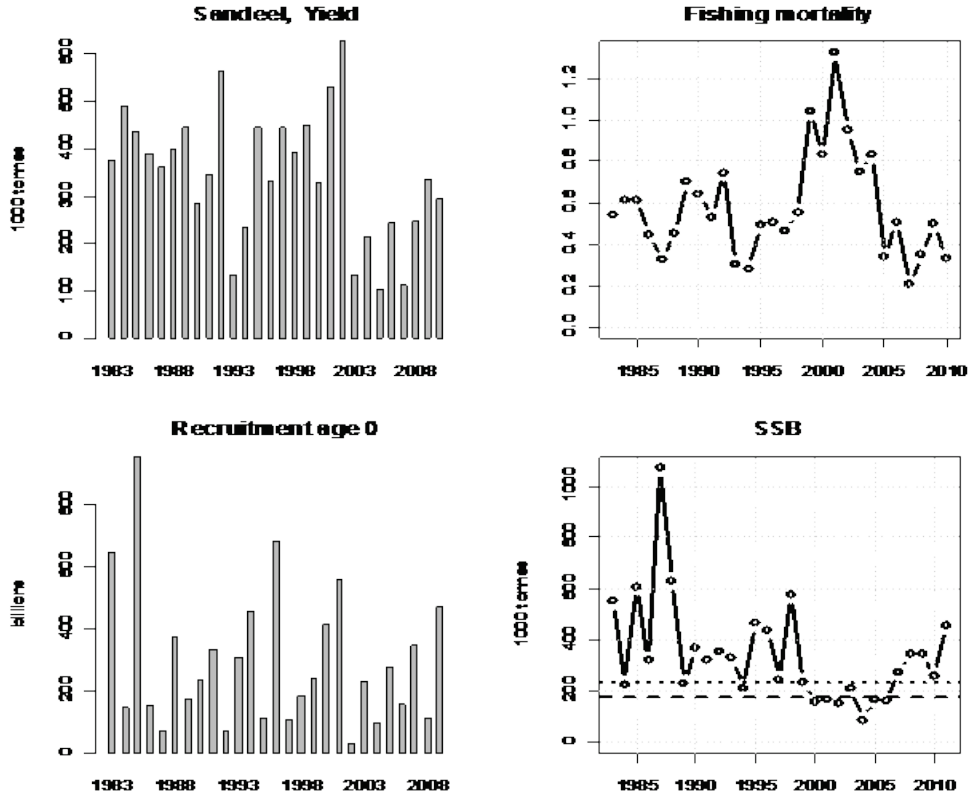


Figure 5. Stock summary for area 1.

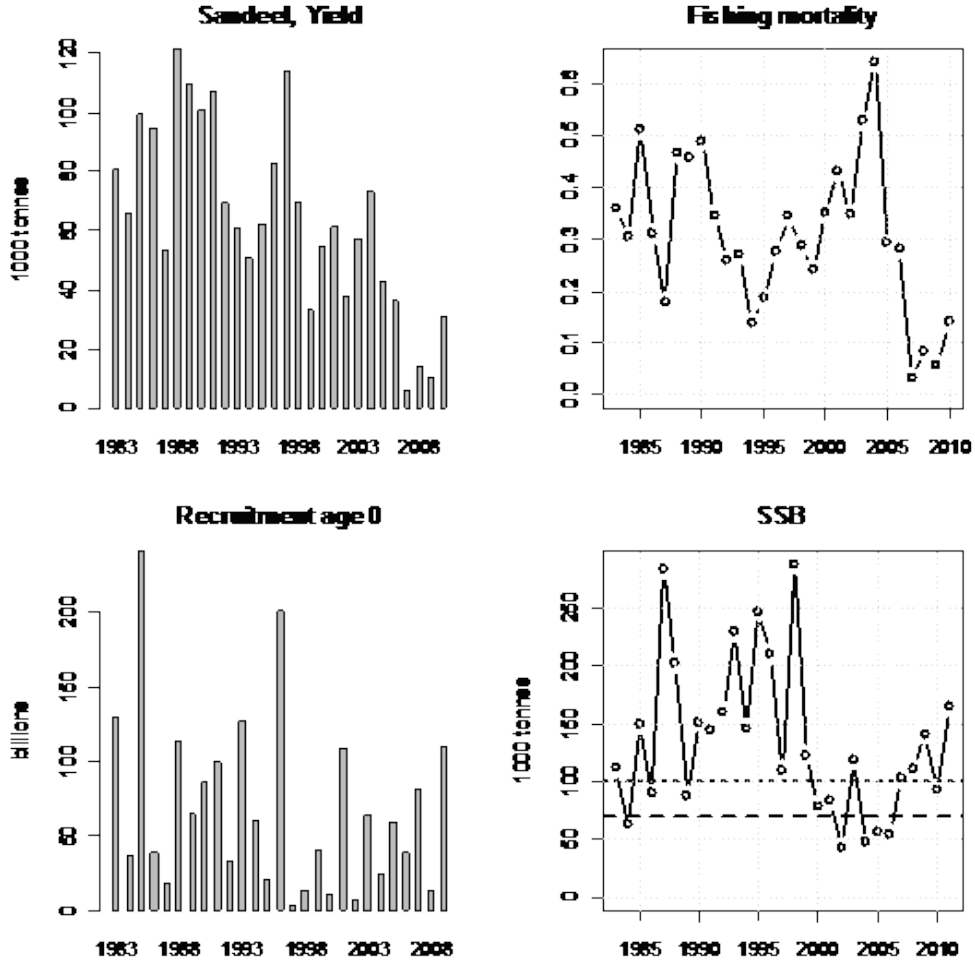


Figure 6. Stock summary for area 2.

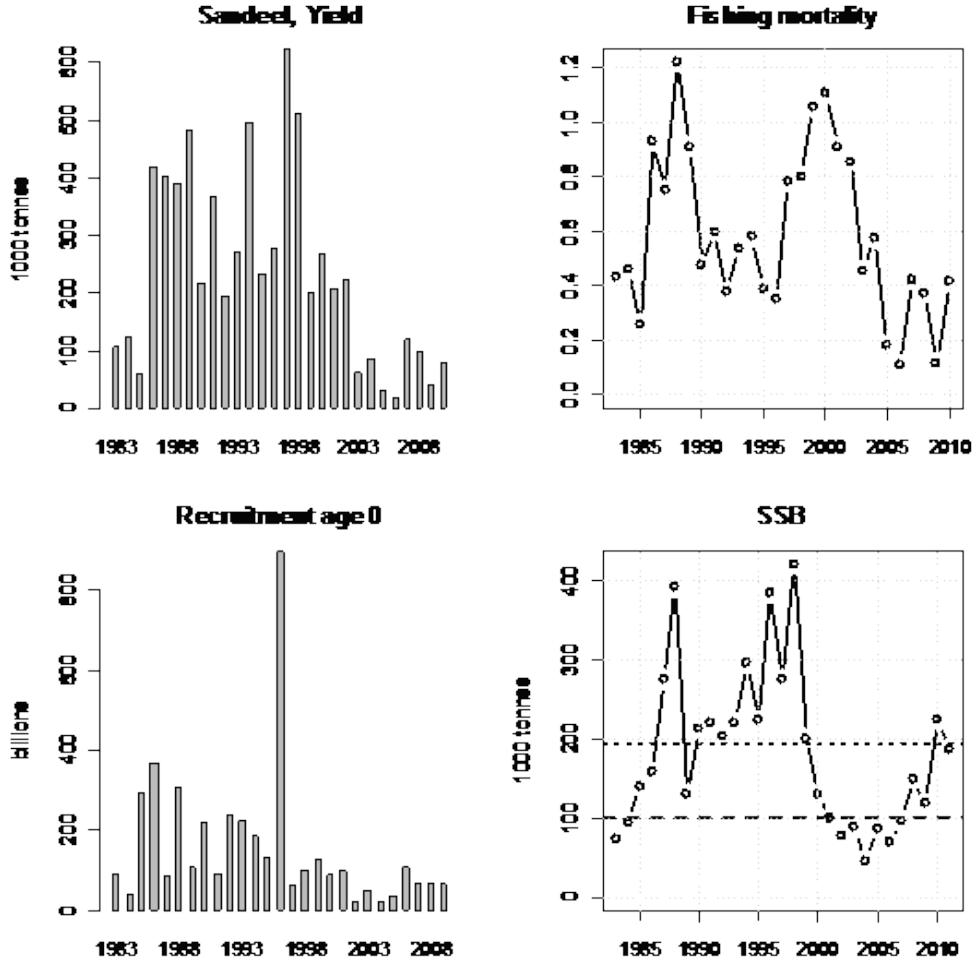


Figure 7. Stock summary for area 3.

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.

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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 objec-
tive.function.weight) (default=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) (de-
fault=1)
1
# phase.SSB.R.beta (beta parameter in SSB-recruitment relation) (de-
fault=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 spe-
cies
   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 op-
tion/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 sea-
sonal selection
       3
#  first year in each group
1983 1989 1999
## year season combinations with zero catch (F=0) (option ze-
ro.catch.year.season)
# 0=no, all year-seasons have catchs, 1=yes there are year-season com-
binations with no catch. Read from file zero_catch_seasons_ages.in
# default=0
1
## season age combinations with zero catch (F=0) (option ze-
ro.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 (km^2)	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

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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

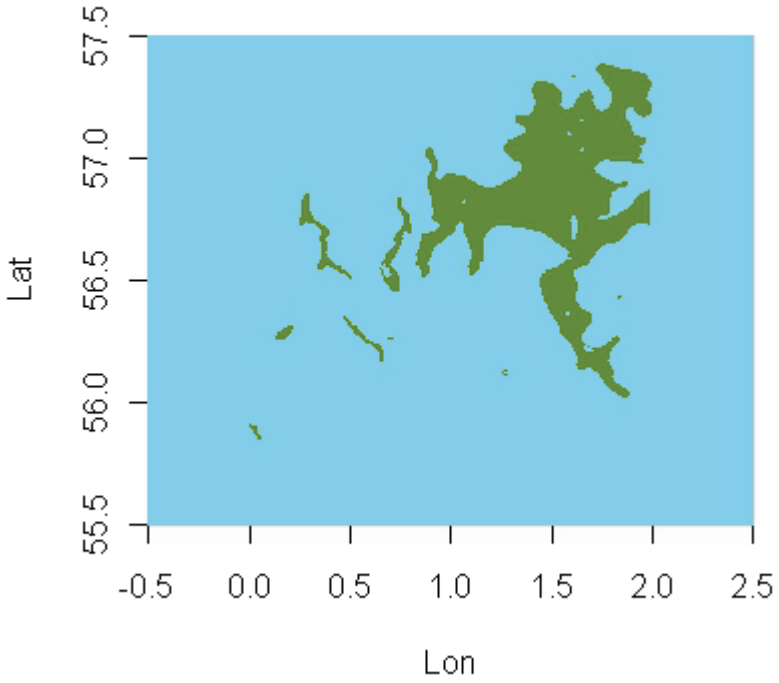


Figure A.1. Distribution of muddy sediment in the central North Sea according to British Geological Survey maps.

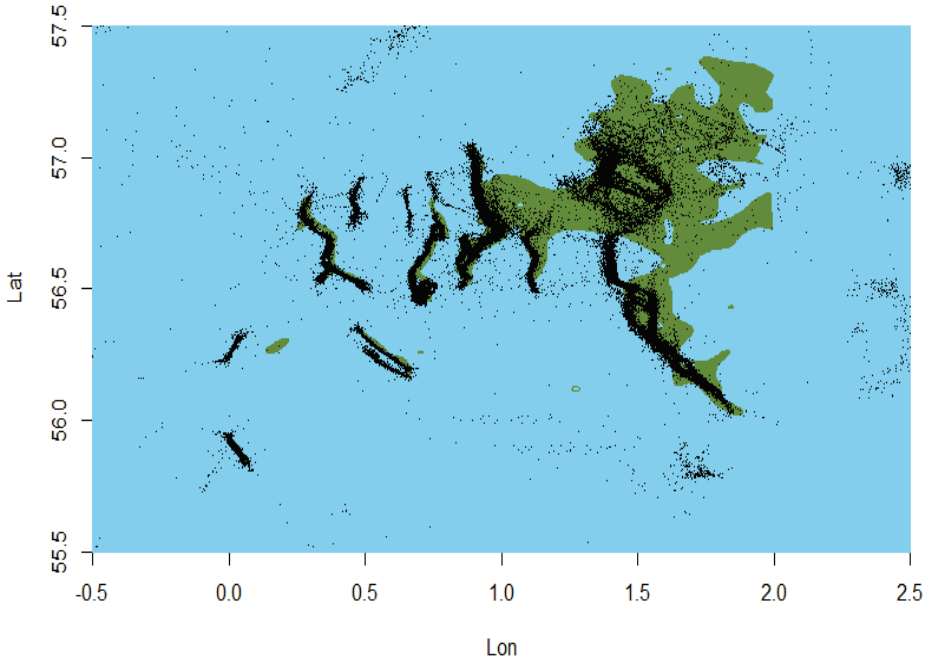


Figure A.2. Comparison of BGS sediment map with VMS data from Scottish trawlers (2007-2011) filtered for landings >30 % of total, speeds of 0.5 – 3.8 knots and mesh size 70 – 99 mm.

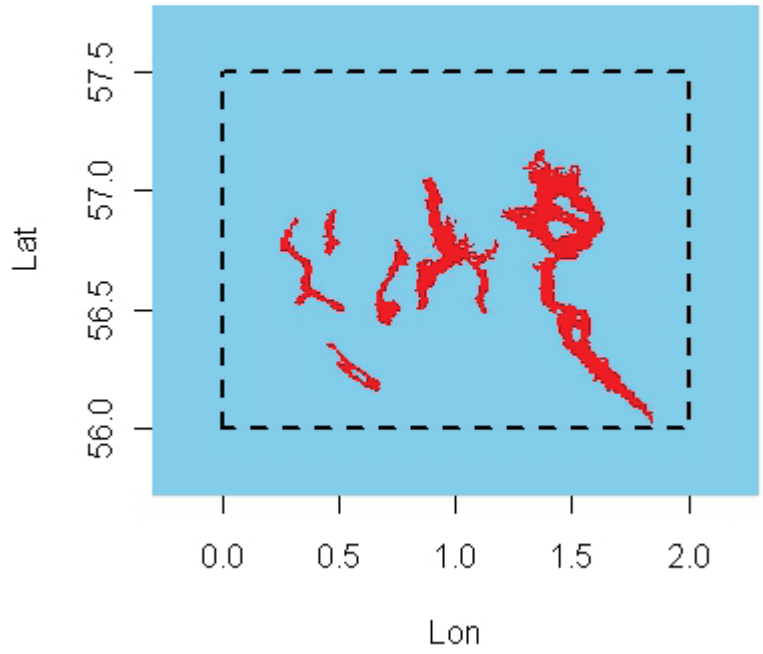


Figure A.3. The area of the spatial extent of the *Nephrops* habitat from VMS data calculated using the alpha-convex hull method.

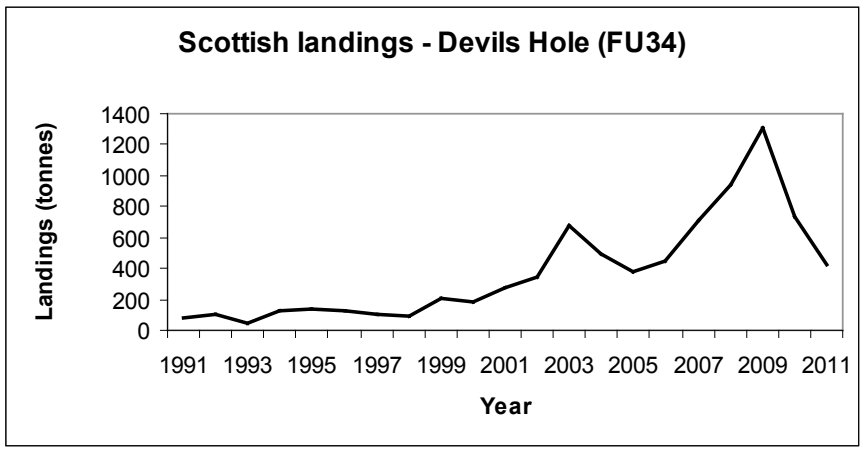


Figure A.4. *Nephrops,* **Devil's Hole (FU 34). Scottish landings from 1991 to 2011.**

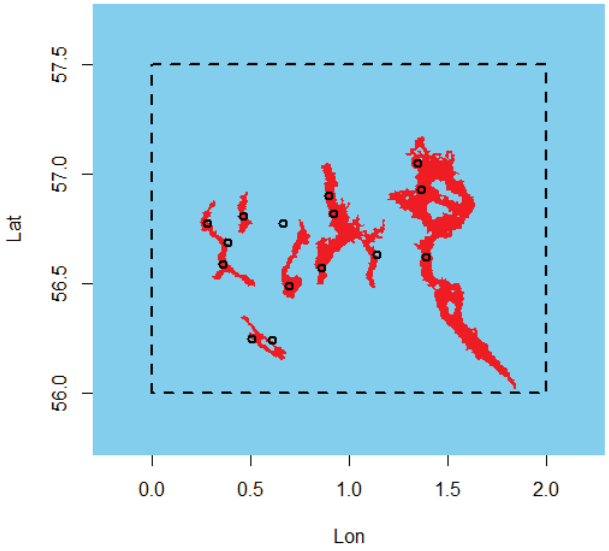
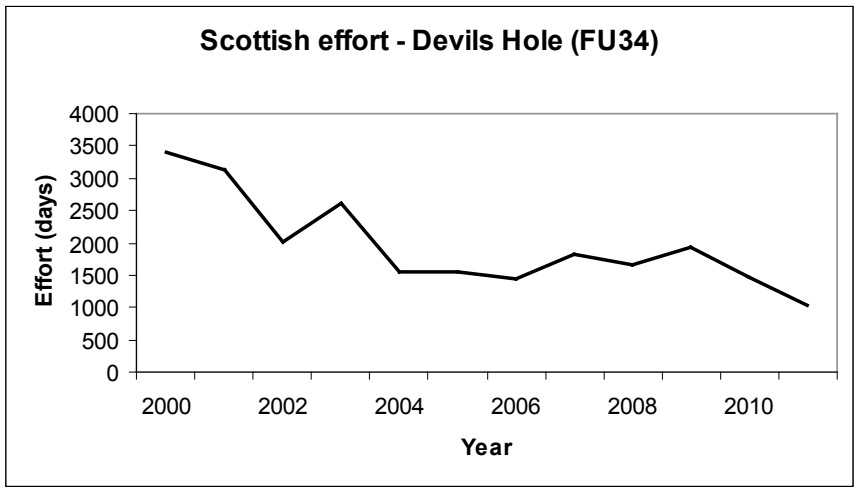


Figure B.1. Fixed UWTV survey station locations (2009 onwards) compared with estimate of spatial extent of *Nephrops* at Devils' Hole.



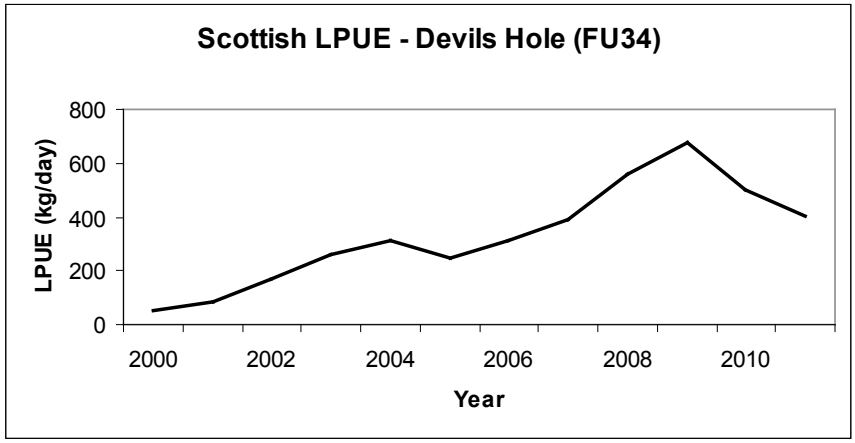


Figure B.2. ***Nephrops,*** **Devil's Hole (FU 34). Effort (days) and LPUE (kg/day by Scottish trawlers).**

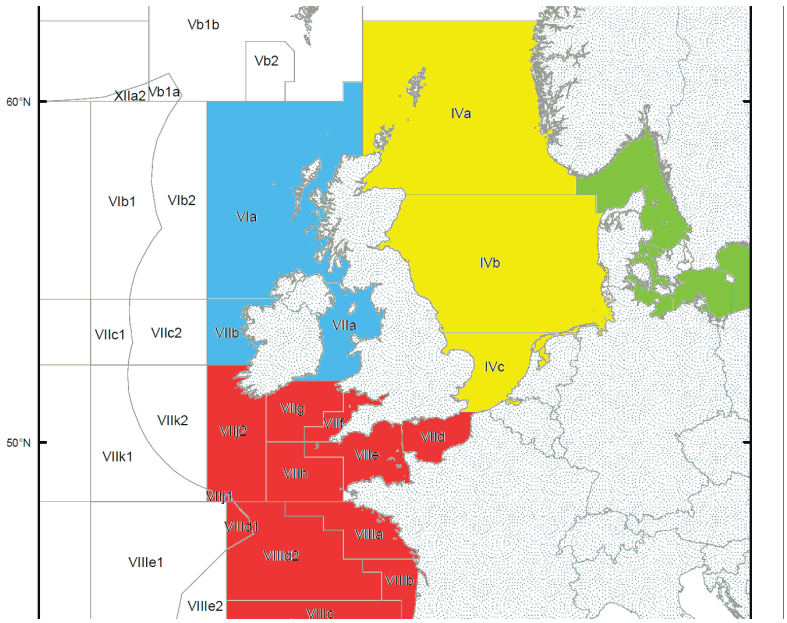
Stock Annex - Turbot in ICES Subarea IV (North Sea)

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 II_a). 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 land-

ings 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 $B_{trigger}$	xxx t	Explain
Approach	F_{MSY}	0.29–0.37 year-1	95% confidence bounds F_{MAX} as proxy for F_{MSY}
	B_{lim}	xxx t	Explain
Precautionary	B_{pa}	xxx t	Explain
Approach	F_{lim}	Xxx	Explain
	F_{pa}	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.

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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.

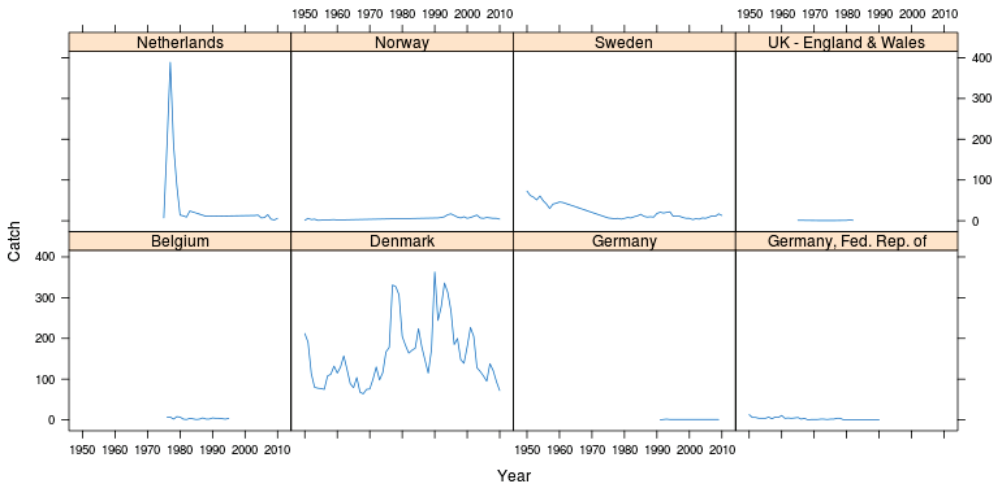


Figure A.1. Landings of turbot by country from 1950 to 2011 in IIIa. UK- Eng+Wales includes N. Ireland in 1991 (0.5 t), while Sweden reported aggregated catches for IIIa and IVa+b in 1973 (9.0) and 1974 (7.0).

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:

7) 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:

7.1) 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;

7.2) 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:

7.3) 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;

7.4) 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 Staging 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 abun-

dant 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.

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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, alt-

hough 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 max-

imum 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.

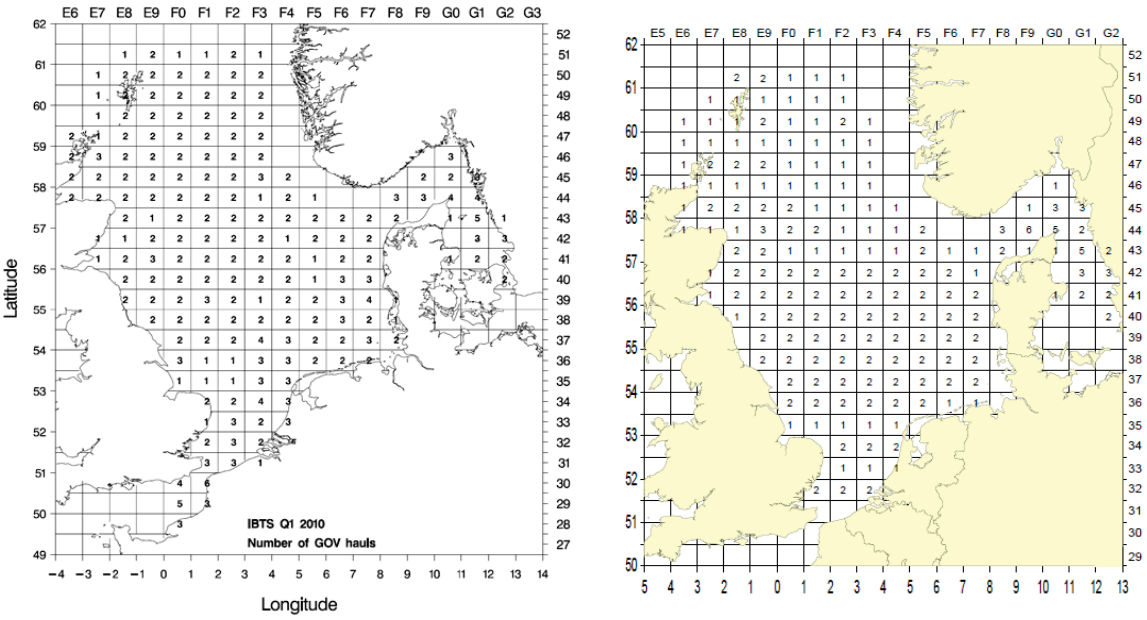


Figure B.3.1. Number of GOV trawl hauls per ICES rectangle in the IBTS Q1 survey in 2010 (left hand plot) and the IBTS Q3 survey in 2009 (right hand plot). Source: ICES IBTSWG reports.

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 $B_{trigger}$	To be determined	Explain
Approach	F_{MSY}	To be determined	Explain
	B_{lim}	To be determined	Explain
Precautionary	B_{pa}	To be determined	Explain
Approach	F_{lim}	To be determined	Explain
	F_{pa}	To be determined	Explain

H. References

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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:
As in 2012, the WGNSSK aknowledged the benefits of meeting slightly earlier in 2012, and not immediately back to back with the WGCSE,. Additionally, the WG recognises that although the work has been significantly streamlined, a 7 days meeting is not enough for achiving all ToRs, and in particular for the audit. The WG recommends a 8 days meeting in 2014.	ICES secretariat
In 2013, there were almost no changes in the species list included in the combined WGNSSK-WGMIXFISH data call. For next year, WGNSSK recommends that the list is expanded to other North Sea demersal species covered WGNSSK and WGNEW, and that better coordination is done with WGCSE for the inclusion of straddling stocks such as saithe, megrim, monk etc.	WGMIXFISH, WGCSE, WGNEW
Whiting Advice is given for Subarea IV and Division VIId combined, however, TACs are set for IV and VIIb-k separately and there is no way of controlling how much of the VIIb-k TAC is taken from VIId. WGNSSK reiterates that there should be explicit management advice for division VIId. As a first step there should be a specific TAC for VIId and advice would be given as part of a standard forecast for the stock. This would follow the same process as for area VIId for cod since 2009.	EU Commission, Norway
There needs also to be clarification of the stock units for whiting in Skagerrak. Whiting IIIa is defined as a stock unit; however the IBTS area for whiting in IV includes some rectangles in Skagerrak, there is therefore inconsistency around the allocation of IBTS data to both stocks.	SIMWG, ICES Data Centre
There is an increasing focus on using SAM assessment model in WGNSSK; WGNSSK expressed however some concerns that total catch data are treated as a a usual obervation with two-sided uncertainty around., since it doesn't make much sense that true catches can be assumed to be lower than oberved catches. WGNSSK recommends that further investigation is given to analysis and parameterisation of one-sided uncertainty for catch information in statistical catch-at-age models	DTU Aqua, WGMG, SISAM
WGNSSK explored the use of a smoother function for computing advice for DLS, instead of the 2:3 or 3:5 average methods which can be driven by noise rather than by trends. However, further investigations are needed to measure the potential of this method, and to provide guidelines on the parameterisation of the smoother span.	WKLIFE, ACOM chairs
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	WGSAM, WGINOSE, WGECO

Annex 5 Benchmark Planning and Data Problems by Stock

Part A

Benchmarks planning WGNSSK

Section X Benchmarks

X.1 Latest benchmark results

Norway Pout

X.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	No	2015	Future proposals for internal use	Investigate model configurations and input data
had-34	Accepted FLXSA model but continued exploratory assessments with SAM and SURBAR	2011 WKBENCH	Yes (2014)			May require an inter-benchmark evaluation following updated work on XSA convergence issue
nep-34	OK	NA	Yes			
nep-5	Data-limited.	NA	No	2018?		TV surveys under developement
nep-6	OK	2009 WKNEPH - only benchmarked the UWTV survey process 2013 benchmark	no		2016?	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		2016?	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		2016?	Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-9	OK	2009 WKNEPH - only	No		2016?	Fuller exploration of other input data

		benchmarked the UWTV survey process 2013 benchmark				(landings, discards, raising procedures, etc)
nep-10	No assessment/no advice		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.	yes	2015	Or alternatively suggested possible benchmark in 2016 within generic Nephrops benchmark. In this case some ongoing data corrections might be presented as IBP earlier in 2014 or 2015.	Fuller exploration of other input data (landings, discards, raising procedures, etc)
nop-34	OK	2012	No	2015		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	No	2015	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)	no	yes in 2015. Likely with Baltic plaice		stock identity, discards data, management plan
ple-nsea	OK	2009, Inter-benchmark procedure in 2013	No	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	Requires an IBP in 2014 or 2015 for ongoing corrections in survey data	Requires an IBP in 2014 or 2015 for ongoing corrections in survey data	Suggested to be fully benchmarked later together with NEA saithe	Further analyses are planned to detect bias in Norwegian commercial CPUE index and to correct NORACU index.
sol-eche	OK	2009	no	no	no	no
sol-nsea	OK	2010	No	2015		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	No	Maybe	Ongoing work on the assessment may lead to major changes, in which case a benchmark or IBP would be required.	See WGNSSK 2013 report (section 18) for list of issues being examined further.
whg-47d	Update deviating from benchmark	2009, 2013		no		Change in catcability of young fish in IBTS surveys – requires application of different but extant method.
whg-kask	No	No	No	No	No	
Pol-nsea						
mur-347d	quantitative advice for data-limited stocks	No	No	2015		No assessment available

X.3 Issue lists for stocks with upcoming benchmarks

[Mind: describe in short both the problem **and** the proposed solution. It helps if it is clear the solution can be brought about at the proposed time]

Issue list template:

Stock	**Haddock in IIIaW, IV and VIa**	
Stock coordinator	Name: Coby Needle	Email: needle@marlab.ac.uk
Stock assessor	Name: Coby Needle	Email: needle@marlab.ac.uk
Data contact	Name: Coby Needle	Email: needle@marlab.ac.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
Tuning series	If stock structure is addressed (see below), we need to determine whether the separate survey indices should be used as they are, or combined. The use of two additional series (UKScoGFS-WIBTS Q1 (short time series) and IGFS-WIBTS-Q4) also needs to be considered.	Survey distribution maps. Comparative analyses of survey indices.	Data exist from the Scottish groundfish surveys (various quarters, IV and VIa), IBTS, and the Irish VIa groundfish survey.	Survey analysis experts (e.g. Norman Graham and David Stokes, MI Galway; Andrzej Jaworski, Finlay Burns and Rui Catarino, MSS Aberdeen).
Discards	Current discard estimates are based principally on Marine Scotland sampling for number, length and age. Two sampling programmes for number and length only are in place (industry observers and CCTV), but cannot yet be incorporated into age-based data collation and assessment. The validity of early estimates of discard and bycatch rates is also in doubt.	Two alternatives routes are to faciliate incorporation of new data streams into existing collation, and to generate parallel length-based assessment and advice. The latter seems more tractable in the short term. It is currently not clear how the issue of early data veracity should be addressed.	Count and length data already available from industry observers, CCTV analysis and surveys.	Experts in CCTV analysis (e.g. Rosanne Dinsdale and Tanja Buch from MSS Aberdeen), and length-based assessment (Helen Dobby, Tanja Buch and Emma Lowe from MSS Aberdeen; Andisheh Bakhshi from University of Strathclyde, Glasgow). The appropriate expertise for the question of early time-series validity still needs to be determined.

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	The North Sea haddock forecast currently uses a method defined by Andrzej Jaworski (MSS Aberdeen) to generate future weights-at-age estimates. Egg production estimates have been generated (infrequently) in the past, and are very useful for ecosystem analyses. Maturity estimates are outdated.	The growth-forecast method needs to be revisited, especially in light of stock structure issues, to determine whether it is still appropriate. Egg production and maturity estimates need to be updated.	Growth analyses are based on weights-at-age data which is generated for the assessments in any case. Survey data for maturity estimation are available, but fecundity estimates for egg production will need to be generated.	Experts in growth modelling (e.g. Andrzej Jaworski, MSS Aberdeen), maturity analysis (e.g. Coby Needle, MSS Aberdeen), and egg production (Peter Wright, MSS Aberdeen).
Assessment method	The current assessment method for the North Sea stock is still FLXSA, although potential convergence issues have been highlighted in the past. The TSA method used in VIa is also not without implementation difficulties (such as whether or not to incorporate catch age structure for years in which catch data are otherwise excluded). Alternative methods need to be explored, and some thought will need to be given to how any model will handle the forthcoming discard ban.	North Sea haddock was a case study stock at WCSAM in Boston in July 2013, and the work done there should be used as a starting point. Potential models include SURBAR (following self-testing), SAM with parameter sensitivity, a4a, TSA, FLXSA (following convergence tests), length-based methods (see above), spatial assessment using INLA, and data-poor methods (to determine how much data can be removed before signal is lost).	All required data should be available.	Experts in stock assessment for the models mentioned: Coby Needle, Rob Fryer and Rui Catarino, MSS Aberdeen; Anders Nielsen, DTU-AQUA Copenhagen; Colin Millar, JRC Ispra; Helen Dobby, Tanja Buch and Emma Lowe, MSS Aberdeen; Andisheh Bakhshi, University of Strathclyde, Glasgow
Biological Reference Points	Reference points will need to be revised if any of the changes mentioned elsewhere in this table are implemented.	Generation of new referemce points after a final assessment configuration is agreed, potentially through risk-based simulation.	Data for this are the same as for the assessment itself.	Experts in simulation risk analysis (e.g. Coby Needle, MSS Aberdeen).
Other	The correct assumptions about stock structure are potentially critical for the haddock assessment, and we need to determine a) whether there are two stocks in the area (IV and VIa) or one, and b) whether combining areas in the assessment (for example) improves the assessment and advice. If the areas are not combined, then the VIa/IVa landings misreporting issue needs to be considered – is it significant & should we adjust the data to account for it (like cod-scow)?	Survey distrubution maps and comparative index analysis (see above); VMS and CCTV-based catch and landings maps; summaries of previous stock-structure analyses (e.g. STEREO). All analyses described in this table should be completed three times: once for IV, once for VIa, and once for the conbined area.	Spatially-defined survey data are available, as are inferences about catch and landings positions from VMS and CCTV data (for Scottish vessels). The practicality of combining IV and VIa catch datasets needs to be considered.	Experts in spatial analysis of VMS and CCTV data (e.g. Coby Needle and Rui Catarino, MSS Aberdeen) and biological stock structure analysis (e.g. Peter Wright, MSS Aberdeen).

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	**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
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[2]	Alternative tuning indices.	Development of alternative tuning indices from commercial fleets.	National data sources	
Tuning series	Evaluate change in design of NORACU. Re-evaluate NORASS to determine if the survey provides an index of abundance. Estimate sampling variance for the survey indices.	Re-evaluation/recalculation of the Norwegian indices including sampling error.	National data sources	
Catch at age data	Determine if low number of Norwegian commercial samples is creating bias in catch-at-age data.	Evaluate the sampling design (any changes?) and address sampling uncertainty.		
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.	Growth and maturity curve fitting.	DATRAS; survey data	None

[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
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	None
Other				

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[3]	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	

[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.

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	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?		
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[4]	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				

[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.

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[5]	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) 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	National data sources/DATRAS	
Catch at age data				
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	
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		
Biological Reference Points	Revision of reference points will be needed	Generation of new reference points after the final assessment.	Stock assessment outputs	

[5] 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
Other				

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

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
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

Stock	Data Problem	How to be addressed in	By who
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. This is being considered by both DTU Aqua and by WGBEAM. Needs some follow up	IBTSWG; WGBEAM; DTU Aqua
Plaice in IIIa, IV and VIId	Small plaice of 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
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)
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 log-books 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 log-books, 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 bet-ter understand-ing 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 bio-logical 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 specif-ic age readings	Studies on whiting stock identity and connec-tivity in western Baltic, Division IIIa and Divi-sion IV should be encouraged In the routine surveys, IBTS quarter 1 and quarter 3 in Divi-sion 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 subdivisi on IIIaW, subarea IV, and division VIId	Perceived catchability problems in IBTS Q1 and Q3 indices, contin-ued improve-ments 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

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Audit of Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat) 1328

Audit of Haddock in ICES Subarea IV and Division IIIaN (HAD – 34) 1330

Audit of Norway Pout in ICES Subarea IV and Division IIIa (NOP – 34) 1335

Audit of Sole in Sub-area VIId 1338

Audit of Whiting in ICES Subarea IV (North Sea) & Division VIId (Eastern Channel) (WHG – 47d) 1341

Audit of Pollack in ICES sub area IV and Division IIIa 1344

Audit of Cod 347d 1346

Audit of *Nephrops* in Subarea IV: Noup (FU10) 1349

Audit of *Nephrops* in Subarea IV: Norwegian Deep (FU32) 1351

Audit of *Nephrops* in Subarea IV: Off Horns Reef (FU33) 1354

Audit of *Nephrops* in Subarea IV: Devil's Hole (FU34) 1356

Audit of *Nephrops* in ICES Subarea IVa (Fladen Ground) nep-7 1358

Audit of *Nephrops* in ICES Subarea IVa (Firth of Forth) nep-8 1361

Audit of Pollack in ICES sub area IV and Division IIIa 1363

Audit of *Nephrops* in ICES Subarea IVa (Moray Firth) nep-9 1365

Audit of Plaice in Division VIId (Eastern Channel) ple-eche 1368

Audit of Plaice in IV 1369

Audit of Saithe in Subareas IV (North Sea), VI West of Scotland), and Division IIIa (Skagerrak) sai – 3a46 1373

Annex 6 – Audit Reports

Audit of Grey gurnard in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat)

Date: 15/05/2013

Reviewer: Henrik Svedäng, Jennifer Devine

For single stock summary sheet advice:

1) **Assessment type:** Biennial year
2) **Assessment**: N/A
3) **Forecast**: N/A

General comments

The assessment report and advice need to be edited. Both stock annex and assessment report lack structuring and are too extensive considering the limited commercial interest in grey gurnard and the want of biological knowledge. Too many figures in the stock annex are presented without any obvious reason.

Technical comments

There were no major errors but please note;

- A number of figures included in the stock annex are not referred to in the text.
- Section 16.4.1 should be restructured. The first paragraph would be better suited as the last paragraph in this section because the support for the statements made here are found in the current paragraph 3. The statement 'obvious that the catch statistics are incomplete for several years' is unsupported. It is only true if bycatch of gurnards is high in other fisheries; this information does not appear until 2 paragraphs later. This section would benefit from a check for grammatical errors.
- The statement 'North Sea landings decreased gradually before WWII' is unsupported. Where is the data (in tables or figures) that shows this?
- The statement 'After an initial post-war peak of 4000 t, annual landings stayed well below 2000 t' is untrue. Figure 16.1a shows catches of 200-300 t post-WWII.
- The statement 'In the same period, however, there was some misreporting as well' is unsupported.
- The legends (figures and tables) need checking. For instance, the legends state 'to 2010' but the data are to 2012.
- The tables in the report are not presented in the proper order. For instance, Table 16.3 is referenced before 16.2 is mentioned.
- Section 16.4.2 uses data on 2010. Are there 2011 and 2012 data?
- Section 16.5: the text on the changes in the distribution patterns of grey gurnard in IBTS Q1 and Q3 is not entirely correct. The text is written as though

grey gurnard are only found in the central North Sea during winter, but the figures show otherwise.

- Section 16.5: A reference is needed to support the statement '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'.
- Table 16.2 legend: Q1 and Q3 should be capitalized. This should be table 16.3, not 16.2.
- Figures 16.3 and 16.4: The legend should state whether these figures are combining data from all years or only specific years.
- The sentence on spawning does not belong in Section 16.5.
- Section 16.5, paragraph 5, last sentence: this is a statement that belongs in the figure legend, not the main text.
- Figure 16.5: 'the exceptional abundance' has no meaning. Replace with 'exceptionally high abundances'.
- The histograms along the side of figures in Figures 16.5 and 16.6 have not been explained in the legend or main text.
- Legend to Figure 16.7: "showing that grey gurnard displays a significant number of individuals" – the use of the word 'significant' is not correct. What is shown is that the age span of grey gurnard collected in Q1 is large (age 2 to age 14), but that not many individuals are aged. The text in Section 16.6 also uses 'significant' incorrectly.
- Section 16.10 lacks a citation for the multi-species model.

Conclusions

The assessment has been performed

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?

  Not applicable

Audit of Haddock in ICES Subarea IV and Division IIIaN (HAD – 34)

Date: 16/05/2013

Reviewer: Guldborg Søvik and J. Rasmus Nielsen

For single stock summary sheet advice:

1) **Assessment type: Update** (Benchmarked in early 2011)

2) **Assessment**: Analytical

3) **Forecast**: Presented

4) **Assessment model**: Age based XSA (Extended Survivors Analysis) + 3 demersal trawl survey indices and no commercial CPUE indices.

5) **Data issues:** Values for natural mortality are varying as used from the SMS multi-species assessment. Maturity-at-age data assumed fixed through time. Discards (observations available since 1978) and industrial by-catch are included in the assessment. Modelled discards for 1963-1977 is included in the assessment. The new discard collation method used from 2009 onwards has not changed the perception of discard rates for haddock.

6) **Consistency:** Last year's assessment was accepted with the changes suggested in the Benchmark assessment early 2011. RG comments from last year not included in the assessment report.

7) **Stock status**: The stock is viewed as being at full reproductive capacity with most recent estimates of SSB>MSY $B_{trigger.}$ Following the ICES MSY approach and the management plan implies fishing mortality to be increased to 0.3, resulting in human consumption landings and a TAC of 37146 t in 2014.

8) **Man. Plan.**: 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 inter-annual 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.

   Following the management plan implies a TAC of 37146 t in 2014, which is a TAC decrease of 11% and is expected to lead to an F increase of 41%. This outcome is due to the absence on young fish recruiting to the population, and hence a predicted decline in spawning-stock biomass. The possibility of extended periods of low recruitment was accounted for in the 2008 evaluation of the management plan that was deemed to be sustainable.

General comments

1) The assessment report and advice is well written, fully documented and ordered. It is easy to follow and interpret. However, the RG comments from last year were not included in the assessment report.

Technical comments

There were no major errors found but a few points to note:

- In general: Often the Table and Figure numbering does not match, i.e. follow the respective text section numbering. This is confusing and can with advantage be adjusted, please.
- In general: Comments from reviewers on last years assessment and how these have been addressed is not included in the text.
- 13.1.2 Text indicate that quota uptake in 2012 was 99% while table 13.2.1.1 indicate 80%. Please, up-date text.
- 13.1.3. The second paragraph is confusing. Is this the advice from last year (2012) as the heading suggests, or is it this year's advice as the content suggests?
- 13.1.4. second paragraph: two TACs: Why is IIIa included in both? (IV and IIIa and IIIa-d)? It is not clear for which areas the two TACs pertain: Report states "IV and IIIa" and "IIIa-d", while advice sheet states "IV" and "IIIaW". Please clarify
- Table 13.2.1.1. IBC is 0.039 in IV and 0 in IIIa, but the sum of IV and IIIa is 1?
- Table 13.2.1.2. Skagerrak is named IIIaN in this table. IIIaN and IIIaW seems to be used interchangeable? If these are different areas, please specify, if not, only one term should be used
- 13.2.1 first paragraph: Text: "Industrial bycatch (IBC) has declined considerably from the high levels observed until the late 1990s." According to Figure 13.2.1.1. high levels were observed until the late 1970s.
- Section 13.2.4: Indicates that M is fixed while the Advice sheet indicate that variable M over time from the SMS multi-species assessment is used in the assessment (?). Please, clarify. The table numbering does not follow the text section, please, renumber the table.
- Section 13.2.5: In the advice sheet it is stated that only 3 survey indices are used in the assessment. In figure 13.2.6.2 there are shown 5 indices. Please, use consistent figure numbering according to the text section, and please indicate in the figure legend as well as in the table legend (13.2.6.1) which time series have been used in the assessment (and in given case very explicitly state which surveys have been combined to totally 3 survey time series). It is not explained what GRT and GOV covers in the text table (i.e. the Granton and the GOV trawls).
- Last part of Table 13.3.5.1 the table text should be in bold.
- Section 13.3: There can with advantage be made reference to the descriptions of the assessment models used (e.g. SURBAR, SAM, XSA) – e.g. referemce to the stock annex.
- Sections 13.3.1, 13.3.2, 13.3.3, 13.3.4: Figure and table numberings do not follow the text sections.
- Figure 13.3.2.5: Figure legend indicate final year 2011, but the Table 13.3.5.1 etc. indicate final year 2012. Please, check and correct Figure legend.

- There is made reference to Figure 13.4.2 before Figure 13.4.1 in the text. Can be adjusted.
- Section 13.4, second paragraph: "The 2006-2008 and 2011-2012 year-classes are estimated to have been weak...", should be 2010-2012 year classes
- Section 13.4, second paragraph, last line: typo: subseuent should be subsequent.
- Section 13.6: Details of the Jaworski method can with advantage be moved to the Stock Annex and only referred to here. Details on methodology of how to calculate average weighted exploitation pattern can with advantage be moved to the stock annex, so it is only mentioned in the text which 3 years have been used in the calculation.
- Stock Annex Section G, p. 1225: There is a future reference to May 2011. This should be up-dated.
- Stock Annex References: Reference to Nielsen (2010) is missing, and reference to Jaworski (in press) is not up-dated.

Technical comments – advice sheet

- Advice for 2014 is missing (first line)
- Fig 6.4.7.1 is missing
- Fig 6.4.7.4 is missing
- Outlook for 2013 should be outlook for 2014
- 1) and 2) should be added to column headers in table on page 6.
- Table on page 6: Line on MSY: F=0 is not what is stated in the text below the table: "Following the ICES MSY approach implies fishing mortality to be increased to 0.3, resulting in human consumption landings of 37146 t in 2014. This would be expected to lead to an SSB of 204 kt in 2015."
- *Regulations and their effects:* […] 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, beam trawl (80–120 mm, BT2), and gillnet has shown a continuous decline (−12%, −39%, and −35%, respectively, between 2004 and 2011). If there was a switch from TR1 to TR2, how come effort by TR1 has been stable, while effort by TR2 has been decreasing?
- **Assessment and management area:** in this section Skagerrak is termed IIIaN, while in the rest of the advice sheet, Skagerrak is termed IIIaW. One term should be used
- Table 6.4.7.1.: (only checked 2012-numbers): Information on official landings in 2012 is missing. This information is found in Table 6.4.7.3. Agreed TAC for 2013 should be known? Please insert
- Table 6.4.7.2.: (only checked 2012-numbers): Agreed TAC for 2013 should be known? Please insert. Why is there no column for official landings? This information is found in Table 6.4.7.3

- Table 6.4.7.3.: (only checked 2012-numbers): Agreed TAC of 2770 in 2012 in IIIa does not agree with agreed TAC of 2.4 in Table 6.4.7.2.
- IBC of 0.039 does not agree with IBC of 1 in Table 6.4.7.1.: How can IBC of IIIa + IV be 1 when IBC for IIIa is 0 and IBC for IBC is 0.039?

Conclusions

The assessment has been performed correctly.

Considerations for future benchmark assessments:

- Stock structure and identity for haddock.
- Within an ecosystem context, species-specific assessments and the latest developments in mixed-fisheries approaches need to be considered. A reduction in direct effort on one stock may lead to a reduction or an increase in effort on another and, hence, the implications of any changes need to be identified and carefully evaluated.
- Isssue of FLXSA convergence has not been solved and must be addressed again.

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

  The section on Ecosystem aspects (in the Stock annex) could have been expanded. There is for instance little information on the co-occurrence of haddock and other gadoid species, which plays an important role in determining the fishing pattern. The influence of cod regulations on the haddock fishery is discussed in several sections. Maybe there can be made reference to specific sections in the multispecies assessment report?

- If a management plan has been agreed, has the plan been evaluated?

  YES

  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 fro appropriate age groups, along with a limitation on interannual TAC variability of ±15%. Fol-

lowing 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 evaluations of the management plan that were carried out during 2007 and 2008 used a recruitment model which is thought to capture the sporadic nature of haddock recruitment. On this basis, a target F = 0.3 with TAC constraint ±15% leads to a low risk (<12% in any year) of B < B_{lim} over the next 20 years, and a mean risk of 5% over all years. Lower Fs lead to lower risks. Interannual quota flexibility (banking and borrowing) has also been evaluated and it is concluded that this has no significant impact on sustainability.

ICES concludes that the management plan can be accepted as precautionary and can be used as the basis for advice.The stipulations of the management plan have been adhered to by the EU and Norway since its implementation in January 2007.

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 Norway Pout in ICES Subarea IV and Division IIIa (NOP – 34)

Date: 13/05/2013

Reviewer: Lynda Blackadder

For single stock summary sheet advice:

1) **Assessment type: Update**

2) **Assessment**: Analytical

3) **Forecast**: Presented

4) **Assessment model**: SXSA (Seasonal Extended Survivors Analysis) + 4 survey indices (IBTS Q1 & Q3, EngGFS-IBTS-Q3, ScoGFS-IBTS-Q3) + 3 commercial indices (CPUE indices up to 2006 (CFQ1, Q3, Q4)).

5) **Data issues:** Values for natural mortality, maturity-at-age, and weight-at-age were updated at the 2012 benchmark. These parameters have impacted on the predictions and estimates of the SSB (slight increase) because the stock consists of very few year classes. The change in natural mortality has resulted in a slight decrease of recruitment.

6) **Consistency**: Last year's assessment was accepted (note above changes in parameters) and the RG agreed with the WG conclusions for this stock.

7) **Stock status**: The stock is viewed as being at full reproductive capacity with most recent estimates of SSB>MSY $B_{escapement} = B_{pa.}$ With catches of up to 457 kt in 2013 the SSB is expected to remain above the reference level of MSY $B_{escapement}$ by 1st January 2014, due to the very strong 2012 recruitment and growth of the 1-group (whilst still taking into account high natural mortality and the short life span of the stock). The status of this stock is mainly determined by natural processes and the recruitment.

8) **Man. Plan.**: There are no specific management objectives for this stock. ICES has evaluated and commented on three management strategies (fixed F(0.35), fixed TAC (50,000 tonnes), and a variable TAC escapement strategy. In recent years, the escapement strategy has been practised. There is consistent bi-annual information available to perform real time monitoring and management of the stock. Real time advice and management options for 2013-2014 will be provided for the stock in the autumn 2013.

General comments

The assessment report and advice was well written, fully documented and ordered. 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.
- 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).
- 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).
- 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?
- 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).
- 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)?
- 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?
- 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?

Conclusions

The assessment has been performed correctly. Future benchmarks should promote the development of a state-space assessment model (SAM) for future use in the assessment of this stock.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

  YES

  - **Please note that InterCatch data still needs to be uploaded to the share point.**
- 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?

  No specific management plan but the advice sheet states;

  "Based on new joint EU-Norway request (ICES, 2012), long term management strategies have been evaluated in September 2012 and April 2013 for the stock, to be available for the September 2012 and May 2013 ICES advice, respectively (Vinther and Nielsen, 2012; 2013). Separate advice will be produced in relation to those long term management strategies."

  ICES. 2012. Joint EU-Norway request on management measures for Norway pout. Report of the ICES Advisory Committee, 2012. ICES Advice, October 2012. Book 6, Section 6.3.3.3.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.

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 Sole in Sub-area VIId

Date: 28/05/2013

Reviewer: Nick Bailey

For single stock summary sheet advice:

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: XSA (Extended Survivors Analysis) + five tuning fleets (two commercial - BE-CBT, UK(E&W)-CBT; and 3 survey UK(E&W)-BTS, UK(E&W)-YFS and the FR-YFS
5) **Data issues:** No revisions of landings data. Slight revisions have been made to the UK effort and LPUE series for 2011. No changes to natural mortality, maturity-at-age, and weight-at-age. The data for 2012 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. Lack of information from the UK YFS potentially affects the quality of the recruitment estimates and therefore the forecast.
6) **Consistency**: Last year's assessment was accepted and the RG agreed with the WG conclusions for this stock. Questions relating to high the high fishing mortalities on age 4 in 2010 and age 5 in 2011 were addressed. This year's assessment revised fishing mortality in 2011 upward only by 2% and SSB downward by 10%. The major issue seems to be associated with the choice for the basis of the recruiting year class size – this year based on RCT3
7) **Stock status**: Fishing mortality has been stable between 2000 and 2005 around Fpa. In the last 6 years fishing mortality has increased to values between Fpa (0.4) and Flim (0.57). These values are well above Fmsy (0.29). 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.
8) **Man. Plan.**: No explicit management objectives are set for this stock. Management of sole in VIId is by TAC and technical measures. Effort limitations on gears operating in this area arise from the EU cod plan.

General comments

The assessment report and advice was well written, fully documented and ordered. It was easy to follow and interpret.

Technical comments

There were no major errors and figure and table numbering appeared to be consistent. A few points to note;

- Throughout the document there were small editorial and grammatical errors which could easily be corrected and in the case of the latter may provide greater understanding. [A track change version has been supplied to the author for consideration and updating on the Sharepoint site]
- Page 1- think the advice section is clearer if we say 'advice for 2012' and advice for 2013
- Page 3- and other places – reference to 'ICES files' – it would be more helpful to say how one gets to these.
- Page 3 – the discarded fish comment is by weight – or course by number (and in terms of mortality) the significance is potentially quite a bigger than implied by the text.
- Page 10 – Management Considerations – it would be helpful I think to point out that F is remaining stubbornly high and shows no sign of reducing towards Fmsy.
- Table 9.2.2 – legend is landings numbers at age ….so 'kg' is inappropraite
- Labelling of lines and improved axis labelling on the new catch weight figures (9.2.1 and 9.2.2) etc might be helpful for next year

Conclusions

The assessment has been performed correctly. Future benchmarks should investigate the variability between surveys which provide estimates of recruits. The expert group suggested that in the absence of an English survey covering this stock, the French survey could visit 'missing stations'. The feasibility of this and some pilot work should be carried out ahead of any benchmark investigation.

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 – nothing new added**

- If a management plan has been agreed, has the plan been evaluated?

  No specific management plan

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 Whiting in ICES Subarea IV (North Sea) & Division VIId (Eastern Channel) (WHG – 47d)

Date: 15/05/2013

Reviewer: Henrik Svedäng, Jennifer Devine

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assess. model**: FLXSA (Extended Survivors Analysis) with two survey indices (IBTS Q1 & Q3).
5) **Data issues:** Values for natural mortality were updated in 2012 assessment. WKROUND recommended that the use of the latest M estimates should be continued. Stock identity issues yet remain to be resolved. No medium-term forecast or MSY estimation were conducted during the WG meeting.
6) **Consistency**: Last year's assessment was accepted.
7) **Stock status**: WGNSSK considers the status of the stock unknown with respect to existing biological reference points and MSY reference points. All indications are that the stock was at an historical low level during 2005 to 2008 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 is low and whiting biomass is therefore likely to decline in future even at low fishing mortality rates until recruitment increases.
8) **Man. plan**: Management of whiting is by TAC and technical measures. 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.

General comments

The assessment report and advice was well written, fully documented and ordered. It was easy to follow and interpret. Tables and Figures are adequately labeled and clear.

The strong increasing trend in mean weight-at-age need attention, as it is important information on the population dynamics and ecological conditions of the stock.

The issue of stock identity is very important; different stock units may have different developments, circumstances that complicate assessment work and might give rise to mis-interpretations.

F_{MSY} has not been defined. Reliable alternatives should be sought for such as $F_{0.1}$

Technical comments

No major errors were noted. Minor comments are as follows:

- Text in Section 3.1 states that there has been a slight decrease in discards for most ages in 2012; however, inspection of Figure 3 shows this is true only for ages 1–3. All other ages show an increase. [stock section already corrected accordingly]
- Short-term forecasts (last sentence p 7) lists the SSB value in kt, when it is in t. [stock section already corrected accordingly]

Conclusions

The assessment has been performed correctly. Stock identification work should be promoted and changes in mean weight-at-age should be given more attention.

Checklist for review process

General aspects

- Has the EG answered those TORs relevant to providing advice?

  YES

  - **Please note that InterCatch data still needs to be uploaded to the share point.**
- 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?

  No specific management plan but the advice sheet states;

  "Based on new joint EU-Norway request (ICES, 2012), long term management strategies have been evaluated in September 2012 and April 2013 for the stock, to be available for the September 2012 and May 2013 ICES advice, respectively (Vinther and Nielsen, 2012; 2013). Separate advice will be produced in relation to those long term management strategies."

  ICES. 2012. Joint EU-Norway request on management measures for Norway pout. Report of the ICES Advisory Committee, 2012. ICES Advice, October 2012. Book 6, Section 6.3.3.3.
  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.

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 Pollack in ICES sub area IV and Division IIIa

Date: 14.05.2013

Reviewer: Alexander Kempf, Jordan Feekings

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: Biennial year**
2) **Assessment**: Landing (and survey) trends
3) **Forecast**: not presented
4) **Assessment model**: no model
5) **Data issues:** Only landings data available, no effort time series, Survey CPUES very noisy
6) **Consistency**: Landings and Survey time series updated. No changes in the perception of the stock compared to last year
7) **Stock status**: unknown
8) **Man. Plan.**: no plan

General comments

No analytical assessment has ever been carried out for this stock.

Landings data alone are not a good indicator for stock abundance. A decreasing trend in landings of a by-catch species can be the result of a decreasing stock or a decrease in effort. The Survey CPUE is extremely noisy and catchability is very low. There is enough indication that the stock was higher in previous periods (e.g., 70ies), but it is not possible to draw final conclusions on stock trends for the last 10-20 years given the data available.

Collection and processing of biological data on growth and maturity recommended by WGNEW and WGNSSK would be helpful to improve information on the stock. Pollack is considered primarily a by-catch in other fisheries.

Technical comments

There is a typo in the survey section. The IBTS q 3 time series starts in 1991 and not 1996.

The sentence: “For Division IIIa (Skagerrak and Kattegat), the trends in landings indicate a decline in the stock...” (beginning of 15.5.2) is critical. As outlined above trends in landings alone cannot indicate a decline in the stock. But there is evidence from the IBTS Q1 that there is a decline in the stock compared to previous time periods.

The labelling of Figure 15.2 is imprecise. It becomes not entirely clear whether the distribution of catches in the IBTS Q1 or Q3 is shown. Or is it the sum over both surveys?

It is not clear from the advice sheet what rules have been applied to give advice. Although it a bi-annual advice, it should be explained also in this year why there is a 20% cut in IV and a zero advice for IIIa.

Conclusion

It is hard to draw any conclusions from the data available. It can be only concluded that the stock is on low level compared to earlier time periods (70ies and before). Therefore, a 20% reduction is justified. A CPUE index could help to get a better idea on stock trends in the future.

Audit of Cod 347d

Date: 13.05.2013

Reviewer: Alexander Kempf; Jordan Feekings

General

The EG has answered the TORs relevant to provide advice. In addition, the EG questioned the use of a catch multiplier after 2005 to account for unaccounted removals. Indications that justify to no longer estimate a catch multiplier after 2005 were collected and are given in the report. Both assessments (SPALY and without catch multiplier after 2005) are presented.

Time variant natural mortalities estimated from a multi species model (SMS) are used in this assessment to account for predation effects on the stock. A general description of ecosystem factors influencing the stock are given in the stock annex. However, the exact reasons for the currently low productivity of the stock remain unclear and further research is needed. Recruitment assumptions for the forecast take into account that the stock is currently in a low productivity regime.

The stock structure of North Sea cod is subject to intensive research for many years, but to draw final conclusions is difficult. Sub-populations are not taken into account in the assessment.

Note any modifications made by the stock assessor are given in curly brackets {}.

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

1) Assessment type: update with changes (catch multiplier)

2) Assessment: analytical

3) Forecast:Stochastic projection from which short term projections were extracted.

4) Assessment model: SAM; 1 survey (IBTS Q1)

5) Data issues: Data were available as described in the stock annex

6) Consistency: Last year's assessment accepted, this year's assessment accepted with changes regarding the catch multiplier.

7) Stock status: Blim < B <Bpa; Fpa > F > Fmsy; R low compared to earlier time periods, but 2005, 2009 and 2011 year classes are a little bit stronger

8) Man. Plan.: Agreed 2008: Plan has a recovery and a long-term phase. Plan changes to the long-term phase in this year according to the final assessment. Target F in the long-term phase = 0.4 with sliding rule if stock is below Bpa. Target F =0.2 if stock is below Blim. Another main element in the plan is a 20% constraint on TAC change between years. Plan is evaluated by ICES.

General comments

In general, this was a well written and ordered section. Figures are good and well described. Only the light grey in plot 14.9b comparing the SPALY and the final assessment is hard to see.

The assessment and forecast have been carried out as described in the stock annex apart from the usage of the catch multiplier. Assumptions on the catch multiplier are a major source of uncertainty and bias in the assessment.

An index from the collaborative scientific–fishing industry surveys (e.g. REX, NSW) could be beneficial for the assessment in the future as catchability of older cod is low in the IBTS surveys.

Data were available as specified in the stock annex. The availability of discard rate estimates and age compositions has improved in 2012, which is encouraging.

Technical comments

- Assumptions regarding the catch multiplier have been changed compared to the stock annex from last year. The catch multiplier is no longer estimated for years after 2005 in the final assessment. The reason for no longer estimating the catch multiplier after 2005 was information from national authorities that indicate that the level of catch misreporting has been decreasing and is likely to have become negligible since about 2006. In contrast to this information the catch multiplier is increasing in most recent years again in the SPALY assessment. In addition, a strong retrospective pattern in F (overestimation) occurs when estimating the catch multiplier for years after 2005; and this pattern has become worse in recent years. The retrospective pattern disappears when the catch multiplier for years after 2005 is no longer estimated.

  Given these arguments it seems to be justified to estimate the catch multiplier only for years up to 2005. But it would help to add some goodness of fit statistic like AIC or BIC to compare the two assessment runs. This "points out" how much we rely on the retrospective performance as a criterion for choosing and not the model fit itself. {Results from the likelihood ratio test, comparing the SPALY run to the proposed final assessment run are now provided in section 14.3.3 “Assessment models” when normalised residuals are discussed.}

  It should be also tried to find out what leads to the high catch multiplier in most recent years. Although “black landings” may no longer be an issue, underestimated discard rates, natural mortality and changes in survey catchability could be responsible. Otherwise the methodology used to estimate the catch multiplier has to be questioned.

- SAM does not assume catch to be known without error. Therefore, total catch estimated by SAM can be higher than the catch given as input. Total catch in tonnes is 5% higher in the final SAM assessment than in the input data for 2012. This 5% increase is much lower than the catch multiplier estimated in the SPALY assessment (>1.5).

- When using status quo F as basis for the intermediate year, the landings are predicted to be considerably above the TAC for 2013 (29% more). This means that under this assumption high discards of over-quota fish are expected (un-

accounted removals are assumed to be negligible after 2005 in the final assessment).

- Result tables are only presented for the final assessment. At least the most important result tables could be also presented for the SPALY assessment. {These additional tables have not been provided in the report because it is customary to produce them only for the final assessment run – too many tables become too confusing for readers. However, the corresponding tables for the SPALY run have been loaded to the sharepoint and are available if needed.}
- Table 14.7a is quite cryptic. A better labeling could improve readability
- Numbering of the tables and figures is sometimes illogical. E.g., 14.5b is mentioned in the text before 14.5a, 14.4 before 14.3a-c. Figure 14.16 is mentioned as the first figure in the text.
- There is a typo in the advice sheet under MSY approach. Landings are 16.2 in 2014 and not 2013. {This has been corrected.}
- Under the section 14.1.4 describing the cod management plan it is implicitly stated that effort reductions should be only applied until the long-term phase is reached. This is not stated in the same way in the plan. Also during the long-term phase effort has to be reduced as long as a reduction in F is needed. {The text comes from the advice sheet previously approved by ACOM, so has been left unchanged.}

Conclusions

The assessment has been performed correctly. It can be justified to no longer estimate the catch multiplier for years after 2005. The final assessment can be used to give advice.

Audit of *Nephrops* in Subarea IV: Noup (FU10)

Date: 22/05/2013

Reviewer: Arved Staby, David Miller

General

For single stock summary sheet advice:

1)	**Assessment type:**	Data limited approach for *Nephrops* stocks
2)	**Assessment**:	None.
3)	**Forecast**:	None.
4)	**Assessment model**: and maps)	Densities from 2007 UWTV survey, mean weight, spatial extent of *Nephrops* grounds (based on BGS
5)	**Data issues**: sampling	UWTV surveys irregular, no landings or discard
6)	**Consistency**:	-
7)	**Stock status**:	unknown
8)	**Man. Plan.**:	None.

General comments

The Noup FU was benchmarked at WKNEPH in 2013. No assessment is possible for this stock, 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 2013.

Technical comments

Check numbering of sections (the same as last years numbering?)

1) Text:

Management considerations. 3P, 3L "….mean density of *Nephrops*(0.11..). The options table does not include scenarios for this density. Alternatively change 0.1 to 0.11

2) Figures:

Figure 3.3.6.1: Include effort and LPUE in figure text

Figure 3.3.6.2: Include figure labels for 2006 and 2007

3) Tables:

Table 3.3.6.1: data shown is from 1997-2012, and not from 1981-2012 as mentioned in the figure text

Table 3.3.6.1: Two 2010 rows

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? **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: 22/05/2013

Reviewer: Arved Staby, David Miller

General

For single stock summary sheet advice:

1) **Assessment type:** Data limited approach for *Nephrops* stocks
2) **Assessment**: Trends in fishery LPUE (Danish trawlers)
3) **Forecast**: None.
4) **Assessment model**: None.
5) **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.
6) **Consistency**: Concerns over effort data because of possible changes in selectivity or gear efficiency leading to technological creep.
7) **Stock status**: unknown
8) **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 was provided for this FU in 2012. No new advice was provided or analyses done at WGNSSK 2013.

Technical comments

Numbering of sections (the same as last year's numbering?)

3.4.7 Norwegian Deep (FU32)

3.4.7.1 General

3.4.7.1.1 Ecosystem aspects

3.4.7.1.2 Fisheries

3.4.7.1.3 Advice

3.4.7.1.4 Management

3.4.7.2 Assessment (This heading is missing in the report)

3.4.7.2.1 Data available

3.4.7.2.2 Data analysis

3.4.7.2.3 Historic stock trends

4.3.7.2.4 Recruitment estimates

4.3.7.2.5 Forecasts

3.4.7.2.6 Biological reference points

3.4.7.2.7 Quality of assessment

3.4.7.2.8 Status of the stock

3.4.7.2.9 Management considerations

The "ICES advice in 2010" section can probably be removed. Only the most recent advice currently impacting on the fishery is required.

1) Text:

Management considerations: 4P, 1L "….spatial extent of *Nephrops* grounds was …"

Could include the final advice recommendation from 2012 in that section. i.e. : "Based on the ICES approach for data-limited stocks, ICES advises that landings should be no more than 800t."

The table at the end of the text should be formatted.

2) Figures:

Correct numbering of Figure 3.3.7.1 (currently 3.7.7.1)

Figure 3.3.7.7….Size distribution in….

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.

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: 22/05/2013

Reviewer: Arved Staby, David Miller

General

For single stock summary sheet advice:

1) **Assessment type:** Trends in fishery LPUE
2) **Assessment**: None.
3) **Forecast**: None.
4) **Assessment model**: None.
5) **Data issues**: No stock annex.
6) **Consistency**: -
7) **Stock status**: unknown
8) **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

Check numbering of sections (the same as last year's numbering?)

1) Text:

Length composition: - check reference to Figure 3.3.8.2 (not found); should be 3.3.8.1?

- check reference to figure 3.4.5.2:figure not found

It is stated that with the exception of the mean CL in 2005 and 2011, mean sizes for the other years are similar. But when comparing values it looks like the 2011 values is similar to the 2004 and 2012 value.

In the "Historic stock trends" section it is mentioned that fluctuations in discarding may reflect corresponding fluctuations in recruitment. In the data section it is mentioned that some discard estimates exist from the Danish at-sea-sampling programme, but these are not presented. It would be useful to present these in future.

2) Figures:

Figure 3.3.8.1 Figure labels for LPUEs and sizes missing. Format of size figure not the same as the others.

3) Tables:

Advice table (as shown in Advice sheet) presenting various options given different densities and landings is missing in the report.

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: 22/05/2013

Reviewer: Arved Staby, David Miller

General

For single stock summary sheet advice:

1) **Assessment type:** Bienniel
2) **Assessment**: UWTV survey data
3) **Forecast**: not presented
4) **Assessment model**: 2012 UWTV survey data density, mean weight (average 2007-2010), discard percentage (average 2007-2011), and VMS based spatial extent
5) **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.
6) **Consistency**: UWTV survey data collected annually since 2009
7) **Stock status**: data poor / unknown
8) **Man. Plan.**: MSY harvest ratio (landings) to fall within 8-16% of absolute biomass based on latest density estimates.

General comments

This is the first assessment of FU34 since it was benchmarked at WKNEPH 2013. The benchmark recommended continuing to provide advice following the ICES approach for DLS.

It is concerning for the future development of an assessment model for this stock that there were no samples taken for landings or discards of *Nephrops* in this FU in 2012.

In 2012 biennial advice was provided for this stock, so no new advice is provided this year.

Technical comments

Check numbering of sections

1) Text :

Length compositions: 2L "Mean sizes in…….for 2006 to 2012"

Data analysis: 2L " Table 3.3.9.4 and Figure 3.3.9.5 show the time series of …..". Annual values differ between the table and figure, is this because one is bias corrected and the other not?

Data analysis: 4P, 6L "…density which fall outside …."

2) Tables

Table 3.3.9.1: "…..to the WG for 2012 (not 2013)

Table 3.3.9.1: "Scottish data only 1991 to 2009". This is not clear from the table

Table 3.3.9.4: the 95% confidence intervals are given in millions?.

3) Figure:

Figure 3.3.9.3: Include landings in figure text

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?

Audit of *Nephrops* in ICES Subarea IVa (Fladen Ground) nep-7

Date: 16/05/2013

Reviewer: Youen Vermard, knut Korsbekke

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented. Predicted landings are derived by applying a harvest rate to the survey index and applying a discard factor and mean weight from the trawl component of the fishery.
4) **Assess. model**: Stock abundance estimates based from UWTV surveys
5) **Consistency**: The methodology for calculating abundance from UWTV is consistent with new methodology presented in the 2011 assessment and in the stock annex.
6) **Stock status**: The 2012 UWTV survey data presented at this meeting show that abundance has continued to drop and is now below 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 2012 (removals/UWTV abundance) was 4.7% and is considerable lower than F0.1.
7) **Man. plan**: 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.

General comments

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 labeled 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.

Technical comments

Values and/or units seem to be different between figure 3.3.3.1 and table 3.3.3.2 for Effort and LPUE. The decrease in LPUE is much stronger in the table than in the figure which indicates a value around 600 (360 in the table).

In Section 3.4.3.6 (commercial catches), LPUE for Scottish vessels decreased by 43% between 2009 and 2012 whereas in the same time LPUE for Danish vessels increased by 33%. Is there any explanation for these contradictory figures? Are spatial distribution of the catches different?

Conclusions

The assessment has been performed correctly.

Stock identification work should be promoted and changes in mean weight-at-age should be given more attention.

We also agree with the WG that management of this stock at the functional unit level as opposed to the sub-area level would be an improvement. This is particularly relevant as landings in Fladen dropped from 12000t to 4000t in 3 years what could result in increasing catches opportunity in the other 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?

  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?

  No specific management plan but the advice sheet states;

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

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 ICES Subarea IVa (Firth of Forth) nep-8

Date: 16/05/2013

Reviewer: Youen Vermard, knut Korsbekke

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented. Predicted landings are derived by applying a harvest rate to the survey index and applying a discard factor and mean weight from the trawl component of the fishery.
4) **Assess. model**: Stock abundance estimates based from UWTV surveys
5) **Consistency**: The methodology for calculating abundance from UWTV is consistent with new methodology presented in the 2012 assessment and in the stock annex.
6) **Stock status**: The 2012 UWTV survey data presented at this meeting show that abundance has declined since 2008 when it was at its highest point in the series. The abundance remains close to the average abundance and is above the biomass trigger (MSY $B_{trigger}$ 292 million individuals, Lowest observed UWTV survey estimate of abundance. Adjusted abundance 2012 = 522 million individuals). Landings increased slightly in 2012 (2091t) and are around the long term average. LPUE have remained high and stable since 2006. There does not appear to be any change in mean length for either sex.
7) **Man. plan**: EC TAC for Sub-area IIIa and IV. 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.

General comments

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 labeled 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 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.

Technical comments

In the commercial catch and effort data paragraph it is stated that the drop in discard rates is most likely to be due to increase in retention of *Nephrops* rather than an absence of small *Nephrops* from the catches. This should have had an effect in the length frequencies for landed *Nephrops*, decreasing the mean size, what is not observed in fig 3.3.4.3 where the mean size in the landing is stable (small increasing trend for male).

Conclusions

The assessment has been performed correctly.

We also agree with the WG that management of this stock at the functional unit level as opposed to the subarea level would be an improvement. This is particularly relevant as landings in Fladen dropped from 12000t to 4000t in 3 years what could result in increasing catches opportunity in the other 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?

  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?

  No specific management plan but the advice sheet states;

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

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 Pollack in ICES sub area IV and Division IIIa

Date: 14.05.2013

Reviewer: Alexander Kempf, Jordan Feekings

General

For single stock summary sheet advice:

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: Biennial year**
2) **Assessment**: Landing (and survey) trends
3) **Forecast**: not presented
4) **Assessment model**: no model
5) **Data issues:** Only landings data available, no effort time series, Survey CPUES

   very noisy
6) **Consistency**: Landings and Survey time series updated. No changes in the perception of the stock compared to last year
7) **Stock status**: unknown
8) **Man. Plan.**: no plan

General comments

No analytical assessment has ever been carried out for this stock.

Landings data alone are not a good indicator for stock abundance. A decreasing trend in landings of a by-catch species can be the result of a decreasing stock or a decrease in effort. The Survey CPUE is extremely noisy and catchability is very low. There is enough indication that the stock was higher in previous periods (e.g., 70ies), but it is not possible to draw final conclusions on stock trends for the last 10-20 years given the data available.

Collection and processing of biological data on growth and maturity recommended by WGNEW and WGNSSK would be helpful to improve information on the stock. Pollack is considered primarily a by-catch in other fisheries.

Technical comments

There is a typo in the survey section. The IBTS q 3 time series starts in 1991 and not 1996.

The sentence: “For Division IIIa (Skagerrak and Kattegat), the trends in landings indicate a decline in the stock...” (beginning of 15.5.2) is critical. As outlined above trends in landings alone cannot indicate a decline in the stock. But there is evidence from the IBTS Q1 that there is a decline in the stock compared to previous time periods.

The labelling of Figure 15.2 is imprecise. It becomes not entirely clear whether the distribution of catches in the IBTS Q1 or Q3 is shown. Or is it the sum over both surveys?

It is not clear from the advice sheet what rules have been applied to give advice. Although it a bi-annual advice, it should be explained also in this year why there is a 20% cut in IV and a zero advice for IIIa.

Conclusion

It is hard to draw any conclusions from the data available. It can be only concluded that the stock is on low level compared to earlier time periods (70ies and before). Therefore, a 20% reduction is justified. A CPUE index could help to get a better idea on stock trends in the future.

Audit of *Nephrops* in ICES Subarea IVa (Moray Firth) nep-9

Date: 16/05/2013

Reviewer: Youen Vermard, knut Korsbekke

For single stock summary sheet advice:

1) **Assessment type:** Update
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented. Predicted landings are derived by applying a harvest rate to the survey index and applying a discard factor and mean weight from the trawl component of the fishery.
4) **Assess. model**: Bias corrected absolute abundance from Underwater TV survey
5) **Consistency**: The methodology for calculating abundance from UWTV is consistent with methodology presented in the 2012 assessment and in the stock annex.
6) **Stock status**: The 2012 UWTV survey data presented at this meeting show that abundance has continued to decline since 2005 and its highest observed value and is now just above the biomass trigger abundance value. The harvest rate was above F_{MSY} in 2011 and decreased in 2012, although it is still above Fmsy. There is no evidence from the mean size information to suggest overexploitation.
7) **Man. plan**: Manangement is at the Sub-area level. 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. There is a by-catch of other species in the Moray Firth area. It is important that effort is made to ensure that unwanted by-catch is kept to a minimum in this fishery.

General comments

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 labeled 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.

Technical comments

In commercial catch and effort data paragraph, the text indicates 832t total landings for Scotland. It should be 860t as 832t is only considering *Nephrops* trawls. England landings of 958kg do not appear in Table 3.3.5.1

Conclusions

The assessment has been performed correctly.

We also agree with the WG that management of this stock at the functional unit level as opposed to the sub-area level would be an improvement. This is particularly relevant as landings in Fladen dropped from 12000t to 4000t in 3 years what could result in increasing catches opportunity in the other 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?

  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?

  No specific management plan but the advice sheet states;

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

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

Plaice in Division VIId (Eastern Channel) ple-eche

1) **Assessment type:** Category 3
2) **Assessment**: Trends (decided by WKFLAT 2010)
3) **Forecast**: Short-term forecast using FLSTF with average F for last three years.
4) **Assessment model**: FLXSA – 3 surveys and 1 fleet for tuning.
5) **Consistency**: Same settings as for the last year assessment were used. No exploratory SURBAR runs done this year.
6) **Stock status**: Trends only. Reference points not valid for advice. F decreasing for last few years, but increased slightly in this year assessment (F_{2012}=0.418). SSB shows an increasing trend since 2003 (SSB_{2012}=5918t).
7) **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.

Most of the problems which were reported already in the last year review were not addressed in the updated assessment (e.g. assumption of M=0.1, 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.

Minor comments

There are a number of references which do not occur in the reference list.

Please check the formulation in section 6.10 Status of the stock. "F has been decreasing for the last years." – True, but in this year assessment it increased slightly. "The SSB has followed a decline in the last 10 years, …" – I cannot see this trend for the last 10 years, where SSB has rather increased (which is stated in one of the next sentences also…).

Fig. 6.3.4.1 move legend for F into the figure caption.

Conclusions

The RG agrees with the WG conclusions for this stock.

Audit of Plaice in IV

Date 28.05.2013

Reviewer: Knut Korsbrekke and Youen Vermard

For the attention of: Advisory drafting group, ACOM and WGNSSK

General

The assessment and short term forecast of Plaice in the North Sea is based on data handling procedures and assessment modeling as described in last benchmark assessment with two exception described below. Both changes improved the quality of the assessment relative to 2012.

For single stock summary sheet advice:

1) **Assessment type:** update/SALY, but change made to tuning and one data problem handled (see also 4, 5 and 6)

2) **Assessment**: analytical

3) **Forecast**: presented (short term)

4) **Assessment model**: FLXSA tuning by 3 series (Beam trawl survey Isis pre 1996,a combined index from two beam trawl surveys after 1996 and 1 sole net survey)

5) **Data issues:** The sum of products adjustments was changed. The current procedure is well described and justified in the report.

6) **Consistency**: The assessment seems to be consistent with the 2012 assessment with the exception of the very much needed combination of survey indices and handling of SOP. The use of a combined tuning series has not yet been described in the stock annex. The analysis and method used was presented to the group in the working document: https://groupnet.ices.dk/WGNSSK2013/Presentations/IBPplaice%20Use%20of%20the%20combined%20BTS%20survey%20for%20NS%20plaice.pptx and is also described in the report. The justification for the change was approved by the working group.

7) **Stock status**: SSB is well above B_{PA} while F is well below F_{PA}. The current F_{2-6} of 0.23 is in the range of plausible F_{MSY} candidates (0.2-0.3).

8) **Man. Plan.**: There is currently no agreed management plan between EU and Norway, but an agreement on: "Basic principles for a long-term management plan for plaice". This agreement has currently no element of MSY consideration, but describes an intention to keep fishing mortality below F_{PA} and SSB above B_{PA}. The advice sheet must include options based on the multiannual plan for plaice and sole in the North Sea adopted by the EU Council in 2007 (EC regulation 676/2007). This is not a straightforward task since article 4 objectives includes both an objective of "*… ensure exploitation … on the basis of MSY*" and "*… attained while maintaining the fishing mortality on plaice at a rate equal to or no lower than 0,3 on ages two to six years.*" The current estimate of F_{MSY} for plaice in the North Sea is 0.25 (or within the range 0.2-0.3). The out-

look table for 2014 should at least contain the following options (basis): F=FPA, F=FMSY=0.25, F=0.3, F=0, TAC+15%

General comments

The assessment was well documented in the report and made this review a relatively simple task.

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.

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.

The much needed change in sampling programs 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.

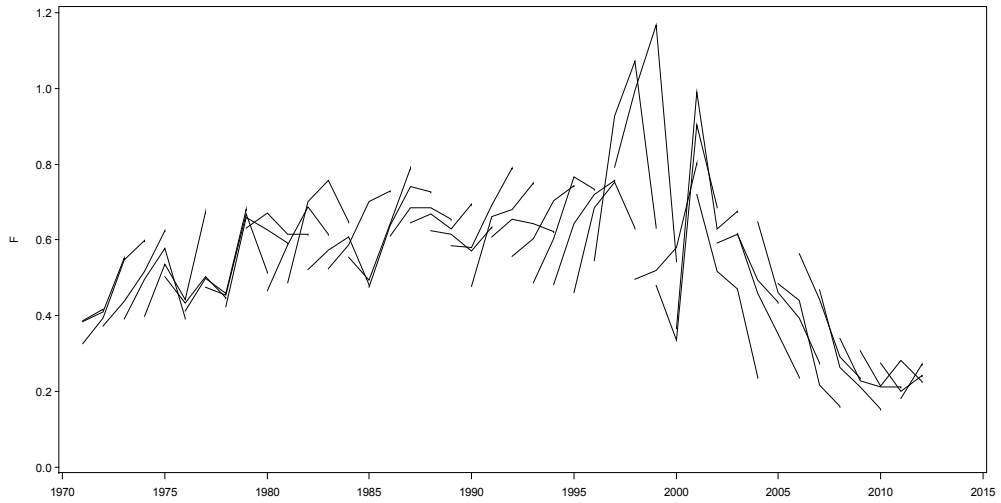


Figure 1 Fishing mortality at ages 2-5 with lines connecting cohorts

We think this illustrates some of the challenges with this assessment.

This is the list of what we would like to see in future plaice research/monitoring:

- 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.

- 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.
- 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.

Technical comments

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).

Conclusions

This assessment with forecast is a good basis for advice

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

- 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?

  No agreed management plan, but the multiannual plan for plaice and sole in the North Sea adopted by the EU Council in 2007 (EC regulation 676/2007)

(This regulation is not in accordance with a MSY approach)

For update assessments

- Have the data been used as specified in the stock annex?

  NO

- Has the assessment, recruitment and forecast model been applied as specified in the stock annex?

  NO

- Is there any **major** reason to deviate from the standard procedure for this stock?

  YES

- Does the update assessment give a valid basis for advice?

  YES

Saithe in Subareas IV (North Sea), VI West of Scotland), and Division IIIa (Skagerrak) sai – 3a46

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Short-term forecast presented
4) **Assessment model**: FLXSA, 3 commercial and 2 survey fleet for tuning.
5) **Consistency**: Different from the previous year assessment, one survey index (NORASS) was excluded from the analysis. One commercial CPUE index (NORTRL_IV2) and one survey index (NORACU) were revised and updated for this year assessment.
6) **Stock status**: SSB (196, 487t) < B_{pa} (200,000t), > B_{lim} (106,000t), and F(0.301) < F_{pa} (0.40) and <F_{lim}(0.60). SSB and F have declined in recent years. F is nearly equal to F_{MSY} in this assessment.
7) **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. According to ICES the plan is consistent with the precautionary approach in the short term (<5 years). Given the current low recruitment and low growth rates of the stock a re-evaluation of the management plan reference points should be considered.

General comments

The section presents the results from two assessments: XSA and alternative SAM model. 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.

Different to the previous year assessment, one survey index was excluded from this year analysis (acoustic survey of pre-recruits along Norwegian coast "NORASS"). Further, two survey indices were revised and updated (NORTRL_IV and NORACU). It is stated in the text that additional revisions of the NORACU index must be completed for the next assessment.

F is currently very close to the target F of 0.3.

The WG outlined how each comment from the review of last year's assessment was addressed for the 2013 assessment. However, the problem of poor estimates of recruitment could not be solved for this year and is still a serious concern for this assessment.

Minor 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}.

Some of the distribution maps lack a legend. Would be nice to have uniform panels in figure

Conclusions
RG agrees with the WG on the conclusions.

Annex 7 Joint WGNSSK and WGMIXFISH data call

Please see pdf files below.

DCF national correspondents

Els Torreele, Marie-Bénédicte Peyrat, Jørgen Dalskov, Christoph Stransky, C. J. M. Verbogt, Maria Hansson, Mathew Elliott

ICES ACOM members

Reidar Toresen, Fredrik Arrhenius, Alain Biseau, Tammo Bult, Steven Degraer, Carl O'Brien, Morten Vinther, Christopher Zimmermann

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International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Our Ref: L.27/NH/AB/HK 20 February 2013

Subject: Data call: Landings, discards, biological sample and effort data from 2012 in support of ICES work for the advice of the stocks in the North Sea (IV), Skagerrak (IIIaN) and Eastern Channel (VIId).

The enclosed document describes the rationale, scope of call and technical details.
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), which will form the basis for ICES advice.
For countries which also are 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.
The data requested will be analysed and used only for scientific evaluation of the stock status and advice.
Please note that there is planned a data call for the Celtic Seas Ecoregion to be issued the 8th March, with a deadline for the data delivery of 8th April.

Sincerely,

Anne Christine Brusendorff

General Secretary

CC:

Steven Holmes (ICES WGMIXFISH Chair), Clara Ulrich (ICES WGNSSK Chair), Amélie Knap (European Commission/ DG-MARE), Bas Drukker (European Commission/ DG-MARE)

Excellence in marine science since 1902

Data call: Data submission for ICES working Groups WGNSSK & WGMIXFISH

Text in red bold (like this text) shows changes compared to last year's call.

Rationale

The mix fisheries advice to the EU and Norway regarding the species in the North Sea is elaborated on the basis of the best available survey and commercial data.

Scope of call

ICES Countries are requested to supply landings, discards, biological sample and effort data from 2012. This information should be according to one or more of the metiers listed in Annex 1. The minimum list of species for which data should be prepared according to Annex 1 is given below and in Appendix 8. The species should be reported for the areas in the area list below.

	COMMON SPECIES NAME	CODE	SCIENTIFIC SPECIES NAME
1	*Cod*	*COD*	*Gadus morhua*
2	*Common sole*	*SOL*	*Solea solea*
3	*Haddock*	*HAD*	*Melanogrammus aeglefinus*
4	*Plaice*	*PLE*	*Pleuronectes platessa*
5	*Saithe*	*POK*	*Pollachius virens*
6	*Whiting*	*WHG*	*Merlangius merlangus*
7	***Hake***	***HKE***	***Merluccius merluccius***
8	*Norway lobster*	*NEP*	*Nephrops norvegicus*
9	***Crangon or Brown Shrimp***	***CSH***	***Crangon crangon***

Area list

AREA	AREA CODE
North Sea (IV)	*IV*
Skagerrak (IIIaN)	*IIIaN*
Eastern Channel (VIId)	*VIId*

Deadline

22 March 2013.

Data to be reported

Landings, discards, sample and effort data from 2012 according to one or more of the metiers listed in Annex 1.

Additionally information by vessel length categories are also requested, please see section 'Aggregation vs. WGMIXFISH Requirements'.

Format to report

The InterCatch format should be used.

Additionally information by vessel length categories should be in comma separated (CSV) file, please see section 'Aggregation vs. WGMIXFISH Requirements'

How to report

The InterCatch formatted national data should be imported into InterCatch. Please use the following link: http://intercatch.ices.dk

Additionally information by vessel length categories should be electronically sent to:

Clara Ulrich [clu@aqua.dtu.dk] -- Chair of WGNSSK

Steven Holmes [s.holmes@marlab.ac.uk] -- Chair of WGMIXFISH

The entries in Annex 1 follow closely the naming convention used for the EU Data Collection Framework (DCF). An explanation of the elements of these metier tags follows:

1. *GEAR TYPE (gear types available under the DCF are shown in Appendix 1. Data can be aggregated over more than one category but in this case the most significant gear type is entered. The aggregations assumed in forming Annex 1 are also shown in Appendix 1)*
2. *METIER CODE (code conforming to target assemblage code of DCF, see Appendix 2. Data can be aggregated over more than one category but in this case the most significant metier code is entered)*
3. *MESH SIZE RANGE (mesh size ranges available under the DCF, see Appendix 3. Data can be aggregated over more than one category but in this case the most significant mesh size range is entered.* ***If for that gear type data has been aggregated over all ranges used by a nation an additional (to the DCF) entry "all" can be used****.)*
4. *SELECTIVITY DEVICE (types of selectivity device available under the DCF are shown in Appendix 4.)*
5. *SELECTIVITY DEVICE MESH SIZE (the actual mesh size of any selectivity device is entered.)*
6. *VESSEL LENGTH CLASS (Member states have indicated national sampling scheme designs do not take account of vessel lengths. Therefore only the non-standard entry of "all" is currently provided for in InterCatch.)*
7. *FULLY DOCUMENTED FISHERIES (If the metier tag defines a fully documented fishery add "_FDF" after length class – but see note below).*

An underscore separates these elements.

Note: DemHC and DemIBC have been replaced by MIS_MIS_0_0_0_HC and MIS_MIS_0_0_0_IBC respectively.

Note: Country and area are supplied to InterCatch separately. Country codes are as shown in Appendix 6. Area codes are as shown in Appendix 7. It is stressed that to reduce the number of entries required in InterCatch data is requested according to the areas shown in Appendix 7 and **not** according to finer spatial resolutions.

IMPORTANT:

- When uploading to InterCatch the year is the data year, which must be entered as **2012.**
- If discard data is unavailable there should be no entry for discards. A value of zero should only be entered when zero discards have been observed.

Effort Data

Effort is required in kWdays **for all species except Crangon. For Crangon the effort is required in horsepower-hours (hp-hrs).** Effort is recorded in position 11 of the InterCatch header information.

Fully Documented Fisheries

To prevent a requirement for large numbers of metier tags to be held within InterCatch metier tags for fully documented fisheries are added on a case by case basis. **FDF fisheries added to InterCatch in 2012 are shown in Annex 1.** If national data submitters have a fully documented fishery for which there are landings and discard data, which is not shown in Annex 1 and which they wish to submit as a unique metier they should contact Henrik Kjems-Nielsen [henrikkn@ices.dk], the contact point for InterCatch.

Aggregations

If national data are aggregated over several DCF level 6 categories, the metier tag corresponding to the most significant category is chosen e.g. a mobile gear with mesh sizes covering 70-119 mm (combining 70-99 and 100-119) but 70-99mm is most significant – code 70-99.

Exceptions to this general rule are cases where data has been aggregated over all

- mesh size ranges

within the national fleet. In these instances the tag "all" can be entered.

In addition Member states have indicated national sampling scheme designs do not take account of vessel lengths and therefore only the non-standard entry of "all" is currently provided for in InterCatch against vessel length. The option has been left open for length category specific metier tags to be added in future years if nations begin to sample and raise data independently for different length categories.

Aggregations vs. WGMIXFISH Requirements

Age specific data is best raised and entered to InterCatch using metiers / groups of vessels that match national sampling schemes. For 2012 data this means that the vessel length categories will be omitted in the data submitted to InterCatch (e.g. metier tag TBB_DEF_>=120_0_0_all). This is sufficient to address the data needs for WGNSSK. However, - for otter and beamtrawl gears only - these aggregations may be too broad for WGMIXFISH needs (leading to overly large fleet entries in the mixed fisheries projections). To fulfil the additional WGMIXFISH specific need for information by vessel

length categories[1], we kindly request estimates of catch weight totals and effort in a format similar to previous WGMIXFISH data calls (albeit using the Metier Tags as used to supply InterCatch) i.e. :

A comma separated (CSV) 'effort' file containing the following entries :

ID, Country, Year, Quarter, Length disaggregated Metier Tag, Area, **KW_Days**[1], Days At Sea, No Vessels

1: KW_Days for all species including vessels targeting Crangon. Required so that the catchabilities of fleets are comparable.

A CSV 'catch' file containing the following entries :

ID, Country, Year, Quarter, Length disaggregated Metier Tag, Area, Species, Landings (tonnes), Discards (tonnes), Value (average price*landings at first sale, expressed in Euros).

- Vessel length splits are only required for metier tags starting OTB or TBB.

Sums of effort and catch across metier tags disaggregated by vessel length should equal the corresponding totals submitted to Intercatch.

Example:

If a nation submitted data to InterCatch according to TBB_DEF_>=120_0_0_all but this data comes from vessels of 24<40m and >=40m WGMIXFISH requests CSV files for entries of

TBB_DEF_>=120_0_0_24<40 and

TBB_DEF_>=120_0_0_>=40

The CSV files should be submitted electronically to

Clara Ulrich [clu@aqua.dtu.dk] -- Chair of WGNSSK

Steven Holmes [s.holmes@marlab.ac.uk] -- Chair of WGMIXFISH

[1] Also, in order to insure consistency and continuity with the data time series previously collected by WGMIXFISH.

Supporting Documentation and work to be undertaken after the data upload

Once data has been submitted to InterCatch a process of fill-ins will be undertaken by the respective stock coordinators for entries containing only bulk weight of landings and/or discards. **To aid this process countries are requested to complete a documentation file (EXCEL spreadsheet) in a format like that shown in Annex 2.**

The documentation spreadsheet should be submitted electronically to

Clara Ulrich [clu@aqua.dtu.dk] -- Chair of WGNSSK

Steven Holmes [s.holmes@marlab.ac.uk] -- Chair of WGMIXFISH

For InterCatch related questions contact: Henrik Kjems-Nielsen [henrikkn@ices.dk]

Conversions to InterCatch Format

A description of the InterCatch Exchange format can be downloaded at the InterCatch information webpage under 'Manuals':

http://www.ices.dk/datacentre/InterCatch/InterCatch.asp

A two page overview of the fields in the InterCatch commercial catch format can be found at the same page, again under 'Manuals' (just below the InterCatch Exchange format manual). From this page the valid codes can be seen.

To ease the process of converting the national data into the InterCatch format Andrew Campbell from Ireland has made a conversion tool 'InterCatchFileMaker', which converts data manually entered in the 'Exchange format spreadsheet' into a file in the InterCatch format. The conversion tool 'InterCatchFileMaker' can be downloaded at the InterCatch information page (the one above) under 'Program to convert to InterCatch file format'. The download includes a spreadsheet in which the landings and sampling data can be placed; the converter then converts the data in the spreadsheet into the InterCatch format.

Annex 1

AREA	GEAR TYPE	AVAILABLE METIER TAGS FOR FULLY DOCUMENTED FISHERIES ADD "_FDF" AFTER LENGTH CLASS.
IIIaN (Skagerrak) Area Type = SubDiv		**TBB_CRU_16-31_0_0_all**
		TBB_DEF_90-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_CRU_32-69_2_22_all
		OTB_CRU_70-89_2_35_all
		OTB_CRU_90-119_0_0_all **OTB_CRU_90-119_0_0_all_FDF**
		OTB_ DEF _>=120_0_0_all **OTB_ DEF _>=120_0_0_all_FDF**
	Seines	SDN_DEF_>=120_0_0_all **SDN_DEF_>=120_0_0_all_FDF**
		SSC_DEF_>=120_0_0_all **SSC_DEF_>=120_0_0_all_FDF**
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all **GNS_DEF_120-219_0_0_all_FDF**
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all **LLS_FIF_0_0_0_all_FDF**
	Others (Human consumption)	**MIS_MIS_0_0_0_HC**
	Others (Industrial bycatch)	**MIS_MIS_0_0_0_IBC**

IV – (North Sea) Area type = SubArea & VIId (Eastern Channel) Area Type = SubDiv		**TBB_CRU_16-31_0_0_all**
		TBB_DEF_70-99_0_0_all
		TBB_DEF_>=120_0_0_all
	Otter trawl	OTB_CRU_16-31_0_0_all
		OTB_CRU_32-69_0_0_all
		OTB_SPF_32-69_0_0_all
		OTB_CRU_70-99_0_0_all **OTB_CRU_70-99_0_0_all_FDF**
		OTB_ DEF _>=120_0_0_all **OTB_ DEF _>=120_0_0_all_FDF**
	Seines	SDN_DEF_>=120_0_0_all **SDN_DEF_>=120_0_0_all_FDF**
		SSC_DEF_>=120_0_0_all **SSC_DEF_>=120_0_0_all_FDF**
	Gill, trammel, drift nets	GNS_DEF_100-119_0_0_all
		GNS_DEF_120-219_0_0_all **GNS_DEF_120-219_0_0_all_FDF**
		GNS_DEF_>=220_0_0_all
		GNS_DEF_all_0_0_all
		GTR_DEF_all_0_0_all
	Lines	LLS_FIF_0_0_0_all **LLS_FIF_0_0_0_all_FDF**
	Pots and Traps	FPO_CRU_0_0_0_all
	Others (Human consumption)	**MIS_MIS_0_0_0_HC**
	Others (Industrial bycatch)	**MIS_MIS_0_0_0_IBC**

Appendix 1 Gear coding (as defined under the DCF). Codes made available in the WGNSSK-WGMIXFISH data call are shown in the left hand column and are based on information from countries fishing in areas IIIaN, IV and VIId about significant fishing gears.

Code available in WGNSSK-WGMIXFISH data call	DCF code	Type of gear
TBB	TBB	Beam trawl
OTB	OTB	Bottom otter trawl
	OTT	Multi-rig otter trawl
	PTB	Bottom pair trawl
	OTM	Midwater otter trawl
	PTM	Midwater pair trawl
SSC	SSC	Fly shooting (Scottish) seine
	SPR	Pair seine
	PS	Purse seine
SDN	SDN	Anchored seine
	SB, SV	Beach and boat seine
GNS	GNS	Set gillnet
	GND	Driftnet
GTR	GTR	Trammel net
LLS	LHP	Pole lines
	LHM	Hand lines
	LLS	Set longlines
FPO	FPO	Pots and Traps
DemHC	FYK	Fyke nets
	FPN	Stationary uncovered pound nets
	DRB	Boat dredge
	HMD	Mechanised/ Suction dredge
	OTH	Other

Appendix 2 Target assemblage (metier code)

The codes in the table below are those permitted under the DCF.

Code	Definition
DEF	Demersal fish
CRU	Crustaceans
SPF	Small pelagic fish
LPF	Large pelagic fish
MOL	Molluscs
DWS	Deep-water species
FIF	Finfish
CEP	Cephalopods
CAT	Catadromous
GLE	Glass eel
MPD	Mixed pelagic and demersal fish
MDD	Mixed demersal and deepwater species
MCD	Mixed crustaceans and demersal fish
MCF	Mixed cephalopods and demersal fish

Appendix 3 Mesh size coding

Mesh size categories below are those permitted under the DCF. Data should be provided according to the categories below or aggregations of the categories below.

If data is aggregated over categories the most significant category is entered e.g. a mobile gear with mesh sizes covering 70-119 mm (combining 70-99, and 100-119) but 70-99mm is most significant receives code 70-99.

Gear type	Area	Code
Mobile gears	IIIaN (Skagerrak)	<16
		16-31
		32-69
		70-89
		90-119
		>=120
	IV & VIId (North Sea and Eastern Channel)	<16
		16-31
		32-69
		70-99
		100-119
		>=120
Passive gears	Whole of IIIaN, IV and VIId	10-30
		50-70
		90-99
		100-119
		120-219
		>=220

Appendix 4 Selectivity device

Selectivity devices are defined under the DCF as follows

Description	Code
None mounted	0
Exit window/selection panel	1
Grid	2
Unknown	3

Appendix 5 Vessel Length

Length categories permitted under the DCF are shown. For 2012 only the non-standard entry of "all" is currently provided for in InterCatch against vessel length. The option has been left open for length category specific metier tags to be added in future years.

DCF categories	
Vessel Length	*Code*
Under 10m	*<10*
10 to 12 m	*10<12*
≥ 12m <18m	*12<18*
≥ 18m < 24m	*18<24*
≥24m < 40m	*24<40*
≥ 40m	*>=40*

Appendix 6 Country coding (as used currently by InterCatch)

BE	Belgium
CA	Canada
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FO	Faroe Islands
FR	France
GG	UK (Channel Island Guernsey)
GL	Greenland
IE	Ireland
IM	UK (Isle of Man)
IS	Iceland
IT	Italy
JE	UK (Channel Island Jersey)
LT	Lithuania
LV	Latvia
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
RU	Russia
SE	Sweden
UK	United Kingdom
UKE	UK (England)
UKN	UK(Northern Ireland)
UKS	UK(Scotland)
US	United States

Appendix 7 Area coding

Codes accepted by InterCatch. Overall the codes are unique to this exercise because of the desire to receive data on Nephrops by Functional Unit (FU).

Finfish and Crangon (or Nephrops if not possible to raise by Nephrops Functional Units)	*Nephrops only*		
	Functional Unit	***InterCatch Code***	***Area Type Code***
IIIaN (Skagerrak)	FU5[1]	IV5	Div
IV (ICES sub-area IV)	FU6	IVb6	SubDiv
VIId (ICES division VIId)	FU7	IVa7	SubDiv
	FU8	IVb8	SubDiv
	FU9	IVa9	SubDiv
	FU10	IVa10	SubDiv
	FU32[1]	IV32	Div
	FU33	IVb33	SubDiv
	FU34	IVb34	SubDiv
	Nephrops caught outside of FUs	IVnotFU	Div

1: FU5 is found in both ICES divisions IVb and IVc and FU32 is found in both ICES divisions IVa and IVb.

Nephrops Functional Units and descriptions by statistical rectangle follow

Functional Unit	Stock	ICES Rectangles	Division
5	Botney Gut	36-37 F1-F4; 35F2-F3	IV
6	Farn Deep	38-40 E8-E9; 37E9	IV
7	Fladen	44-49 E9-F1; 45-46E8	IV
8	Firth of Forth	40-41E7; 41E6	IV
9	Moray Firth	44-45 E6-E7; 44E8	IV
10	Noup	47E6	IV
32	Norwegian Deep	44-52 F2-F6; 43F5-F7	IV
33	Off Horn Reef	39-41F4; 39-41F5	IV
34	Devil's Hole	41-43 F0-F1	IV

Appendix 8.

Species for inclusion in WGNSSK-WGMIXFISH joint data call.

Whitefish species coding according to Council Regulation (EC) No. 2298/2003 and as used in InterCatch.

	Common name	***Code***	***Scientific name***
1	*Cod*	*COD*	*Gadus morhua*
2	*Common sole*	*SOL*	*Solea solea*
3	*Haddock*	*HAD*	*Melanogrammus aeglefinus*
4	*Plaice*	*PLE*	*Pleuronectes platessa*
5	*Saithe*	*POK*	*Pollachius virens*
6	*Whiting*	*WHG*	*Merlangius merlangus*
7	***Hake***	***HKE***	***Merluccius merluccius***
8	*Norway lobster*	*NEP*	*Nephrops norvegicus*
9	***Crangon or Brown Shrimp***	***CSH***	***Crangon crangon***

Annex 2

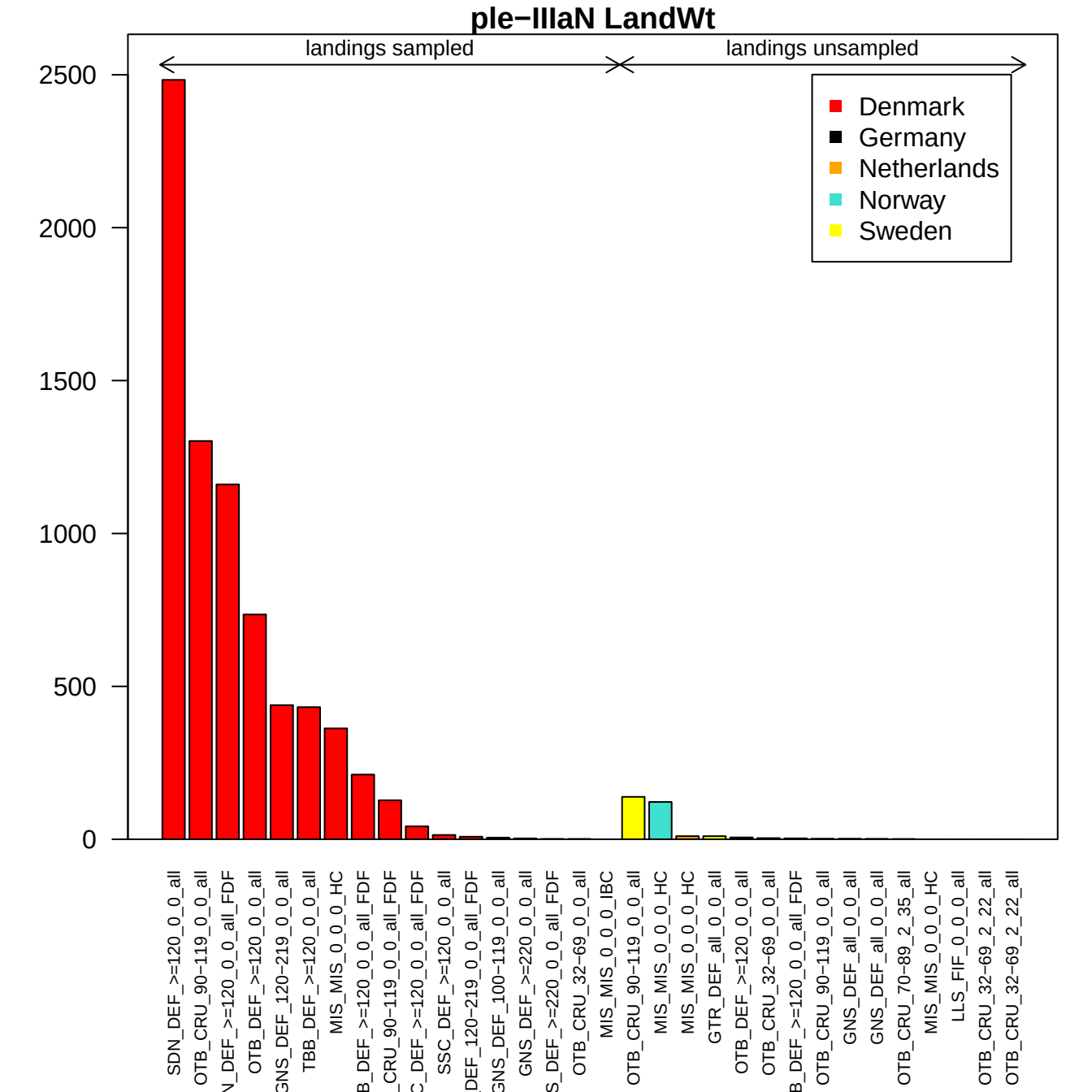
The documentation spreadsheet

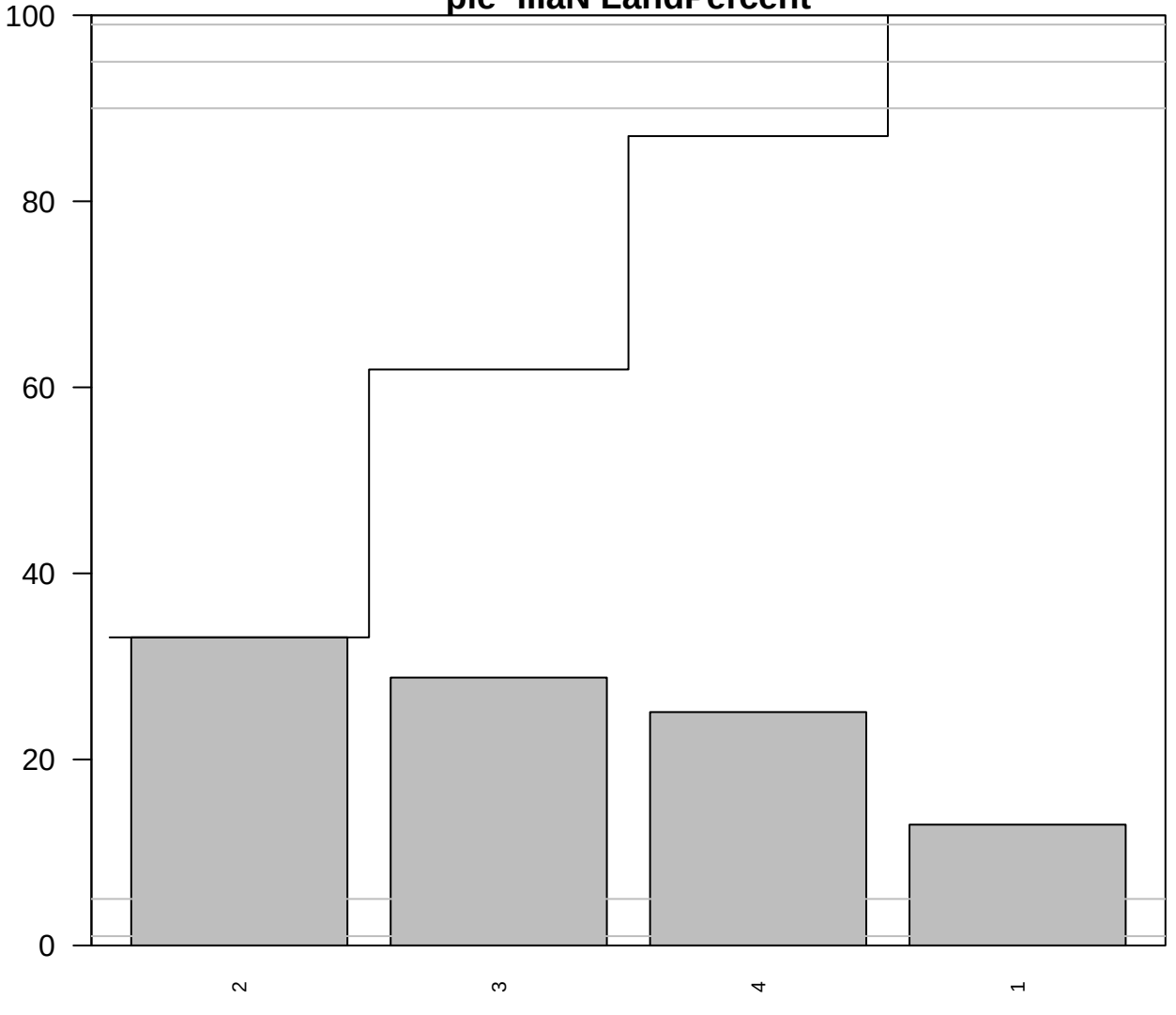
Example of how to describe specific DCF categories contributing to supra-metiers uploaded to InterCatch

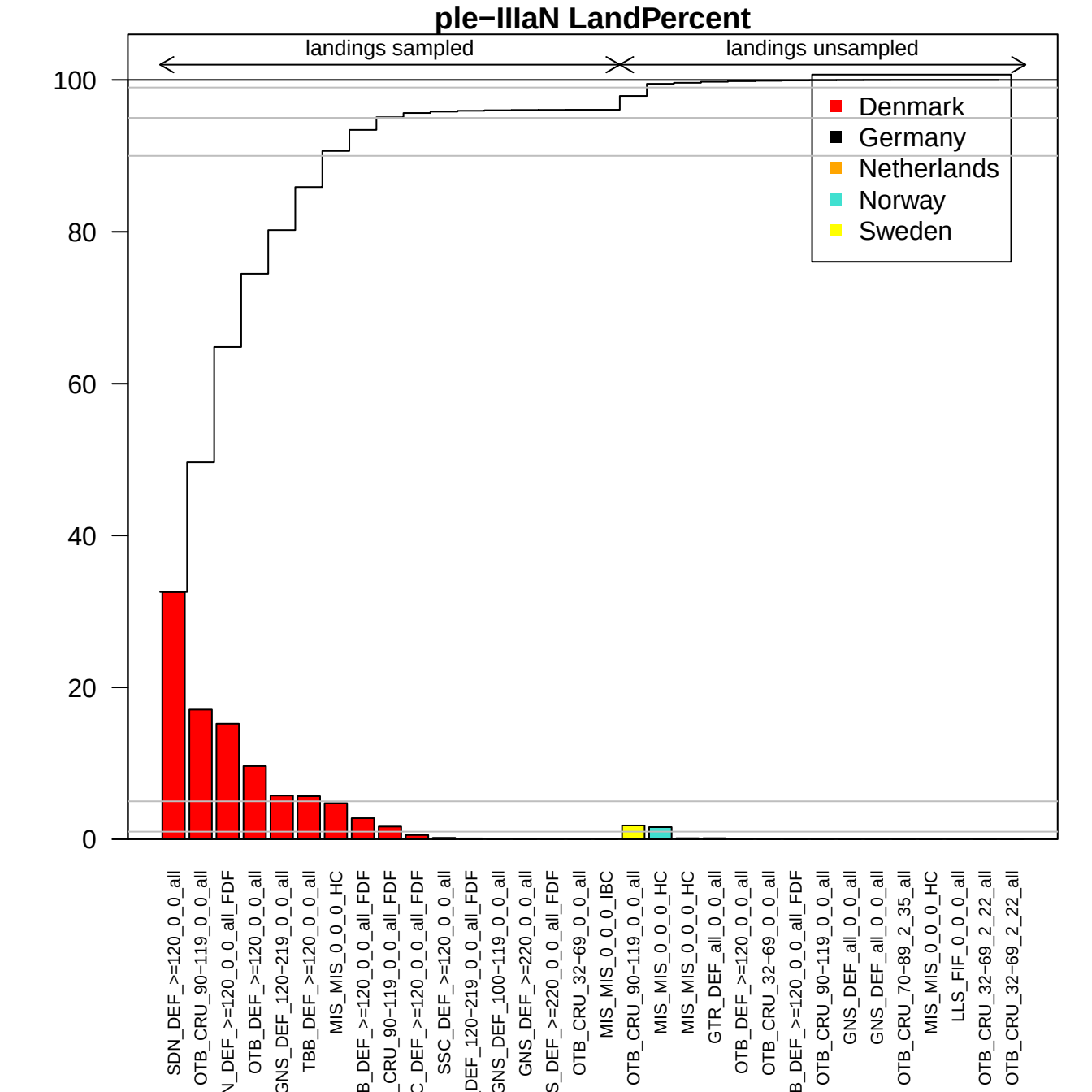
Metier code WGMIXFISH	Area	Vessel length classes	Gear types	Mesh size range	Description
OTB_CRU_70-99_0_0_all	4	<10 10<12 12<18 18<24 24<40 >=40	OTB OTT PTB SSC	70-99	Bottom trawls with mesh size >=70 & < 100 mm. No distinction between gear with or without selective devices. Notes NEP7 - majority of vessels 18<24 length with use of OTT gear. NEP8 & NEP9 - majority of vessels 12<18 length.
OTB_DEF_>=120_0_0_all	4	<10 10<12 12<18 18<24 24<40 >=40	OTB OTT PTB SSC	100-119 >=120	Bottom trawls with mesh size >=100mm. No distinction between gear with or without selective devices.
FPO_CRU_0_0_0_all	4	<10 10<12 12<18 18<24 24<40 >=40	FPO	na	Creels There are very small amounts of creel landings - no sampling. Mostly <10m vessels

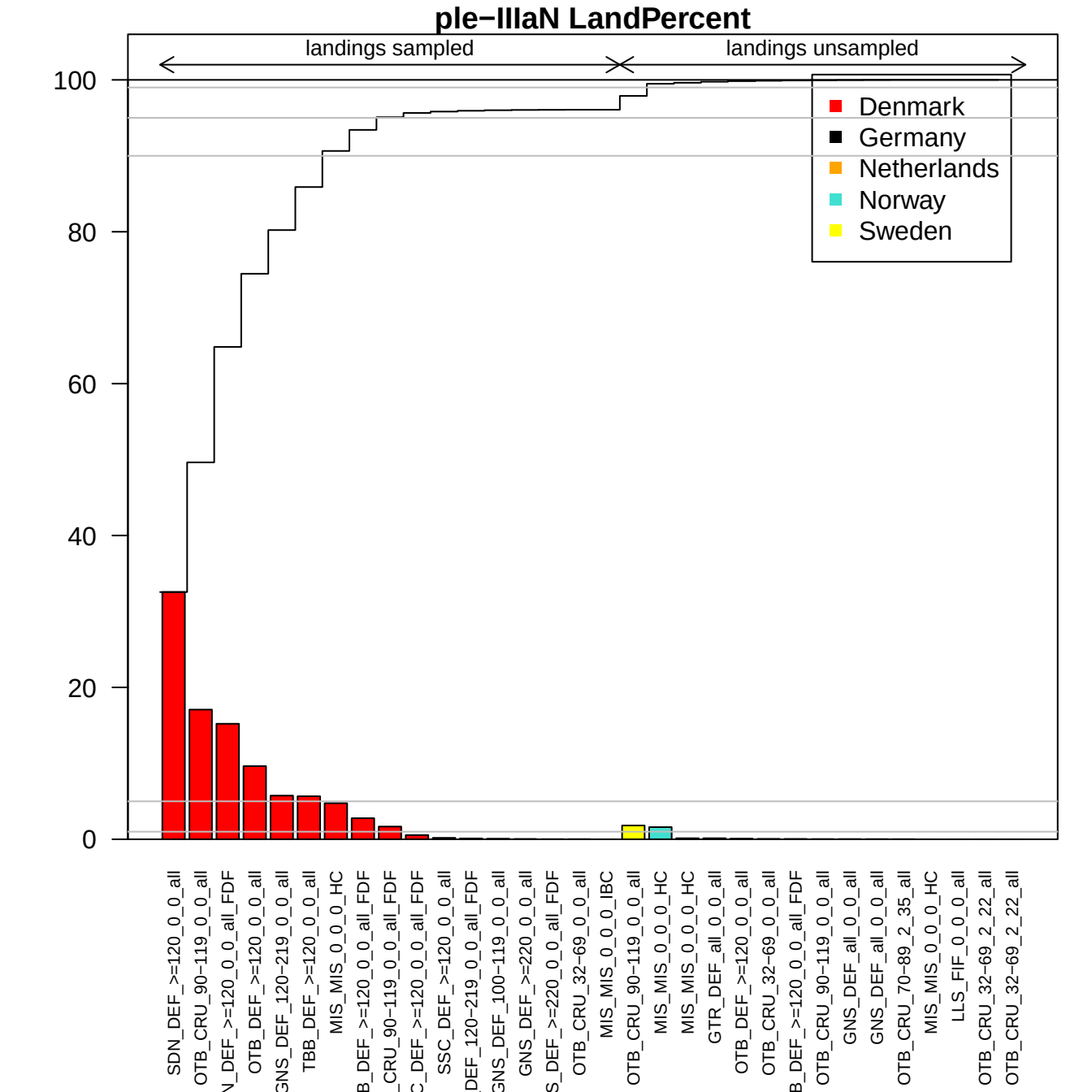
Annex 8 – Working Documents

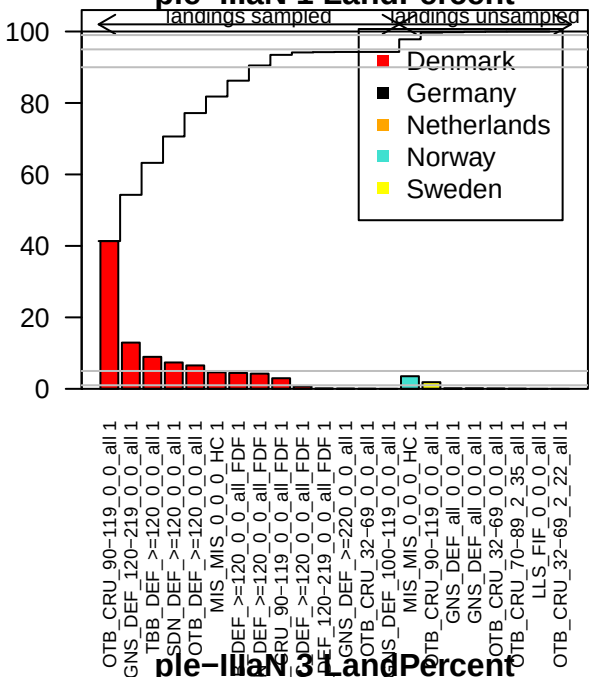
2 pdf documents inserted below

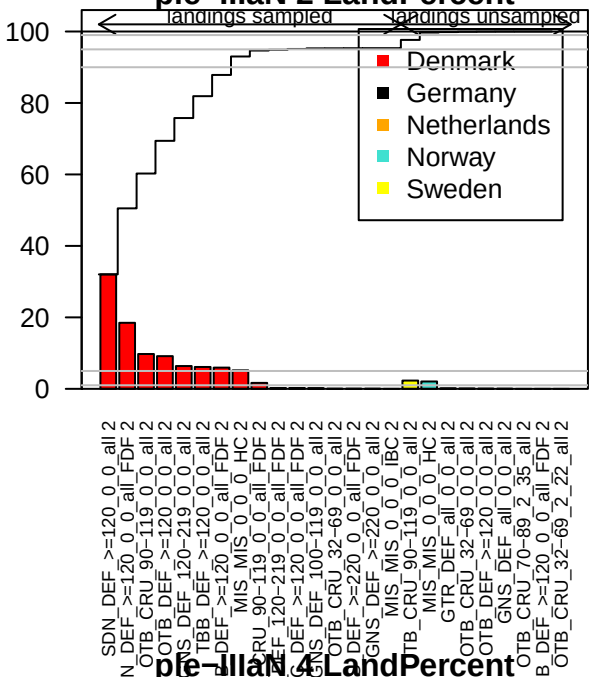

ple−IIIaN LandWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
2500
2000
1500
1000
500
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
_CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

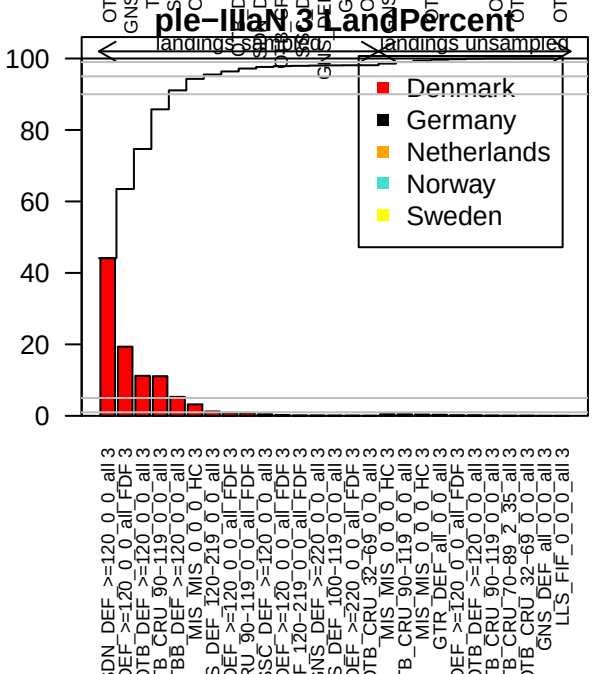

ple−IIIaN LandPercent
100
80
60
40
20
0
2
3
4
1

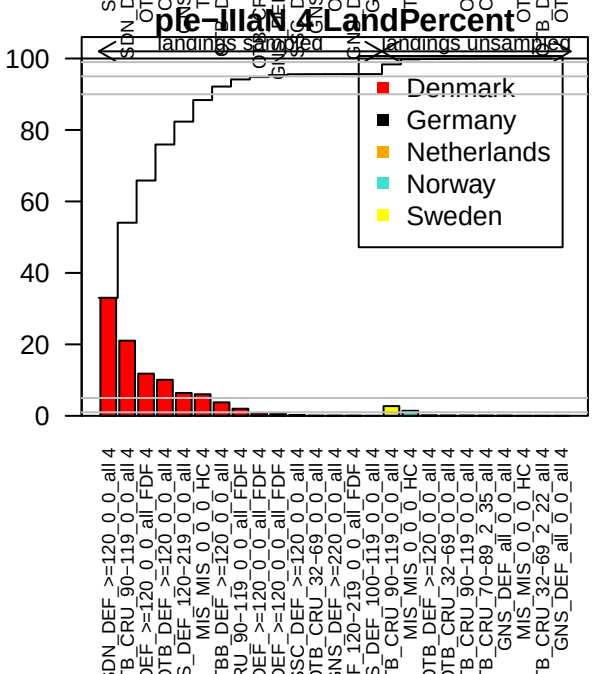

ple−IIIaN LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
GNS_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
TBB_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all_FDF
OTC_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
OTB_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
TBB_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

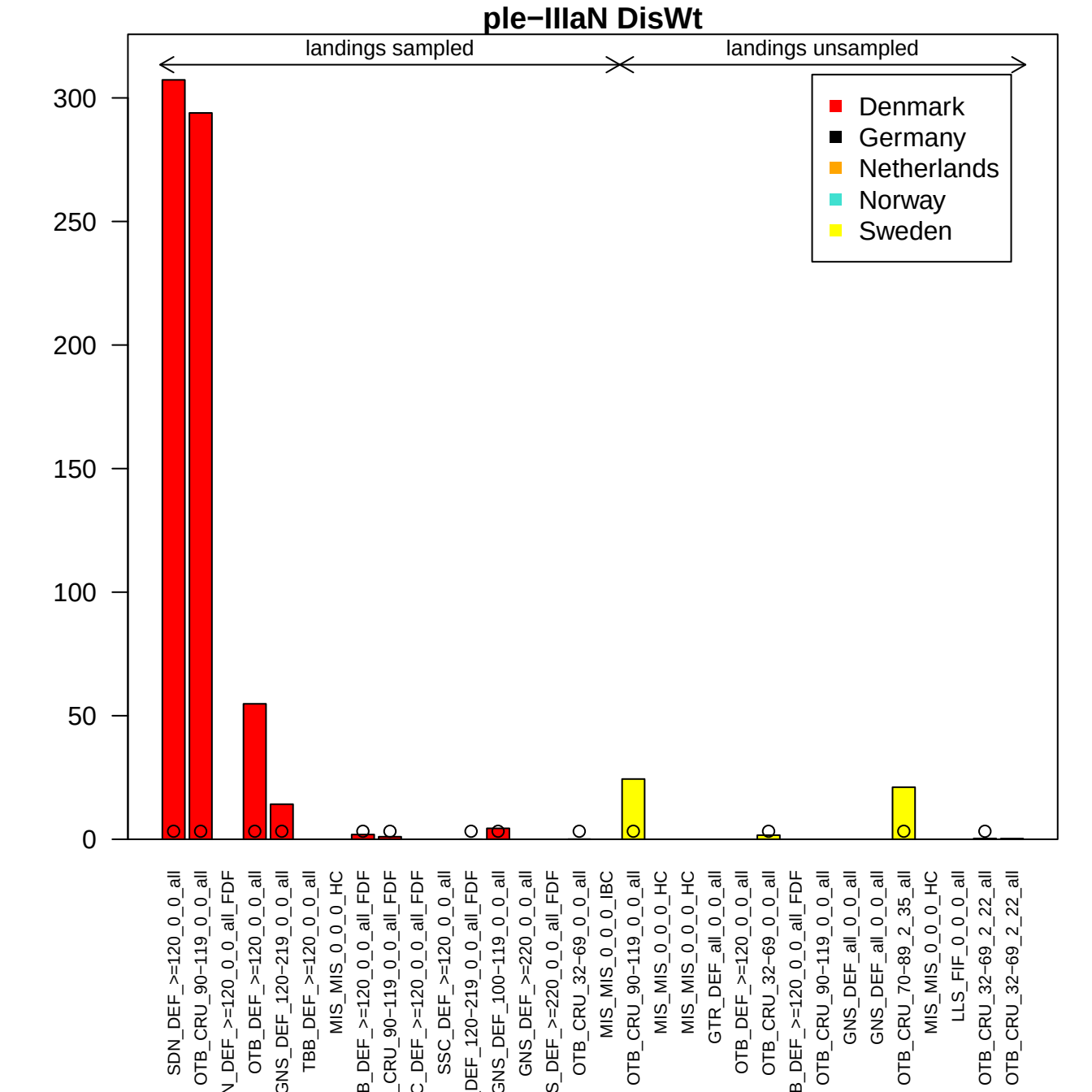

ple−IIIaN LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
GNS_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
TBB_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all_FDF
OTC_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
OTB_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
TBB_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

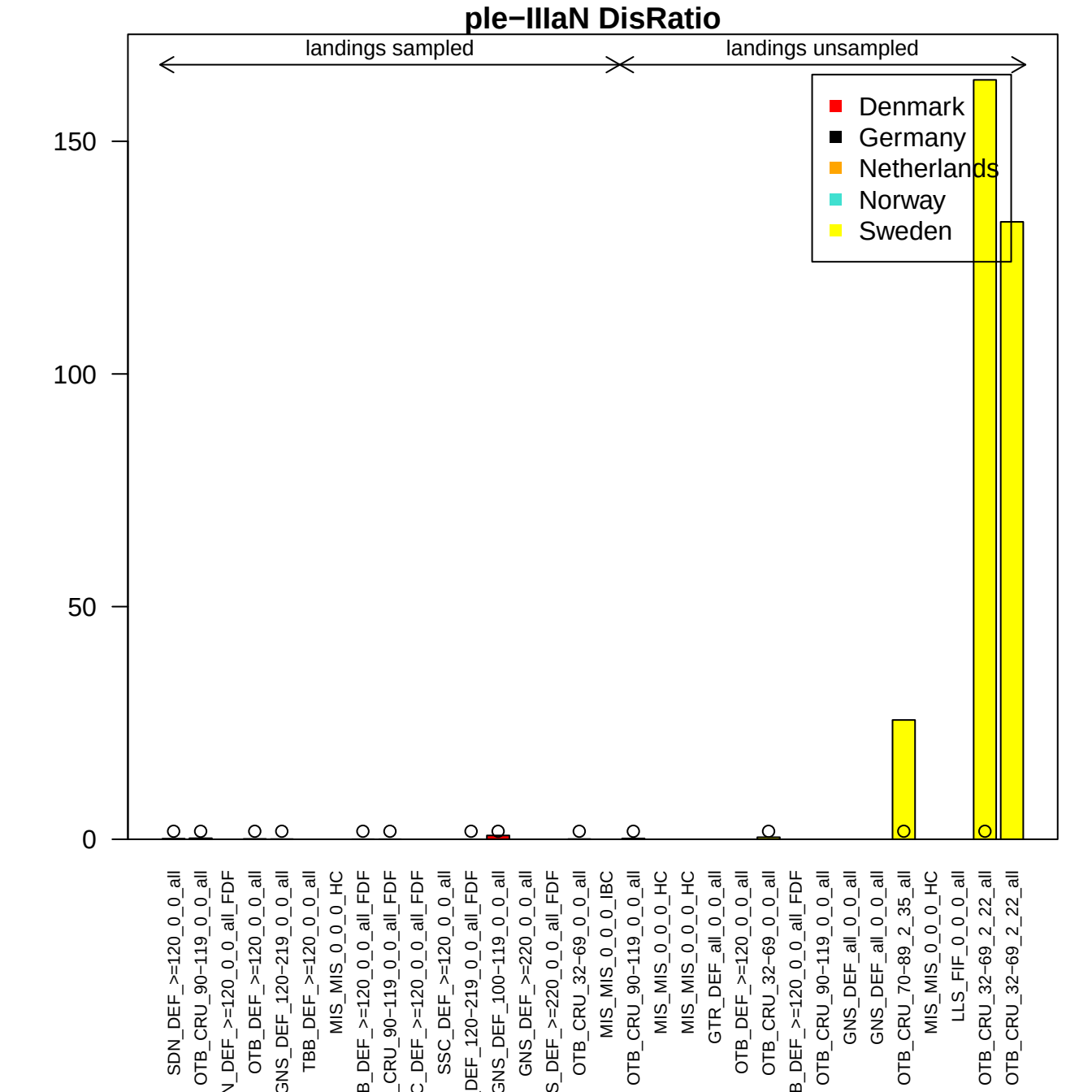

ple−IIIaN 1 LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
OTB_CRU_90−119_0_0_all 1
GNS_DEF_120−219_0_0_all 1
TBB_DEF_>=120_0_0_all 1
SDN_DEF_>=120_0_0_all 1
OTB_DEF_>=120_0_0_all 1
MIS_MIS_0_0_0_HC 1
SSC_DEF_>=120_0_0_all 1
DEF_>=120_0_0_all_FDF 1
DEF_>=120_0_0_all_FDF 1
CRU_90−119_0_0_all_FDF 1
DEF_>=120_0_0_all_FDF 1
DEF_120−219_0_0_all_FDF 1
GNS_DEF_>=220_0_0_all 1
OTB_CRU_32−69_0_0_all 1
S_DEF_100−119_0_0_all 1
MIS_MIS_0_0_0_HC 1
TB_CRU_90−119_0_0_all 1
GNS_DEF_all_0_0_all 1
GNS_DEF_all_0_0_all 1
OTB_CRU_32−69_0_0_all 1
TB_CRU_70−89_2_35_all 1
LLS_FIF_0_0_0_all 1
OTB_CRU_32−69_2_22_all 1

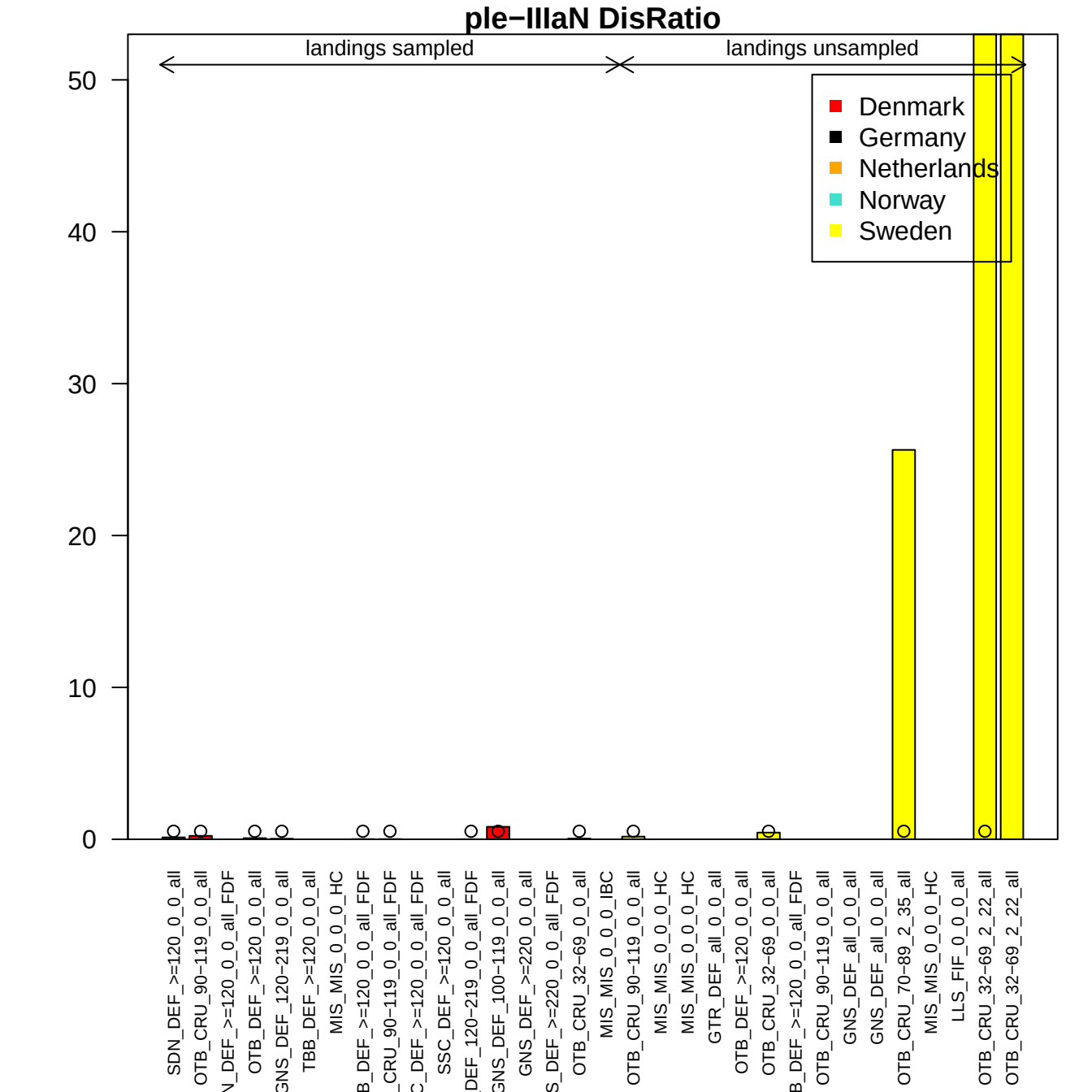

ple−IIIaN 2 LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
SDN_DEF_>=120_0_0_all 2
SDN_DEF_>=120_0_0_all_FDF 2
OTB_CRU_90−119_0_0_all 2
OTB_DEF_>=120_0_0_all 2
S_DEF_120−219_0_0_all 2
TBB_DEF_>=120_0_0_all_FDF 2
DEF_>=120_0_0_all_FDF 2
MIS_MIS_0_0_0_HC 2
CRU_90−119_0_0_all_FDF 2
F_120−219_0_0_all_FDF 2
DEF_>=120_0_0_all 2
S_DEF_100−119_0_0_all 2
OTB_CRU_32−69_0_0_all 2
GNS_DEF_>=220_0_0_all 2
MIS_MIS_0_0_0_IBC 2
TB_CRU_90−119_0_0_all 2
MIS_MIS_0_0_0_HC 2
GTR_DEF_all_0_0_all 2
OTB_CRU_32−69_0_0_all 2
OTB_DEF_>=120_0_0_all 2
GNS_DEF_all_0_0_all 2
OTB_CRU_70−89_2_35_all 2
TB_DEF_>=120_0_0_all_FDF 2
OTB_CRU_32−69_2_22_all 2

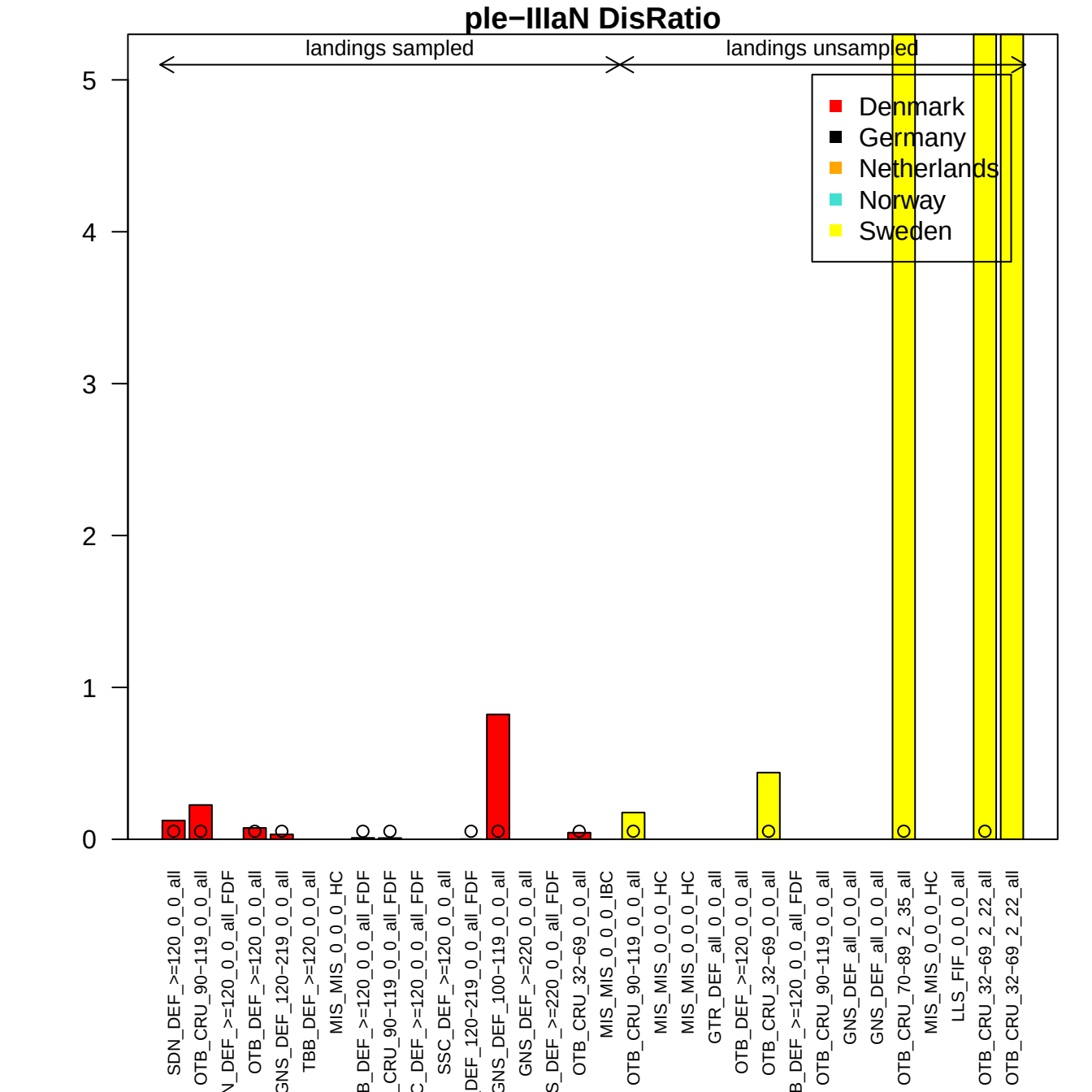

ple−IIIaN 3 LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
SDN_DEF_>=120_0_0_all 3
DEF_>=120_0_0_all_FDF 3
OTB_DEF_>=120_0_0_all 3
TB_CRU_90−119_0_0_all 3
TBB_DEF_>=120_0_0_all 3
MIS_MIS_0_0_0_HC 3
S_DEF_120−219_0_0_all 3
DEF_>=120_0_0_all_FDF 3
DEF_>=120_0_0_all_FDF 3
SSC_DEF_>=120_0_0_all 3
DEF_>=120_0_0_all_FDF 3
F_120−219_0_0_all_FDF 3
GNS_DEF_>=220_0_0_all 3
S_DEF_100−119_0_0_all 3
DEF_>=220_0_0_all_FDF 3
OTB_CRU_32−69_0_0_all 3
MIS_MIS_0_0_0_HC 3
B_CRU_90−119_0_0_all 3
MIS_MIS_0_0_0_HC 3
GTR_DEF_all_0_0_all 3
DEF_>=120_0_0_all_FDF 3
OTB_DEF_>=120_0_0_all 3
B_CRU_90−119_0_0_all 3
B_CRU_70−89_2_35_all 3
OTB_CRU_32−69_0_0_all 3
GNS_DEF_all_0_0_all 3
LLS_FIF_0_0_0_all 3

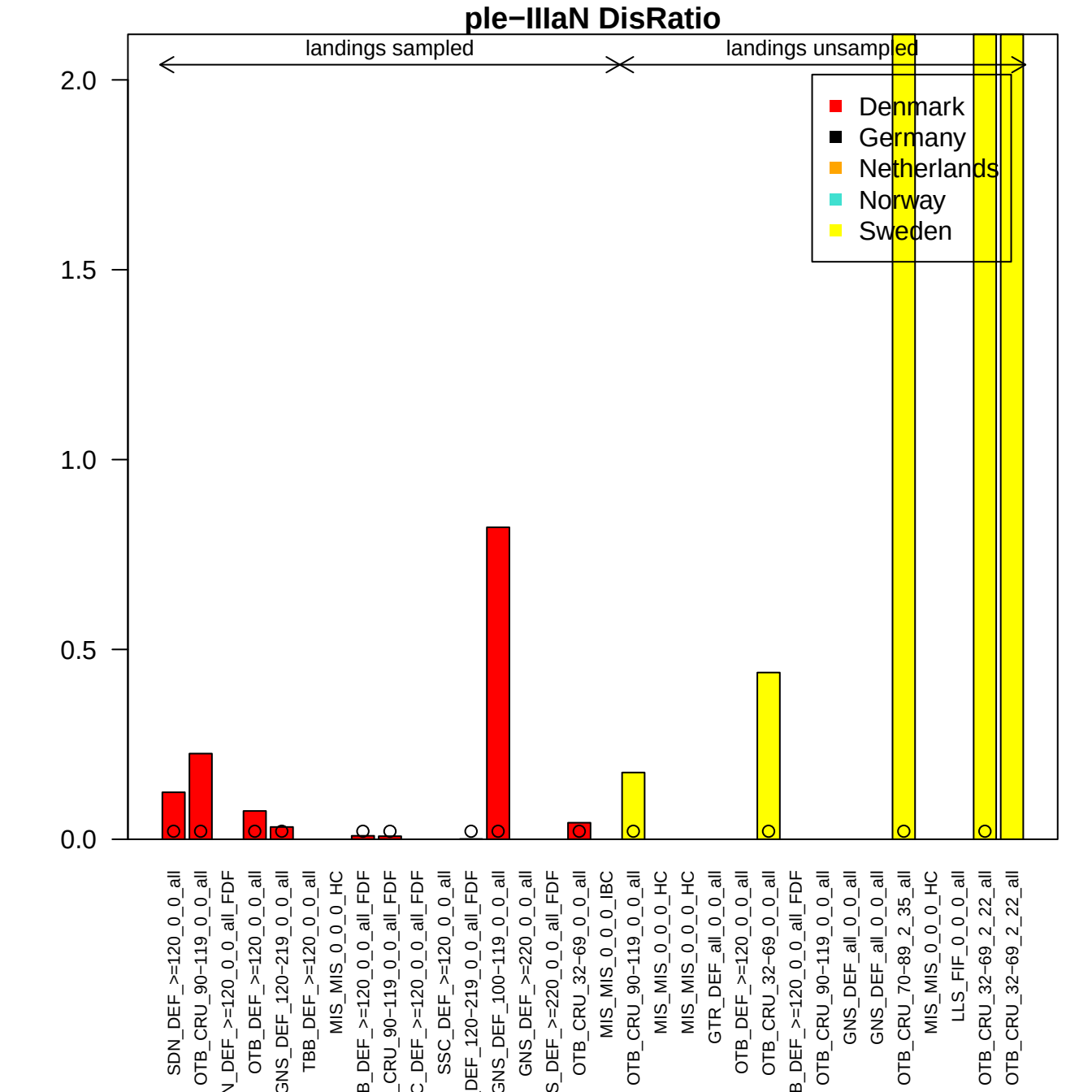

ple−IIIaN 4 LandPercent
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
100
80
60
40
20
0
SDN_DEF_>=120_0_0_all 4
B_CRU_90−119_0_0_all 4
DEF_>=120_0_0_all_FDF 4
OTB_DEF_>=120_0_0_all 4
S_DEF_120−219_0_0_all 4
MIS_MIS_0_0_0_HC 4
TBB_DEF_>=120_0_0_all 4
RU_90−119_0_0_all_FDF 4
DEF_>=120_0_0_all_FDF 4
SSC_DEF_>=120_0_0_all 4
DEF_>=120_0_0_all_FDF 4
F_120−219_0_0_all_FDF 4
GNS_DEF_>=220_0_0_all 4
S_DEF_100−119_0_0_all 4
DEF_>=220_0_0_all_FDF 4
OTB_CRU_32−69_0_0_all 4
MIS_MIS_0_0_0_HC 4
B_CRU_90−119_0_0_all 4
MIS_MIS_0_0_0_HC 4
GTR_DEF_all_0_0_all 4
DEF_>=120_0_0_all_FDF 4
OTB_DEF_>=120_0_0_all 4
B_CRU_90−119_0_0_all 4
B_CRU_70−89_2_35_all 4
OTB_CRU_32−69_0_0_all 4
GNS_DEF_all_0_0_all 4
MIS_MIS_0_0_0_HC 4
TB_CRU_32−69_2_22_all 4
GNS_DEF_all_0_0_all 4

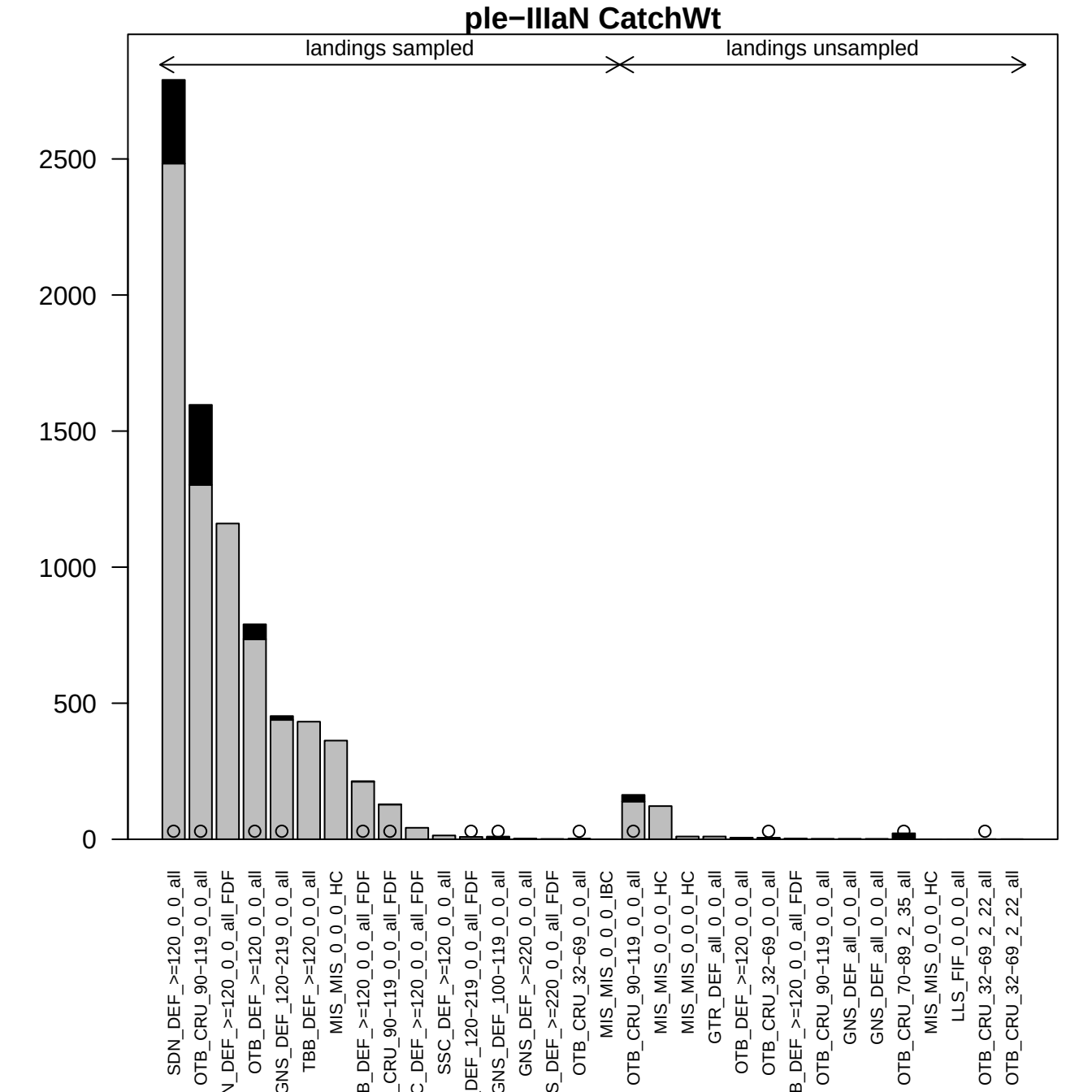

ple−IIIaN DisWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
300
250
200
150
100
50
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

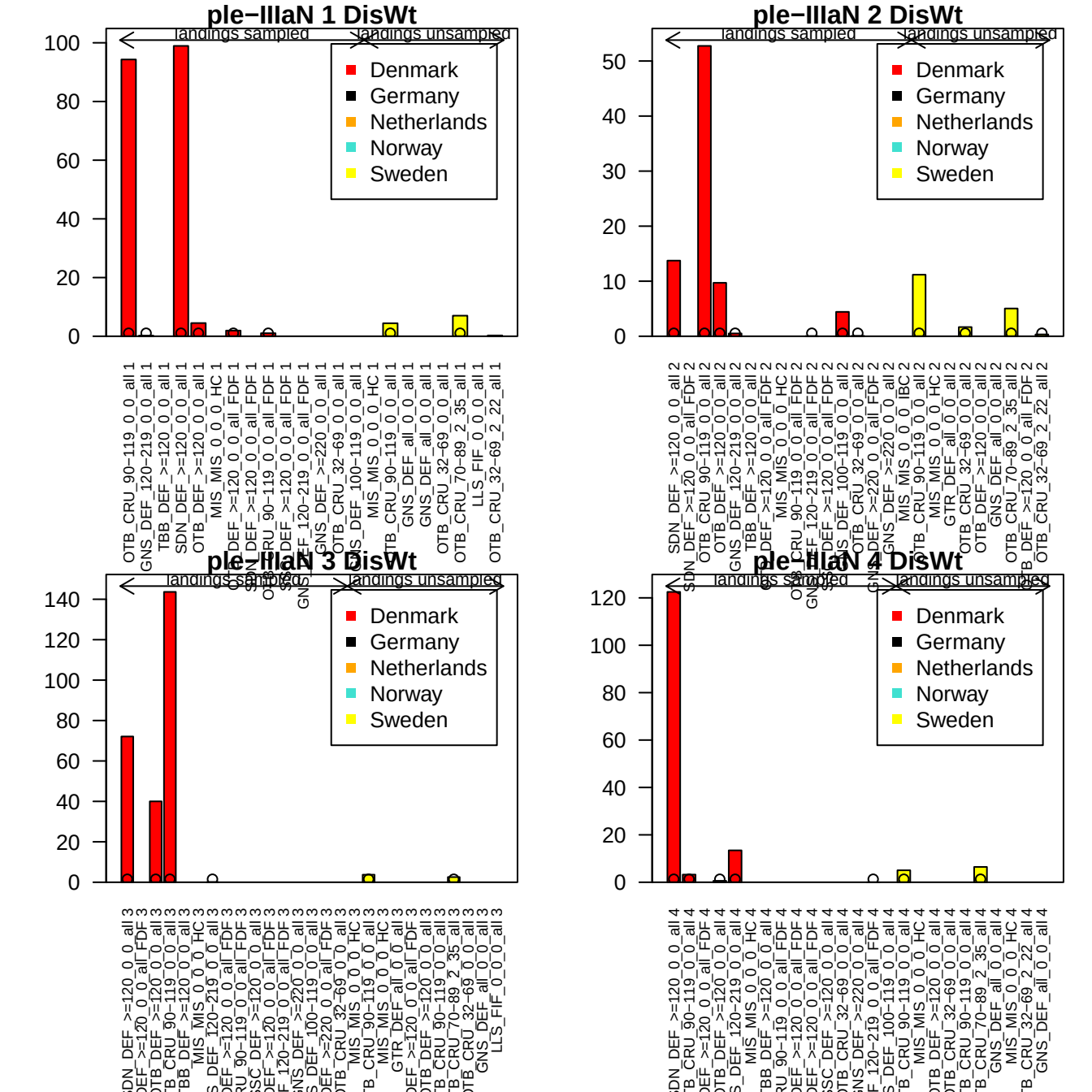

ple−IIIaN DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
150
100
50
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

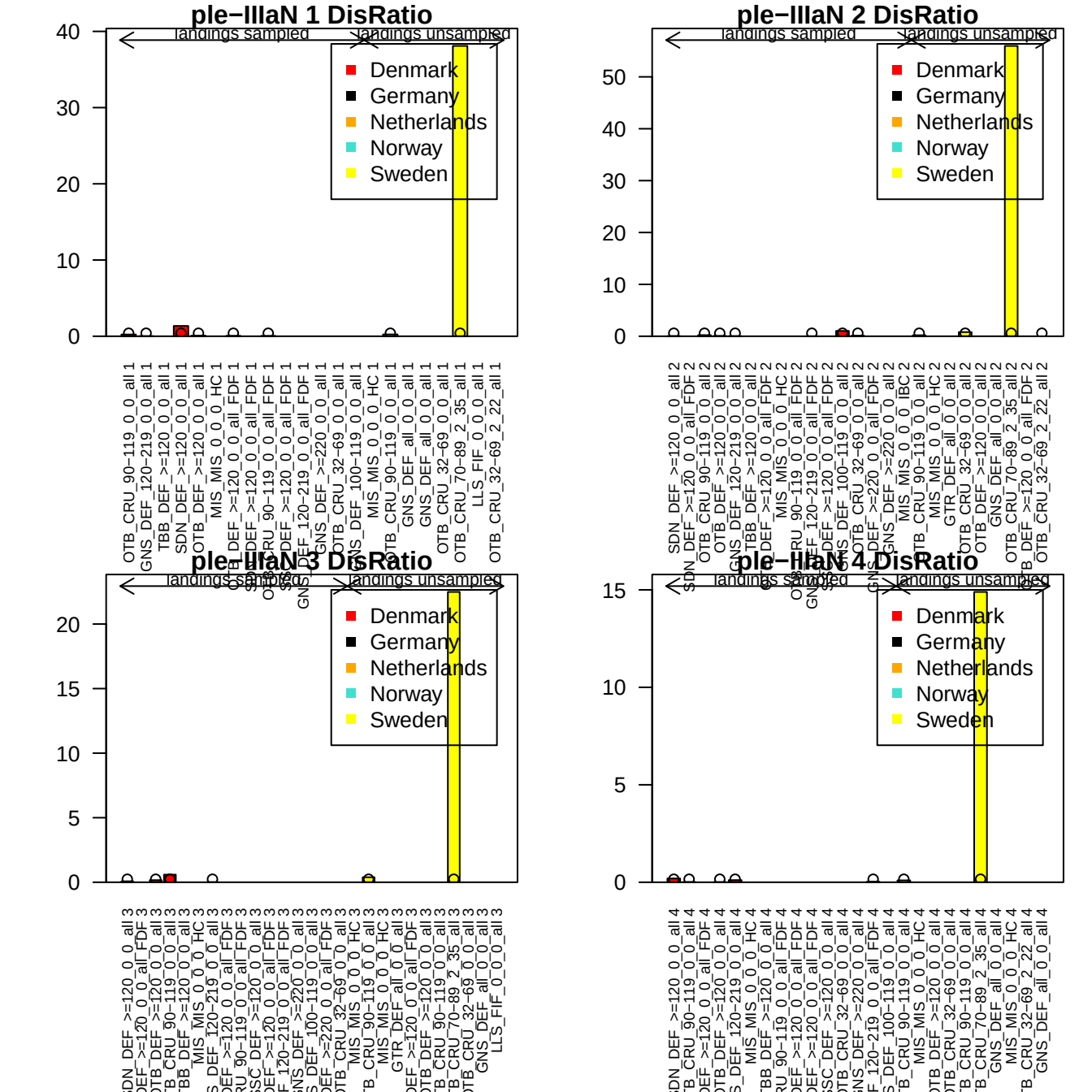

ple−IIIaN DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
50
40
30
20
10
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

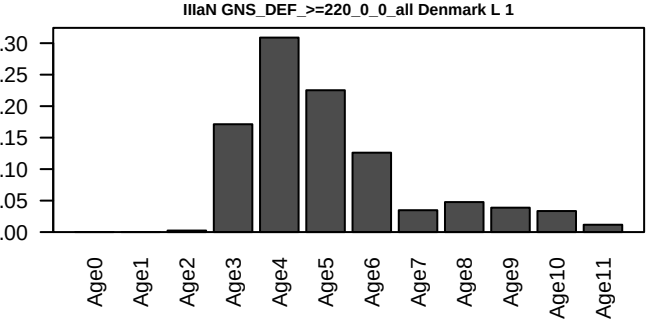

ple−IIIaN DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
0
1
2
3
4
5
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

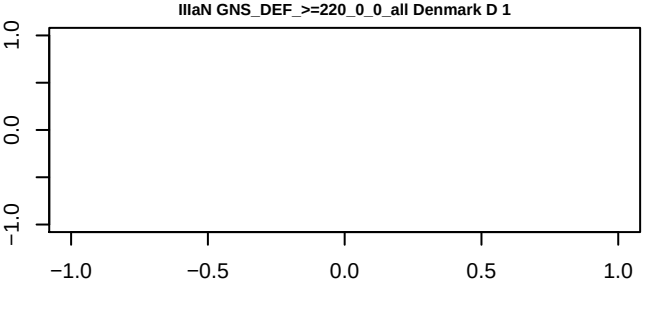

ple−IIIaN DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
2.0
1.5
1.0
0.5
0.0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

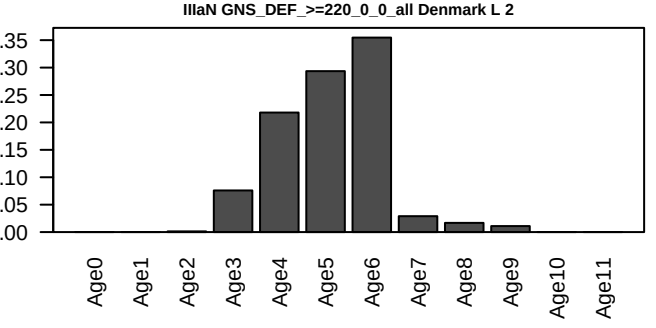

ple−IIIaN CatchWt
landings sampled
landings unsampled
2500
2000
1500
1000
500
0
SDN_DEF_>=120_0_0_all
OTB_CRU_90−119_0_0_all
N_DEF_>=120_0_0_all_FDF
OTB_DEF_>=120_0_0_all
GNS_DEF_120−219_0_0_all
TBB_DEF_>=120_0_0_all
MIS_MIS_0_0_0_HC
B_DEF_>=120_0_0_all_FDF
CRU_90−119_0_0_all_FDF
C_DEF_>=120_0_0_all_FDF
SSC_DEF_>=120_0_0_all
DEF_120−219_0_0_all_FDF
GNS_DEF_100−119_0_0_all
GNS_DEF_>=220_0_0_all
S_DEF_>=220_0_0_all_FDF
OTB_CRU_32−69_0_0_all
MIS_MIS_0_0_0_IBC
OTB_CRU_90−119_0_0_all
MIS_MIS_0_0_0_HC
MIS_MIS_0_0_0_HC
GTR_DEF_all_0_0_all
OTB_DEF_>=120_0_0_all
OTB_CRU_32−69_0_0_all
B_DEF_>=120_0_0_all_FDF
OTB_CRU_90−119_0_0_all
GNS_DEF_all_0_0_all
GNS_DEF_all_0_0_all
OTB_CRU_70−89_2_35_all
MIS_MIS_0_0_0_HC
LLS_FIF_0_0_0_all
OTB_CRU_32−69_2_22_all
OTB_CRU_32−69_2_22_all

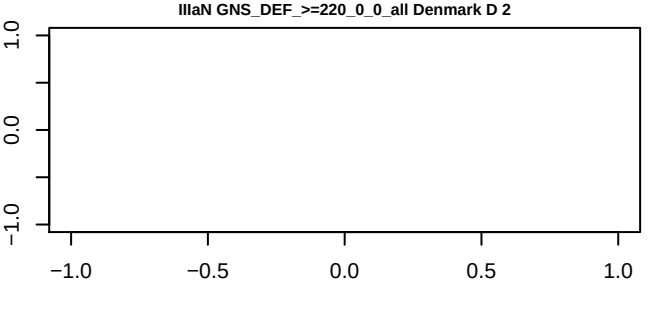

ple−IIIaN 1 DisWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 2 DisWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 3 DisWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 4 DisWt
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden

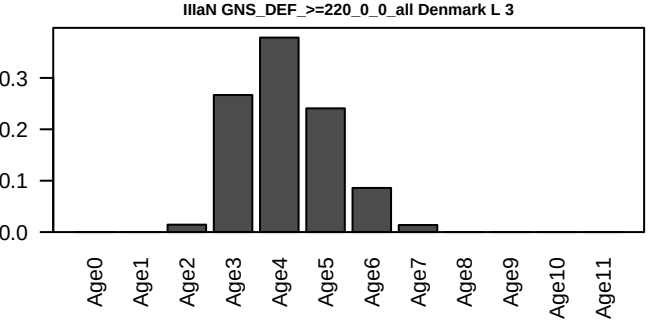

ple−IIIaN 1 DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 2 DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 3 DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden
ple−IIIaN 4 DisRatio
landings sampled
landings unsampled
Denmark
Germany
Netherlands
Norway
Sweden

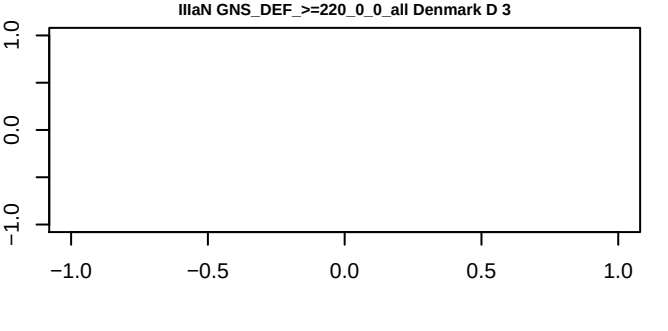

IIIaN GNS_DEF_>=220_0_0_all Denmark L 1
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

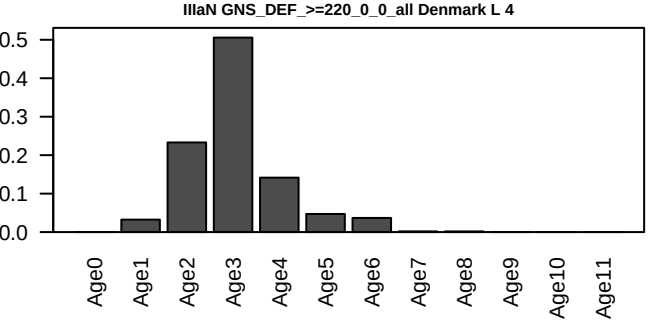

IIIaN GNS_DEF_>=220_0_0_all Denmark D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

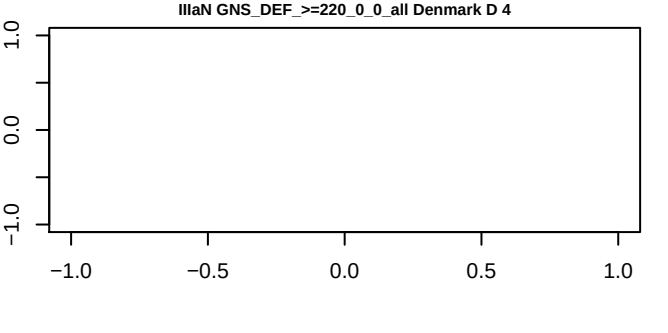

IIIaN GNS_DEF_>=220_0_0_all Denmark L 2
.35
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

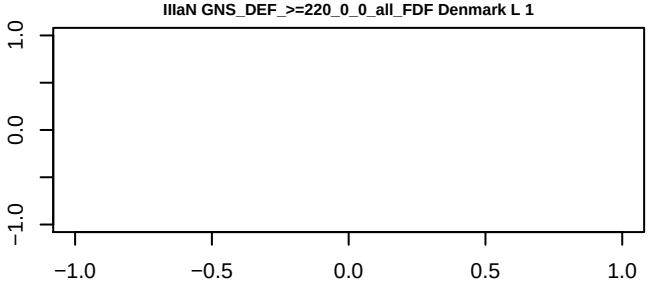

IIIaN GNS_DEF_>=220_0_0_all Denmark D 2
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

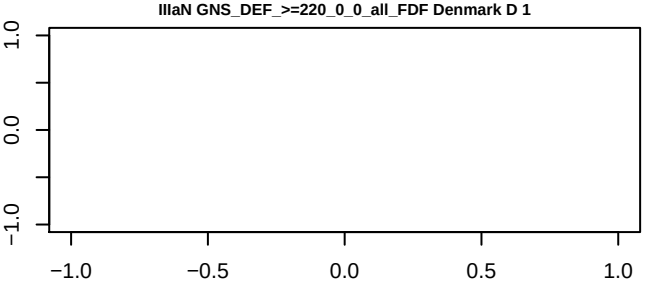

IIIaN GNS_DEF_>=220_0_0_all Denmark L 3
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

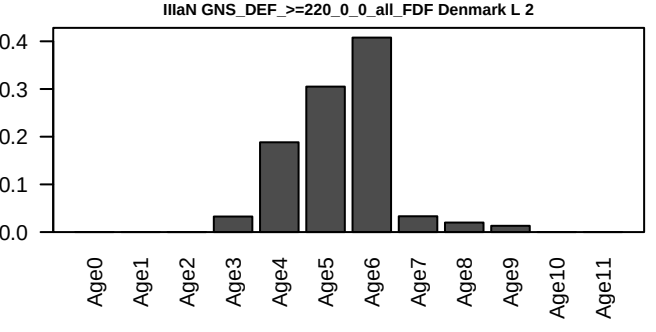

IIIaN GNS_DEF_>=220_0_0_all Denmark D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

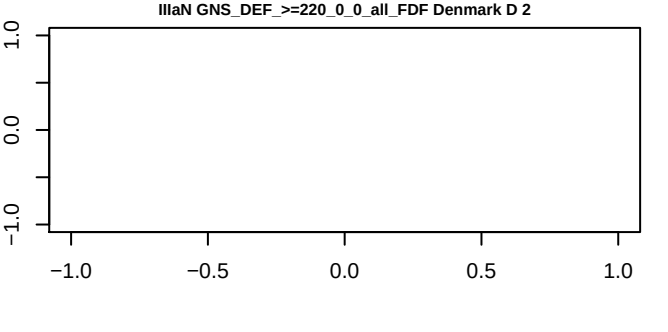

IIIaN GNS_DEF_>=220_0_0_all Denmark L 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

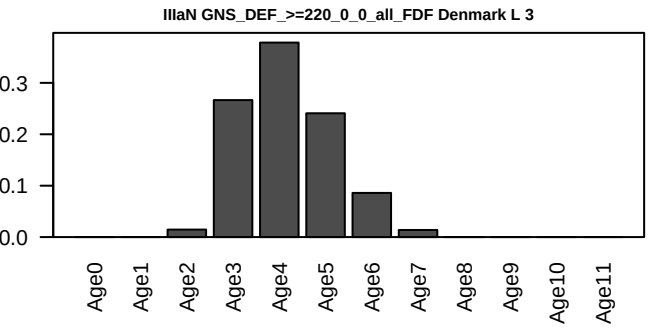

IIIaN GNS_DEF_>=220_0_0_all Denmark D 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

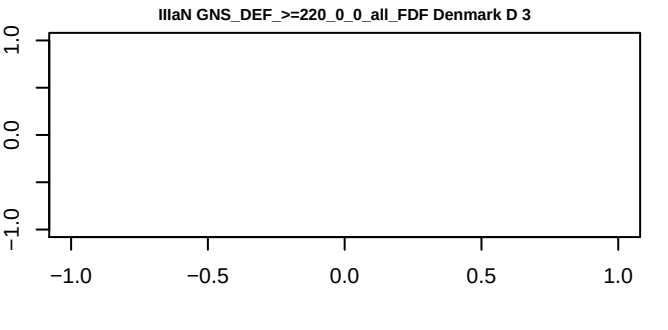

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark L 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

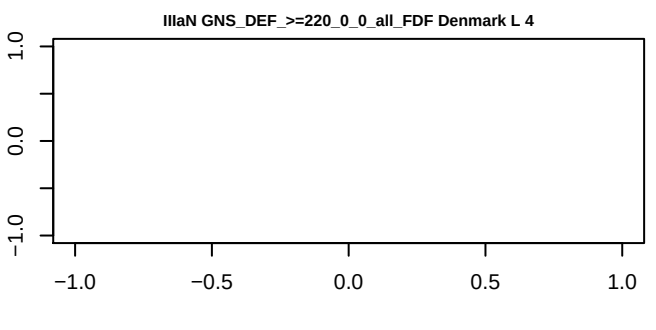

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

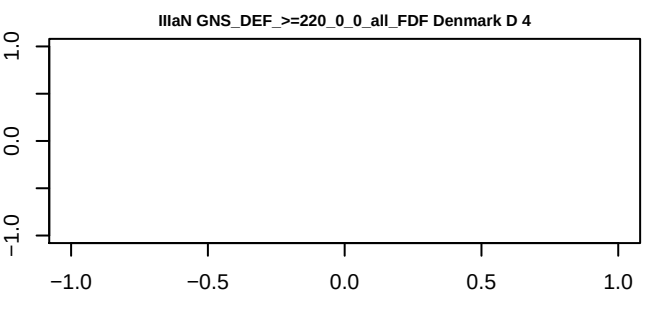

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark L 2
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

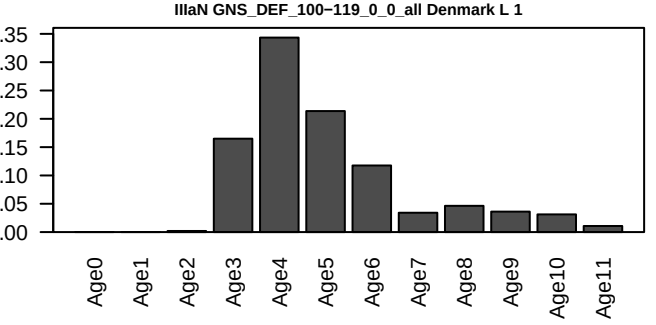

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark D 2
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

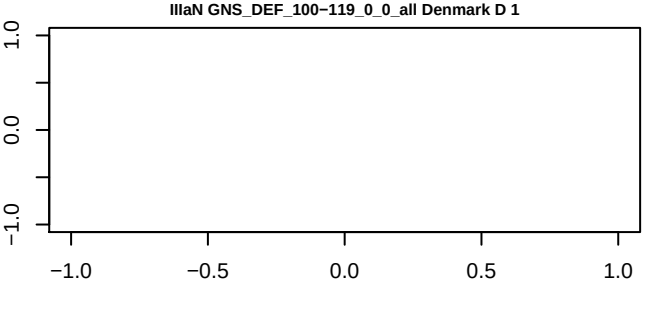

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark L 3
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

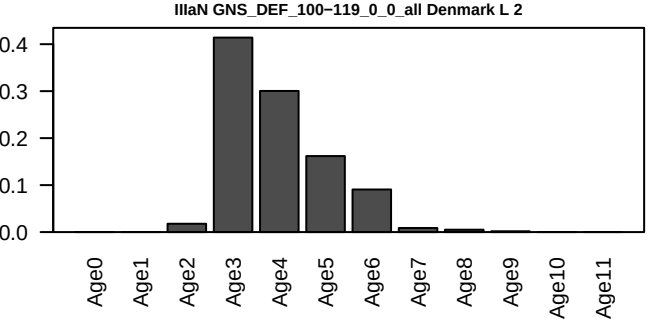

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

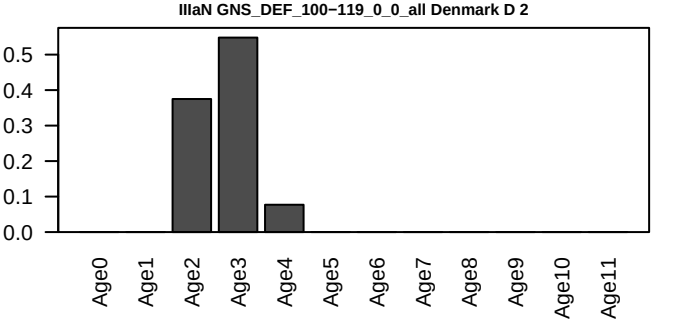

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark L 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

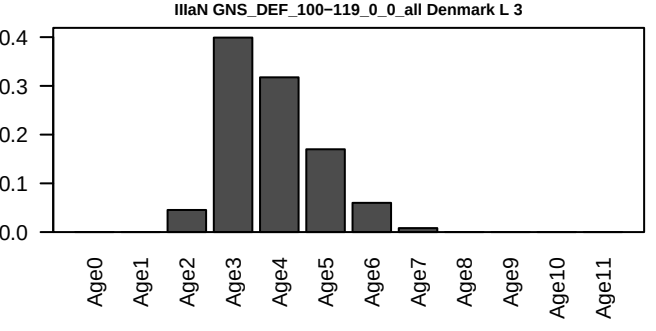

IIIaN GNS_DEF_>=220_0_0_all_FDF Denmark D 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

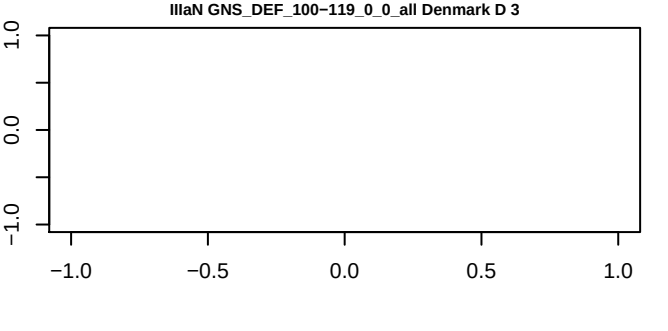

IIIaN GNS_DEF_100−119_0_0_all Denmark L 1
.35
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

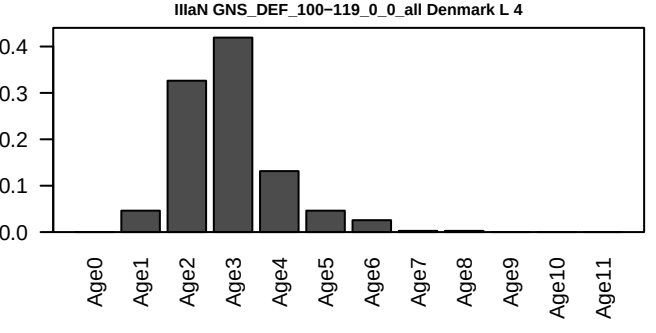

IIIaN GNS_DEF_100−119_0_0_all Denmark D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

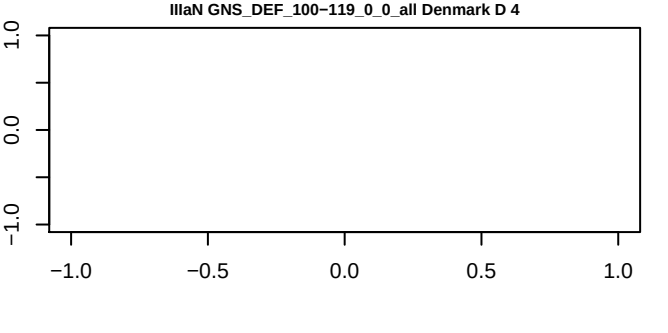

IIIaN GNS_DEF_100−119_0_0_all Denmark L 2
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

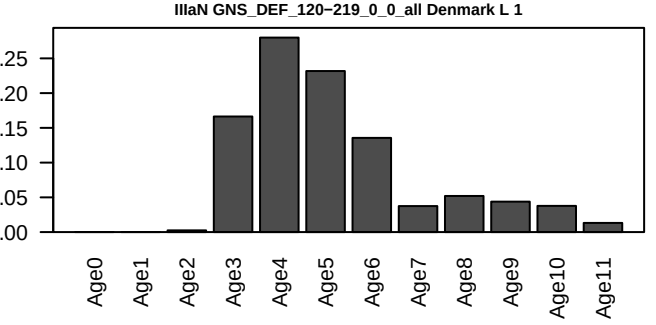

IIIaN GNS_DEF_100−119_0_0_all Denmark D 2
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

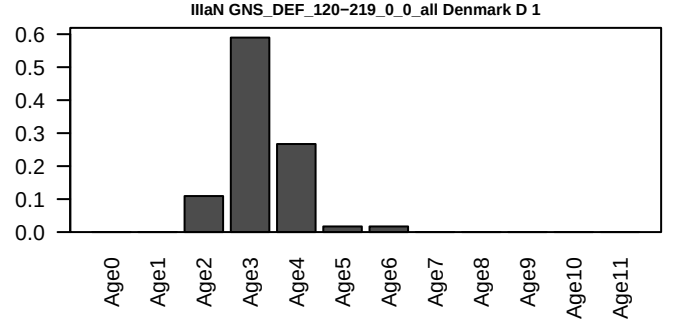

IIIaN GNS_DEF_100−119_0_0_all Denmark L 3
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

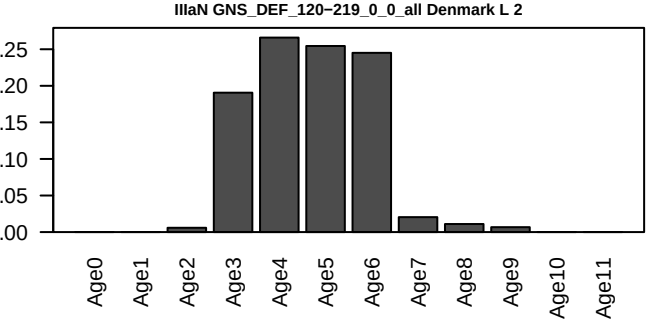

IIIaN GNS_DEF_100−119_0_0_all Denmark D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

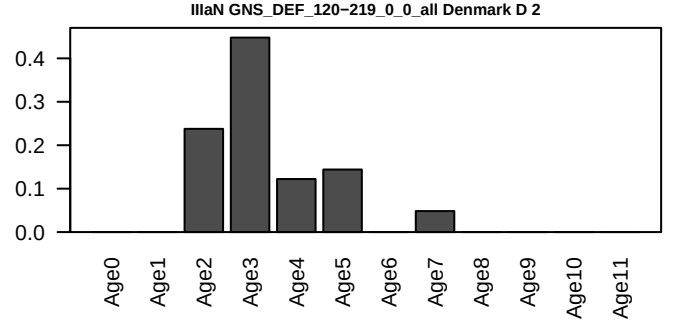

IIIaN GNS_DEF_100−119_0_0_all Denmark L 4
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

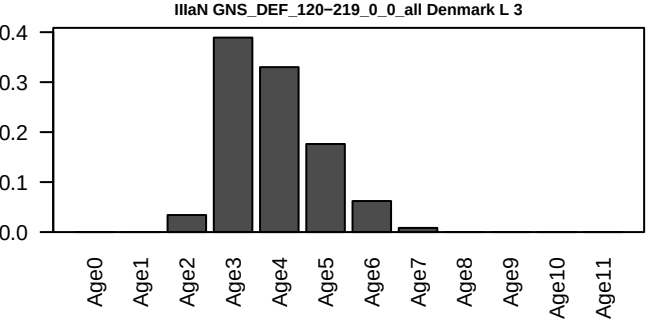

IIIaN GNS_DEF_100−119_0_0_all Denmark D 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

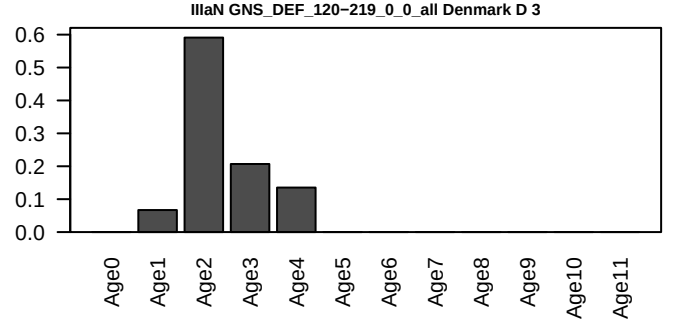

IIIaN GNS_DEF_120−219_0_0_all Denmark L 1
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

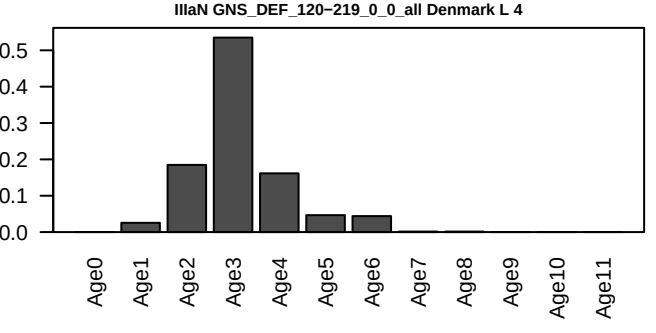

IIIaN GNS_DEF_120−219_0_0_all Denmark D 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

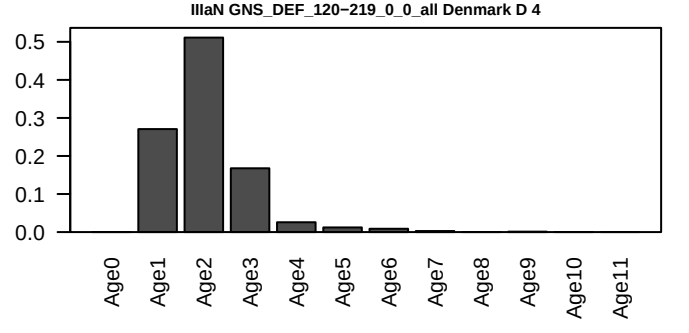

IIIaN GNS_DEF_120−219_0_0_all Denmark L 2
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

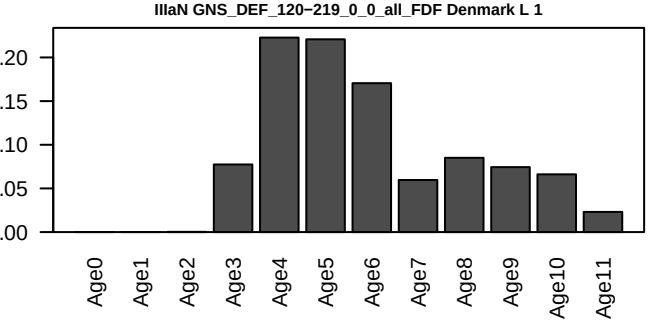

IIIaN GNS_DEF_120−219_0_0_all Denmark D 2
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

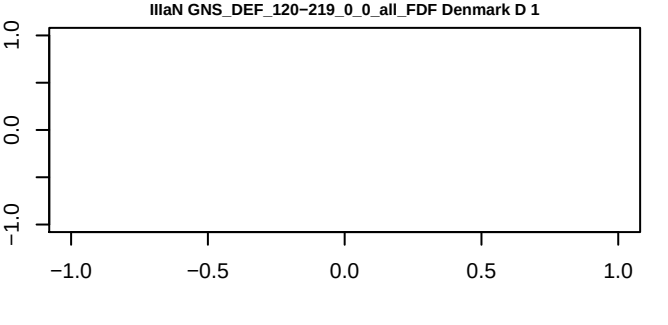

IIIaN GNS_DEF_120−219_0_0_all Denmark L 3
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

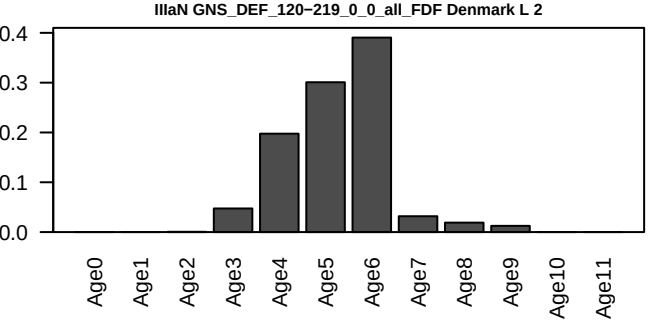

IIIaN GNS_DEF_120−219_0_0_all Denmark D 3
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

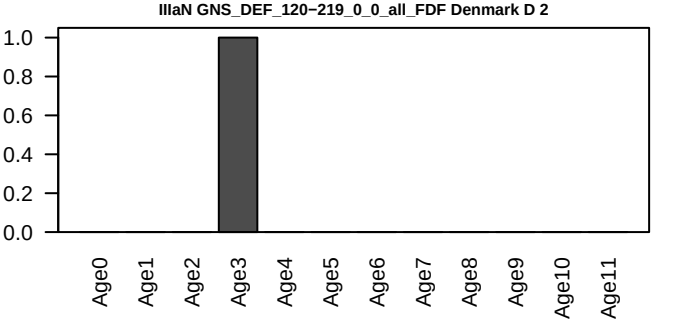

IIIaN GNS_DEF_120−219_0_0_all Denmark L 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

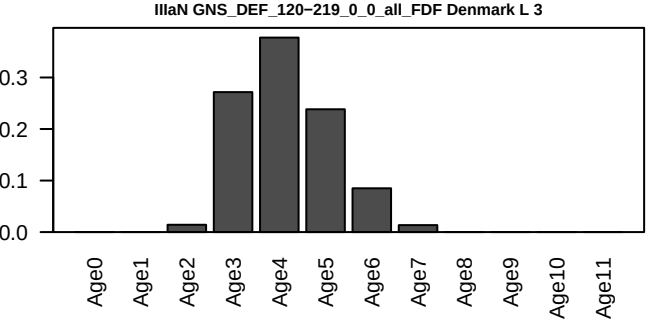

IIIaN GNS_DEF_120−219_0_0_all Denmark D 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

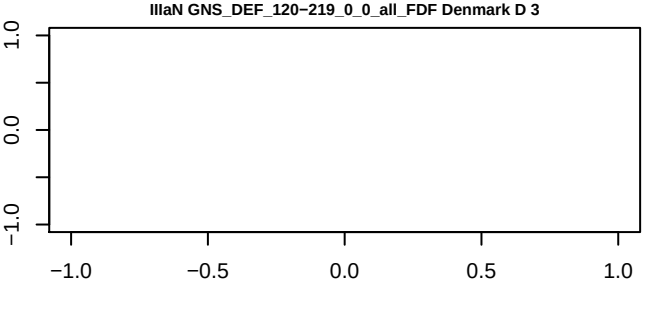

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark L 1
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

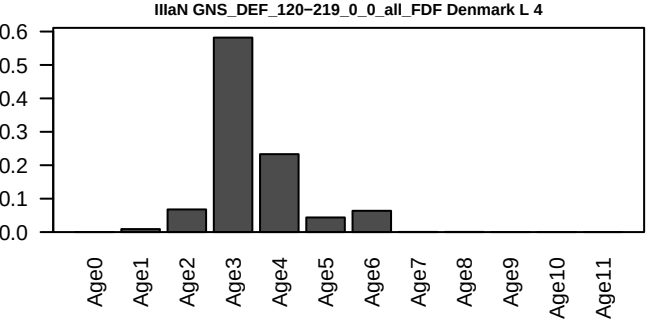

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

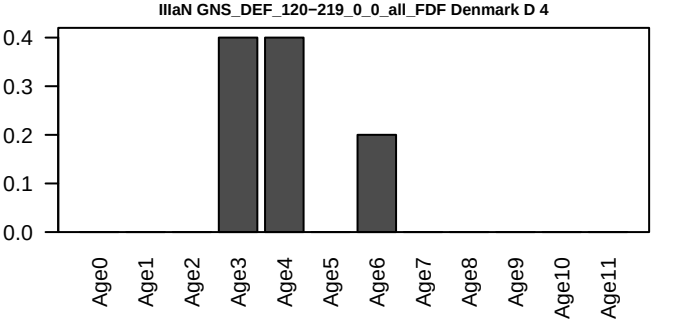

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark L 2
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

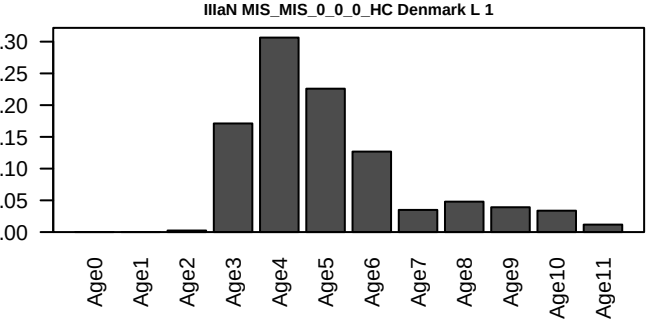

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark D 2
1.0
0.8
0.6
0.4
0.2
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

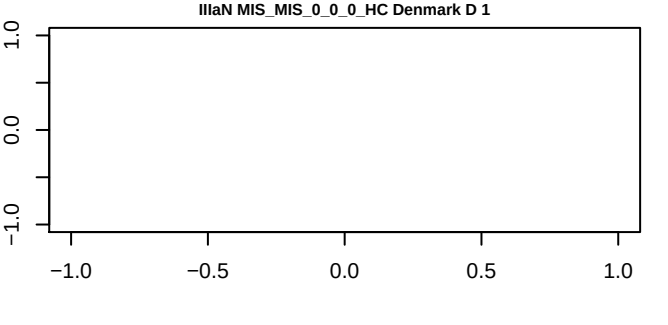

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark L 3
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

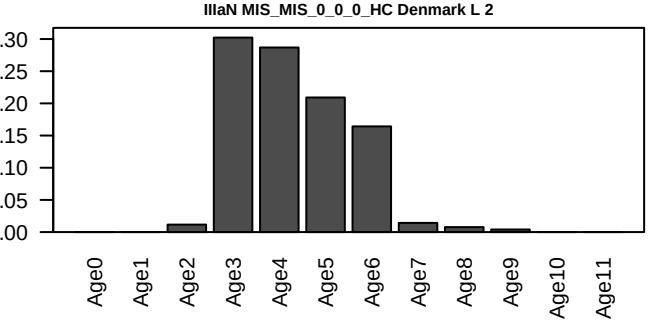

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

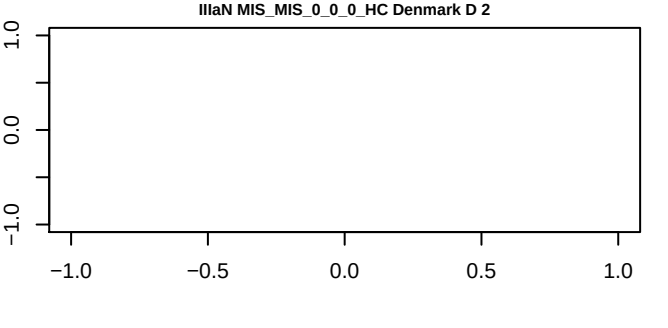

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark L 4
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

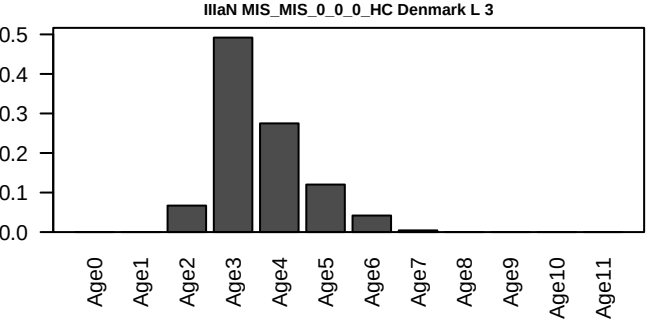

IIIaN GNS_DEF_120−219_0_0_all_FDF Denmark D 4
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

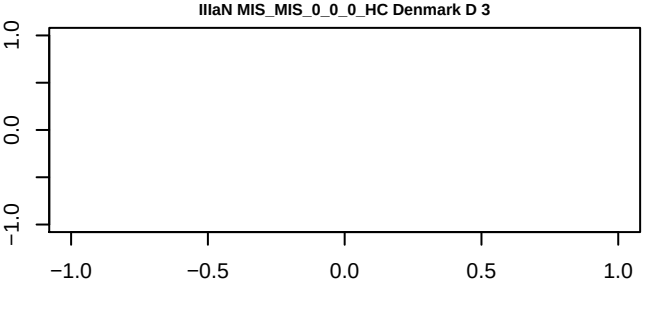

IIIaN MIS_MIS_0_0_0_HC Denmark L 1
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

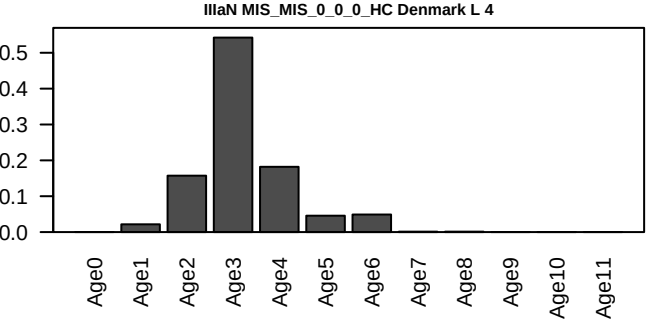

IIIaN MIS_MIS_0_0_0_HC Denmark D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

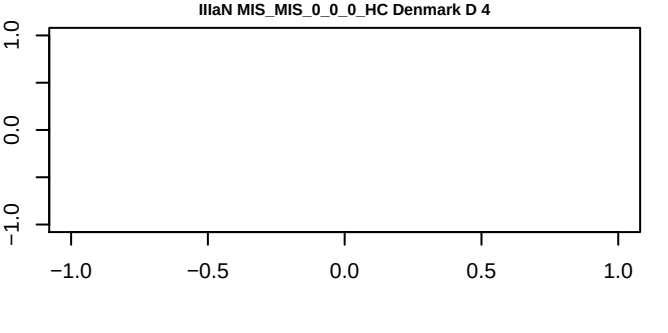

IIIaN MIS_MIS_0_0_0_HC Denmark L 2
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

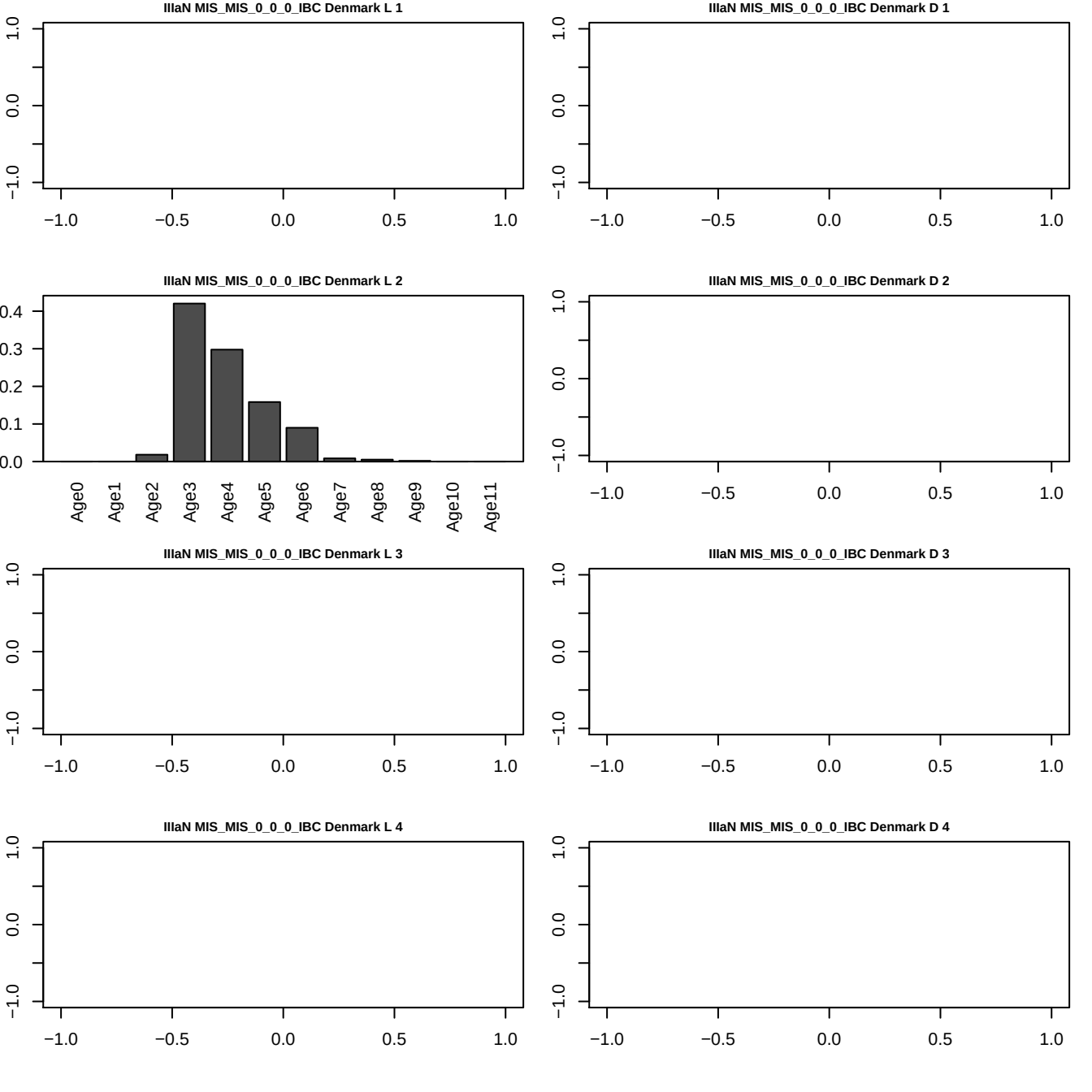

IIIaN MIS_MIS_0_0_0_HC Denmark D 2
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−1.0
−1.0
−0.5
0.0
0.5
1.0

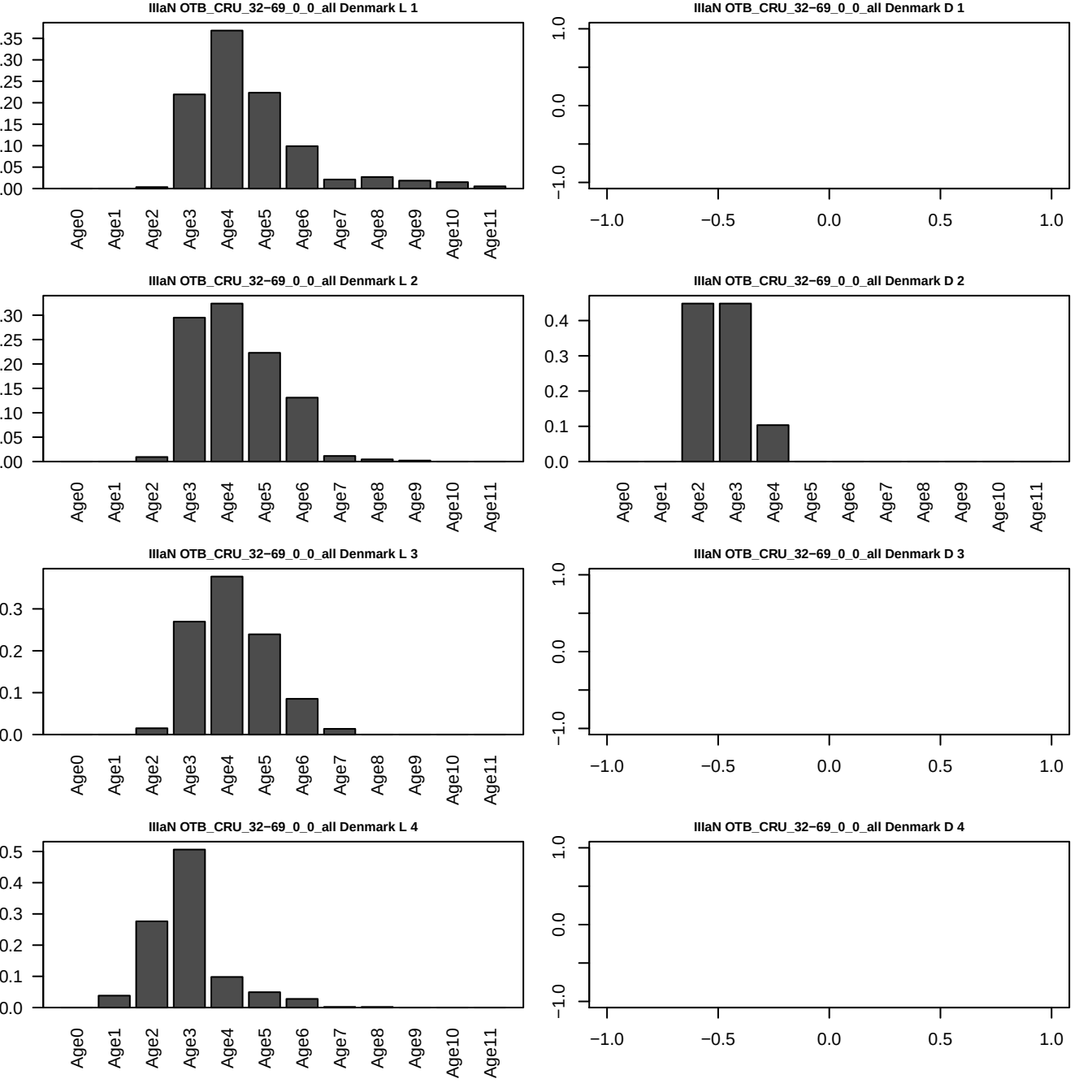

IIIaN MIS_MIS_0_0_0_HC Denmark L 3
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

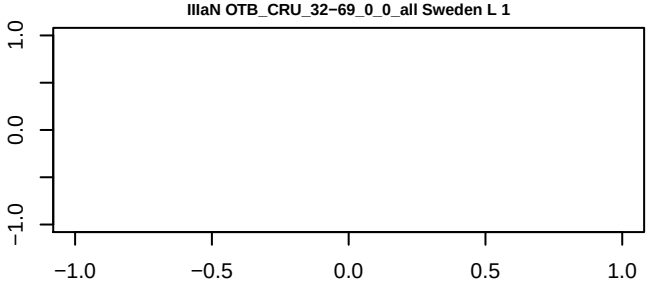

IIIaN MIS_MIS_0_0_0_HC Denmark D 3
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0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

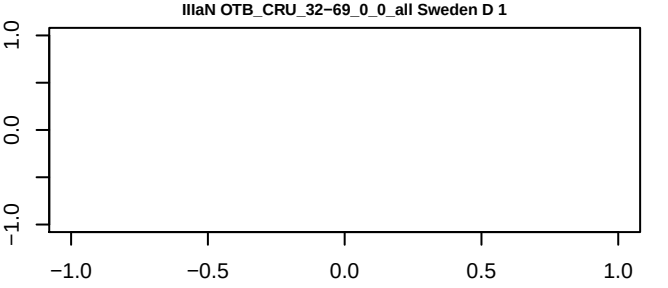

IIIaN MIS_MIS_0_0_0_HC Denmark L 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

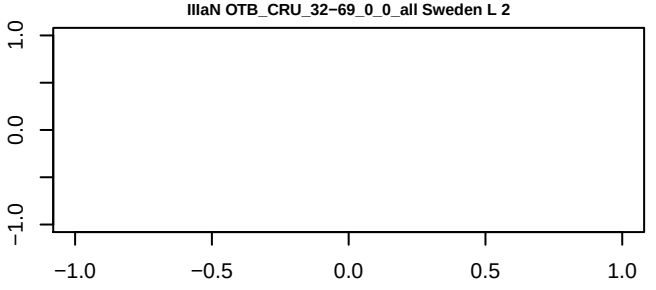

IIIaN MIS_MIS_0_0_0_HC Denmark D 4
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−1.0
−0.5
0.0
0.5
1.0

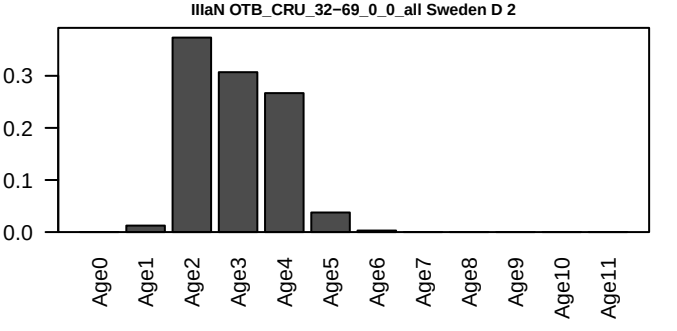

IIIaN MIS_MIS_0_0_0_IBC Denmark L 1
IIIaN MIS_MIS_0_0_0_IBC Denmark D 1
IIIaN MIS_MIS_0_0_0_IBC Denmark L 2
IIIaN MIS_MIS_0_0_0_IBC Denmark D 2
IIIaN MIS_MIS_0_0_0_IBC Denmark L 3
IIIaN MIS_MIS_0_0_0_IBC Denmark D 3
IIIaN MIS_MIS_0_0_0_IBC Denmark L 4
IIIaN MIS_MIS_0_0_0_IBC Denmark D 4
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

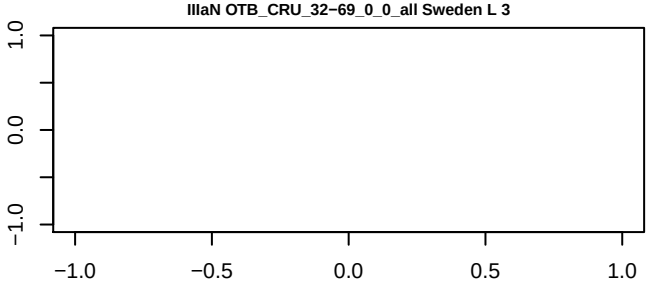

IIIaN OTB_CRU_32−69_0_0_all Denmark L 1
IIIaN OTB_CRU_32−69_0_0_all Denmark D 1
IIIaN OTB_CRU_32−69_0_0_all Denmark L 2
IIIaN OTB_CRU_32−69_0_0_all Denmark D 2
IIIaN OTB_CRU_32−69_0_0_all Denmark L 3
IIIaN OTB_CRU_32−69_0_0_all Denmark D 3
IIIaN OTB_CRU_32−69_0_0_all Denmark L 4
IIIaN OTB_CRU_32−69_0_0_all Denmark D 4
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11
−1.0
−0.5
0.0
0.5
1.0

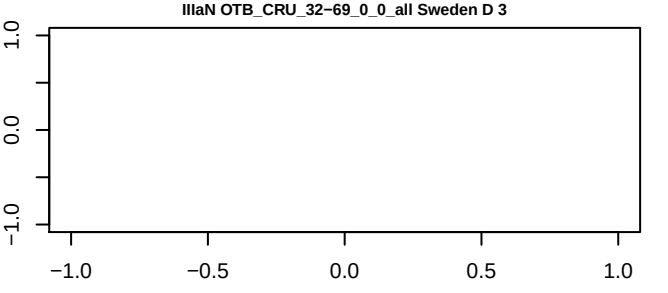

IIIaN OTB_CRU_32−69_0_0_all Sweden L 1
1.0
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0.5
1.0

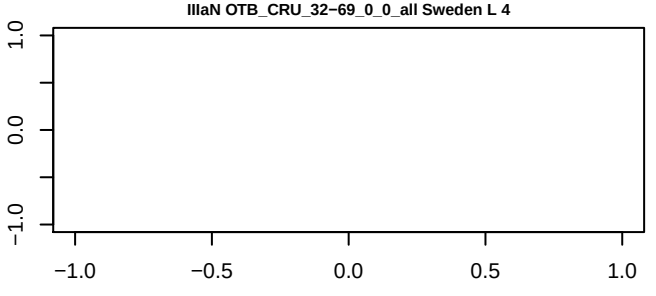

IIIaN OTB_CRU_32−69_0_0_all Sweden D 1
1.0
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0.5
1.0

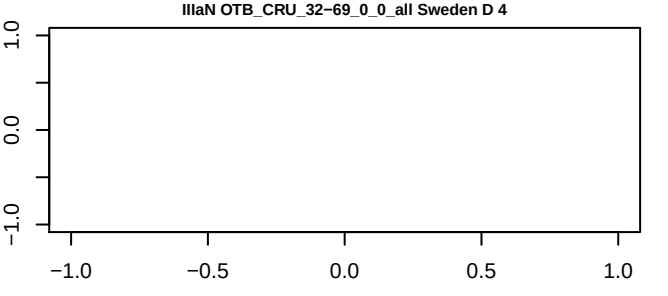

IIIaN OTB_CRU_32−69_0_0_all Sweden L 2
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0.5
1.0

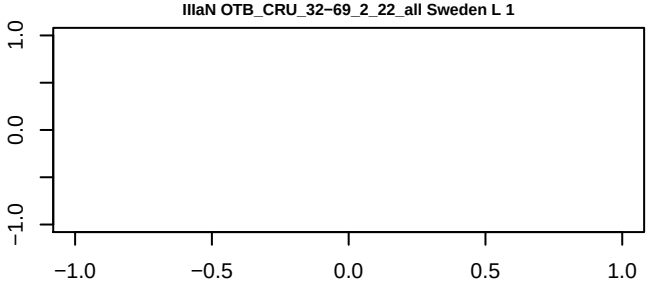

IIIaN OTB_CRU_32−69_0_0_all Sweden D 2
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

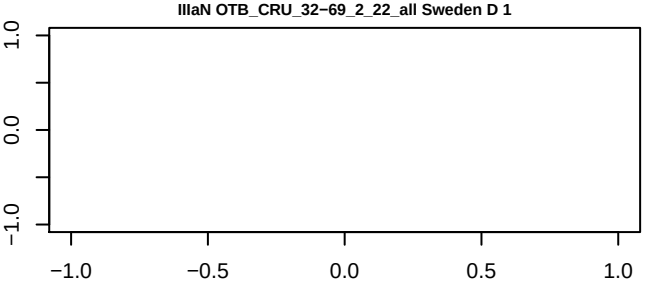

IIIaN OTB_CRU_32−69_0_0_all Sweden L 3
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−1.0
−1.0
−0.5
0.0
0.5
1.0

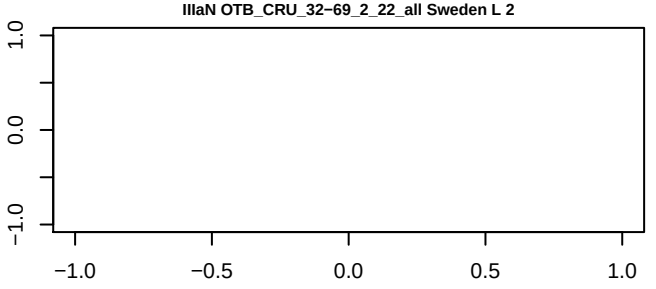

IIIaN OTB_CRU_32−69_0_0_all Sweden D 3
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−1.0
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0.5
1.0

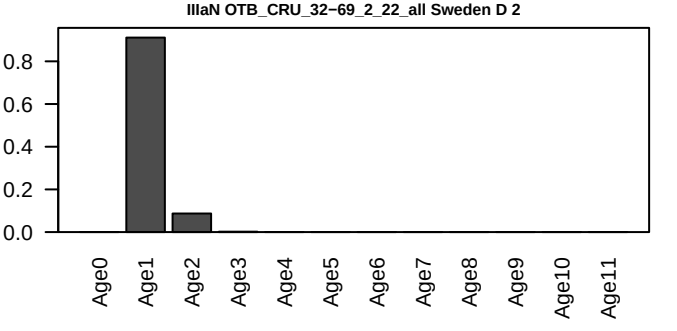

IIIaN OTB_CRU_32−69_0_0_all Sweden L 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

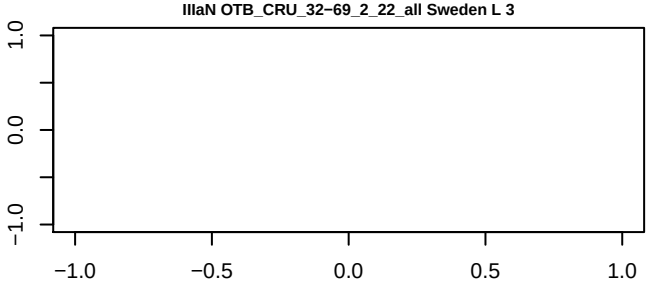

IIIaN OTB_CRU_32−69_0_0_all Sweden D 4
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0.5
1.0

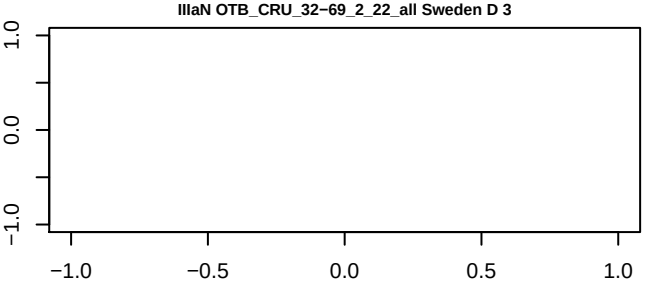

IIIaN OTB_CRU_32−69_2_22_all Sweden L 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

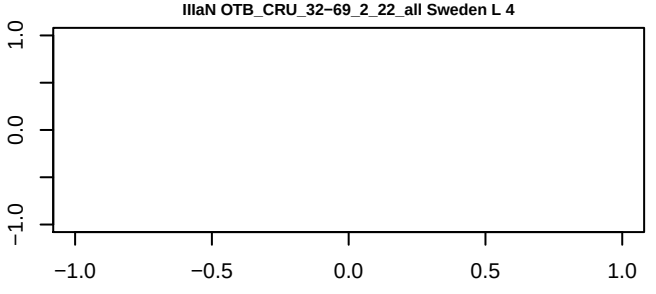

IIIaN OTB_CRU_32−69_2_22_all Sweden D 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

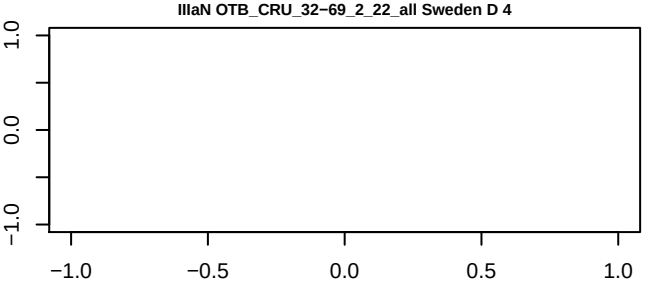

IIIaN OTB_CRU_32−69_2_22_all Sweden L 2
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

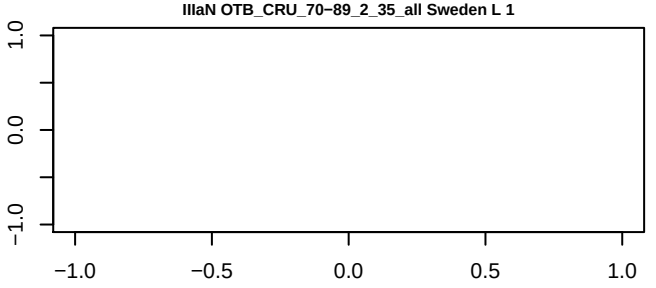

IIIaN OTB_CRU_32−69_2_22_all Sweden D 2
0.8
0.6
0.4
0.2
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

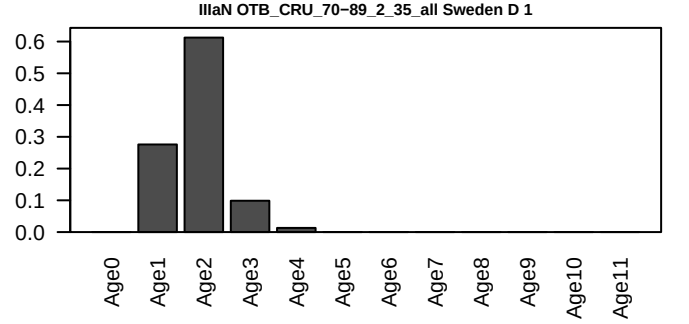

IIIaN OTB_CRU_32−69_2_22_all Sweden L 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

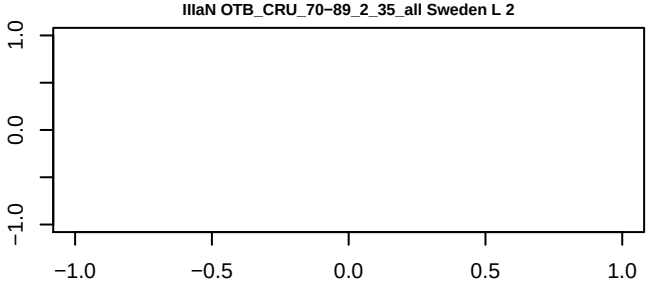

IIIaN OTB_CRU_32−69_2_22_all Sweden D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

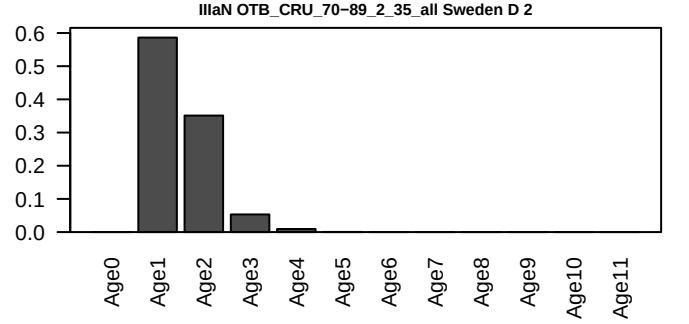

IIIaN OTB_CRU_32−69_2_22_all Sweden L 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

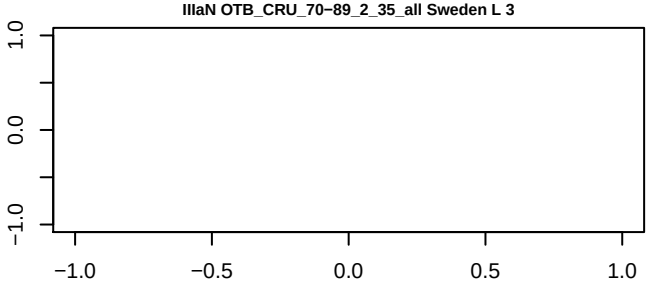

IIIaN OTB_CRU_32−69_2_22_all Sweden D 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

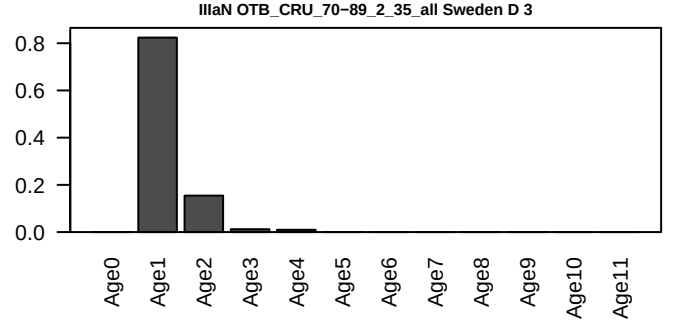

IIIaN OTB_CRU_70−89_2_35_all Sweden L 1
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

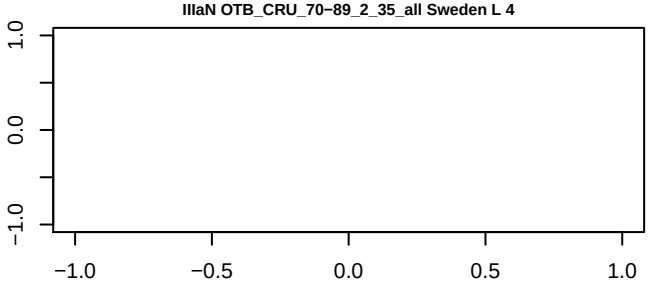

IIIaN OTB_CRU_70−89_2_35_all Sweden D 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

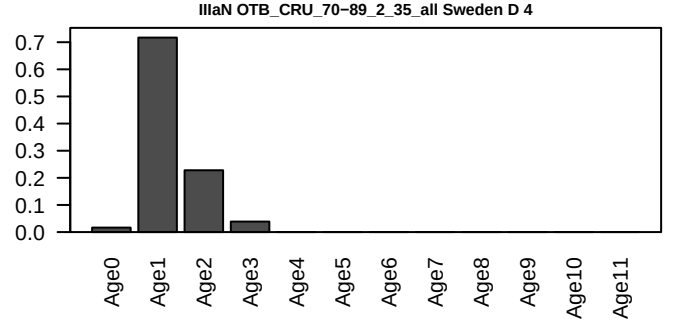

IIIaN OTB_CRU_70−89_2_35_all Sweden L 2
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

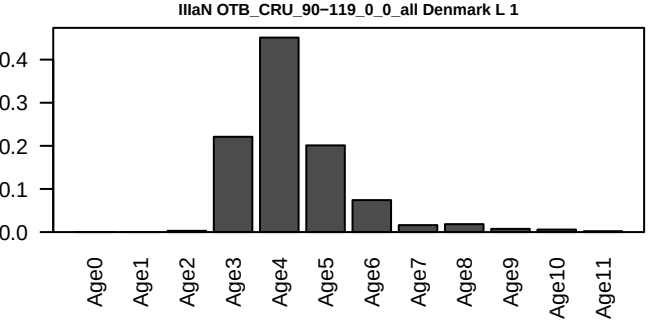

IIIaN OTB_CRU_70−89_2_35_all Sweden D 2
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

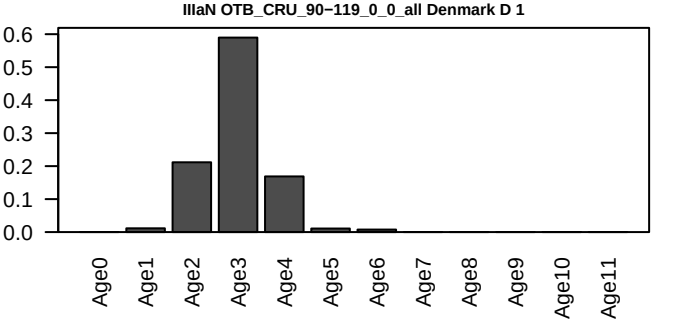

IIIaN OTB_CRU_70−89_2_35_all Sweden L 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

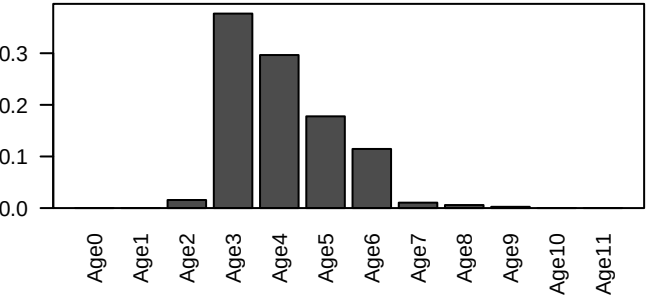

IIIaN OTB_CRU_70−89_2_35_all Sweden D 3
0.8
0.6
0.4
0.2
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

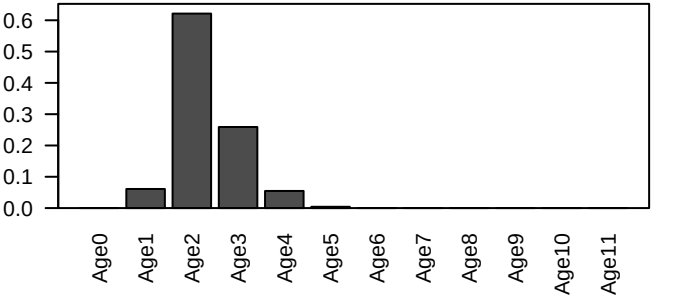

IIIaN OTB_CRU_70−89_2_35_all Sweden L 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

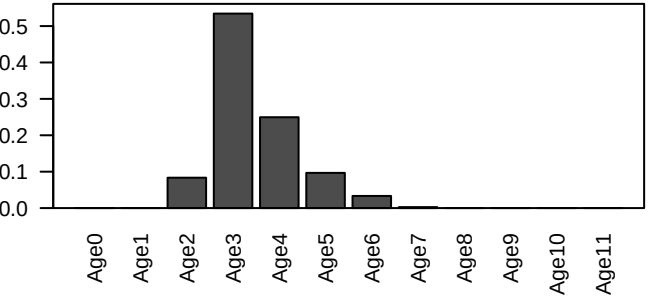

IIIaN OTB_CRU_70−89_2_35_all Sweden D 4
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

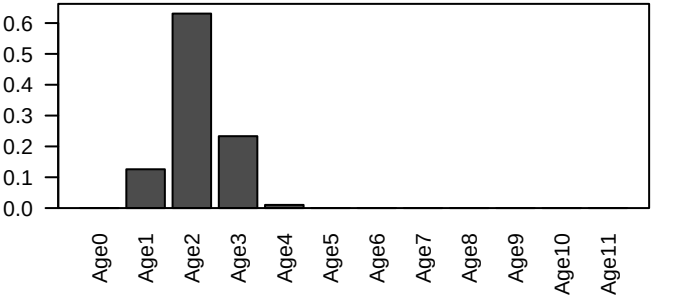

IIIaN OTB_CRU_90−119_0_0_all Denmark L 1
0.0
0.1
0.2
0.3
0.4
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

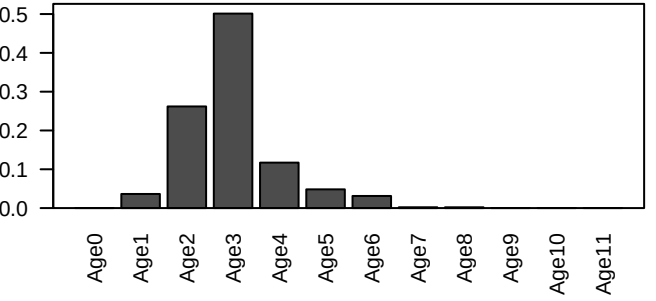

IIIaN OTB_CRU_90−119_0_0_all Denmark D 1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

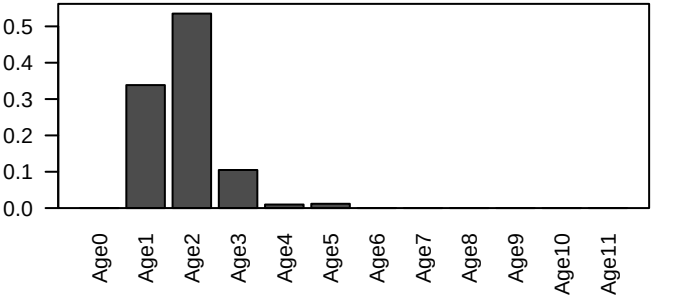

IIIaN OTB_CRU_90−119_0_0_all Denmark L 2
0.0
0.1
0.2
0.3
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

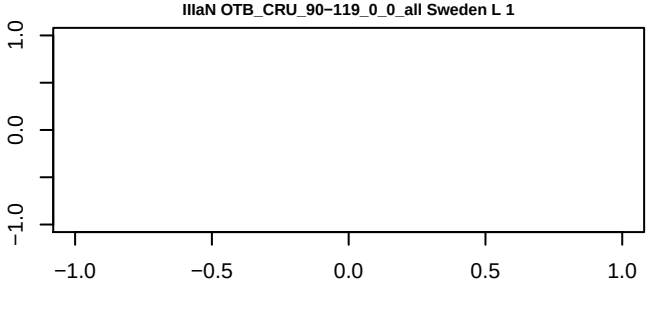

IIIaN OTB_CRU_90−119_0_0_all Denmark D 2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

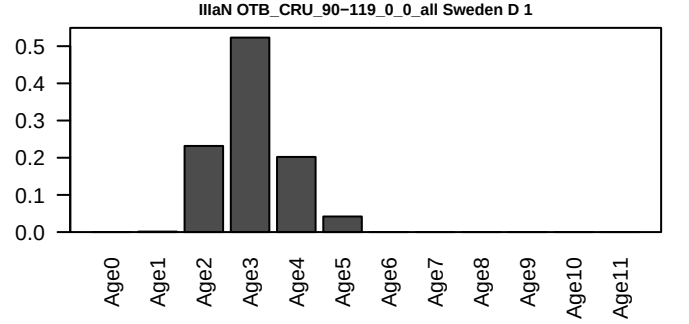

IIIaN OTB_CRU_90−119_0_0_all Denmark L 3
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

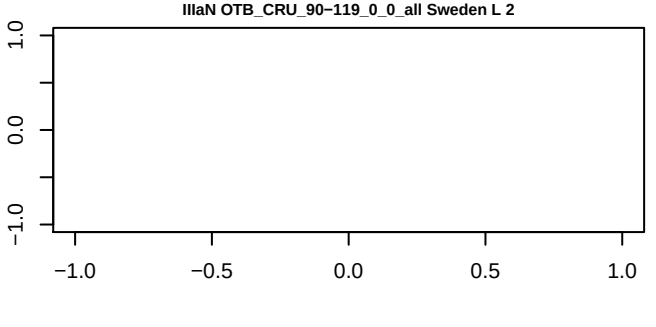

IIIaN OTB_CRU_90−119_0_0_all Denmark D 3
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

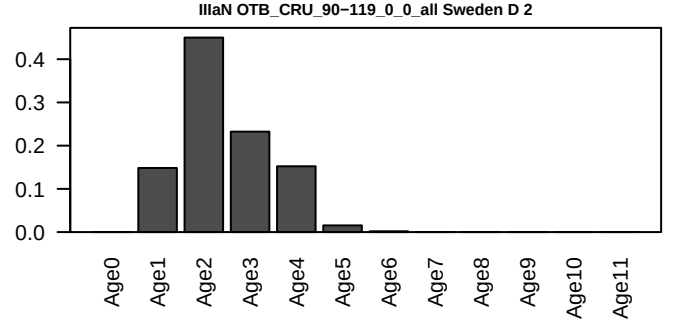

IIIaN OTB_CRU_90−119_0_0_all Denmark L 4
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

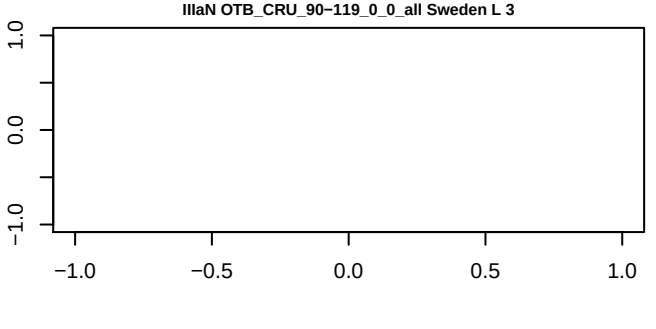

IIIaN OTB_CRU_90−119_0_0_all Denmark D 4
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

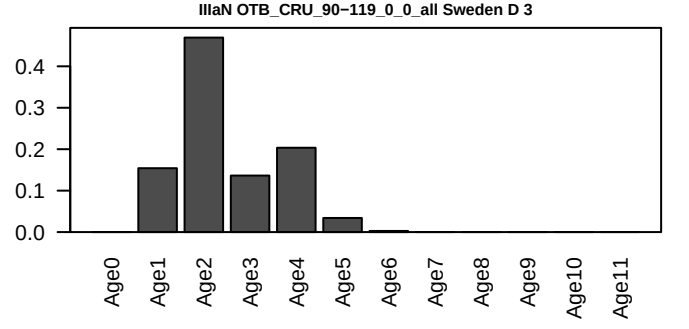

IIIaN OTB_CRU_90−119_0_0_all Sweden L 1
1.0
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−1.0
−1.0
−0.5
0.0
0.5
1.0

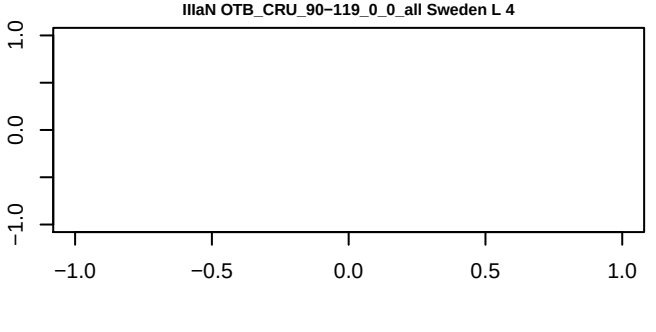

IIIaN OTB_CRU_90−119_0_0_all Sweden D 1
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

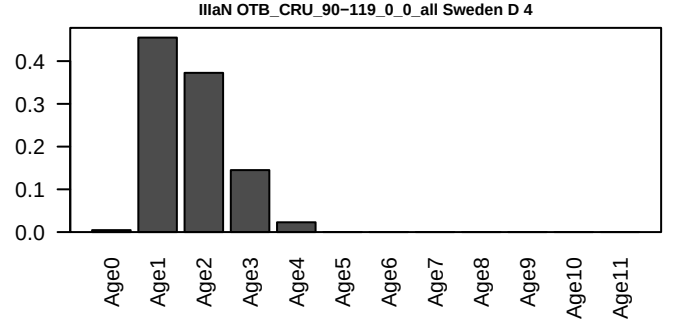

IIIaN OTB_CRU_90−119_0_0_all Sweden L 2
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

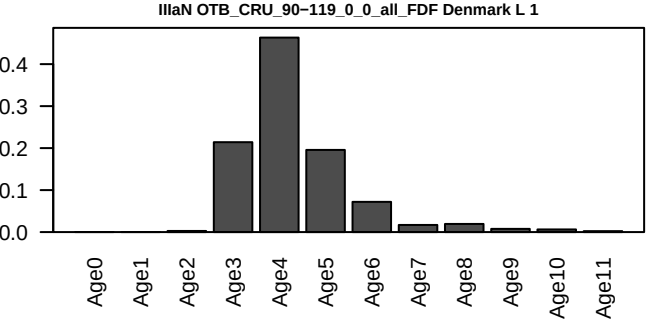

IIIaN OTB_CRU_90−119_0_0_all Sweden D 2
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

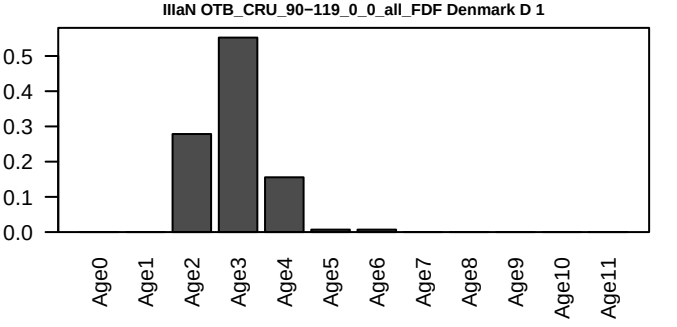

IIIaN OTB_CRU_90−119_0_0_all Sweden L 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

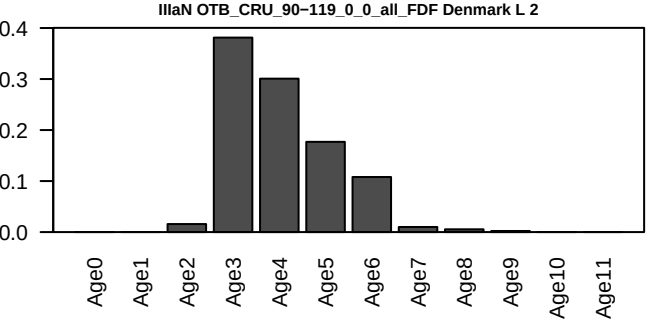

IIIaN OTB_CRU_90−119_0_0_all Sweden D 3
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

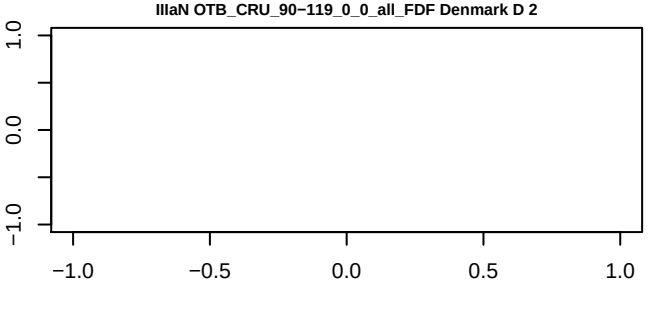

IIIaN OTB_CRU_90−119_0_0_all Sweden L 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

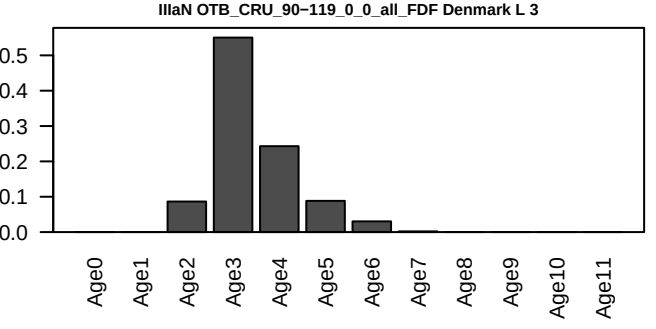

IIIaN OTB_CRU_90−119_0_0_all Sweden D 4
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

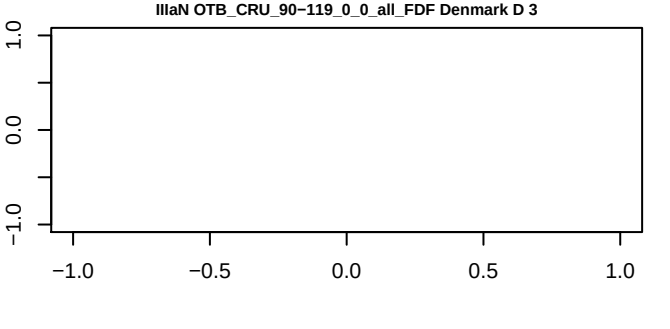

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark L 1
0.0
0.1
0.2
0.3
0.4
Age0
Age1
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Age7
Age8
Age9
Age10
Age11

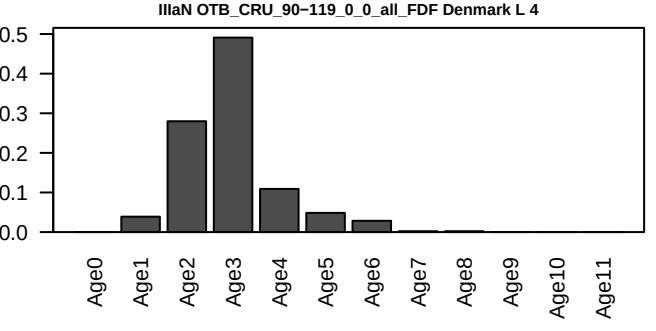

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark D 1
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

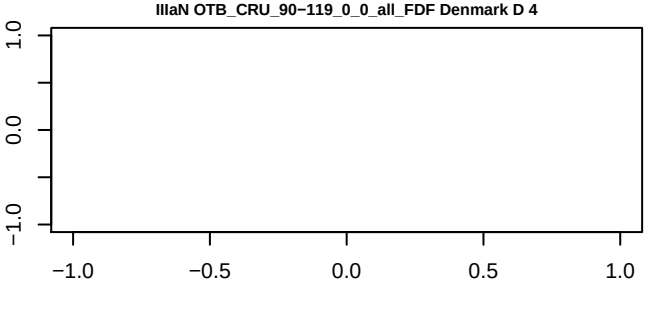

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark L 2
0.0
0.1
0.2
0.3
0.4
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

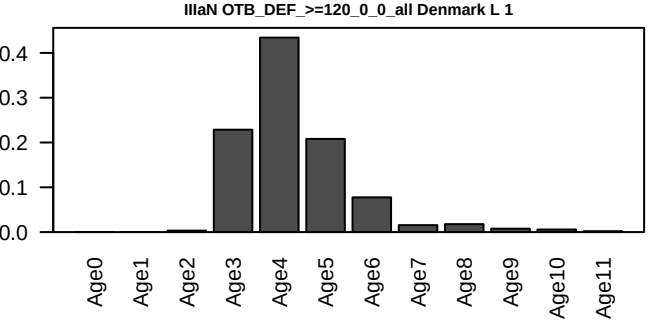

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark D 2
−1.0
0.0
1.0
−1.0
−0.5
0.0
0.5
1.0

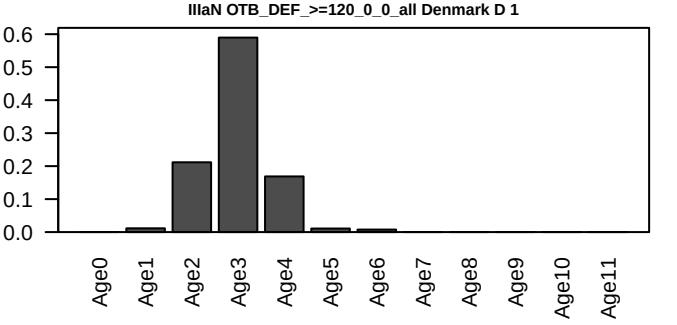

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark L 3
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

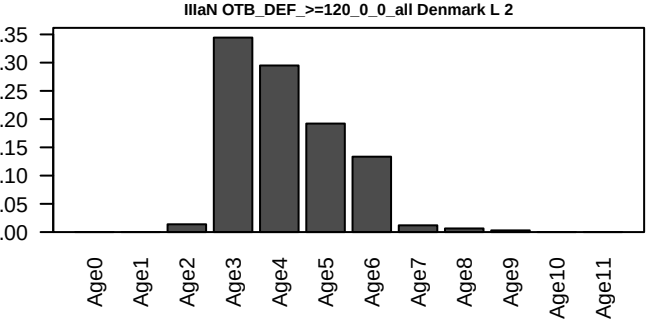

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark D 3
−1.0
0.0
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−1.0
−0.5
0.0
0.5
1.0

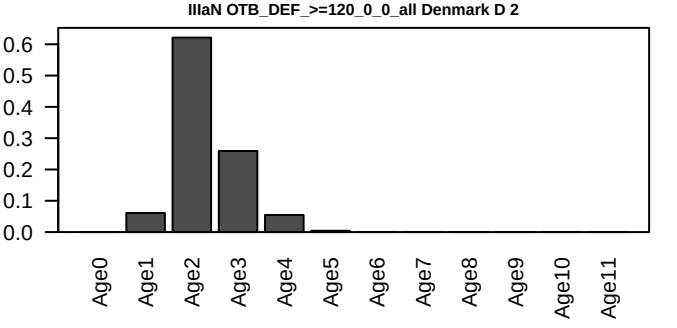

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark L 4
0.0
0.1
0.2
0.3
0.4
0.5
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

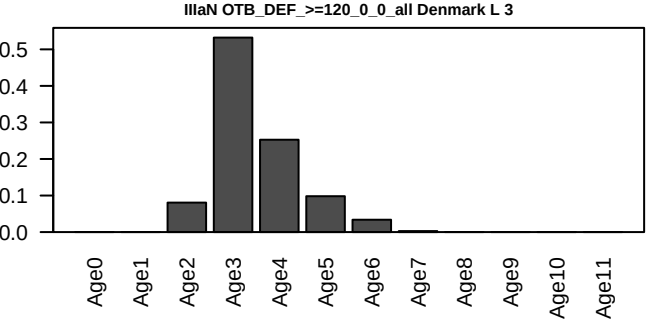

IIIaN OTB_CRU_90−119_0_0_all_FDF Denmark D 4
−1.0
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1.0
−1.0
−0.5
0.0
0.5
1.0

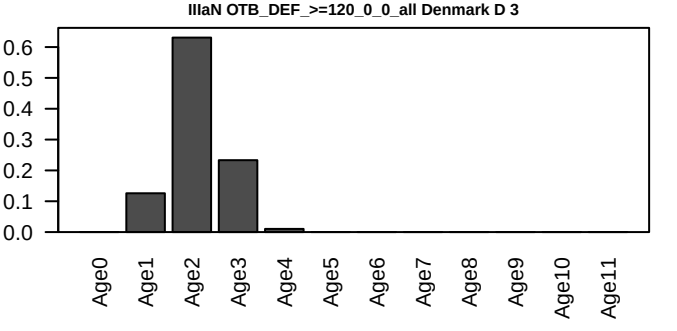

IIIaN OTB_DEF_>=120_0_0_all Denmark L 1
0.4
0.3
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0.1
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Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

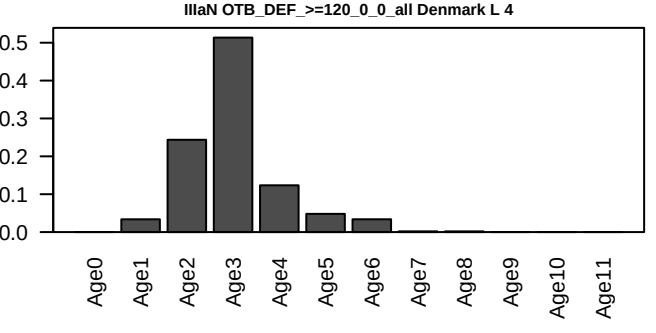

IIIaN OTB_DEF_>=120_0_0_all Denmark D 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

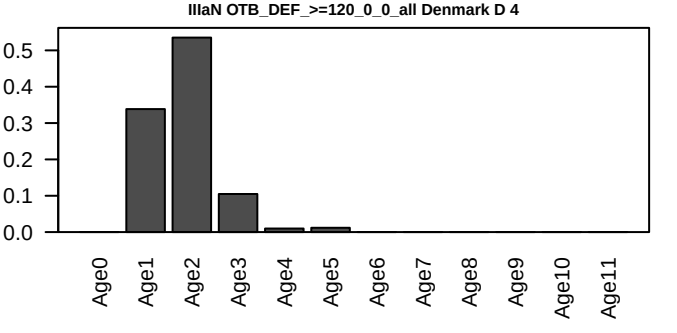

IIIaN OTB_DEF_>=120_0_0_all Denmark L 2
.35
.30
.25
.20
.15
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.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

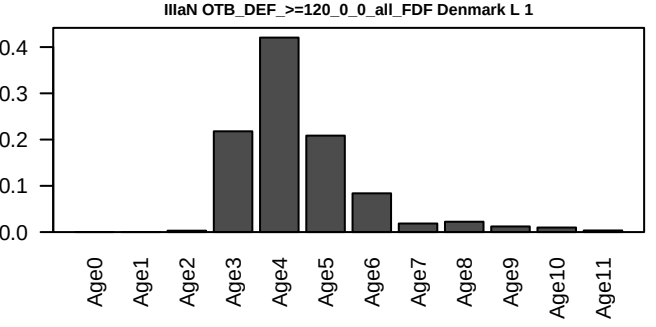

IIIaN OTB_DEF_>=120_0_0_all Denmark D 2
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

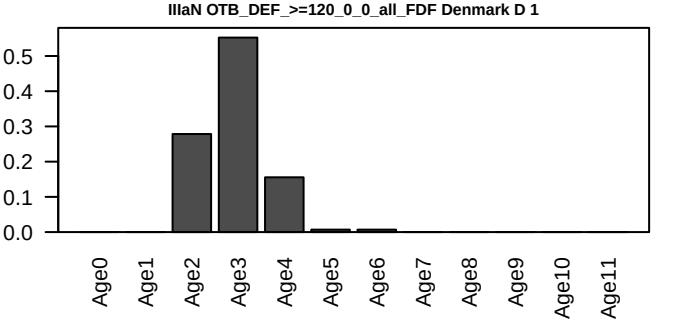

IIIaN OTB_DEF_>=120_0_0_all Denmark L 3
0.5
0.4
0.3
0.2
0.1
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Age0
Age1
Age2
Age3
Age4
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Age6
Age7
Age8
Age9
Age10
Age11

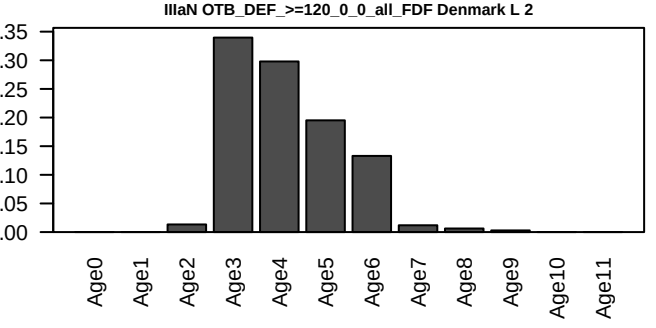

IIIaN OTB_DEF_>=120_0_0_all Denmark D 3
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
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Age9
Age10
Age11

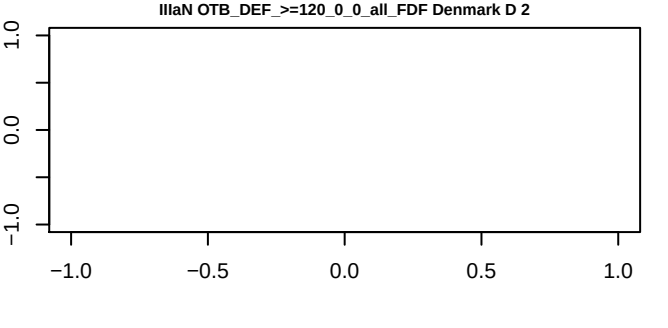

IIIaN OTB_DEF_>=120_0_0_all Denmark L 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

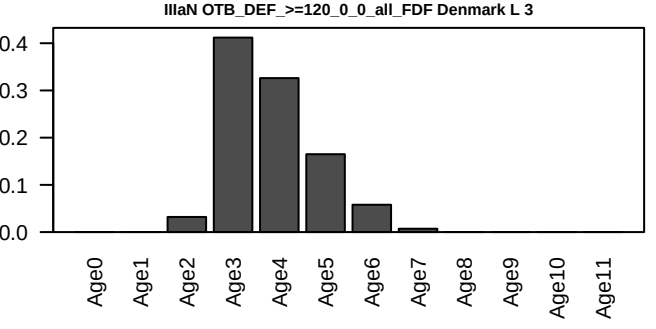

IIIaN OTB_DEF_>=120_0_0_all Denmark D 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

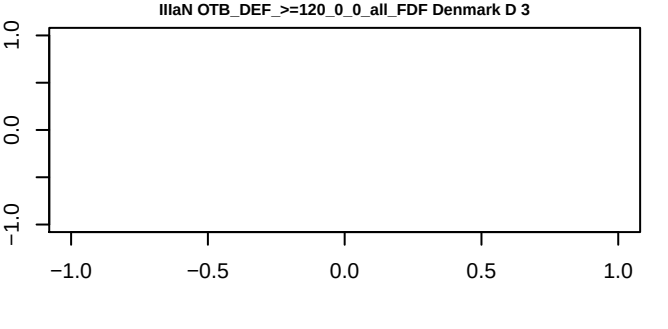

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark L 1
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

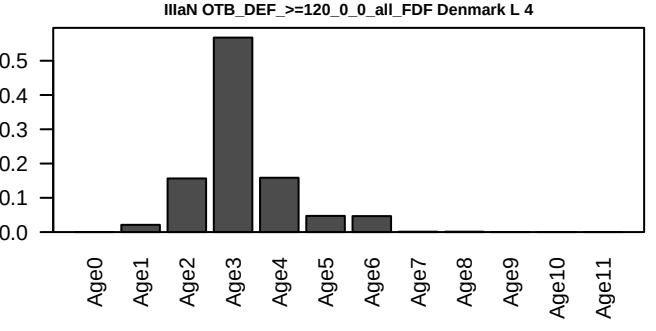

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark D 1
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

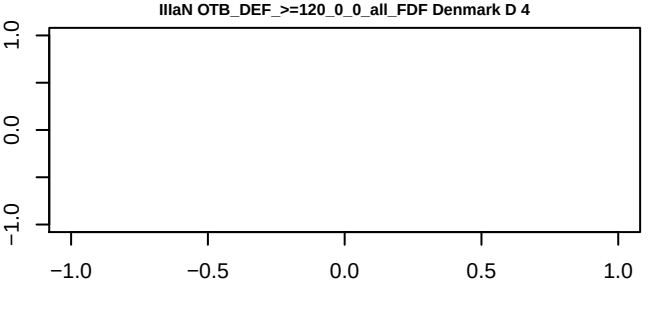

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark L 2
.35
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

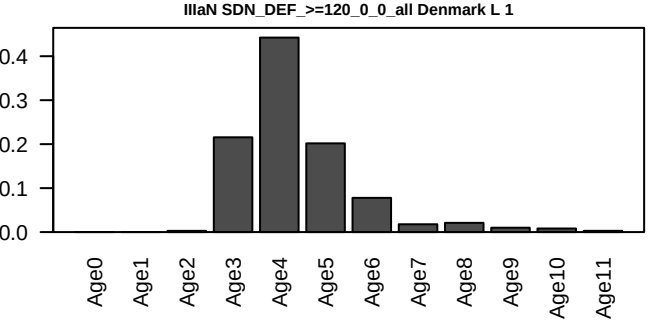

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark D 2
1.0
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−1.0
−1.0
−0.5
0.0
0.5
1.0

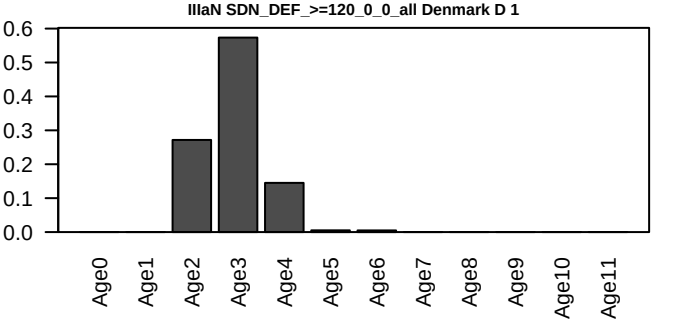

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark L 3
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

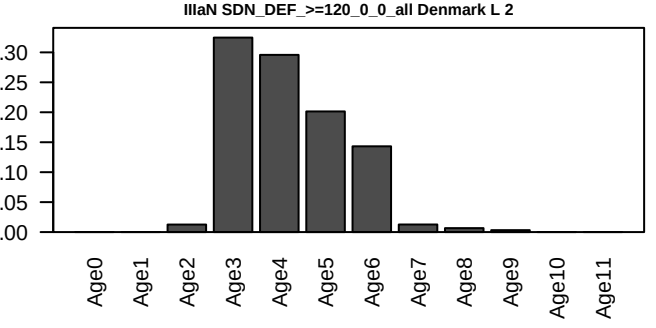

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark D 3
1.0
0.0
−1.0
−1.0
−0.5
0.0
0.5
1.0

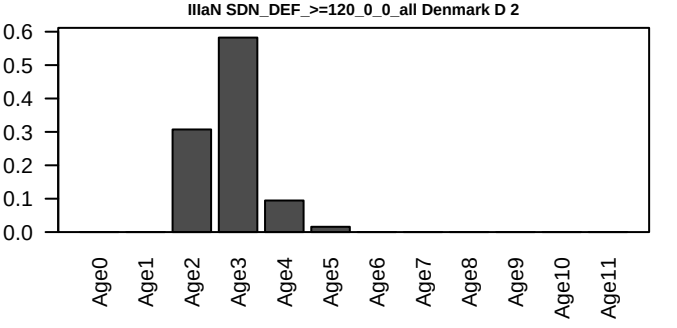

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark L 4
0.5
0.4
0.3
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0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
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Age9
Age10
Age11

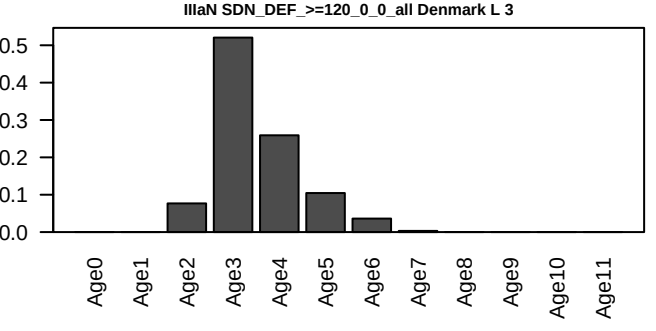

IIIaN OTB_DEF_>=120_0_0_all_FDF Denmark D 4
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−1.0
−0.5
0.0
0.5
1.0

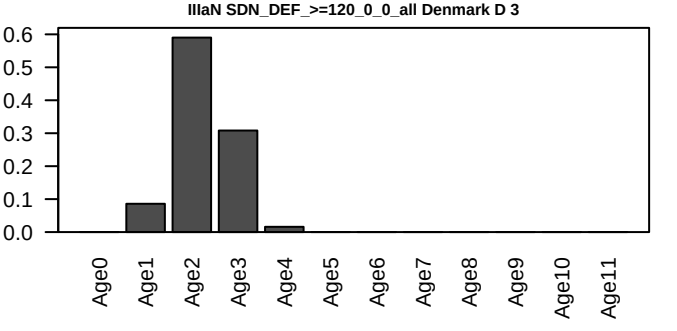

IIIaN SDN_DEF_>=120_0_0_all Denmark L 1
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

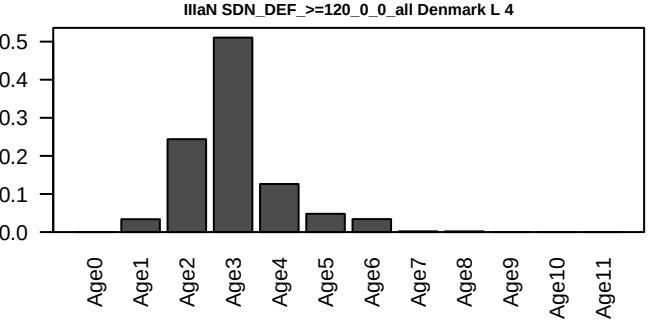

IIIaN SDN_DEF_>=120_0_0_all Denmark D 1
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

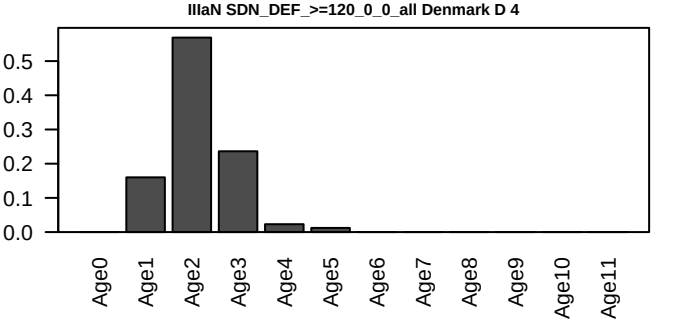

IIIaN SDN_DEF_>=120_0_0_all Denmark L 2
.30
.25
.20
.15
.10
.05
.00
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
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Age10
Age11

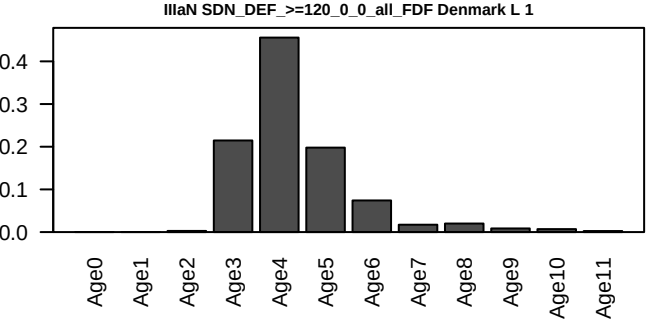

IIIaN SDN_DEF_>=120_0_0_all Denmark D 2
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
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Age6
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Age9
Age10
Age11

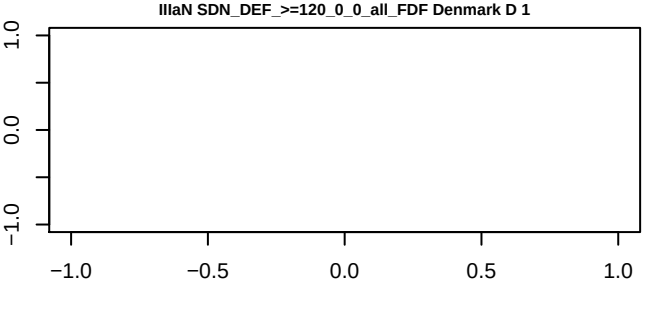

IIIaN SDN_DEF_>=120_0_0_all Denmark L 3
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0.4
0.3
0.2
0.1
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Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

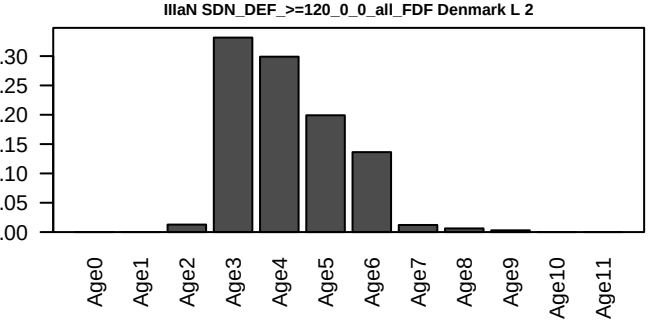

IIIaN SDN_DEF_>=120_0_0_all Denmark D 3
0.6
0.5
0.4
0.3
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0.0
Age0
Age1
Age2
Age3
Age4
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Age6
Age7
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Age9
Age10
Age11

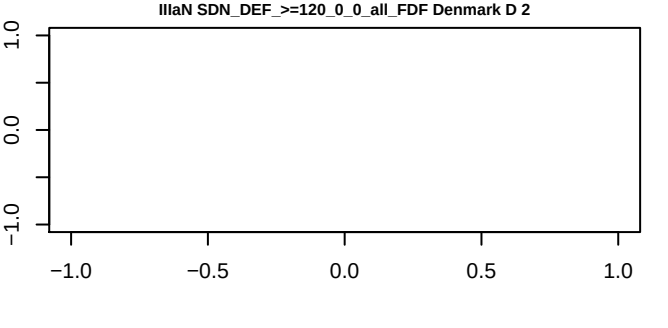

IIIaN SDN_DEF_>=120_0_0_all Denmark L 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

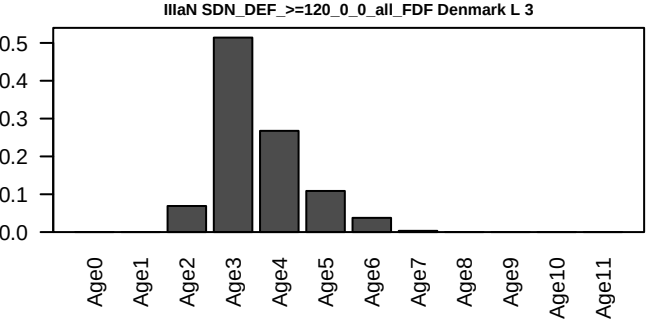

IIIaN SDN_DEF_>=120_0_0_all Denmark D 4
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
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Age6
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Age10
Age11

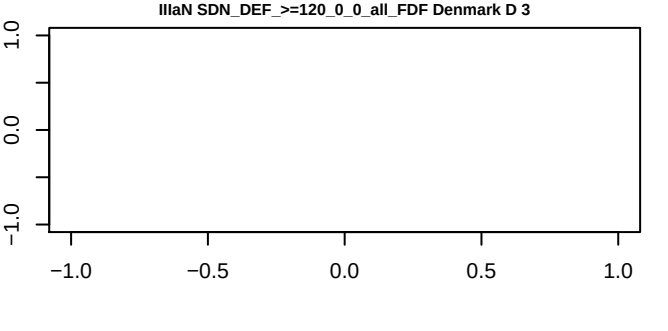

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark L 1
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

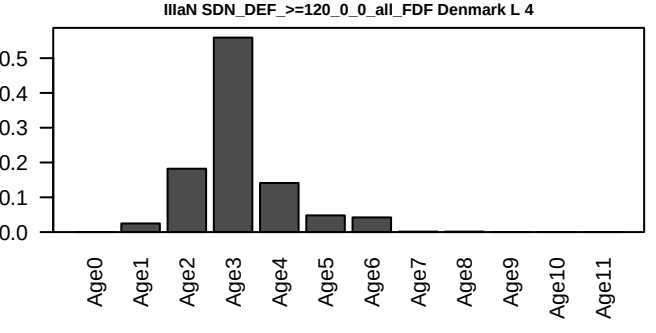

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark D 1
1.0
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−1.0
−1.0
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0.5
1.0

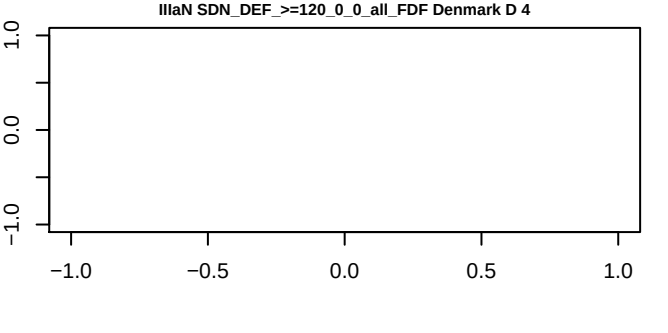

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark L 2
.30
.25
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.15
.10
.05
.00
Age0
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Age9
Age10
Age11

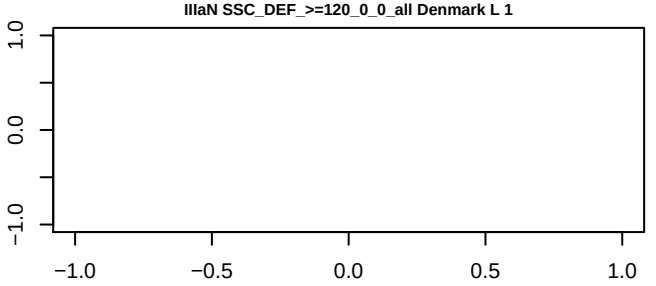

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark D 2
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−1.0
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0.5
1.0

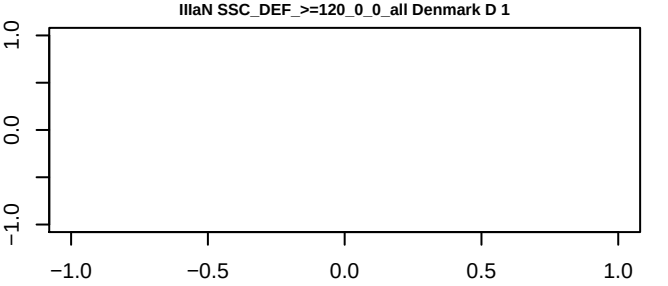

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark L 3
0.5
0.4
0.3
0.2
0.1
0.0
Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

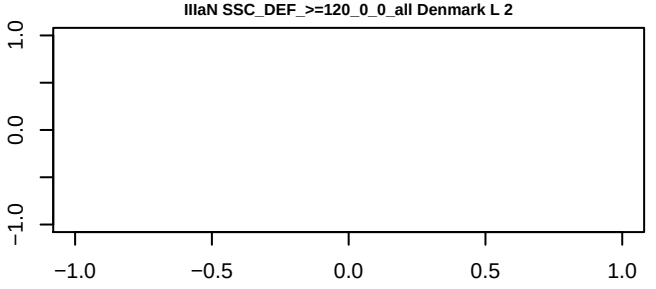

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark D 3
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−1.0
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0.5
1.0

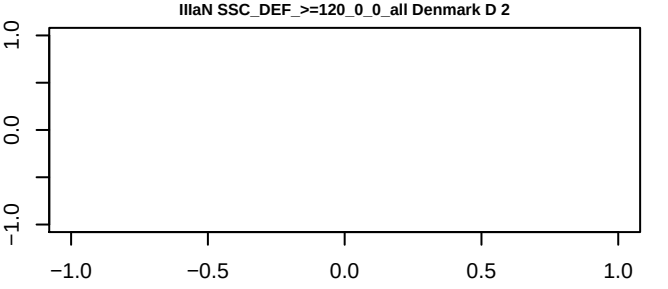

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark L 4
0.5
0.4
0.3
0.2
0.1
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Age0
Age1
Age2
Age3
Age4
Age5
Age6
Age7
Age8
Age9
Age10
Age11

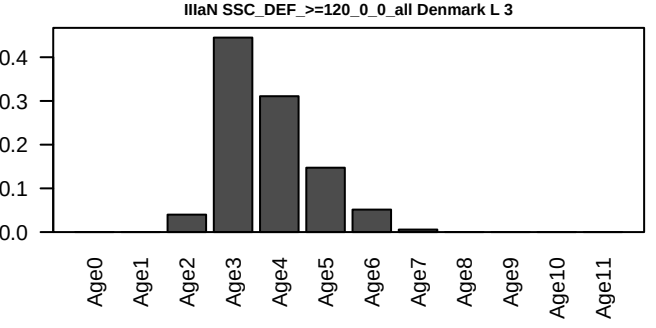

IIIaN SDN_DEF_>=120_0_0_all_FDF Denmark D 4
1.0
0.0
−1.0
−1.0
−0.5
0.0
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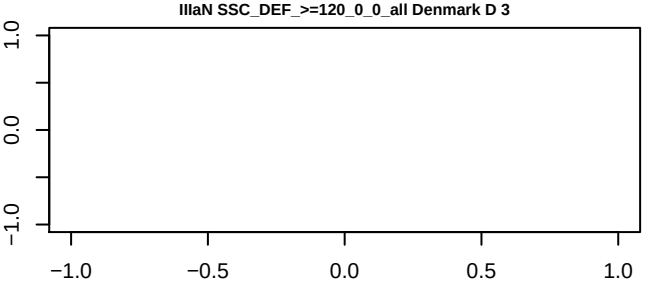

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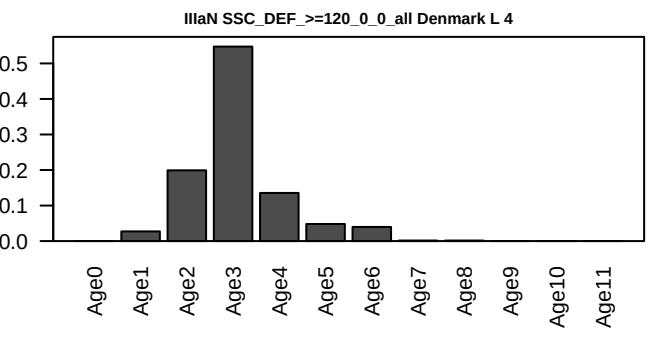

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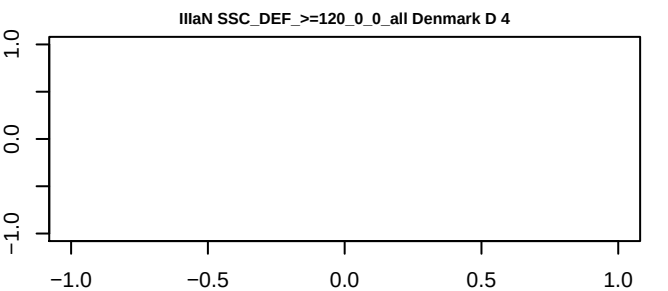

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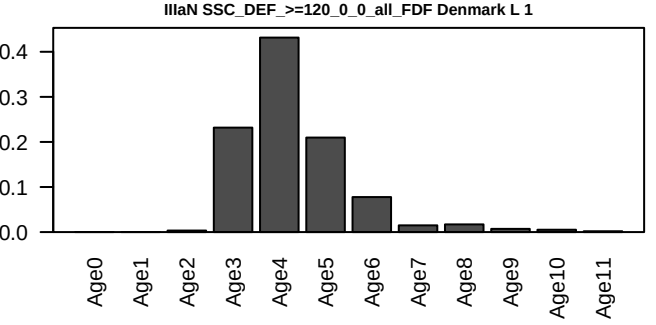

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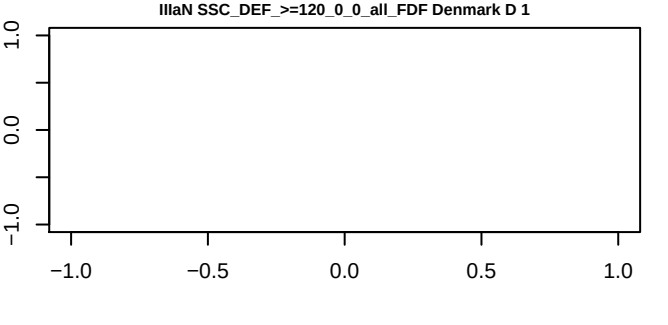

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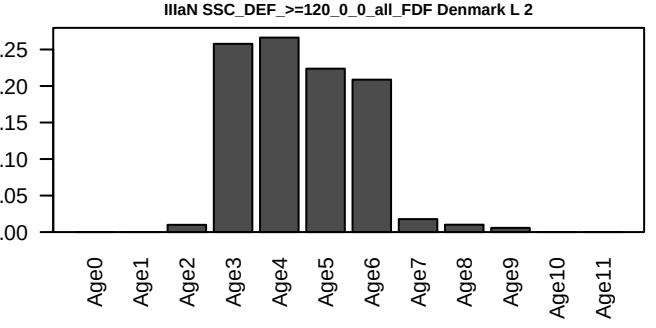

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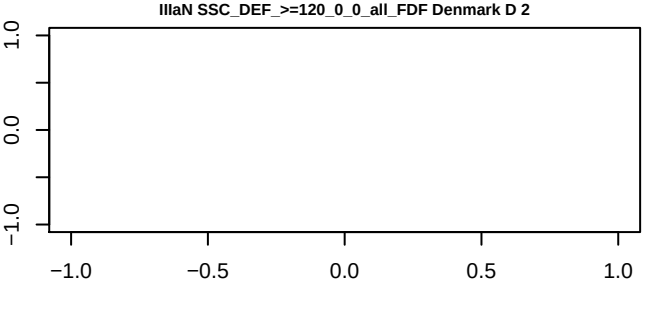

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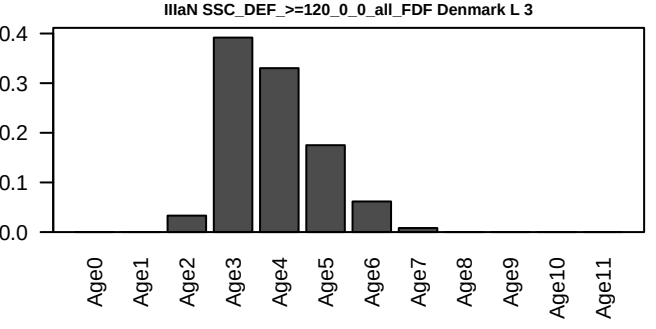

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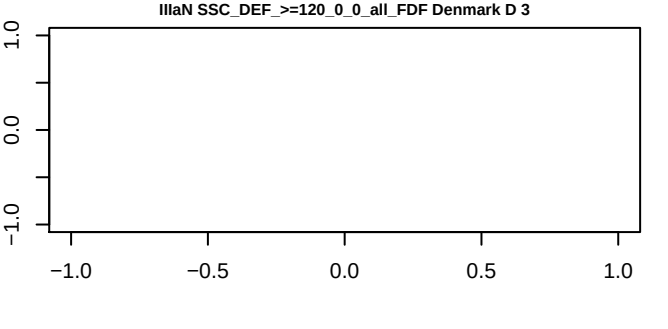

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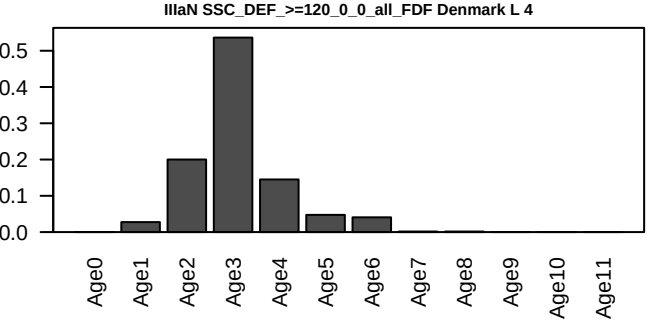

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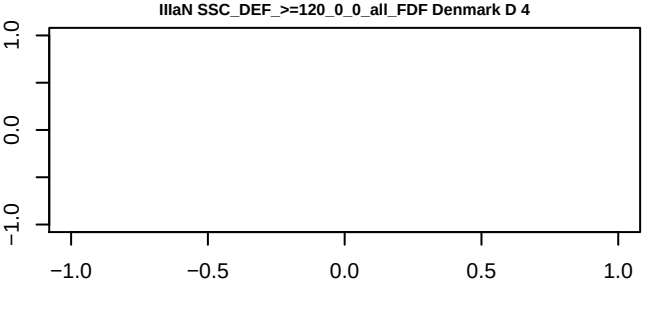

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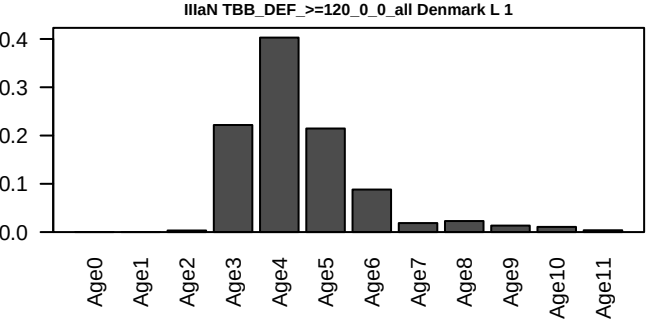

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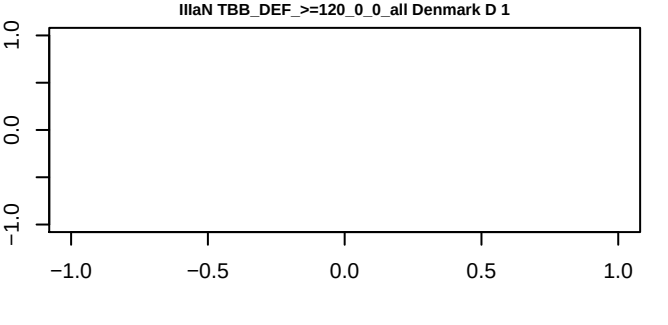

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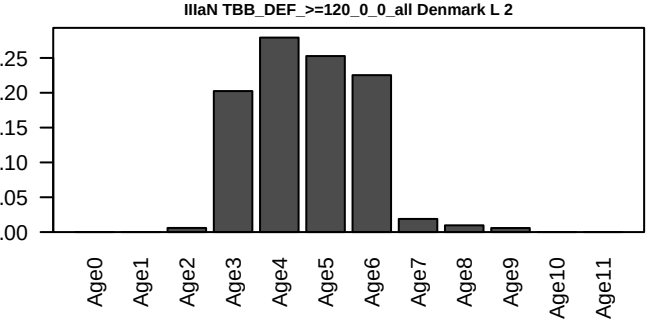

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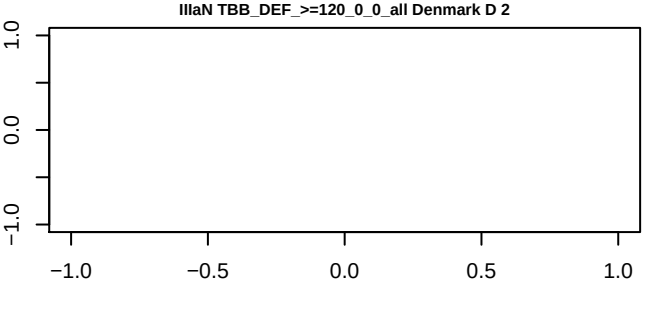

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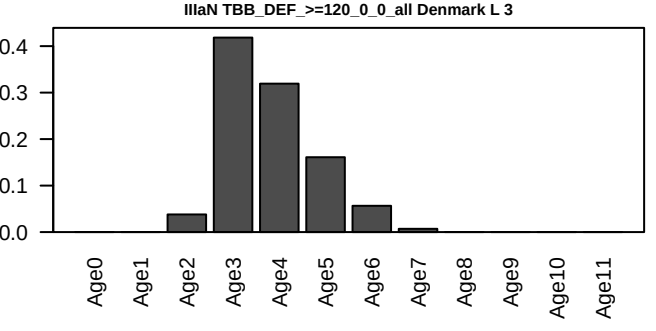

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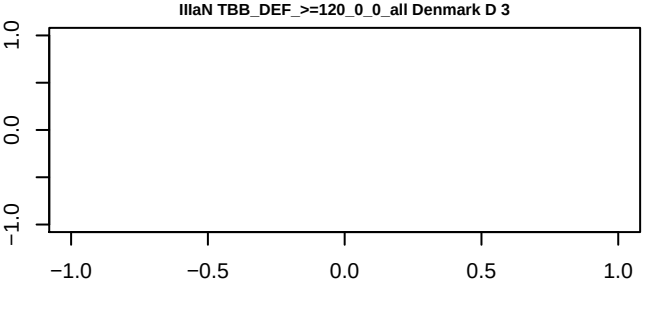

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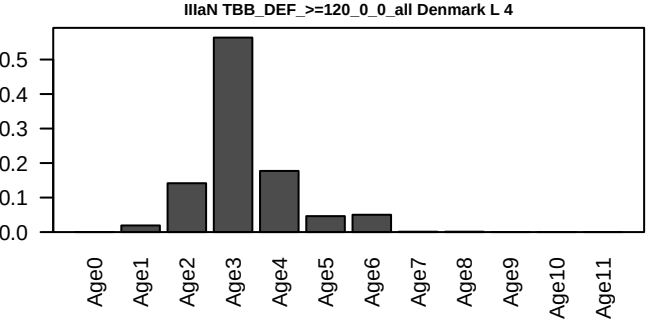

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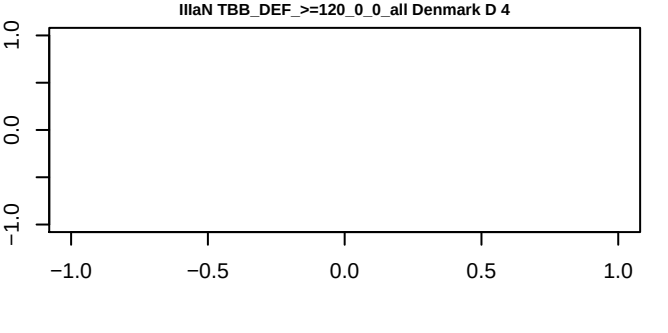

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Working document for ICES WGNSSK, 24-30/4-2013

Sub-structuring of cod populations within the North Sea – evidence from genetic data

Jakob Hemmer-Hansen[1] and Peter Wright[2]

1. DTU Aqua, Section for Marine Living Resources, Denmark
2. Marine Scotland Science, Marine Laboratory, UK

Population structure of Atlantic cod in the North Sea

In Atlantic cod, population genetic research has identified major genetic breaks over large geographical scales, such as between the eastern and western Atlantic (O'Leary *et al.* 2007; Bigg *et al.* 2008) and between North Sea and Baltic Sea populations (Nielsen *et al.* 2001; Nielsen *et al.* 2003). Recent research has also demonstrated significant levels of structuring on much smaller geographical scales, also in the North Sea and adjacent areas (Hutchinson *et al.* 2001; Knutsen *et al.* 2003), and temporal stability of some of these patterns strongly suggest that they are biologically meaningful and not just resulting from high statistical power to detect minute genetic differences between samples (Knutsen *et al.* 2011).

In the northern North Sea, genetic isolation of the Viking Bank from nearby location in Scotland and Norway was suggested by Nielsen *et al.* (2009). This information, along with new genetic and tagging data from the same geographical regions led Wright *et al.* (2011a) to propose the existence a unique population component restricted to deep and cooler waters in the northern North Sea (Figure 1).

Additional support for isolated populations in the northern North Sea was provided in studies employing a suite of Single Nucleotide Polymorphisms (SNPs) by Poulsen *et al.* (2011), who found evidence for a genetically isolated population in the northeastern part of the North Sea (Figure 1, yellow circle) and from the UK NERC supported cod project considered by Wright *et al.* 2011a (Figure 1, red and black dots). The signal in the Poulsen *et al.* (2011) study was primarily driven by one of the 92 genetic markers, suggesting the involvement of natural selection in generating signals of genetic isolation at this location. Recently, this sample from the northeastern North Sea was re-analysed with the use of more

than 1100 SNPs. Furthermore, additional population samples were included in order to facilitate interpretation of results from the North Sea. In this new analysis, the sample from the northeastern part of the North Sea was clearly genetically distinct from other North Sea samples (Figure 2), but seemed to somewhat resemble a Norwegian coastal cod population sample collected near Lofoten. This may suggest some relationship between the Northeast sample and Norwegian coastal cod despite the large geographical distance separating the sampling sites. Such a relationship is consistent with electronic tagging information from a UK study of cod movements (Neat *et al.*, in prep.).

Conclusions

In summary, there is genetic evidence from several studies that at least two semi-independent population components inhabit the northern parts of the North Sea. Importantly, these studies have analysed samples from more than one geographical location and from two different time periods (Viking samples analysed by Nielsen *et al.* (2009) were collected in 2002 and 2003, while samples in the eastern and northeastern part of the North Sea were collected in 2007), and have been supported by the analyses of different types of molecular markers (microsatellites and SNPs). Electronic tagging and tag-recapture studies indicate there is very limited exchange of adult cod between the two regions during any time of year, with cod from the northern region occupying deeper cooler waters all year round (Righton *et al.*, 2010; Neat *et al.*, in prep). Wright *et al.* (2011a) suggested that such sub-structuring could explain differences in survey indexes in northern and southern North Sea regions through a de-coupling of population dynamics in the two regions. Indeed, recent studies have found differences in spawning stock biomass and maturation patterns between cod inhabiting the two regions (Holmes *et al.* 2008; Wright *et al.* 2011b). Thus, the genetic data also aligns with underlying physiological and life-history differences between cod populations within the North Sea, and it is possible that signals normally interpreted as evidence for distributional shifts within the North Sea (Perry *et al.* 2005) instead reflect fluctuating densities within semi-independent population units.

Knowledge gaps

Although the recent studies have advanced our understanding about structuring of cod in the North Sea region, important knowledge gaps still remain. Firstly, the relationship between the northern North Sea populations and populations in nearby region, such as along the southern Norwegian coast and in Skagerrak is poorly known. Thus, future work should focus on

detailed mapping of the geographical distribution of these and other populations of cod in the North Sea, particularly aiming at linking to neighbouring areas. Secondly, seasonal dynamics in the distribution patterns of individual populations as well as the proportion of different population components targeted in mixed stock fisheries is not known at present. Here, genetic markers could be used to assign fish to population of origin and to estimate mixing proportions in mixed fisheries, thereby providing a direct link to fisheries management. Finally, the degree of temporal variation on longer time scales (i.e. 50-100 years) in the northern parts of the North Sea is presently unknown. Retrospective analyses of DNA extracted from archived material (Nielsen & Hansen 2008) could be used to examine temporal changes in the genetic composition of identified populations. With this approach, it would be possible to examine if geographic differences and trends in abundance indexes are explained by migration, shifting distributions of individual populations, or different population dynamics, perhaps even evolutionary response, within each of several independent populations.

Technological developments have allowed population genetics to move from large to smaller spatial and temporal scales of relevance to fisheries management. Thus, it is envisaged that cross-disciplinary work combining genetic information with life-history data, tagging and modelling of migration and juvenile dispersal could provide valuable support for ICES advice and the management of sustainable cod fisheries in the North Sea.

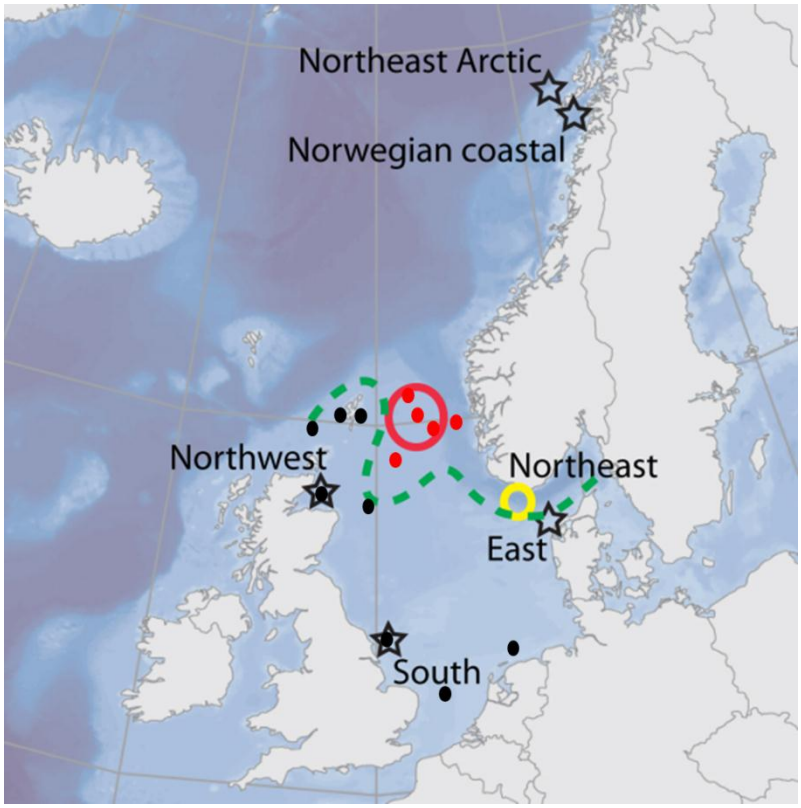


Figure 1. Location of samples analysed for genetic variation. Red circle shows Viking Bank where Nielsen *et al.* (2009) identified a genetically unique population. Yellow circle represents the divergent population identified in Poulsen *et al.* (2011) and in this document. Dots represent sample locations 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).

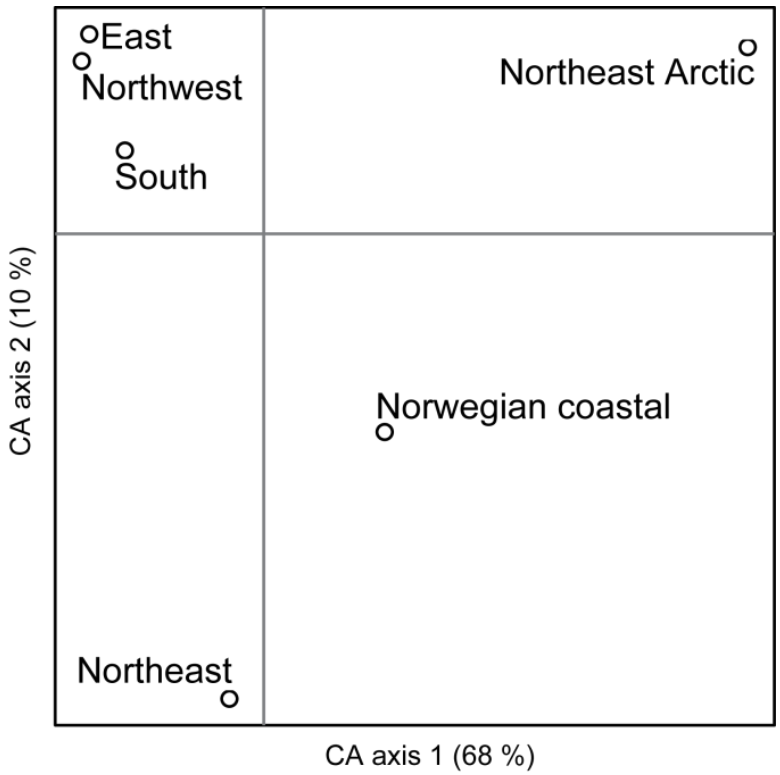


Figure 2. Population relationships among Atlantic cod population samples (stars and yellow circle in Figure 1) as estimated with correspondence analysis on 1141genetic markers.

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