ICES WGNSSK REPORT 2012

ICES ADVISORY COMMITTEE

ICES CM 2012/ACOM:13

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

27 April - 3 May 2012

ICES Headquarters, Copenhagen

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

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

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

Recommended format for purposes of citation:

ICES. 2012. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 27 April - 3 May 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:13.1346 pp.

Contents

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 27 April – 3 May 2012. There were 21 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 the assessment of the stocks.

0.1 Working procedures

Two new stocks were added to the groups Terms of Reference, Grey Gurnard and Striped Red Mullet in the North Sea ecoregion. These stocks were first dealt with by WGNEW, and then passed to WGNSSK. Full analytical assessments were not possible (and will likely not be for several years to come) and the Group was restricted to compiling landings and some effort data.

There were significant progresses achieved in the quality of the data collection process. Notably, the ICES WGMIXFISH initiated in late 2011 a joint data call aiming a merging data needs for both WGNSSK and WGMIXFISH groups, through using catch and effort reporting by country and métiers defined according to the various national sampling programs from the Data Collection Framework (DCF) and making use of the ICES InterCatch database for storing and raising the data. The deadline for providing national data had be set up through an official ICES data call to 4 weeks before the WG, and was followed by most countries. However, some data issues were discovered afterwards, and furthermore the process of raising discards ratio and age distribution proved to be highly time-consuming, and consequently not all data were ready in due time and some preliminary assessments were delayed.

In 2012, only Norway Pout assessment was benchmarked, and the new setup was used by WGNSSK. Furthermore, extensive discussion have taken place in 2012 about the stock identity of plaice in IIIa, as well as about alternative options for that stock, whose assessment has been considered too uncertain to form the basis of advice for many years. Consequently, this report contains both the old setup of the assessment of plaice IIIa, as well as an alternative assessment of plaice in Kattegat, Belt Sea and Sound (SD 21-23) and options for management of plaice in Skagerrak.

0.2 State of the Stocks

The yields for stocks of ***Nephrops*** are fairly stable from year to year. Reported landings for FU 3 (Skagerrak) and FU 4 (Kattegat) have averaged 2500t and 1500t respectively since 2000 with relatively little variation. There are no signs of overexploitation in IIIa and given the apparent stability of the stock, the current levels of exploitation appear to be sustainable.

Landings from almost all FUs in area IV in 2010 were reduced from the 2009 values and overall there was a ~16% reduction in landings. TV survey results for FUs 7, 8 and 9 were also slightly reduced although the stocks in these areas are considered to be harvested sustainably. In FU6 where there has been concern in recent years a small increase was observed in the TV survey but concern regarding the status of the stock remains.

The **Norway Pout** fishery has fluctuated considerably in recent years with full or partial closures in 2005, 2006, and 2007 due to very low recruitments in 2003 & 2004. Again now, the stock size has decreased significantly since 2011 due to the very low recruitment in 2010 and 2011. 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). The status of the stock is mainly determined by natural processes and recruitment.

Since 2010 the **sandeel** assessment has moved from a single region to 7 distinct regions, for which analytical assessments can be undertaken for 3 areas (covering the majority of the fishery). The sandeel assessments rely upon the DTU-Aqua dredge survey undertaken in December to provide sufficient data to estimate the size of the incoming year class 0-group in areas SA1 (Dogger) and SA2 (SE North Sea). The stock assessments of Sandeels are therefore performed in January. However the ICES assessment and advice, March 2012 (ICES 2012), estimated of a low TAC (23 000 t) of sandeel in Area 1 for 2012, due to very low 2010 and 2011 year classes. There had been concerns that bad weather conditions during the 2011 survey might have biased the estimate of the 2011 year class, and Real Time Monitoring (RTM) for 2012 was therefore performed in April and May 2012, but this led to an even lower advice.

Assessment of **cod in Subarea IV and Divisions IIIa and VIId** was comprehensively revised in 2011. The assessment model was moved from B-Adapt to SAM in order to utilise a stronger statistical basis and provide a more stable estimate of exploitation in recent years. Following the difficulties encountered with the 3rd quarter IBTS survey this dataset has been removed from the assessment until the discrepancies are better understood. Estimated spawning-stock biomass reached a low in 2006 but has subsequently increased and is now just below B_{lim}. Fishing mortality declined from 2000 and is now below F_{pa}, but is estimated to be well above FMSY

Fishing mortality for **Haddock in area IV and IIIa** 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.

Whiting in IV and VIId is in a relatively good state. SSB has increased on the back of three average recruitments indicating that the stock has emerged from the period of successive low recruitment. Fishing mortality continues to decline. MSY reference points remain undefined for this stock.

A number of improvements to the assessment of **Saithe in IIIa, IV and VI** have been provided in 2012. Age distribution of Norwegian catch data for 2010 has been revised substantially, and the overall quality of the assessment has improved. The status of the stock has deteriorated in the last few years.

There is a common theme of decreasing fishing mortality, average to good recruitments and correspondingly increasing SSB across the plaice and sole stocks in the North Sea and Eastern Channel.

The fishing mortality for **Sole in IV** is estimated to have decreased in recent years, although not as much as for **Plaice in IV** (the management plans for these two stocks being linked). For Plaice, fishing mortality is estimated to be at the F_{msy} value whereas the estimate for Sole is above F_{msy} but below F_{pa}. Recent recruitment for both stocks has been average or above and as a result the spawning stocks of both species are at or above MSY $B_{trigger}$, particularly so for the Plaice stock.

Like its North Sea counterpart, the stock of Sole in **VIId** is estimated to be well above MSY $B_{trigger}$ following a sequence of higher recruitments although the fishing mortality value continues to be above both F_{msy} and F_{pa}.

Landings data for **Pollack** (*Pollachius pollachius*) in **IV and IIIa** were compiled. From these data two fairly distinct centres of distribution exist; one in the northern North Sea/Skagerrak extending north along the Norwegian coast, and 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. Landings from the intermediate areas (VIa and IVc) are generally small.

1 General

1.1 Terms of Reference

2011/2/ACOM14 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, 27 April – 3 May 2012 to:

a) Address generic ToRs for Fish Stock Assessment Working Groups (see table below). The Sandeel and Norway pout assessments shall be developed by correspondence;

b) Assess the progress on the benchmark preparations and planning.

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

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

WGNSSK will report by 3 February (on sandeel), 11 May (all stocks except sandeel) and 21 September 2012 (Norway pout) for the attention of ACOM. The group will report on the AGCREFA 2012 procedure on reopening 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)				Regional update
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)				Regional update
nep-5	*Nephrops* in Division IVbc (Botney Gut - Silver Pit, FU 5)	UK(England)	UK(England)	Denmark	Biennial 1st year
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	Biennial 1st year
nep-32	*Nephrops* in Division IVa (Norwegian Deeps, FU 32)	Norway	Norway	Denmark	Biennial 1st year
nep-33	*Nephrops* in Division IVb (Off Horn Reef, FU 33)	Denmark	Denmark	Sweden	Biennial 1st year

nep-iiia	*Nephrops* in Division IIIa (Skagerak Kattegat, FU 3,4)	Denmark	Denmark	Sweden	Update
nop-34	Norway Pout in Subarea IV and Division IIIa	Denmark	Denmark	Norway	Update
ple-eche	Plaice in Division VIId (Eastern Channel)	France	France	Belgium	Update
ple-kask	Plaice in Division IIIa (Skagerrak - Kattegat)	Denmark	Denmark	Sweden	Update
ple-nsea	Plaice Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Update
pol-nsea	Pollack in Subarea IV and Division IIIa				Regional update
sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)	Norway	Norway	Germany	Update
san-nsea	Sandeel in Division IIIa and Subarea IV	Denmark	Denmark	Norway	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	Update

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

The working group should focus on:

ToRs a) to g) for stocks that will have advice (or biennial first year),

ToRs b) to d) and f) for stocks with biennial advice in the second year

a) 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).

b) Update, quality check and report relevant data for the working group:

   i) Load fisheries data on effort and catches (landings, discards, bycatch, including estimates of misreporting when appropriate) in the INTERCATCH database by fisheries/fleets. 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;

   ii) Abundance survey results;

   iii) Environmental drivers.

   iv) Propose specific actions to be taken to improve the quality of the data (including improvements in data collection). Where relevant suggest improvement for the revision of the DCF.

c) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database and report the use of InterCatch;

d) 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.

e) For each stock update the assessment by applying the agreed assessment method (analytical, forecast or trends indicators) as described in the stock annex. If no stock annex is available this should be prepared prior to the meeting.

f) Produce a brief report of the work carried out by the Working Group. This report should summarise for the stocks and fisheries where the item is relevant:

   i) Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);
   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   iii) Stock status and catch options for next year;
   iv) Historical performance of the assessment and brief description of quality issues with the assessment;
   v) Mixed fisheries overview and considerations;
   vi) Species interaction effects and ecosystem drivers;
   vii) Ecosystem effects of fisheries;
   viii) Effects of regulatory changes on the assessment or projections;

g) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AGCREFA2 (2012 report).

The ToRs specific to the individual stocks are dealt with within the relevant stock sections. New sections compared to previous years assessment include 1) new sections dealing with the new MoU species grey gurnard (section XX) and striped red mullet (Section XX), following upon the work by WGNEW 2012, and 2) an entire new section addressing alternative assessment and possible advice for the plaice in area IIIa, following the work performed by ICES WKPESTO 2012 (Workshop on the Evaluation of Plaice Stocks)

Below is a overview of the ToRs of more generic aspects (ToRs b) and f)

1.2 InterCatch

1.2.1 A new 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.

A pilot trial was conducted between September and December 2011 using 2010 data, and the final setup was officialised by a data call issued by ICES on February 24th 2012 (see WGMIXFISH 2012 report). Data were submitted by individual countries by March 30th, and the subsequent data collation was performed by the respective stock coordinators using InterCatch features, involving two processes: 1) inferring of unreported discards using existing discards ratios reported for some other strata and 2) allocation of age structure (numbers at age and mean weight at age) for the strata with only bulk weight landings and discards based on raising from some other samled strata.

While these procedures are straightforward enough when data are only reported by country, they become significantly more complex when numerous metiers are involved. WGMIXFISH had suggested an *a-priori* hierarchy, that was presented to the ICES WGCHAIRS in January 2012, and slightly revised by WGNSSK during the actual raising. The hierarchy was as follows:

a) Assign across nations first.

b) Assign across quarter second.

c) Assign across country and quarter third.

d) Assign across metier tag forth. Allow substitution of similar gear types (e.g. SSC for OTB).

e) e. Assign across area as last resort.

If none of the above can be used then all raised information should be used in order to derive an average distribution.

In addition, it was suggested that :

* Inferring discards ratio should be by default be done using "landings CATON" procedure.

* Inferring age distribution should be by default be done using "Mean weight weighted by numbers at age or length"

1.2.2 Outcomes and issues encountered

Overall, the catch data were thus required into much more detailed strata than before. It had been anticipated that some errors in national data could occur; therefore additional buffer time had been planned. And indeed, a number of errors were spotted during the raising process, and some data had to be corrected and imported again. This brought significant delays in the completion of data sets. In particular, it was experienced that previous allocations and raising were imperfectly copied to an updated dataset, meaning that a lot of allocations procedures, which in themselves are largely manual and time-consuming, had to be redone by the stock coordinator a number of times. This InterCatch issue was known before but wasn't a tremendous problem as long as data were only submitted by country – however this turned to be a major source of time waste and frustration when the datasets grow to so many strata.

A single incident for cod in the North Sea (cod-nsea) also occurred, where a copying of the set up of unreported discards failed abnormally.

All together, the raising of metier-based data with InterCatch involves a lot of manual steps that must be taken sequentially. Even in the absence of errors, this can be very time-consuming, especially when remote connections are slow.

Finally, it was felt that the responsibility falling on the stock coordinator is very large, as it must be taken decision on behalf of other countries on the best estimates for raising discards and age structure, and the stock coordinator may not necessarily have the proper knowledge to do so.

Since this year was the first time WGNSSK used InterCatch for so many stocks, data submitters and stock coordinators had also to learn new formats and a new system. All users will be also more confident and knowledgeable in the future, which might also ease the future use of Intercatch.

Nevertheless, the WGNSSK acknowledged that InterCatch appeared to be a suitable and powerful tool that would fulfil the needs and works after its requirements. In spite of the many issues encountered this year, which must be seen as a transition year within a wider process, it was felt that this was an improvement compared to the previous spreadsheet-based raising processes, allowing for a much better transparency and improved knowledge and communication on the basic data. A comparison of the age composition obtained with InterCatch and some of these spreadsheets showed overall good agreement, and the assessment time series were therefore not broken up.

1.2.3 Future improvements

In conclusion, the new data process engaged by WGNSSK and WGMIXFISH led to major improvements in the availability and transparency of the data used in the assessment. But it represented also the largest challenge ever for testing the abilities of the InterCatch database. A number of positive and negative feedbacks were returned to the ICES secretariat, and a list of tasks for improvements before next year has been established in collaboration:

- The main concern by far is the lengthy process of raising discards and allocating age/length structure for every single stratum one after the other. This requires a lot of manual clicking, which is both time-consuming and boring, but also error-prone as it is not possible to keep concentration high throughout the many strata. Allocations choices end up also being largely blind guess, as the stock coordinators do not have enough knowledge on the best allocation schemes to choose Some suggestions have been put forward to smooth this. One way could be to be able set up unreported discards and allocations schemes by groups of strata, thus reducing significantly the amount of manual procedures. Another way could be to have an automatic algorithm pre-programmed which would do all or most of the fill in by default, and the stock coordinator would have the responsibility to inspect the result (for example by visual inspection of the average discards ratios used for setting-up unreported discards). Ideally, some (graphical) output functions should be developed to ease the overview of existing discards ratio and age structure by sampled strata. ICES secretariat will work together with ICES WGNSSK and WGMIXFISH in the near future to find out the best technical improvements that can be provided before next year.
- Also, in order to reduce the responsibility of the stock coordinator to take decisions on behalf of other countries, discussion on best allocation schemes should be taken together with national data submitters, for example by We-

bex. ICEs PGCCDBS recommended also the establishment of such regional data workshops ahead of EGs,

- InterCatch have been designed after a stepwise approach where the stock coordinator first import all data. When all data have been imported and are correct, then the stock coordinators add unreported discards, if the stock includes discards, finally the age allocations are done. But in reality, it was experienced that InterCatch was used more sporadically, for example the some allocations of unsampled catches were started before the raising of unreported discards was completed. This means that InterCatch should ideally be more dynamic and support this way of working. A new feature, where it is possible to add unreported discards to the list of unsampled catches after allocations have been started, was implemented during the WGNSSK meeting, to support the need.
- For *Nephrops* stocks it was requested to produce outputs of numbers at length (or age) per quarter per sex. This have been implemented in InterCatch just before WGNSSK
- As mentioned above, a great issue is the fact that existing allocations are improperly copied out to an updated dataset if data have been corrected. ICES Secretariat will make sure this works better in the near future.
- Currently, InterCatch refreshes the webpage each time a choice is made (each click), which is difficult to cope with when Internet connections are slow. ICES Secretariat will make sure this works better.
- It is so far not intuitive to edit again and make changes to existing allocations schemes, which seem locked out after they have been defined once. ICES Secretariat will look into this

In conclusion, the use of InterCatch for the collation and raising of metier-based data for the needs of both WGNSSK and WGMIXFISH was globally a positive, albeit difficult and sometimes even painful experience. There is a common agreement that provided that the technical improvements mentioned above are implemented and tested in due time before the next WG season, this process will continue. This represents also a major step towards the Regional Data Bases, given that a number of the issues encountered here will likely be of similar type when using these RDB in the future.

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	In parallel with another	Comparison with the historical spreadsheets with data provided by country and year	Small and acceptable	
Cod-3a47d	In parallel with another tool	Comparison with the historical spreadsheets with data provided by country and year	Small and acceptable	
had-3a4	In parallel with another tool	Comparison with the historical spreadsheets with data provided by country and year	Small and acceptable	
NOP34		Norwegian data is missing		
Sai-3a46		Used		
Ple-7d		Used		
Sol-7d		Used		
Ple-3a		Used		
whg-3a		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		Used		
NEP 5		Used		
NEP 6		Used		
NEP 7		Used		
NEP 8		Used		
NEP 9		Used		
NEP 10		Used		
NEP iiia	In parallel with another tool	Used		
NEP 32		Used		
NEP 33		Used		
NEP 34		Used		

Pollack	No age data collected
Grey gurnard	No age data collected
Stripped red mullet	No age data collected

1.3 IBTS data

As in 2011, WGNSSK has again experienced significant delays and issues regarding IBTS indices delivered from ICES DATRAS. These were again largely linked to quality control issues in resubmission of old data sets by national labs. WGNSSK recommends a strengthening in filter checks when uploading data, a version control allowing an simpler comparison of datasets, and a better communication flow (notably between people dealing with IBTS data and people attending WGNSSK within the labs themselves) allowing information on which data changes have been submitted and why. WGNSSK recommends also a "resubmission ban" or a gateway scheme where no recalculations are performed within the two weeks before the WG meeting (consistently with EG's ToRs), to avoid changes in the indices after the data compilation has started..

In 2010, WGNSSK expressed concerned that the IBTS indices did not appear robust to the hindrance of some nations to conduct their survey, and evidenced changes in catchability in IBTS Q3 over time. In 2011, The Inter-Benchmark workshop for the assessment of North Sea Cod (WKCOD 2011) recommended the establishment of a Working Group on improving the use of survey data for assessment and advice, that would look at such issues. The 2012 WGNSSK supports entirely this suggestion and recommended therefore that this group was established. However in 2012 such a group, WKISDAA was established but WGNSSK does not believe that this issue has been addressed and recommends therefore that this is investigated further

1.4 Multispecies assessment and new natural mortalities

A new keyrun with the stochastic multi species assessment model SMS has been provided by the Working Group on Multi Species Stock Assessment Methods (for details see WGSAM 2011). SMS estimates of natural mortality (M= M2 (predation mortality) + M1 (residual mortality)) are used for the assessments of cod and whiting. Therefore, results of the new keyrun are of interest for WGNSSK and it was decided during WGNSSK to use the newest natural mortality estimates from keyrun 2011 for the 2012 assessments of cod and whiting.

Compared to the last keyrun in 2008 three major things have been changed:

- Seals and harbour porpoise were included as predators. While seals were also part of the MSVPA runs up to 2005, harbour porpoise was included for the very first time. Stomach samples were available from three decades, however, sample size was low and samples were mainly from stranded animals.

Table 1.4.1 Number of harbour porpoise stomachs analysed per country and decade

Decade	UK	Denmark
1980–1989	0	40
1990–1999	46	62
2000–2009	56	10

- Inclusion of sprat as dynamic prey
- Change from a log-normal to a dirichlet distribution to estimate the likelihood of relative stomach content distributions

The inclusion of seals and harbour porpose as new predators had the highest impact on SMS results from the three changes mentioned. Harbour porpoise are estimated to be a major predator in especially for cod and whiting (Figure 1.4.1). Species as Haddock and Norway pout are less impacted.

Compared to the 2008 keyrun the changes in model setup led to substantially higher recruitment estimates for cod (Figure 1.4.2). SSB and F were only impacted to a minor extent. For whiting larger changes were also estimated for SSB and F. Recruits and SSB were higher in keyrun 2011 compared to keyrun 2008, while F was estimated to be lower (1.4.3).

The inclusion of the new predators in keyrun 2011 led to higher M2 values for cod age 0 to 3 (Figure 1.4.4). The trend over time was similar in both runs despite for age 3 where now an increasing trend was visible while predation in the former keyrun was close to 0. For whiting, M2 values were higher for all age groups (Figure 1.4.5). Only for age 0 estimates remained nearly unchanged.

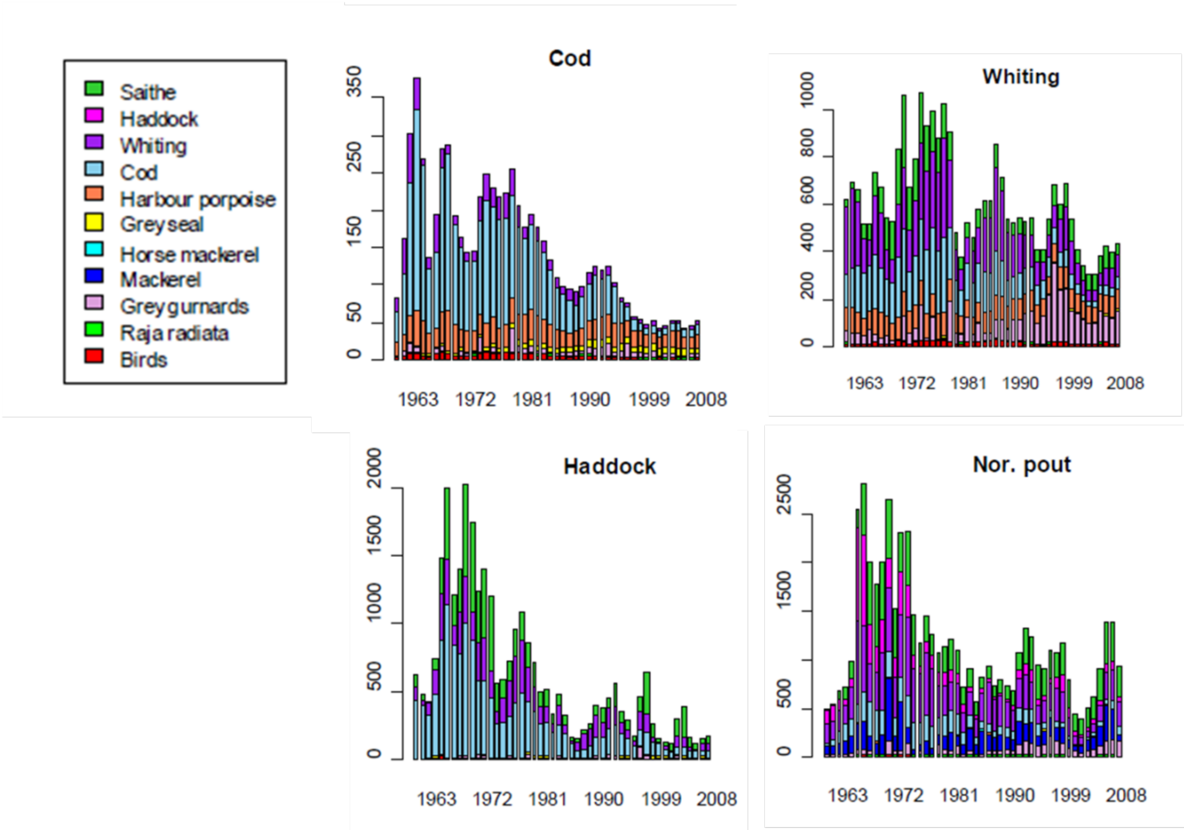


Figure 1.4.1. Time series of biomass eaten by each predator in the SMS keyrun 2011

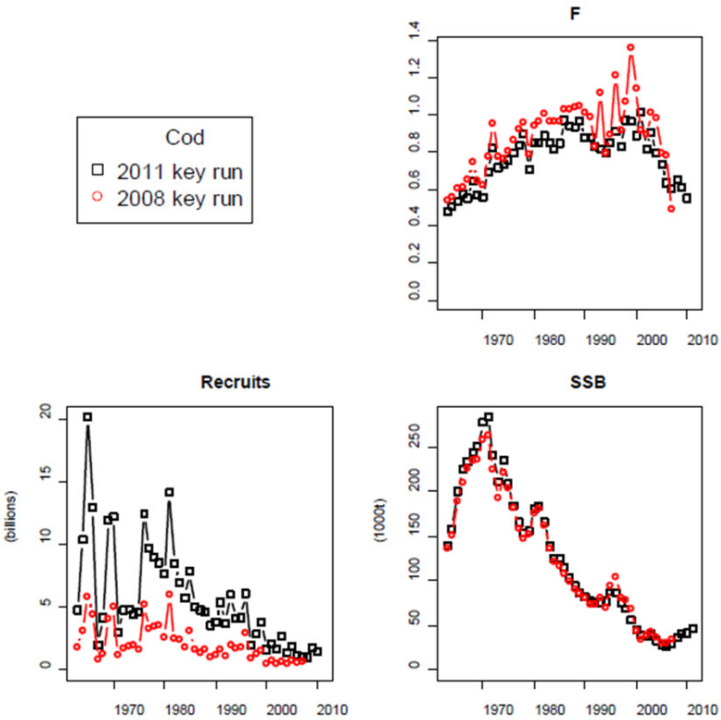


Figure 1.4.2. Comparison of main results between keyrun 2011 and 2008 for cod

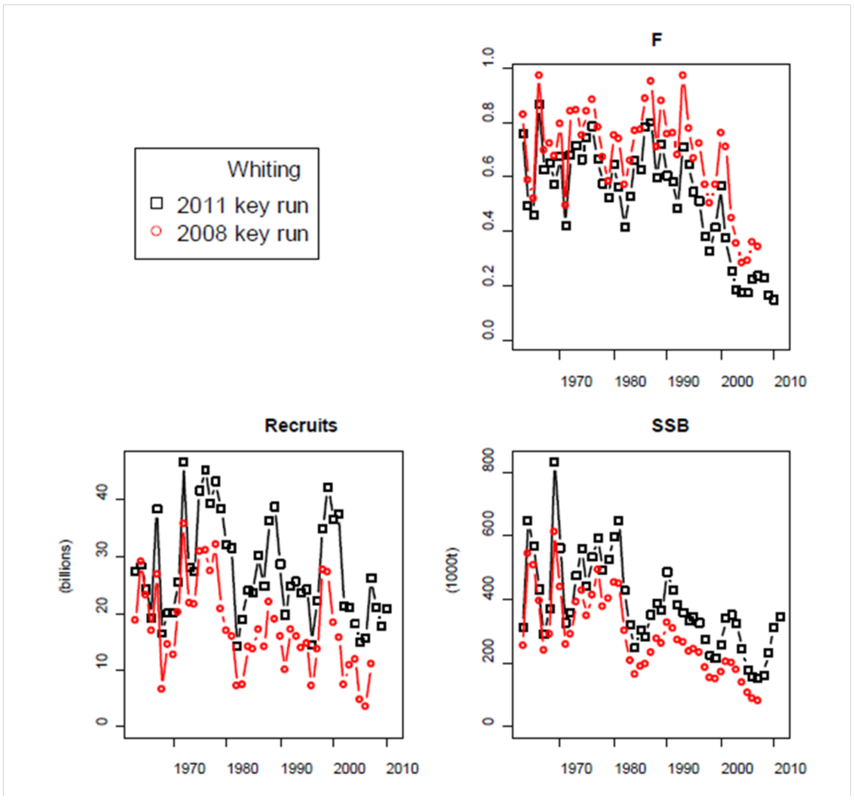


Figure 1.4.3. Comparison of main results between keyrun 2011 and 2008 for whiting

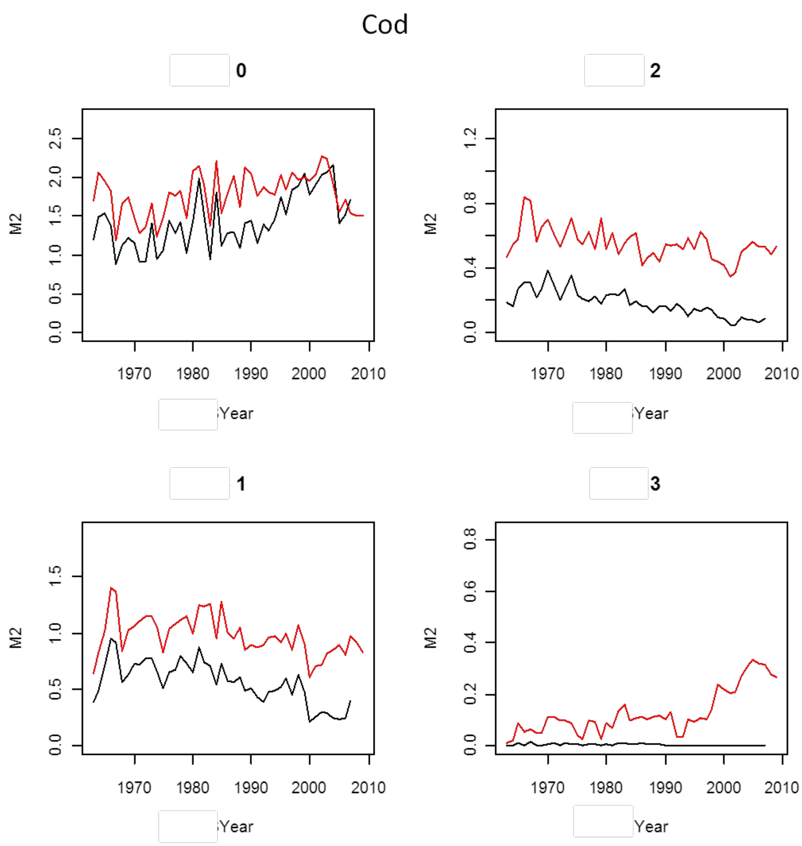


Figure 1.4.4. Comparison of M2 estimates between keyrun 2008 (black line) and keyrun 2011 (red line) for cod age 0 to age 3.

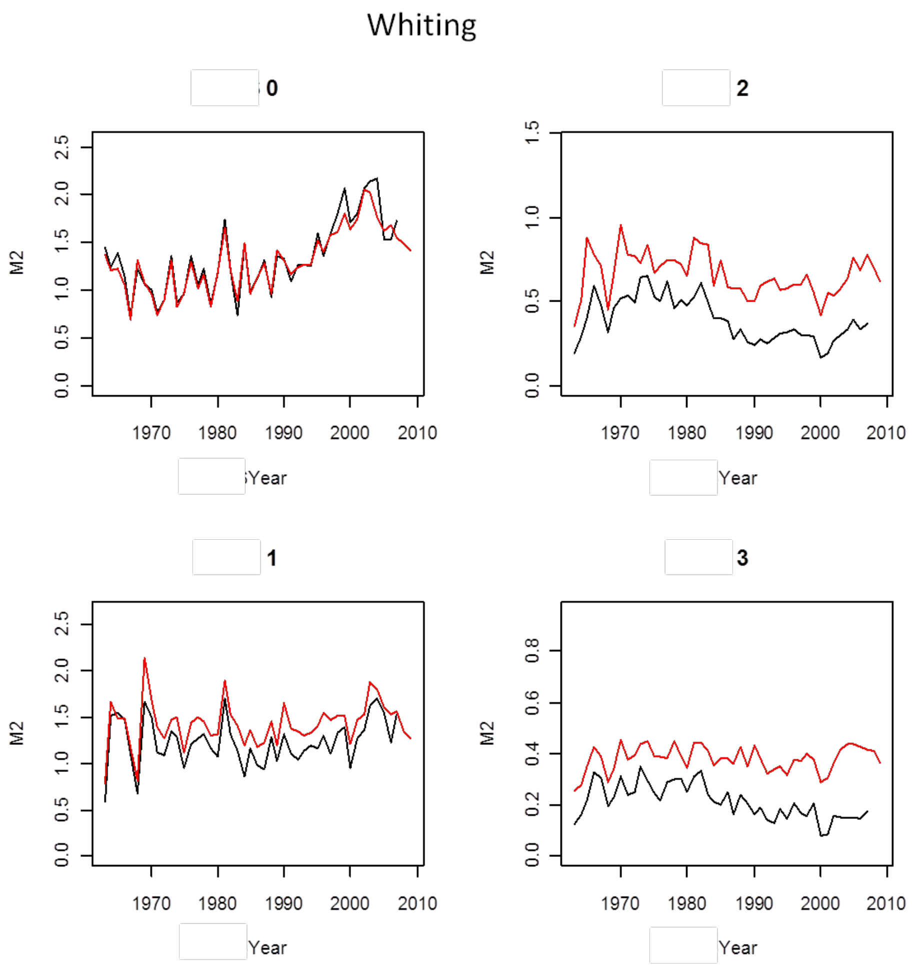


Figure 1.4.5. Comparison of M2 estimates between keyrun 2008 (black line) and keyrun 2011 (red line) for whiting age 0 to age 3.

1.5 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 in 2012, which greatly improved the quality and scheduling of data delivery. As a consequence, WGMIXFISH could meet in May 2012 instead of August as in previous years, and mixed-fisheries advice for the North Sea was integrated into single stock advice for the first time in 2012.

It I therefore referred to ICES WGMIXFISH 2012 report for any further description of mixed-fisheries context.

1.6 North Sea Stock Survey (NSSS)

The Fishers' North Sea Stock Survey (www.nsss.eu) is an annual survey of Fishers' perceptions of the state of fish stocks in the North Sea, with the aim of making this knowledge available to fisheries scientists and fisheries managers.

The survey uses questionnaires circulated to fishermen in Belgium, Denmark, England, the Netherlands, and Scotland. Fishermen are asked to record their perceptions of how the abundance, size range, discards and recruitment of eight species of fish (cod, common sole, haddock, monkfish, *Nephrops*, plaice, saithe, & whiting) have change from the previous year. The fishermen are also asked for information on their fishing vessel size, fishing gear used and area of operation, and about their perceptions of changes in the difficulty of getting or retaining crew, their economic circumstances (costs & profits), and their general level of optimism for the future.

As every year, WGNSSK has included the results of the NSSS within the relevant stocks section, and has commented on the consistency of these with the scientific perception of the stocks development. In addition this year, WGNSSK had a thorough discussion on the future of this survey, which is summarized below.

WGNSSK acknowledges the effort made to involve fishers' knowledge in a broad-ranging, long-lasting and formal way, and appreciates the continuous work made by the NAFC Marine Centre to maintain a high level of responsiveness among fishers from many countries and types of fisheries.

There is for many stocks a global agreement between the overall NSSS index and the ICES assessment, which is considered as a positive result which strengthen the credibility of both the scientific assessment and the NSSS estimates. The main disagreement is to be found about the saithe assessment, where fishers and scientists perception differ significantly. It must be however underlined that saithe assessment has been rather problematic in 2010 and 2011 due to a number of reasons. The overall quality of the scientific assessment has improved in 2012, so the consistency for that stock should re-investigated with the latest figure.

However, in spite of the many years of inclusion of this survey into the ICES reports, WGNSSK recognizes that the outcomes and added value of this haven't unfortunately been as large as maybe expected. WGNSSK discussed a number of issues hampering the actual inclusion of this survey in the assessment itself. These are:

- First of all, a stock assessment is by definition a highly quantitative process, while the NSSS stays essentially qualitative, and the established assessment models cannot account for such information. Some valuable progresses have already been made in developing a unique quantitative summary NSSS index. But in spite of that there are still no easy solutions on how this can be incorporated into models, and this prevents treating this information as other sources of information.
- Over the years, there has been an increasing trend within stock assessment to limit the use of commercial CPUE as abundance indices, because of the known source of potential bias linked to e.g. i) technical creeping, ii) potential concentration of fishing on aggregation to maintain high CPUE when abundance decreases, iii) uncertain catch figures due to external factors such as discarding, highgrading, regulations, lack of quotas and fishing opportunities etc. WGNSSK fears that similar factors might influence the fishers response, but this potential bias is very difficult to apprehend.
- For *Nephrops*, the NSSS follows the same roundfish areas as for other stocks, while ICES evaluates *Nephrops* on the basis of Functional Units (FU), which show to have very different productivity. Several FUs can be included within one NSSS area, or conversely some other FUs can straddle over two areas. All together, it makes it difficult to relate NSSS with ICES assessment for *Nephrops*. WGNSSK would recommend fine tuning the approach and analyses for *Nephrops* (for example by adding the fishing grounds names such as "Fladen" or "Firth of Forth") in the questionnaire in order to achieve higher consistency with ICES areas.
- WGNSSK observes that NSSS trends are increasingly optimistic for basically all regions and stocks. While this is fortunately also observed within scientific data for some cases, there are nevertheless some cases that are difficult to relate to. For example, WGNSSK mentioned the observation of increased sole abundance in the Northern North Sea or haddock abundance in the Southern North Sea in the NSSS, while data used by scientists indicate that these species are not caught in these areas. These discrepancies are difficult to interpret.

WGNSSK discussed also the potential future use of this survey, in order to increase the uptake of it. A couple of interesting possibilities would deserve being exploring further – possibly in advance of the next WG:

- WGNSSK discussed the possibility to use the NSSS results as a qualitative recruitment index in the forecast, given that coming recruitment are often largely unknown by the time of the WG. This information could for example help choosing between the various estimates coming from the assessment or the recruitment forecasts (RCT3). However, WGNSSK is uncertain whether NSSS perception of recruitment is exactly dealing with same ages classes as scientists, given that the first (recruiting) age is often heavily discarded and/or avoided. Given the annual variability of year-class strength for most North Sea stocks, if NSSS perception of recruitment covers more than that single first age then it would blur the whole picture. WGNSSK recommends that this is tested further by additional pilot studies confounding fishers' and scientists' perception of small fishes age.
- For the first time in 2012, WGNSSK collected landings and discards data by country and métier, providing thus more detailed information on the actual

fishing patterns. There is thus scope for exploring further the consistency of discards patterns reported by scientific institutes and NSSS, also in the context of applying the available estimated discards ratio to the fisheries without discards estimates.

- WGNSSK does not deal with economic analyses, but recommends strongly that the economic surveys are made available to the STECF Annual Economic Report (if this is not already the case). Cf for example http://stecf.jrc.ec.europa.eu/web/stecf/ewg05 for the 2012 meeting.
- WGNSSK wishes also to underline that STECF Effort Regime, which collect catch and effort information for all EU fleets, will also from 2012 collect catch statistics at the level of the ICES rectangle, thus allowing a much finer mapping of commercial abundance. That would also allow a better analysis of the consistency of NSSS perception with scientific data used for the assessment.

In conclusion, while WGNSSK is very keen and open for better involvement of fishers' knowledge in assessment, it must recognize that NSSS is still not fully accommodated for in the assessment. WGNSSK acknowledges that some other initiatives involving fishers in a more quantitative way, such as for example self-sampling, have been easier to integrate in the assessment flow.

However, WGNSSK is also aware that not all possibilities for including NSSS work have been investigated in depth. WGNSSK underlines that this network of involvement from fishers is precious and must be maintained and motivated, but WGNSSK recommends that that a workshop takes place between ICES, NAFC and NSRAC on possible ways forwards. This workshop should take place before the next WGNSSK meeting in 2013.

1.7 Special requests

A number of EU-Norway requests dealing with North Sea demersal stocks have been issued in 2012. Below follows a simple summary on how these have been treated by WGNSSK and where to find the information.

1.7.1 Joint EU-Norway request on management measures for Norway Pout

The European Union and Norway jointly request ICES 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 ifTAC 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 of0.35;

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.

WGNSSK did not consider this request during its meeting, mainly due to time overlap with the 2012 Benchmark assessment for Norway Pout. This request will be dealt with separately. See Section 05

1.7.2 Joint EU-Norway Request on mixed-fisheries advice

ICES is requested to provide in 2012, alongside its recurrent advice for single stocks, mixed-fisheries TAC advice for stocks in the North Sea and the Skagerrak. The mixed fisheries advice should reflect the target level of fishing mortalities as set in current management plans, and to the extent possible be consistent with the MSY framework, taking account of plausible ranges in the choice of MSY targets. The advice should also consider eventual adjustments to the MSY framework as a consequence of a mixed fisheries approach.

In 2012, the ICES WGMIXFISH group will meet in May instead of August as in previous years, and the joint data call mentioned above should facilitate the completion of the necessary data sets for providing mixed-fisheries advice. This Request will therefore be dealt with by WGMIXFISH.

1.7.3 Joint EU-Norway request on management measures for plaice in the Skagerrak

With the objective of establishing a long-term management plan for plaice in Skagerrak to provide for sustainable fisheries with high and stable yield in conformity with the MSY approach, ICES is requested by 30 June 2012:

1) To consider the stock identities of plaice in the Skagerrak and adjacent waters.
2) To evaluate possible approaches to develop a long-term management plan for plaice in Skagerrak, including a possible link with trends in the status of the plaice stock in the North Sea.

This request was first considered and partially answered by ICES WKPESTO, which met in early March 2012. WGNSSK addressed this further during its meeting. The contribution to this request is to be found on section 18.

1.7.4 EU Request on Real-Time monitoring for sandeel

The ICES assessment and advice for sandeel, provided in March 2012, estimates of a low TAC (23 000 t) of sandeel in Area IV for 2012, due to very low 2010 and 2011 year classes. Information for the 2011 year-class is entirely based on observation from a dredge survey that took place during December 2011. It is possible that bad weather conditions during the 2011 survey might have biased the estimate of the 2011 year-class. In view of these concerns, the Danish Ministry for Food, Agriculture & Fisheries have proposed an alternative approach to monitoring the fishery based on real-time monitoring. This is described in the attached document. ICES are requested to review this document, to advice on the suitability of the approach described fro monitoring sandeel abundance, and to advice on the implications for management of the sandeel fishery during 2012.

The results of the Real Time monitoring for sandeel were presented and discussed during the WGNSSK meeting. See section 04 and Annex 09

1.7.5 Request on flatfish management plan

A special request by the Netherlands, to evaluate a proposal by the Netherlands, in respect of amending the multiannual plan for plaice and sole in the North Sea (EC regulation 676/2007) was received by ICES shortly before the WGNSSK 2012 meeting. WGNSSK did not have time to prepare a response to the request and possibly base advice on an amended multi annual plan. ICES MoU partners indicated (pers.com. B.

Schoute) that they consider that ICES can continue using the plan as a basis for advice even if revisions of the plan have not yet been proposed or implemented. Consequently, WGNSSK concludes that the objectives of stage 1 are currently met and provides advice based on the plan's TAC setting procedure acknowledging to be in a transitional stage until the Impact Assessment as stipulated in article 5 of the EC regulation and the evaluation of the plan have been conducted. Since ICES has established a generic approach to evaluate whether new survey information that becomes available in September should initiate an update of the advice, the results of this evaluation can be taken into account when the stocks of sole and plaice are revisited at that time in November 2012.

1.8 References

Levin PS, Fogarty MJ, Murawski SA, Fluharty D (2009) Integrated Ecosystem Assessments: Developing the Scientific Basis for Ecosystem-Based Management of the Ocean. PLoS Biol 7(1): e1000014. doi:10.1371/journal.pbio.1000014

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. 2010. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH), 31 August - 3 September

Beare, D. J. B., Hintzen, N. T., Piet, G. J., Nielsen, J. R., Manco, F., South, A., Bastardie, F., *et al.* 2011. Development of tools for logbook and VMS data analysis. Studies for carrying out the common fisheries policy. Open call for tenders No MARE/2008/10 Lot 2.

STECF. Report of the SG-MOS-10-05 Working Group on Fishing Effort Regime Edited by Nick Bailey & Hans-Joachim Rätz 27 september – 1 october 2010, Edinburgh, Scotland. Ispra, Italy. https://stecf.jrc.ec.europa.eu/reports/effort

ICES. 2011. Report of the Workshop on the Analysis of the Benchmark of Cod in Su-barea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011), 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51. 94 pp.

ICES. 2011. Report of the Working Group on Integrated Assessments of the North Sea (WGINOSE), 21–25 February 2011, Hamburg, Germany. ICES CM 2011/SSGRSP:02. 69 pp

ICES. 2011. Report of the Workshop on Implementing the ICES Fmsy Framework (WKFRAME-2), 10-14 January 2011, ICES, Denmark. ICES CM 2011/ACOM:33. 110 pp.

2 Overview

2.1 Stocks in the North Sea (Subarea IV)

2.1.1 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 were 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.

Following a benchmark meeting in 2010 on sandeels, assessment has now moved from treating them as a single unit to six separate stock units. The timing of assessment has also moved and is now undertaken in January of the TAC year in order to make use of the mid-winter dredge survey and the first of these new assessments was performed in January 2011. In 2012 though, a Real-Time Monitoring was conducted, due to uncertainty on the outcomes of the dredge survey. These results are presented in the sandeel section 4.

Biological interactions are not dynamically incorporated in the assessments or the forecasts for the North Sea stocks. However, average values of natural mortalities estimated by multispecies assessments for cod, haddock, whiting and sandeel are incorporated in the assessments of these species. These values have been revised in 2012, following the 2011 key run of the Multispecies WG (ICES WGSAM)

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 2012), which for the first time met in 2012 straight after the WGNSSK, and made use of 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 2012 based on the new data call WGMIXFISH defined 39 national fleets from nine countries. These fleets engaged in one to four different métiers each, resulting in 88 combinations of country*fleet*metier*area catching cod, haddock, whiting, saithe, plaice, sole and *Nephrops*.

ICES WGMIXFISH (2012) produces a number of synthetic figures describing main trends, between 2003 and 2011, of effort and catches and landings by fleet and stock.

The total effort (expressed in KW*days at sea) for these 39 fleets decreased by 21% between 2003 and 20qq, with largest decreases between 2006 and 2008.

2.1.2 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.

2.1.2.1 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. 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 43/2012).

Table 2.1.1 Maximum allowable fishing effort in kilo watt days in 2012.

Geographical area:	Regulated gear	DK	DE	SE
(a) Kattegat	TR1	197 929	4 212	16 610
	TR2	830 041	5 240	327 506
	TR3	441 872	0	490
	BT1	0	0	0
	BT2	0	0	0
	GN	115 456	26 534	13 102
	GT	22 645	0	22 060
	LL	1 100	0	25 339

Geographical area	Regulated gear	BE	FR	IE	NL	UK
(c) ICES division VIIa	TR1	0	48 193	33 539	0	339 592
	TR2	10 166	744	475 649	0	1 088 238
	TR3	0	0	1 422	0	0
	BT1	0	0	0	0	0
	BT2	843 782	0	514 584	200 000	111 693
	GN	0	471	18 255	0	5 970
	GT	0	0	0	0	158
	LL	0	0	0	0	70 614

Geographical area	Regulated gear	BE	DE	ES	FR	IE	UK
(d) ICES division VIa and EU waters of ICES division Vb	TR1	0	9 320	0	1 324 002	428 820	1 033 273
	TR2	0	0	0	34 926	14 371	2 972 845
	TR3	0	0	0	0	273	16 027
	BT1	0	0	0	0	0	117 544
	BT2	0	0	0	0	3 801	4 626
	GN	0	35 442	13 836	302 917	5 697	213 454
	GT	0	0	0	0	1 953	145
	LL	0	0	1 402 142	225 861	4 250	630 040

The STECF has performed annual monitoring of deployed effort trends since 2004. Overall effort (kW-days) by demersal trawls, seines, beam trawls, and gillnets in the North Sea, Skagerrak, and Eastern Channel has been substantially reduced (−30% between 2003 and 2009; STECF, 2011). Effort by beam trawl in both small mesh size (80–120 mm, BT2) and large mesh size (> 120 mm, BT1) has shown a continuous decline (−38% and −70%, respectively, between 2003 and 2009).

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)

2.1.2.2 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 different timing, procedures, stakeholders and scientists involved, disregarding mixed-fisheries interactions (ICES WGMIXFISH 2012). The technical basis of the individual management plans is detailed in the relevant stock section.

2.1.3 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). Quotas for these fisheries have only recently been introduced. Technical measures relevant to each stock are listed in each stock section – for convenience, the recent history of technical measures in the area as a whole is also summarised here.

Until 2001, the technical measures applicable to the North Sea demersal stocks in EU waters were laid down in the Council Regulation (EC) No 850/98. Additional technical measures have been established in 2001 by the Commission Regulation (EC) No 2056/2001, for the recovery of the stocks of cod in the North Sea and to the west of Scotland. In 2001, an emergency measure was enforced by the Commission to enhance cod spawning (Commission Regulation EC No 259/2001).

2.1.3.1 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

2.1.3.2 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.

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

Plaice box

To reduce the discarding of plaice in the nursery grounds along the continental coast of the North Sea, an area between 53°N and 57°N has been closed to fishing for trawlers with engine power of more than 221 kw (300 hp) in the second and third quarter since 1989, and for the whole year since 1995. Beare *et al*. (2010) 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 special landing regulations were complied with. It was discontinued at the end of 2004.

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.

2.1.4 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.

2.1.5 Human consumption fisheries

2.1.5.1 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). A combination of observed and reconstructed discard rates was used in the North Sea plaice assessment. Other discard sampling programmes (e.g. industry self-sampling) have been in place in recent years and the data are beginning to enter the assessment process in some instances. In many cases the data from these cases have not been used in the assessments yet because of short time-series, or because of collation problems. 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.

For a number of years there have 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 has used a modified assessment method for North Sea cod (Section 14) which estimates unallocated removals. Such removals may be due to reporting problems, unrecorded discards, changes in natural mortality, or changes in survey catchability, and cannot be interpreted as necessarily representing mis- or underreporting. Increased enforcement of regulations (and measures such as the UK Buyers and Sellers Regulation) means that mis- or underreporting is considered to be less now than previously (cf also ICES WKCOD 2011)

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 is being 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.

2.1.5.2 Stock impressions

In the North Sea all stocks of roundfish and flatfish species have at some time been exposed to high levels of fishing mortality for a long period. For most of these stocks their lowest observed spawning stock size has been seen in recent years. This has resulted from excessive fishing effort, possibly combined with an effect of a climatic phase which is unfavourable to recruitment. For a number of years, ICES has recommended significant and sustained reductions in fishing mortality on some of the stocks. In order to achieve this, significant reductions in fishing effort are required. In recent years, estimated fishing mortality has declined in most stocks for which analytic assessments are available, and a number of stocks are showing signs of increasing abundance.

The methodology used for the assessment of **cod** in Subarea IV and Divisions IIIa and VIId changed for 2011 following a specially convened benchmark meeting which was a response to the difficulties encountered with the assessment in 2010. A statistical, state-space model is now used to model the development of the population as opposed to the VPA based approach used previously. In 2010 divergence in perception of the state of the stock indicated by the 1st quarter IBTS and 3rd quarter IBTS reached a point where it was considered by WGNSSK to unreliable for use in assessment.. The reason for this divergence appears to be a result of changing stock distribution or survey catchability in the 3rd quarter and until a mechanism to explain this has been found the 3rd quarter survey will not be used in the assessment. Catches of **cod** in have increased over the last three of years in line with increasing TAC after having been at historic low levels for several years. Estimated spawning-stock biomass reached a low in 2006 but has subsequently increased and is now just below B_{lim}. Fishing mortality declined from 2000 and is now below F_{pa}, but is estimated to be well above FMSY. Recruitment since 2000 has been poor. Although discards are still high, there has been a decreasing trend since 2008.

Haddock 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.

After several years of problematic assessments of **whiting** in Subarea IV and Division VIId, the 2012 assessment is consistent with the 2011 and 2010 assessment and appears to have broken the pattern of sequentially under-estimating recruitment and SSB and over-estimating F. SSB in 2011 is slightly lower than in 2010, but remains around the long-term average. Fishing mortality has been stable with minor fluctuations since 2003. Recruitment was low between 2003 and 2007, with above-average recruitments estimated in 2008 and 2009. Whiting is no longer considered to be in a period of impaired recruitment.

In 2010 a lack of key **saithe** data prevented an assessment from taking place and was replaced by an extension of the forecast from the 2009 assessment. In May 2011, a new assessment had been made using the results of the 2011 benchmark, but was revised again in October 2011 due to conflicting information from the various data. A number of improvements has been provided in 2012. Age distribution of Norwegian catch data for 2010 has been revised substantially, and the overall quality of the assessment has improved. The status of the stock has deteriorated in the last few years. Recruitment in 2006, 2008, and 2009 was among the lowest on record. SSB was above B_{pa} during 1997–2011 but has declined since 2005 towards B_{pa}. Fishing mortality has fluctuated around F_{msy} since 1997.

The **sole** assessment in IV shows the stock to be almost unchanged from recent years. SSB has fluctuated around the precautionary reference points for the last decade and is estimated to be at B_{pa} in 2011. Fishing mortality has shown a declining trend since 1995 and is estimated to be below F_{pa} since 2008.

Landings of plaice in Subarea IV increased over the past couple of years and are low compared to historical levels although discarding levels are quite high. SSB has increased dramatically over the last five years to well above MSY $B_{trigger}$ and is at the historical maximum. Fishing mortality has decreased to its lowest observed level. Recent year class strength has been at the long-term mean.

The yields for stocks of *Nephrops* are fairly stable from year to year. Reported landings for FU 3 (Skagerrak) and FU 4 (Kattegat) have decreased in 2011 by 22% compared to 2010. There are no signs of overexploitation in IIIa and given the apparent stability of the stock, the current levels of exploitation appear to be sustainable. Absolute estimates of abundance were available in 2010 and 2011 from an underwater TV (UWTV) survey. The estimate of 2010 and 2011 harvest ratio (6.4% and 5.0% respectively) from these UWTV surveys and the fishery indices (effort and lpue) both suggest that the stock is exploited sustainably and below the 8% level chosen as a proxy for F_{msy}. Discarding levels in this fishery are particularly high due to a high minimum landings size.

Landings in 2011 for the North Sea *Nephrops* FU have dropped by 40% in the largest and most remote area (FU 7) but have increased in other FUs (mainly 6, 9 and 33), leading to global decrease of 23% of the overall *Nephrops* landings. TV surveys for FUs 7, 8 and 9 decreased slightly again in 2011, continuing a downward trend since 2008. The TV survey in FU6 increased slightly but this stock is considered to be recovering from a depleted state due to high levels of fishing effort.

2.1.6 Industrial fisheries

Sandeel in area IV underwent the benchmark process in September 2009, resulting in a move away from a single area assessment to regional assessments (7 sandeel areas, SAs). The majority of the stock biomasses are contained within SAs 1, 2 and 3 covering the central and southern North Sea and analytical assessments are possible in these areas. Sandeel assessment will now be performed in January in order to make use of the winter dredge survey conducted by Denmark.

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 by area in 2011:

		3AN	3AS	4AW	4BE	4BW	4C	Total
Anchovy	ANS	0	4		9			14
Argentine	ARG			12				12
blue whiting	BLH			28				28
Sprat	BRS	1734	3220		82951	8092	20022	116020
	BSP	0	0		10	22		32
Pandalus	DVR			7				7
Greater Weever	FJS	0	348					348
poor cod	GLY		0	10				10
horse mackrel	HMK	0	0	6	54			61
American plaice	HSG		0	8	20	2		31
whiting	HVL	2	44	82	146	788	78	1139
dab	ISG	2	6		138	8	3	158
gurnard	KNH	1	4		137	89	13	244
crabs	KRA	0	1		3			4
haddock	KUL	0	0	9		8		17
mackerel	MAK	7	0		188	939	33	1166
plaice	RSP	7	1		8			16
herring	SIL	650	1942	510	7900	435	116	11552
flounder	SKR		0					0
Hagfish	SLI			6				6
norway pout	SPE		0	3310		5		3315
sandeel	TBS	4	399		38584	233099	5207	277292
sole	TNG				0			0
cod	TOR	0	1					1
	Total	**2406**	**5973**	**3989**	**130148**	**243488**	**25473**	**411477**

2.2 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 progress was made this year. A specific workshop convened in early March 2013 (ICES WKPESTO 2012), that investigated stock structure and connectivity of plaice populations between the Eastern North Sea and the Baltic Sea as well as alternatives to current assessment and management (see also sections 7 and 18). In general, the sources of information are mostly old and sporadic, and the stock structure remains fairly uncertain. WKPESTO draw nevertheless some hypotheses and conclusions on this basis, underlining though that the knowledge could only be qualitative but not quantitative, and that new tagging and genetic data are absolutely needed in to verify these hypotheses and quantify the exchanges between populations. WKPESTO concluded that the collected information on biology and fishery of plaice in IIIa and adjacent waters suggest for changes in assessment units Plaice in Skagerrak (Division 20) is considered to be closely associated with plaice in the North Sea and is proposed to be included in the North Sea plaice stock assessment, although it is recognised that local populations are present in the area. Therefore, separate management of the Skagerrak plaice is suggested to take place to assure the preservation of the local populations. Plaice in Kattegat (SD 21), the Belts (SD 22) and the Sound (SD 23) is considered a stock unit and is proposed to be assessed as such. However, separate management for the Kattegat, the Belts and the Sound is suggested to take place to assure the preservation of the local populations. Plaice in the Baltic (SD 24-32) is considered a stock unit and is proposed to be assessed and managed as such.

In this WGNSSK report, both the old setup (plaice IIIa alone) and the new suggestions (Plaice 21-23 assessment and plaice North Sea-Skagerrak assessment) are presented.

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).

2.3 Stocks in the Eastern Channel (Division VIId)

The stock of Plaice in VIId was benchmarked in 2010 (ICES WKFLAT 2010), leading to significant improvements in a number of areas. However, the validity of the as-assessment is still undermined by the structural issues of stock discrimination and migration, leading to significant mixing with plaice in VIIe and in the North Sea. The assessment is considered indicative of trends only due to uncertainty in the proportion of mixing. The assessment also currently lacks discard data although it is anticipated that the time series of available data will be of sufficient length in the near future. This year's Working group proposed to adjust the plus group from age 10 to age 7, as there was hardly any landings of plaice older than age 8. This improved the retrospective remarkably.

Sole in VIId is assessed to be in a similar state to 2011. Since 2005, fishing mortality has been slightly above Fpa and above F_{msy}. The spawning-stock biomass has increased since 2002 and is above MSY Btrigger. The 2009 year class is the highest in the time-series and the 2001, 2004, 2005, 2008 and 2010 year classes were above average. The cessation of the English Young Fish Survey in 2007 has irrevocably increased the uncertainty regarding the assessment of incoming year classes.

In addition, it should be noted that 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).

2.4 Industrial fisheries in Division VIa

This section has not been updated since 2009. For the most recent overview see Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) 2008 CM 2008\ACOM:09, section 2.

2.5 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. The latest report from 2011 was available to the Group and contains 4 pages specifically describing developments in the North Sea fisheries. (ICES 2011, WGFTB).

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; 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.

3.3 *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 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). This ability may contribute to maintaining a high production of this species in IIIa, due to increased organic production.

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 2011. ICES concluded that:

'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 shows an increasing trend in recent years (Figures 3.2.4.3 and 3.2.4.4). 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 high amount of discards observed in 2007, 2008 and 2009 could indicate high recruitment in these years.

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

Management for FU 3 and FU 4

The TAC for *Nephrops* in ICES area IIIa was increased from 5170 tonnes in 2011 to 6000 t in 2012. 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 rate and at present 69% 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 traditional *Nephrops* trawlers using 90mm mesh are in general restricted by KW day's pool at national level. To less extent avoid the restricted KW regulation more selective gears (such as square mesh panel) can be used. Swedish gear regulations since 2004 imply that it is mandatory to use a 35 mm species selective grid and 8 m of 70 mm full square mesh codend 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 SELTRA panel which compromise a large mesh square panel (180mm) placed in the front of a 90 mm codend (except for 4th quarter there is allowed to use 90mm codend with 120 square mesh panel). As Sweden has bilateral agreements with Denmark and Norway to fish inside the 12 nm limit, the regulations cover only waters exclusively fished by Swedish vessels (inside 3 nm in Kattegat and 4 nm in Skagerrak). In Article 11 in the cod recovery plan, member states may apply for unlimited number of days for this species selective trawl. In the negotiations between EU and Norway it has been agree prosed in Skagerrak from 2013 a mandatory use of either 120 mm square mesh in the cod-end, of sorting grid (35mm bar spacing) together with a square mesh cod-end with a minimum mesh of 70 mm or a SELTRA panel (a (with a square mesh sizes panel of 140mm or a diamond mesh size panel of 270 mm) which represent a legitimate alternative to 129 mm codend.

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 72 % and 25 % by weight of the landings in 2011. Landings by the Swedish creel fishery represented 13-18 % of the total Swedish *Nephrops* landings from the Skagerrak in the period 1991 to 2002 and has then increased to around 30% in 2007 to 2011 (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 2011, Denmark accounted for about 77 % of total landings in FU4, while Sweden took 22 % (Table 3.2.2.5). Minor landings are taken by Germany (1%).

After a decline in the observed landings in 1994, total *Nephrops* landings from the Kattegat increased again until 1998 and have fluctuated around 1500 t. However, since 2006 the landings have increased and were in 2010 the highest record in the period of data but shows a decrease to around the average in 2011 (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 1991-2011. 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 1990-2011, and from Denmark for 1992-2011. 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 2011. 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 15 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 1978-2011 (Figure 3.2.2.1 and Table 3.2.2.2). In recent years the twin trawlers have shifted to target both fish and *Nephrops*, and this shift has 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 (an increase from 1992 to 1998, a decrease from 1999 to 2001 and a subsequent increase in the last 6 years) is similar in the Swedish and Danish fisheries. Total Swedish trawl effort shows a decreasing trend since 1992. From 2004 onwards total Swedish trawl effort has been estimated from LPUEs from the grid single trawl (targeting only *Nephrops*) and total trawl landings.

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 2011. 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 to 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 during 1995 to 2001, but since then it has been showing a gradually decreasing trend until 2007. In 2007 to 2009 the recorded effort was on the same level, increased in 2010 (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* the major *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). In Figure 3.2.3.4 are presented the distribution of stations with valid density estimates from both the Danish and Swedish survey. 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 more detailed described in ICES (2011). The areas estimate for each subarea are represented 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 by subareas (Figure 3.2.3.2) are shown in table 3.2.3.1 and Figure 3.2.3.4.

In WK*NEPH (*2009) it was highlighted a number of bias sources related 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 2010 Assessment.

The assessment of the state of the *Nephrops* stock in IIIa is based on UWTV survey from 2011 and patterns in fluctuations of total combined LPUE by Denmark and Sweden during the period 1990-2011 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 2011 (Figure 3.2.4.1) while combined relative LPUE shows an increasing trend and is at a high level in recent 5 years (Figure 3.2.4.2), Technical creep and changes in targeting behaviour may be responsible for some of this increase. Changes in LPUE may reflect changes in stock size, catchability but also consequences of changes in management system. High LPUEs attributable to sudden changes in catchability (caused by e.g. poor oxygen conditions) 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 recruitment in 1993-95 are believed to have significantly contributed to the high LPUE in 1998-99. The high amount of discards observed in 2007, 2008 and 2009 would then indicate high recruitment in these years.

MSY consideration (TV-survey)

There are no precautionary reference points defined for *Nephrops*. Under the 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 difference 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).

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 the history fishery is stable 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 rates observed in the fishery.

The harvest ratio suggested as a proxy for F_{MSY} for FU 3&4 is the F_{max} combined sex = 7.9% HR. For 2013 this corresponds to landing of 5200 tonnes,

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 2013 (tonnes)
	2.0	1 300
	4.0	2 600
F2011 (UWTV)	5.0	3 300
	5.6	3 700
MSY approach	7.9	5 200
	10.5	6 900

A summary of the results from the TV survey 2011 is presented in Table 3.2.3.1. The estimated bias corrected abundance index was 0.363 resulting in a total biomass of 136 thousand tons (3577 million individuals). Total removals (landings + dead discards) was estimated to 7305 tons resulting in a harvest rate of 5.0%.

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 form 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 has been conducted on a quarterly basis for Danish and Swedish *Nephrops* trawlers in this fishery since 1990, and is considered to represent the fishery adequately.

The UWTV survey 2011 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 proxies for F_{msy} for this stock gives relatively low Harvest Ratio which may depend on the high amount of discards (48% in weight) due to the high minimum landing size, where these removals do not increase the yield from the stock.

All F_{MSY} proxy harvest rate values are considered preliminary and may be modified following further data exploration and analysis.

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 values. 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 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.

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 five 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 catch 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. The current effort regulation (days at sea) in IIIa may increase the incentives to use gears with sorting grid or other selective devises which is not subject to the otherwise restrictive effort limitations in force.

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 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 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 fishing 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	F	HR (%)	SPR (%) M	F	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.

3.4.3.10 Short-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 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 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.

		Fbar(20-40 mm)		HR (%)	SPR (%)		
WGNSSK 2011		M	F		M	F	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 $_{Btrigger}$. 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 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 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
$F_{0.1}$	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

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 exclusively 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 (km2)	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.

Year	Denmark	UK Scotland			Other countries **	Total
		Nephrops trawl	Other trawl	Sub-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).

		Abundance	Mean density	95% confidence interval
Year	Stations	millions	burrows/m^2	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 (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 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 (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 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.

		Mean density	95% confidence interval
Year	Stations	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

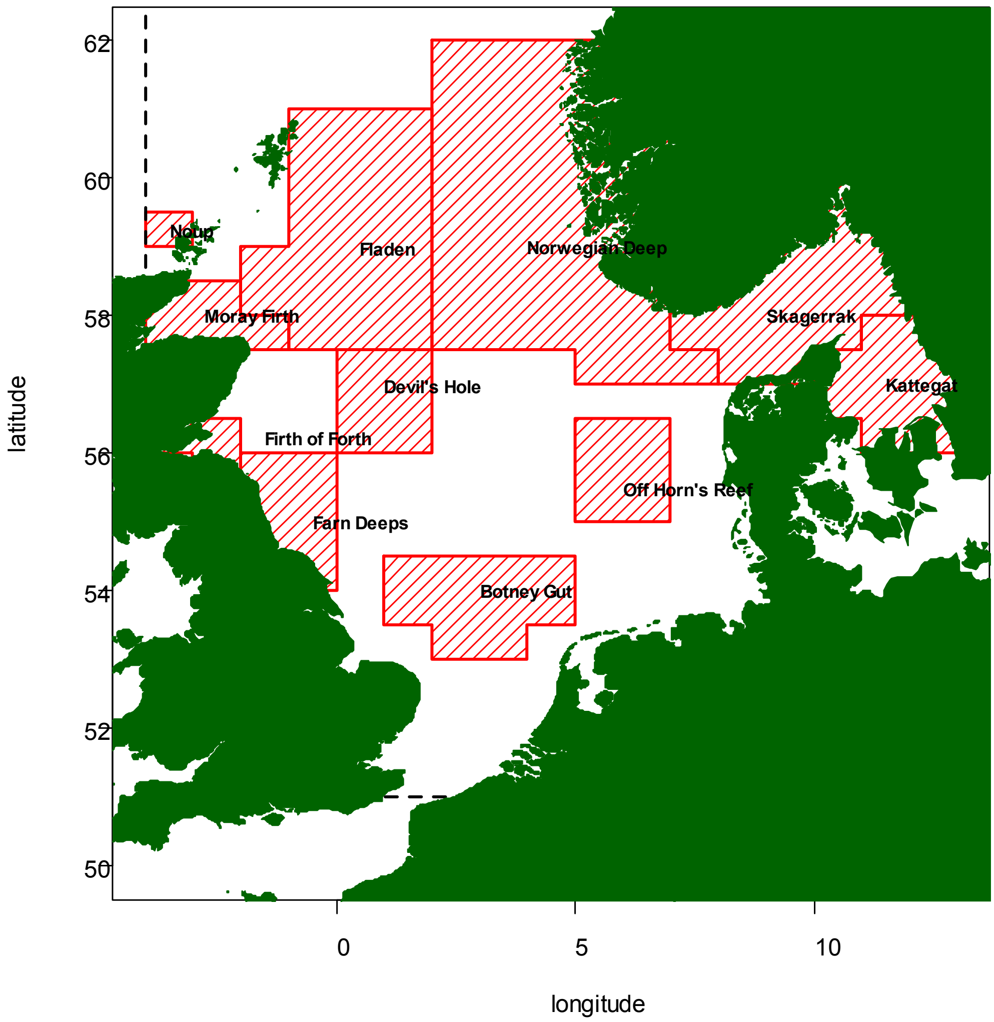


Figure 3.1.1. Nephrops Functional Units in the North Sea and Skagerrak/Kattegat region.

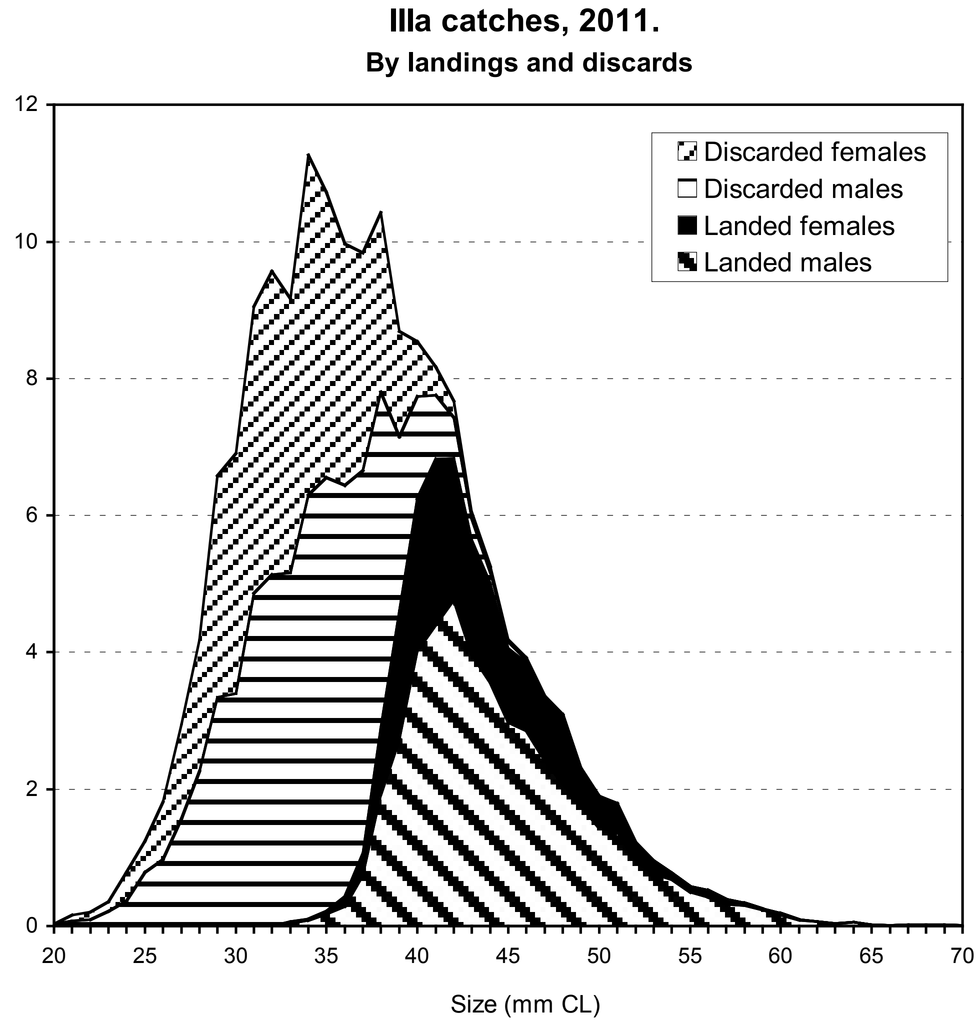


Figure 3.2.1.1. - Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of Nephrops catches, split by catch fraction (landings and discards) and sex. Data for Den-mark and Sweden combined for 2011.

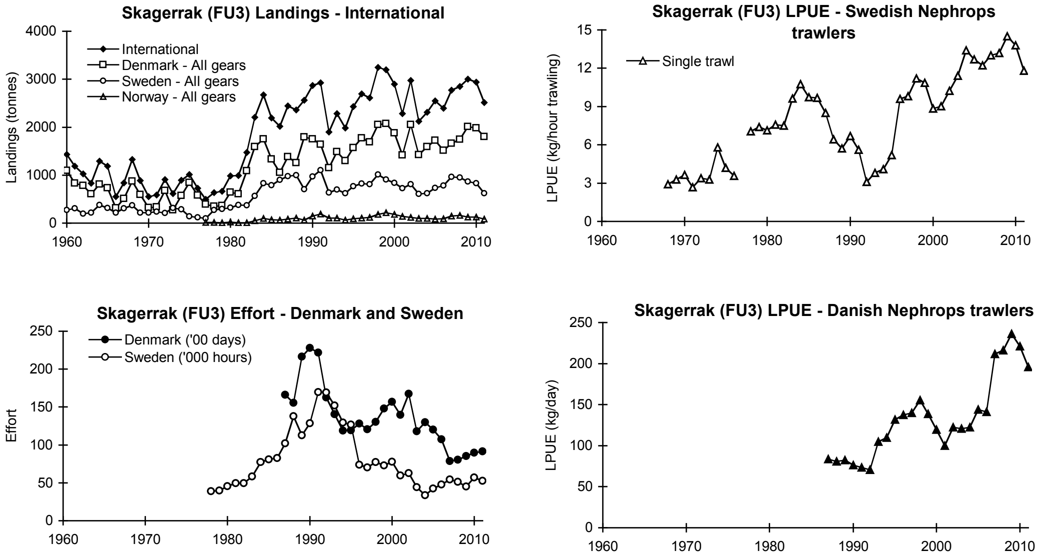


Figure 3.2.2.1. Nephrops Skagerrak (FU 3): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.

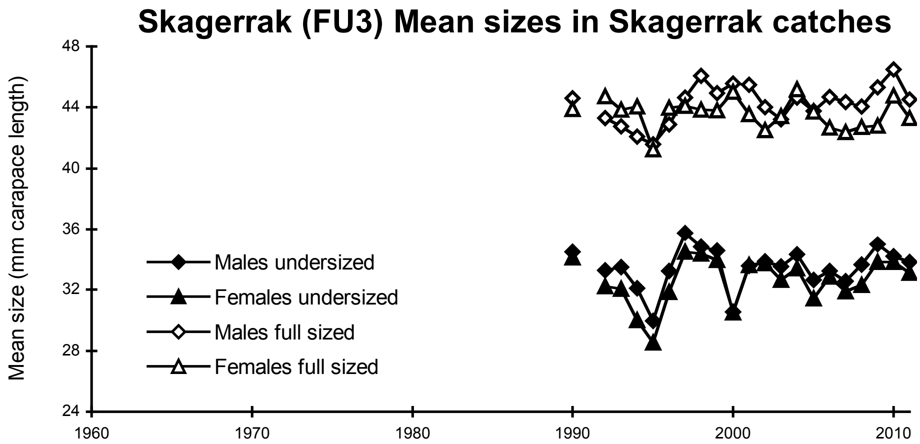


Figure 3.2.2.2 Nephrops in FU 3. Mean sizes in the catches.

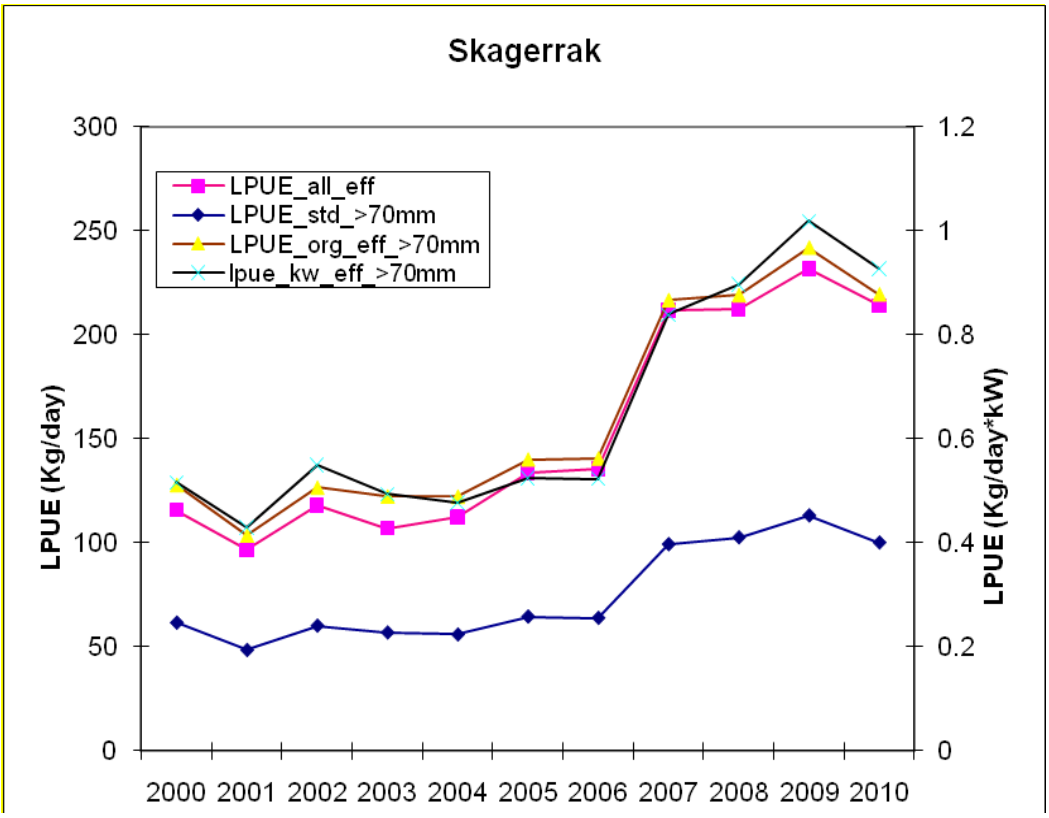


Figure 3.2.2.3 Nephrops in FU 3. LPUE trends.

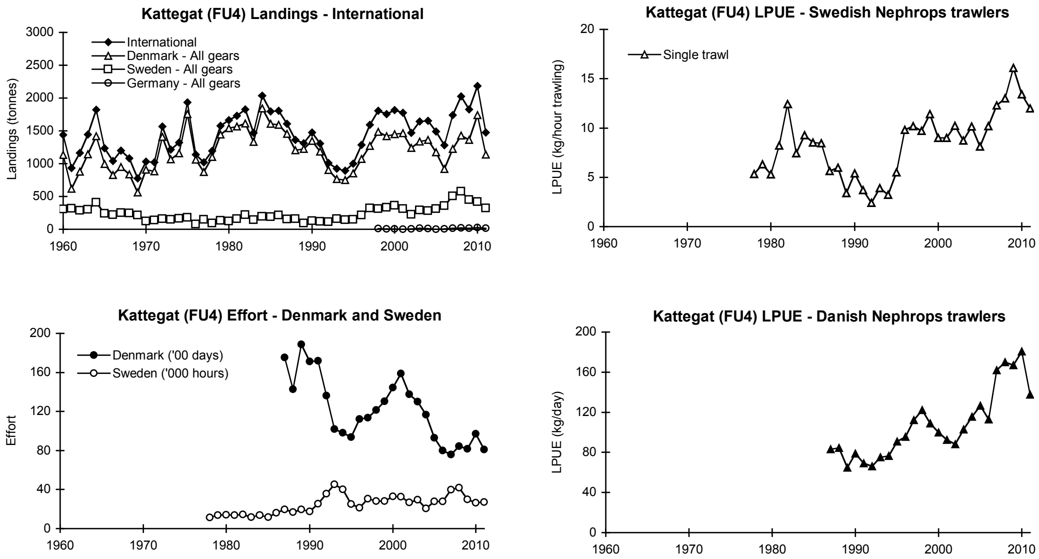


Figure 3.2.2.4. Nephrops Kattegat (FU 4): Long-term trends in landings, effort, LPUEs, and mean sizes of Nephrops.

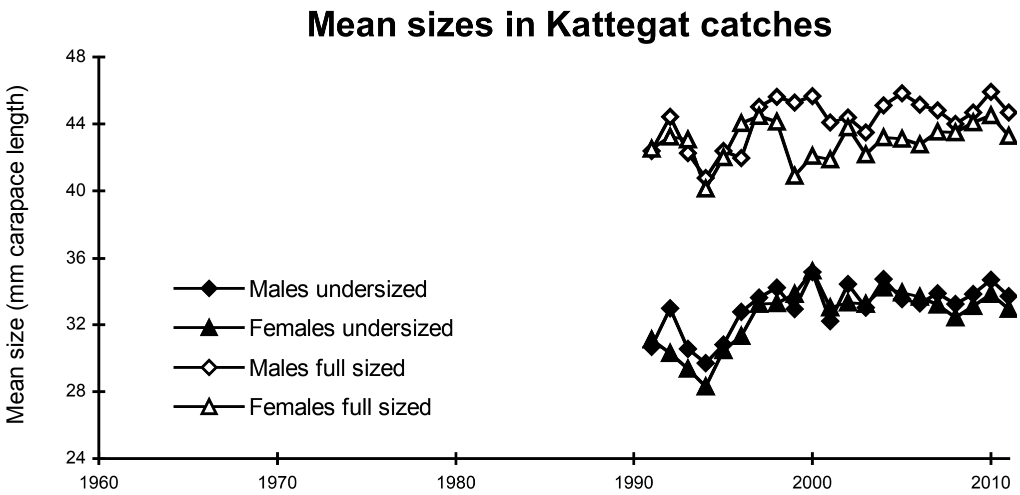


Figure 3.2.2.5 Nephrops in FU 4. Mean sizes in the catches.

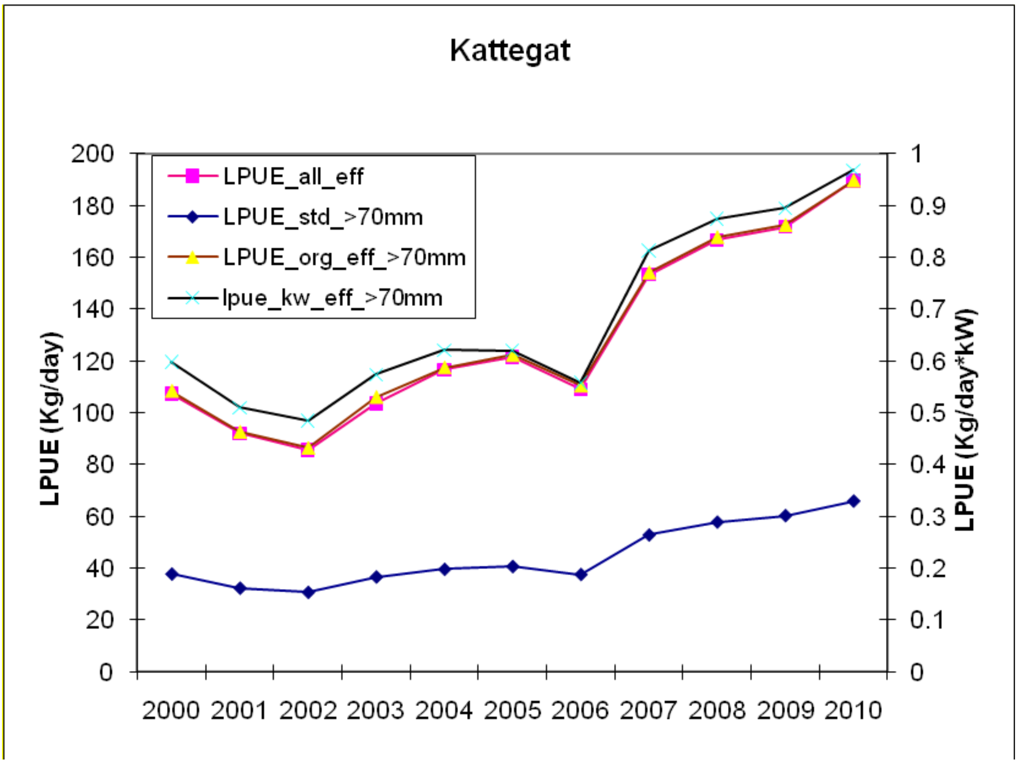


Figure 3.2.2.6 Nephrops in FU 4. LPUE trends.

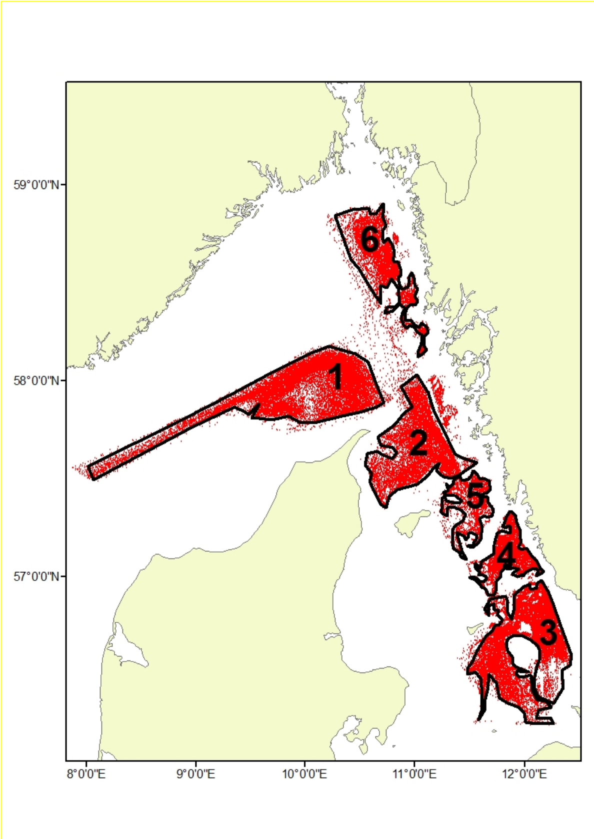


Figure 3.2.3.2. The defined sub areas of the Nephrops stock in IIIa.

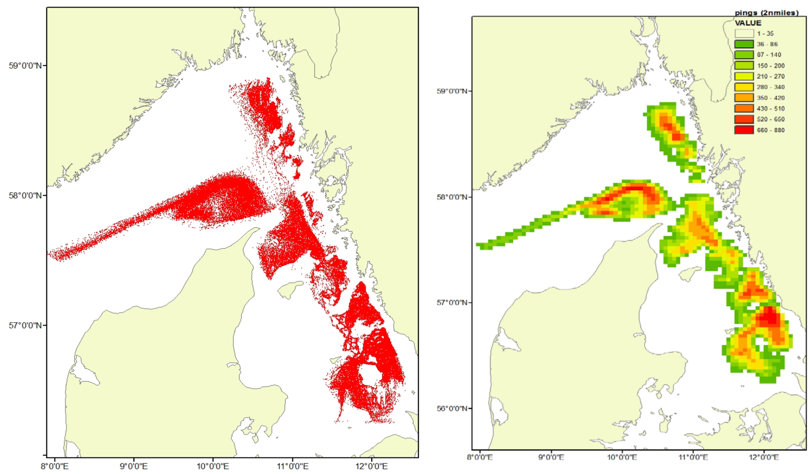


Figure 3.2.3.3. The spatial distribution of the Danish and Swedish Nephrops fishery in 2010. Left map shows vms pings and the right map shows density of vms pings.

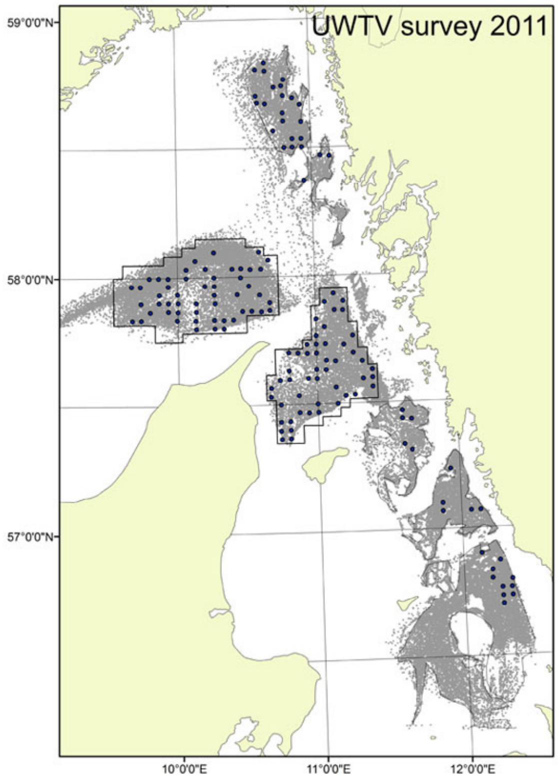


Figure 3.2.3.4. Stations of the Danish and Swedish TV-survey in 2011.

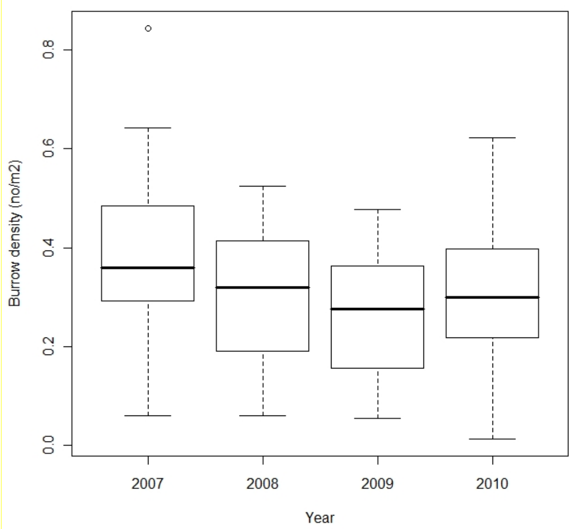


Figure 3.2.3.5. Boxplot of the density (no. of burrows/m2) bias corrected for sub-area 2 from 2007 to 2010.

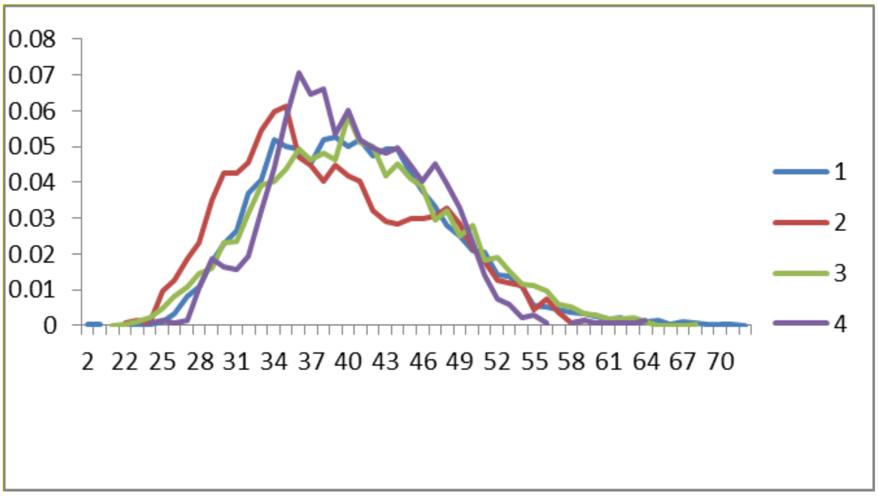


Figure 3.2.3.6. Length distributions of the Danish sea-samples in 2010 by subarea(1-4). No information exist for subarea 5 and 6.

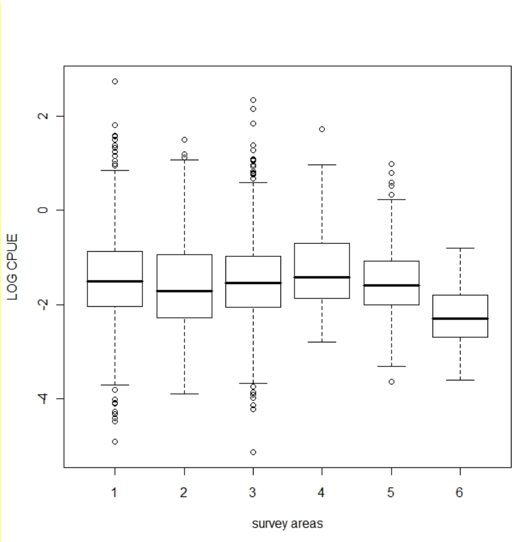


Figure 3.2.3.7. Boxplot of the catch rate (kilo Nephrops/kilowatt days) for the Danish fleet in 2010 by subarea.

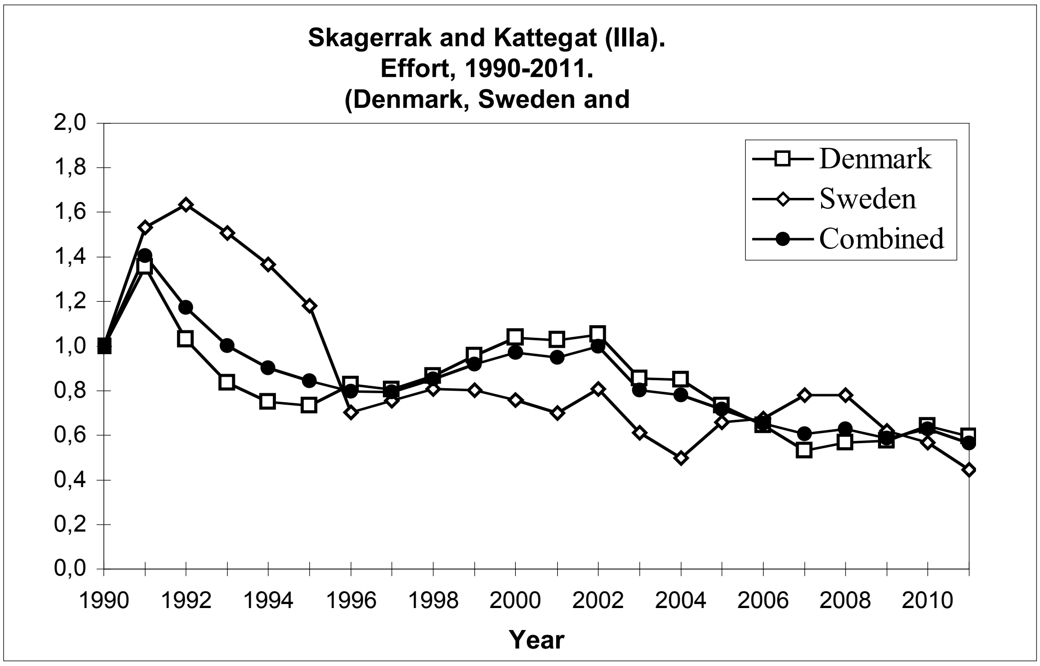


Figure 3.2.4.1 Nephrops in Area IIIa. Combined Effort for FU 3&4

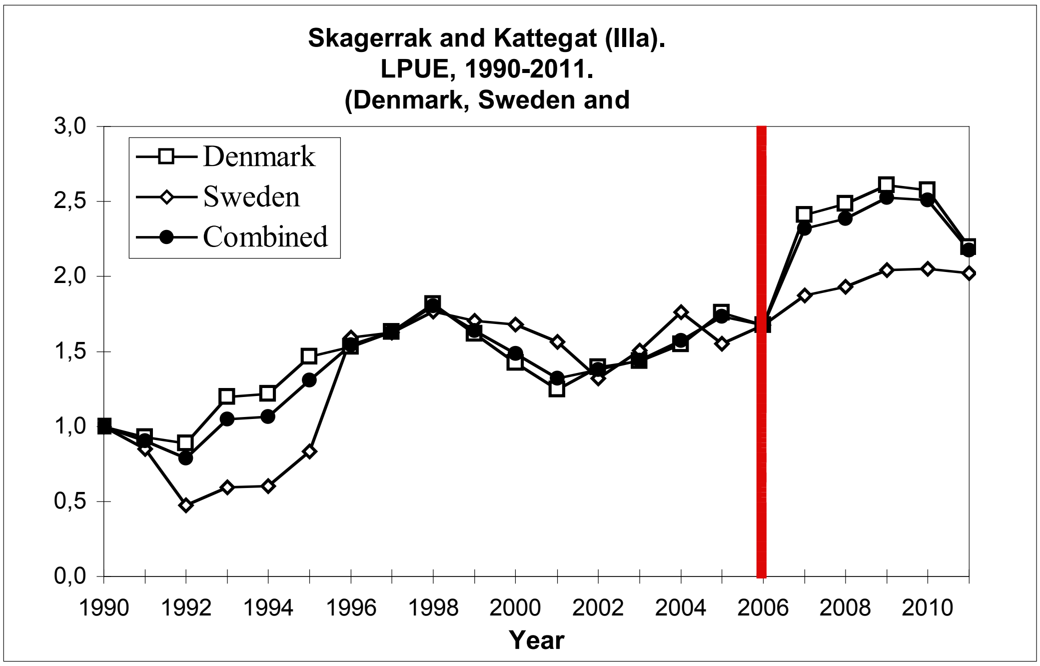


Figure 3.2.4.2 Nephrops in Area IIIa. Combined LPUE for FU 3&4. Red dotted line shows the year before the shift in Danish management system.

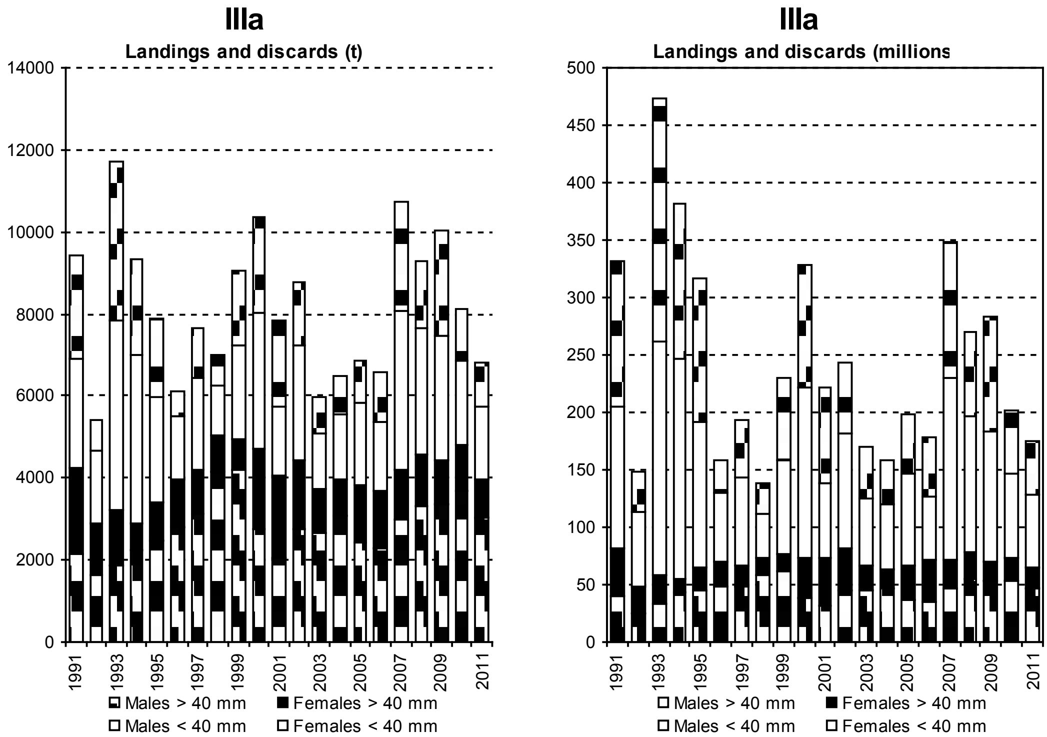


Figure 3.2.4.3 ***Nephrops*** **in IIIa FUs 3&4. Catch by sex and size category in numbers and biomass.**

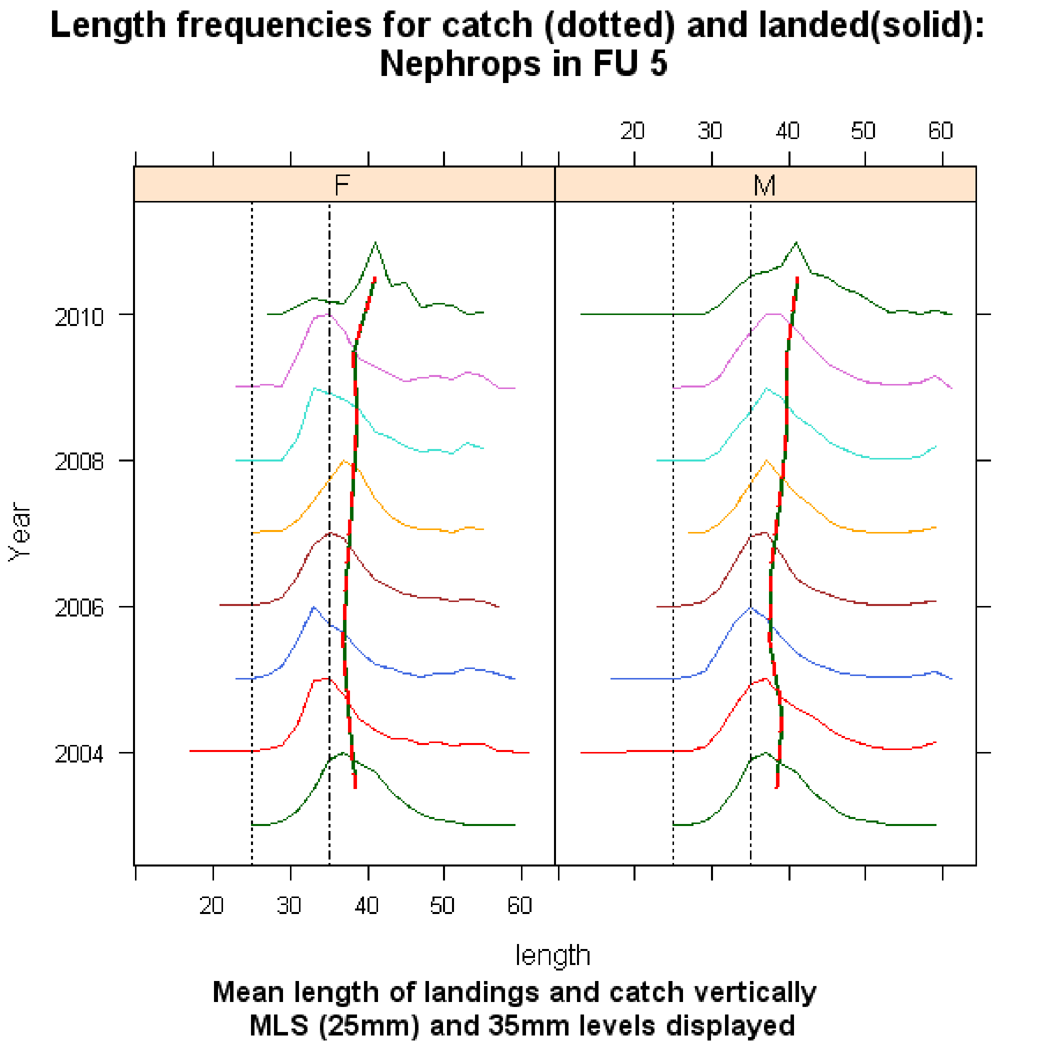


Figure 3.3.1.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2003 to 2011. For 2003 the length distribution is given by sex combined.

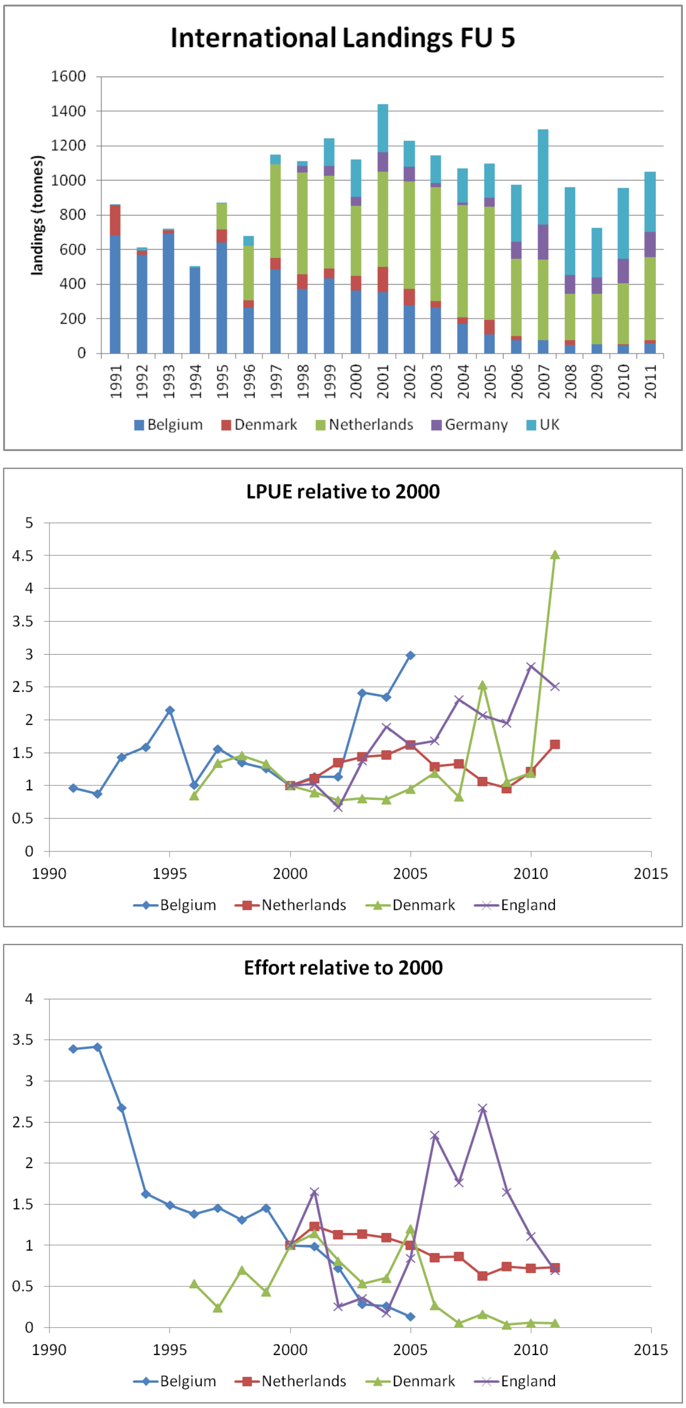


Figure 3.3.1.2 - FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUEs.

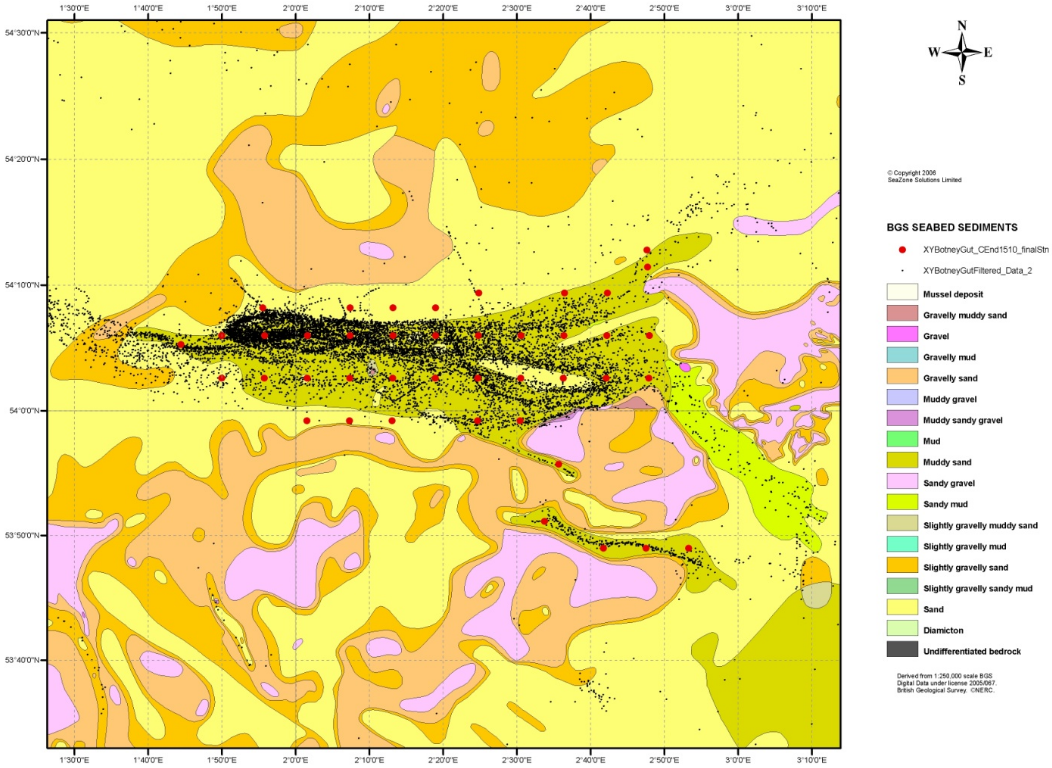


Figure 3.3.1.3 - FU5 Botney Gut/Silver Pit. Map showing BGS sediment data, fishing vessel activity from satellite data and the 42 survey station locations.

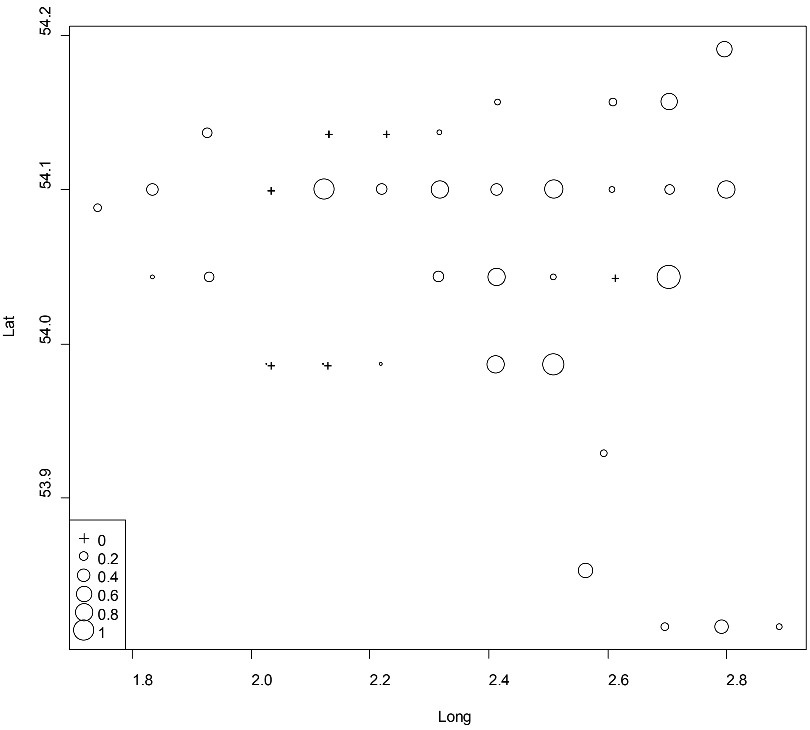


Figure 3.3.1.5. Preliminary UWTV survey results for FU5.

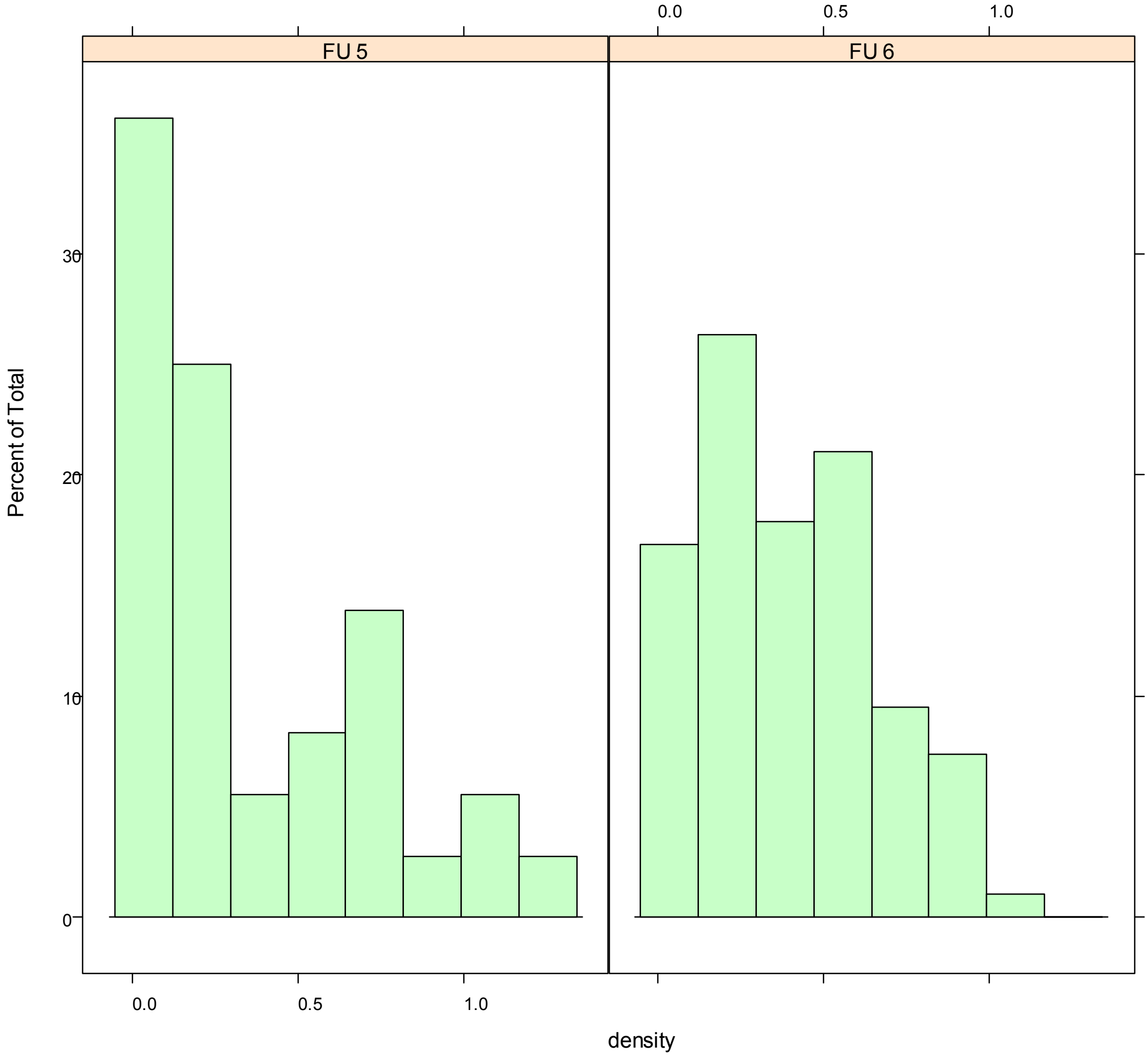


Figure 3.3.1.6. Comparison of burrow density composition between functional units 5 and 6

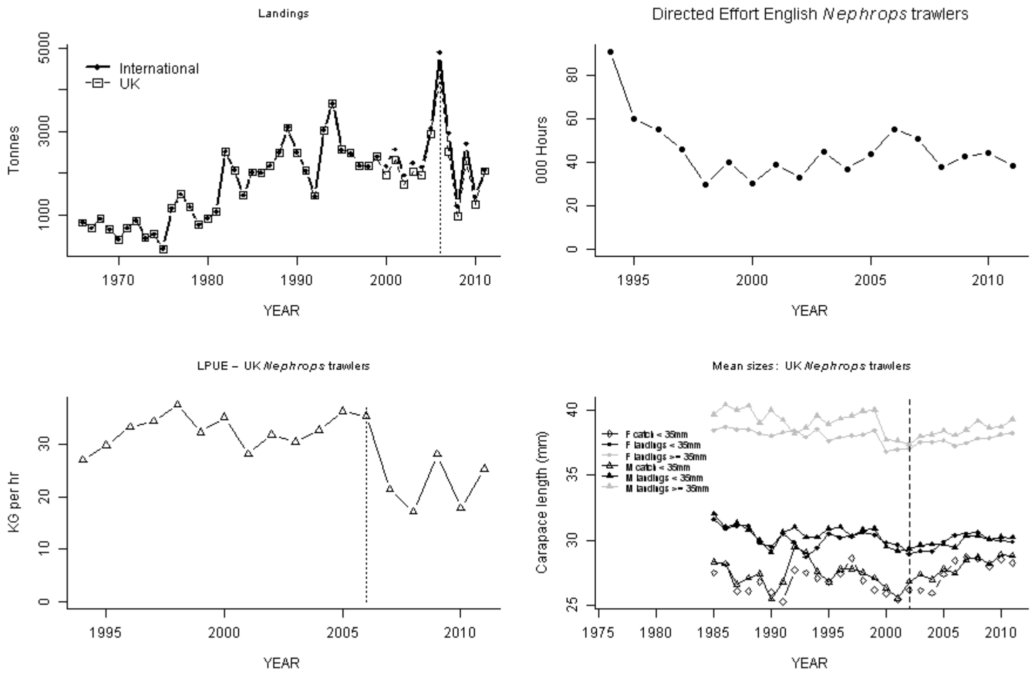


Figure 3.3.2.1 ***Nephrops*** **in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.**

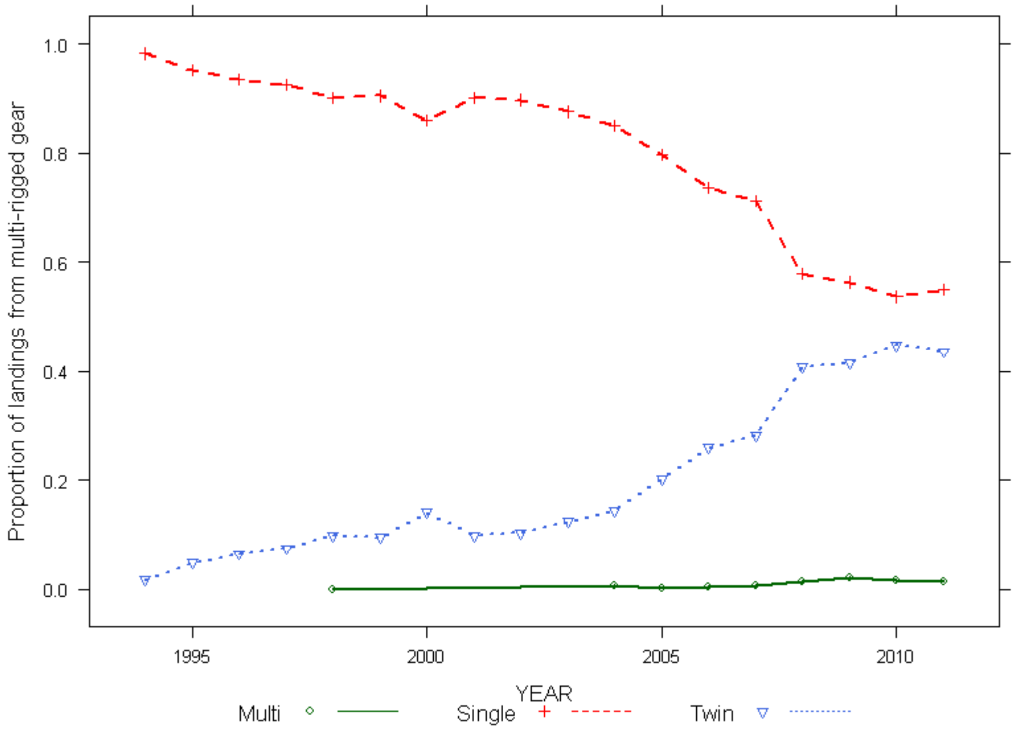


Figure 3.3.2.2 ***Nephrops*** **in FU6. Proportion of landings from different gear types.**

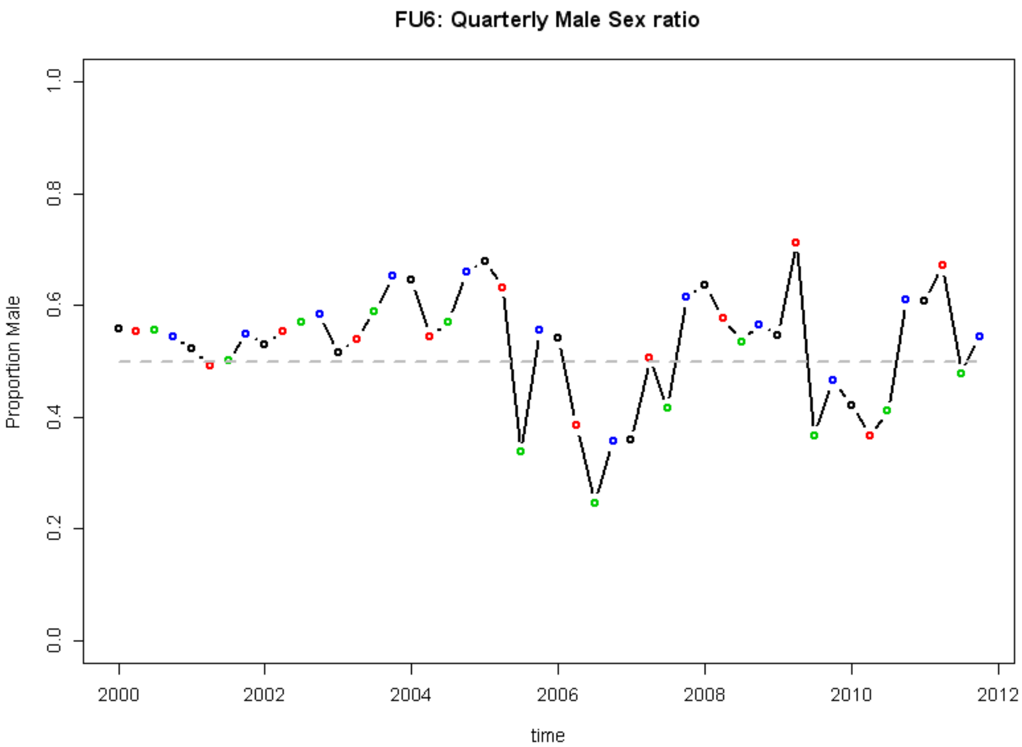


Figure 3.3.2.4 ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

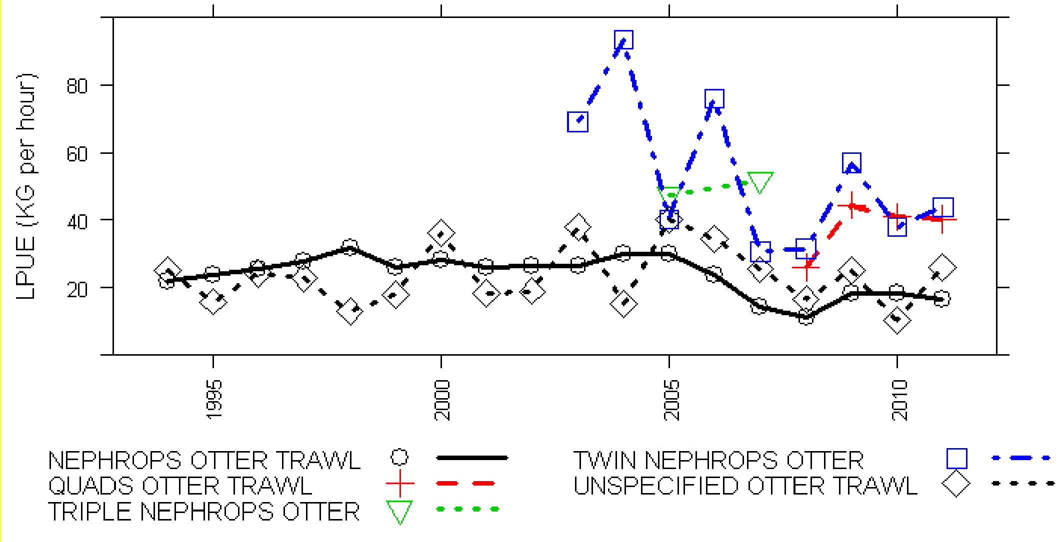


Figure 3.3.2.5 ***Nephrops*** **in FU6: LPUE for directed English trawlers by gear type.**

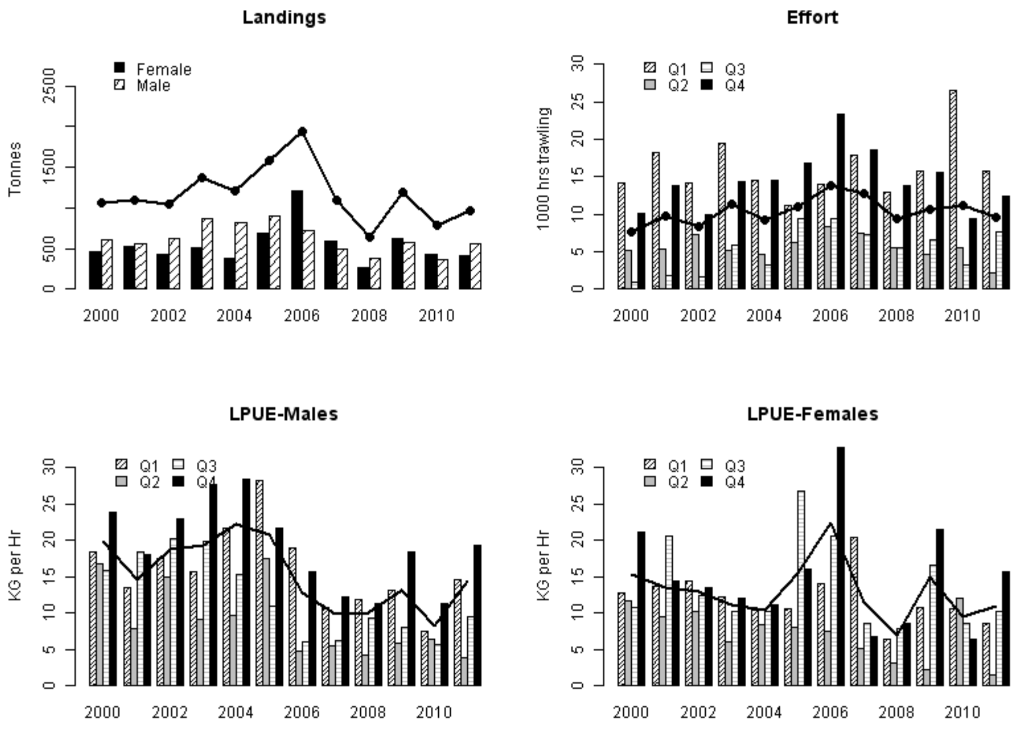


Figure 3.3.2.6 ***Nephrops*** **in FU6: LPUE by sex and quarter.**

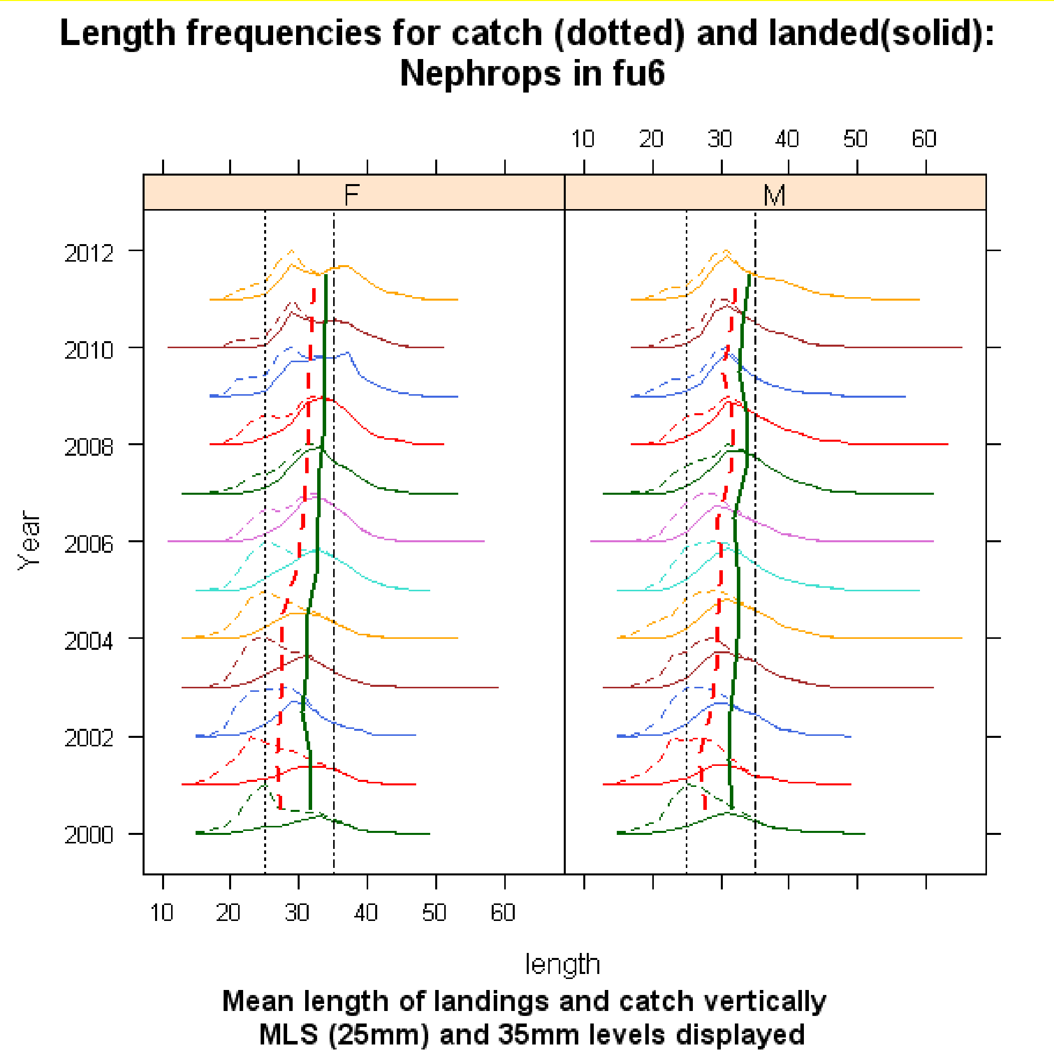


Figure 3.3.2.7 ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

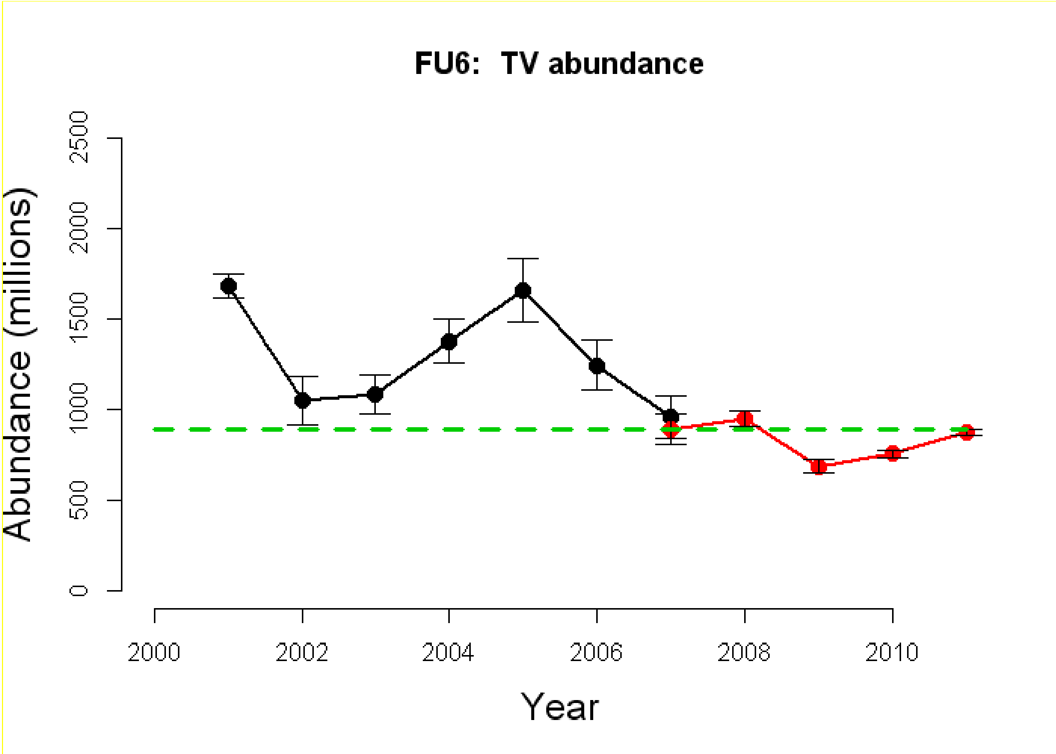


Figure 3.3.2.8 *Nephrops* in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$, the abundance estimate for 2007. The red line since 2007 gives the Geostatsistical abundance estimate. Prior to 2007 the estimate was raised using stratified boxes of ground but due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

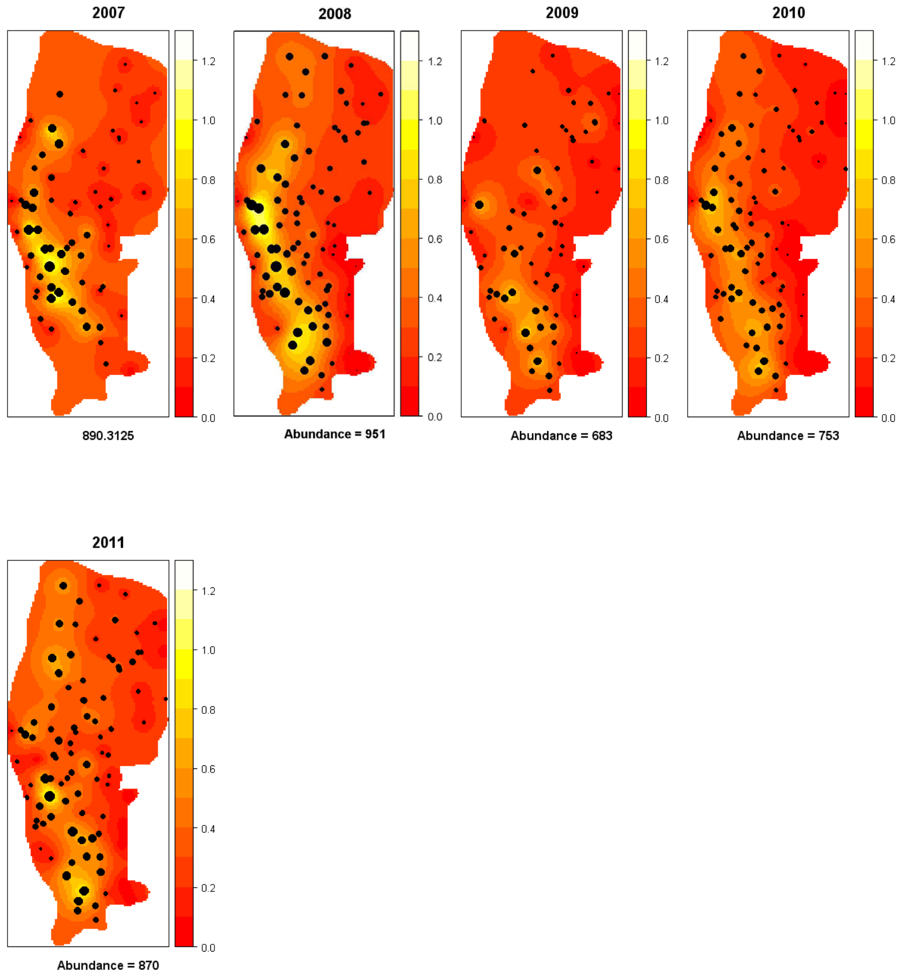


Figure 3.3.2.9 *Nephrops* in FU6: Results of the UWTV survey.

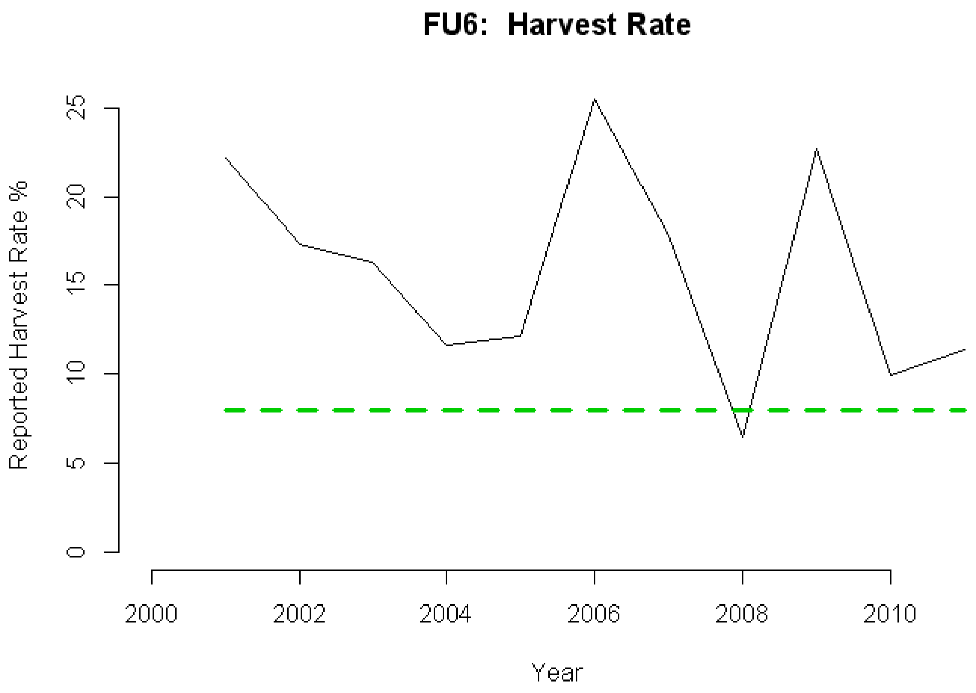


Figure 3.3.2.10 ***Nephrops*** **in FU6: Observed harvest ratio (removals divided by abundance estimate).**

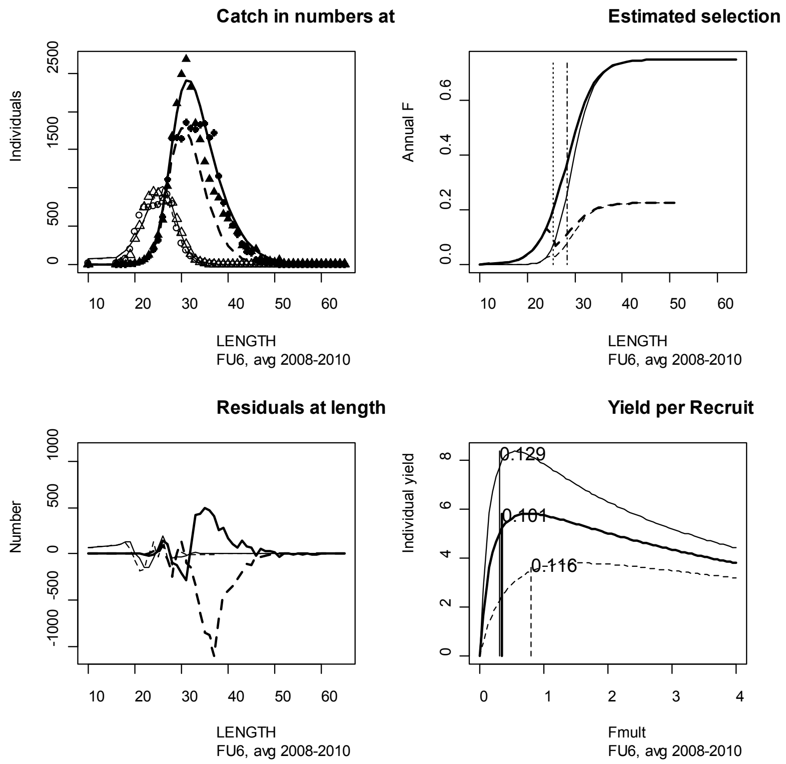


Figure 3.3.2.10 ***Nephrops*** **in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded component. The top left panel gives observed and predicted numbers at length in the discards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

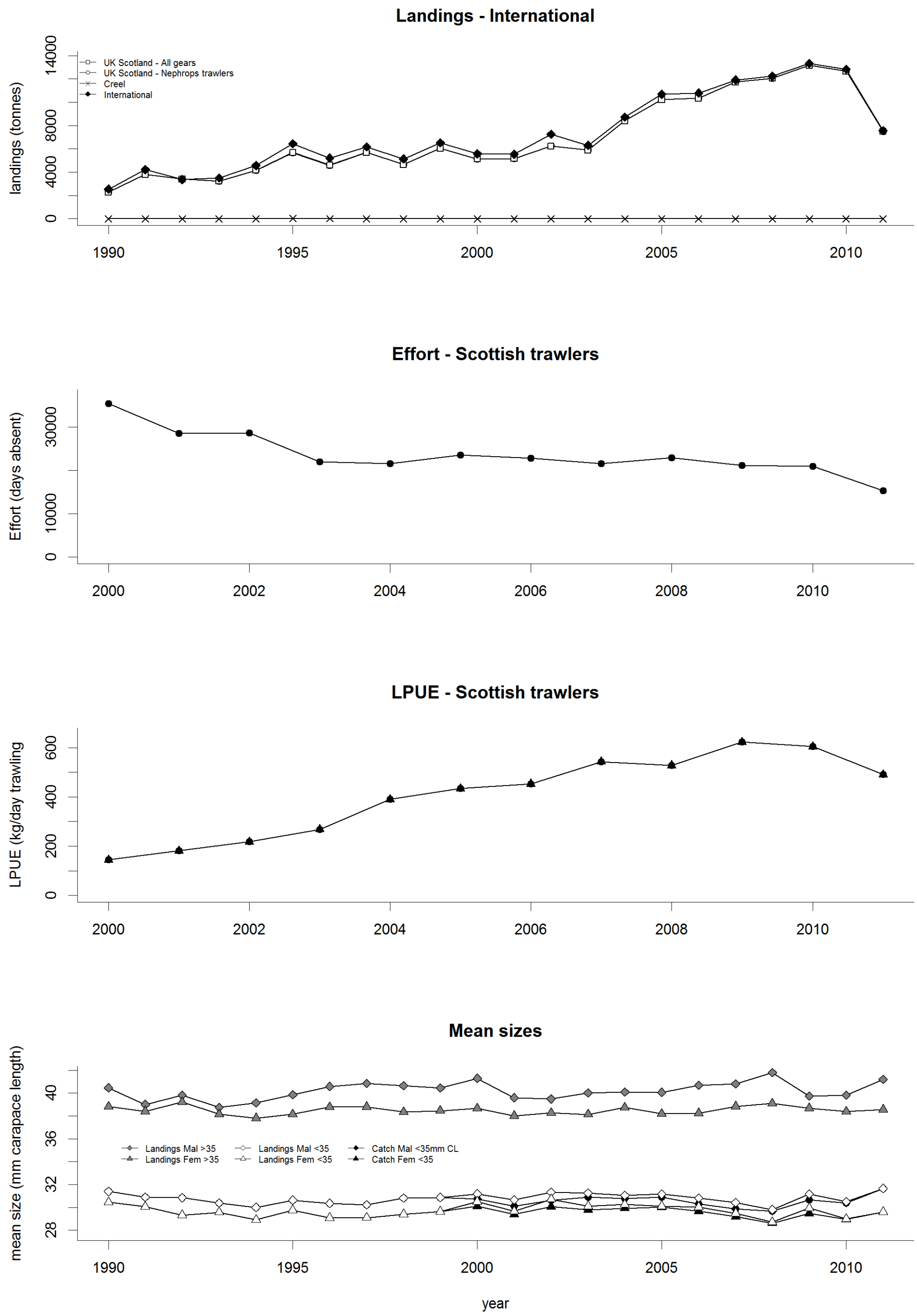
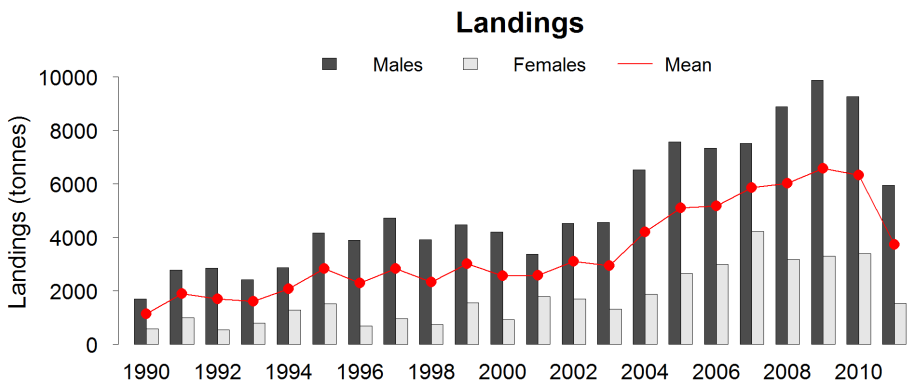


Figure 3.3.3.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2012**



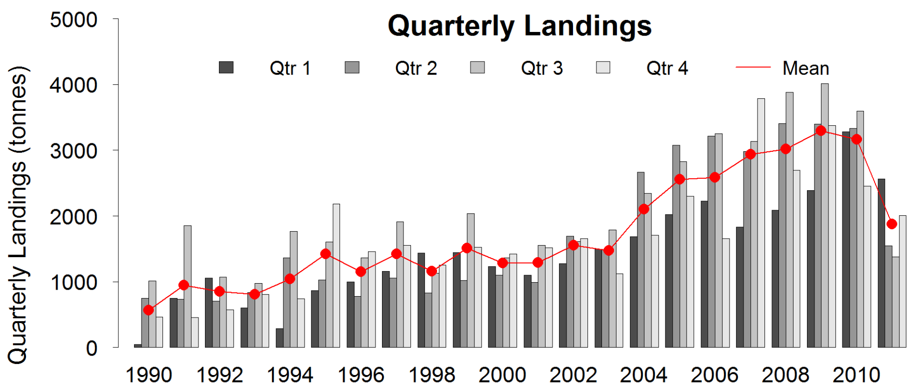


Figure 3.3.3.2 ***Nephrops*****, Fladen (FU 7), Landings by sex and effort by quarter from Scottish trawlers.**

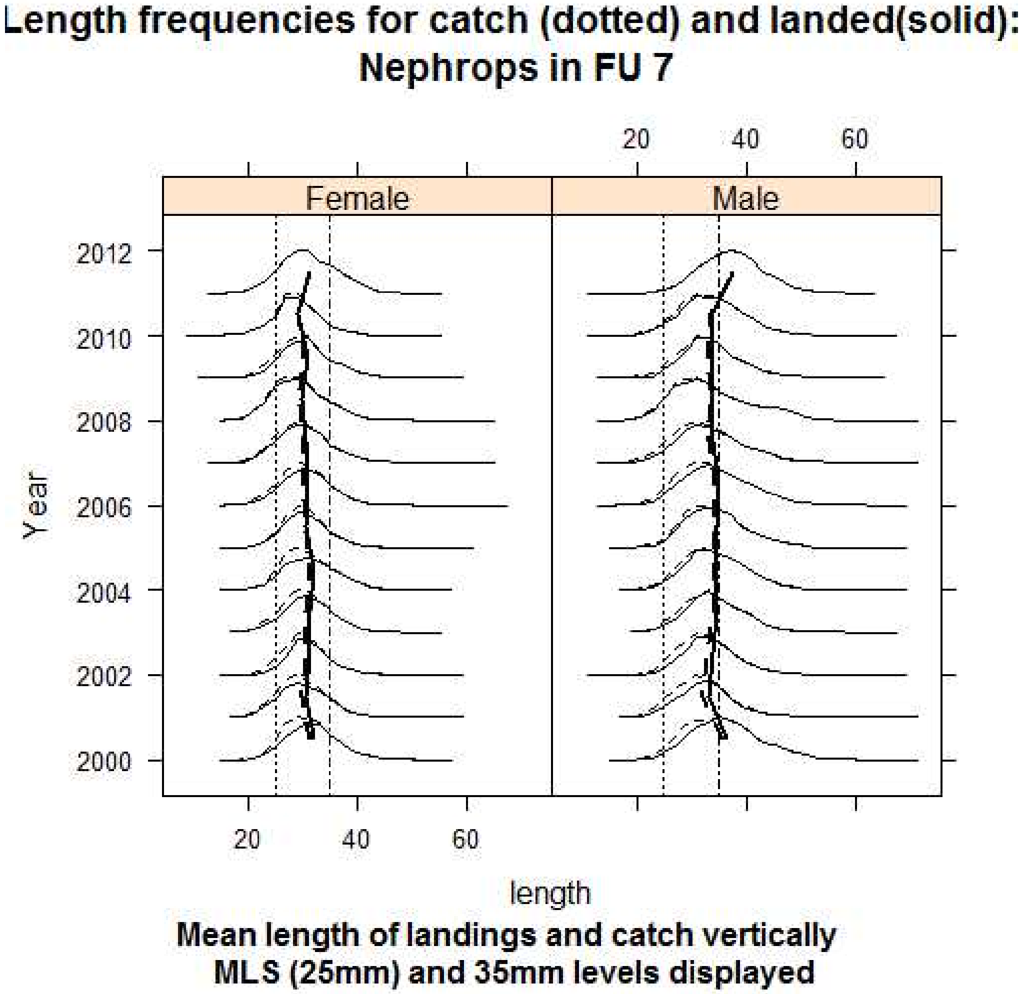


Figure 3.3.3.3. ***Nephrops*** **Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

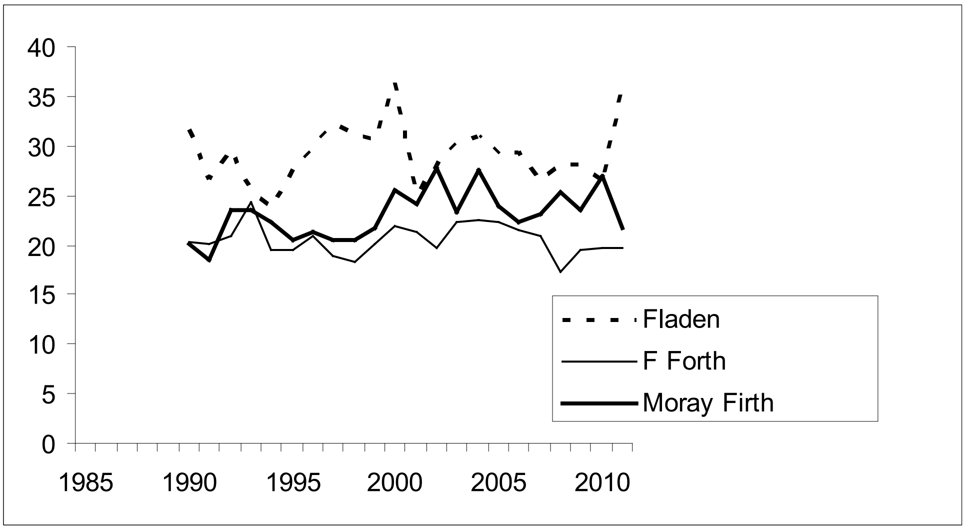


Figure 3.3.3.4 *Nephrops*, (FUs 7-9), individual mean weight in the landings from 1990-2011 (from Scottish market sampling data).

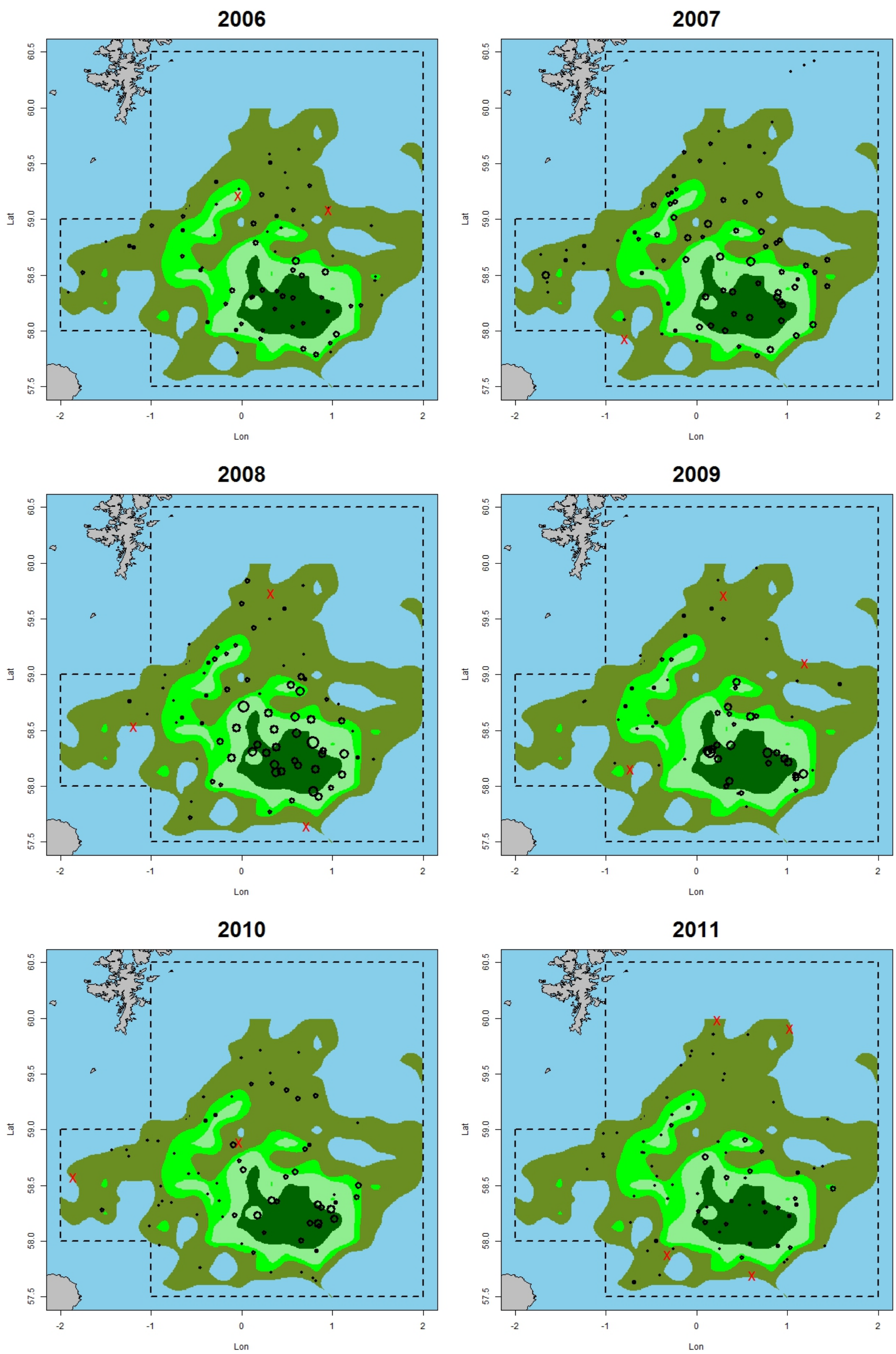


Figure 3.3.3.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

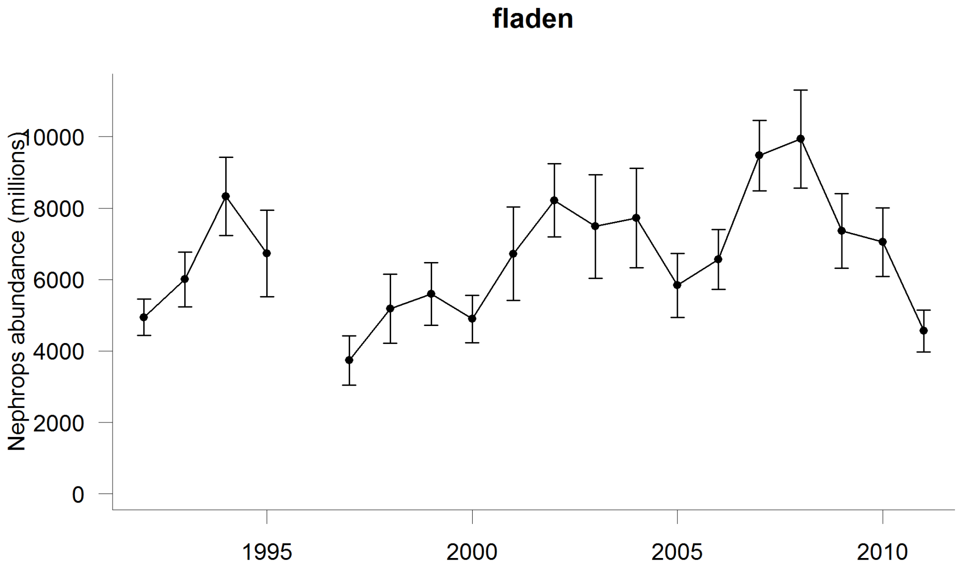


Figure 3.3.3.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates (not bias adjusted), with 95% confidence intervals, 1992 – 2011.**

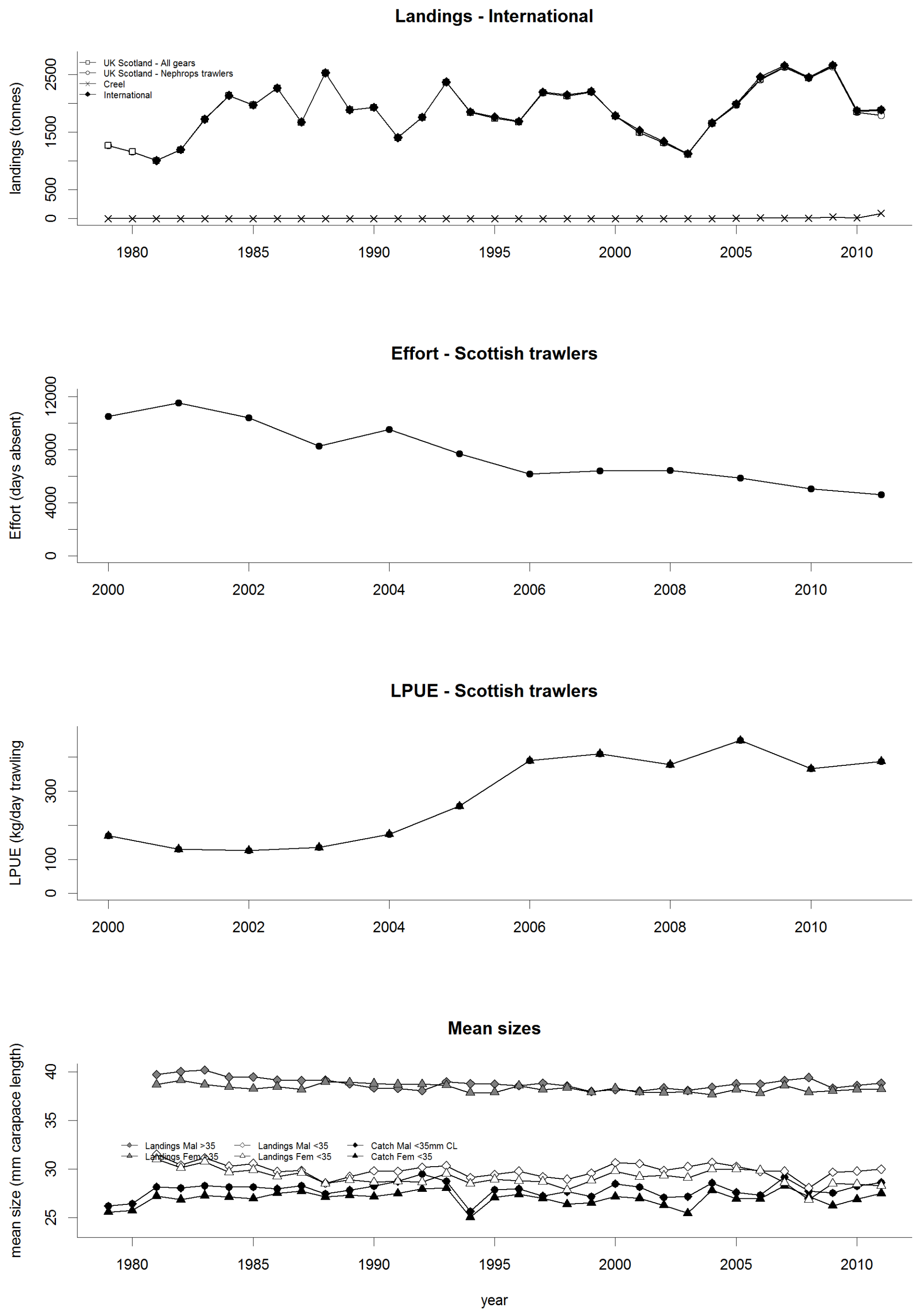
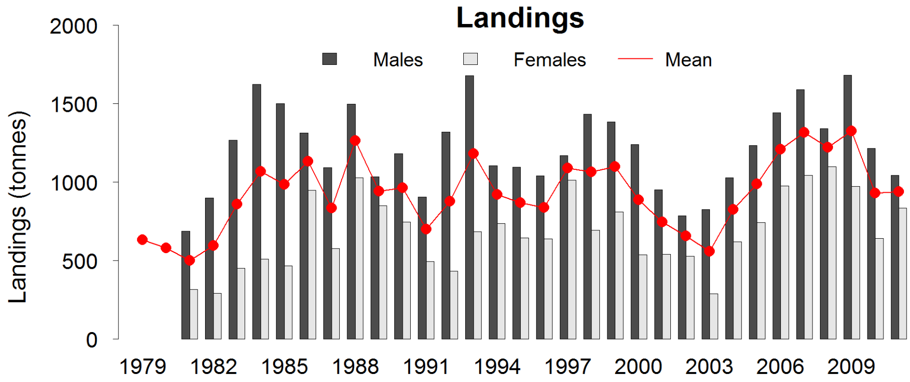


Figure 3.3.4.1 ***Nephrops*, Firth of Forth (FU 8),), Long term landings, effort, LPUE and mean sizes. Note that the effort and LPUE from Scottish trawlers cover a shorter period 2000-2012**



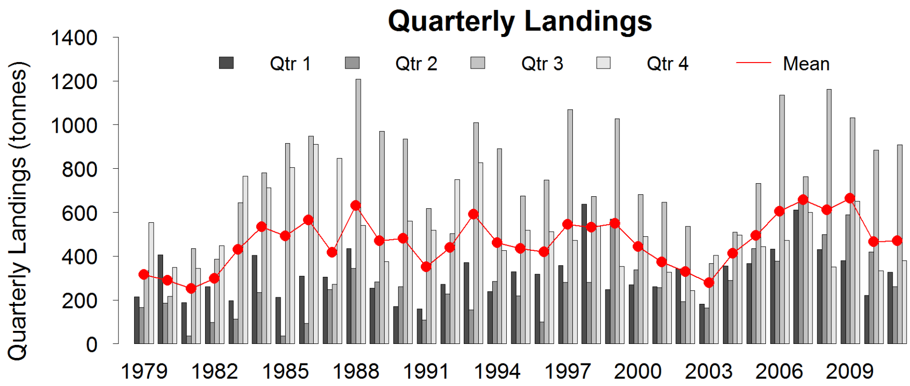


Figure 3.3.4.2 ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

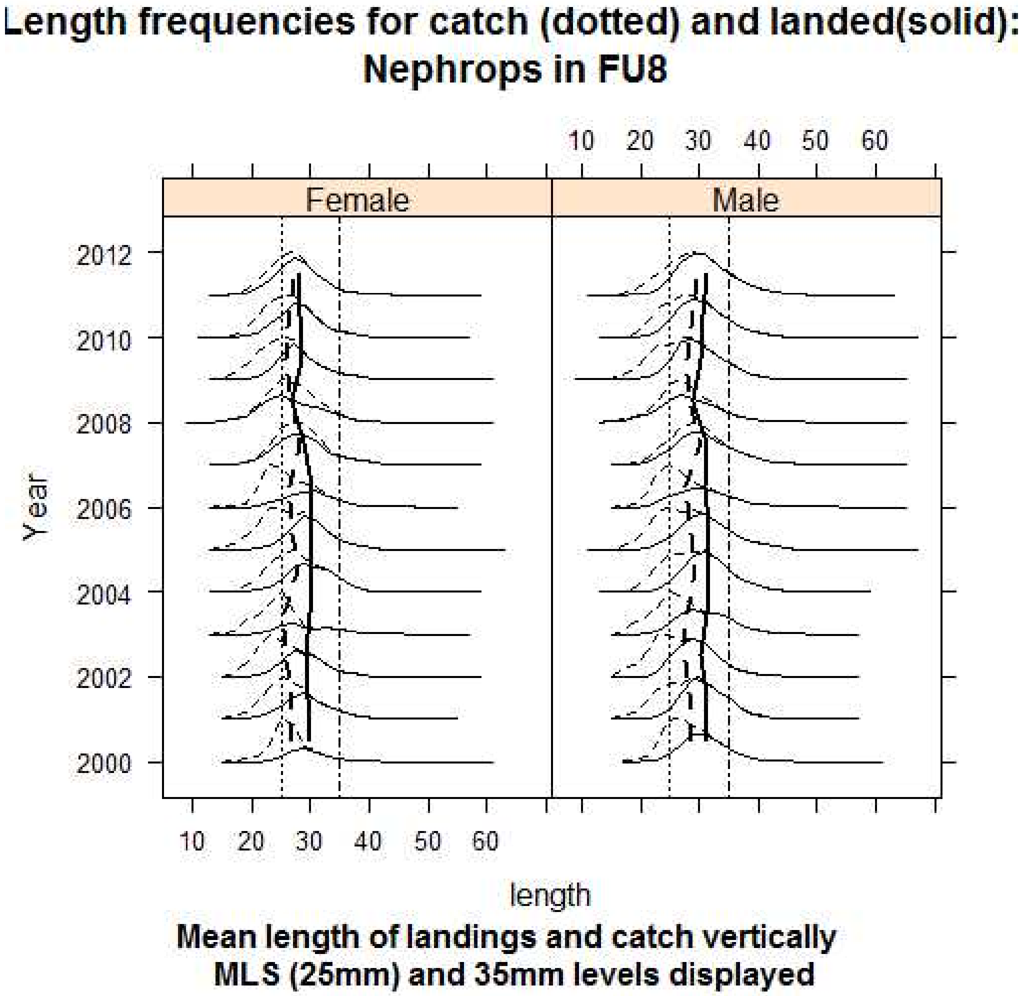


Figure 3.3.4.3 ***Nephrops*** **Firth of Forth (FU 8)Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

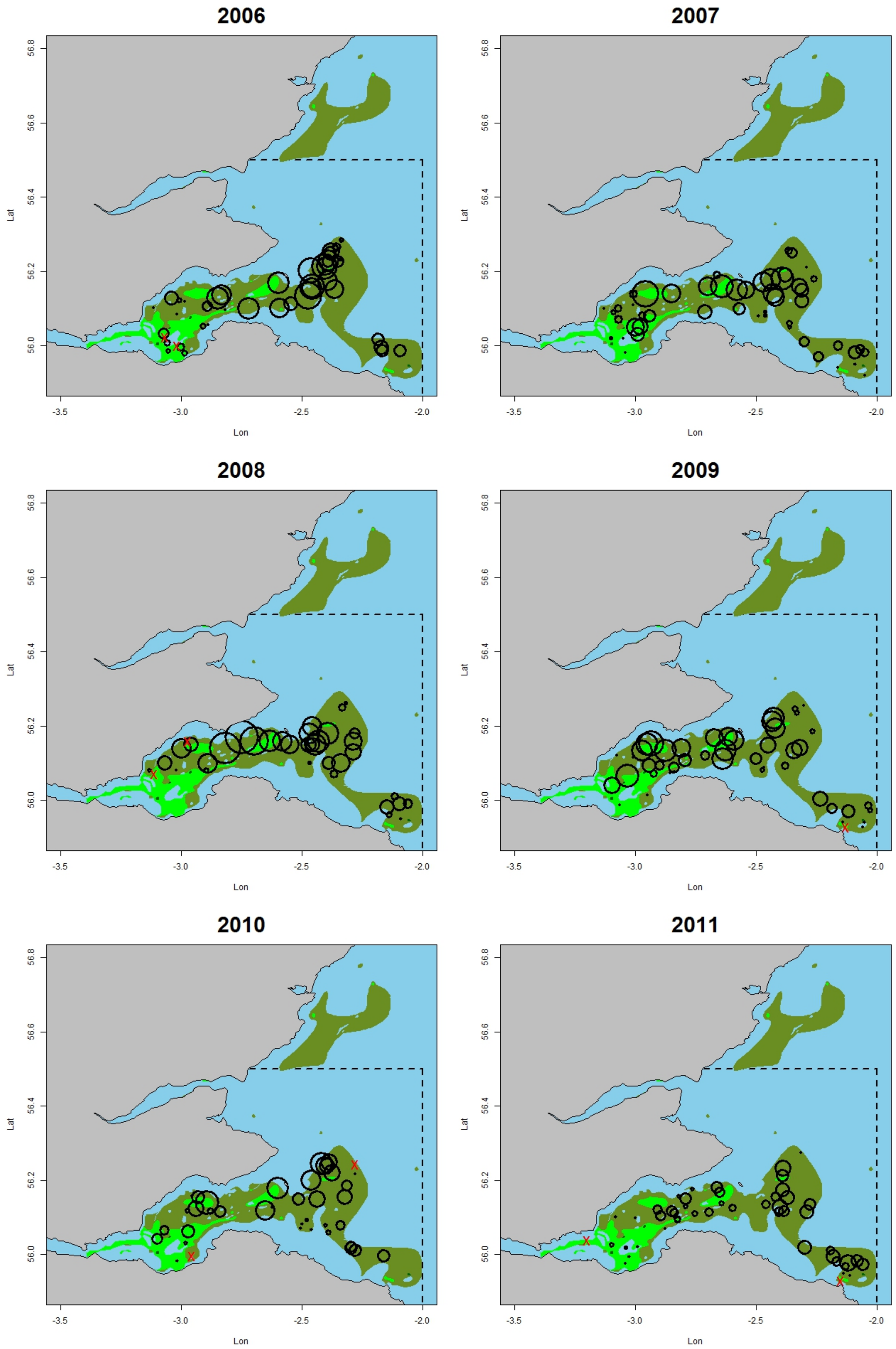


Figure 3.3.4.4 ***Nephrops*****, Firth of Forth (FU 8). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

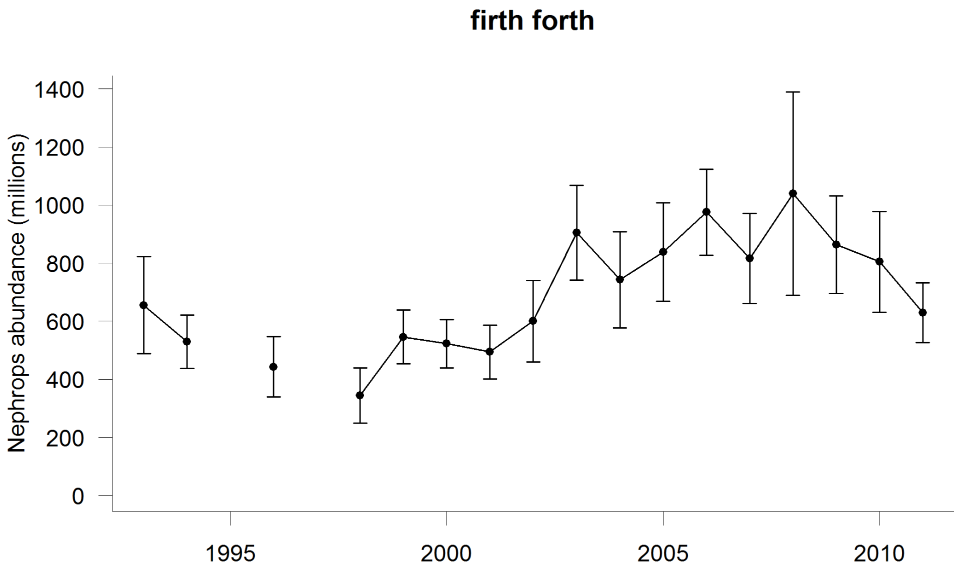


Figure 3.3.4.5 *Nephrops*, Firth of Forth (FU 8), Time series of TV survey abundance estimates, with 95% confidence intervals, 1995 – 2011.

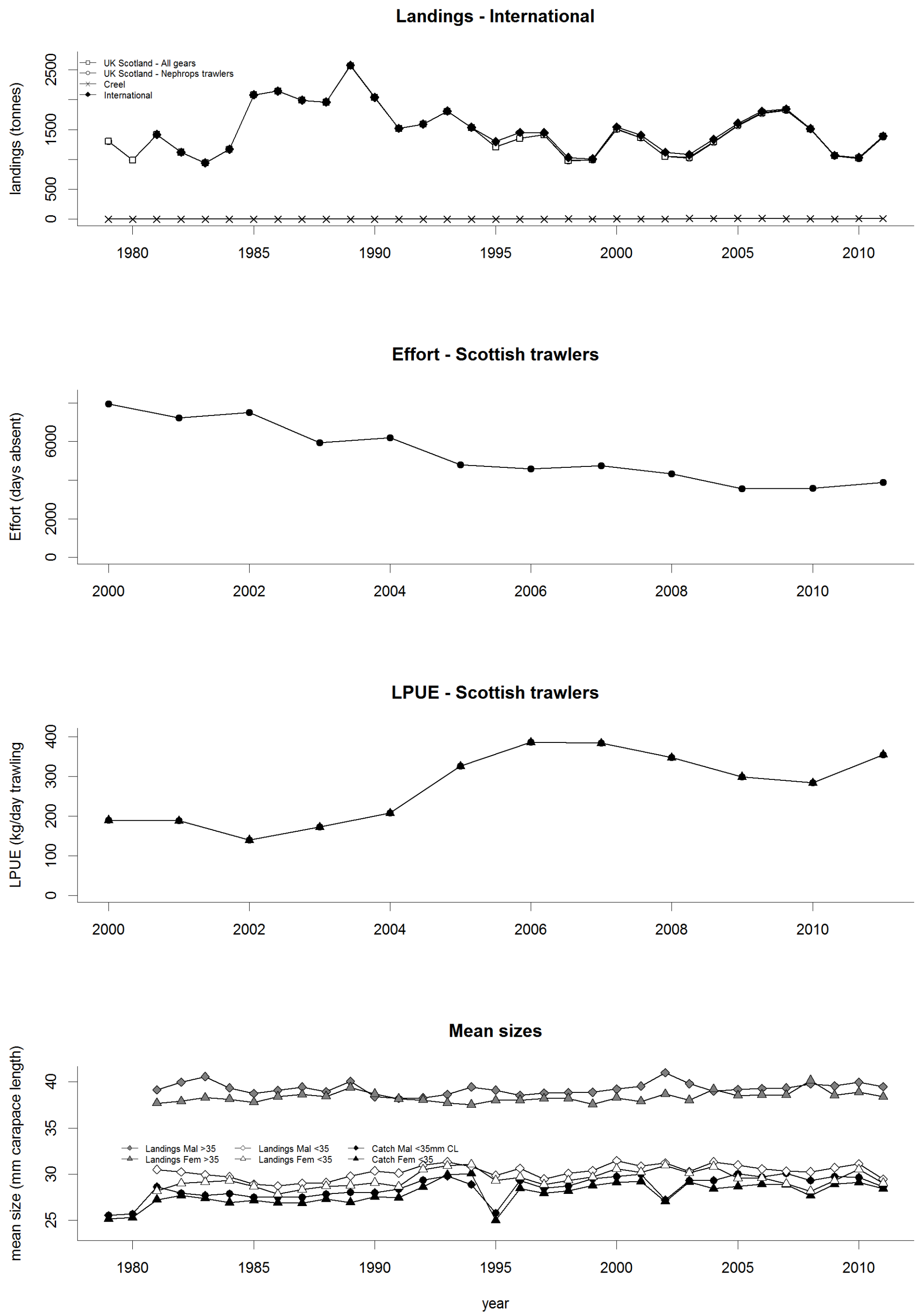
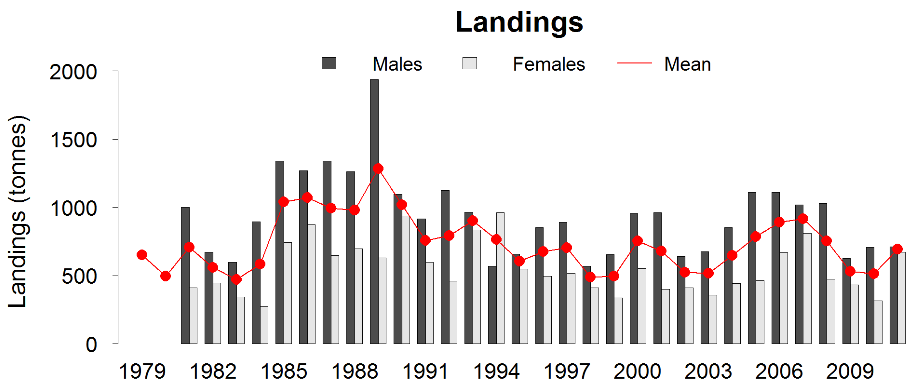


Figure 3.3.5.1 ***Nephrops*****, Moray Firth (FU 9), Long term landings and mean sizes.**



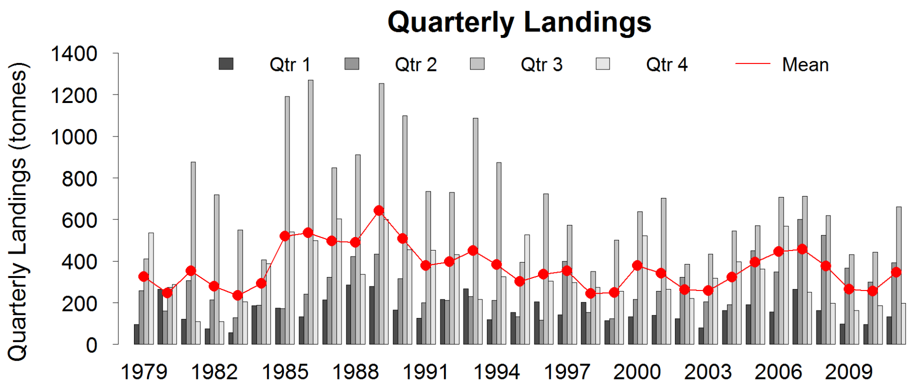


Figure 3.3.5.2 *Nephrops*, Moray Firth (FU 9), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

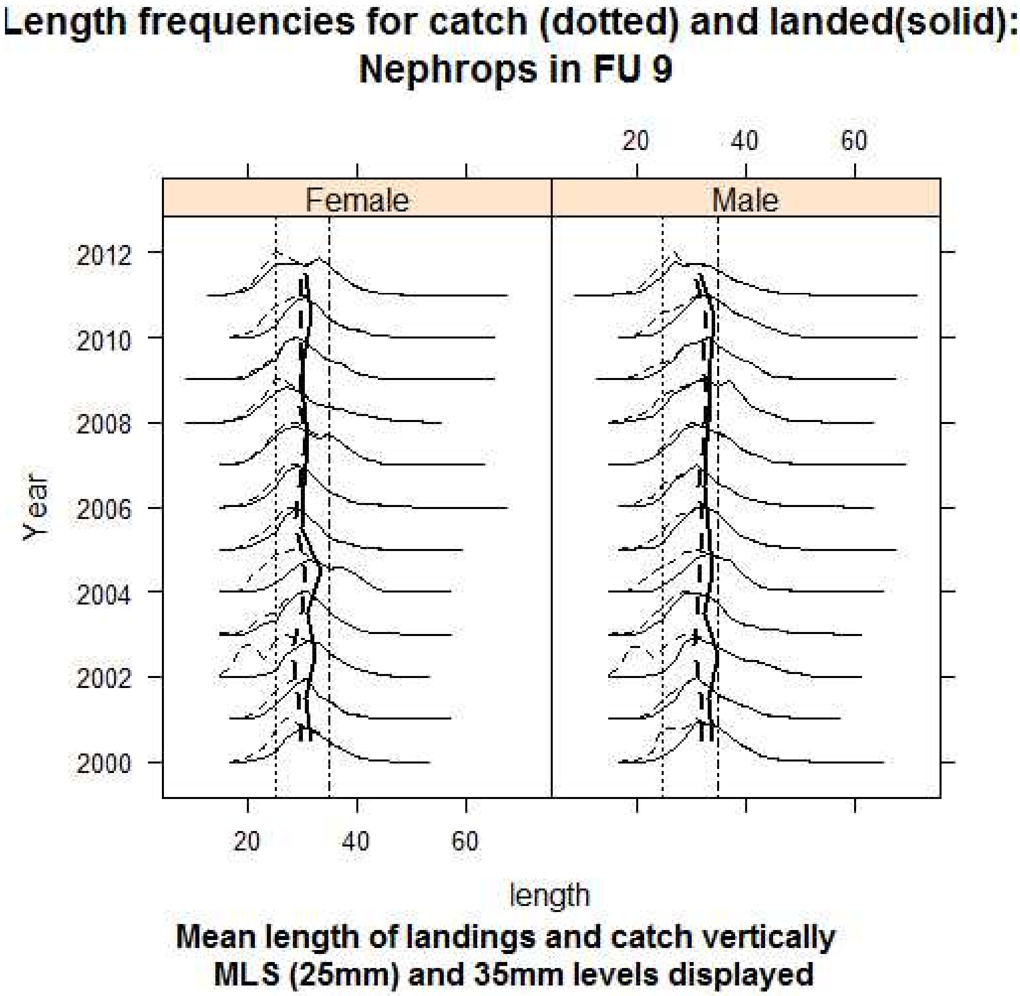


Figure 3.3.5.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2011 (top). Mean sizes of catch and landings are displayed vertically.**

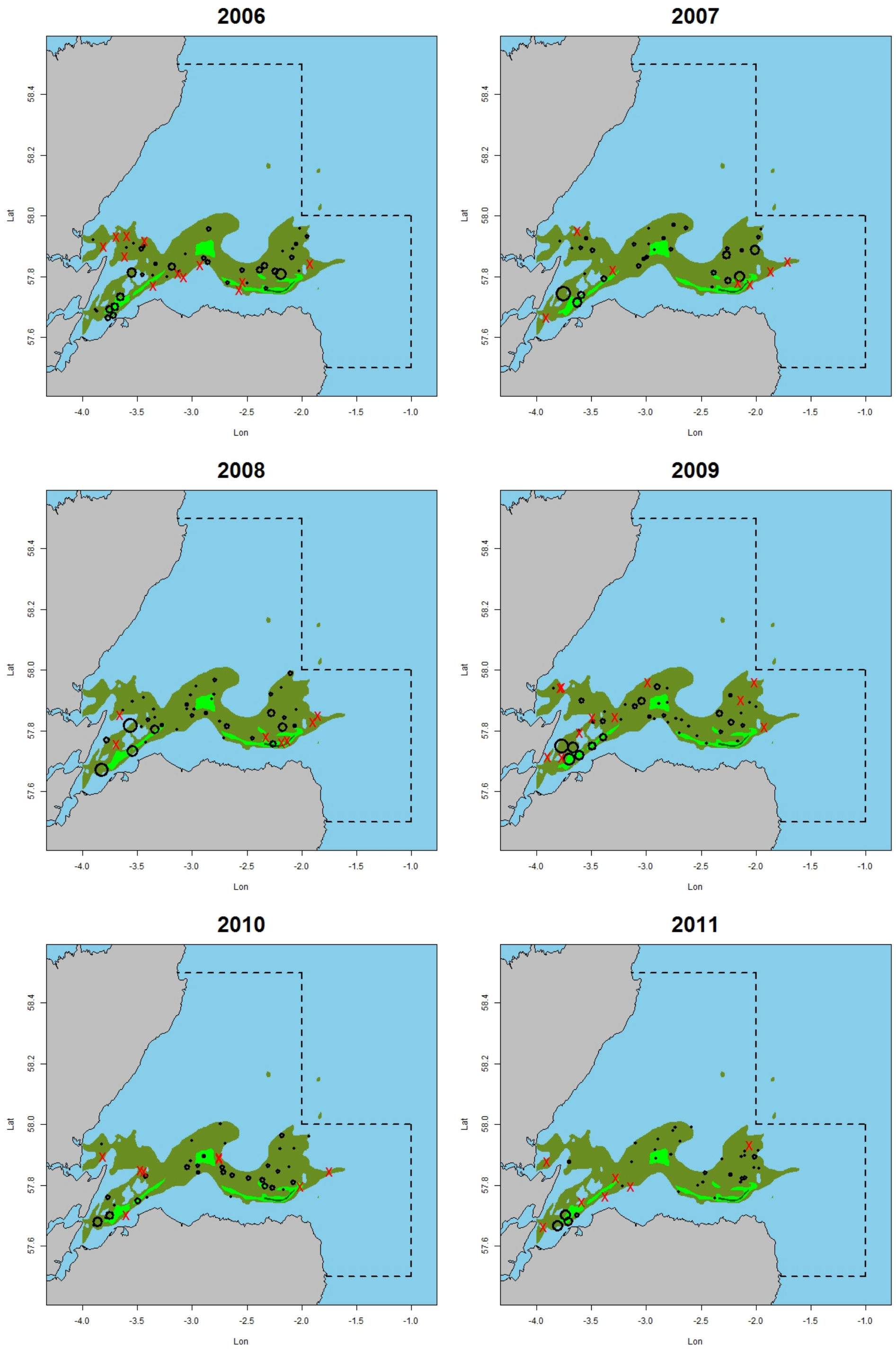


Figure 3.3.5.4 *Nephrops*, Moray Firth (FU 9). TV survey distribution and relative density (2006-2011). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

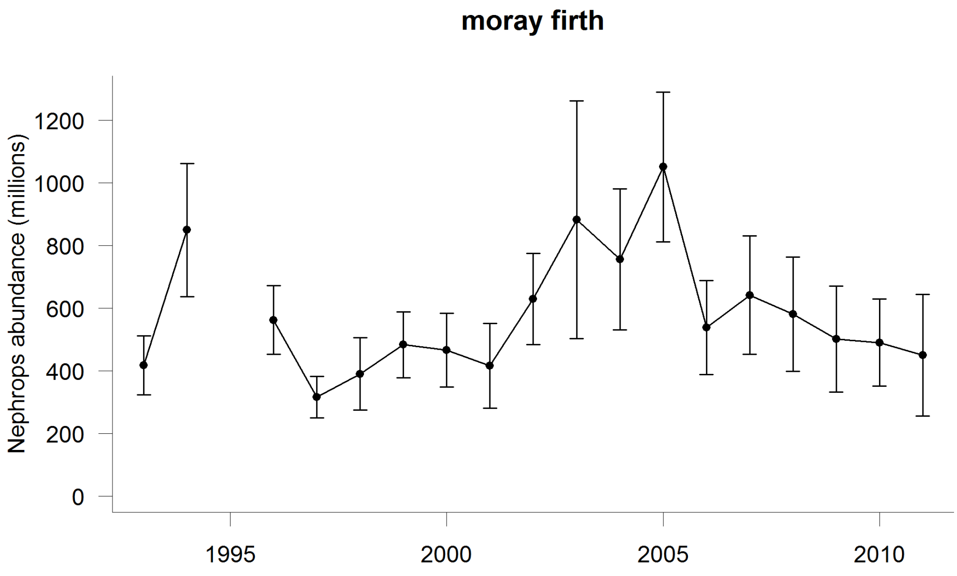


Figure 3.3.5.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates, with 95% confidence intervals, 1993 – 2011.

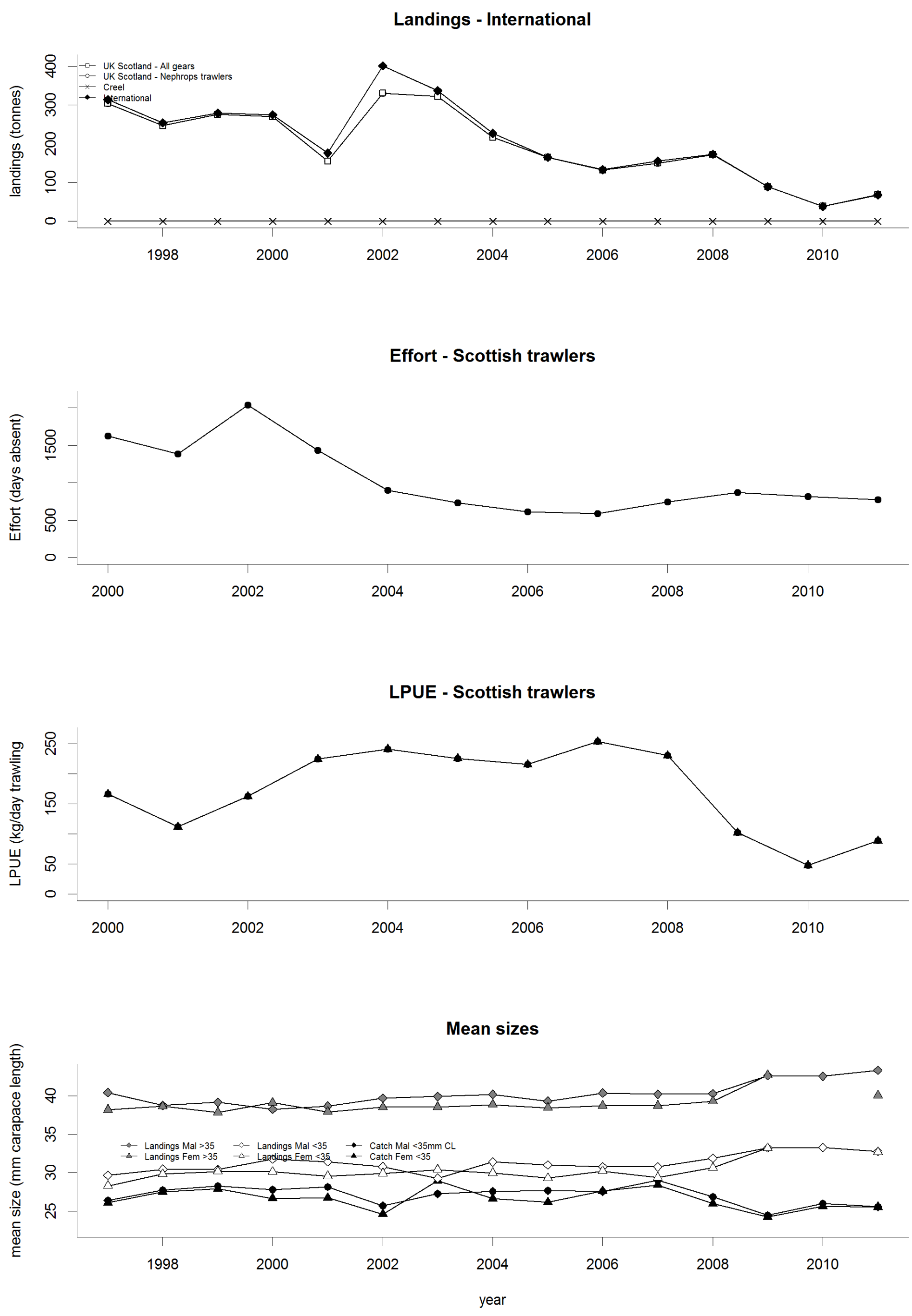


Figure 3.3.6.1 ***Nephrops*****, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010).**

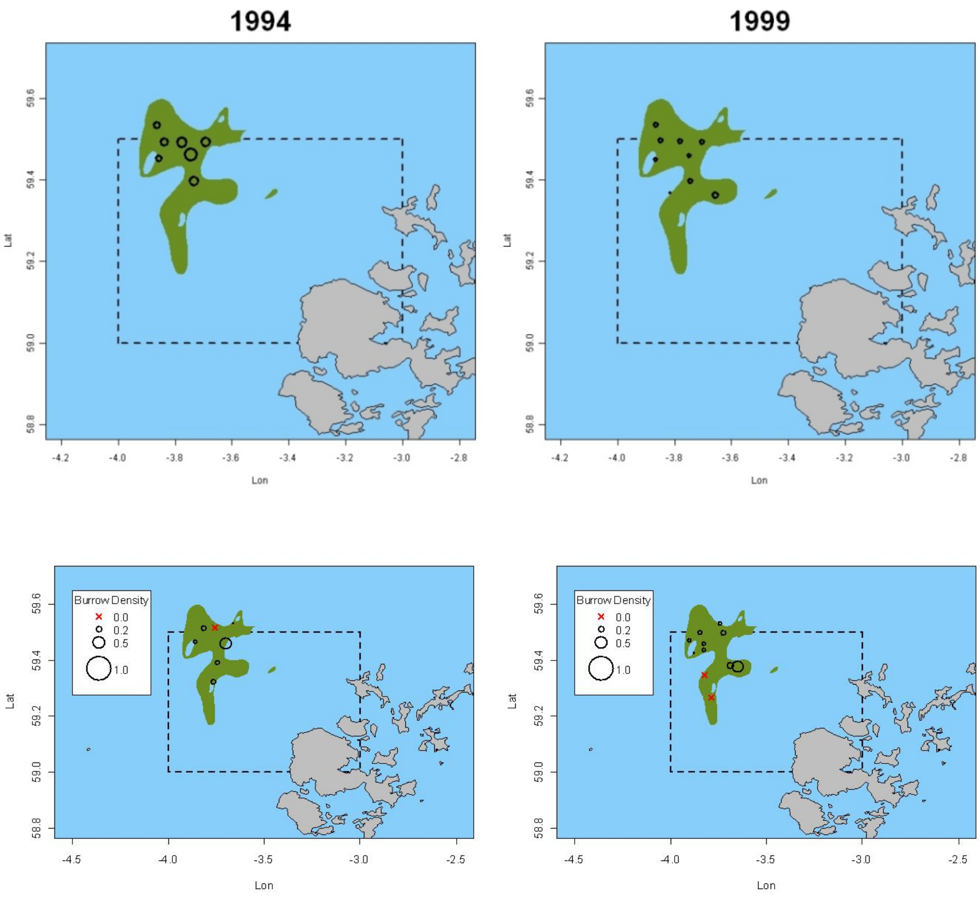


Figure 3.3.6.2 ***Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

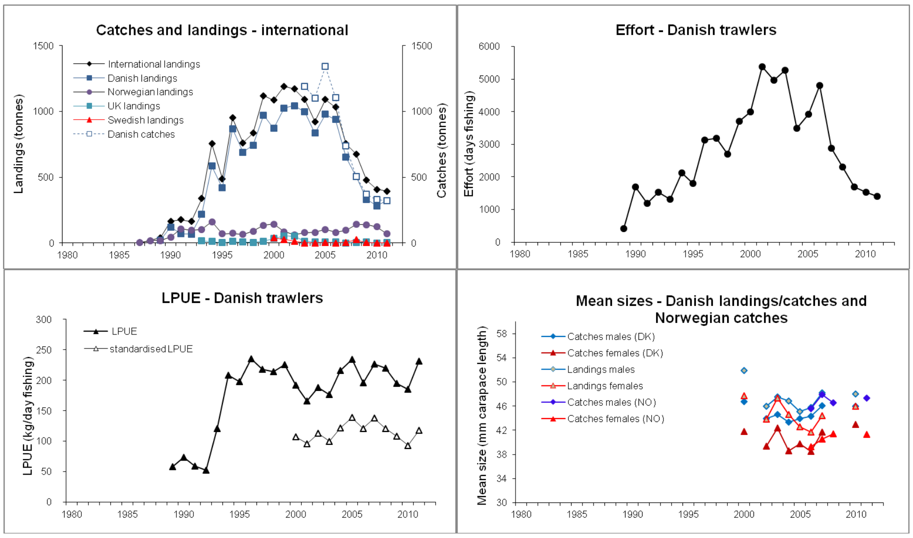


Figure 3.3.7.1, *Nephrops* in FU 32 (Norwegian Deep): Landings, effort, LPUE and mean size.

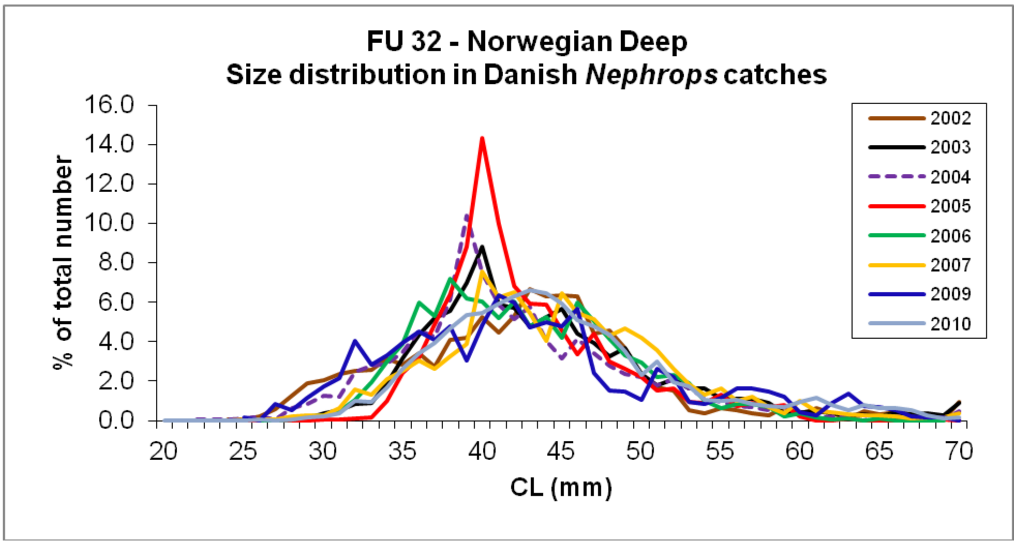


Figure 3.3.7.2, Nephrops in FU 32 (Norwegian Deep): Size distribution in Danish catches.

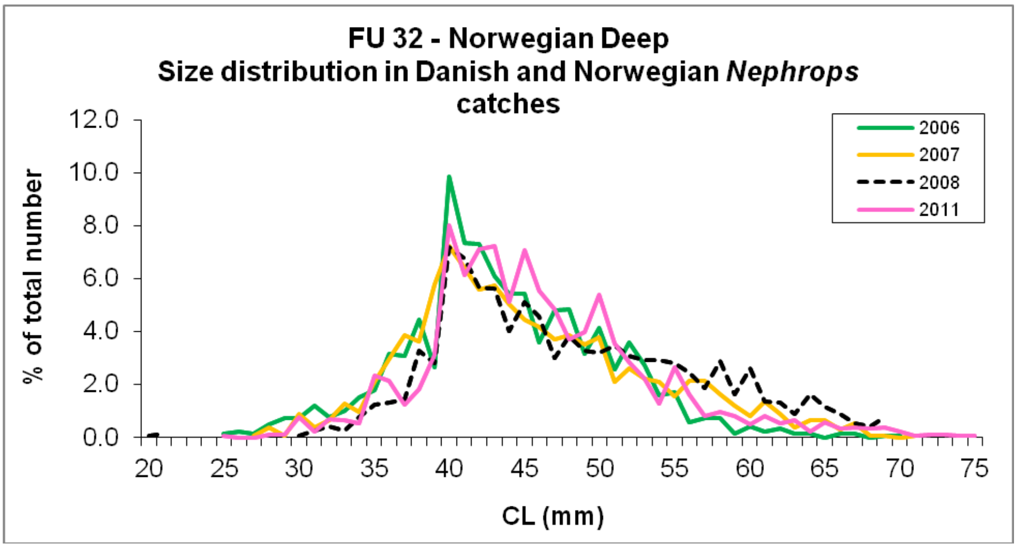


Figure 3.3.7.3, Nephrops in FU 32 (Norwegian Deep): Size distribution of Danish and Norwegian catches. Data from the Norwegian coast guard.

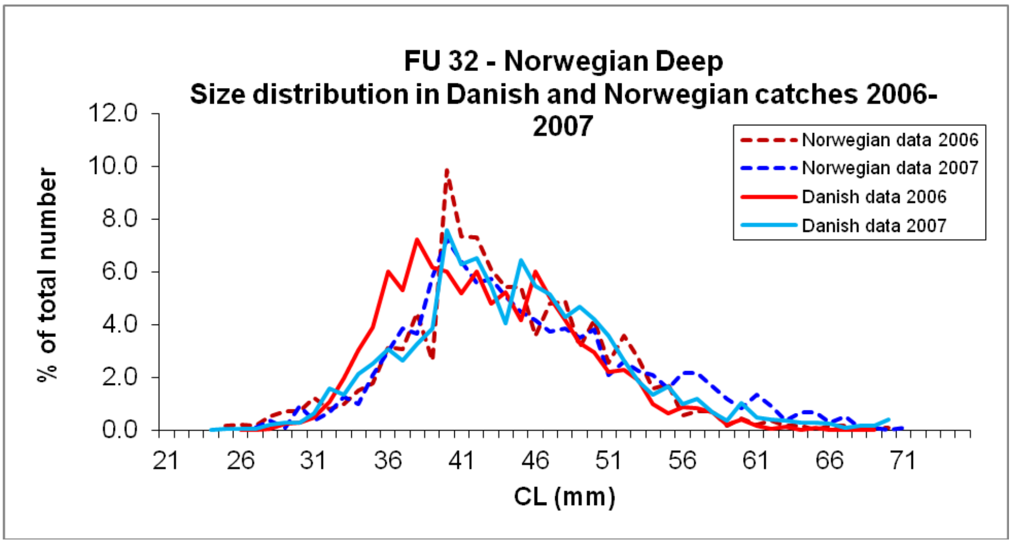


Figure 3.3.7.4, Nephrops in FU 32 (Norwegian Deep): Comparison of size distribution in catches (2006-2007) from Danish and Norwegian data sources.

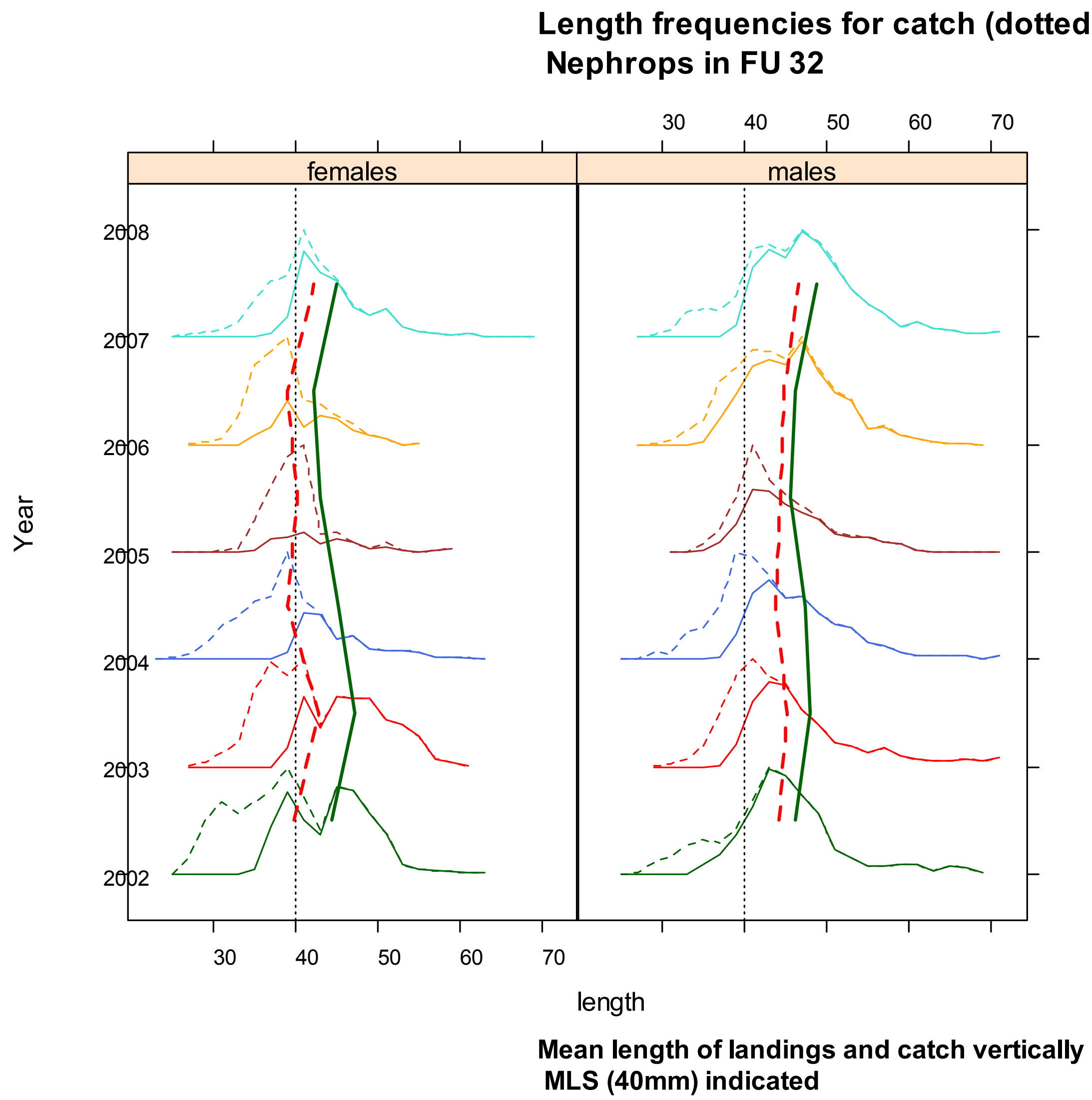


Figure 3.3.7.5, *Nephrops* in FU 32 (Norwegian Deep): Evolution of size composition in landings and discards.

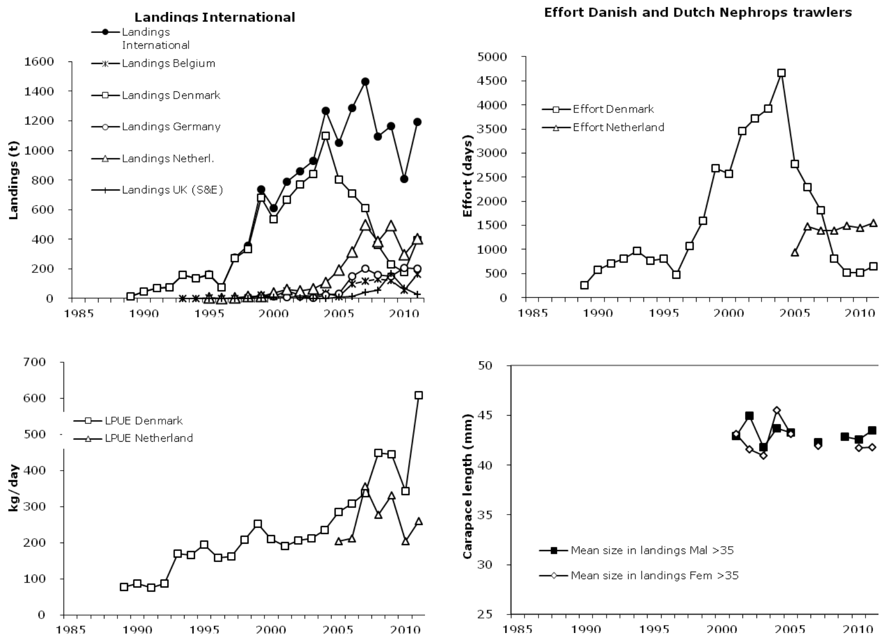


Figure 3.3.8.1 ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

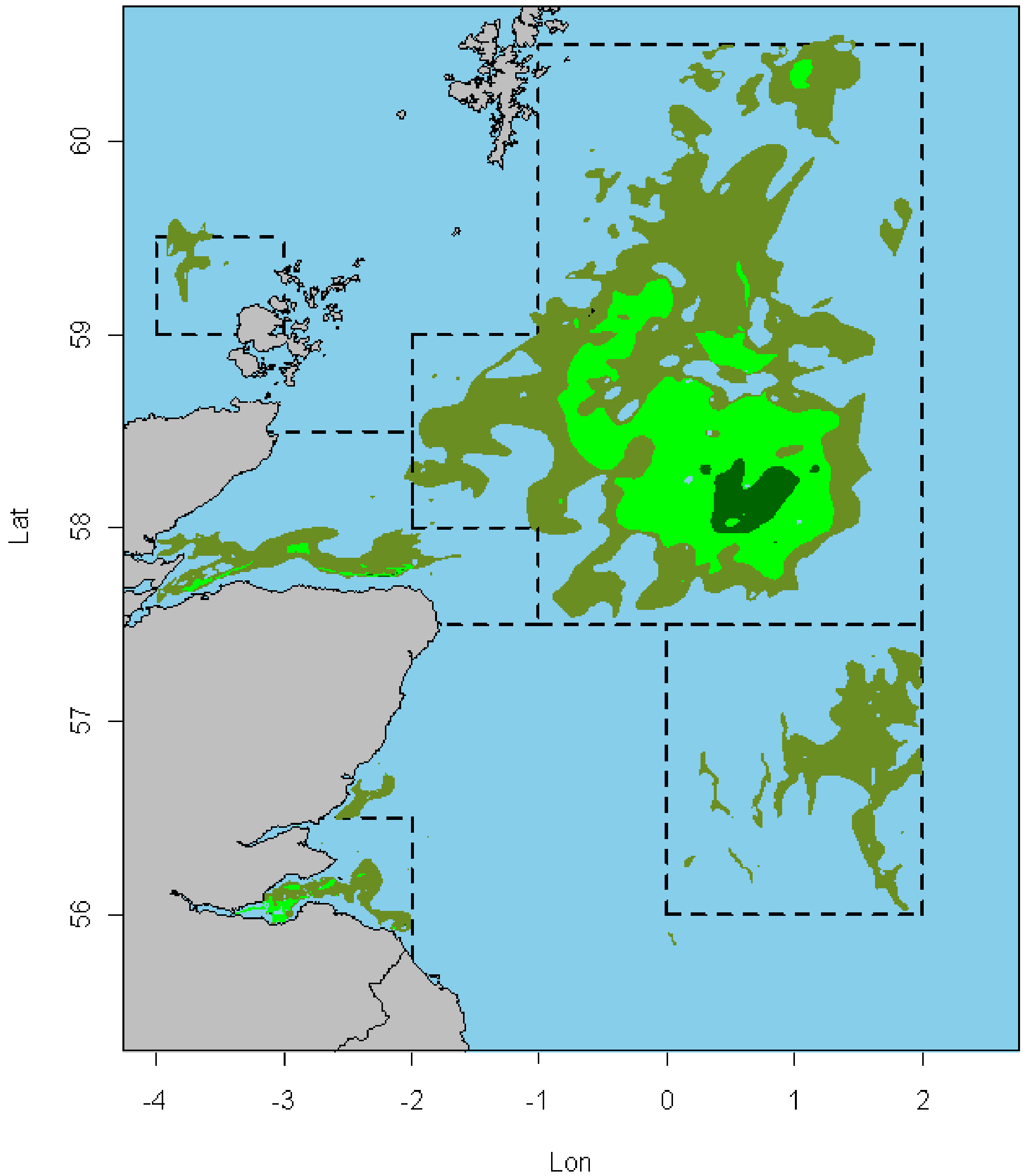


Figure 3.3.9.1. ***Nephrops*****, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.**

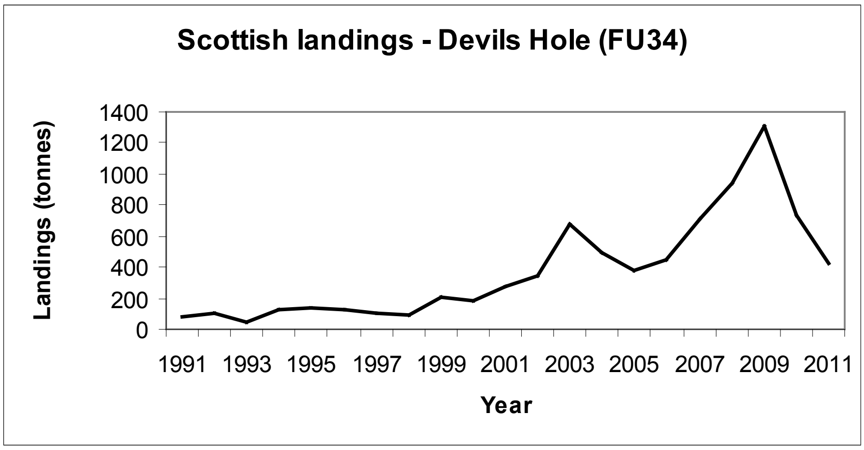
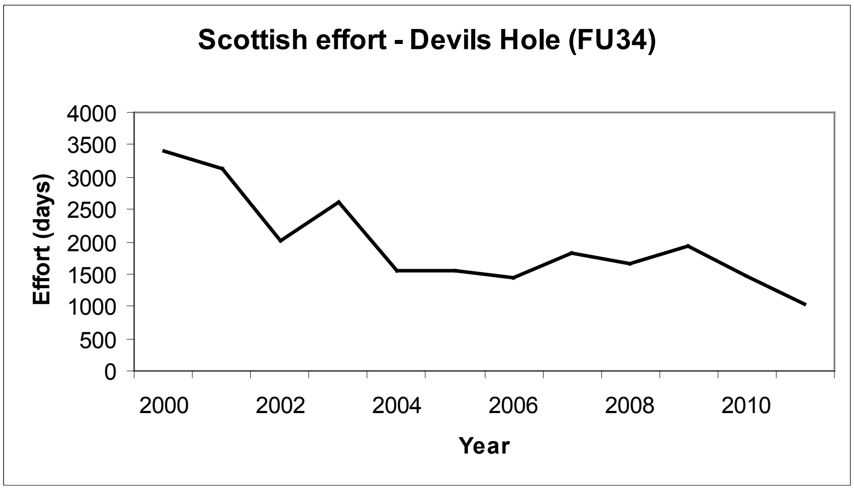


Figure 3.3.9.2. ***Nephrops*, Devil's Hole (FU 34). Scottish landings from 1991 to 2011.**



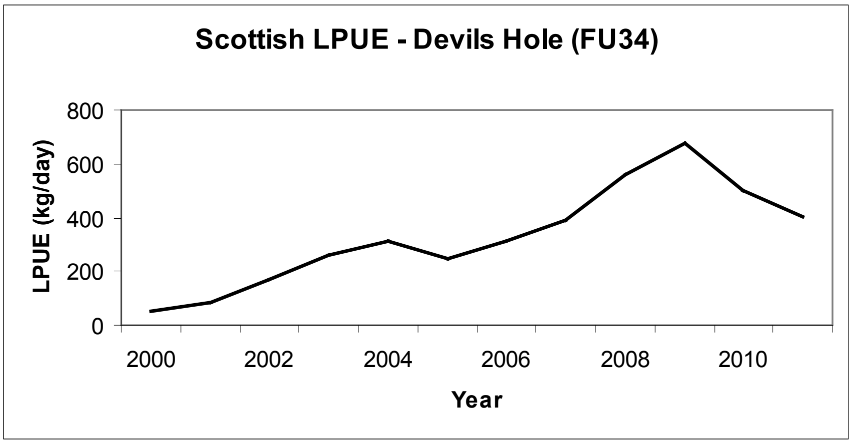


Figure 3.3.9.3. ***Nephrops*, Devil's Hole (FU 34). Effort (days) and LPUE (kg/day by Scottish trawlers.**

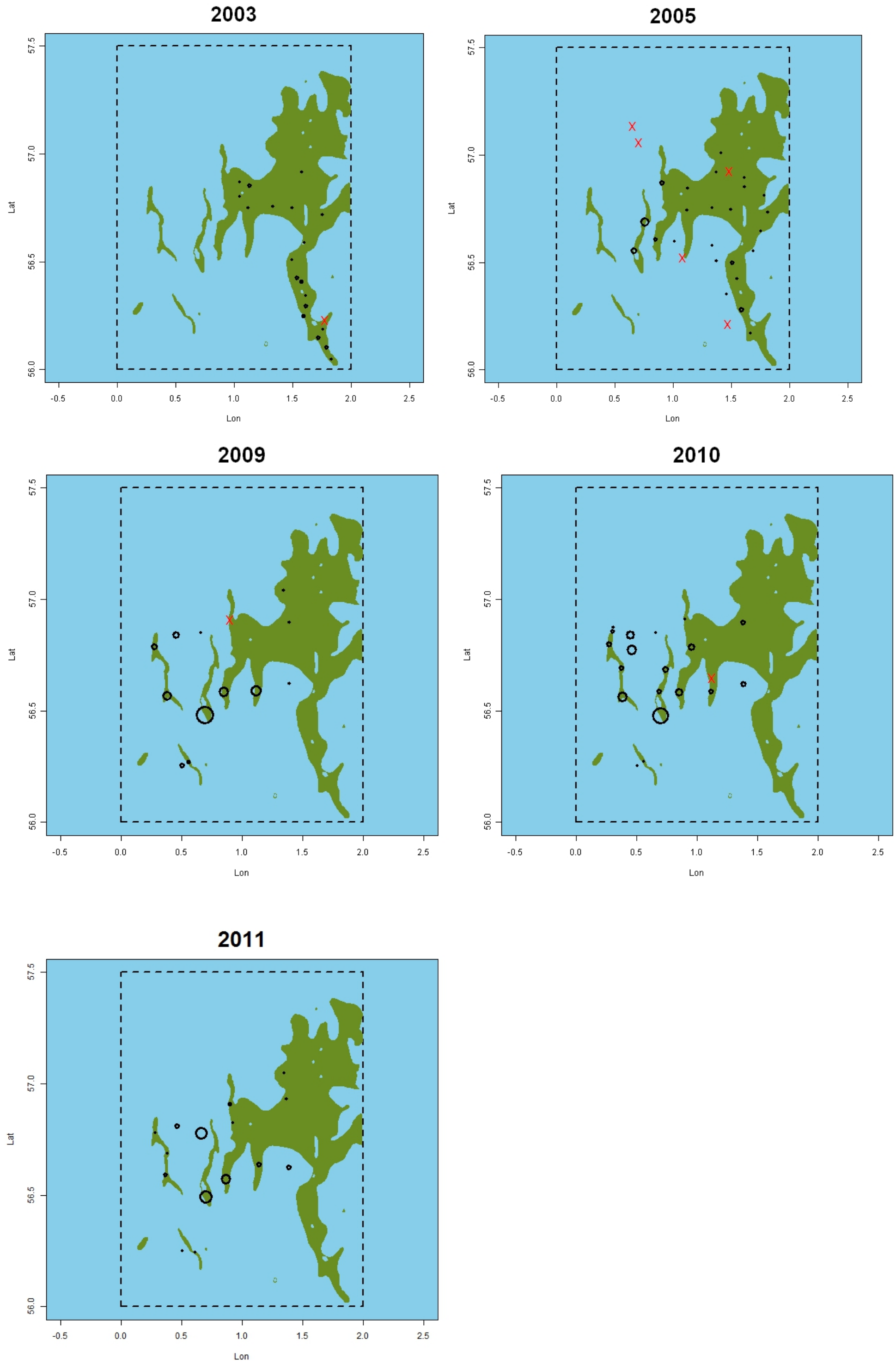


Figure 3.3.9.4. *Nephrops*, Devil's Hole (FU 34). TV survey distribution and relative density (2003, 2005, 2009-2011). Olive areas indicate areas of suitable sediment for *Nephrops*. 2009 - 2011 survey station locations generated from VMS data. Density proportional to circle radius.

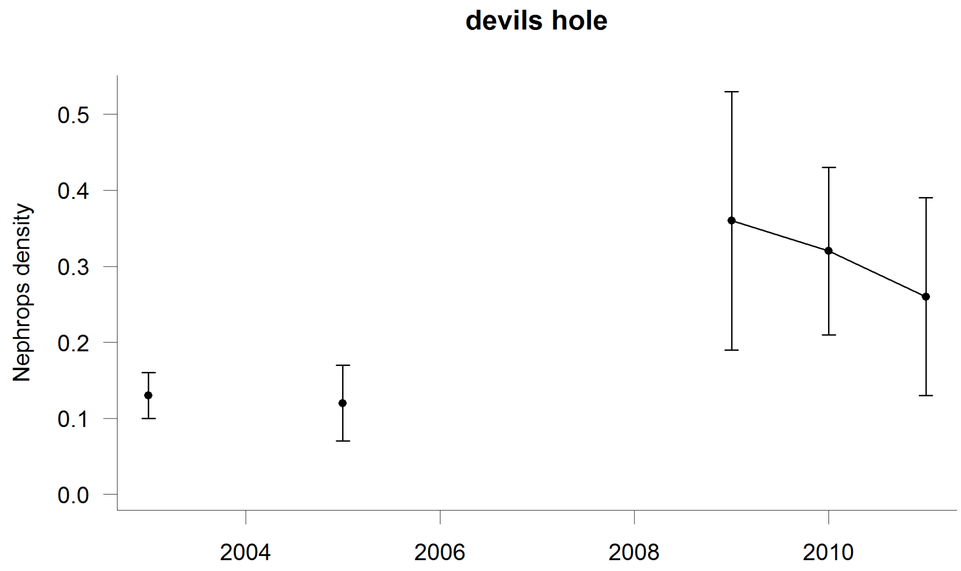


Figure 3.3.9.5. *Nephrops*, Devil's Hole (FU 34). Time series of TV survey density estimates, with 95 % confidence intervals, 2003, 2005, 2009-11.

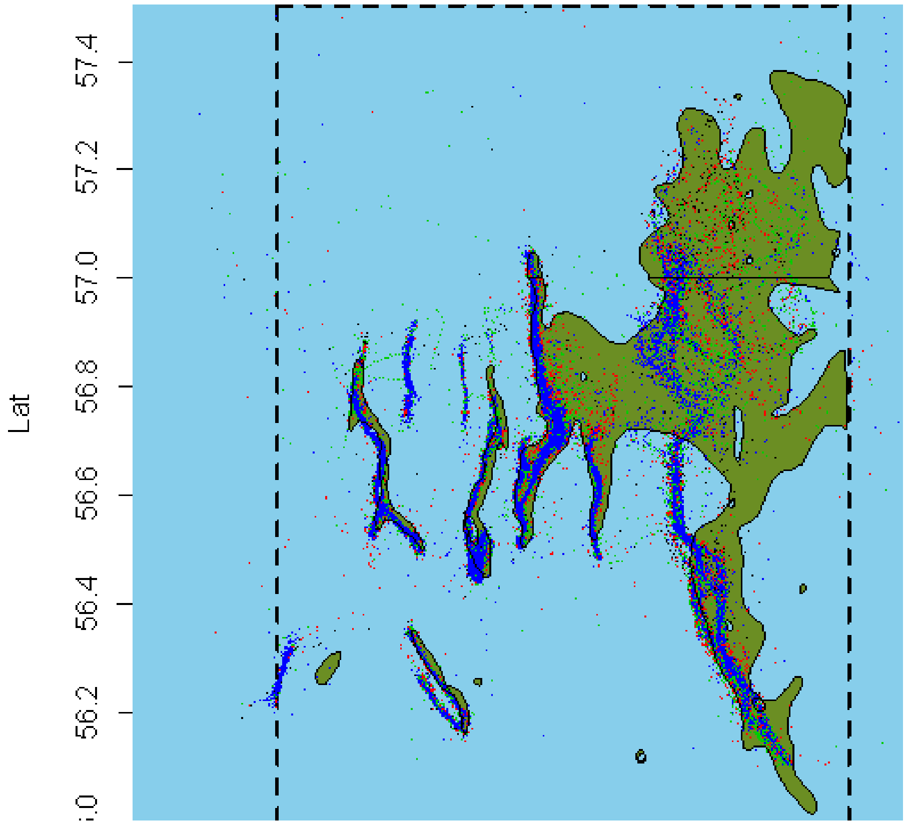


Figure 3.3.9.6. ***Nephrops*, Devil's Hole (FU 34). Comparison of BGS muddy sediment and VMS data from Scottish *Nephrops* trawlers (2006-2009).**

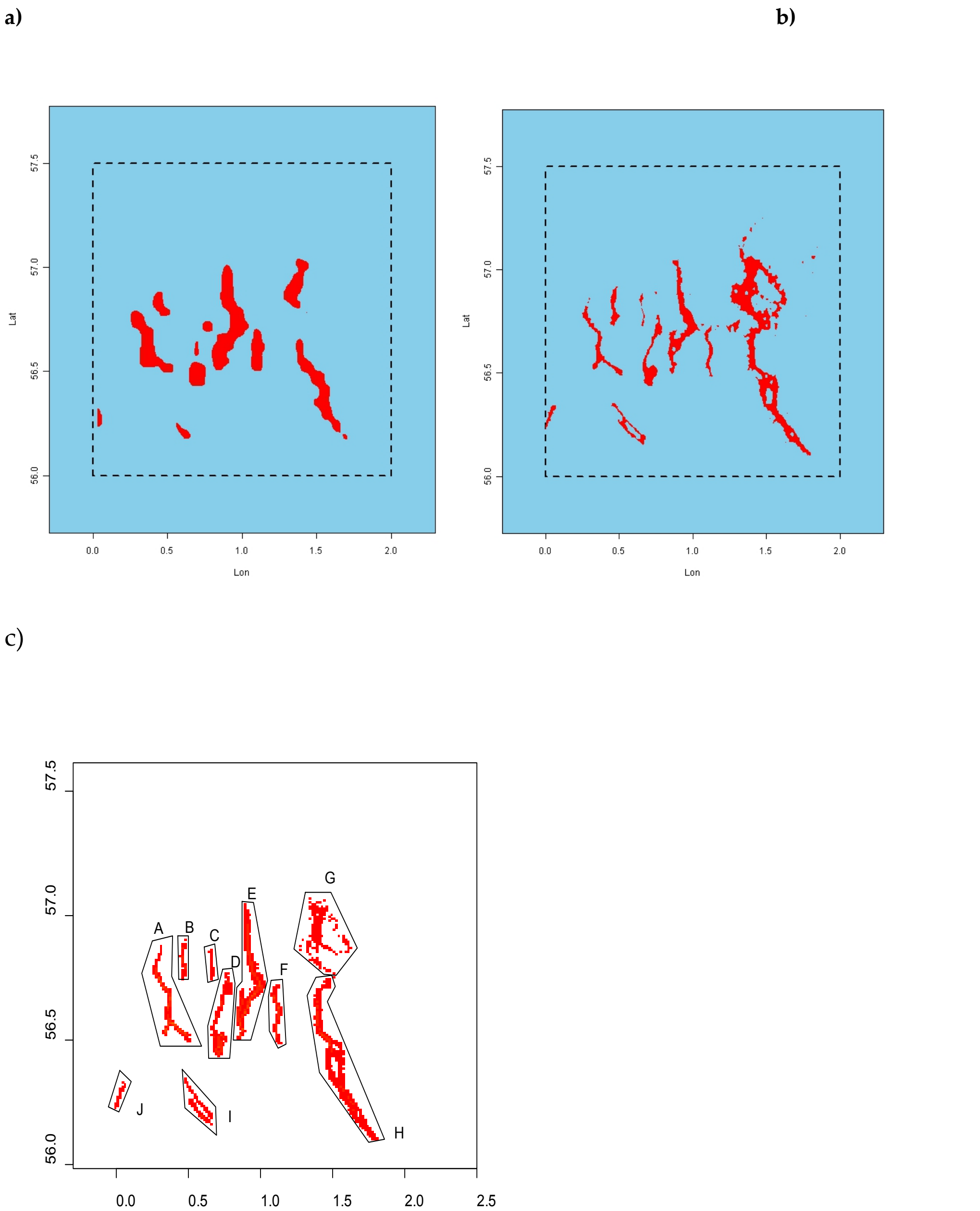


Figure 3.3.9.7. ***Nephrops*, Devil's Hole (FU 34). Estimated fished area by a) thin plate regression spline method (2009 data), b) alpha convex hull (2009 data) and c) cells containing on average > 2 pings/year.**

4 Sandeel in IV (WGNSSK Feb. 2011)

For assessment purposes, the European continental shelf has since 1995 been divided into four regions: Division IIIa (Skagerrak), Division IV (the North Sea excl Shetland Islands), Division Vb2 (Shetland Islands), and Division VIa (west of Scotland). Only the stock in Division IV and part of IIIa is assessed in this report.

Before 1995 two independent sandeel assessments were made: One for the northern North Sea and one for the southern North Sea. In 1995, it was decided to amalgamate the two stocks into a single stock unit The Shetland sandeel stock was assessed separately. ICES assessments used these stock definitions from 1995 to 2009.

Larval drift models and studies on growth differences have indicated that the assumption of a single stock unit is invalid and that the total stock is divided in several sub-populations. Based on this information ICES (ICES CM 2009\ACOM:51) suggested that the North Sea should be divided into seven sandeel assessment areas as indicated in Figure 4.1.1. On this basis the benchmark assessment (ICES 2010, (WKSAN 2010)) decided to make area specific assessments from 2010 onwards.

In 2010 the SMS-effort model was used for the first time to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2010. This model assumes that fishing mortality is proportional to fishing effort.

Further information on the stock areas and assessment model can be found in the Stock Annex and in the benchmark report (WGSAN, 2010).

4.1 General

4.1.1 Ecosystem aspects

Sandeels in the North Sea can be divided into a number of reproductively isolated sub-populations (see the Stock Annex). A decline in the sandeel population in recent years concurrent with a marked change in distribution has increased the concern about local depletion, of which there has been some evidence (ICES WGNSSK 2006b, ICES AGSAN 2008b).

Local depletion of sandeel aggregations at a distance less than 100 km from seabird colonies may affect some species of birds, especially black-legged kittiwake and sandwich tern, whereas the more mobile marine mammals and fish are likely to be less vulnerable to local sandeel depletion.

The stock annex contains a comprehensive description of ecosystem aspects.

4.1.2 Fisheries

General information about the sandeel fishery can be found in the Stock Annex.

The size distribution of the Danish fleet has changed through time, with a clear tendency towards fewer and larger vessels (ICES WGNSSK 2006b). In 2009 only 84 Danish vessels participated in the North Sea sandeel fishery, compared to more than 200 vessels in 2004.

The same tendency was seen for the Norwegian vessels fishing sandeels until 2005. In 2006 only 6 Norwegian vessels were allowed to participate in an experimental sandeel fishery in the Norwegian EEZ compared to 53 in 2002. However, the number of Norwegian fishing vessels participating in the sandeel fishery has increased to 42 in 2008. From 2002 to 2008 also the average GRT per trip in the Norwegian fleet increased from 269 to 507 t. Norwegian EEZ was closed in 2009, and in 2010 an experimental fishery started 23 April in a small area. The quota was 20 000 t, and half of the vessels could fish from 23 April to 30 April, and the other half could fish between 28 April and 5 May. The objective of the experiment was to measure the abundance of sandeel with acoustic before and after the fishery and examine the effect of the fishery on the biomass. Based on the acoustic survey an additional quota on 30 000 t was given. This fishery started 15 May and closed 23 June. In accordance to the Norwegian management plan (sec 4.1.4), only subareas 1b, 2b, and 3b were open for fishery in 2010 (Fig. 4.1.5). In 2011, the preliminary quota in the Norwegian EEZ was 60 000 t, which was increased with 30 000 t based on the acoustic survey results. Only subareas 1a, 2a and 3a were open for fishery. The fishing season was from 23 April to 23 June.

The rapid changes of the structure of the fleet that have occurred in recent years may introduce more uncertainty in the assessment, as the fishing pattern and efficiency of the "new" fleet may differ from the previous fleet and the participation of fewer vessels has limited the spatial coverage of the fishery.

The sandeel fishery in 2011 was opened 1st of April. As in the most recent years the main fishery took place in the in the Dogger Bank area and grounds north east of Dogger Bank.

4.1.3 ICES Advice

ICES advised that, the fishery in 2011 should be allowed only if analysis of data from the in-year monitoring programme indicated that the stock would be above B_{pa} by 2012.

Subsequently, based on results from the in-year monitoring programme ICES recommended that the catches in area 1 and 2 2011 should not exceed 320 000 and 34 000 t, respectively. Catches in area 3 were recommended to be zero.

ICES noted that the management of sandeel fisheries should try to prevent depletion of local aggregations, particularly in areas where predators congregate.

ICES recommended that future management should take into account the spatial structure of sandeels.

4.1.4 Management

TAC

The guidelines for setting the provisional TAC and quotas regarding sandeels in 2011 in EU zone are given by the Council Regulation (EC) No. 57/2011. In 2011, the Provisional TAC was set up at 265 000 tonnes, shared between EU (242 250 t) and Norway (22 750 t). This TAC was revised in June (Council Regulation No 683/2011) after the publication of ICES advice, and the final TAC for 2011 was set at 354 420 t (of which 20 000 t allocated to Norway)

In 2011, the preliminary quota in the Norwegian EEZ was 60 000 t, which was subsequently increased to 90 000 t.

For 2012 the EU Council Regulation set a preliminary TAC at 200 000 t in the EU waters of IIa, IIIa and IV (Council Regulation (EC) No. 44/2012). This TAC is further divided on sandeel area. The TAC will be revised on the basis of the advice from ICES (this assessment) and STECF. For the Norwegian EEZ, Norway has not set a preliminary TAC for 2012, but the TAC advice is 40 000 t restricted to the subareas 1b, 2b and 3b (Figure 4.1.5).

Norwegian sandeel management plan

An Area Based Sandeel Management Plan for the Norwegian EZZ was fully implemented in 2011, but was also used in 2010. Based on historical fishing patterns and local stock developments 6 areas are defined, each consisting of "a" and "b" subareas (Figure 4.1.5). The main objective of the Plan is to rebuild the spawning stocks in all 6 areas and thereby enhance the total recruitment and catch potential. Acoustic surveys and catch information (if available) are used to estimate the abundance, age structure and geographical distribution of the sandeel population. If the analyses show that the spawning stock is large and widely distributed within an area (Figure 4.1.6), one of the adjacent subareas can be open for fishery. The subsequent year, if the state of the spawning stock still is strong, the other subarea will be open. Prior to the fishing season, which is restricted to 23 April – 23 June, a preliminary TAC is given and within the open subareas the fleet can operate freely. The acoustic surveys carried out in the current year will be used to validate previous biomass estimates and to estimate the recruitment strength of the 1-year old sandeels. Based on this updated survey information, the TAC within the current year can be increased and new areas (subareas) can be open.

Closed periods

From 2005 to 2007 the fishery in the Norwegian EEZ opened April 1 and closed again June 23. In 2008 the ordinary fishery was stopped 2 June, and only a restricted fishery with 5 vessels continued. No fishery was allowed in 2009. From 2010 the fishing season is 23 April – 23 June in the Norwegian EEZ.

Since 2005 Danish vessels have not been allowed to fish sandeels before 31st of March. In 2010 sandeel fishery in the EU zone was opened on the 1st of April and closed 1t of August.

Closed areas

The Norwegian EEZ closed for an ordinary fishery in 2006 based on the results of a three week RTM fishery. In 2007, no ordinary fishery was allowed north of 57°30′N and in the ICES rectangles 42F4 and 42F5 after the RTM fishery ended. In 2008, the ordinary fishery was closed except in ICES rectangles 42F4 and 44F4, and for 5 vessels only, the ICES rectangles 44F3, 45F3, 44F2 and 45F2 were open. The Norwegian EEZ was closed to fishery in 2009. In accordance with the Norwegian sandeel management plan, only the Norwegian management subareas 1b, 2b and 3b were open. In 2011, only the subareas 1a, 2a and 3a were open.

In the light of studies linking low sandeel availability to poor breeding success of kittiwake, there has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000, except for a limited fishery in May and June for stock monitoring purposes.

4.1.5 Catch

Landing and trends in landings

Landings statistics for Division IV are given by country in Table 4.1.1. Landing statistics and effort by assessment area are given in Tables 4.1.2 to 4.1.7. Figure 4.1.1 shows the areas for which catches are tabulated.

The sandeel fishery developed during the 1970s, and landings peaked in 1997 and 1998 with more than 1 million tons. Since 1983 the total landings have fluctuated between 1.2 million tons (1997) and 180 000 tons (2005) with an overall average at 678 000 tons (Figure 4.1.3). There was a significant decrease in landings in 2003. The average landings of the period 1983 to 2002 was 835 000 tons whereas the average landings of the period 2003 to 2010 was 313 000 tons. Total landings in 2011 were 437 000 t.

Spatial distribution of landings

Yearly landings for the period 2000–2011 distributed by ICES rectangle are shown in Figure 4.1.2. Dogger Bank remains the main fishing area, with one rectangle (39F1) contributing the highest landings of all rectangles in 8 out of the last 10 years. The fishery in the Norwegian EEZ has varied over time, primarily as a result of changes in regulations.

Figure 4.1.3 shows the landings by area. There are large differences in the regional patterns of the landings. Areas 1 and 3 have always been the most important with regard to sandeel landings. On average, together these two areas have contributed 85% of the total sandeel landings in the period 1983 to 2011. 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 47 and 36% respectively whereas their contributions were 65 and 21% in the period 2003 to 2011. In Area-3 landings in the Norwegian EEZ have declined since 2006 due to national regulation of the fishery.

The third most important area for the sandeel fishery is area 2. In the period 2003 to 2011 landings from this area contributed 11% of the total landings on average. The contribution of area 2 over the entire period is 10% on average.

Area 4 has contributed about 5% of the total landings since 1994 but there have 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 2011 the average contributions from area 4 was 8 and 3% respectively.

Several banks in the Norwegian EEZ have not provided landings for the last 8-12 years due to very low abundance of sandeels. For several years after 2001 almost all landings from the Norwegian EEZ came from the Vestbank area (Figure 4.1.5). However, due to a strong recruitment in 2006 some of the southerly banks in Norwegian EEZ were repopulated, but Inner Shoal East and Outer Shoal were commercially depleted in 2007, and the stock at English Klondyke, which was closed after the RTM fishery in 2007, was commercially depleted in 2008. In 2009, high densities of sandeel in the Norwegian EEZ were restricted to the Vestbank area and in a small area at Inner Shoal West (Figure 4.1.6). In 2010, the about 19 000 t were landed from small areas at Vestbanken during the experimental fishery, and 30 000 t were landed from 1b, 2b and 3b. In 2011, about 89 000 t were landed from 1a, 2a and 3a.

Estimation of effort

For the first time, individual Norwegian logbook records were included in the dataset used to estimate effort in 2011. However, before the data could be used, a number of issues had to be addressed. Firstly, the method used to record fishing days differs between the two countries. Secondly, it had to be investigated whether the Danish and Norwegian CPUEs were comparable both in absolute levels and in the difference between vessel sizes.

Measuring days fished

In the Norwegian data, days fished refer to the actual days fished whereas in the Danish data, days fished refer to the number of days from the first day of fishing to landing of the catch. To ensure comparability of the two sets, one day was added to each Norwegian logbook record before estimating CPUE.

Effect of vessel size on CPUE

In order to avoid bias in effort introduced by changes in the average size of fishing vessels over time, the CPUEs are used to estimate a vessel standardization coefficient, *b*. The parameter *b* was estimated using the model

$$\ln(\hat{CPUE}_{w,r,y,V}) = a_{w,r,y} + b_y \ln\left(\frac{V}{V^*}\right)$$

where indices *sq*, *w* and *y* denote square, week (Julian day of midpoint of trip/7, rounded to the nearest integer) and year, respectively, V is vessel size, V^* is 200 GRT, $\hat{CPUE}_{w,r,y,V}$ is median CPUE in the given rectangle, week and year for a vessel size of V and a and b are estimated using general linear models with normal error distribution. The effect of country on b was estimated and found not to be significant (b of Denmark=0.478 (std=0.030) and Norway=0.665 (std=0.100), P=0.0739). The estimated common value of b was 0.495 (std=0.040) which is close to the average from 2000-2010 (0.434).

Effect of country on CPUE

There was a significant (P=0.0099) difference in a between countries as Danish ln(CPUE) was on average 0.586 less than Norwegian ln(CPUE), corresponding to Norwegian average CPUE being 178% of Danish CPUE. This difference was estimated from CPUEs in ICES statistical rectangle 39F1 in weeks 23 and 24, as there was no spatio-temporal overlap between Norwegian and Danish logbooks in other places. In spite of the limited data available, a correction factor was estimated and used to standardise Norwegian effort to Danish levels (i.e. one Norwegian fishing day corrected for vessel size counted as 1.78 Standardised Fishing Days). As more data is added in the coming years, this issue should be revisited.

4.2 Sandeel in Area-1

4.2.1 Catch data

Total catch weight by year for area 1 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.2.1.

In 2011 the proportion of 2-group in the catch was almost 90% (Figure 4.2.1). Such a high proportion has never been observed before.

4.2.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.2.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.2.2. From 2004 there is an increasing trend in mean weights for all age groups except for age group 0.

4.2.3 Maturity

Maturity estimates from 2005 onwards are obtained from the Danish dredge survey in December as described in the stock annex.

For 1983 to 2004 the means of the period 2005-2010 are applied (Table 4.2.3)

4.2.4 Natural mortality

As described in the Stock Annex values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

4.2.5 Effort and research vessel data

Trends in overall effort and CPUE

The Tables 4.1.5-4.1.7 and Figure 4.2.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peeked in 2001 (10500 days), and declined thereafter to the all time lowest (1776 days) in 2007. In the period 2007 to 2011 effort has been fluctuating around a mean of 3100 days. The average CPUE in the period 1994 to 2002 was 60 tons/day. In 2003 the CPUE declined to the all time lowest at 21 tons/day. Since 2004 the CPUE has increased and reached the all time highest (101 tons/day) in 2010 followed by a lower, but still above average value in 2011 (87 tons/day).

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

In 2010, for the first time, a time series of stratified catch rates (Table 4.2.4) from a dredge survey was used to calibrate the assessment.

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year. The internal consistency plot (Figure 4.2.4) shows a modest consistency between age 0 and age 1 which has deteriorated in recent years.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

4.2.6 Effects of adverse weather conditions during the 2011 survey on assessment

The weather during the 2011 dredge survey was extremely windy, and wind speeds during dredging ranged from 15 to 22 m/s (dredging was not possible at higher wind speeds). In spite of the hard weather, the dredge maintained bottom contact during the survey. This was confirmed by bottom contact sensors and video recordings. However, the weather could potentially affect the behaviour of sandeel and hence their catchability. To investigate this, dredging at 4 positions in the Dogger Bank area was repeated after 20 days when the weather was calmer (wind speed around 8 m/s). The sampling protocol was identical to that in the previous survey (3 hauls per position). Catch of 1+ year olds was substantially higher in 3 of the 4 positions (up to 18 times higher at one position). However, as the fish were observed to have commenced spawning (running fish, milk and eggs observed on deck), it is unclear whether this increase in catch rate was related to spawning behaviour. 0-group catch rates were comparable in levels and the relative catch rate in the later survey ranged from 65% to 309% for the four positions with a geometric mean of 130%. The catch rates did not differ significantly between the two sampling times (ANOVA of log(catch rate), P for difference between sampling times for 0-group=0.7268, 1-group=0.2246).

To investigate the possible effect of weather conditions on the assessment, an explorative run was performed setting the 0-group dredge index in 2011 to 130% of the observed. All other settings were kept as in the final run described below. The resulting forecast is shown in table 4.2.5. The difference between this and the final assessment is a moderate increase in TAC (to 48 000 tons).

4.2.7 Data analysis

Based on the results from the Benchmark assessment (WKSAN, 2010) the SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2011. In the SMS model it is assumed that fishing mortality is proportional to fishing effort. For details about the SMS model and model settings, see the Stock Annex.

The diagnostics output from SMS are shown in Table 4.2.6. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is as expected rather constant over the three year ranges used, showing a stable relationship between effort and F for the full assessment period. The "age catchability" ("F, age effect" in the table) shows a change in the fishery pattern where the fishery was mainly targeting the age 2+ sandeel in the beginning of the period, to a fishery mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 4.2.6) is low (0.43) for age 0 and high (1.27) for age 1, indicating a reasonable consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 4.2.5) shows no clear bias for this relatively short time series. The 2011 survey estimate of the 2010 year class is considerably higher than the estimate from all data sources.

The model CV of catch at age is low (0.272) for age 1 and age 2 in the first half of the year and medium or high for the remaining ages and season combinations. The residual plots for catch at age (Figure 4.2.6) confirm that the fit is generally poor except for age 1 and 2 in the first half year. There is a cluster of negative residuals (observed catch is less than model catch) for age 4+ in most recent years, but for age 1 – age 3 there is no obvious bias in first half year catches in most recent years.

The CV of the fitted Stock recruitment relationship (table 4.2.6) is high (0.87) which is also indicated by the stock recruitment plot (Figure 4.2.7). The estimated recruitment in 2011 is the third lowest in the time series and follows directly after the lowest recruitment ever (2010).

The retrospective analysis (Figure 4.2.8) shows very consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2011) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.2.9) are in general small, which gives relatively narrow 95% confidence limits (Figure 4.2.10). The confidence limits of SSB show that SSB has been above B_{lim} since 2007 with a high probability.

The plot of standardised fishing effort and estimated F (Figure 4.2.11) show a clear relation between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the three periods 1983-1988, 1989-1998 and 1999-2011, the relation between effort and F varies between these periods. It is clearly seen that an effort unit in 1983 gives a smaller F than one in the most recent years. This is due to technical creeping, i.e. a standard 200 GT vessel has become more efficient over time.

4.2.8 Final assessment

The output from the assessment is presented in Tables 4.2.7 (fishing mortality at age by half year), 4.2.8 (fishing mortality at age by year), 4.2.9 (stock numbers at age) and 4.2.10 (Stock summary).

4.2.9 Historic Stock Trends

The stock summary (Figure 4.2.13 and Table 4.2.10) shows that SSB have been at or below B_{lim} from 2000 to 2002 and again in 2004 and 2006. Since 2007, SSB has been above B_{pa}. $F_{(1\text{-}2)}$ is estimated to have been below the long time average since 2005.

4.2.10 Recruitment estimates

Recruitment estimates are given in the summary table (Table 4.2.10). Based on results from the dredge survey December 2011 which are included in the assessment, the recruitment in 2011 is estimated at 55 billion. This is the third lowest estimate for the entire time series and follows directly after a very poor 2010 year class (25 billion, lowest on record). These poor year classes are not caused by lack of SSB, as SSB in both years has been above B_{lim} with a high probability. Two consecutive years of such bad recruitment has never previously been observed. The second lowest value of biennial recruitment was around twice the current and was recorded in the years 1986 and 1987, following the strongest year class on record (1985). For comparison, the 2009 year class was the 3rd largest on record. Hence, the recruitment success could potentially be depressed by the large biomass of older fish. However, it is equally possible that other effects are the cause.

4.2.11 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.2.11. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year of 2012 is the geometric mean of the recruitment 1983-2010 (222 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2011. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of years is not critical. Mean weight at age in the catch and in the sea is the average value for the years 2008-2011. The maturity estimate in 2012 is obtained from the dredge survey in December 2011. For 2013 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

The Stock annex gives more details about the forecast methodology.

Output

The short term forecast shows that a TAC of 23 000 t in 2012 is consistent with a SSB at B $MSY_{trigger}$ at 215 000 tons. Such at TAC will require a reduction of F (effort) of 92% compared to 2011 (table 4.2.11).

4.2.12 Biological reference points

B_{lim} is set at 160 000 tons and B_{pa} at 215 000 tons. B $MSY_{trigger}$ is set at B_{pa}.

Further information about biological reference points for sandeels in IV can be found in the Stock Annex.

4.2.13 Quality of the assessment

The quality of the present assessment is considered much improved compared to the combined assessment for whole North Sea previously presented by ICES. This is mainly due to the fact that the present division of stock assessment areas better reflects the actual spatial stock structure and dynamic of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment. Application of the new statistical assessment model SMS-effort has removed the retrospective bias in F and SSB for the most recent years. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. This assumption in combination with the available data, give rather narrow confidence limits for the model estimates of F, SSB and recruitment.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish and Norwegian (in 2011) CPUE and total international landings. Danish catches are by far the weightiest in the area, but effort by the individual countries would improve the quality of the assessment.

4.2.14 Status of the Stock

The stock has recovered from the low levels of SSB estimated for 2000-2006, due to recent recruitments around the long term mean and a decrease in F from around 1.0 in the period 1999-2004 to around 0.5 since 2005. Recruitment in 2009 is estimated to be twice the long term mean but recruitment in both 2010 and 2011 is less than 10% of the recruitment in 2009. SSB has been above B_{pa} since 2007.

4.2.15 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. The assessment indicates that F must be doubled in order to catch the TAC that is consistent with the present MSY $B_{trigger}$ at B_{pa} (215 000 tonnes). However, taking the historical F and stock development into account an F value above 0.6 is probably not recommendable. As effort is assumed proportional to F, the management plan should include an upper effort limit defined on the basis of the effort applied in the most recent years.

4.3 Sandeel in Area-2

4.3.1 Catch data

Total catch weight by year for area 2 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.3.1.

In 2010 the proportion of 1-group in the catch was more than 80% (Figure 4.3.1) followed by a proportion of 2-group in 2011 of 68%. Such high proportion has been observed in other years as well. The proportion of 1-groups in 2011 was low (11%), but lower values have been recorded in 17% of the years since 1983.

4.3.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.3.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.3.2. From 2000 there is a general decrease in 1st half-year mean weights for all age.

4.3.3 Maturity

The dredge survey does not cover Area-2. Therefore means of the maturity estimates from Area-1 in the period 2005-2010 are used for the entire time series in Area-2.

The Danish dredge survey is described in the stock annex.

4.3.4 Natural mortality

As described in the Stock Annex, values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

4.3.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.3.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account.

Total international standardized effort has shown a clear drop from 13240 days in 1985 136 days in 2007. In 2011 the effort was 760 days. The CPUE increased from 1983 (36 tons/day) to 1994 (57 tons/day). Since 2004 the CPUE has increased and reached the all time highest (59 tons/day) in 2010 followed by a decline to 40 tons/day in 2011.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

A dredge survey in area 2 was initiated in 2010 such that the time series is too short for assessment purposes. However, as there is a strong correlation between recruitments in Area-1 and Area-2 (Figure 4.3.4) the catch rate indices of age group 0 from Area-1 (Table 4.2.4) was used to calibrate the assessment of Area-2.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

4.3.6 Effects of adverse weather conditions during the 2011 survey on assessment

As described in section 4.2.6, the weather during the 2011 dredge survey was extremely windy, and wind speeds during dredging ranged from 15 to 22 m/s (dredging was not possible at higher wind speeds). In spite of the hard weather, the dredge maintained bottom contact during the survey. This was confirmed by bottom contact sensors and video recordings. However, the weather could potentially affect the behaviour of sandeel and hence their catchability. To investigate this, dredging at 4 positions in the Dogger Bank area was repeated after 20 days when the weather was calmer (wind speed around 8 m/s). The sampling protocol was identical to that in the previous survey (3 hauls per position). Catch of 1+ year olds was substantially higher in 3 of the 4 positions (up to 18 times higher at one position). However, as the fish were observed to have commenced spawning (running fish, milk and eggs observed on deck), it is unclear whether this increase in catch rate was related to spawning behaviour. 0-group catch rates were comparable in levels and the relative catch rate in the later survey ranged from 65% to 309% for the four positions with a geometric mean of 130%. The catch rates did not differ significantly between the two sampling times (ANOVA of log(catch rate), P for difference between sampling times for 0-group=0.7268, 1-group=0.2246).

To investigate the possible effect of weather conditions on the assessment, an explorative run was performed setting the 0-group dredge index in 2011 to 130% of the observed. All other settings were kept as in the final run described below. The resulting forecast is shown in table 4.3.4. As shown in the table, the increase in 0-group index does not result in a SSB above B_{pa} even with a TAC of 0 and hence has no effect on advice.

4.3.7 Data analysis

The diagnostics output from SMS-effort are shown in Table 4.3.5. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is as expected rather constant over the two year ranges used, showing a stable relationship between effort and F for the full assessment period. The "age catchability" ("F, age effect" in the table) and the "Exploitation pattern" show that the exploitation in the second half of the year is highest for the most recent period 1999-2011.

The CV of the dredge survey (Table 4.3.5) is low (0.30) for age 0 indicating a high consistency between the results from the dredge survey and the overall model results. The residual plot (Figure 4.3.5) shows no bias for this relatively short time series.

The model CV of catch at age 1 and 2 is medium (0.425) in the first half of the year and high for the remaining ages and season combinations. The residual plots for catch at age (Figure 4.3.6) confirm that the fit is generally poor except for age 1 and 2 in the first half year. There is a clusters of positive and negative residuals for age 1 in the first half-year.

The CV of the fitted Stock recruitment relationship (Table 4.3.5) is very high (1.01) which is also indicated by the stock recruitment plot (Figure 4.3.7).

The retrospective analysis (Figure 4.3.8) shows a reasonable consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2011) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.3.9) are in general medium to high, which gives rather wide confidence limits (Figure 4.3.10).

The plot of standardised fishing effort and estimated F (Figure 4.3.11) shows a clear relation between effort and F as specified by the model. As the model assumes a different efficiency and catchability for the two periods 1983-1998, 1998-2011, the relation between effort and F varies between these periods. It is seen that an effort unit prior to 1998 gives a smaller F than one in the most recent years. This indicates technical creep, i.e. a standard 200 GT vessel has become more efficient over time.

4.3.8 Final assessment

The output from the assessment is presented in Tables 4.3.6 (fishing mortality at age by half year), 4.3.7 (fishing mortality at age by year), 4.3.8 (stock numbers at age) and 4.3.9 (Stock summary).

4.3.9 Historic Stock Trends

The stock summary (Figure 4.3.13 and Table 4.3.9) show that recruitment has been highly variable but without a clear trend for the whole time series. SSB has decreased considerably from 1999 to 2002 where SSB was below B_{lim}. From 2004 SSB has increased and SSB was above B_{pa} in 2011 but fell just below B_{pa} in 2012. $F_{(1–2)}$ is estimated to have been below the long time average since 2005.

4.3.10 Recruitment estimates

The recruitment estimate obtained from the dredge survey December 2011 indicates recruitment at 17 billion. The 2010 year-class was also poor, and the biennial average has only been below that in the most recent years once in the time series (following the strong 1996 year-class).

4.3.11 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.3.10. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in the second half year of 2012 is the geometric mean of the recruitment 1983-2010 (44 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2011. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical for. Mean weight at age in the catch and in the sea is the average value for the years 2008-2011. Proportion mature in 2011 is obtained from the dredge survey December 2010. For 2012 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

The Stock annex gives more details about the forecast methodology.

Short-term forecast

The assessment forecast (Table 4.3.11) indicates that with a zero TAC, the stock will be just below B_{lim} (99%) at 69% of B $MSY_{trigger}$ (100 000 tonnes). However, a TAC of 0 will not provide any information on the status of 1-year olds and older on which future advice can be based. The low and variable catchability of these age classes in the dredge together with the lack of a reasonable survey time series for area 2 renders the assessments completely dependent on information on age distributions from the fishery. Past analyses have shown that stable estimates of catch per unit effort and mean weights at age could be achieved with less than 100 samples (see Real Time Monitoring advice 2010, ICES advice report section 6.3.3.1). Based on past average sandeel tons per haul (commercially around 55 t) and the fact that it would be preferable to sample no more than one every three hauls in order to reduce correlation, a monitoring catch obtaining a minimum of 30 samples would be of the order of 5 000 t. The low sandeel abundance in 2012 will likely mean that less than 55 tons may be obtained per haul and, hence, more than 30 samples could be obtained from 5 000 t of monitoring catch.. This monitoring TAC should be taken as similar to previous year's fishery as possible. A fishery landing 5000 tons and aimed at providing information of particularly older age groups for next year's assessment will result in an SSB at 66 000 tons (94% of B_{lim}).

4.3.12 Biological reference points

B_{lim} is set at 70 000 tons and B_{pa} at 100 000 tons. B $MSY_{trigger}$ is set at B_{pa}.

Further information about biological reference points can be found in the Stock Annex.

4.3.13 Quality of the assessment

The quality of the present assessment is considered much improved compared to the combined assessment for whole North Sea previously presented by ICES. This is mainly due to the fact that the present division of stock assessment areas better reflects the actual spatial stock structure and dynamic of sandeel. Addition of fishery independent data from the dredge survey has also improved the quality of the assessment although it would be preferable to have area specific survey data. Application of the new statistical assessment model SMS-effort has removed the retrospective bias in F and SSB for the most recent years. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. This assumption in combination with the available data, give reasonable confidence limits for the model estimates of F, SSB and recruitment.

There is only two years (2010 and 2011) of fishery independent data available from the dredge survey in December covering the main fishing banks in area 2. The present use of data from the dredge survey in area 1 improves the quality of the assessment, but the newly established survey will be continued.

The model uses effort as basis for the calculation of F. The total international effort is derived from Danish CPUE and total international landings. Danish catches are by far the weightiest in the area, but effort by the individual countries would improve the quality of the assessment.

4.3.14 Status of the Stock

In spite of a low value of F (around 0.1) since 2007 and the strong 2009 year class, SSB in 2012 is below B_{pa}. This is caused by the two subsequent extremely small year-classes (2010 and 2011).

4.3.15 Management Considerations

A management plan needs to be developed. The ICES approach for MSY based management of a short-lived species as sandeel is the so-called escapement strategy, i.e. to maintain SSB above MSY $B_{trigger}$ after the fishery has taken place. Taking the historical F and stock development into account an F value above 0.4-0.5 is probably not recommendable. Such F ceiling can be expressed as an effort ceiling for management usage as effort is assumed proportional to F.

4.4 Sandeel in Area-3

4.4.1 Catch data

Total catch weight by year for area 3 is given in Tables 4.1.2-4.1.4. Catch numbers at age by half-year is given in Table 4.4.1.

In 2011 the proportion of 2-group in the catch was around 70% (Figure 4.4.1). However, this proportion is very different between the Norwegian EEZ and the remainder of area 3 (see section 4.4.14). The proportion of 0-groups in the catch has been very low since 2004.

4.4.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.4.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.4.2. The mean weights of age 4 have been very variable over the full time series.

4.4.3 Maturity

Maturity estimates from 2005 onwards are obtained from the Danish dredge survey as described in the stock annex.

For 1983 to 2004 the means of the period 2005-2011 are applied (Table 4.4.3).

4.4.4 Natural mortality

As described in the Stock Annex values of natural mortality are obtained from a multispecies model where predation mortality is estimated (ICES, 2008).

Text table: Values for natural mortality by age and half year used in the assessments.

Age	First half year	Second half year
0		0.96
1	0.46	0.58
2	0.44	0.42
3	0.31	0.37
4+	0.28	0.36

4.4.5 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.4.3 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. Total international standardized effort peeked in 1998 (12176 days), and declined thereafter to less than 2000 days since 2005. CPUE has fluctuated without a clear trend over the full time series, with minimum CPUE in 2003.

Tuning series used in the assessments

No commercial tuning series are used in the present assessment.

In 2010, for the first time, a time series of stratified catch rates (Table 4.1.8) from a dredge survey was used to calibrate the assessment. This survey covers only the southern part of area 3.

The internal consistency, i.e. the ability of the survey to follow cohorts, was evaluated by plotting catch rates of an age group in a given year versus the catch rates of the next age group in the following year. The internal consistency plot (Figure 4.4.4) shows a medium consistency for age 0 and high consistency for age 1.

Details about the dredge survey and the consistency analysis are given in the Stock Annex and the benchmark report (WKSAN, 2010).

4.4.6 Explorative analysis using the Norwegian Acoustic Survey in assessment

The Norwegian Acoustic survey in NEZ has been conducted in April-May in five years (2007-2011) allowing a preliminary analysis of the potential use of this survey in the assessment in area 3. Until 2011, the main focus of the survey was to establish and test the acoustic sandeel survey methodology, but in 2011 the survey design was fully implemented. The survey strata are defined by detailed information of the fishing distribution (Figure 4.4.5). The survey design is stratified systematic with parallel or zig-zag transects. The starting position in each stratum is random. Based on previous survey results, more effort is allocated to stratum with expected high densities of sandeel. Due to the experimental phase during the first four years, not all the acoustic data followed a strict sampling design, which may have biased the results. An ongoing study is investigating this effect. By using multifrequency acoustic, the sandeel schools are identified and the average nautical area scattering coefficient (NASC) classified as sandeel is calculated by stratum (Figure 4.4.5). Age, length and weight information is collected with pelagic and demersal trawls, dredges and for some surveys grabs. In addition, data from the commercial fishery has been included to estimate age-length keys and the weight-length function.

The number of sandeel in each length group within the surveyed area (A) is then computed as:

$$N_i = f_i \frac{NASC \cdot A}{\sigma}$$

where:

$$f_i = \frac{n_i L_i^2}{\sum_{i=1}^{m} n_i L_i^2}$$ is the "acoustic contribution" from the length group L_i to the total energy.

A new paper in preparation will give updated target strength (TS), but old measurements for 38 kHz are used in the current estimations:

$$TS = 20 \log L - 93dB$$

Where the conversion $\sigma = 4\pi 10^{TS/10}$ is used for estimating the backscattering cross section from the mean TS. From the age-length-key the number by age by stratum is calculated, and summed for all strata except Vikingbanken and Klondyke (Figure 4.4.5) which have had a very variable sampling effort between years. The acoustic estimate in number of individuals by age and survey is presented in Table 4.4.6 and Figure 4.4.6, and the biomass by stratum in Figure 4.1.7.

The CV was generally low, indicating a good fit of the acoustic survey. The acoustic index is a biomass index covering the biomass in May in the NEZ, and hence should have a catchability of 1 for fish in the NEZ and 0 for fish outside. In total, this should result in a catchability <1, as the model adjusts for survey timing. The resulting estimate of catchability for ages 1, 3 and4 fit well with this whereas that of age 2 is somewhat higher, corresponding to the acoustic survey recording 147% of the 2-year olds present in area 3 (table 4.4.7). The reason for this is unclear but it is possible that it is simply an effect of the short time series available. Including the acoustic survey in the assessment resulted in a slightly lower SSB in 2012 than the final assessment (fig. 4.4.8).

4.4.7 Data analysis

The diagnostics output from SMS-effort model are shown in Table 4.4.8. The seasonal effect on the relation between effort and F ("F, Season effect" in the table) is quite different over the three year ranges used. One effort unit applied in the first half year in the period 1989-1998 produces more than twice the fishing mortality in the second half year (ratio between 1.235 and 0.500), presumably because of the higher catchability of fish in the first half of the year where the majority are present in the water column. The "age catchability" ("F, age effect" in the table) shows a change in the fishery: where the fishery was mainly targeting the age 2+ sandeel in the beginning of the period, it was mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 4.4.8) is low (0.30) for age 0 and high (1.08) for age 1, showing a medium consistency between the results from the dredge survey and the overall model results. This might be due to the southerly survey coverage of the stock area. The problem for age 1 seems to be increasing over time as indicated by the suite of high positive residuals (figure 4.4.8). Catchability for the ages has been combined, as the independent estimates were not statistical different. The residual plot for age 0 (Figure 4.4.9) shows no clear bias for this relatively short time series.

The model CV of catch at age is high (0.52) for age 1 and age 2 in the first half of the year. For the older ages and for all ages in the second half year, the CVs are very high. The residual plots for catch at age (Figure 4.4.10) confirm that the fits is generally very poor except for age 1 and 2 in the first half year. There is a cluster of negative residuals (observed catch is less than model catch) for age 4+ in most recent years, but for age 1 – age 3 there is no obvious bias in first half year catches in most recent years.

The CV of the fitted Stock recruitment relationship (Table 4.4.10) is high (0.90) which is also indicated by the stock recruitment plot (Figure 4.4.11). The very high recruitment in 1996 is a clear outlier. The estimated recruitments in 2010 and 2011 are the lowest observed.

The retrospective analysis (Figure 4.4.12) shows a very consistent assessment results from one year to the next. This is probably due to the assumed relationship between effort and F, which is rather insensitive to removal of a few years. However, it should be noted that the very short time series (2004-2011) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.4.13) are in general large, which gives wide confidence limits (Figure 4.4.14) on output variables.

The plot of standardised fishing effort and estimated F (Figure 4.4.15) show a clear relation between effort and F as specified by the model. As the model assumes a different catchability at age for the three periods 1983-1988, 1989-1998 and 1999-2011, and as the seasonal distribution of the fishery is variable from one year to the next, the relation between effort and F varies between these periods. There is a shift in the ratio between effort and F over the full time series. In the year range 1989-1998 F is in general lower than effort on the plot, while the opposite is the case for the remaining periods. This is probably due to fact that F presented on the graph is the mean F(age1-age2) while a substantial part of the effort in 1989-1998 has been use to target the 0-group sandeel in the second half year.

4.4.8 Final assessment

The output from the assessment is presented in Tables 4.4.9 (fishing mortality at age by half year), 4.4.10 (fishing mortality at age by year), 4.4.11 (stock numbers at age) and 4.4.12 (Stock summary).

4.4.9 Historic Stock Trends

The stock summary (Figure 4.4.16 and Table 4.4.12) shows that SSB have been at or below B_{lim} from 2001 to 2007 after which it has increased for two years and the decreased again. SSB in 2012 is estimated below B_{pa}. $F_{(1-2)}$ is estimated to have been below the long time average since 2005. Recruitment seems to have been at a lower level since the very high recruitment in 1996.

4.4.10 Recruitment estimates

Based on the dredge survey December 2011 the recruitment is estimated to 6 billion which is the lowest recruitment on record (Table 4.4.12). Together with the previously lowest year-class the previous year, this results in an unprecedented recruitment failure with a biennial average of less than 25% of the previously recorded historical low (in 2004-2005). The recruitment failure was apparently not caused by lack of spawners as SSB in both years have been above B_{lim}.

4.4.11 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.4.13. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year is the geometric mean of the recruitment 1983-2010 (99 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2011. As the SMS-model assumes a fixed exploitation pattern since 1999, the choice of year is not critical for. Mean weight at age in the catch and in the sea is the average value for the years 2008-2010. Proportion mature in 2011 is given in table 4.4.1. For 2012 the long term average proportion mature is applied. Natural mortality is the fixed M applied in the assessment.

The Stock annex gives more details about the forecast methodology.

Output

The assessment indicates that even with a TAC at 0 tons for 2012, SSB will be at 90 000 tons, corresponding to 90% of B_{lim} (46% of $MSY_{trigger}$) in 2013 (table 4.4.14). However, a TAC of 0 will not provide any information on the status of 1-year olds and older on which future advice can be based. The low and variable catchability of these age classes in the dredge together with the lack of a reasonably long acoustic survey time series renders the assessments completely dependent on information on age distributions from the fishery. Past analyses have shown that stable estimates of catch per unit effort and mean weights at age could be achieved with less than 100 samples (see Real Time Monitoring advice 2010, ICES advice report section 6.3.3.1). Based on past average sandeel tons per haul (commercially around 55 t) and the fact that it would be preferable to sample no more than one every three hauls in order to reduce correlation, a monitoring catch obtaining a minimum of 30 samples would be of the order of 5 000 t. The low sandeel abundance in 2012 will likely mean that less than 55 tons may be obtained per haul and, hence, more than 30 samples could be obtained from 5 000 t of monitoring catch. This monitoring TAC should be taken as similar to previous year's fishery as possible. A fishery landing 5000 tons and aimed at providing information of particularly older age groups for next year's assessment will result in an SSB at 86 000 tons (86% of B_{lim}). Removing 40 000 tons (equal to the TAC set by Norway) would bring the stock to 63% of B_{lim}.

4.4.12 Biological reference points

B_{lim} is set at 100 000 t and B_{pa} is estimated to 195 000 tons. B $MSY_{trigger}$ is set at B_{pa}. Further information about biological reference points can be found in the Stock Annex.

4.4.13 Quality of the assessment

In the assessments for the combined "North Sea sandeel stock" previously done by ICES, catches of sandeel in the Northern North Sea (mainly area 3 sandeel) have decreased far more than sandeel from the Southern North Sea (mainly area 1 sandeel). This heterogeneity is one of reason for the present assessments by area. While the quality (based on confidence limits of SSB and F) is high the quality of the area 3 assessment is low. This is partly due to quality of input to the assessment. Norwegian effort data with the right resolution are only available for 2011, and the relationship between Norwegian and Danish CPUEs cannot be estimated from data from area 3 alone due to the differences in regulations and the resulting lack of spatial overlap between the two fleets.

The dredge survey covers mainly the southern part of area 3. A northerly extension of the survey area will increase the quality of the survey results for assessment purpose and was planned by Norway for 2011. However, the adverse weather conditions prevented the survey, and the result is that only the southeastern parts of area 3 are covered by the survey. Both the dredge survey and the commercial catches show pronounced differences in age composition between the NEZ and the EU part of area 3 (Figures 4.4.17 and 4.4.18), and the extremely low recruitment in 2010 and 2011 seems to be derived primarily from the western part of area 3. The difference between the two parts of the area is particularly concerning in the light of the very uneven sampling effort: there are 19 samples taken from the catches in NEZ (app. 90 000 tons) and 9 samples from the catches in non-NEZ (app. 3600 tons)

Application of the new statistical assessment model SMS-effort has no retrospective bias in F and SSB for the most recent years, in contrast to the assessment for the combined North Sea stock. This is probably due to the robust model assumption of fishing mortality being proportional to fishing effort. However, the difference in regulation (NEZ has been closed in some years and partially open in other) conflicts with the assumption of cohort models such as SMS.

4.4.14 Status of the Stock

The stock has increased from the record low SSB in 2004 at half of B_{lim} to above B_{pa} in 2010 and 2011 and then decreased again in 2012. Recruitment was at the long term mean in 2008 and 2009 and has been historically low since. F has been below the long term mean since 2004, however highly variable between years.

4.4.15 Management Considerations

A management plan needs to be developed for area 3 sandeel. Area 3 comprises both Norwegian and EU EEZ and currently there is no agreement between the parties on management of the stock. The EU fishery has previously been part of the Real Time Monitoring system, while the Norwegian EEZ is managed based on a system of closed areas in combination with acoustic monitoring of the geographical distribution and size of the stock. Both approaches might be applicable in the future. Even though the new assessment for area 3 sandeel is considered uncertain, it is considered adequate as the basis for TAC advice.

The Danish dredge survey covers only the most southern part of area 3 in the North Sea. The Skagerrak area was covered for the first time in 2011, but the results will not be included in the dredge index until a longer time series exists. Extension of the area covered by the dredge survey index will probably decrease the assessment uncertainty. The Sandeel Benchmark group (WKSAN 2010) concluded that the dredge survey estimates of the incoming year class appear less robust for area 3 and it is therefore appropriate that in-season monitoring (e.g. acoustic monitoring and age based commercial CPUE) to continue in area 3. The survey index for the 2010 and 2011 year class is very low and outside the range of previously observed values which might be due to a very low recruitment or a result of poor survey efficiency (2011 only, see section 4.4.8).

4.5 Sandeel in Area-4

4.5.1 Catch data

Total catch weight by year for area 4 is given in Tables 4.1.2-4.1.4.

Catch numbers at age by half-year is given in Table 4.5.1.

4.5.2 Weight at age

The methods applied to compile age-length-weight keys and mean weights at age in the catches and in the stock are described in the Stock Annex.

The mean weights at age observed in the catch are given in Table 4.5.2 by half year. It is assumed that the mean weights in the sea are the same as in the catch. The time series of mean weight in the catch and in the stock is shown in Figure 4.5.1. The mean weights of age 4 have been very variable over the full time series.

4.5.3 Effort and research vessel data

Trends in overall effort and CPUE

Tables 4.1.5-4.1.7 and Figure 4.5.2 show the trends in the international effort over years measured as number of fishing days standardised to a 200 GRT vessel. The standardisation includes just the effect of vessel size, and does not take changes in efficiency into account. The figure also shows the development in CPUE. In recent years, very low catches have been taken in the area and the uncertainty in the estimated mean CPUE has therefore increased as has the estimates of mean weight and catch at age.

Abundance indices

The Scottish sandeel survey of area 4, off the north east UK coast, was established in 1999. Dredge hauls encompassing the major Firth of Forth banks were taken at 8 stations in 1999 – 2003 and 2008-10; 3 stations on the Wee Bankie, 3 on Marr Bank and 2 on Berwick bank. Since 2008, the Turbot bank has also been surveyed with 2 stations in 2008 and 3 stations from 2009. The survey is undertaken in November-December to coincide with the Danish sampling (see the Stock Annex for more details).

The CPUE from the survey areas is presented in Table 4.5.3. As only sandeels ≥ 8.5 cm TL are fully selected by the gear and 0-group are typically below this length, age 1 catches are higher than age 0 for a given year class. Nevertheless, high catch rate at age 0 gave rise to high catches at age 1 and catch rates of age 1 and 2 were significantly correlated ($P < 0.05$, Figure 4.5.3). Based on the 3 years of data the temporal changes in 0-group abundance around Turbot Bank appeared to follow that in the Firth of Forth.

The 2011 year class was lower than the 2009 year class but slightly higher than that in 2008 (Table 4.5.3). High 0-group CPUE at one station on Berwick bank had a positive bias on the Firth of Forth estimate as exclusion of this station reduced 0-group CPUE from 119 to 33 sandeels per hour. Overall, it is clear that the 2011 year-class is relatively weak and close to the lowest observed in all years surveyed. As in 2010, the 2009 year class still dominates dredge catches.

To produce an analytical assessment for area 4, information on older age groups is needed. The low and variable catchability of older age classes in the dredge renders the assessments completely dependent on information on age distributions from the fishery. Past analyses have shown that stable estimates of catch per unit effort and mean weights at age could be achieved with less than 100 samples (see Real Time Monitoring advice 2010, ICES advice report section 6.3.3.1). Based on past average sandeel tons per haul (commercially around 55 t) and the fact that it would be preferable to sample no more than one every three hauls in order to reduce correlation, a monitoring catch obtaining a minimum of 30 samples would be of the order of 5 000 t. The low sandeel abundance in 2012 will likely mean that less than 55 tons may be obtained per haul and, hence, more than 30 samples could be obtained from 5 000 t of monitoring catch. This monitoring TAC should be taken as similar to previous year's fishery as possible and should over time result in an analytical assessment for area 4.

4.6 Sandeel in Area-5

4.6.1 Catch data

Total catch weight by year for area 5 is given in Tables 4.1.2-4.1.4.

4.7 Sandeel in Area-6

4.7.1 Catch data

Total catch weight by year for area 6 is given in Tables 4.1.2-4.1.4.

4.8 Sandeel in Area-7

4.8.1 Catch data

Total catch weight by year for area 7 is given in Tables 4.1.2-4.1.4

4.9 Review of the method suggested for real time monitoring of the Area-1 sandeel stock in 2012

4.9.1 Background

ICES has been asked to review the methods suggested by DTU Aqua for the 2012 RTM. The following give the guidelines for RTM suggested by WGNSSK based on the proposal. The proposal itself is given in Annex 09.

4.9.2 Data and methods

The aim of Real Time Monitoring of sandeel is to estimate stock abundance of sandeel from observations of catch per unit effort (CPUE) from the fishery in April. This information is then used as a stock abundance index together with similar information for the period since 1999 to update the ICES assessment, which finally will be the basis for the final setting of the TAC for 2012. In the period prior to 1999, less than 20 biological samples were taken in April, and the estimate of CPUE at age in April is considered unreliable. The same applies to 2000, and this year is excluded from the time series.

Stock abundance is measured as CPUE in number per age class. Effort is measured as number days absent from harbour for the individual fishing trips, standardised to an average vessel size of 200 GT. The document reviewed contained the following equation:

$$\overline{CPUE} = \frac{1}{N}\frac{\sum_1^N Catch_i}{\sum_1^N Daysabsent_i * \left(\frac{GT_i}{200}\right)^{0.449}}$$

The actual calculation that was executed however is:

$$\overline{CPUE} = \frac{\sum_1^N Catch_i}{\sum_1^N Daysabsent_i * \left(\frac{GT_i}{200}\right)^{0.449}}$$

Where N is the number of trips, *Catch* is the catch in tonnes on a given trip, *Daysabsent* is the number of days absent on a given trip, GT is the gross tonnage of the vessel and 0.449 is the average effect of vessel size as measured over the past 10 years (2002 to 2011) using data from all months and the method described in ICES (ICES 2010). Effort (days absent), vessel GT and total catch weight of sandeel by trip are obtained from log book data.

In the most recent 5 years, a number of large vessels (>700 GT) have entered the April fishery. Their effort was low in the first years, and in total, they have participated in the fishery for less than half the total period. It is therefore not currently possible to evaluate whether they affect the accuracy of the RTM, and the vessels >700 GT are excluded in 2012. This decision should be re-evaluated when more data become available.

Age distribution of the catch is obtained from samples of the catch taken in the harbour. Currently around 100 samples are taken and this appears to deliver a robust estimate of the age distribution. A reduction in the sampling level may deliver a sufficiently robust estimate but this should be preceded by a statistical evaluations. Samples taken at sea by the industry from every third haul, with detailed information on catch position and time can be used when available to estimate the age distribution of the catch. However, samples taken by the industry should be supplemented by samples taken in the harbour to ensure that the sample age composition is unbiased.

All data available from the April fishery should be used and the sampling period should be long enough to ensure a sufficient number of samples and logbook records. The number necessary can be evaluated using statistical analysis. It was suggested by DTU Aqua that after April, the fishery could probably continue beyond the original quota if catch rates in April exceeds the average of the same period in the years 2007 to 2011, where the stock was above B_{pa}. WGNSSK was not able to evaluate whether this method was appropriate as no quantitative analyses were performed and so cannot recommend the use of it.

References

ICES 2010. Report of the Benchmark Workshop on Sandeel. ICES CM 2010/ACOM: 57

Table 4.1.1. SANDEEL in ICES div IV and IIIa. Landings ('000 t), 1955-2011. (Data provided by Working Group Members)

Year	Denmark	Germany	Faroes	Ireland	Netherlands	Norway	Sweden	UK	Lithuania	Total
1955	37.6	+	-	-	-	-	-	-	-	37.6
1956	81.9	5.3	-	-	+	1.5	-	-	-	88.7
1957	73.3	25.5	-	-	3.7	3.2	-	-	-	105.7
1958	74.4	20.2	-	-	1.5	4.8	-	-	-	100.9
1959	77.1	17.4	-	-	5.1	8.0	-	-	-	107.6
1960	100.8	7.7	-	-	+	12.1	-	-	-	120.6
1961	73.6	4.5	-	-	+	5.1	-	-	-	83.2
1962	97.4	1.4	-	-	-	10.5	-	-	-	109.3
1963	134.4	16.4	-	-	-	11.5	-	-	-	162.3
1964	104.7	12.9	-	-	-	10.4	-	-	-	128.0
1965	123.6	2.1	-	-	-	4.9	-	-	-	130.6
1966	138.5	4.4	-	-	-	0.2	-	-	-	143.1
1967	187.4	0.3	-	-	-	1.0	-	-	-	188.7
1968	193.6	+	-	-	-	0.1	-	-	-	193.7
1969	112.8	+	-	-	-	-	-	0.5	-	113.3
1970	187.8	+	-	-	-	+	-	3.6	-	191.4
1971	371.6	0.1	-	-	-	2.1	-	8.3	-	382.1
1972	329.0	+	-	-	-	18.6	8.8	2.1	-	358.5
1973	282.9	-	1.4	-	-	17.2	1.1	4.2	-	306.8
1974	432.0	-	6.4	-	-	78.6	0.2	15.5	-	532.7
1975	372.0	-	4.9	-	-	54.0	0.2	13.6	-	444.7
1976	446.1	-	-	-	-	44.2	0.1	18.7	-	509.1
1977	680.4	-	11.4	-	-	78.7	6.1	25.5	-	802.1
1978	669.2	-	12.1	-	-	93.5	2.3	32.5	-	809.7
1979	483.1	-	13.2	-	-	101.4	-	13.4	-	611.1
1980	581.6	-	7.2	-	-	144.8	-	34.3	-	767.9
1981	523.8	-	4.9	-	-	52.6	-	46.7	-	628.1
1982	528.4	-	4.9	-	-	46.5	0.4	52.2	-	632.4
1983	515.2	-	2.0	-	-	12.2	0.2	37.0	-	566.8
1984	618.9	-	11.3	-	-	28.3	-	32.6	-	691.1
1985	601.7	-	3.9	-	-	13.1	-	17.2	-	635.9
1986	832.7	-	1.2	-	-	82.1	-	12.0	-	928.0
1987	609.2	-	18.6	-	-	193.4	-	7.2	-	828.4
1988	708.8	-	15.5	-	-	185.1	-	5.8	-	915.3
1989	841.6	-	16.6	-	-	186.8	-	11.5	-	1056.3
1990	512.1	-	2.2	-	0.3	88.9	-	3.9	-	607.5
1991	726.5	-	11.2	-	-	128.8	-	1.2	-	867.7
1992	803.7	-	9.1	-	-	89.3	0.6	4.9	-	907.6
1993	533.4	-	0.3	-	-	95.5	-	1.5	-	630.8
1994	688.6	-	10.3	-	-	165.8	-	5.9	-	870.7
1995	672.6	-	-	-	-	263.4	-	6.7	-	942.8
1996	649.5	-	5.0	-	-	160.7	-	9.7	-	824.8
1997	831.8	-	11.2	-	-	350.1	-	24.6	-	1217.8
1998	628.2	-	11.0	-	+	343.3	8.6	23.8	-	1014.8

1999	511.3	-	13.2	0.4	+	187.6	23.2	11.5	-	747.1
2000	557.3	-	-	-	+	119.0	28.6	10.8	-	715.7
2001	650.0	-	-	-	-	183.0	50.0	1.3	-	884.3
2002	659.5	-	-	-	-	176.0	19.2	4.9	-	859.6
2003	282.8	-	-	-	-	29.6	21.8	0.5	-	334.7
2004	288.8	2.7	-	-	-	48.5	33.3	+	-	373.3
2005	158.9	-	-	-	-	17.3	0.5	-	-	176.6
2006	255.4	3.2	-	-	-	5.6	27.9	-	-	292.8
2007	166.9	1.0	2.0	-	-	51.1	7.9	1.0	-	229.9
2008	246.9	4.4	2.4	-	-	81.6	12.5	-	-	347.8
2009	293.0	12.2	2.5	-	1.8	27.4	12.4	3.6	2.0	352.9
2010	285.9	13.0	-	-	-	78.0	32.7	4.0	0.6	414.2
2011	278.5	9.8	-	-	-	109.0	32.7	6.1	1.7	437.8

+ = less than half unit.

- = no information or no catch.

Table 4.1.2. Total catch (tonnes) by area

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	377558	80482	105974	2796	0	0	0	566810
1984	491950	66352	123639	2570	6587	0	0	691098
1985	436214	99428	59090	38123	3004	0	0	635858
1986	389081	94604	420304	12706	11277	0	0	927973
1987	360867	53761	403897	8179	1713	0	0	828417
1988	401551	121394	391050	1335	0	0	0	915330
1989	445586	109691	492395	4384	3353	909	0	1056318
1990	283259	100960	219103	3314	374	499	0	607508
1991	346621	107663	368324	41372	3697	17	0	867694
1992	564285	69848	195733	68905	4554	4277	0	907600
1993	136538	59820	296118	133136	666	4490	0	630768
1994	209631	50648	444084	159789	2765	3748	0	870666
1995	410687	60143	266720	52759	150637	1830	0	942776
1996	324561	80205	250252	162338	6176	1263	0	824796
1997	431871	102730	608164	59353	11279	2373	2068	1217839
1998	371060	68950	507269	58460	2984	936	5182	1014841
1999	428307	32117	228163	53959	140	134	4263	747083
2000	363356	52235	256250	37748	325	680	4370	714964
2001	521724	58645	253088	47828	1687	312	976	884260
2002	599585	35553	209344	12213	10	2378	521	859604
2003	150711	56262	62569	64002	44	869	261	334718
2004	206696	71426	87695	6915	0	570	0	373302
2005	103777	41447	29667	1486	0	262	0	176640
2006	238296	35392	18867	85	0	161	0	292802
2007	109363	5910	113905	11	4	661	0	229855
2008	238523	13065	94576	1201	0	472	0	347836
2009	308596	10177	33889	0	0	260	0	352922
2010	301306	31746	80725	273	0	132	0	414183
2011	311795	30264	94941	270	0	490	0	437761
arith. mean	340116	62101	231579	35707	7285	956	608	678352

Table 4.1.3 Total catch (tonnes) by area, first half year

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	313567	65008	64173	2796	0	0	0	445544
1984	412200	47036	93138	2570	6587	0	0	561531
1985	365080	73442	33030	37901	3004	0	0	512457
1986	353390	71597	245682	12527	7940	0	0	691135
1987	305160	34380	399843	7857	1713	0	0	748953
1988	371971	105426	314622	1254	0	0	0	793273
1989	432962	100439	447387	4382	2037	897	0	988104
1990	257861	96519	138394	2926	0	485	0	496185
1991	267842	69370	290017	17140	3697	17	0	648083
1992	520040	56893	163533	67068	4554	4270	0	816357
1993	119220	43201	209146	123143	252	4393	0	499354
1994	190869	23473	388488	148007	2763	3222	0	756821
1995	372896	25371	242186	52665	150632	1829	0	845578
1996	289986	58639	102168	45209	1827	1168	0	498997
1997	349671	52649	514991	48410	9021	2194	1654	978590
1998	353605	42984	382308	56934	2881	935	4525	844172
1999	393869	23013	101596	51769	140	21	2078	572487
2000	322880	36493	247827	37748	310	679	3805	649742
2001	356462	33526	82525	47404	1687	52	739	522395
2002	595335	20905	207937	12213	10	2378	116	838894
2003	128752	46618	27886	62533	44	816	187	266837
2004	191061	53186	68170	6893	0	569	0	319878
2005	100678	32044	28563	1486	0	262	0	163034
2006	233961	22054	15811	55	0	160	0	272040
2007	109357	5910	113905	11	4	660	0	229848
2008	235131	9752	94450	1201	0	472	0	341005
2009	290826	9813	22018	0	0	259	0	322916
2010	297383	22596	78031	273	0	132	0	398414
2011	308856	29043	94941	270	0	490	0	433600
arith. mean	304858	45220	179751	29401	6866	909	452	567456

Table 4.1.4. Total catch (tonnes) by area, second half year

Year	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	All
1983	63991	15474	41801	0	0	0	0	121266
1984	79750	19317	30501	0	0	0	0	129567
1985	71133	25986	26060	222	0	0	0	123401
1986	35691	23007	174623	179	3337	0	0	236838
1987	55707	19382	4053	322	0	0	0	79464
1988	29580	15968	76428	81	0	0	0	122057
1989	12624	9251	45008	2	1316	12	0	68214
1990	25397	4440	80709	388	374	14	0	111323
1991	78779	38293	78307	24232	0	0	0	219611
1992	44245	12954	32200	1837	0	6	0	91243
1993	17317	16619	86972	9993	414	97	0	131414
1994	18762	27175	55596	11783	3	526	0	113845
1995	37791	34773	24534	94	5	1	0	97198
1996	34575	21566	148084	117129	4349	95	0	325799
1997	82201	50082	93173	10943	2258	179	414	239249
1998	17455	25966	124961	1526	102	1	657	170669
1999	34438	9104	126567	2189	0	113	2185	174596
2000	40475	15743	8423	0	15	1	565	65221
2001	165262	25118	170563	425	0	261	237	361865
2002	4250	14648	1407	0	0	0	405	20710
2003	21960	9644	34683	1468	0	53	73	67881
2004	15635	18239	19526	22	0	2	0	53424
2005	3098	9404	1104	0	0	0	0	13606
2006	4335	13339	3057	30	0	0	0	20762
2007	6	0	0	0	0	1	0	7
2008	3392	3313	126	0	0	0	0	6831
2009	17770	364	11871	0	0	0	0	30006
2010	3924	9151	2695	0	0	0	0	15769
2011	2940	1221	0	0	0	0	0	4161
arith. mean	35258	16881	51829	6306	420	47	156	110896

Table 4.1.5. Effort (days fishing for a standard 200 GT vessel)

Year	Area 1	Area 2	Area 3	Area 4	All
1983	8944	2257	3391	64	14656
1984	10129	1947	3579	48	15703
1985	10173	3240	2136	652	16200
1986	7435	1968	7516	283	17203
1987	5406	1143	5333	176	12058
1988	7522	2908	9384	41	19855
1989	8564	2843	11889	56	23351
1990	7856	3032	7081	51	18020
1991	6393	2213	8209	343	17158
1992	9065	1619	5011	570	16265
1993	3667	1711	8121	1327	14826
1994	3423	895	7628	1597	13543
1995	6013	1205	4977	423	12618
1996	6130	1761	6394	1453	15738
1997	5567	2245	10988	646	19447
1998	6729	1862	12176	623	21390
1999	8614	905	6705	812	17037
2000	6878	1261	5511	408	14058
2001	10547	1537	5973	664	18721
2002	8071	1187	4240	136	13635
2003	6186	2035	2781	1145	12147
2004	6985	2393	3147	213	12738
2005	2905	1112	904	84	5005
2006	4314	1015	567	2	5897
2007	1776	136	2062	1	3976
2008	2974	311	1819	8	5112
2009	4179	233	655	0	5066
2010	2990	540	2137	4	5671
2011	3586	760	1833	16	6194
arith. mean	6311	1596	5246	409	13562

Table 4.1.6 Effort (days fishing for a standard 200 GT vessel) first half year

Year	Area 1	Area 2	Area 3	Area 4	All
1983	6914	1838	2400	64	11217
1984	7848	1154	2564	48	11615
1985	8135	2373	1259	648	12416
1986	6653	1352	4714	280	13000
1987	4254	630	5201	161	10246
1988	6684	2472	7071	39	16266
1989	8175	2584	10283	56	21098
1990	7226	2927	4841	46	15040
1991	4863	1348	6558	112	12882
1992	8000	1317	4245	308	13871
1993	3194	1232	5407	1154	10987
1994	3056	408	6585	1417	11467
1995	5362	572	4467	422	10822
1996	5445	1148	2816	469	9877
1997	4127	898	8371	509	13905
1998	6205	957	7934	587	15683
1999	7543	643	2975	812	11973
2000	5961	771	5296	408	12437
2001	7694	906	2268	651	11519
2002	7893	576	4138	136	12743
2003	5348	1566	1462	1070	9447
2004	6536	1675	2362	212	10784
2005	2860	821	870	84	4636
2006	4184	624	500	2	5310
2007	1776	136	2062	1	3976
2008	2895	213	1812	8	4927
2009	3963	226	472	0	4661
2010	2882	352	2060	4	5297
2011	3509	697	1833	16	6054
arith. mean	5489	1118	3891	335	10833

Table 4.1.7. Effort (days fishing for a standard 200 GT vessel) second half year

Year	Area 1	Area 2	Area 3	Area 4	All
1983	2029	419	991	0	3439
1984	2280	793	1015	0	4088
1985	2038	867	877	3	3784
1986	782	616	2802	3	4203
1987	1152	513	132	16	1812
1988	838	436	2313	2	3589
1989	388	260	1606	0	2254
1990	630	105	2240	5	2980
1991	1529	865	1651	231	4276
1992	1064	302	766	262	2394
1993	473	479	2714	172	3839
1994	367	487	1043	179	2076
1995	651	634	510	1	1797
1996	685	614	3578	984	5860
1997	1441	1347	2617	138	5542
1998	524	905	4242	36	5707
1999	1072	262	3730	0	5064
2000	917	490	215	0	1621
2001	2853	631	3705	13	7202
2002	179	611	103	0	892
2003	838	469	1318	75	2701
2004	449	718	785	2	1954
2005	45	290	33	0	369
2006	129	390	67	0	587
2007	0	0	0	0	0
2008	79	98	8	0	185
2009	216	6	183	0	405
2010	108	188	78	0	374
2011	77	63	0	0	140
arith. mean	822	478	1356	73	2729

Table 4.2.1. Area-1 Sandeel. Catch at age numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	9012	2254	237	26355	2634	709	480	291	2
1984	0	44054	8817	1641	90	9256	539	308	41
1985	6877	5867	1109	29368	1904	1878	1294	208	172
1986	173	45239	3875	7522	213	1624	170	30	13
1987	159	4499	1656	23174	3455	1178	102	168	26
1988	683	1908	66	8090	168	14127	1342	2183	44
1989	194	62021	913	6238	85	1382	15	4607	52
1990	1397	15548	1331	12325	426	1824	63	551	19
1991	8672	16388	6836	6837	206	1002	66	345	0
1992	1451	50586	3022	8649	295	873	121	542	26
1993	1958	2055	439	5623	312	1464	178	440	52
1994	0	24171	1885	2841	137	1283	56	970	100
1995	22	37430	3776	6355	1002	747	117	293	28
1996	5097	12531	1271	14658	1232	4965	239	954	76
1997	0	38993	8912	2388	176	3641	168	726	56
1998	251	9627	465	28301	1228	2143	124	1470	70
1999	1135	45248	2880	5481	231	10130	805	613	162
2000	8399	32806	2773	3242	148	467	54	681	78
2001	59325	56332	2993	8182	414	1050	41	828	69
2002	16	83678	490	10574	89	1177	13	214	3
2003	2575	3729	412	11456	4351	852	113	210	24
2004	608	30373	2613	677	100	2224	229	453	48
2005	53	9902	326	3337	139	143	5	222	11
2006	42	32935	656	2447	64	750	28	142	12
2007	0	10429	1	4666	0	311	0	171	0
2008	8	27196	267	4057	61	1213	23	217	5
2009	1075	19242	2471	14088	313	1546	14	393	4
2010	11	40643	541	2158	18	957	1	110	0
2011	5	1740	39	32280	329	1101	14	232	1
arith. mean	3765	26463	2106	10104	683	2414	221	640	41

Table 10. Area-1 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2.4	5.5	7.8	10.0	10.8	13.9	14.2	17.0	17.7
1984	3.4	5.5	7.5	10.1	11.6	13.8	14.2	17.0	17.7
1985	2.4	5.5	7.7	10.0	11.4	13.9	14.6	17.9	19.3
1986	2.8	5.5	7.6	10.0	11.2	13.8	14.1	16.3	18.8
1987	1.3	5.8	9.0	11.0	10.8	15.6	21.4	18.1	19.8
1988	3.0	4.0	13.2	12.5	15.5	15.5	17.1	18.7	19.6
1989	5.0	4.0	10.1	12.5	14.4	15.5	17.0	18.0	19.0
1990	2.3	4.1	10.8	12.5	14.8	15.8	18.1	19.9	21.5
1991	2.7	8.1	7.5	16.4	13.6	17.1	12.1	17.7	44.0
1992	5.3	7.4	9.5	13.7	16.6	17.6	20.0	23.0	22.6
1993	4.1	7.2	7.1	11.1	9.5	14.0	12.9	20.0	17.6
1994	3.5	5.4	7.7	8.4	11.7	12.5	14.6	19.9	18.6
1995	2.4	7.6	6.8	11.3	9.9	14.0	14.0	19.0	18.7
1996	3.1	5.5	4.8	8.2	7.6	11.7	9.5	17.7	15.3
1997	3.2	7.3	8.5	8.2	14.4	9.9	15.5	14.4	16.2
1998	2.8	6.3	6.1	8.8	9.3	11.4	11.6	13.3	14.8
1999	2.8	5.3	6.1	7.5	9.2	10.2	11.5	12.2	14.7
2000	2.6	6.2	5.7	8.4	8.6	10.5	10.7	12.4	13.7
2001	2.5	4.5	3.8	8.5	9.0	11.3	12.3	15.9	17.8
2002	2.9	6.0	6.4	7.4	9.7	9.8	12.1	13.7	15.5
2003	2.1	3.5	2.5	6.8	3.3	8.3	7.5	10.4	7.0
2004	3.4	5.0	4.3	7.8	5.9	8.6	6.0	10.0	8.1
2005	2.4	6.5	5.2	8.9	7.8	10.4	9.8	11.5	12.5
2006	2.3	5.9	5.1	9.7	7.7	11.7	9.6	13.0	12.3
2007	2.3	5.5	5.1	9.4	7.7	13.5	9.6	14.7	12.2
2008	3.7	6.3	8.1	10.8	12.3	13.3	15.4	15.8	19.6
2009	2.4	6.1	5.1	9.4	7.8	12.0	9.7	13.1	12.4
2010	3.2	6.3	6.8	12.3	10.3	13.8	12.9	17.1	16.4
2011	2.5	5.1	5.2	8.7	7.8	13.2	9.8	15.4	12.5
arith. mean	2.9	5.8	6.9	10.0	10.4	12.8	13.0	16.0	17.1

Table 4.2.3. Sandeel in Area-1. Percent mature.

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2004	0.02	0.83	1.00	1.00
2005	0.06	0.98	1.00	1.00
2006	0.01	0.90	1.00	1.00
2007	0.01	0.94	1.00	1.00
2008	0.02	0.97	1.00	1.00
2009	0.00	0.61	1.00	1.00
2010	0.01	0.56	1.00	1.00
2011	0.00	0.58	1.00	1.00
2012	0.03	0.77	0.98	1.00

Table 4.2.4. Sandeel in Area-1. Dredge survey CPUE (number / hour)

		Age		
Area	Year	0	1	2
1	2004	931	171	7
	2005	2266	53	10
	2006	1481	236	7
	2007	3443	95	29
	2008	429	345	31
	2009	3733	92	34
	2010	424	1959	142
	2011	652	872	581

Table 4.2.5. Explorative forecast for sandeel in Area-1 raising age0 by 130% to investigate possible effects of weather. Short term forecast.

F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	247	-8%	-100%
0.25	Fsq*0.25	0.112	30	227	-16%	-90%
0.5	Fsq*0.5	0.224	58	209	-22%	-81%
0.75	Fsq*0.75	0.336	83	192	-29%	-73%
1	Fsq*1	0.448	107	177	-34%	-66%
1.25	Fsq*1.25	0.56	128	163	-39%	-59%
1.5	Fsq*1.5	0.672	148	150	-44%	-52%
1.75	Fsq*1.75	0.784	167	138	-49%	-46%
2	Fsq*2	0.896	184	128	-53%	-41%
0.41	MSY	0.184	48	215	-20%	-85%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.2.6. Area-1 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  28.6849
Number of parameters: 54
Maximum gradient: 1.79101e-005
Akaike information criterion (AIC):   165.37
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             290      16      28       0     334
objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.01
unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
               25.4     3.2    10.0     0.0 0.00e+000    38.6
unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.09    0.20    0.35    0.00
contribution by fleet:
----------------------
Dredge survey 2004-2011     total:   3.228   mean:   0.202
F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2011:   0.000 1.000
age: 1 - 4
    1983-1988:   0.501 0.500
    1989-1998:   0.469 0.500
    1999-2011:   0.404 0.500
F, age effect:
                0      1      2      3      4
1983-1988:  0.027  0.285  1.232  2.067  2.067
1989-1998:  0.055  0.848  1.355  1.461  1.461
1999-2011:  0.054  1.757  2.139  1.346  1.346

Exploitation pattern (scaled to mean F=1)
                        0      1      2      3      4
1983-1988 season 1:  0.000  0.290  1.257  2.109  2.109
          season 2:  0.016  0.085  0.368  0.617  0.617
1989-1998 season 1:  0.000  0.733  1.171  1.262  1.262
          season 2:  0.005  0.037  0.059  0.064  0.064

1999-2011 season 1:  0.000  0.767  0.934  0.587  0.587
          season 2:  0.008  0.135  0.164  0.103  0.103
```

Table 4.2.6 (continued). Area-1 Sandeel. SMS settings and statistics.

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		1.095
1	0.272	0.702
2	0.272	0.702
3	0.687	1.291
4	0.687	1.291

Survey catchability:

	age 0	age 1
Dredge survey 2004-2011	2.106	1.578

sqrt(Survey variance) ~ CV:

	age 0	age 1
Dredge survey 2004-2011	0.43	1.27

Recruit-SSB		alfa	beta	recruit s2	recruit s
Area-1	Hockey stick -break.:	1337.906	1.600e+005	0.754	0.868

Table 4.2.7. Area-1 Sandeel. Fishing mortality at age

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.009	0.156	0.046	0.677	0.198	1.136	0.332	1.136	0.332
1984	0.010	0.178	0.051	0.768	0.223	1.289	0.374	1.289	0.374
1985	0.009	0.184	0.046	0.797	0.199	1.336	0.334	1.336	0.334
1986	0.003	0.151	0.018	0.651	0.076	1.093	0.128	1.093	0.128
1987	0.005	0.096	0.026	0.417	0.112	0.699	0.189	0.699	0.189
1988	0.004	0.151	0.019	0.654	0.082	1.098	0.137	1.098	0.137
1989	0.003	0.515	0.026	0.823	0.042	0.888	0.045	0.888	0.045
1990	0.006	0.455	0.042	0.728	0.068	0.785	0.073	0.785	0.073
1991	0.013	0.306	0.103	0.490	0.164	0.528	0.177	0.528	0.177
1992	0.009	0.504	0.072	0.806	0.114	0.869	0.123	0.869	0.123
1993	0.004	0.201	0.032	0.322	0.051	0.347	0.055	0.347	0.055
1994	0.003	0.193	0.025	0.308	0.039	0.332	0.043	0.332	0.043
1995	0.006	0.338	0.044	0.540	0.070	0.582	0.075	0.582	0.075
1996	0.006	0.343	0.046	0.548	0.074	0.591	0.079	0.591	0.079
1997	0.013	0.260	0.097	0.416	0.155	0.448	0.167	0.448	0.167
1998	0.005	0.391	0.035	0.625	0.056	0.674	0.061	0.674	0.061
1999	0.009	0.849	0.149	1.034	0.182	0.650	0.114	0.650	0.114
2000	0.008	0.671	0.128	0.817	0.156	0.514	0.098	0.514	0.098
2001	0.024	0.866	0.397	1.054	0.484	0.663	0.304	0.663	0.304
2002	0.002	0.888	0.025	1.082	0.030	0.680	0.019	0.680	0.019
2003	0.007	0.602	0.117	0.733	0.142	0.461	0.089	0.461	0.089
2004	0.004	0.735	0.063	0.896	0.076	0.563	0.048	0.563	0.048
2005	0.000	0.322	0.006	0.392	0.008	0.247	0.005	0.247	0.005
2006	0.001	0.471	0.018	0.573	0.022	0.361	0.014	0.361	0.014
2007	0.000	0.200	0.000	0.243	0.000	0.153	0.000	0.153	0.000
2008	0.001	0.326	0.011	0.397	0.013	0.250	0.008	0.250	0.008
2009	0.002	0.447	0.031	0.544	0.038	0.342	0.024	0.342	0.024
2010	0.001	0.308	0.014	0.374	0.018	0.236	0.011	0.236	0.011
2011	0.001	0.393	0.011	0.479	0.013	0.301	0.008	0.301	0.008
arith. mean	0.006	0.397	0.059	0.627	0.100	0.625	0.108	0.625	0.108

Table 4.2.8. Area-1 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.009	0.236	0.961	1.597	1.598	0.598
1984	0.010	0.267	1.087	1.805	1.806	0.677
1985	0.009	0.271	1.100	1.823	1.822	0.686
1986	0.003	0.207	0.832	1.369	1.367	0.519
1987	0.005	0.144	0.586	0.976	0.976	0.365
1988	0.004	0.208	0.840	1.382	1.380	0.524
1989	0.003	0.670	1.001	1.065	1.062	0.835
1990	0.006	0.609	0.913	0.973	0.971	0.761
1991	0.013	0.471	0.714	0.770	0.770	0.593
1992	0.009	0.693	1.041	1.112	1.111	0.867
1993	0.004	0.282	0.425	0.454	0.453	0.353
1994	0.003	0.265	0.399	0.426	0.425	0.332
1995	0.006	0.464	0.697	0.744	0.743	0.580
1996	0.006	0.472	0.710	0.758	0.756	0.591
1997	0.013	0.408	0.619	0.668	0.669	0.514
1998	0.005	0.523	0.784	0.836	0.834	0.654
1999	0.009	1.176	1.358	0.856	0.855	1.267
2000	0.008	0.943	1.088	0.685	0.684	1.015
2001	0.024	1.400	1.632	1.036	1.037	1.516
2002	0.002	1.121	1.285	0.807	0.805	1.203
2003	0.007	0.849	0.980	0.616	0.616	0.915
2004	0.004	0.968	1.112	0.698	0.697	1.040
2005	0.000	0.414	0.473	0.294	0.293	0.443
2006	0.001	0.608	0.696	0.435	0.433	0.652
2007	0.000	0.255	0.291	0.181	0.180	0.273
2008	0.001	0.422	0.483	0.301	0.300	0.453
2009	0.002	0.590	0.676	0.422	0.421	0.633
2010	0.001	0.402	0.460	0.287	0.286	0.431
2011	0.001	0.507	0.579	0.361	0.360	0.543
arith. mean	0.006	0.546	0.821	0.818	0.818	0.684

Table 4.2.9. Area-1 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	618936	16683	56070	2617	274
1984	146686	234945	4817	9890	339
1985	950453	55622	66040	757	984
1986	153171	360773	15618	10327	170
1987	72911	58453	107773	3192	1569
1988	372528	27780	18282	26870	1006
1989	176723	142130	8282	3705	4112
1990	238093	67436	29237	1476	1592
1991	331319	90663	14490	5584	673
1992	73712	125174	21282	3188	1573
1993	310167	27962	24878	3589	906
1994	461180	118270	7828	7253	1537
1995	111006	176017	33639	2341	3084
1996	688518	42262	42474	7734	1457
1997	106629	262053	10122	9649	2397
1998	182075	40316	64818	2421	3326
1999	237703	69396	9304	13878	1430
2000	406192	90184	9041	1168	3624
2001	548790	154313	14344	1447	1357
2002	28747	205062	15422	1304	550
2003	222248	10990	29085	2147	472
2004	97766	84490	1894	5131	771
2005	248770	37291	13445	303	1631
2006	135982	95216	9494	3816	788
2007	296534	52009	20643	2215	1615
2008	113366	113541	15053	6848	1694
2009	644801	43378	28657	4227	3371
2010	25384	246413	9501	6771	2716
2011	55481	9711	63117	2716	3800
2012		21230	2292	16331	2480

Table 4.2.10. Area-1 : Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits	TSB	SSB	Yield	Mean F
	(million)	(tonnes)	(tonnes)	(tonnes)	ages 1-2

1983	618936	692508	506903	349232	0.598
1984	146686	1484880	207960	467609	0.677
1985	950453	993012	580735	424114	0.686
1986	153171	2290050	315338	382735	0.519
1987	72911	1602770	1068990	357671	0.365
1988	372528	776824	627683	398271	0.524
1989	176723	809443	229109	445695	0.835
1990	238093	697171	364033	283040	0.761
1991	331319	1080840	319061	347096	0.593
1992	73712	1308610	352543	564298	0.867
1993	310167	547537	302297	124082	0.353
1994	461180	830519	188752	209538	0.332
1995	111006	1811020	433700	410513	0.580
1996	688518	697039	410379	298702	0.591
1997	106629	2118460	237276	431808	0.514
1998	182075	896145	550266	371117	0.654
1999	237703	598871	224556	427691	1.267
2000	406192	692534	131603	284521	1.015
2001	548790	853809	152634	513068	1.516
2002	28747	1357150	139917	596049	1.203
2003	222248	258154	186983	121863	0.915
2004	97766	485797	72600	195274	1.040
2005	248770	382536	153354	100835	0.443
2006	135982	704362	143683	231448	0.652
2007	296534	536892	239449	108600	0.273
2008	113366	992904	290346	237447	0.453
2009	644801	628729	258325	291247	0.633
2010	25384	1805150	221518	300954	0.431
2011	55481	693689	413173	311134	0.543
2012			265887*		
arith. mean	277789	987152	319635	330540	0.684
geo. mean**	204231				

***using weights from 2010**

****period 1983-2009**

Table 4.2.11. Sandeel in Area-1. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2012) (millions)	204231	21230	2292	16331	2480
Exploitation patttern 1st half		0.393	0.479	0.301	0.301
Exploitation patttern 2nd half	0.001	0.011	0.013	0.008	0.008
Weight in the stock 1st half (gram)		5.84	10.14	13.03	15.20
Weight in the catch 1st half (gram)		5.84	10.14	13.03	15.20
weight in the catch 2nd half (gram)	2.69	5.71	8.63	10.81	13.76
Proportion mature(2012)	0.00	0.03	0.77	0.98	1.00
Proportion mature(2013)	0.00	0.02	0.83	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.2.12. Sandeel in Area-1. Forecast for 2012 for various levels of F.

Basis: Fsq=F(2011)=0.44; Yield(2011)=310; Recruitment(2011)=57; Recruitment(2012)= geometric mean (GM 83-10) = 205 billion;SSB(2012)=269						
F multiplier	Basis	F (2012)	Landings (2012)	SSB (2013)	%SSB change*	%TAC change**
0	F=0	0	0	231	-14%	-100%
0.25	Fsq*0.25	0.112	28	212	-21%	-91%
0.5	Fsq*0.5	0.224	53	195	-27%	-83%
0.75	Fsq*0.75	0.336	77	180	-33%	-75%
1	Fsq*1	0.448	98	166	-38%	-68%
1.25	Fsq*1.25	0.56	118	153	-43%	-62%
1.5	Fsq*1.5	0.672	137	141	-47%	-56%
1.75	Fsq*1.75	0.784	154	130	-51%	-51%
2	Fsq*2	0.896	169	120	-55%	-46%
0.21	MSY	0.094	23	215	-20%	-92%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.3.1. Area-2 Sandeel. Catch numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2237	444	61	5479	602	147	109	61	0
1984	0	5041	2127	200	22	1036	130	35	10
1985	2600	1187	414	5867	707	381	487	45	65
1986	210	9208	2391	1484	133	308	100	6	7
1987	55	508	576	2610	1202	133	35	19	9
1988	155	550	15	2313	92	3986	783	616	26
1989	127	14306	669	1400	63	342	11	1016	39
1990	351	5749	206	4667	63	691	9	209	3
1991	4208	4562	3327	1650	100	251	32	87	0
1992	458	5408	869	1137	85	122	35	76	8
1993	153	736	220	1250	531	693	185	212	43
1994	0	1849	2243	296	342	172	192	78	85
1995	0	1131	430	1009	1623	103	190	65	146
1996	90	700	538	1273	443	1555	344	280	68
1997	2	6004	6789	227	116	270	82	177	47
1998	0	32	3	2370	1459	252	115	348	161
1999	292	243	98	101	37	874	299	247	77
2000	0	1064	619	351	186	338	129	813	173
2001	2242	259	356	1157	620	147	81	473	257
2002	3	2449	1329	120	189	109	34	58	29
2003	244	136	27	3460	624	387	84	149	24
2004	0	5054	1330	409	209	626	293	120	54
2005	3	1786	459	1425	339	154	34	305	93
2006	2	1796	1014	383	119	157	56	47	23
2007	0	298	0	198	0	35	0	6	0
2008	0	985	208	148	79	66	48	9	7
2009	17	410	106	680	2	22	0	1	0
2010	1	2488	1601	143	43	374	34	60	5
2011	0	307	19	1820	73	439	24	95	4
arith. mean	464	2576	967	1504	348	489	136	197	50

Table 4.3.2. Area-2 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age0, 2nd half	Age1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	2.5	5.5	8.5	10.0	11.1	13.9	14.3	17.0	17.7
1984	4.0	5.5	7.6	10.3	12.3	13.8	14.2	17.0	17.7
1985	2.4	5.5	7.5	10.0	10.9	14.2	14.2	19.9	18.8
1986	2.9	5.5	7.9	10.2	12.1	14.1	14.1	16.3	18.8
1987	1.3	5.8	9.0	11.0	10.8	15.6	21.4	18.1	19.8
1988	3.0	4.1	13.2	12.5	14.6	15.5	17.0	18.7	19.3
1989	5.0	4.1	10.1	12.5	14.3	15.6	17.0	18.0	19.0
1990	2.6	4.0	11.0	12.5	15.7	15.6	19.4	19.5	23.0
1991	2.7	8.0	7.5	16.3	13.6	17.4	12.1	18.5	44.0
1992	5.3	7.1	9.5	12.8	16.6	17.9	20.0	25.5	22.6
1993	6.2	8.4	12.6	15.9	16.0	17.7	18.4	21.9	23.3
1994	3.8	7.7	8.3	14.7	11.9	19.1	14.8	20.3	18.1
1995	7.2	8.0	11.3	13.2	14.2	16.4	18.8	19.4	22.6
1996	7.9	11.4	12.2	14.3	15.3	17.0	17.5	20.9	21.7
1997	3.1	7.3	6.9	11.5	12.6	13.3	13.6	14.6	14.7
1998	4.0	9.1	6.4	13.6	14.4	16.0	17.2	18.2	18.6
1999	4.2	11.3	9.3	13.9	13.2	16.3	16.5	18.7	20.1
2000	4.0	10.4	11.8	13.8	13.7	16.2	18.4	18.6	20.2
2001	3.8	10.8	8.5	14.0	12.1	17.7	15.2	21.6	18.5
2002	2.9	6.9	8.3	11.5	13.3	14.4	15.4	17.6	17.7
2003	6.2	9.1	9.6	10.6	10.1	14.1	13.9	18.5	16.3
2004	3.6	7.6	8.1	11.5	11.4	13.4	14.3	15.4	17.4
2005	3.5	7.2	7.8	9.3	11.1	11.4	13.9	13.5	16.9
2006	3.0	8.5	10.8	10.5	11.6	12.6	13.1	14.1	14.0
2007	2.3	8.8	5.1	13.3	7.3	15.7	9.1	18.6	11.1
2008	3.6	7.0	7.9	12.5	11.3	12.8	14.1	13.5	17.1
2009	1.4	7.0	3.1	9.8	4.5	15.0	5.6	13.9	6.8
2010	2.4	6.4	5.3	11.0	7.5	11.7	9.4	13.3	11.4
2011	3.2	8.0	7.0	11.0	10.0	12.0	12.4	13.3	15.1
arith. mean	3.7	7.5	8.7	12.2	12.2	15.0	15.0	17.7	18.7

Table 4.3.3. Area-2 Sandeel. Proportion mature at age

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2011	0.02	0.83	1	1

Table 4.3.4. Explorative forecast for sandeel in Area-2 raising age0 by 130% to investigate possible effects of weather. Short term forecast.

F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	75	-14%	-100%
0.25	Fsq*0.25	0.047	5	72	-18%	-83%
0.5	Fsq*0.5	0.093	10	69	-21%	-67%
0.75	Fsq*0.75	0.14	15	66	-24%	-52%
1	Fsq*1	0.187	19	63	-28%	-37%
1.25	Fsq*1.25	0.234	23	60	-31%	-23%
1.5	Fsq*1.5	0.28	27	58	-34%	-9%
1.75	Fsq*1.75	0.327	31	55	-36%	4%
2	Fsq*2	0.374	35	53	-39%	16%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.3.5. Area-2 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  90.5155
Number of parameters: 47
Maximum gradient: 8.17665e-005
Akaike information criterion (AIC):   275.031
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             290       8      29       0     327

objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.01

unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
               97.4    -7.0    14.7     0.0 0.00e+000   105.0

unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.34   -0.88    0.51    0.00

contribution by fleet:
----------------------
Dredge survey 2004-2011     total:  -7.045   mean:  -0.881

F, season effect:
-----------------
age: 0
    1983-1998:   0.000 1.000
    1999-2011:   0.000 1.000
age: 1 - 4
    1983-1998:   0.551 0.500
    1999-2011:   0.351 0.500
F, age effect:
--------------
                0      1      2      3      4
1983-1998:  0.019  0.270  0.656  0.597  0.597
1999-2011:  0.003  0.727  1.423  1.183  1.183

Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                       0      1      2      3      4
1983-1998 season 1:  0.000  0.483  1.174  1.068  1.068
          season 2:  0.014  0.100  0.243  0.221  0.221
1999-2011 season 1:  0.000  0.428  0.837  0.696  0.696
          season 2:  0.002  0.248  0.487  0.404  0.404
```

Table 4.3.5 (continued). Area-2 Sandeel. SMS settings and statistics.

```
sqrt(catch variance) ~ CV:
--------------------------
              season
----------------------
age        1       2

 0               2.131
 1       0.425   0.891
 2       0.425   0.891
 3       1.159   1.116
 4       1.159   1.116


Survey catchability:
--------------------           age 0
 Dredge survey 2004-2011       8.897

sqrt(Survey variance) ~ CV:
---------------------------    age 0
 Dredge survey 2004-2011        0.30

Recruit-SSB                                  alfa       beta        recruit s2
recruit s
Area-2          Hockey  stick  -break.:        613.829    7.000e+004    1.011
1.006
```

Table 4.3.6. Area-2 Sandeel. Fishing mortality at age

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.005	0.160	0.033	0.389	0.081	0.354	0.073	0.354	0.073
1984	0.009	0.103	0.064	0.251	0.157	0.228	0.142	0.228	0.142
1985	0.010	0.217	0.072	0.528	0.175	0.480	0.159	0.480	0.159
1986	0.007	0.125	0.052	0.305	0.126	0.277	0.114	0.277	0.114
1987	0.006	0.059	0.043	0.143	0.106	0.130	0.096	0.130	0.096
1988	0.005	0.230	0.037	0.561	0.090	0.510	0.082	0.510	0.082
1989	0.003	0.243	0.022	0.592	0.054	0.538	0.049	0.538	0.049
1990	0.001	0.275	0.009	0.669	0.022	0.609	0.020	0.609	0.020
1991	0.011	0.127	0.074	0.309	0.180	0.281	0.164	0.281	0.164
1992	0.004	0.124	0.026	0.301	0.063	0.274	0.057	0.274	0.057
1993	0.006	0.116	0.041	0.282	0.100	0.256	0.091	0.256	0.091
1994	0.006	0.038	0.042	0.093	0.101	0.085	0.092	0.085	0.092
1995	0.008	0.054	0.054	0.131	0.132	0.119	0.120	0.119	0.120
1996	0.008	0.108	0.052	0.263	0.127	0.239	0.116	0.239	0.116
1997	0.016	0.084	0.115	0.205	0.280	0.187	0.254	0.187	0.254
1998	0.011	0.090	0.077	0.219	0.188	0.199	0.171	0.199	0.171
1999	0.001	0.104	0.060	0.203	0.118	0.169	0.098	0.169	0.098
2000	0.001	0.124	0.113	0.243	0.221	0.202	0.183	0.202	0.183
2001	0.001	0.146	0.145	0.286	0.284	0.238	0.236	0.238	0.236
2002	0.001	0.093	0.140	0.182	0.275	0.151	0.229	0.151	0.229
2003	0.001	0.252	0.108	0.494	0.211	0.411	0.175	0.411	0.175
2004	0.002	0.270	0.165	0.529	0.323	0.439	0.269	0.439	0.269
2005	0.001	0.132	0.067	0.259	0.131	0.215	0.108	0.215	0.108
2006	0.001	0.101	0.090	0.197	0.176	0.164	0.146	0.164	0.146
2007	0.000	0.022	0.000	0.043	0.000	0.036	0.000	0.036	0.000
2008	0.000	0.034	0.023	0.067	0.044	0.056	0.037	0.056	0.037
2009	0.000	0.037	0.001	0.072	0.003	0.060	0.002	0.060	0.002
2010	0.000	0.054	0.042	0.107	0.081	0.089	0.068	0.089	0.068
2011	0.000	0.112	0.014	0.219	0.028	0.182	0.024	0.182	0.024
arith. mean	0.004	0.125	0.061	0.281	0.134	0.248	0.116	0.248	0.116

Table 4.3.7. Area-2 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.005	0.231	0.528	0.478	0.478	0.379
1984	0.009	0.182	0.425	0.390	0.391	0.304
1985	0.010	0.333	0.768	0.698	0.699	0.550
1986	0.007	0.201	0.464	0.424	0.424	0.332
1987	0.006	0.109	0.255	0.235	0.236	0.182
1988	0.005	0.323	0.737	0.666	0.665	0.530
1989	0.003	0.328	0.744	0.671	0.669	0.536
1990	0.001	0.357	0.808	0.726	0.724	0.582
1991	0.011	0.220	0.512	0.470	0.471	0.366
1992	0.004	0.179	0.410	0.371	0.371	0.294
1993	0.006	0.180	0.416	0.379	0.379	0.298
1994	0.006	0.081	0.192	0.178	0.179	0.137
1995	0.008	0.111	0.261	0.242	0.243	0.186
1996	0.008	0.179	0.416	0.380	0.381	0.297
1997	0.016	0.197	0.467	0.436	0.439	0.332
1998	0.011	0.175	0.411	0.380	0.382	0.293
1999	0.001	0.180	0.337	0.282	0.283	0.258
2000	0.001	0.247	0.466	0.394	0.396	0.357
2001	0.001	0.300	0.568	0.481	0.483	0.434
2002	0.001	0.228	0.435	0.372	0.375	0.331
2003	0.001	0.407	0.757	0.632	0.633	0.582
2004	0.002	0.474	0.888	0.745	0.747	0.681
2005	0.001	0.222	0.414	0.346	0.347	0.318
2006	0.001	0.199	0.375	0.317	0.319	0.287
2007	0.000	0.028	0.052	0.042	0.042	0.040
2008	0.000	0.062	0.116	0.097	0.097	0.089
2009	0.000	0.048	0.089	0.073	0.072	0.069
2010	0.000	0.102	0.193	0.162	0.163	0.147
2011	0.000	0.155	0.285	0.235	0.234	0.220
arith. mean	0.004	0.208	0.441	0.390	0.391	0.325

Table 4.3.8. Area-2 : Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	128696	4244	11924	762	50
1984	36492	49043	1237	3154	269
1985	239358	13844	14662	348	1201
1986	38621	90708	3666	3073	427
1987	18683	14678	26864	1009	1205
1988	117693	7109	4684	8865	914
1989	65416	44825	1923	1034	2752
1990	85143	24968	12150	427	1097
1991	98664	32559	6643	2576	424
1992	32608	37379	9414	1724	980
1993	128011	12439	11376	2768	998
1994	60949	48727	3759	3287	1363
1995	20933	23198	15900	1309	1998
1996	202269	7953	7361	5175	1352
1997	3107	76867	2395	2109	2339
1998	13246	1170	22259	624	1480
1999	40460	5016	350	6271	757
2000	10520	15483	1505	107	2739
2001	106072	4024	4318	400	1019
2002	6558	40558	1063	1033	461
2003	63637	2507	11352	285	524
2004	25458	24341	618	2373	234
2005	48594	9732	5569	112	653
2006	30148	18594	2819	1596	290
2007	72729	11534	5434	822	705
2008	19296	27847	3988	2203	761
2009	109935	7387	9299	1510	1383
2010	10150	42093	2513	3652	1404
2011	16951	3885	13515	881	2216
2012		6490	1210	4466	1315

Table 4.3.9. Area-2 : Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	128696	153827	110575	74481	0.379
1984	36492	331018	64022	63046	0.304
1985	239358	251426	151794	96645	0.550
1986	38621	589397	91455	93146	0.332
1987	18683	418223	284555	53284	0.182
1988	117693	242278	203883	120382	0.530
1989	65416	275417	89452	109703	0.536
1990	85143	280965	156274	100917	0.582
1991	98664	421948	147939	107795	0.366
1992	32608	440451	161011	69825	0.294
1993	128011	357229	223413	59652	0.298
1994	60949	521693	143657	50656	0.137
1995	20933	456599	238136	60138	0.186
1996	202269	311756	205280	80012	0.297
1997	3107	651494	96146	102726	0.332
1998	13246	351199	289136	68953	0.293
1999	40460	177819	121446	32108	0.258
2000	10520	234534	73052	52228	0.357
2001	106072	132939	80120	56934	0.434
2002	6558	314730	38788	35494	0.331
2003	63637	157418	114424	55924	0.582
2004	25458	226626	45085	71413	0.681
2005	48594	132161	54495	41420	0.318
2006	30148	212693	52025	35351	0.287
2007	72729	199566	88030	5911	0.040
2008	19296	284401	83802	13064	0.089
2009	109935	184595	118688	10240	0.069
2010	10150	357087	89623	31747	0.147
2011	16951	220037	164185	30259	0.220
2012			83007[1]		
arith. mean	63807	306535	128783	61499	0.325
geo. mean[2]	41852				

[1]**Using weights from 2011**

[2]**Period 1983 – 2010**

Table 4.3.10. Sandeel in Area-2. Input values for preliminary short term forecast.

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2012) (millions)	41852	6490	1210	4466	1315
Exploitation patttern 1st half		0.112	0.219	0.182	0.182
Exploitation patttern 2nd half	0.000	0.014	0.028	0.024	0.024
Weight in the stock 1st half (gram)		7.12	10.61	12.87	13.51
Weight in the catch 1st half (gram)		7.12	10.61	12.87	13.51
weight in the catch 2nd half (gram)	2.32	5.15	7.33	9.13	11.12
Proportion mature(2012)	0.00	0.02	0.83	1.00	1.00
Proportion mature(2013)	0.00	0.02	0.83	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.3.11. Sandeel in Area-2. Short term forecast.

Basis: Fsq=F(2011)=0.187; Yield(2011)=30; Recruitment(2011)=17; Recruitment(2012)= geometric mean (GM 83-10) = 42 billion; SSB(2011)=87

F multiplier	Basis	F (2012)	Landings (2012)	SSB (2013)	%SSB change*	%TAC change**
0	F=0	0	0	69	-21%	-100%
0.25	Fsq*0.25	0.047	5	66	-24%	-84%
0.5	Fsq*0.5	0.093	9	63	-27%	-69%
0.75	Fsq*0.75	0.14	14	60	-30%	-55%
1	Fsq*1	0.187	18	58	-34%	-41%
1.25	Fsq*1.25	0.234	22	55	-36%	-28%
1.5	Fsq*1.5	0.28	26	53	-39%	-15%
1.75	Fsq*1.75	0.327	29	51	-42%	-3%
2	Fsq*2	0.374	33	48	-44%	9%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.4.1. Area-3 Sandeel. Catch numbers (millions) by half year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	8788	6876	335	1722	376	114	26	17	0
1984	0	11628	1800	1454	173	502	65	16	0
1985	826	812	232	1164	496	300	199	138	25
1986	9564	33702	9744	3681	649	291	10	0	1
1987	20	34149	253	14264	53	463	1	203	0
1988	13754	7165	1337	18861	366	1021	224	29	21
1989	2659	56641	3176	2245	216	3367	0	33	0
1990	13612	12174	1951	3676	409	544	61	165	18
1991	18977	32228	1338	1885	43	708	12	248	4
1992	5550	14005	124	5593	11	668	3	419	1
1993	23259	19369	1427	865	243	336	89	1651	16
1994	0	45466	2566	7918	1250	1015	165	426	24
1995	2873	28112	1055	2393	182	338	26	176	32
1996	34618	4672	8917	2860	115	411	36	360	266
1997	3214	89081	11945	4255	213	900	14	222	10
1998	31377	4292	1071	30566	845	2762	226	315	34
1999	12349	5453	2551	1584	163	2045	558	445	233
2000	1	25715	779	3617	7	584	3	633	15
2001	25320	8079	6724	1205	14	193	4	197	12
2002	0	22844	107	3706	5	719	2	183	0
2003	9231	1183	127	911	97	144	3	87	3
2004	1832	7975	1341	663	31	127	14	171	2
2005	1	3091	51	252	47	33	5	22	9
2006	0	2078	177	84	41	36	27	6	26
2007	0	14895	0	630	0	87	0	19	0
2008	0	7531	9	2201	3	469	0	77	0
2009	65	3251	1773	185	138	28	26	2	1
2010	0	6773	472	734	13	942	10	162	1
2011	0	1547	0	5325	0	829	0	24	0
arith. mean	7514	17613	2117	4293	214	689	62	222	26

Table 4.4.2. Area-3 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	3.0	5.6	13.2	12.6	26.5	26.5	31.8	39.6	17.7
1984	4.1	5.6	13.0	12.9	27.8	17.2	34.7	22.9	17.7
1985	2.9	5.6	12.6	12.4	26.3	26.7	32.8	43.0	46.4
1986	3.0	5.6	13.1	13.0	27.5	26.7	14.1	16.3	18.8
1987	2.9	5.6	12.9	13.0	13.4	27.1	21.4	43.7	19.8
1988	3.0	5.6	13.2	13.1	27.4	26.6	27.6	34.2	40.1
1989	5.0	6.2	8.9	14.0	16.0	16.3	17.0	18.0	19.0
1990	3.0	5.6	13.1	13.0	27.0	27.1	35.0	43.8	42.5
1991	3.4	7.4	9.4	14.3	14.8	22.3	15.7	30.6	44.0
1992	5.5	5.5	12.1	10.9	18.6	18.5	20.0	29.8	22.6
1993	3.0	6.2	7.8	15.6	16.2	16.6	21.0	23.2	22.1
1994	3.5	5.7	9.1	12.8	20.8	19.9	34.3	20.6	27.0
1995	4.7	5.8	7.9	10.3	9.8	14.3	13.1	16.4	15.6
1996	2.6	8.0	5.3	13.4	15.2	25.7	17.3	37.3	26.2
1997	2.9	5.1	6.8	9.3	9.8	13.7	14.2	18.2	14.4
1998	3.2	5.0	7.0	10.1	15.0	13.7	17.1	20.2	20.7
1999	6.4	7.4	11.7	10.1	15.7	14.1	17.0	25.9	24.8
2000	4.2	6.8	10.1	10.3	17.6	15.3	21.4	20.3	23.8
2001	4.8	6.3	7.1	13.1	13.9	17.2	14.2	22.0	20.6
2002	4.8	6.6	11.6	12.0	20.3	12.1	24.6	19.0	27.3
2003	3.5	5.2	5.0	14.3	14.5	19.8	22.4	26.1	29.8
2004	5.1	6.3	7.2	8.6	12.3	12.9	16.0	13.1	11.1
2005	2.8	7.6	6.7	15.8	11.8	18.9	14.3	21.8	15.8
2006	3.5	6.8	8.4	12.6	14.6	16.3	17.8	24.8	19.7
2007	4.7	6.8	11.3	14.6	19.8	21.6	24.0	14.7	26.7
2008	3.4	6.6	8.3	14.7	14.5	22.0	17.6	25.5	19.5
2009	7.6	5.9	5.3	9.4	11.3	20.0	18.8	11.2	10.9
2010	2.2	6.2	5.2	17.1	9.1	20.6	11.0	24.1	12.2
2011	4.1	7.4	9.8	12.5	17.1	19.4	20.7	36.2	23.0
arith. mean	3.9	6.2	9.4	12.6	17.4	19.6	20.9	25.6	23.4

Table 4.4.3. Area-3 Sandeel. Proportion mature at age

Year/Age	Age 1	Age 2	Age 3	Age 4
1983-2004	0.05	0.77	1.00	1.00
2005	0.12	0.96	1.00	1.00
2006	0.08	0.78	1.00	1.00
2007	0.02	0.80	1.00	1.00
2008	0.03	0.69	1.00	1.00
2009	0.01	0.48	1.00	1.00
2010	0.04	0.92	1.00	1.00
2011	0.00	0.82	1.00	1.00
2012	0.01	0.70	1.00	1.00

Table 4.4.4. Area-3 Sandeel. Dredge survey CPUE (number / hour)

		Age		
Area	Year	0	1	2
3	2004	83	20	7
	2005	376	48	2
	2006	903	60	1
	2007	426	212	12
	2008	1094	334	129
	2009	553	1087	111
	2010	40	405	81
	2011	41	60	1257

Table 4.4.5. Norwegian acoustic survey. Estimated number of sandeels (billions).

	Age			
Year	1	2	3	4+
2007	167.1	36.1	6.9	3.8
2008	27.0	41.4	3.0	1.0
2009	60.2	66.9	21.6	1.8
2010	183.9	88.8	12.6	8.6
2011	2.2	93.1	6.6	3.6

Table 4.4.6. Explorative forecast for sandeel in Area-3 raising age0 by 130% to investigate possible effects of weather. Short term forecast.

F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	92	-23%	-100%
0.25	Fsq*0.25	0.094	6	88	-26%	-94%
0.5	Fsq*0.5	0.189	11	85	-29%	-89%
0.75	Fsq*0.75	0.283	16	81	-32%	-83%
1	Fsq*1	0.377	21	78	-35%	-78%
1.25	Fsq*1.25	0.472	25	75	-37%	-73%
1.5	Fsq*1.5	0.566	29	72	-39%	-69%
1.75	Fsq*1.75	0.66	34	70	-42%	-65%
2	Fsq*2	0.755	37	67	-44%	-61%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.4.7. Explorative assessment of Area 3 including acoustic survey

```
objective function (negative log likelihood):  117.437
Number of parameters: 59
Maximum gradient: 3.68526e-005
Akaike information criterion (AIC):   352.874
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             290      36      28       0     354

objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.01

unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
              120.1    -2.8    11.9     0.0 0.00e+000   129.2

unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.41   -0.08    0.41    0.00

contribution by fleet:
----------------------
Dredge survey 2004-2011     total:   1.804   mean:   0.113
Acoustic                    total:  -4.592   mean:  -0.230

F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2011:   0.000 1.000
age: 1 - 4
    1983-1988:   0.883 0.500
    1989-1998:   1.214 0.500
    1999-2011:   0.843 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.084  0.564  1.156  2.060  2.060
1989-1998:  0.283  0.415  0.333  0.269  0.269
1999-2011:  0.056  1.663  1.251  0.703  0.703
```

```
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:  0.000  0.533  1.092  1.947  1.947
          season 2:  0.037  0.123  0.252  0.450  0.450

1989-1998 season 1:  0.000  1.042  0.837  0.676  0.676
          season 2:  0.091  0.067  0.054  0.043  0.043

1999-2011 season 1:  0.000  0.655  0.492  0.277  0.277
          season 2:  0.033  0.487  0.366  0.206  0.206


sqrt(catch variance) ~ CV:
--------------------------

              season
----------------------
age        1       2

 0              1.795
 1       0.508   1.054
 2       0.508   1.054
 3       0.939   1.579
 4       0.939   1.579

Survey catchability:
--------------------          age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2011       1.939    1.939
 Acoustic                               0.361    1.472    0.731    0.423

sqrt(Survey variance) ~ CV:
---------------------------   age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2011        0.41     1.12
 Acoustic                                0.47     0.47     0.50     0.50

Recruit-SSB                                  alfa       beta        recruit s2
recruit s
Area-3           Hockey  stick  -break.:       1102.682     1.000e+005     0.859
0.927
```

Table 4.4.8. Area-3 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  119.915

Number of parameters: 53

Maximum gradient: 7.95453e-005

Akaike information criterion (AIC):   345.83

Number of observations used in the likelihood:

                            Catch    CPUE     S/R Stomach     Sum

                             290      16      28       0     334

objective function weight:

                          Catch  CPUE   S/R

                          1.00  1.00  0.01

unweighted objective function contributions (total):

                Catch    CPUE    S/R    Stom.  Penalty     Sum

              121.8    -2.0    11.0     0.0 0.00e+000   130.8

unweighted objective function contributions (per observation):

                Catch   CPUE     S/R   Stomachs

               0.42   -0.12    0.38    0.00

contribution by fleet:

----------------------

Dredge survey 2004-2011     total:  -1.952   mean:  -0.122

F, season effect:

-----------------

age: 0

    1983-1988:   0.000 1.000

    1989-1998:   0.000 1.000

    1999-2011:   0.000 1.000

age: 1 - 4

    1983-1988:   0.887 0.500

    1989-1998:   1.232 0.500

    1999-2011:   0.844 0.500

F, age effect:

--------------

                0      1      2      3      4

1983-1988:  0.083  0.559  1.150  2.034  2.034

1989-1998:  0.278  0.399  0.315  0.245  0.245

1999-2011:  0.053  1.513  1.046  0.495  0.495

Exploitation pattern (scaled to mean F=1)

-----------------------------------------

                        0      1      2      3      4

1983-1988 season 1:  0.000  0.532  1.094  1.935  1.935

          season 2:  0.036  0.122  0.251  0.445  0.445


1989-1998 season 1:  0.000  1.051  0.830  0.645  0.645

          season 2:  0.093  0.067  0.053  0.041  0.041

1999-2011 season 1:  0.000  0.679  0.469  0.222  0.222

          season 2:  0.035  0.504  0.348  0.165  0.165
```

Table 4.4.8 (continued). Area-3 Sandeel. SMS settings and statistics.

```
sqrt(catch variance) ~ CV:
--------------------------


              season
----------------------
age        1       2


 0              1.825
 1       0.517   1.066
 2       0.517   1.066
 3       0.922   1.605
 4       0.922   1.605

Survey catchability:
--------------------          age 0    age 1
 Dredge survey 2004-2011       1.637    1.637

sqrt(Survey variance) ~ CV:
---------------------------   age 0    age 1
 Dredge survey 2004-2011        0.30     1.08



Recruit-SSB                                  alfa       beta        recruit s2
recruit s
Area-3           Hockey  stick  -break.:      1092.613     1.000e+005     0.805
0.897
```

Table 4.4.9. Area-3 Sandeel. Fishing mortality at age by half-year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1983	0.015	0.217	0.050	0.446	0.102	0.789	0.181	0.789	0.181
1984	0.016	0.233	0.053	0.479	0.108	0.848	0.191	0.848	0.191
1985	0.014	0.117	0.046	0.240	0.095	0.424	0.168	0.424	0.168
1986	0.044	0.442	0.148	0.909	0.304	1.608	0.538	1.608	0.538
1987	0.002	0.490	0.007	1.006	0.014	1.780	0.026	1.780	0.026
1988	0.037	0.666	0.123	1.369	0.253	2.422	0.447	2.422	0.447
1989	0.085	0.969	0.061	0.765	0.048	0.594	0.038	0.594	0.038
1990	0.119	0.456	0.086	0.360	0.068	0.279	0.052	0.279	0.052
1991	0.088	0.618	0.063	0.488	0.050	0.379	0.039	0.379	0.039
1992	0.041	0.400	0.029	0.315	0.023	0.245	0.018	0.245	0.018
1993	0.144	0.509	0.104	0.402	0.082	0.312	0.064	0.312	0.064
1994	0.055	0.620	0.040	0.489	0.031	0.380	0.024	0.380	0.024
1995	0.027	0.421	0.019	0.332	0.015	0.258	0.012	0.258	0.012
1996	0.190	0.265	0.137	0.209	0.108	0.163	0.084	0.163	0.084
1997	0.139	0.788	0.100	0.622	0.079	0.483	0.061	0.483	0.061
1998	0.225	0.747	0.162	0.590	0.128	0.458	0.099	0.458	0.099
1999	0.038	0.727	0.540	0.503	0.373	0.238	0.177	0.238	0.177
2000	0.002	1.295	0.031	0.895	0.022	0.423	0.010	0.423	0.010
2001	0.037	0.554	0.536	0.383	0.371	0.181	0.175	0.181	0.175
2002	0.001	1.011	0.015	0.699	0.010	0.331	0.005	0.331	0.005
2003	0.013	0.357	0.191	0.247	0.132	0.117	0.062	0.117	0.062
2004	0.008	0.577	0.114	0.399	0.079	0.189	0.037	0.189	0.037
2005	0.000	0.213	0.005	0.147	0.003	0.070	0.002	0.070	0.002
2006	0.001	0.122	0.010	0.084	0.007	0.040	0.003	0.040	0.003
2007	0.000	0.504	0.000	0.348	0.000	0.165	0.000	0.165	0.000
2008	0.000	0.443	0.001	0.306	0.001	0.145	0.000	0.145	0.000
2009	0.002	0.116	0.027	0.080	0.018	0.038	0.009	0.038	0.009
2010	0.001	0.487	0.011	0.337	0.008	0.159	0.004	0.159	0.004
2011	0.000	0.446	0.000	0.309	0.000	0.146	0.000	0.146	0.000
arith. mean	0.046	0.511	0.093	0.474	0.087	0.471	0.087	0.471	0.087

Table 4.4.10. Area-3 : Annual Fishing mortality (F) at age

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4	Avg. 1-2
1983	0.015	0.316	0.613	1.072	1.072	0.464
1984	0.016	0.339	0.656	1.148	1.147	0.498
1985	0.014	0.185	0.362	0.641	0.642	0.274
1986	0.044	0.677	1.316	2.304	2.305	0.997
1987	0.002	0.623	1.187	2.031	2.026	0.905
1988	0.037	0.933	1.795	3.101	3.099	1.364
1989	0.085	1.248	0.940	0.725	0.723	1.094
1990	0.119	0.644	0.483	0.373	0.373	0.563
1991	0.088	0.826	0.620	0.478	0.477	0.723
1992	0.041	0.529	0.395	0.304	0.303	0.462
1993	0.144	0.725	0.544	0.421	0.421	0.635
1994	0.055	0.810	0.606	0.466	0.465	0.708
1995	0.027	0.547	0.408	0.313	0.313	0.478
1996	0.190	0.445	0.336	0.263	0.264	0.391
1997	0.139	1.063	0.800	0.618	0.617	0.931
1998	0.225	1.064	0.802	0.621	0.621	0.933
1999	0.038	1.345	0.897	0.431	0.432	1.121
2000	0.002	1.604	1.066	0.504	0.503	1.335
2001	0.037	1.126	0.753	0.363	0.365	0.939
2002	0.001	1.259	0.832	0.392	0.391	1.046
2003	0.013	0.605	0.401	0.191	0.191	0.503
2004	0.008	0.817	0.538	0.254	0.254	0.678
2005	0.000	0.275	0.179	0.084	0.083	0.227
2006	0.001	0.164	0.107	0.050	0.050	0.136
2007	0.000	0.635	0.415	0.194	0.194	0.525
2008	0.000	0.560	0.366	0.171	0.171	0.463
2009	0.002	0.169	0.111	0.052	0.052	0.140
2010	0.001	0.623	0.407	0.191	0.190	0.515
2011	0.000	0.564	0.368	0.172	0.172	0.466
arith. mean	0.046	0.714	0.631	0.618	0.618	0.673

Table 4.4.11. Area-3: Stock numbers (millions). Age 0 at start of 2nd half-year, age 1+ at start of 1st half-year

Year/Age	Age 0	Age 1	Age 2	Age 3	Age 4
1983	93349	22343	6391	181	12
1984	43037	35217	6048	1563	37
1985	299056	16223	9355	1423	287
1986	371351	112946	4873	2833	483
1987	85769	136068	22126	613	198
1988	309998	32772	29269	3374	68
1989	105090	114433	5262	2447	99
1990	210121	36945	14428	987	687
1991	91968	71431	7601	3983	619
1992	238718	32255	12772	1879	1544
1993	225569	87758	7424	3853	1357
1994	177963	74767	16803	1937	1832
1995	138816	64467	13661	4224	1299
1996	898312	51731	14674	4085	2157
1997	64091	284411	12234	4522	2506
1998	97066	21354	41358	2568	2096
1999	123453	29666	3041	8541	1378
2000	86556	45523	2953	536	3339
2001	96526	33070	4274	500	1317
2002	19136	35602	3927	851	663
2003	51443	7319	4509	817	558
2004	18529	19437	1495	1306	592
2005	41290	7039	3442	392	777
2006	111003	15804	2002	1253	567
2007	62985	42474	4896	773	894
2008	111471	24116	9069	1462	732
2009	105362	42678	5468	2823	975
2010	7419	40267	13081	2097	1856
2011	5787	2839	8652	3924	1734
2012		2216	642	2689	2508

Table 4.4.12. Area-3: Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), landings weight (Yield) and average fishing mortality.

Year	Recruits (million)	TSB (tonnes)	SSB (tonnes)	Yield (tonnes)	Mean F ages 1-2
1983	93349	211734	73516	105946	0.464
1984	43037	303826	97830	123635	0.498
1985	299056	258097	144541	59083	0.274
1986	371351	783954	164221	420341	0.997
1987	85769	1080980	285620	403908	0.905
1988	309998	658759	395318	391081	1.364
1989	105090	822375	133629	481893	1.094
1990	210121	452965	212091	219183	0.563
1991	91968	747499	218236	368105	0.723
1992	238718	398867	197029	195700	0.462
1993	225569	753733	211866	263954	0.635
1994	177963	715943	263068	444119	0.708
1995	138816	594481	209227	218922	0.478
1996	898312	793311	357031	247397	0.391
1997	64091	1674320	267531	604159	0.931
1998	97066	601971	404355	499333	0.933
1999	123453	406362	190496	223160	1.121
2000	86556	416539	115000	242732	1.335
2001	96526	303095	91066	245290	0.939
2002	19136	305851	70816	209302	1.046
2003	51443	133060	82292	58942	0.503
2004	18529	159689	40604	79234	0.678
2005	41290	132382	83127	29677	0.227
2006	111003	166445	62738	18863	0.136
2007	62985	391818	92814	113232	0.525
2008	111471	343431	147655	94491	0.463
2009	105362	369497	94614	33350	0.140
2010	7419	561655	303702	80576	0.515
2011	5787	267917	239149	94946	0.466
2012			150945*		
arith. mean	147974	510709	180004	226571	0.673
geo. mean**	99411				

***Using weights from 2011**

****Period 1983-2010**

Table 4.4.13. Sandeel in Area-3. Input values for preliminary short term forecast

Age	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2012) (millions)	99411	2216	642	2689	2508
Exploitation patttern 1st half		0.446	0.309	0.146	0.146
Exploitation patttern 2nd half	0.000	0.000	0.000	0.000	0.000
Weight in the stock 1st half (gram)		6.49	13.02	19.96	23.87
Weight in the catch 1st half (gram)		6.49	13.02	19.96	23.87
weight in the catch 2nd half (gram)	4.62	6.75	12.48	16.84	15.37
Proportion mature(2012)	0.00	0.01	0.70	1.00	1.00
Proportion mature(2013)	0.00	0.05	0.77	1.00	1.00
Natural mortality 1st half		0.46	0.44	0.31	0.28
Natural mortality 2nd half	0.96	0.58	0.42	0.37	0.36

Table 4.3.14. Sandeel in Area-3. Short term forecast.

Basis: Fsq=F(2011)=0.377; Yield(2011)=95; Recruitment(2011)=7; Recruitment(2012)= geometric mean (GM 83-10) = 99 billion;SSB(2012)=120						
F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	90	-25%	-100%
0.25	Fsq*0.25	0.094	5	86	-28%	-94%
0.5	Fsq*0.5	0.189	10	83	-31%	-89%
0.75	Fsq*0.75	0.283	15	80	-33%	-84%
1	Fsq*1	0.377	19	77	-36%	-80%
1.25	Fsq*1.25	0.472	24	74	-38%	-75%
1.5	Fsq*1.5	0.566	28	71	-40%	-71%
1.75	Fsq*1.75	0.66	32	69	-42%	-67%
2	Fsq*2	0.755	35	66	-44%	-63%

***SSB in 2013 relative to SSB in 2012**

**** TAC in 2012 relative to landings in 2011**

Table 4.5.1. Area-4 Sandeel. Catch numbers (millions) by half-year

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1994	0	1079	258	1532	63	5177	259	2106	160
1995	4	2699	4	1232	1	531	0	30	0
1996	2769	685	2734	2371	3705	445	244	122	1177
1997	0	2924	1390	295	36	1710	44	419	10
1998	0	2148	60	3748	96	234	6	129	3
1999	0	1492	88	1150	47	1560	47	255	12
2000	0	6530	0	376	0	322	0	296	0
2001	10	2044	65	4952	20	600	1	377	0
2002	0	323	0	772	0	490	0	97	0
2003	180	4319	175	1001	12	2719	6	1252	2
2004	0	924	4	221	1	46	0	82	0
2005	0	47	0	138	0	30	0	17	0
2006	0	8	2	0	0	0	0	0	0
2007	0	2	0	0	0	0	0	0	0
2008	0	205	0	18	0	4	0	1	0
2009	0	0	0	0	0	0	0	0	0
2010	0	48	0	1	0	1	0	0	0
2011	0	4	0	25	0	2	0	0	0

Table 4.5.2. Area-4 Sandeel. Individual mean weight(g) at age in the catch and in the sea

Year/Age	Age 0, 2nd half	Age 1, 1st half	Age 1, 2nd half	Age 2, 1st half	Age 2, 2nd half	Age 3, 1st half	Age 3, 2nd half	Age 4+, 1st half	Age 4+, 2nd half
1994	4.0	11.2	11.1	11.4	14.6	15.1	18.5	21.1	23.5
1995	7.3	8.8	11.9	16.4	13.7	19.9	16.7	16.2	20.5
1996	7.6	5.2	9.0	12.7	16.0	18.4	21.9	22.8	27.1
1997	4.0	6.8	6.9	7.6	10.7	11.4	15.4	18.4	15.1
1998	3.6	6.2	6.2	10.6	10.8	13.9	14.1	14.8	18.9
1999	4.0	6.2	6.9	11.0	12.1	16.3	18.3	20.4	21.0
2000	4.0	4.2	9.1	8.7	16.0	14.2	18.6	18.7	24.9
2001	3.5	3.5	3.8	6.1	6.8	9.2	10.7	14.5	14.8
2002	4.0	3.7	9.1	5.9	16.0	9.4	18.6	17.8	24.9
2003	3.4	5.1	5.2	7.4	5.8	9.1	7.3	12.2	9.4
2004	4.0	4.2	3.3	7.8	5.7	9.7	8.1	14.4	10.3
2005	4.0	4.2	9.1	6.1	16.0	8.6	18.6	11.0	24.9
2006	4.1	6.2	10.3	10.1	12.6	12.4	14.4	14.8	15.9
2007	4.0	5.7	9.1	9.6	16.0	12.0	18.6	13.1	24.9
2008	4.0	5.7	9.1	9.7	16.0	12.0	18.6	13.7	24.9
2009	4.0	5.9	9.1	10.8	16.0	15.6	18.6	19.8	24.9
2010	4.0	5.1	9.1	9.3	16.0	13.4	18.6	17.1	24.9
2011	4.0	4.9	9.1	8.9	16.0	12.8	18.6	16.2	24.9

Table 4.5.3 Area-4 sandeel: Average dredge survey CPUE by age for a) area 4 and b) Firth of Forth

	a) Area 4			b) Firth of Forth		
Year	Age 0	Age 1	Age 2	Age 0	Age 1	Age 2
1999				615	494	301
2000				586	3170	258
2001				48	2656	1561
2002				243	404	916
2003				580		
2008	52	24	18	68	24	24
2009	832	87	38	1023	174	56
2010	147	1032	67	186	1244	78
2011	89	165	407	119	220	534

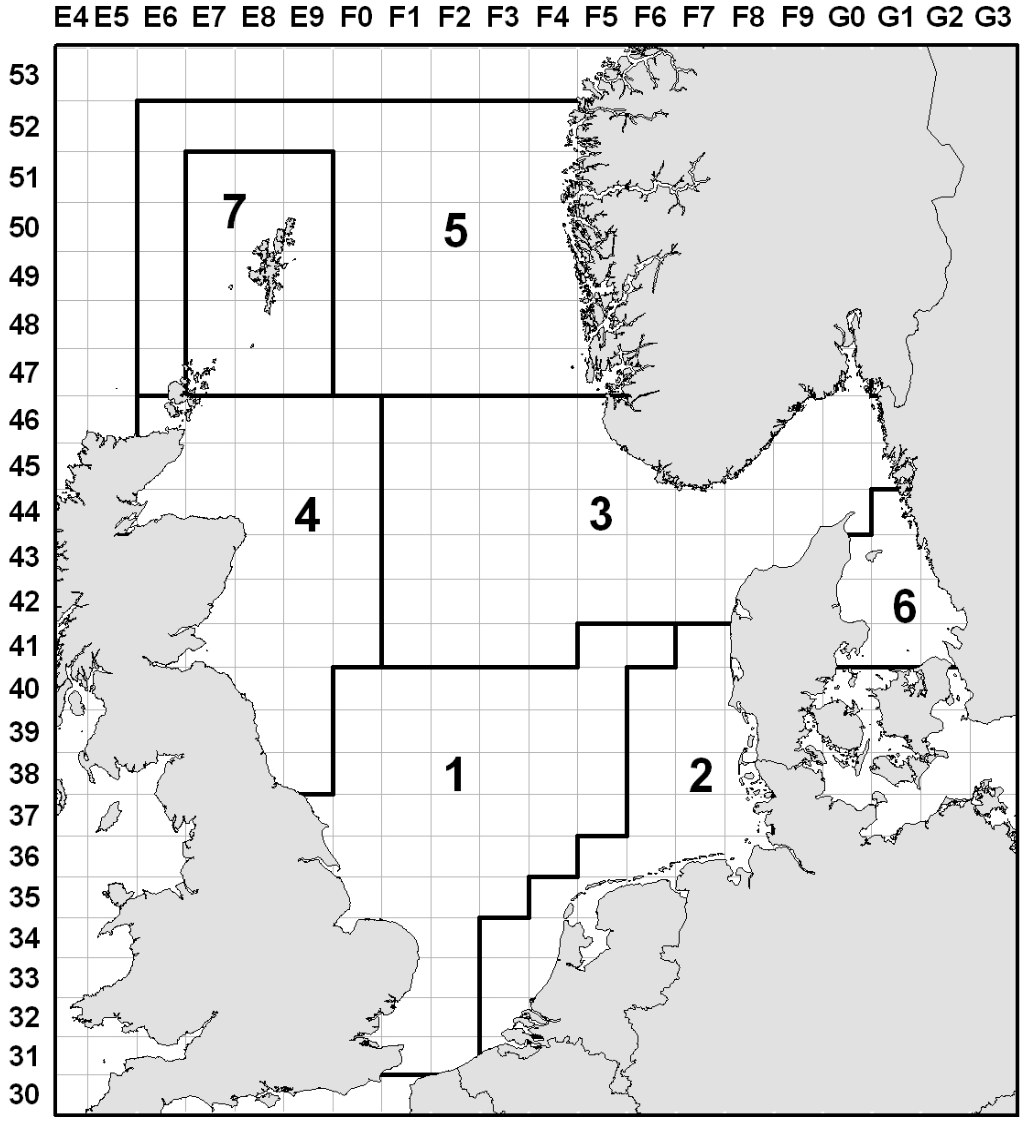


Figure 4.1.1 Sandeel in Division IV. Sandeel assessment areas.

Figure 4.1.2. Sandeel in IV. Landings by ICES rectangles 2000-2011.

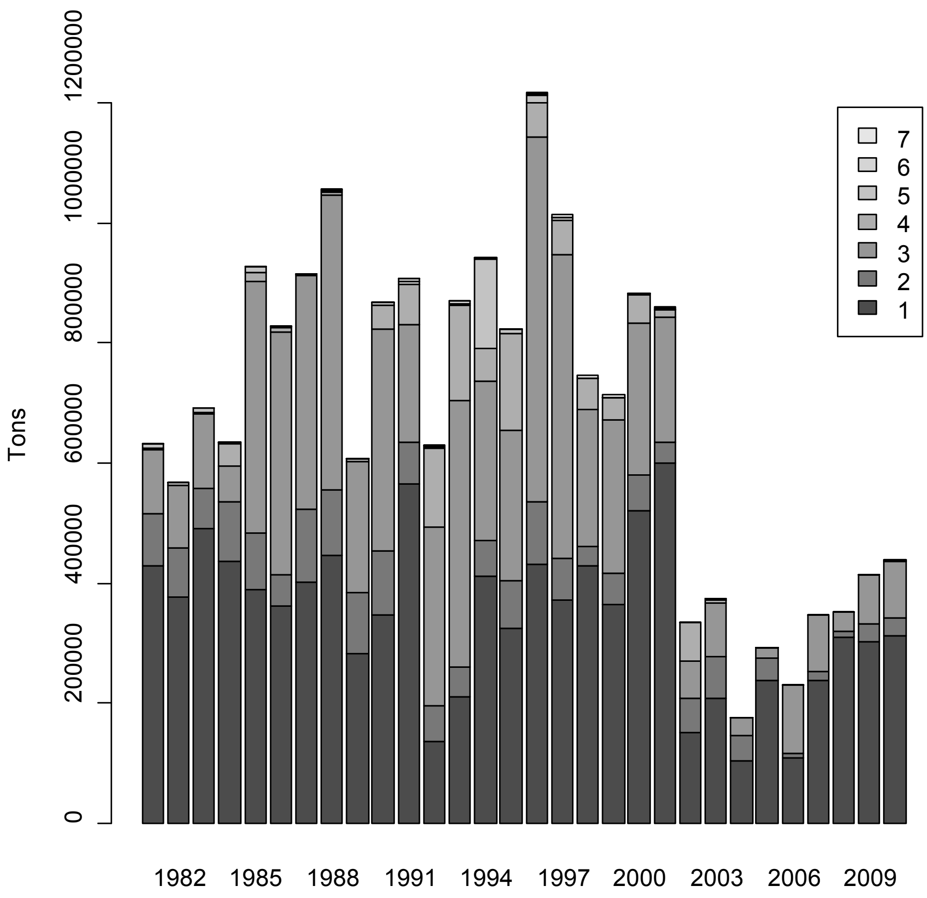


Figure 4.1.3. Sandeel in IV. Total annual landings by area.

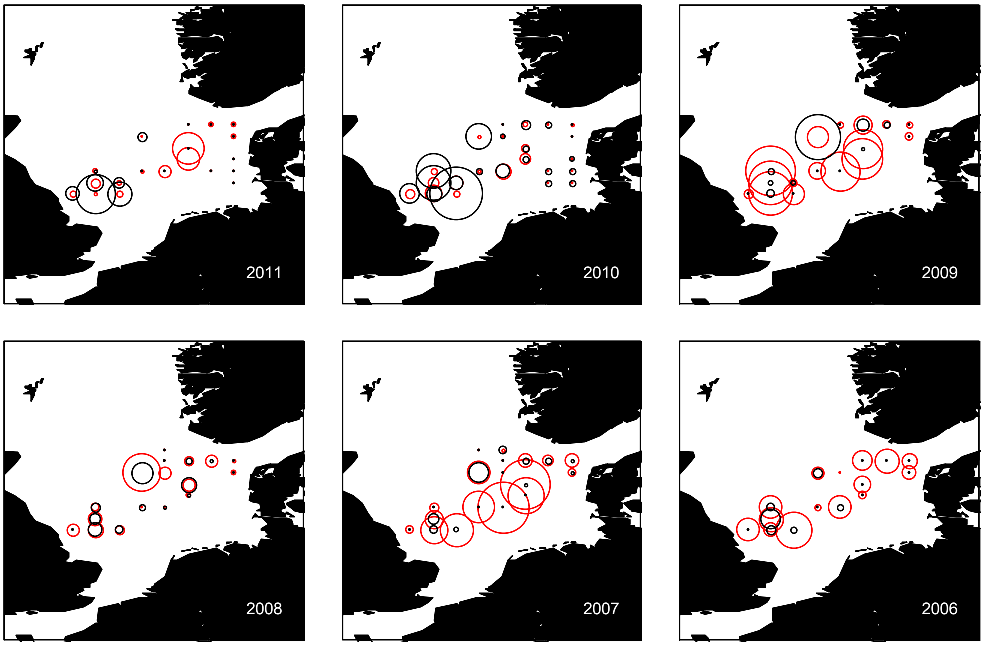


Figure 4.1.4. Danish survey-indices by year and ICES-square. Red circles: 0-group, black circles: 1-group.

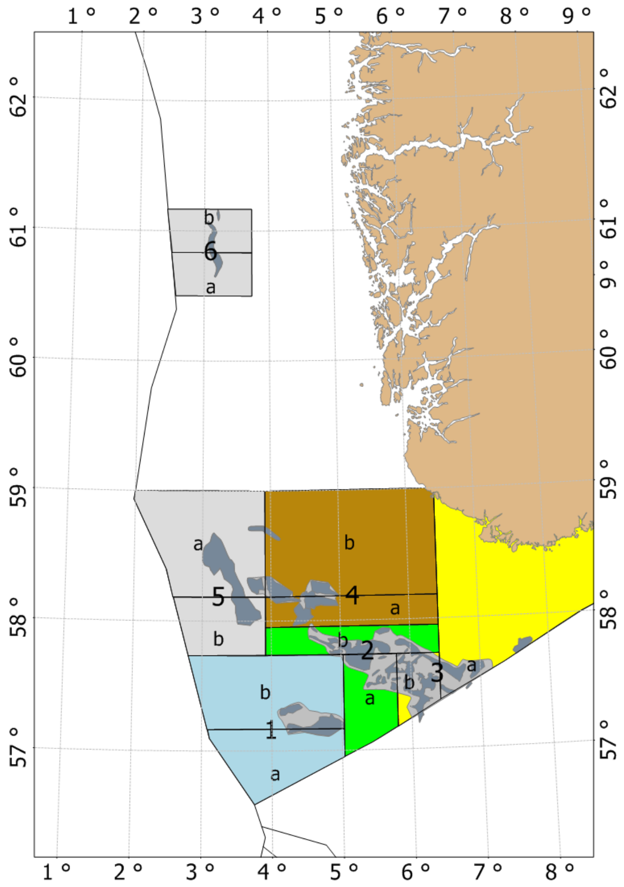
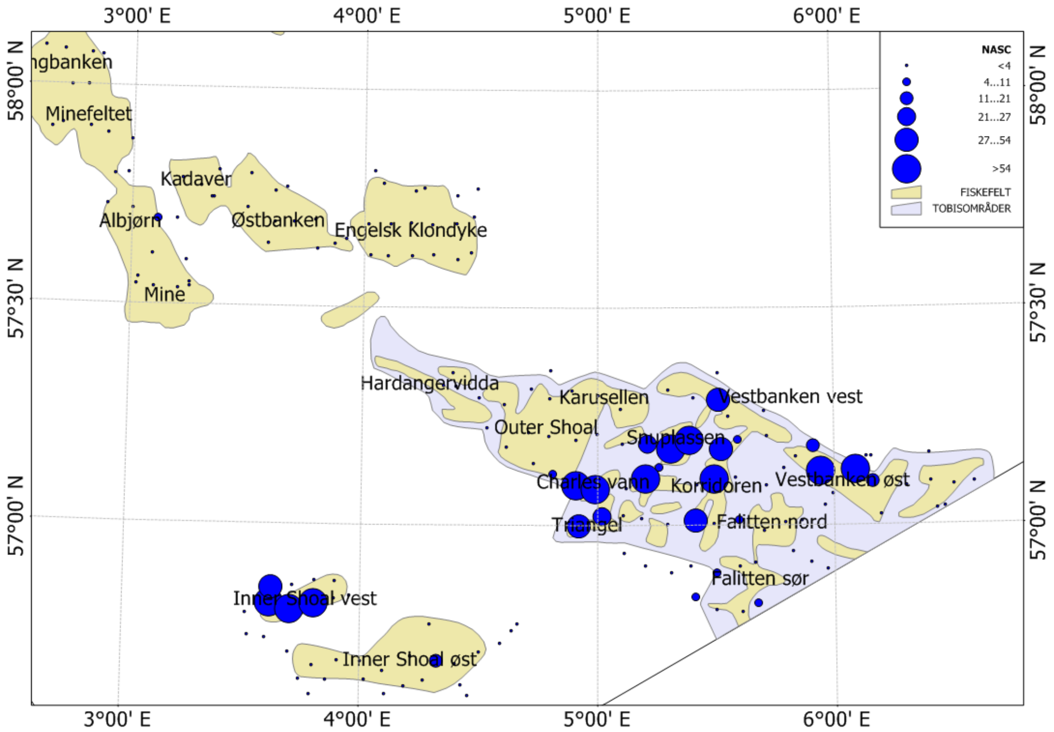
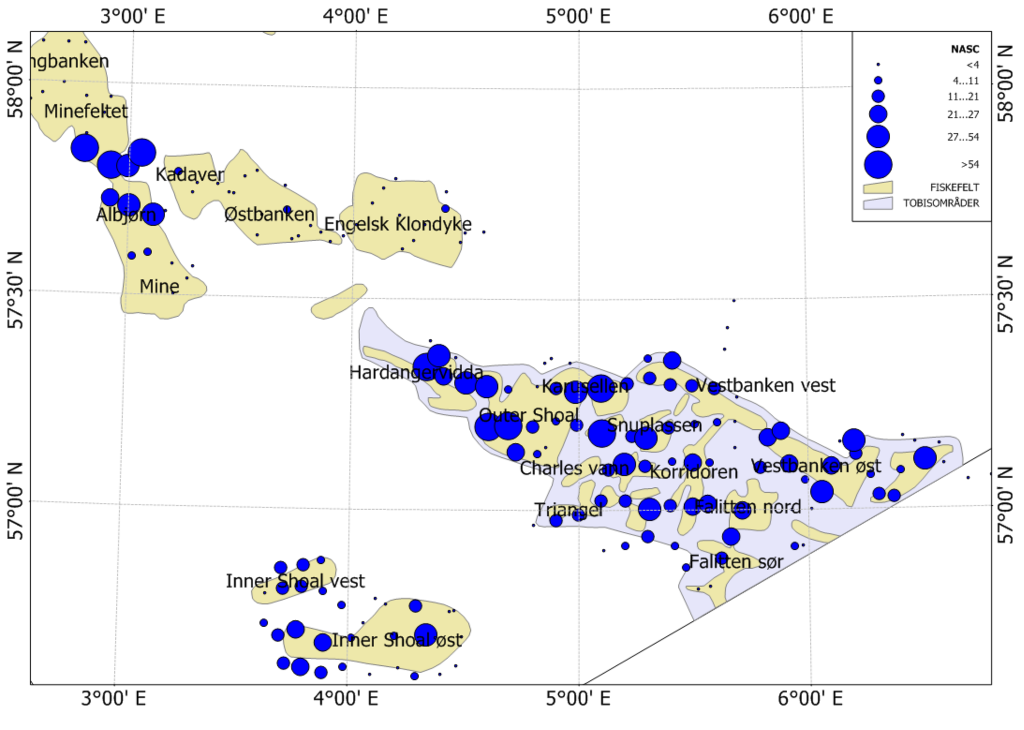


Figure 4.1.5. The Norwegian sandeel management areas. There are 6 main areas each consisting of "a" and "b" subareas.


3°00' E
4°00' E
5°00' E
6°00' E
58°00' N
57°30' N
57°00' N
ngbanken
Minefeltet
Kadaver
Albjørn
Østbanken
Engelsk Klondyke
Mine
Hardangervidda
Karusellen
Vestbanken vest
Outer Shoal
Snuplassen
Charles vann
Korridoren
Vestbanken øst
Triangel
Falitten nord
Falitten sør
Inner Shoal vest
Inner Shoal øst
NASC
<4
4...11
11...21
21...27
27...54
>54
FISKEFELT
TOBISOMRÅDER


3°00' E
4°00' E
5°00' E
6°00' E
58°00' N
57°30' N
57°00' N
ngbanken
Minefeltet
Kadaver
Albjørn
Østbanken
Engelsk Klondyke
Mine
Hardangervidda
Karusellen
Vestbanken vest
Outer Shoal
Snuplassen
Charles vann
Korridoren
Vestbanken øst
Triangel
Falitten nord
Falitten sør
Inner Shoal vest
Inner Shoal øst
NASC
<4
4...11
11...21
21...27
27...54
>54
FISKEFELT
TOBISOMRÅDER

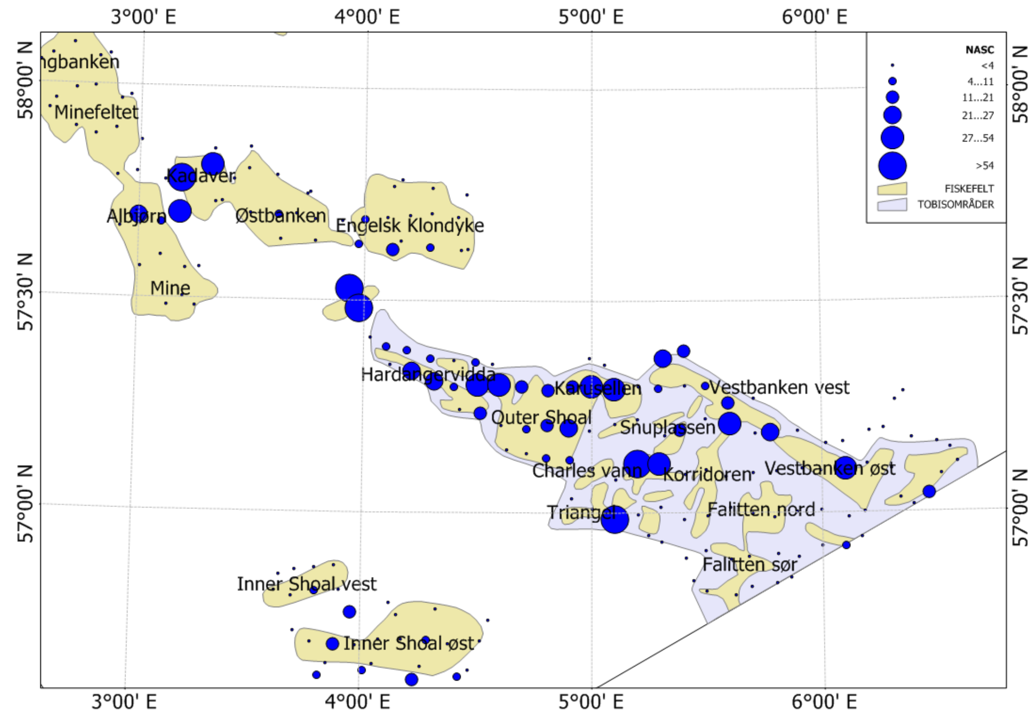


Figure 4.1.6. Sandeel distribution in the Norwegian EEZ measured as mean acoustic density (NASC) by cells of 0.1x0.1 degrees during the acoustic surveys in 2009 (top), 2010 (center) and 2011 (under). Grey indicates the sandeel areas, and yellow the areas with the historical fishing activity.

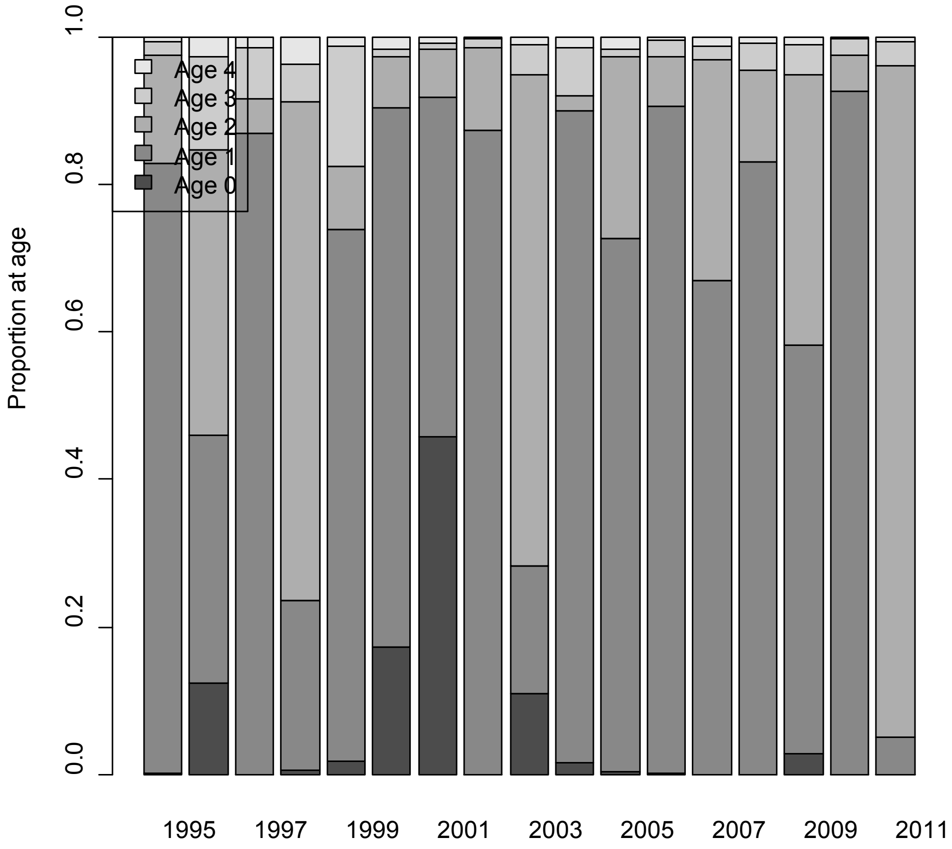


Figure 4.2.1 . Sandeel in Area-1. Catch numbers, Proportion at age.

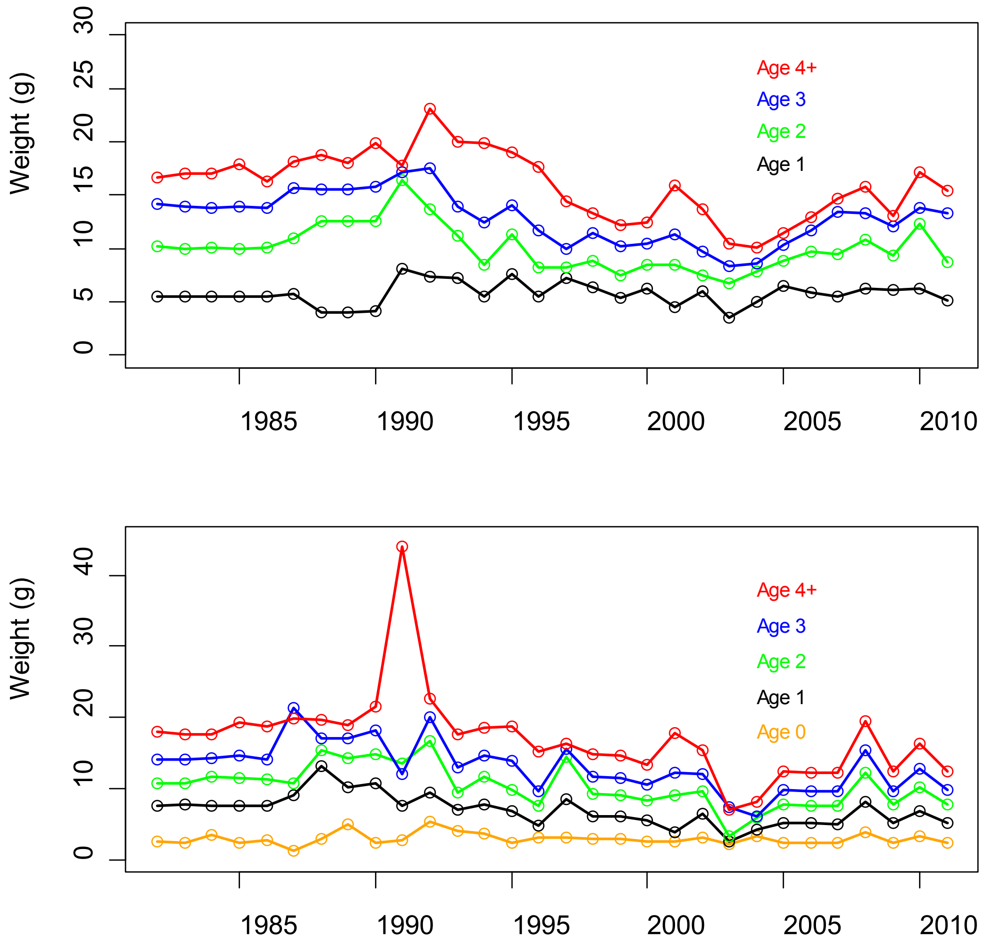


Figure 4.2.2. Sandeel in Area-1. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

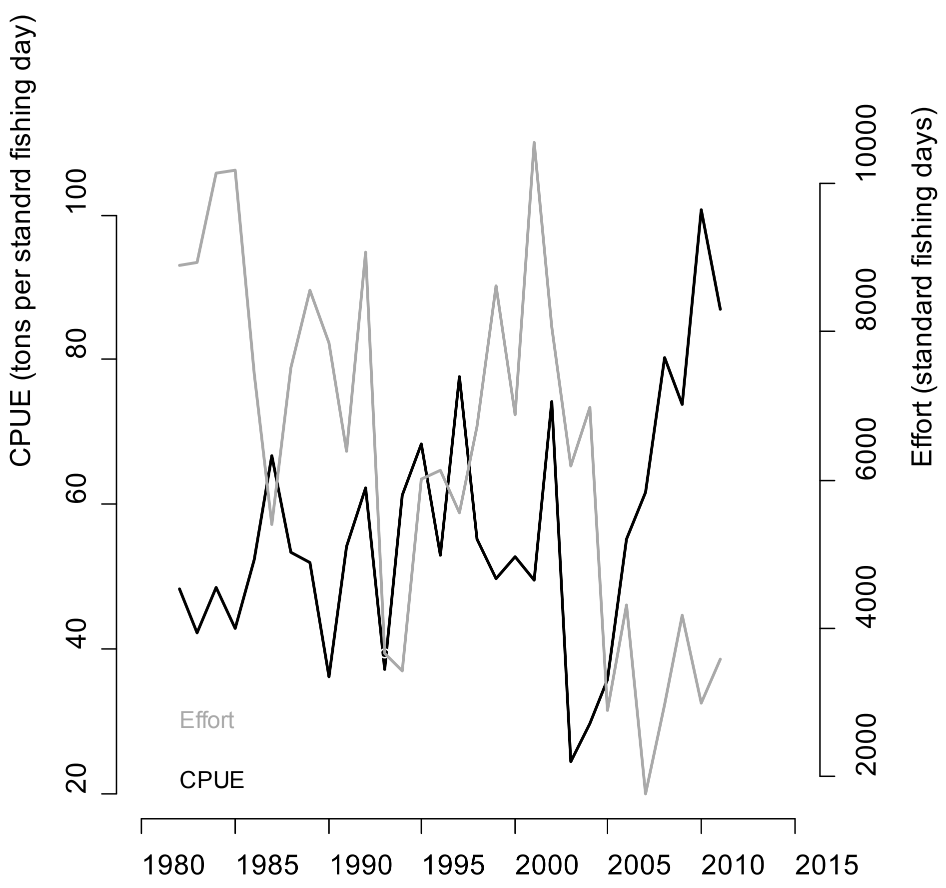


Figure 4.2.3. Sandeel in Area-1. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

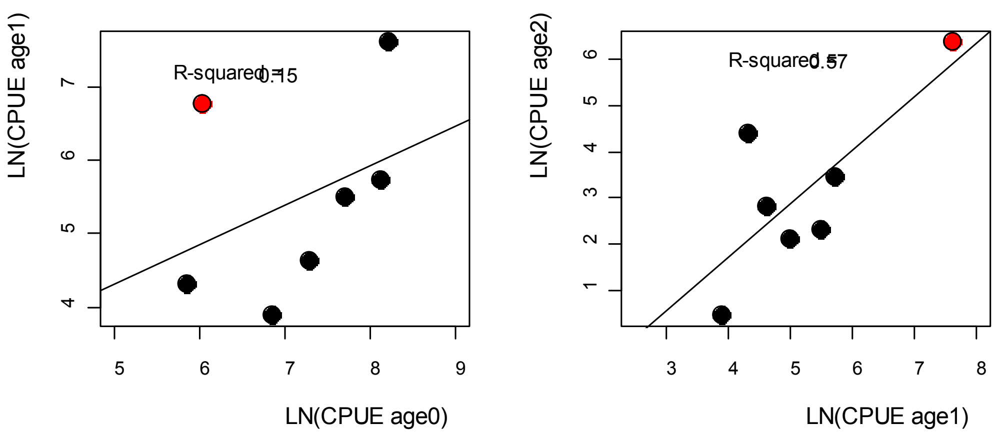


Figure 4.2.4. Sandeel in Area-1. Internal consistence by age of the Danish dredge survey. Red dot indicates most recent data point.

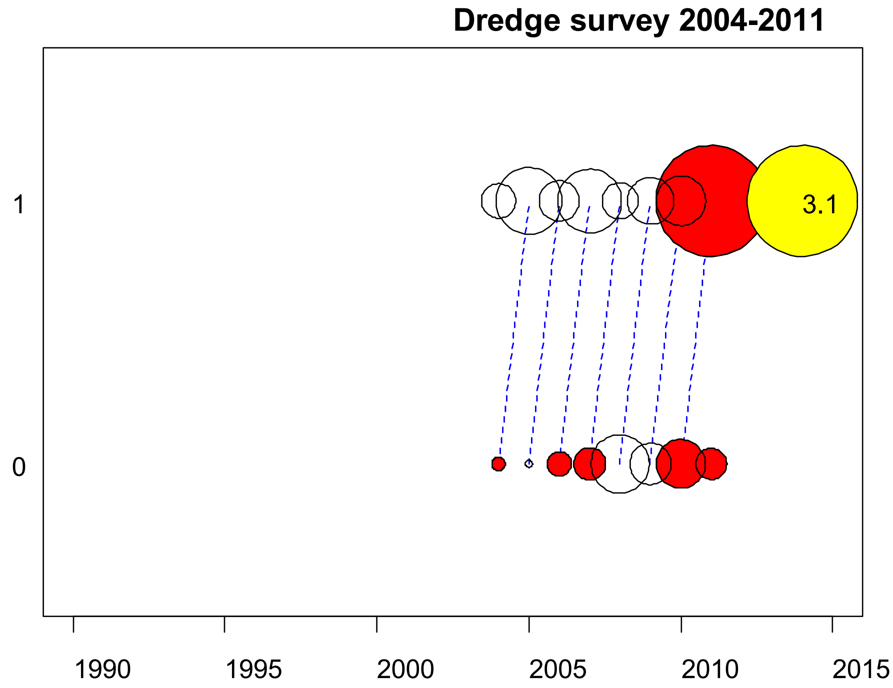


Figure 4.2.5. Sandeel in Area-1. Dredge survey residuals (log(observed CPUE) - log(expected CPUE). 'Red' dots show a positive residual.

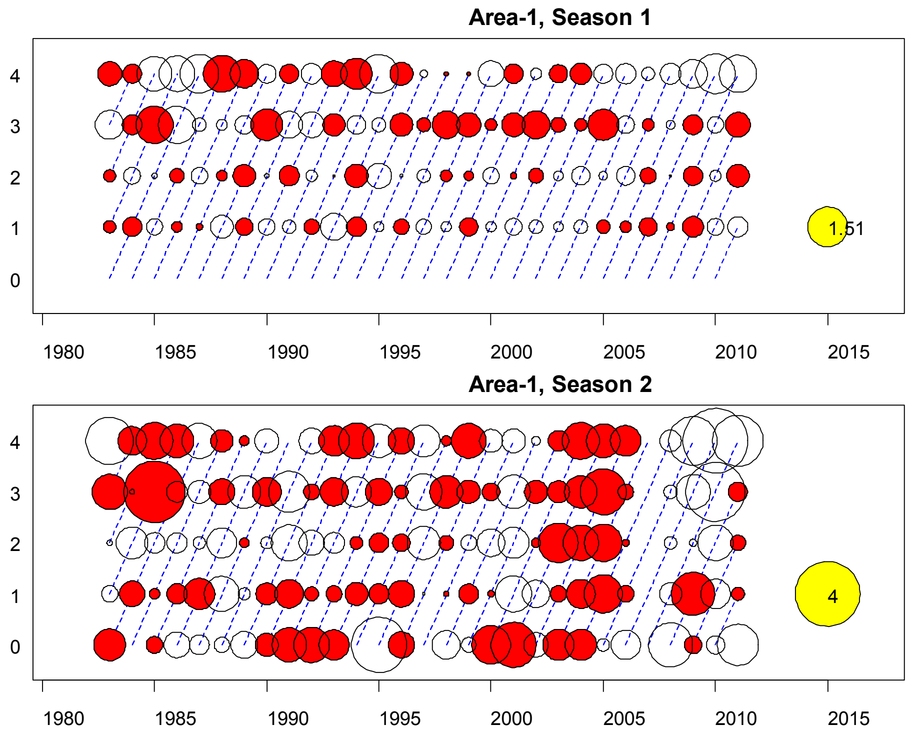


Figure 4.2.6. Sandeel in Area 1. Catch at age residual (log(observed catch) - log(expected catch). 'Red' dots show a positive residual.

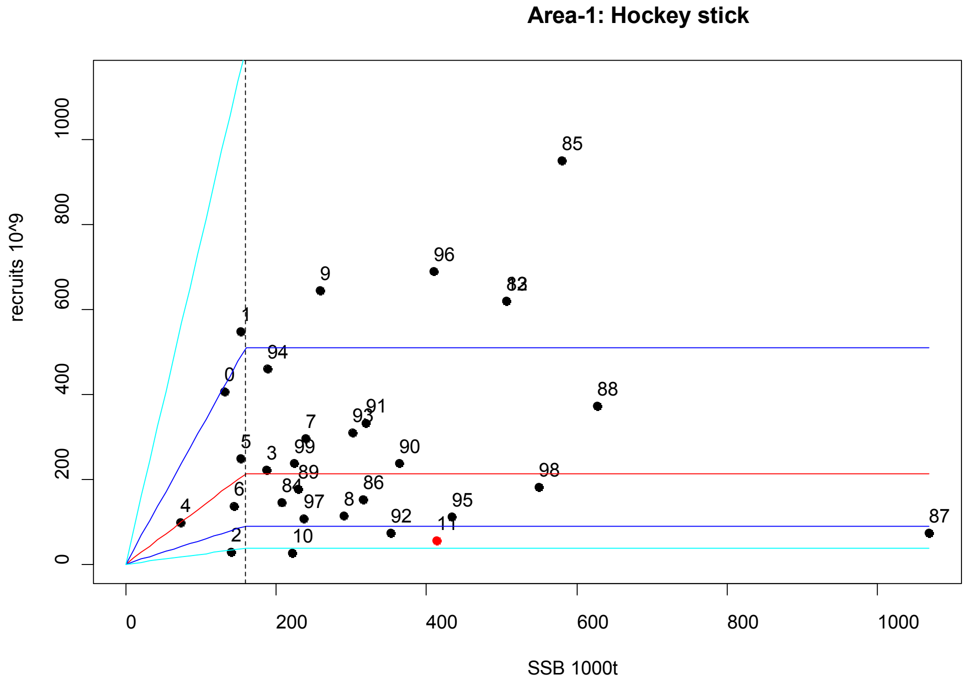


Figure 4.2.7. Sandeel in Area 1. Estimated stock recruitment relation. The 2011 recruitment is highly uncertain and has not been used for the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

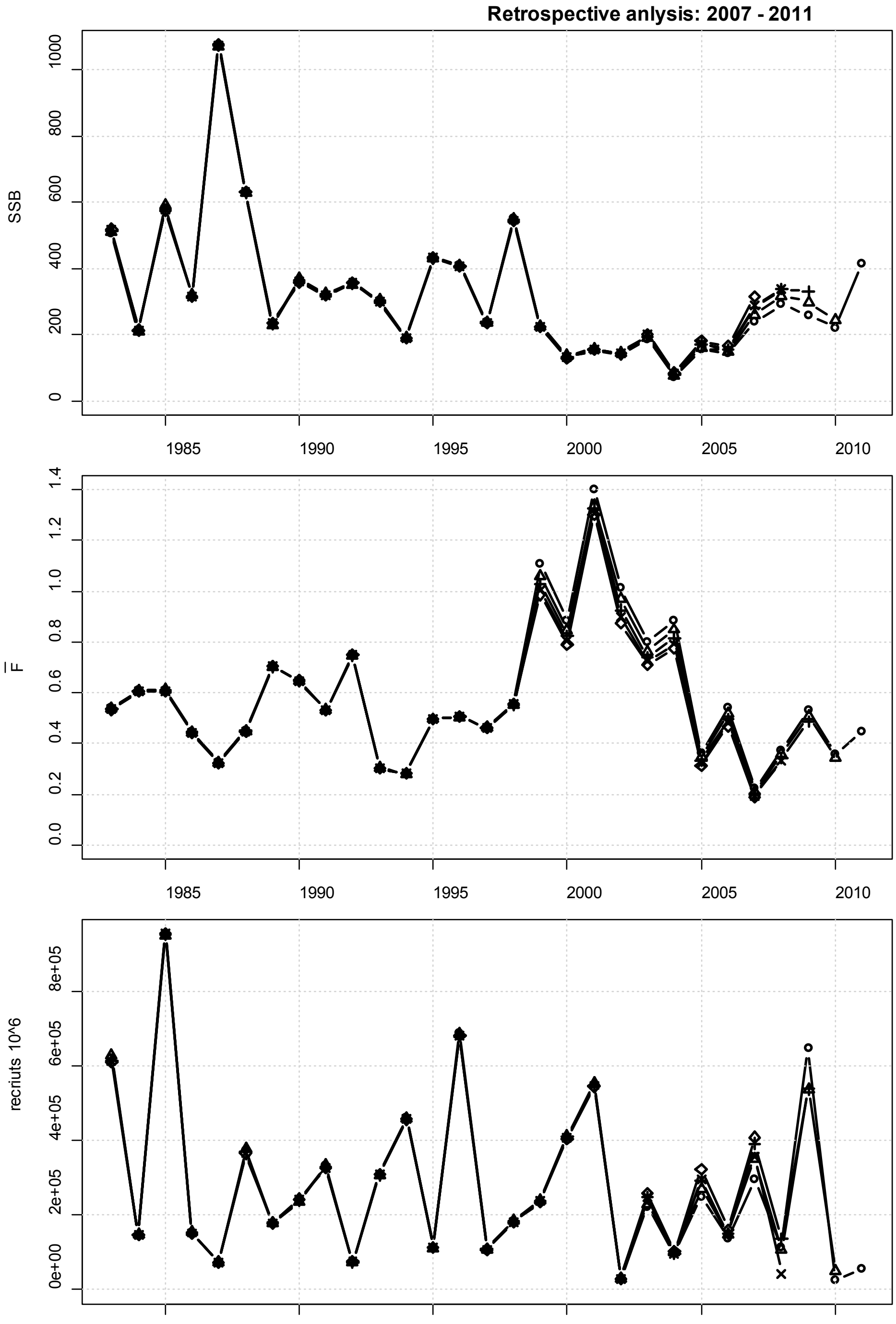


Figure 4.2.8. Sandeel in Area-1. Sandeel retrospective plot. Recruitment in 2010 is a random number.

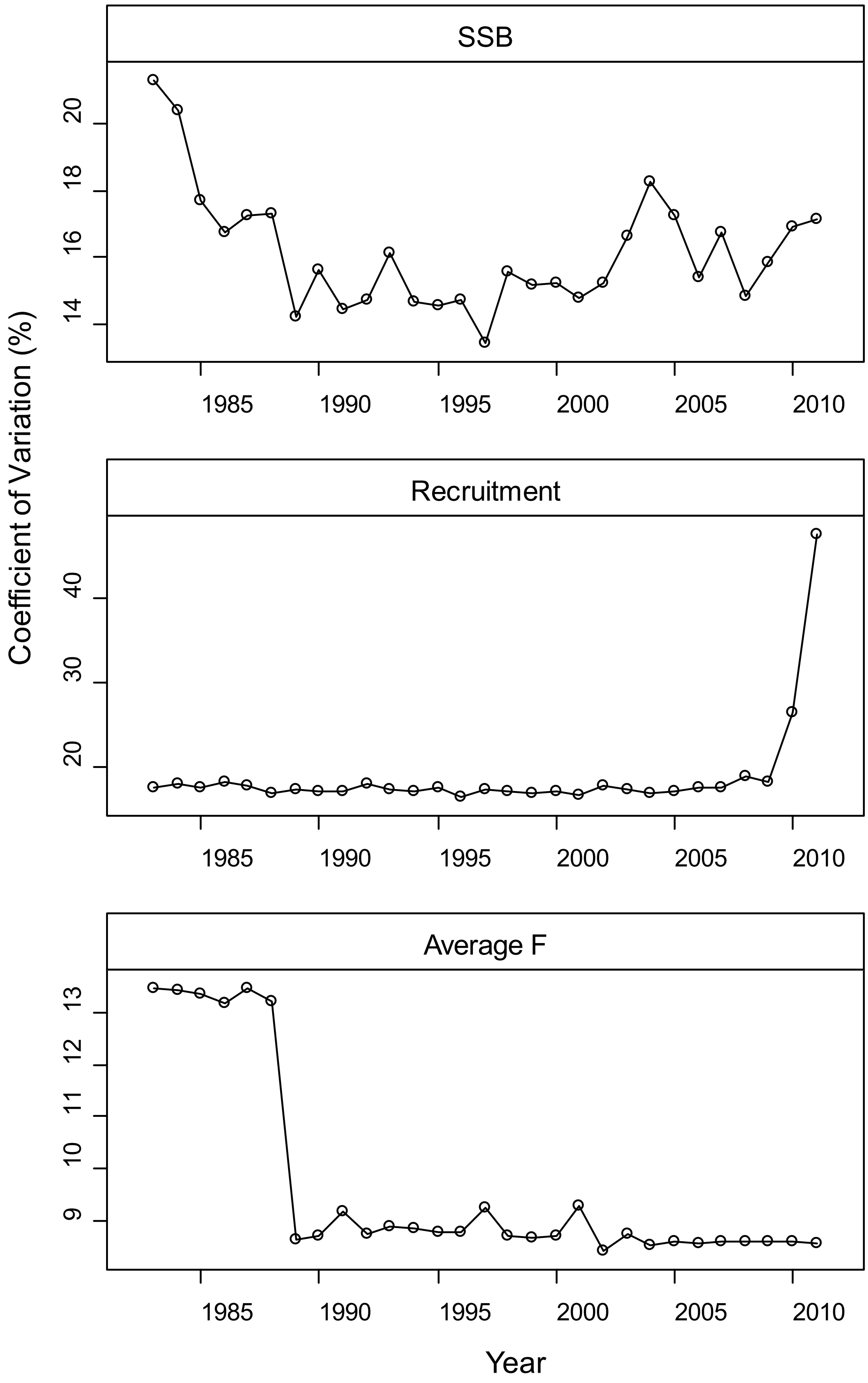


Figure 4.2.9 . Sandeel in Area-1. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

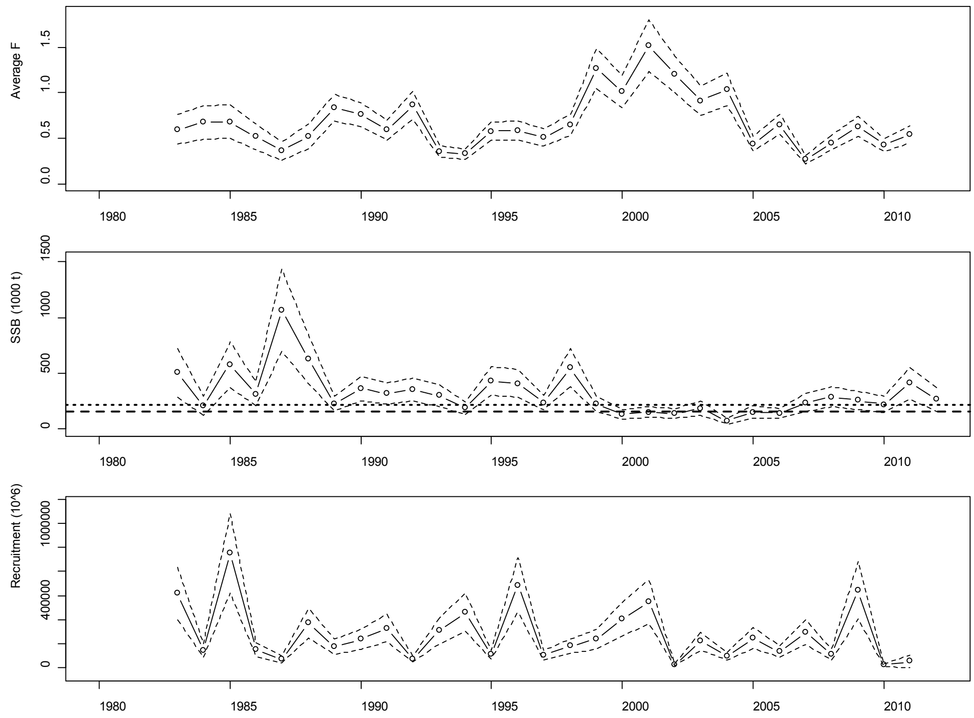


Figure 4.2.10 . Sandeel in Area-1. Model output with mean values and plus/minus 2 * standard deviation.

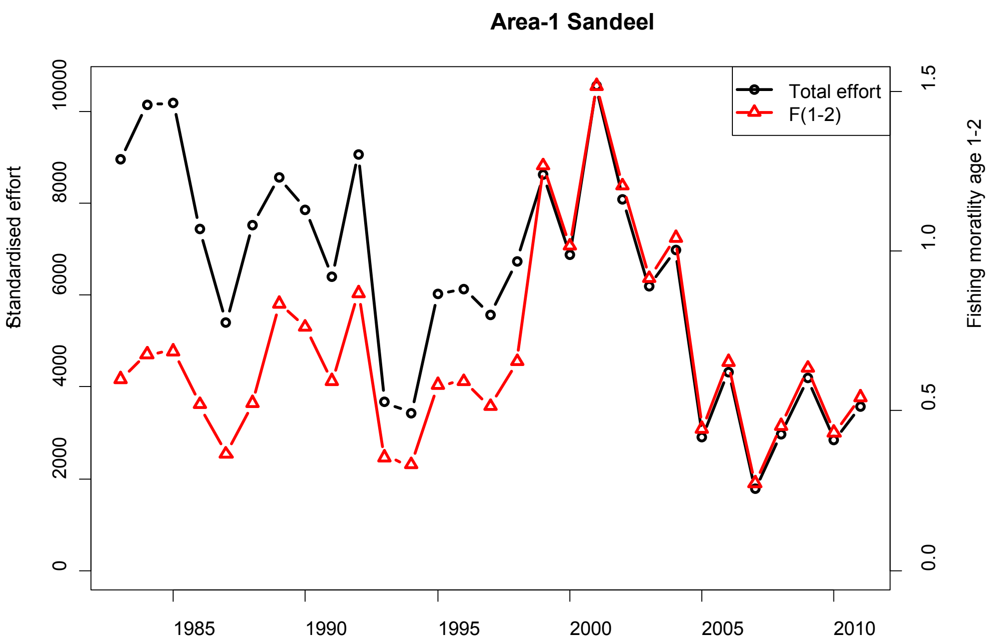


Figure 4.2.11 . Sandeel in Area-1. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

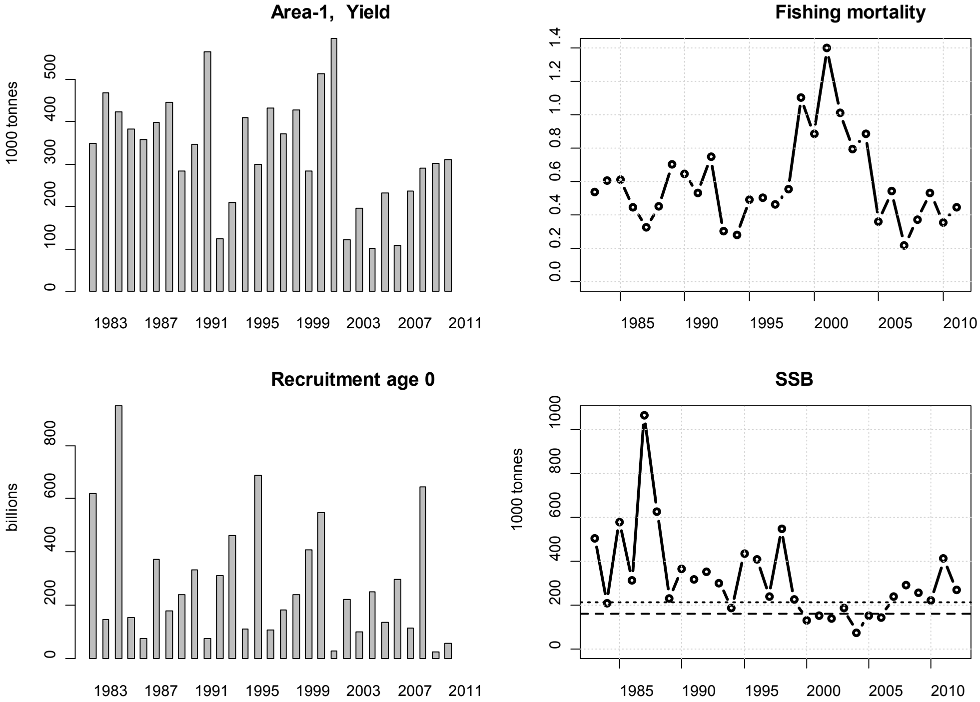


Figure 4.2.12. Sandeel in Area-1. Stock summary.

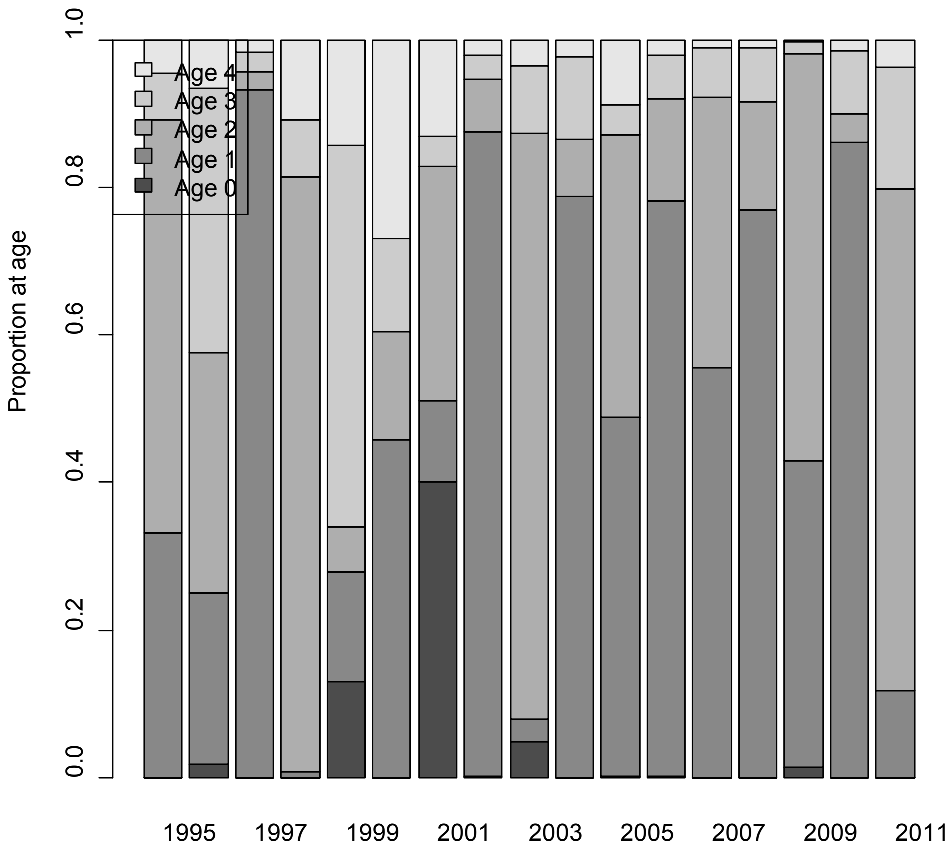
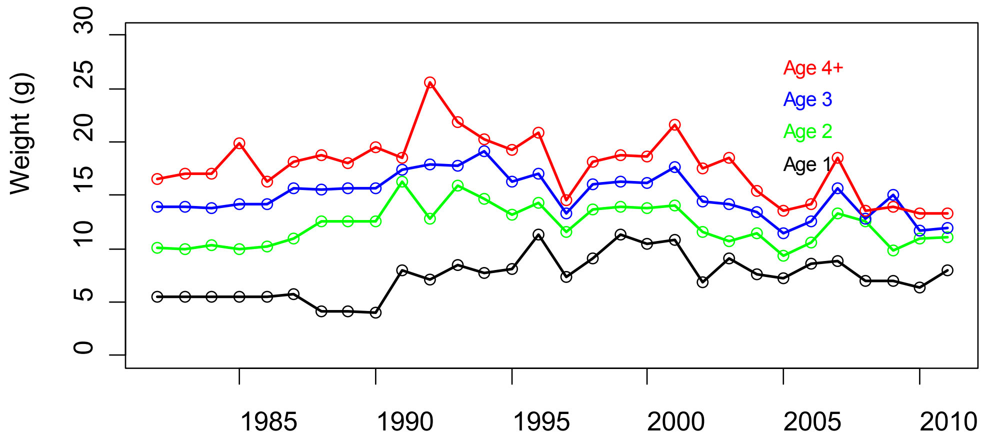


Figure 4.3.1. Sandeel in Area-2. Catch numbers; proportion at age.



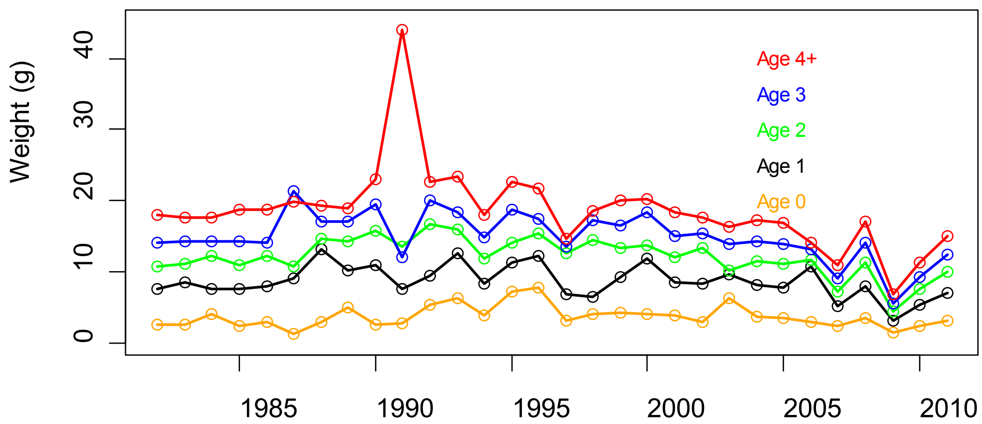


Figure 4.3.2 Sandeel in Area-2. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

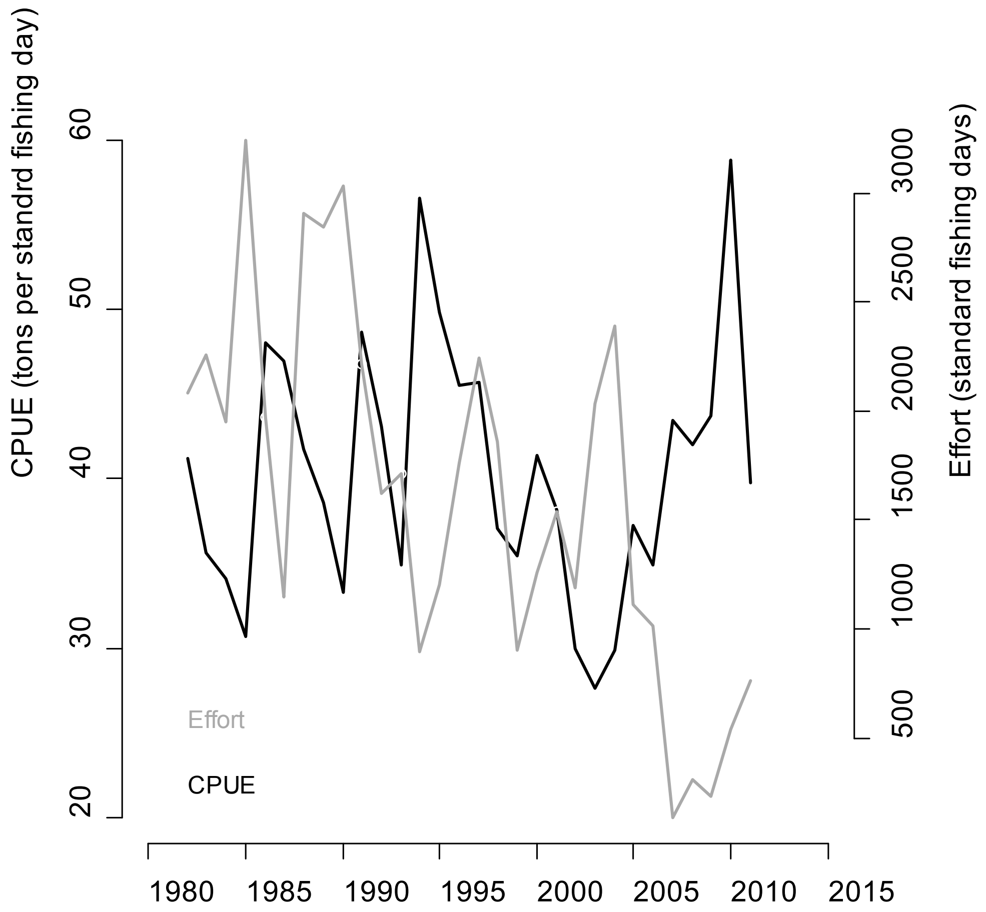


Figure 4.3.3. Sandeel in Area-2. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

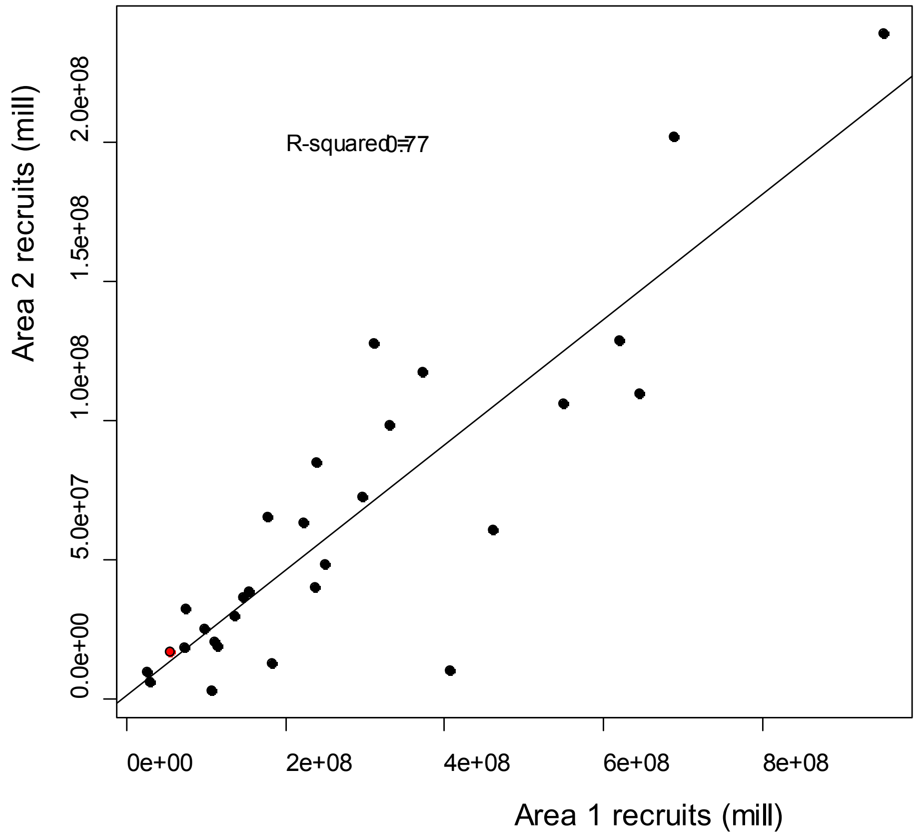


Figure 4.3.4. Sandeel in Area-2. Consistency of recruitments in Area-1 and Area-2

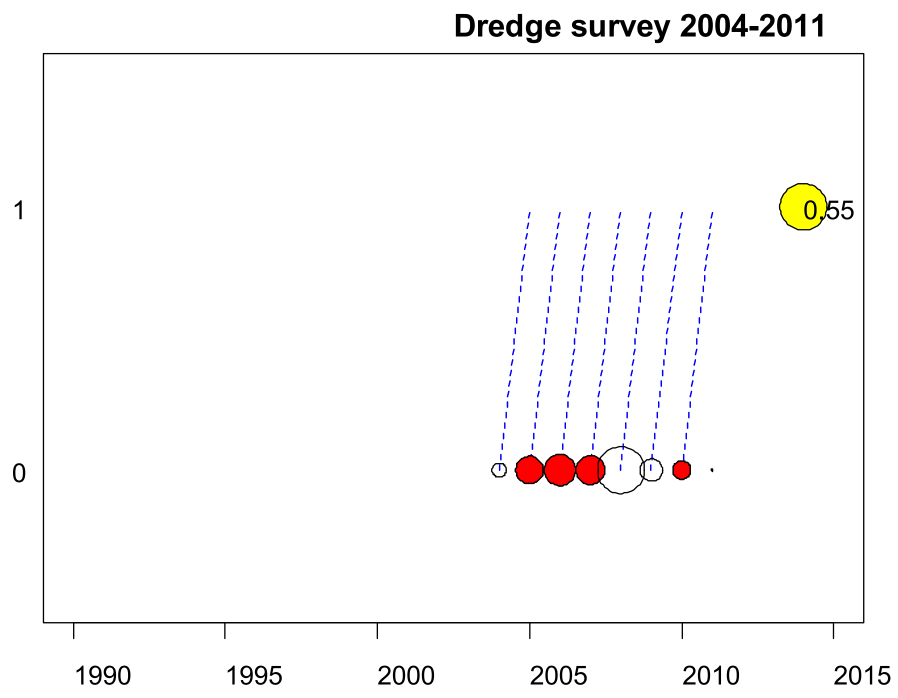


Figure 4.3.5. Sandeel in Area-2. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

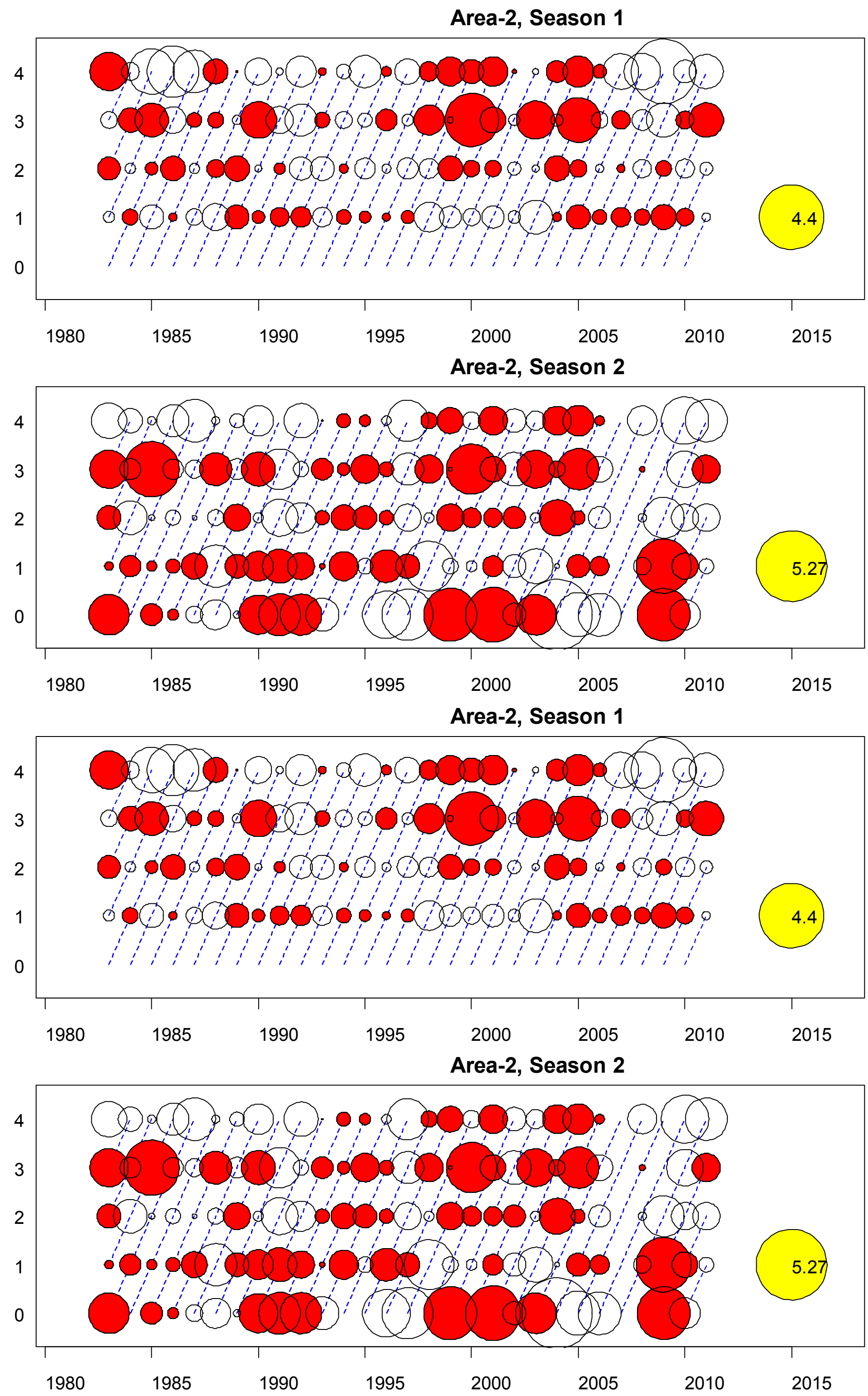


Figure 4.3.6. Sandeel in Area-2. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

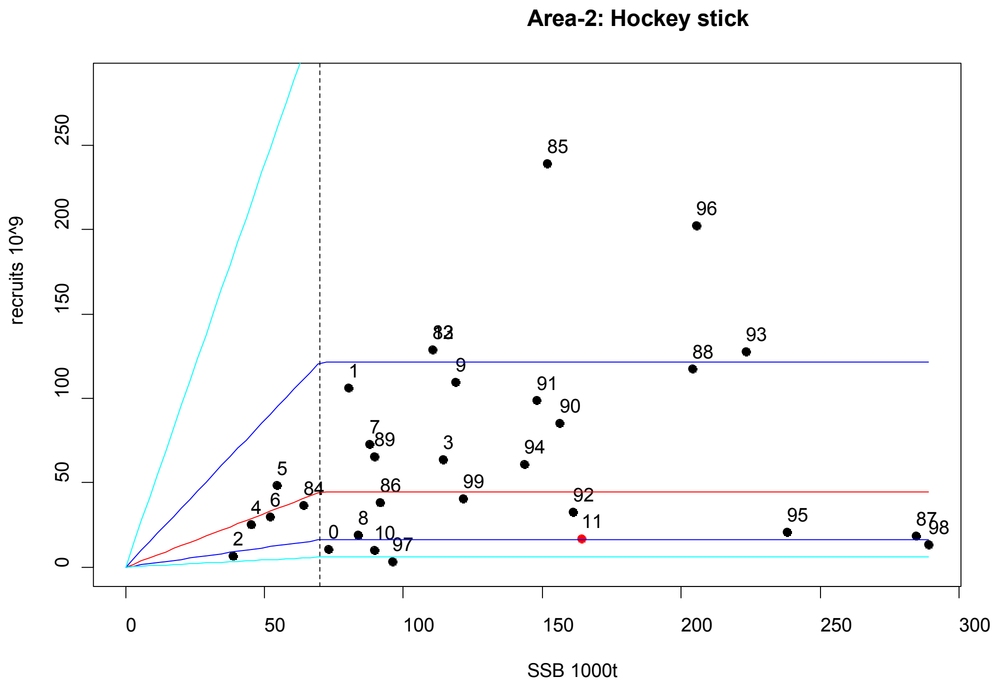


Figure 4.3.7. Sandeel in Area-2. Estimated stock recruitment relation. The 2011 recruitment is highly uncertain and was not used for the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

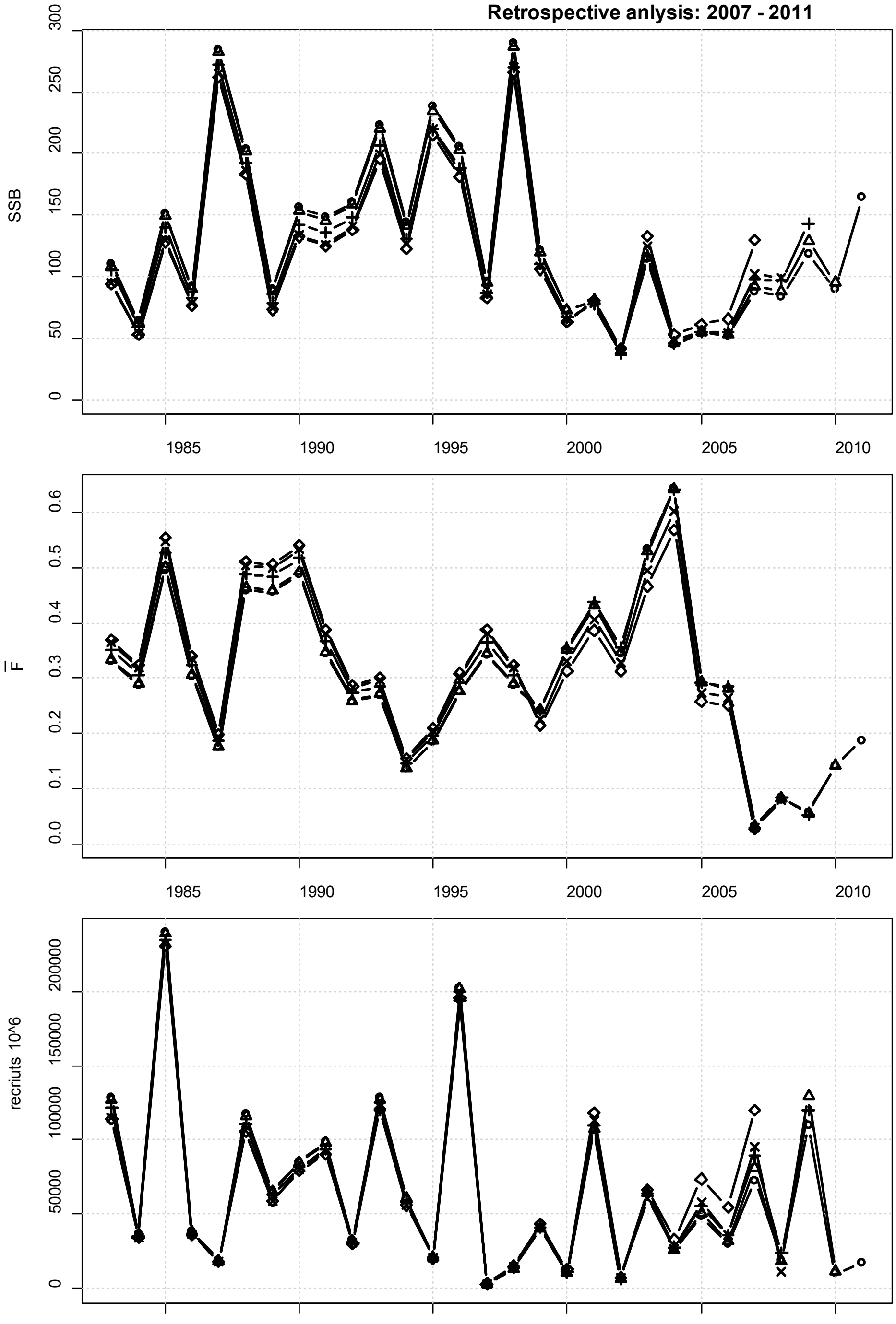


Figure 4.3.8.Sandeel in Area-2. Sandeel retrospective plot. Recruitment in 2010 is a random number and should be disregarded.

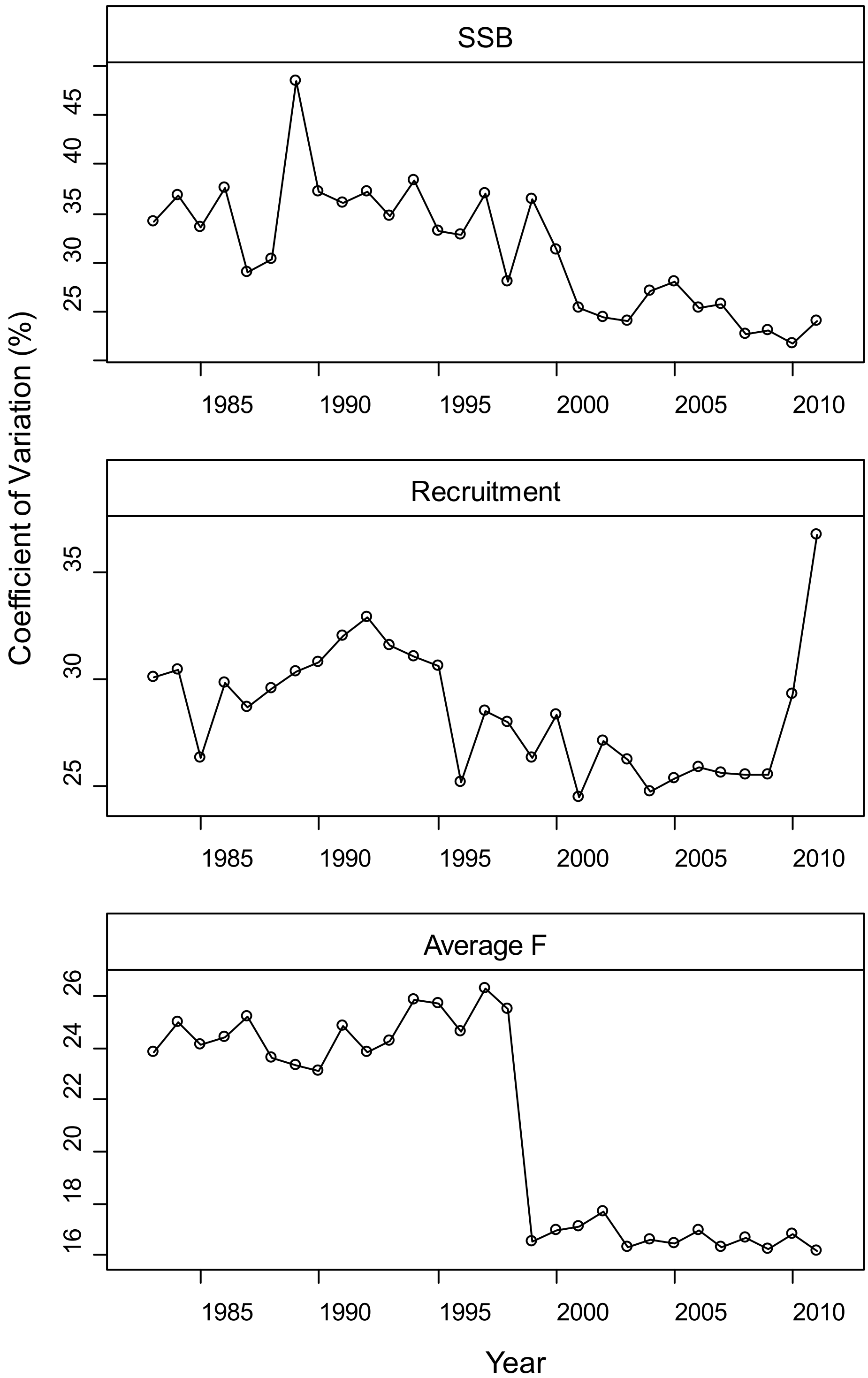


Figure 4.3.9. Sandeel in Area-2. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

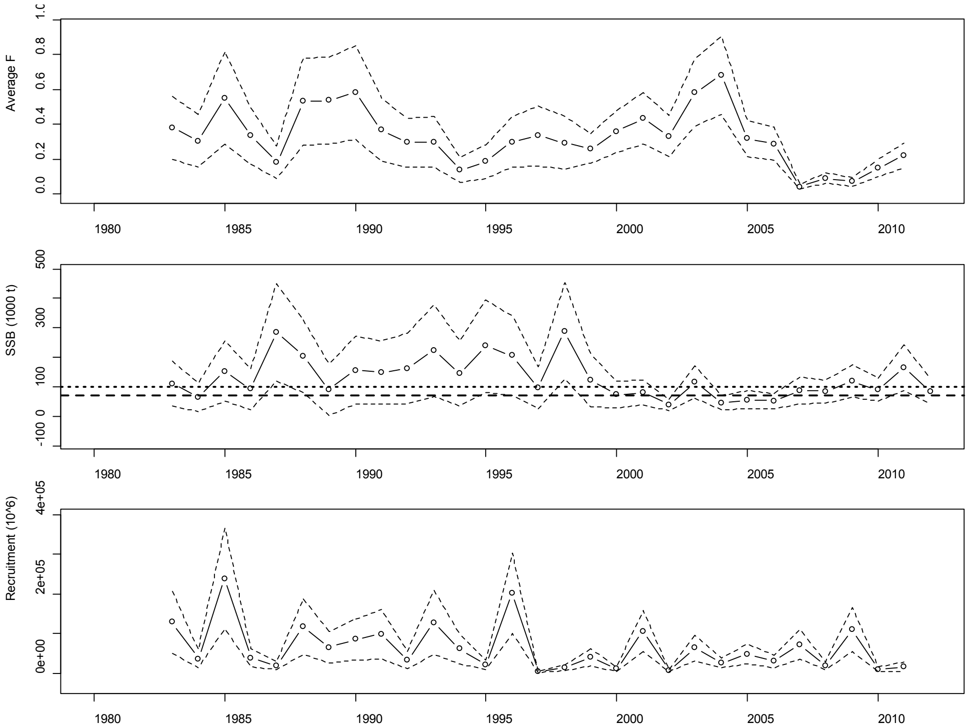


Figure 4.3.10. Sandeel in Area-2. Model output with mean values and plus/minus 2*standard deviation (95% confidence interval).

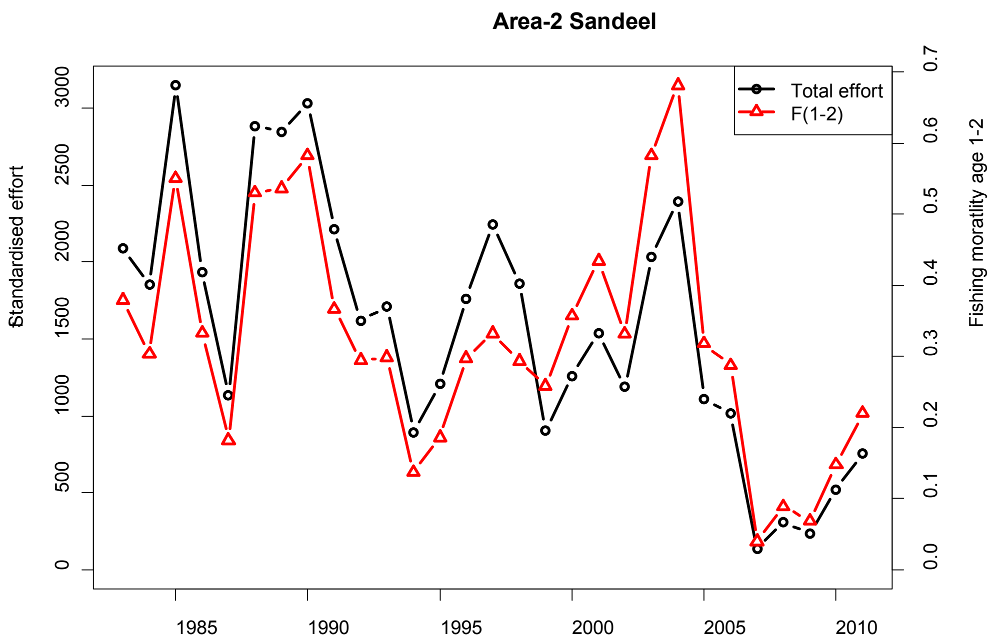


Figure 4.3.11. Sandeel in Area-2. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

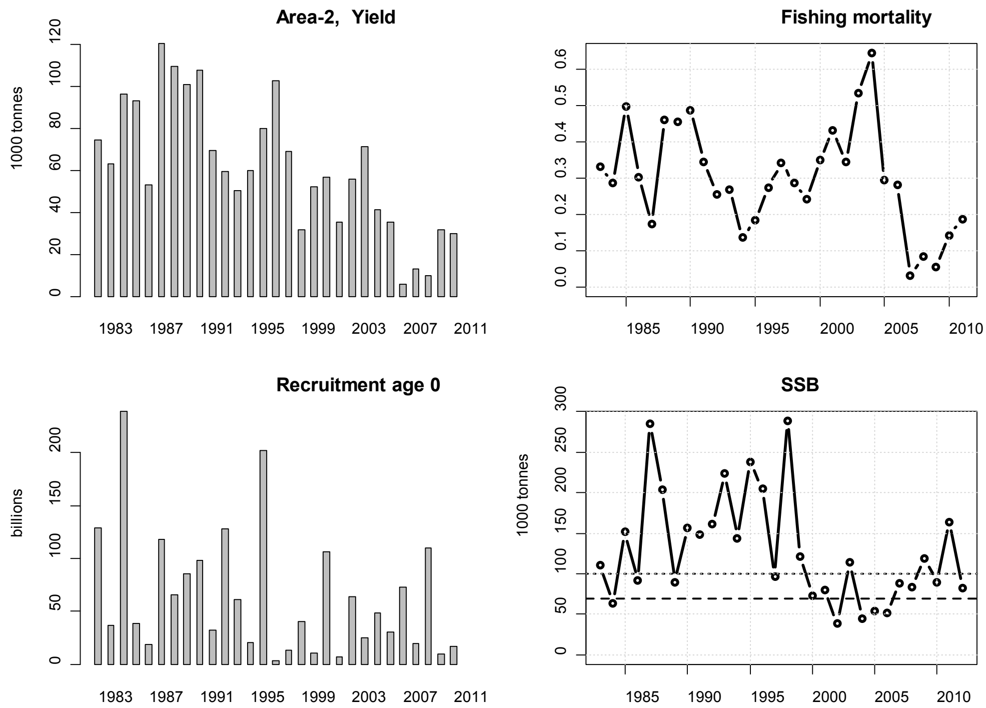


Figure 4.3.12.Sandeel in Area-2. Stock summary.

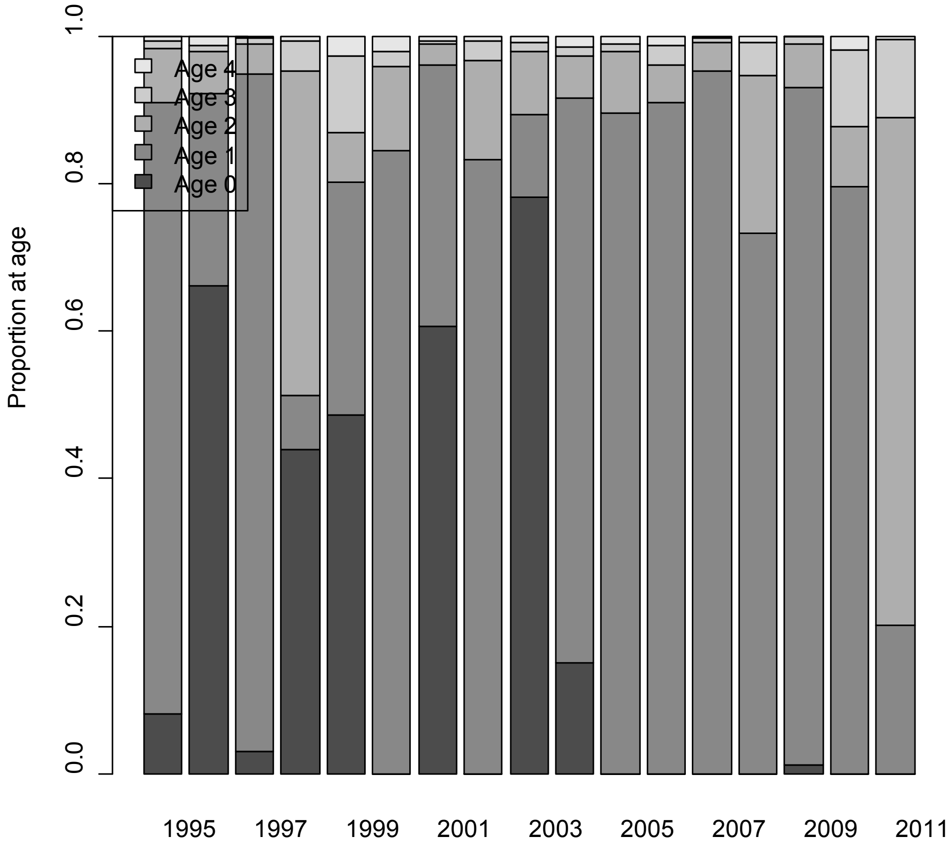
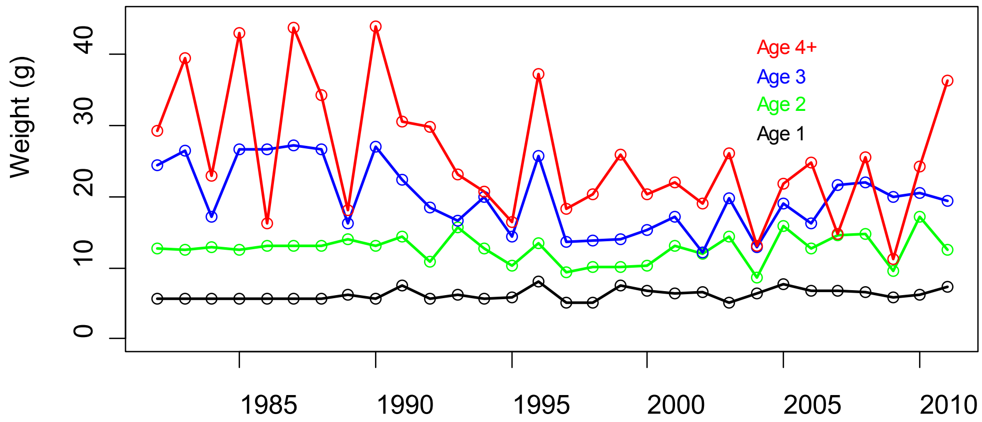


Figure 4.4.1. Sandeel in Area-3. Catch numbers; proportion at age.



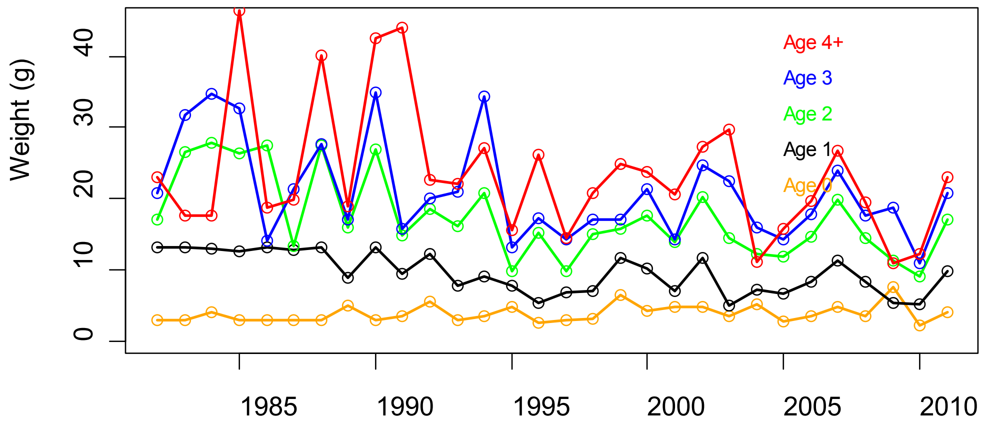


Figure 4.4.2. Sandeel in Area-3. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

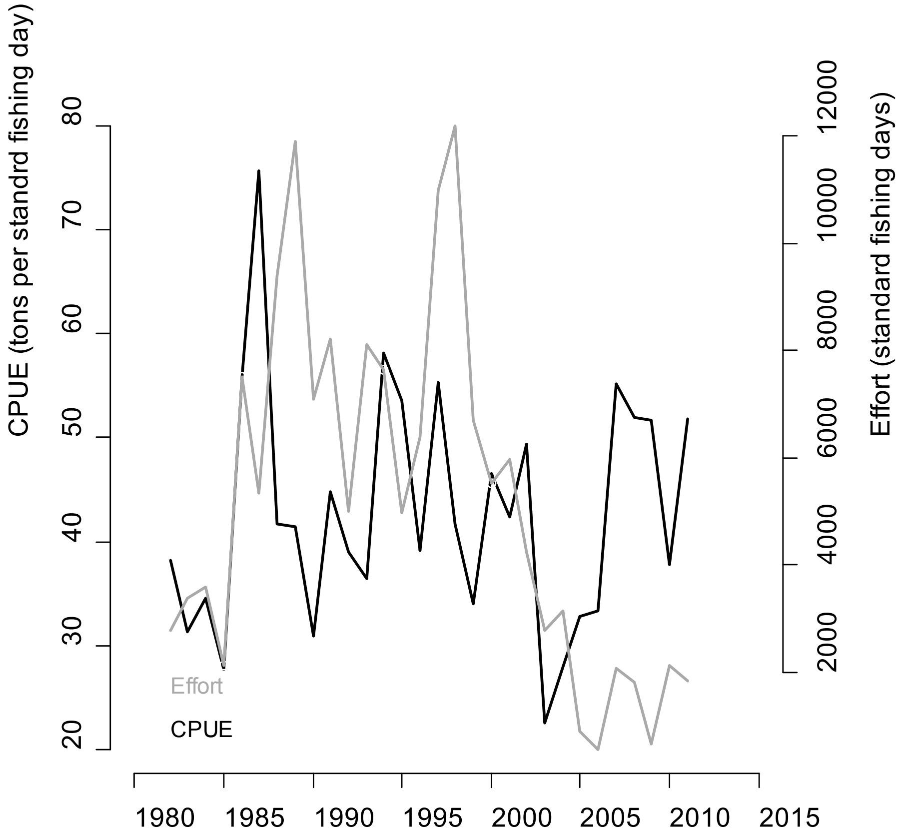


Figure 4.4.3. Sandeel in Area-3. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day).

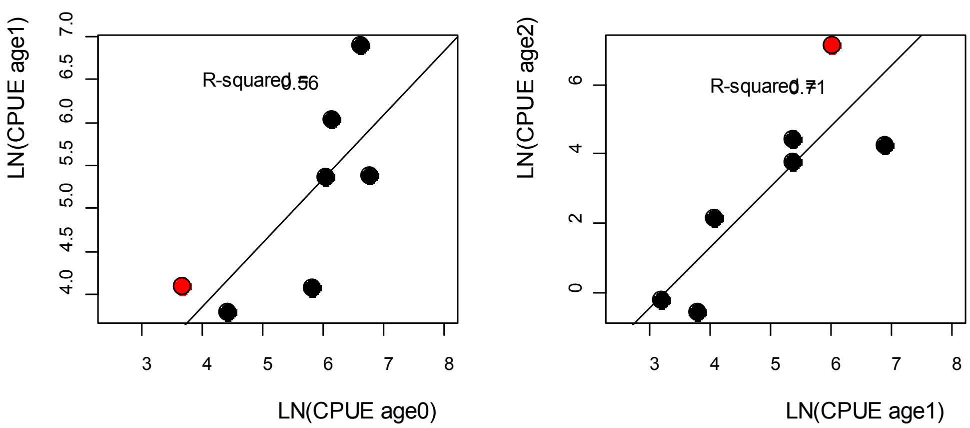


Figure 4.4.4. Sandeel in Area 3. Internal consistency by age of the Danish dredge survey. Red dot indicates most recent data point.

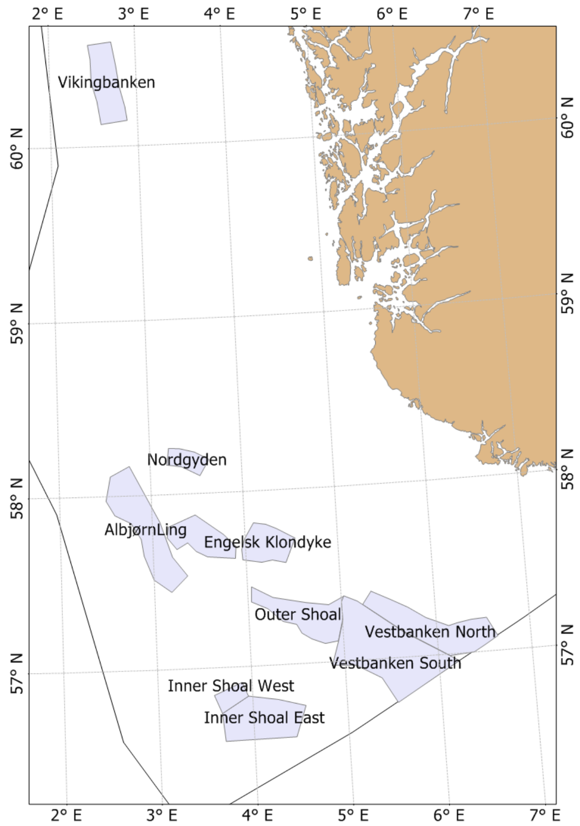


Figure 4.4.5. The strata that have been surveyed during the Norwegian acoustic sandeel surveys.

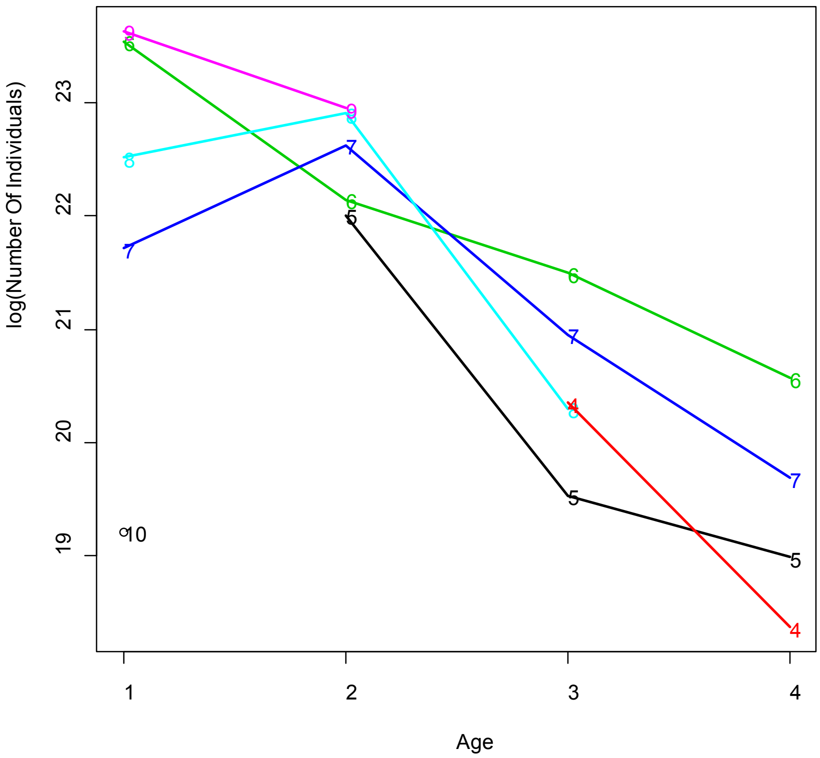


Figure 4.4.6. Internal consistency by age of the Norwegian acoustic surveys. The colored and numbered lines indicate the year-classes.

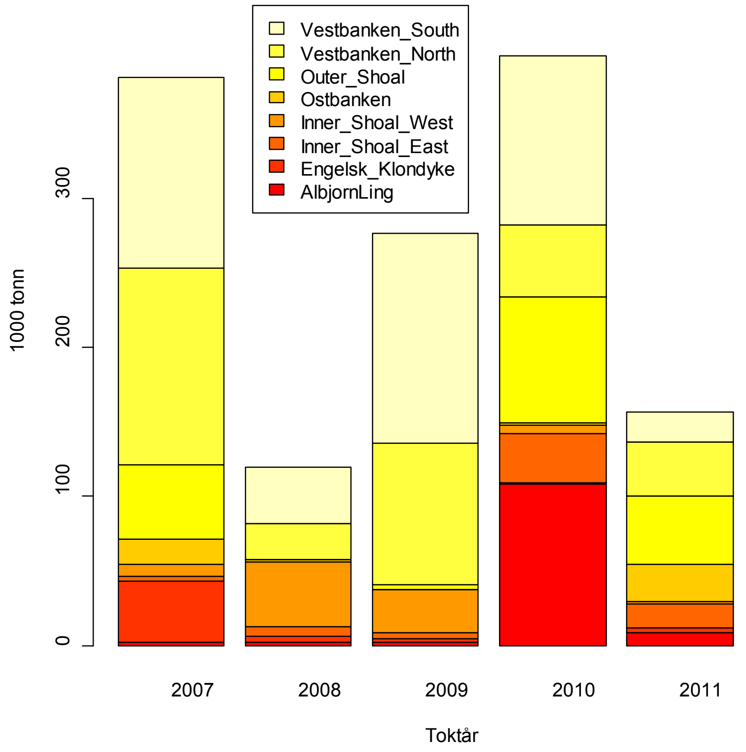


Figure 4.4.7 Biomass estimates from the Norwegian acoustic surveys by strata and year.

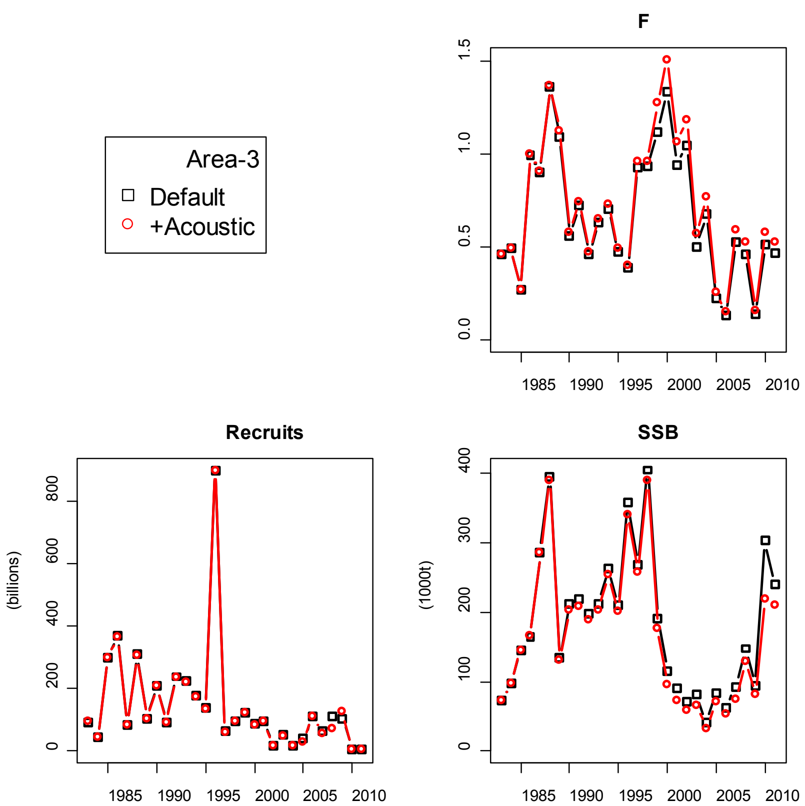


Figure 4.4.8. Comparison between final and explorative assessment with acoustic survey data.

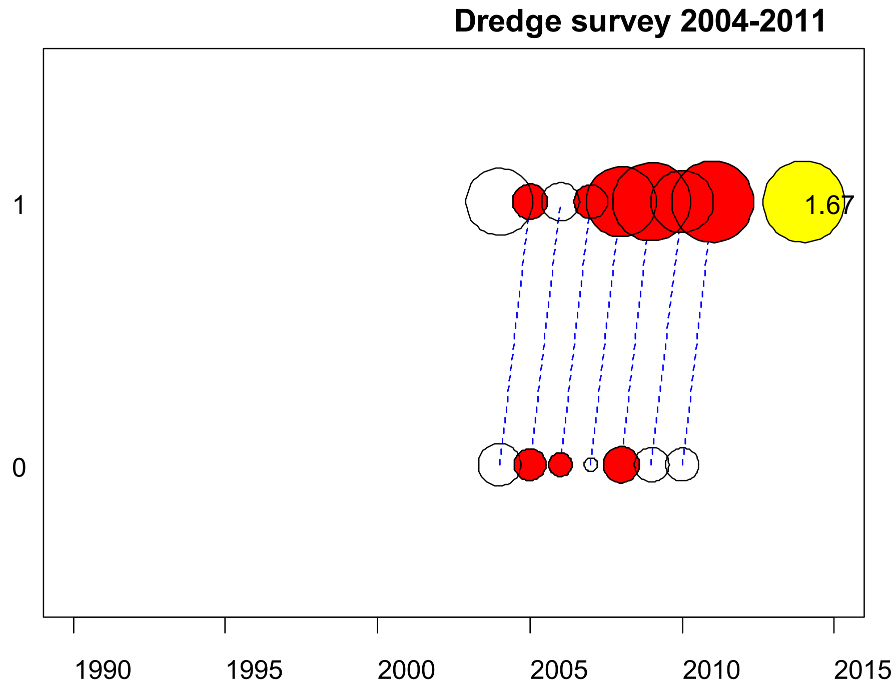


Figure 4.4.9. Sandeel in Area-3. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

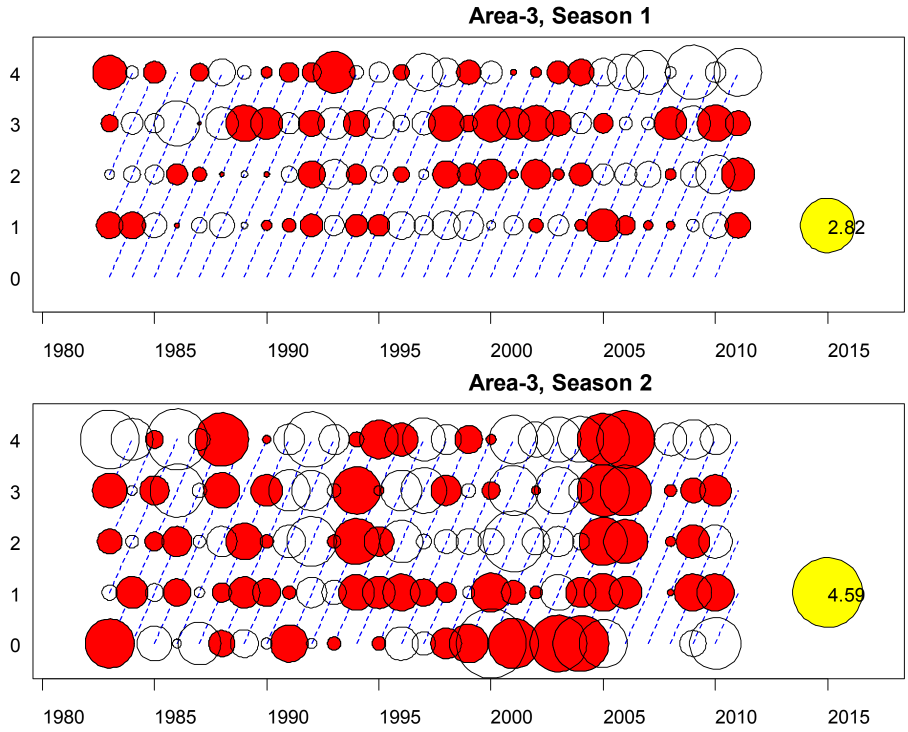


Figure 4.4.10.Sandeel in Area-3. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

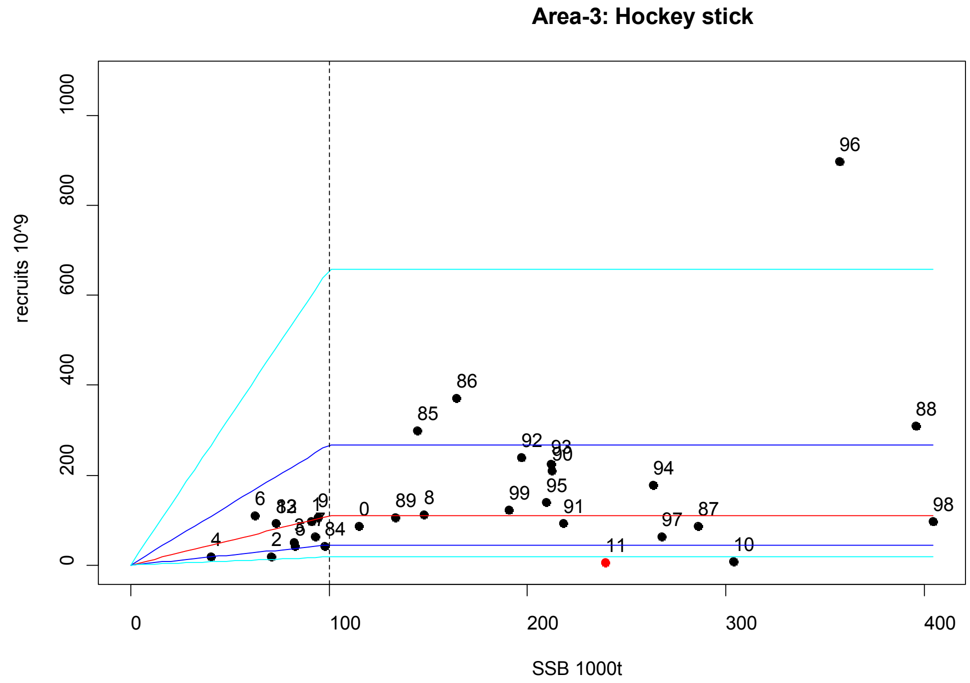


Figure 4.4.11. Sandeel in Area-3. Estimated stock-recruitment relation. The 2011 recruitment is highly uncertain and was not used in the estimation. Red line = median of the expected recruitment, Dark blue lines = one standard deviation, Light blue lines = 2 standard deviations. The area within the light blue lines can be seen as the 95% confidence interval of recruitment.

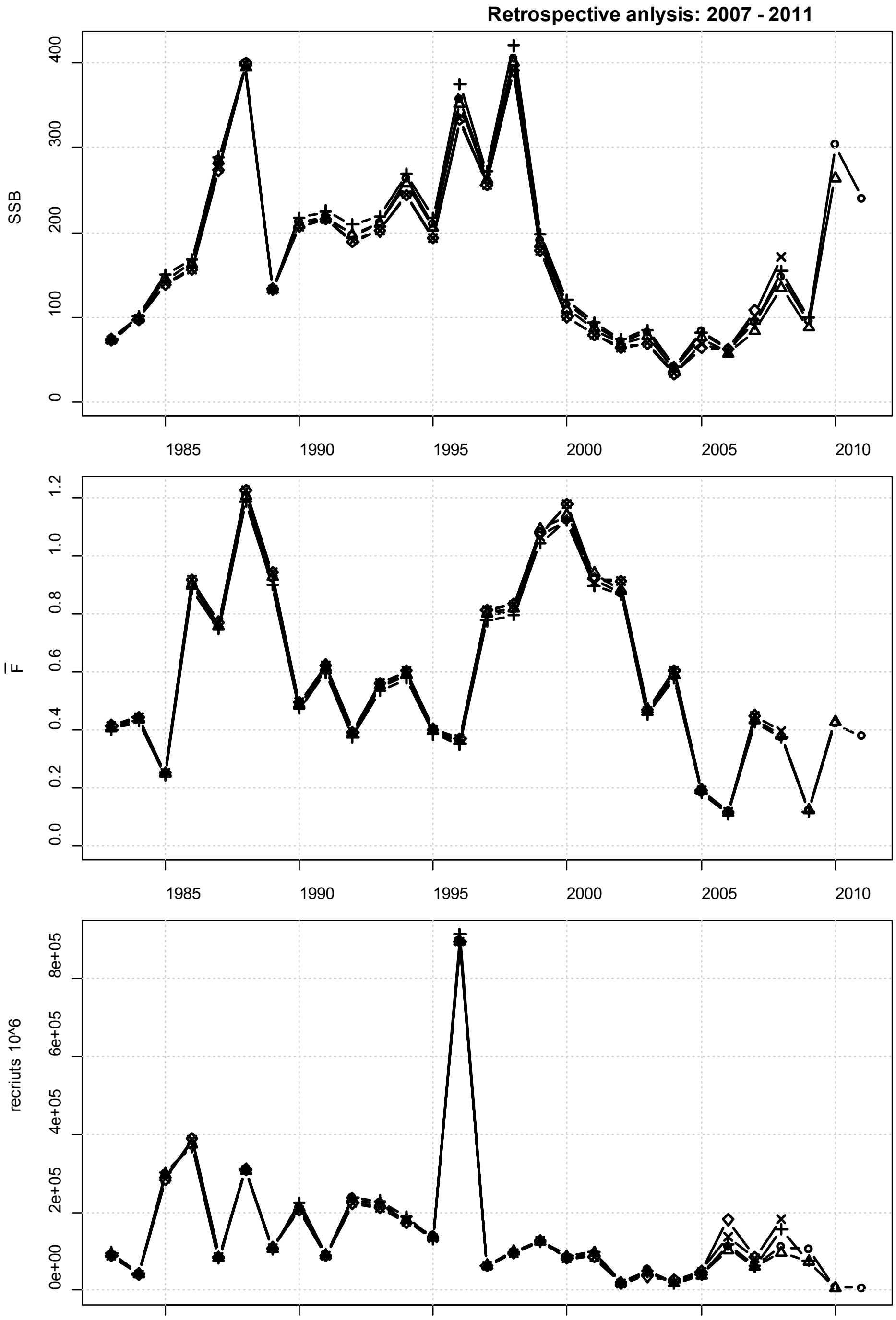


Figure 4.4.12. Sandeel in Area-3. Sandeel retrospective plot.

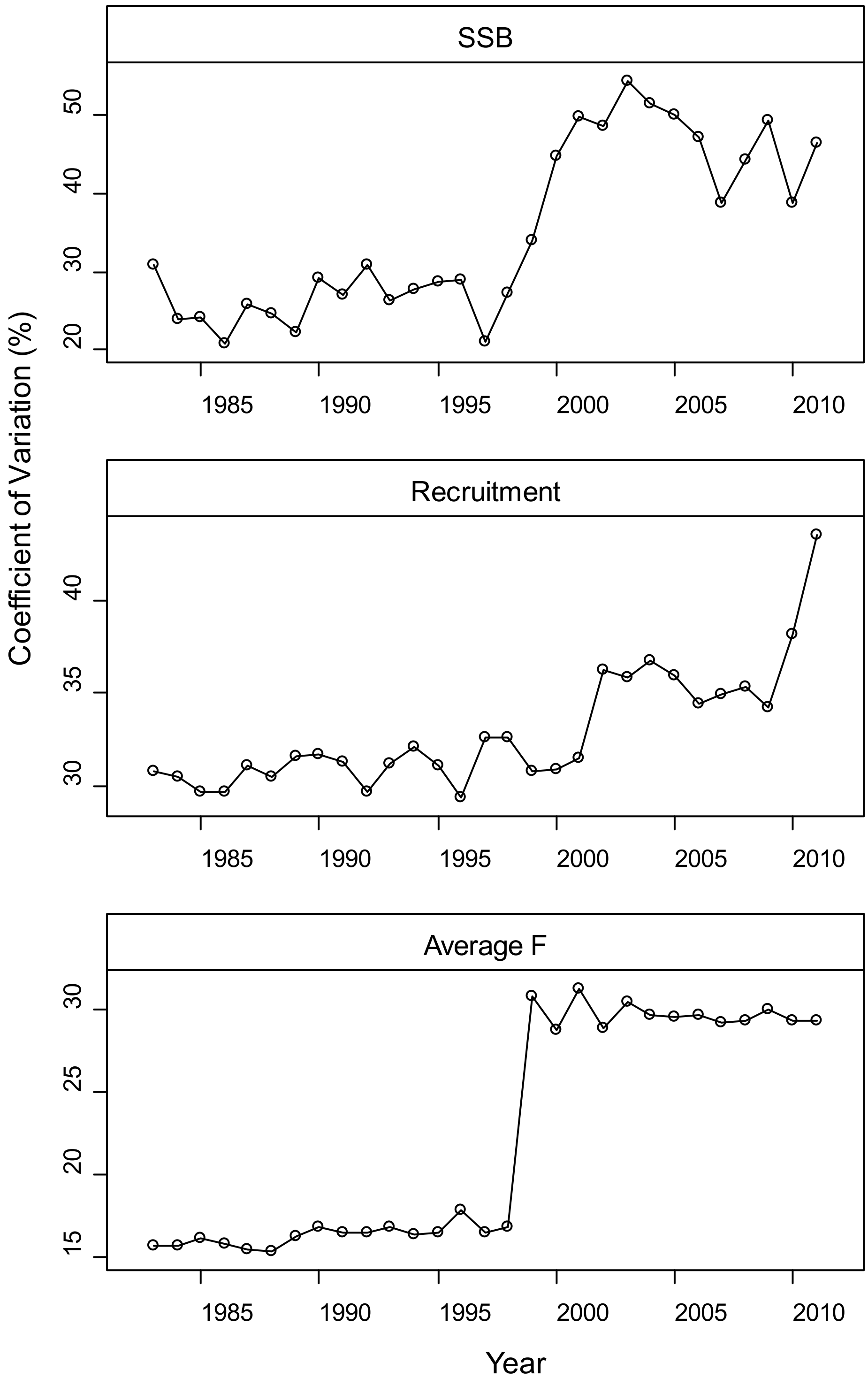


Figure 4.4.13. Sandeel in Area-3. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

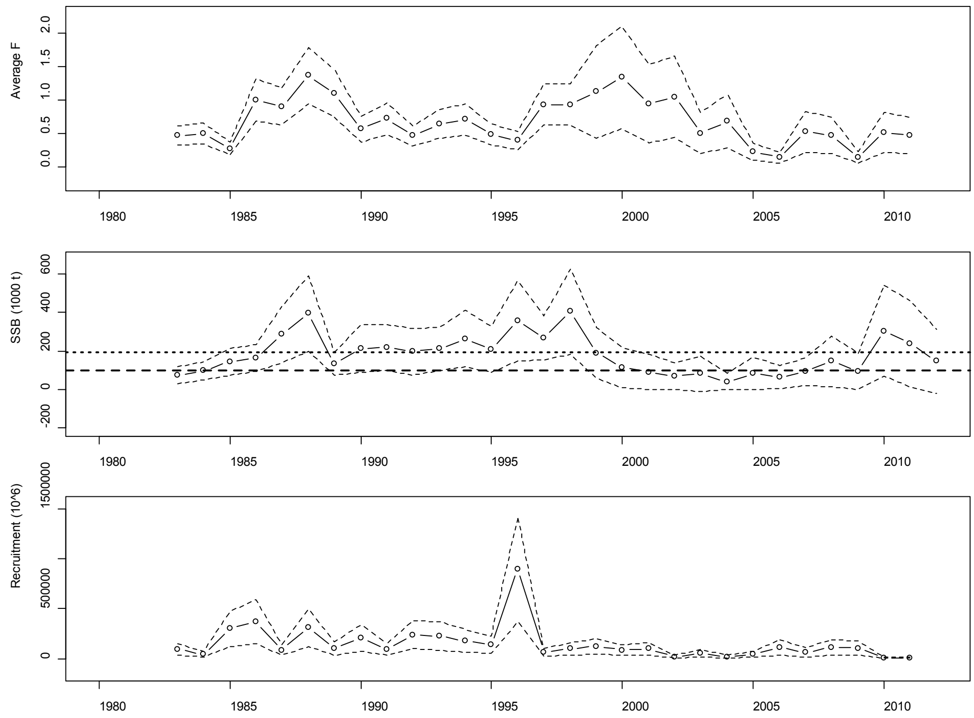


Figure 4.4.14. Sandeel in Area-3. Model output with mean values and plus/minus 2*standard deviation.

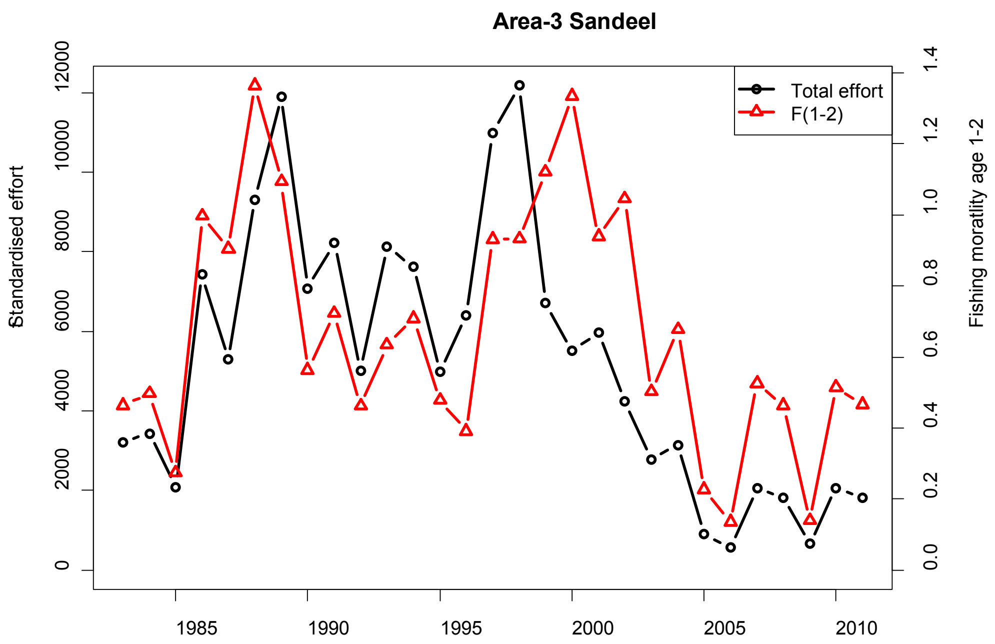


Figure 4.4.15. Sandeel in Area-3. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

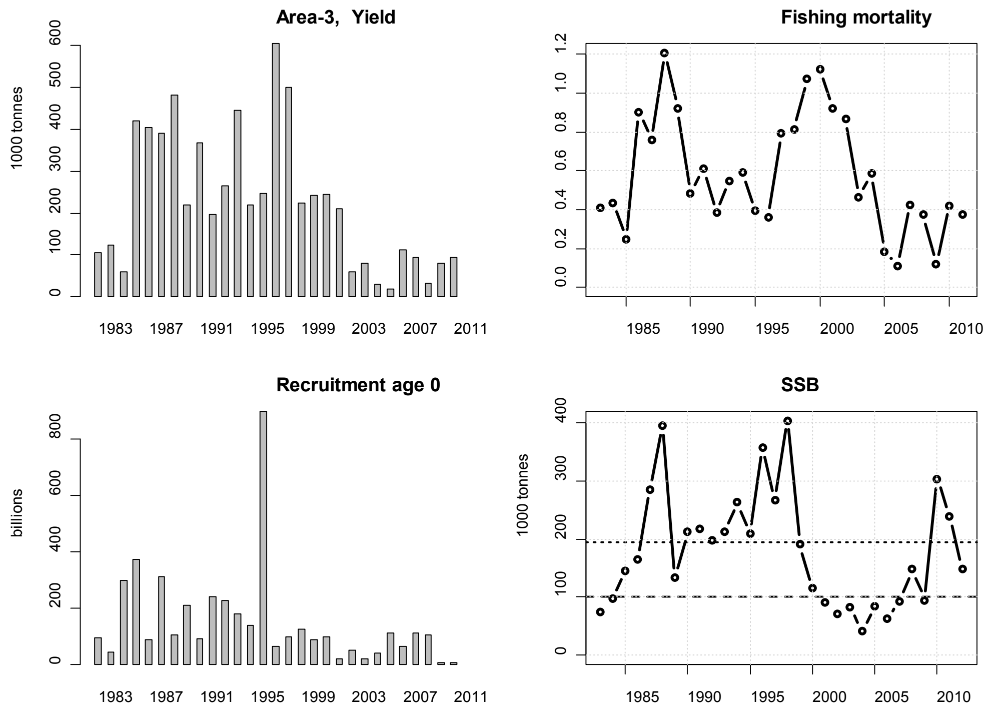


Figure 4.4.16. Sandeel in Arrea-3. Stock summary.

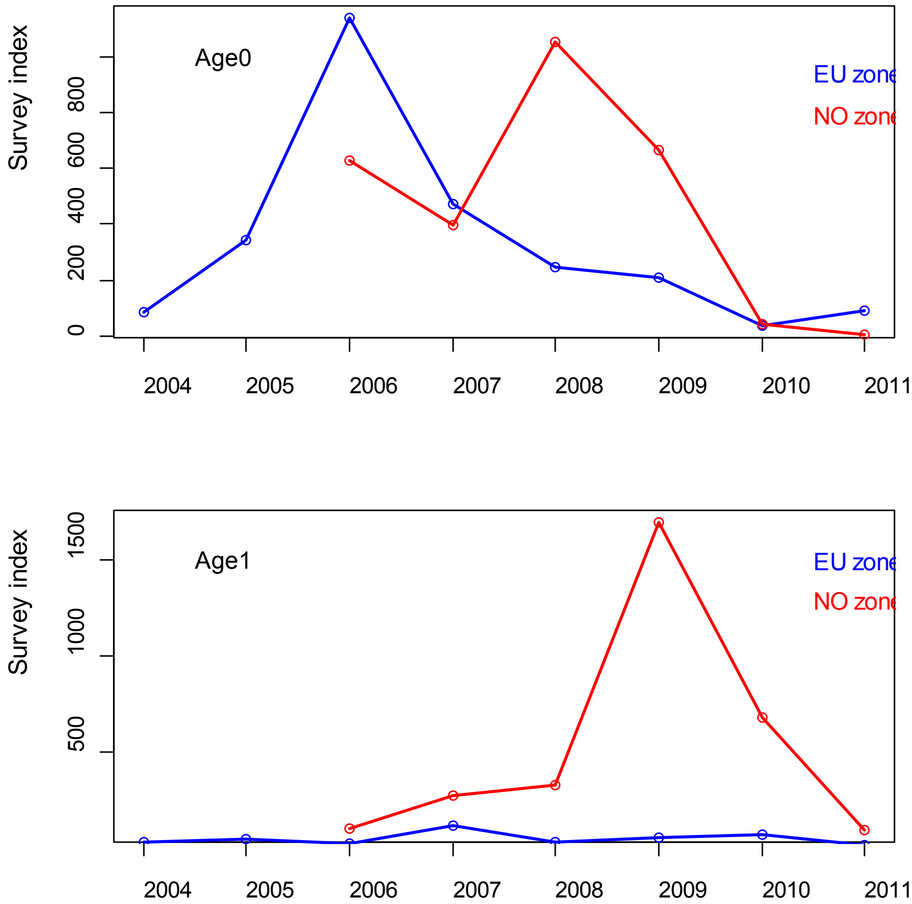


Figure 4.4.17. Comparison of dredge survey index trends in the EU and Norwegian parts of area 3.

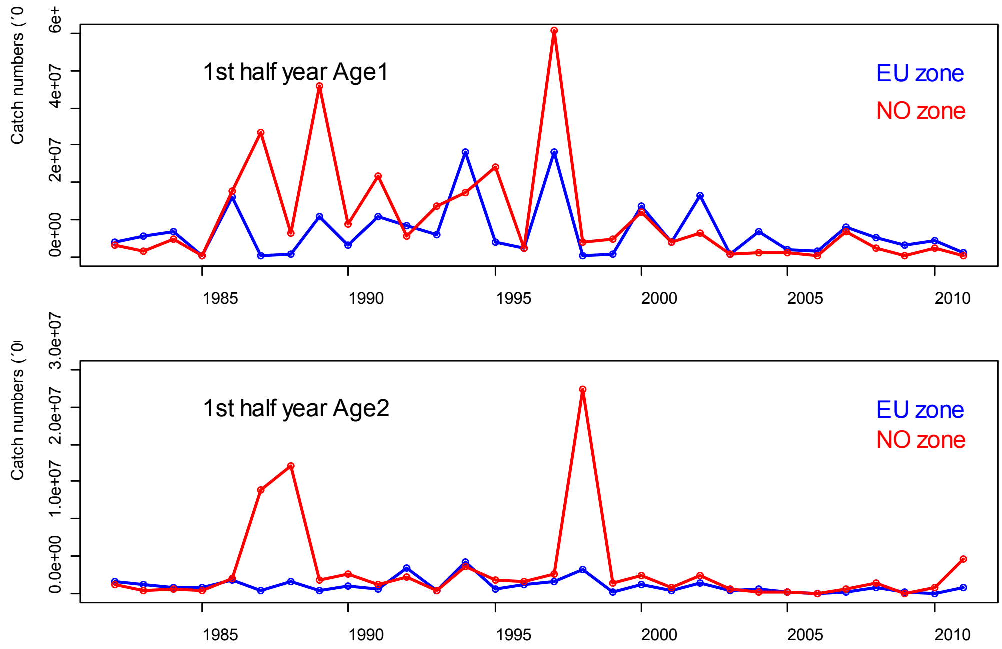


Figure 4.4.18. Comparison of catch in numbers at age in the EU and Norwegian parts of area 3.

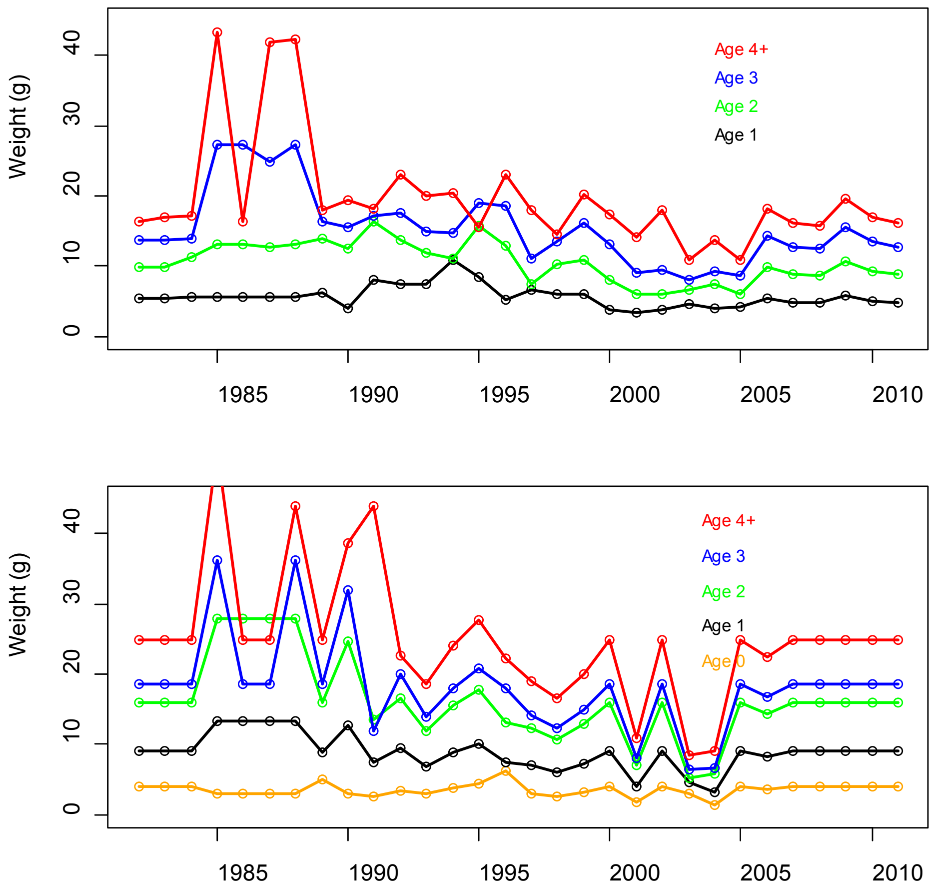


Figure 4.5.1 Sandeel in Area-4. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

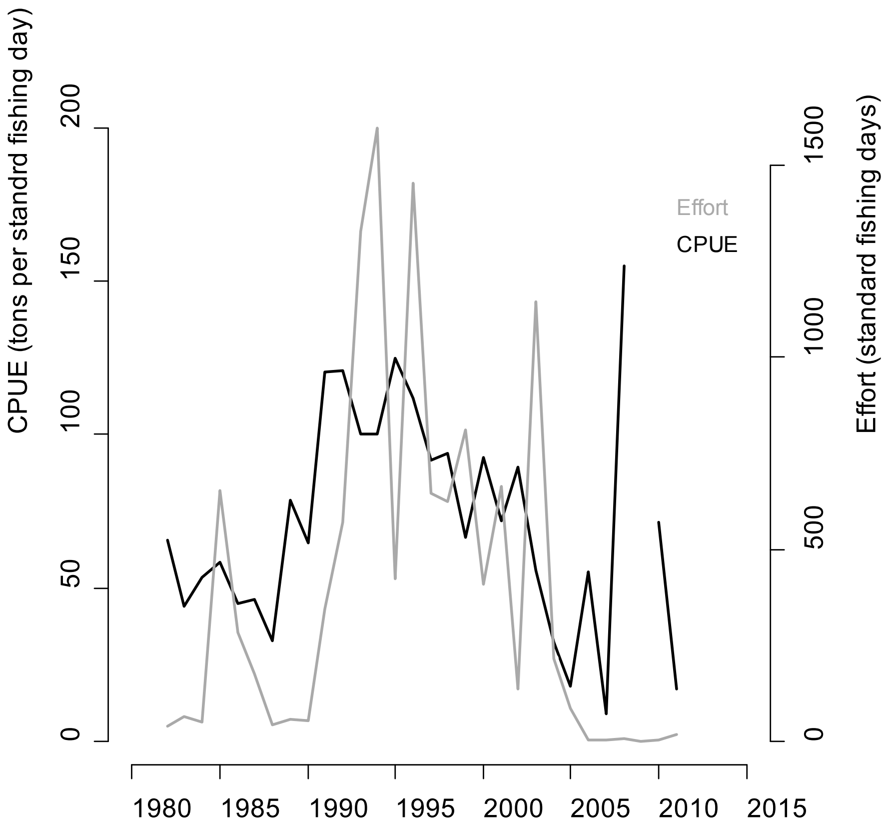


Figure 4.5.2.Sandeel in Area-4. Effort (days fishing for a standard 200GT vessel) and CPUE(tons per standard fishing day).

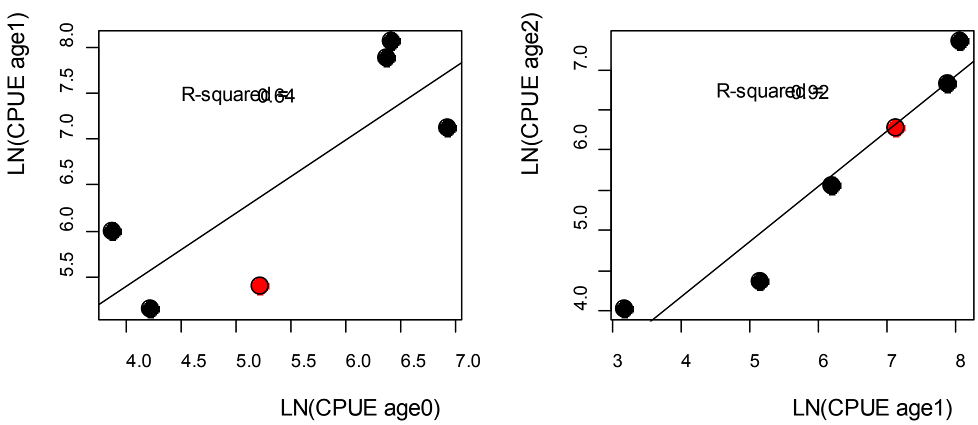


Figure 4.5.3. Internal consistency plot. Average dredge CPUE of consecutive ages from the same year-class for Firth of Forth samples. Red dot indicates most recent data point.

Annex 1: Real time monitoring of the Area-1 sandeel stock in 2012

Background

The ICES assessment and advice, March 2012 (ICES 2012), estimates of a low TAC (23 000 t) of sandeel in Area for 2012, due to very low 2010 and 2011 year classes. Information for the 2011 year-class is entirely based on observation from a dredge survey, December 2011. However, bad weather conditions during the 2011 survey might have biased the estimate of the 2011 year-class and may indicate the relevancy of an analysis of Real Time Monitoring (RTM) for 2012 (ICES 2012).

This document outlines data and method to be used for the 2012 RTM.

Data and methods

The aim RTM of sandeel is to estimate stock abundance of sandeel from observations of catch per unit effort (CPUE) from the fishery in April 2012. This information is then used as a stock abundance index together with similar information for the period since 1999 to update the ICES assessment, which finally will be the basis for the final setting of the TAC for 2012.

Stock abundance is measured as CPUE in number per age class. Effort is measured as number days absent from harbour for the individual fishing trips, standardised to an average vessel size of 200 GT:

$$\overline{CPUE} = \frac{1}{N}\frac{\sum_1^N Catch_i}{\sum_1^N Daysabsent_i * \left(\frac{GT_i}{200}\right)^{0.449}}$$

Where N is the number of trips, *Catch* is the catch in tonnes on a given trip, *Daysabsent* is the number of days absent on a given trip, GT is the gross tonnage of the vessel and 0.449 is the average effect of vessel size as measured over the period 2002 to 2011 using data from all months and the method described in ICES (ICES 2010). Effort (days absent), vessel GT and total catch weight of sandeel by trip are obtained from log book data extracted from the Danish AgriFish Agency's database. Age distribution of the catch is obtained from samples taken by the Danish AgriFish Agency; ideally one sample from each landing. Samples taken at sea by the industry from every third haul, with detailed information on catch position and time will also be used when available to estimate the age distribution of the catch.

The default ICES assessment did not include the new time series of CPUE in April. Figure 2 presents the output of the default assessment and an assessment using the new index for the period 1999-2011. It is clearly seen that the two assessments give almost identical result, however fishing mortality is slightly higher in the assessment with use of the new abundance index. Survey residuals for the Dredge survey in the new assessment (Figure 3) show a very similar picture compared to the default assessment (ICES 2012, Figure 4.2.5). The "RTM April" index shows in general a good correlation between CPUE in April and the year class strength. The CV of the catchability of the RTM age 1 index (0.35) is lower than the CV for the 0-group from the dredge survey (0.44) (Table 1).

The Danish fishery will be opened the 15 April. Catches and effort for the period up to the 1st May (or when the Danish quota has been taken) will be used to calculate the RTM abundance indices for 2012. After the 1st May it will take at least a week before biological samples are analysed so data can be applied in the new assessment and advice. During the period from May 1st to the new assessment and advice is available, DTU Aqua considers that the fishery can continue (even if the Danish Quota has already been taken) without probable harm to the stock if the CPUE in the second half of April exceeds the average of the same period in the years 2007 to 2011, where the stock was above Bpa. This level amounts to an average of 18 ton/day absent for a standard vessel of 200 GT. Catch rates of vessels of other size are standardised using the equation given above.

References

ICES 2010. Report of the Benchmark Workshop on Sandeel. ICES CM 2010/ACOM: 57

Table 1. Statistics for abundance indices in sandeel assessment including the RTM time series.

Survey catchability:

--------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	2.068	1.604			
RTM April. 1999-		1.734	1.610	1.041	1.041

sqrt(Survey variance) ~ CV:

---------------------------	age 0	age 1	age 2	age 3	age 4
Dredge survey 2004-2011	0.44	1.26			
RTM April. 1999-		0.35	0.66	0.66	0.66

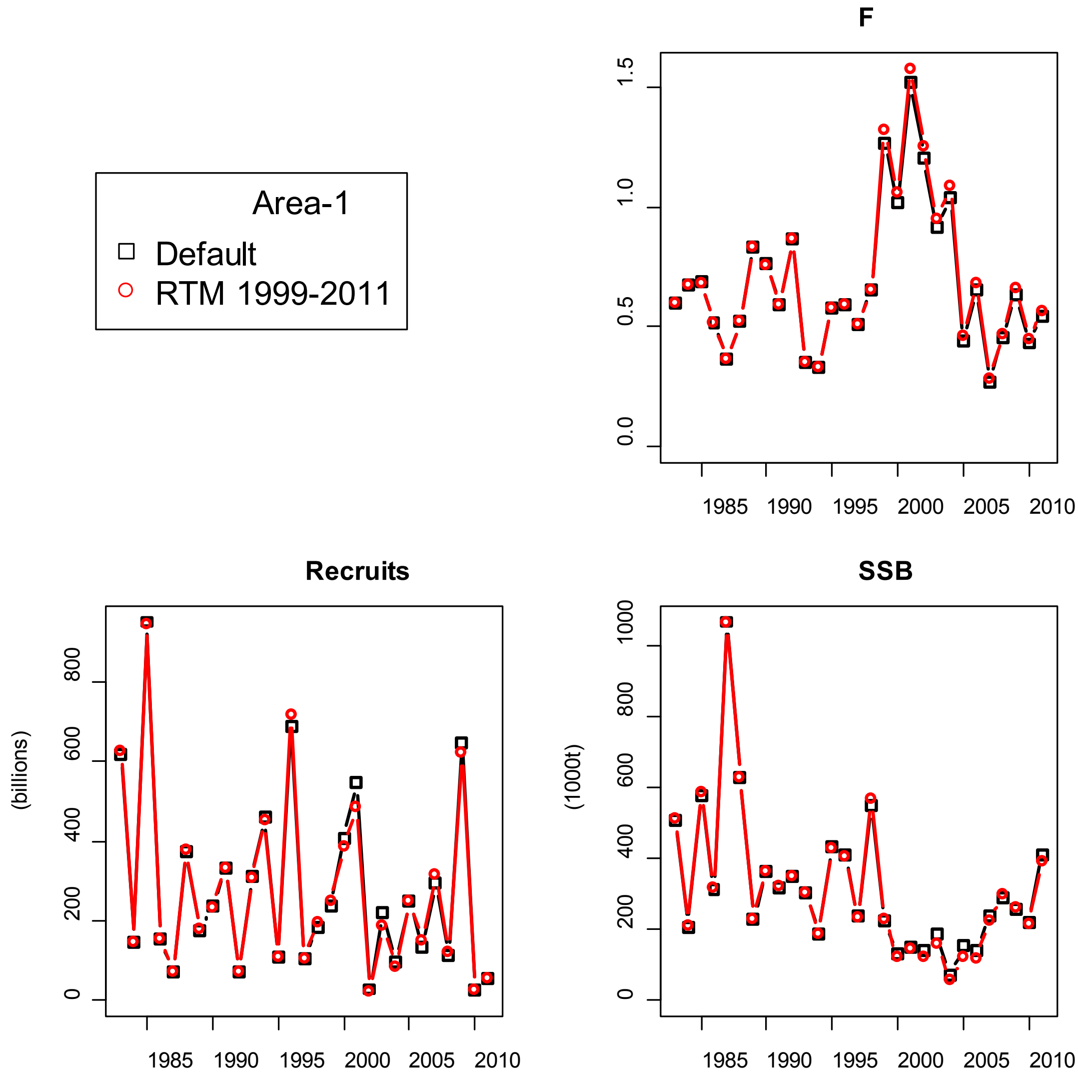


Figure 2. Assessment results from the default ICES assessment of area 1 sandeel (ICES, 2012) and the same assessment updated with e new Real Time Monitoring abundance index obtained from the fishery in April.

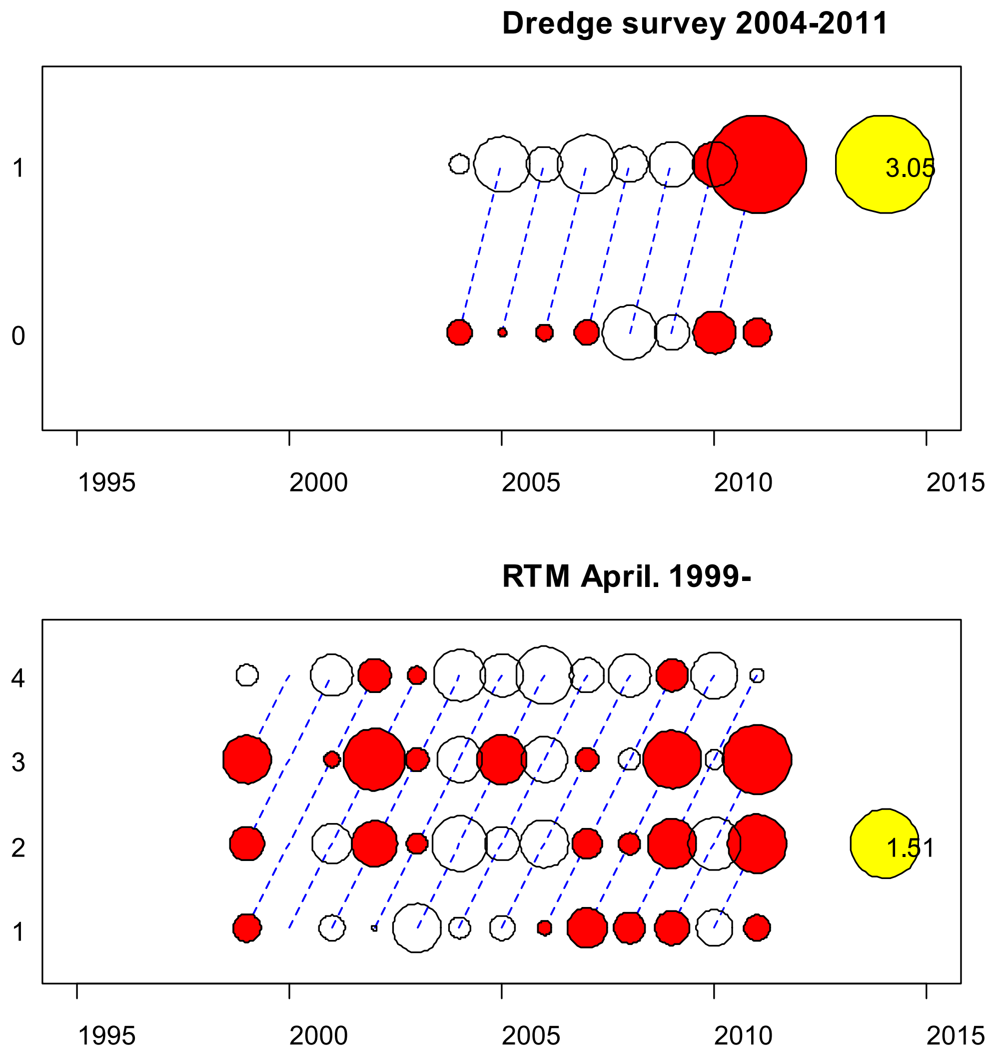


Figure 3. Residual plots from abundance indices. The area of the dots is proportional to the absolute value of the residual. Red dots show that the observed CPUE is higher than the expected.

5 Norway Pout in ICES Subarea IV and Division IIIa (May 2012)

Introduction: Update and inter-benchmark assessment

The May 2012 assessment of Norway pout in the North Sea and Skagerrak is basically an update assessment from the May and September 2011 assessments, which are update assessments of the 2004 and 2006 benchmark assessments, with respect to use of the same assessment model, tuning fleets and assessment parameter settings. However, based on the Inter-benchmark assessment in spring 2012 (ICES IBPNorwayPout, ICES 2012c) the population dynamic parameter settings for natural mortality, maturity at age and mean weight at age has been changed in the assessment. The assessment is a "real time" monitoring (and management) run up to 1st April 2012, and includes new information from second half year 2011 and 1st quarter 2012.

Furthermore, a within year short term prognosis (Forecast) up to 1st January 2013 is given for the stock based on the up-date assessment.

5.1 General

5.1.1 Ecosystem aspects

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). 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 on which the maturity ogive in the assessment has been based. Results in 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 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, Lassen, Sparholt and Nielsen (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).

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.

In order to protect other species (cod, haddock, whiting, saithe and herring as well as mackerel, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as the closed Norway pout box, by-catch regulations, minimum mesh size, and minimum landing size (cf **Stock Annex)**.

5.1.2 Fisheries

The fishery is nearly exclusively performed by Danish and Norwegian vessels using small mesh trawls in the north-western North Sea, especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea. Main fishing seasons are 3rd and 4th quarters of the year with also high catches in 1st quarter of the year especially previous to 1999. The average quarterly spatial distribution of the Norway pout catches during a ten year period from 1994-2003 is shown in figures in the **Stock Annex**. The Norway pout fishery is a mixed commercial, small meshed fishery conducted nearly exclusively by Denmark and Norway directed towards Norway pout as one of the target species together with Blue Whiting in the Norwegian fishery.

Landings have been 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 (Table 5.2.9). 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. The TAC was not taken in 2008, 2009 and 2010. 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). The 2010 landings was 126 kt based on the strong 2009 year class, but based on the very low 2010 and 2011 year classes being at the same level as the low 2003-04 year classes the fishery has been closed in the first half years of 2011 and 2012. The fishery was re-opened in second half year 2011 where a small TAC of 6 kt was taken. Trends in yield are shown in Table 5.3.5 and Figures 5.3.1-3.

By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2)), and recent by-catch numbers in the Danish and Norwegian small meshed fisheries are given in section 2 of this report. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years. The declining tendency to present very 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, but modification of the selective devices and their implementation in management is ongoing. Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained. A detailed description of the regulations and their background can be found in the **Stock Annex**.

5.1.3 ICES advice

In September 2011 the advice on North Sea Norway pout was updated with the addition of the 3rd quarter 2011 English and Scottish groundfish surveys.

Based on the estimates of SSB in September 2011, ICES classified the stock to show full reproductive capacity (SSB>B_{pa}). 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. The in year (September) ICES advice according to the escapement management strategy was in 2008, 2009 and 2010 148 kt, 157 kt and 434 kt, respectively, while the TAC in 2008 was 115 kt, 116 kt (only EU Part) in 2009, and 162 kt in 2010, and the respective landings were 36 kt, 55kt and 126kt in 2008, 2009 and 2010. Consequently, the TACs were not taken in this period. Catches and fishing mortality was low in 2008 and 2009, but increased in 2010 based on the relatively strong 2008-2009 year classes. Due to the weak 2010 and 2011 year classes ICES adviced 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. 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 2012 will be provided for the stock in autumn 2012 as well.

ICES provides advice according to 3 management strategies for the stock (see below). ICES advised in September 2011 - on the basis of precautionary limits - that in order to maintain the spawning stock biomass above B_{pa} by 1st January 2013 the directed Norway pout fishery should be maximum 6 kt in 2011 and closed in first part of) 2012 (i.e. 0 t in first half year 2012 until the 2012 advice is available) 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 0.59), and under the long term fixed fishing mortality or fishing effort strategy (TAE) a TAC on 31 000 t corresponding to a fixed F=0.35.

ICES advises 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. 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, and 162 kt for 2010, however, the TACs were not taken during this period. This is due to high fishing (fuel) costs in both years as well as bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch). Fishery was closed in first half year 2011 only allowing for by-catch, and the set TAC of 6 kt in 2011 has been taken. Also, the fishery has been closed in the first part of 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, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained.

Long term management strategies have been evaluated for this stock. (See section 5.11). Based on a new joint EU-Norway request management strategies will be evaluated again in summer 2012 for the stock to be available for the September 2012 ICES advice (ICES 2012b). 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

Data for annual nominal landings of Norway pout as officially reported to ICES are shown in Table 5.2.1. Historical data for annual landings as provided by Working Group members are presented in Table 5.2.2, and data for national landings by quarter of year and by geographical area are given in Table 5.2.3.

Both the Danish and Norwegian landings of Norway pout were low in 2008 and 2009 and moderate in 2010 and the TAC was not reached. Landings were low in 2011 based on the small TAC of 6kt. 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, first half year 2006, 2007, 2011 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 2011-12 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 and second half year 2010 and 2011.

Mean weight at age in the stock is given in Table 5.2.6. The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al.*, 2009). The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. In section 5.2.4 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 furthermore 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 section 5.2.4 a summary is given of the Inter-benchmark revisions of the population dynamic parameters used in the assessment. Furthermore, maturity and natural mortality used in the assessment is described in the Stock Annex. 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 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. The revised values are shown in Table 5.2.6.

5.2.5 Summary of Inter-benchmark with revised weight, maturity and natural mortality parameters at age included in the assessment

5.2.5.1 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, Figure. 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.

5.2.5.2 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 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. This is in summary also described in the **Stock Annex**.

5.2.6 Catch, Effort and Research Vessel Data

Description of catch, effort and research vessel data used in the assessment is given in the **Stock Annex.** Data used in the present assessment is given in **Table**s 5.2.7-5.2.11

as described below. No commercial fishery tuning fleet is included for 2005-2011 except for second half year 2006. Recent catch information for 2008-2012 is included in this assessment. Catches in all of 2005, 1st quarter 2009 and 2012 as well as first half year 2011 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 2012 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 size category and year for the Danish commercial fishery in ICES area IVa. The basis for these data is described in the **Stock Annex**. However, no Danish effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Data for 2008-2011 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 2010-11 has not been prepared because of introduction of selective grids in the Norwegian fishery in 2010. 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 2010-11 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 2007-2012.

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 2012 IBTS and the 3rd quarter 2011 IBTS research surveys have been included in this assessment (as well as the 3rd quarter 2011 EGFS and SGFS research survey information which also were included in the September 2011 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 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. 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 2011 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 was a well documented, well ordered and considered section. It was easy to follow and interpret.

Technical comments

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 2010 assessments as well as previous up-date assessments.

In section 5.3.2, first paragraph, it says that SXSA uses the geometric mean for the stock recruitment relationship. I don't understand how the model uses it. In traditional XSA,it estimates de recruitments and then usually geometric mean is used for the forecast but the XSA does not used it for anything.

Reply: This is a typing error, and has been corrected (see section 5.3.2 below). It is naturally the forecast which uses the geometric mean of the stock recruitment.

In section 5.3.2, first paragraph, it is not explained why no back-shifting of the third quarter surveys indices was undertaken given that it was done in previous assessments.

Reply: This has been explained now – see explanation in section 5.3.2 below.

Conclusions

The assessment has been performed correctly. Suggestions for future benchmarks:

Revise maturity, natural mortality and weight at age parameters. *Reply:* This has been done in the spring 2012 Inter-benchmark assessment.

Revise commercial fleet standardization. *Reply:* This evaluation is still suggested for future benchmark – see section on other issues below.

Investigate the pattern in the residuals of IBTS 3rd quarter survey. From 2002 all the residuals are lower than 0. Reply: This pattern has changed in the 2012 assessment - see Figures 5.3.1 and 5.2.2 where the residuals and standardiced cpue indices show positive trends.

ICES PGCCDBS point at that the missing Norwegian data time series of samplings should be made available in Intercatch, and that missing Norwegian CPUE data by vessel category for 2008, 2010 and 2011 should be made available. *Reply*: The stock coordinator agrees on this and continued efforts will be made to accomplish this.

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 2012. 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 2011 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 (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 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 year class, and the lowered fishing mortality. The stock biomass fell to a level well below B_{lim} in 2005 which is the lowest level ever recorded. By 1st January 2007 and 2008 the stock was at B_{pa} (=MSY $B_{trigger}$) (i.e. at increased risk of suffering reduced reproductive capacity), while the stock by 1st January 2009, 1st January 2010, and 1st January 2011 has been well above Bpa (i.e. the stock show full reproductive capacity). The stock is 1st of January 2012 just above Bpa. 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. On this basis the SSB is expected to decrease in 2012 to below B_{pa} (=MSY $B_{trigger}$) even with no fishery due to high natural mortality and 20% maturation at age 1 (see forecast).

5.3.3 Comparison with 2011 assessment

The final, accepted May 2012 SXSA assessment run was compared to the Inter-benchmark May 2011 Scenario 2 SXSA assessment with new population dynamic parameters. The results of the comparative run between the May 2011 and the May 2012 assessments are shown in **Figure** 5.3.5. The retrospective analysis based on the May 2012 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 44 billions (arithmetic mean) and 35 billions (geometric mean) for the period 1983-2012 (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.

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 2013 using full assessment information for 2011 and 1st quarter 2012, i.e. it is based on the SXSA assessment estimate of stock numbers at age at the start of 2012.

The purpose of the forecast is to calculate the catch of Norway pout in 2012 which would result in SSB at or above $\mathbf{B_{pa}}$ = MSY $\mathbf{B_{trigger}}$ (=150 000 t) 1st of January 2013. 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 5.11 below).

Input to the forecast is given in **Table** 5.6.1. Observed fishing mortalities for all quarters of 2011 have been used (assessment year). The forecast assumes a 2012 (the 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) for 3rd and 4th quarter 2012 and a fishing mortality of 0 for all ages in quarter 1 and 2 2012 because of the fishery closures here. As the TAC and landings in 2011 was only 11kt with a total yearly fishing mortality of 0.034 then the fishing mortality in 2011 is not included in the calculation of the average exploitation pattern used for 2012. As the fishery is closed in the first half year 2012, and the average exploitation pattern for 2008-2010 (Table 5.6.1) shows that main fishing mortality in general is in the 3rd and 4th quarter of the year, then the average exploitation pattern from 3rd and 4th quarter 2008-2010 has been used for 3rd and 4th quarter 2012 even when setting the fishing mortality to 0 in first half year 2012. Recruitment in the forecast year is assumed to the 25th percentile = 24 234 millions of the SXSA recruitment estimates (GM = 34 933 millions) in the 3rd quarter of the year. The background for selecting these 3 recent years exploitation pattern is that the exploitation pattern between seasons (and ages) has changed since 2004 which was the last year where the directed Norway pout fishery was open in all seasons of the year in the EU Zone up to 2007. The recent exploitation pattern is very different from the average previous long term (1991-2004) exploitation pattern. The targeting in the small meshed trawl fishery has changed recently where targeting of Norway pout has decreased (see also the **Stock Annex**). Also, there has in recent years been introduced sorting grids in the fishery also changing the exploitation pattern of Norway pout (Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012).

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 (2011) and based on recent running 5 year averages (i.e. for the 5 last years with covering observations) for the forecast year (2012). 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). Accordingly, the revised constant weight at age in 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 2012.

Twenty percent of age 1 is mature and is included in SSB. Therefore, the recruitment in 2011 does influence the SSB in 2012.

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 $B_{trigger}$ = B_{pa} by 1st of January 2013 then no catch can be taken in 2012 corresponding to a F around 0. according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 31 000 t can be taken in 2012. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2012 (corresponding to a F around 0.60) according to the long term management strategies. In recent years the escapement strategy has been practiced in reality in management. Even with zero catch in 2012 then the stock will decrease to below Bpa by 1st of January 2013. Under a fixed F-management-strategy with F around 0.35 in 2012 as well as under a fixed TAC strategy with a TAC of 50 000 t 2012 the stock will accordingly also decrease to be under Bpa by 1st of January 2013 according to the long term management strategies.

According to the escapement strategy a zero catch in 2012 will result in a spawning stock biomass below MSY $B_{escapement}$. With the objective to maintain the spawning stock biomass at or above a reference level of MSY $B_{escapement}$ by 1st of January 2013 the spring 2012 advice is that the fishery is closed (i.e. no catch should be taken) in first part of 2012 in the directed Norway pout fishery. Accordingly, the fishery is adviced to be closed in the first part of 2012 until the strength of the 2012 year class is known in September 2012.

The reason for this advice of no directed Norway pout fishery in 2012 is the very low 2010 and 2011 recruitment and 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 $B_{escapement}$	150 000 t	= B_{pa}
Approach	F_{MSY}	Undefined	None advised
	B_{lim}	90 000 t	B_{lim} = B_{loss}, the lowest observed biomass in the 1980s
Precautionary	B_{pa}	150 000 t	= $B_{lim}\ e^{0.3*1.65}$
Approach	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

(unchanged since: 2011)

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. 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

$$B_{pa} = B_{lim}\, e^{0.3*1.65} \text{ (SD)}.$$

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 B_{MSY} = 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 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) 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 2011 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 2011, ICES classified the stock at full reproductive capacity with SSB well above Bpa at the start of 2011 (up to 1st July 2011). Also, the most recent estimates of SSB (Q1 2012) show full reproductive capacity of the stock (SSB> MSY $B_{trigger}$ = B_{pa}), however SSB is expected to decrease in 2012 to below $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{trigger}}$) even with no fishery in 2012 due to high natural mortality and 20% maturation at age 1 and rececent low recruitment (see below).

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 year 2011 and 2012 and fishing mortality and effort has accordingly reached historical minima in these periods (**Table** 5.3.6). The fishery was open for the second half year of 2006 and in all of 2008, 2009 and 2010 where fishing mortality was low in 2008 and 2009 and moderate in year 2010. Fishing mortality was very low F in 2011.

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 (**Tables** 5.3.3 and Table 5.3.6).

5.10 Management considerations

There are no management objectives for this stock.

From the results of the forecast presented here it can be seen that if the objective is to maintain the spawning stock biomass above a reference level of MSY $B_{trigger}$ = B_{pa} by 1st of January 2013 then no catch can be taken in 2012 corresponding to a F=0 in 2012 according to the variable TAC escapement strategy. Even with zero catch in 2012 then the stock is expected to decrease to below Bpa by 1st of January 2013. Under a fixed F-management-strategy with F around 0.35 a catch around 31 000 t can be taken in 2012. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2012 (corresponding to a F around 0.60) according to the long term management strategies. In recent years the escapement strategy has been practiced in reality in management. Under a fixed F-management-strategy with F around 0.35 in 2012 as well as under a fixed

TAC strategy with a TAC of 50 000 t in 2012 the stock will decrease to be under Bpa by 1st of January 2013 according to the long term management strategies.

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 2012-2013 will be provided for the stock in autumn 2012 (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 B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$. (see also the Inter-benchmark assessment from 2012, ICES, 2012c).

There is a need to ensure that the stock remains high enough to provide food for a variety of predator species. Natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES WGSAM, 2011; ICES-SGMSNS, 2006).

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. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006; Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012). ICES suggests that these devices (or modified forms of those) are fully implemented and brought into use in the fishery. In 2010-11 grids have been used in the Norwegian and Danish fishery. The introduction 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, 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 $B_{pa} = B_{MSY\text{-}trigger}$, 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 has higher long term yield compared to the fixed fishing mortality 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.

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.

Based on a new EU-Norway request management strategies will be evaluated again in the summer 2012 for the stock to be available for the ICES September 2012 advice (ICES, 2012b).

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. 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.

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.

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O. R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fisheries Research, 68: 99–112.

Eigaard, O., and Nielsen, J. R. 2009. Reduction of bycatch in a small meshed trawl fishery through gear developments facilitating ecosystem-based fisheries management. ICES CM 2009/M:22. 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

ICES 2006 SGMSNS 2006.

ICES 2011 WGNSSK Report

ICES 2011. WGSAM Report

ICES. 2012a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 27 April–10 May 2012. ICES CM 2012/ACOM:13.

ICES 2012b (EU Request on new management plan evaluations on Norway pout)

ICES 2012c (IBPNorwayPout Inter-benchmar assessment report)

Lambert, G. *, Nielsen, J. R. *[1], Larsen, L., and Sparholt, H. 2009. Maturity and growth population dynamics of Norway pout (*Trisopterus esmarkii*) in the North Sea, Skagerrak and Kattegat. ICES Journal of Marine Science, 66(9): 1899–1914; *Authorship equal; [1]Corresponding author. doi:10.1093/icesjms/fsp153.

Nielsen, J. R., and Madsen, N. 2006. Gear technological approaches to reduce unwanted bycatch in commercial Norway Pout Fishery in the North Sea. Working Document No. 23, ICES WGNSSK (2006). ICES CM 2007/ACFM:35. 10 pp.

Nielsen, J.R.*[1], Lambert, G.*, Bastardie, F., Sparholt, H., and M. Vinther. 2012. Do Norway pout (Trisopterus esmarkii) die from spawning stress? Mortality of Norway pout in relation to growth, maturity and density in the North Sea, Skagerrak and Kattegat. ICES J. Mar. Sci. 69(2): 197-207. *Authorship equal; [1]Corresponding author. Doi:10.1093/icesjms/fss001

Poulsen, E.M. 1968. Norway pout: Stock movement in the Skagerrak and in the north-eastern North Sea. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer, 158: 80-85.

Raitt, D.F.S. 1968. The population dynamics of Norway Pout in the North Sea. Marine Research 5 : 1-23.

Sparholt, H., Larsen, L. I., and Nielsen, J. R. 2002a. Verification of multispecies interactions in the North Sea by trawl survey data on Norway pout (*Trisopterus esmarkii*). ICES Journal of Marine Science, 59: 1270–1275.

Sparholt, H., Larsen, L. I., and Nielsen, J. R. 2002b. Non-predation natural mortality of Norway pout (*Trisopterus esmarkii*) in the North Sea. ICES Journal of Marine Science, 59: 1276–1284.

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 2000-2011, as officially reported to ICES and EU. By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	13,619	3,780	4,235	110	-	18	24	156	4 *	51 *	2 *
Faroe Islands	-	-	50	45	-	-	-	-	-	-	-
Norway	-	96	30	41	-	2	-	-	209	711	-
Sweden	780	-	-	-	-	-	-	-	-	10	-
Germany	-	-	-	54	-	-	-	-	-	-	-
Total	14,399	3,876	4,315	250	0	20	24	156	213	772	2

*Preliminary.

Norway pout ICES area IVa

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	44,818	68,858	12,223	10,762	941***	39,531	2,032 ***	32,158	19,226	71,261	4,038 *
Faroe Islands	49	3,367	2,199	1,085	24	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	22	18	-
Germany	-	-	-	27	-	15	-	-	-	-	-
Norway	17,158	23,657	11,357	4,953	311	13,618	4,712	6,650	36,961	64,303	3,189
Sweden	-	-	-	-	-	-	-	10	-	+	1
UK(Scotland)	-	-	-	-	-	-	-	-	-	29	-
Total	62,025	95,882	25,779	16,827	1,092	53,164	6,744	38,818	56,209	135,582	7,228

*Preliminary.

Norway pout ICES area IVb

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	632	556	191	473	-	394	-	244	595	229	32 *
Faroe Islands	-	12	125	29	-	-	-	-	-	-	-
Germany	-	-	-	26	-	19	-	3	75	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	2	0	0	82	620	21
Sweden	-	-	-	88	-	-	-	-	-	-	-
UK (E/W/NI)	-	+	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	-	-
Total	632	568	316	616	0	415	0	247	752	849	53

*Preliminary.

Norway pout ICES area IVc

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	304	-	-	-	-	-	-	-	-	-	-
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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	59,069	73,194	16,649	11,345	941***	39,943	2,056	32,558	19,825	71,541	4,072
Faroe Islands	49	3,379	2,374	1,159	24	0	0	0	0	0	0
Norway	17,158	23,753	11,387	4,994	311	13,622	4,712	6,650	37,252	65,634	3,210
Sweden	780	0	0	88	0	0	0	10	0	10	1
Netherlands	0	0	0	0	0	0	0	0	22	18	0
Germany	0	0	0	107	0	34	0	3	75	0	0
UK	0	0	0	0	0	0	0	0	0	0	0
Total nominal landings	77,056	100,326	30,410	17,693	1,252	53,599	6,768	39,221	57,174	137,203	7,283
By-catch of other species and other	-11,456	-20,326	-3,310	-4,193	-	-6,973	-	-3,083	-2,674	-11,248	-759
WG estimate of total landings (IV+IIIaN)	65,600	80,000	27,100	13,500	-	46,626	-	36,138	54,500	125,955	6,524
Agreed TAC	211,200	198,000	198,000	198,000	0****	95,000	0****	114,616	######	162,950	6,000

* provisional
** provisional
*** 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

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 1961-2011 (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

* 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 1996-2012. (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
1996	1	1,231	164	1,395	6,133	3,149	658	2	9,943	11,174	10604	10604	21,778
	2	7,323	970	8,293	1,018	452	1,476	-	2,946	10,269	4281	4281	14,550
	3	20,176	836	21,012	7,119	17,553	1,517	-	26,188	46,364	27466	27466	73,830
	4	5,028	500	5,528	9,640	25,498	42	-	35,180	40,208	5466	5466	45,674
	Total	33,758	2,470	36,228	23,910	46,652	3,692	2	74,257	108,015	47,817	47817	155,832
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	-	0	15

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			
0		0	0	0	0	0	0	0	1	0			
1		6	799	1118	716	0	1	44	23	0			
2		1	905	738	331	0	5	69	61	0			
3		0	17	15	0	0	0	4	0	0			
4+		0	0	0	0	0	0	0	0	0			
SOP		198	40322	57487	33071	0	222	3749	2872	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 2012: No directed Norway pout fishery in 2012, but only 15 t caught by Denmark. As there has been no samplings
(age distribution and mean weigh at age) of Norway pout in Q1 2012, 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 1983-2012, 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 2010-2012. 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			
Age 0								8.90				
1	25.60	15.51	25.37	27.75		20.33	22.14	30.50				
2	37.20	29.99	38.55	39.88		37.75	37.50	35.61				
3		47.00	45.50	62.20		52.00	52.00	52.00				
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 2012: No directed Norway pout fishery in 2012, but only 15 t caught by Denmark. As there has been no samplings
(age distribution and mean weigh at age) of Norway pout in Q1 2012, 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 1988-2011. 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
51-100	-	-	-	-
101-150	-	-	-	-
151-200	-	-	-	-
201-250	-	-	-	-
251-300	-	-	-	-
301-	79.13	94.78	106.15	96.63

* 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, 1983-2011.

	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	***	***	***	***	***	***	***	***	***	***	***

* 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

* 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 2010-11 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	1,939	129	27	1,680	2,147	151	18	1,127	1,285	69	9	1,337	1,837	152	15
2007	1,010	388	7	3,329		339	1	5,003	1,023	395	8	4,143	1,191	447	11
2008	2,345	506	186	1,435	1,084	253	35	3,456	1,263	263	57	3,035	1,643	274	58
2009	5,413	1,620	150	6,401	1,371	428	3	5,835	1,750	202	16	5,829	2,562	254	11
2010	4,655	1,438	137	235	5,368	626	31	1,449	5,101	930	29	834	4,744	833	17
2011	552	2.237	276	1,304	3,977	1,014	37	1,895	226	935	38	1797	471	1126	60
2012	977	303	576		863										

[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 2005-2012 assessments compared to the 2003 assessment.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-12 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	1982-2012
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2011
	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	1998-2011
	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	1991-2011
	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 2012
Run: May 2012 (Summary from NP512)
The following parameters were used:
Year range:                                    1983 - 2012
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):                                   tun2012.xsa
Weighting for rhats:                                  rweigh.xsa
```

Table 5.3.3 Norway pout IV & IIIaN (Skagerrak). Seasonal extended survivor analysis (SXSA).

Stock numbers, SSB and TSB at start of season.

Year	1983				1984				1985			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	85094.	63287.	*	*	46218.	34583.	*	*	31331.	23438.
1	74062.	51779.	37164.	22770.	45045.	31318.	21486.	11501.	23947.	15960.	11201.	7170.
2	12951.	7701.	4198.	1547.	13322.	7889.	4383.	1583.	5585.	2660.	1681.	486.
3	126.	69.	37.	10.	735.	358.	15.	3.	467.	147.	84.	39.
4+	7.	3.	0.	0.	1.	0.	0.	0.	2.	1.	1.	0.
SSN	27896.				23067.				10845.			
SSB	462487.				443566.				201566.			
TSN	87145.	59551.	126493.	87614.	59102.	39566.	72103.	47670.	30002.	18767.	44298.	31134.
TSB	995733.	817465.	1439616.	1011446.	767887.	590975.	898251.	558526.	373984.	265415.	477657.	341572.

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	62105.	46471.	*	*	16597.	12412.	*	*	49486.	36388.
1	16951.	12341.	9009.	5715.	29953.	20088.	14101.	9144.	9091.	6588.	4847.	3468.
2	2778.	1001.	606.	209.	2728.	1517.	977.	521.	4982.	2797.	1833.	1035.
3	186.	62.	37.	19.	109.	61.	39.	25.	161.	88.	57.	36.
4+	25.	14.	9.	6.	16.	10.	6.	4.	15.	9.	6.	4.
SSN	6379.				8844.				6976.			
SSB	108799.				127387.				148178.			
TSN	19940.	13418.	71767.	52420.	32806.	21675.	31720.	22106.	14249.	9482.	56229.	40932.
TSB	230849.	176971.	500147.	431184.	343048.	282546.	460352.	325375.	213634.	153891.	395829.	348563.

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	53150.	39633.	*	*	47391.	35443.	*	*	92225.	68374.
1	24507.	16835.	12011.	7541.	25458.	17457.	11523.	7782.	25662.	17903.	12847.	8298.
2	2049.	1348.	803.	324.	4137.	2320.	1100.	593.	4802.	2152.	1125.	584.
3	368.	232.	145.	89.	143.	76.	34.	17.	306.	122.	64.	23.
4+	26.	17.	11.	7.	52.	25.	16.	10.	14.	4.	3.	2.
SSN	7344.				9423.				10254.			
SSB	111491.				157863.				179276.			
TSN	26949.	18432.	66119.	47595.	29789.	19879.	60064.	43846.	30784.	20182.	106263.	77282.
TSB	287938.	248251.	553659.	444484.	341158.	272717.	523678.	431911.	364043.	275013.	738878.	642410.

Year	1992				1993				1994			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	39638.	28899.	*	*	28505.	21246.	*	*	116122.	86331.
1	48147.	32950.	23338.	14473.	20799.	13883.	9685.	6255.	14881.	9427.	6732.	4147.
2	5303.	2697.	1585.	753.	8422.	5127.	3082.	1336.	3772.	2067.	1165.	443.
3	242.	61.	23.	14.	290.	175.	66.	27.	539.	302.	171.	53.
4+	2.	0.	0.	0.	8.	5.	3.	2.	17.	11.	7.	5.
SSN	15176.				12879.				7304.			
SSB	229003.				260001.				143592.			
TSN	53693.	35708.	64585.	44139.	29518.	19190.	41341.	28866.	19209.	11807.	124197.	90978.
TSB	575658.	465882.	806805.	566159.	409754.	303789.	483395.	338872.	250738.	180529.	689657.	642457.

Year	1995				1996				1997			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	36542.	26738.	*	*	87246.	64656.	*	*	24234.	18040.
1	60932.	42140.	29884.	20160.	18543.	13413.	9552.	6245.	46203.	33990.	25348.	16294.
2	2110.	1231.	623.	383.	12188.	7617.	4992.	2555.	4110.	2515.	1595.	774.
3	189.	118.	50.	30.	211.	125.	50.	3.	1456.	874.	468.	217.
4+	37.	24.	15.	10.	23.	15.	10.	6.	6.	4.	2.	1.
SSN	14523.				16131.				14812.			
SSB	172093.				347822.				244469.			
TSN	63269.	43513.	67115.	47320.	30966.	21169.	101849.	73465.	51774.	37383.	51647.	35327.
TSB	610802.	543684.	921186.	681484.	481334.	358442.	790427.	646434.	577128.	514677.	822507.	559151.

Year	1998				1999				2000			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	34164.	25482.	*	*	83554.	62485.	*	*	28255.	21079.
1	13202.	9653.	7041.	4913.	18775.	13873.	10106.	6439.	45781.	33691.	24968.	17499.
2	10530.	6561.	4187.	2562.	3217.	2072.	1222.	549.	4319.	2772.	1706.	937.
3	353.	190.	108.	68.	1557.	944.	534.	316.	241.	153.	60.	22.
4+	113.	66.	23.	15.	43.	27.	17.	11.	192.	124.	80.	51.
SSN	13637.				8572.				13908.			
SSB	307475.				178906.				210770.			
TSN	24199.	16470.	45523.	33040.	23592.	16917.	95434.	69801.	50533.	36740.	55068.	39588.
TSB	402531.	293076.	486639.	382129.	314084.	267032.	667775.	576186.	540392.	488164.	809037.	602692.

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	*	*	25820.	19293.	*	*	17496.	12798.	*	*	7774.	5811.
1	15512.	11417.	8428.	6201.	14118.	10144.	7287.	4915.	9325.	6927.	5127.	3671.
2	9100.	5466.	3499.	2346.	4409.	2863.	1919.	1066.	3269.	2150.	1416.	859.
3	433.	251.	81.	51.	1227.	777.	496.	301.	436.	263.	150.	84.
4+	42.	27.	18.	11.	40.	26.	16.	11.	179.	116.	74.	48.
SSN	12678.				8500.				5749.			
SSB	275125.				186952.				125996.			
TSN	25087.	17161.	37846.	27903.	19794.	13810.	27215.	19090.	13210.	9456.	14541.	10472.
TSB	386809.	287718.	458804.	367619.	288599.	233594.	358696.	259728.	193137.	156517.	224901.	165863.

Year	2004				2005				2006			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	9043.	6754.	*	*	34986.	26179.	*	*	18555.	13876.
1	4347.	3241.	2422.	1769.	5005.	3745.	2802.	2097.	19588.	14631.	10900.	8044.
2	2700.	1783.	1194.	766.	1237.	837.	567.	384.	1569.	1019.	653.	388.
3	449.	282.	177.	109.	455.	293.	188.	121.	260.	160.	84.	49.
4+	58.	37.	24.	15.	79.	51.	33.	21.	92.	59.	38.	24.
SSN	4077.				2771.				5838.			
SSB	96549.				62523.				89993.			
TSN	7554.	5343.	12860.	9413.	6775.	4926.	38576.	28801.	21508.	15870.	30230.	22381.
TSB	127848.	99662.	155113.	121688.	98557.	83346.	243979.	231871.	231030.	212383.	377869.	302688.

Year	2007				2008				2009			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	30844.	23080.	*	*	58515.	43784.	*	*	83168.	62182.
1	10065.	7514.	5586.	4152.	17269.	12918.	9619.	7054.	31743.	23709.	17710.	12714.
2	5079.	3404.	2283.	1533.	3098.	2089.	1381.	840.	4899.	3316.	2207.	990.
3	221.	142.	92.	58.	1033.	665.	428.	276.	543.	350.	221.	135.
4+	46.	30.	19.	12.	45.	29.	19.	12.	185.	119.	77.	49.
SSN	7360.				7630.				11977.			
SSB	156557.				152368.				211730.			
TSN	15412.	11090.	38825.	28835.	21445.	15701.	69962.	51967.	37371.	27494.	103383.	76071.
TSB	229023.	184067.	359879.	306964.	276708.	242124.	555462.	488674.	440277.	391587.	876950.	738387.

Year	2010				2011				2012
Season	1	2	3	4	1	2	3	4	1
AGE									
0	*	*	8418.	6299.	*	*	18241.	13649.	*
1	46518.	34803.	25351.	18002.	4713.	3527.	2638.	1936.	10212.
2	9367.	6341.	3549.	1796.	12851.	8701.	5887.	3929.	1429.
3	648.	418.	255.	152.	944.	608.	391.	249.	2610.
4+	119.	76.	49.	32.	118.	76.	49.	32.	181.
SSN	19438.				14856.				6262.
SSB	350490.				374134.				168629.
TSN	56653.	41638.	37623.	26281.	18627.	12912.	27206.	19794.	14432.
TSB	685422.	601317.	824715.	568514.	408071.	294501.	397866.	301898.	242155.

Table 5.3.4 Norway pout IV & IIIaN (Skagerrak). Seasonal extended survivor analysis (SXSA).

Fishing mortalities by quarter of year.

Partial fishing mortality for fleet: 1
commercial q134

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	0.418	0.115	0.064	0.154	0.619
2	0.128	0.212	0.570	0.342	0.132	0.194	0.587	0.751	0.340	0.068	0.768	0.539
3	0.156	0.185	0.766	1.539	0.270	1.586	0.928	0.000	0.656	0.117	0.326	0.000
4+	0.000	1.788	*	*	0.000	0.000	0.000	0.000	0.478	0.000	0.000	0.000
F (1- 2)	0.098	0.127	0.384	0.292	0.103	0.140	0.457	0.585	0.228	0.066	0.461	0.579

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.148	*	*	0.001	0.021	*	*	0.017	0.104
1	0.027	0.025	0.163	0.434	0.109	0.063	0.142	0.310	0.032	0.017	0.044	0.233
2	0.589	0.110	0.627	0.251	0.193	0.049	0.233	0.715	0.184	0.032	0.178	0.601
3	0.613	0.059	0.218	0.000	0.146	0.000	0.010	0.279	0.165	0.000	0.000	0.000
4+	0.159	0.000	0.000	0.000	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.308	0.067	0.395	0.342	0.151	0.056	0.187	0.512	0.108	0.025	0.111	0.417

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	0.087	0.124	0.102	0.190	0.070	0.042	0.145	0.156
2	0.029	0.126	0.490	0.411	0.185	0.344	0.224	0.265	0.396	0.253	0.258	0.468
3	0.020	0.032	0.040	0.195	0.187	0.358	0.243	0.336	0.452	0.210	0.541	1.697
4+	0.000	0.000	0.000	0.000	0.268	0.000	0.000	0.000	0.667	0.000	0.000	0.000
F (1- 2)	0.057	0.087	0.332	0.357	0.136	0.234	0.163	0.228	0.233	0.147	0.202	0.312

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	0.089	0.055	0.185	0.247	0.113	0.070	0.146	0.213	0.165	0.047	0.192	0.374
2	0.279	0.140	0.343	0.532	0.105	0.117	0.427	0.492	0.207	0.180	0.544	0.438
3	0.824	0.492	0.054	0.187	0.064	0.502	0.422	0.094	0.136	0.125	0.666	0.000
4+	*	*	*	*	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.184	0.097	0.264	0.389	0.109	0.093	0.286	0.352	0.186	0.113	0.368	0.406

Year	1995				1996				1997			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.022	0.075	*	*	0.010	0.046	*	*	0.005	0.022
1	0.078	0.053	0.103	0.210	0.034	0.049	0.134	0.127	0.017	0.003	0.150	0.145
2	0.147	0.284	0.094	0.204	0.079	0.032	0.272	0.170	0.100	0.065	0.323	0.379
3	0.037	0.393	0.076	0.131	0.085	0.453	1.528	0.143	0.069	0.182	0.317	0.216
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	0.169	0.099	0.207	0.057	0.041	0.203	0.148	0.058	0.034	0.236	0.262

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	0.027	0.159	0.108	0.017	0.010	0.065	0.354
2	0.082	0.059	0.100	0.106	0.049	0.136	0.394	0.418	0.053	0.094	0.206	0.368
3	0.178	0.125	0.018	0.271	0.060	0.129	0.083	0.094	0.014	0.475	0.521	0.391
4+	0.091	0.569	0.000	0.000	0.015	0.008	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.053	0.042	0.085	0.119	0.031	0.081	0.276	0.263	0.035	0.052	0.135	0.361

Year	2001				2002				2003			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.001	0.022	*	*	0.023	0.026	*	*	0.001	0.000
1	0.016	0.013	0.017	0.051	0.040	0.041	0.103	0.117	0.007	0.011	0.044	0.017
2	0.118	0.056	0.010	0.252	0.041	0.010	0.194	0.478	0.029	0.028	0.108	0.252
3	0.105	0.632	0.017	0.022	0.017	0.008	0.060	0.114	0.064	0.123	0.138	0.597
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.033
F (1- 2)	0.067	0.035	0.013	0.151	0.041	0.025	0.149	0.298	0.018	0.019	0.076	0.135

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	0.010	*	*	0.000	0.000	*	*	0.001	0.031
1	0.004	0.001	0.024	0.067	0.000	0.000	0.000	0.000	0.002	0.004	0.014	0.168
2	0.025	0.011	0.053	0.130	0.000	0.000	0.000	0.000	0.041	0.055	0.128	0.169
3	0.025	0.025	0.049	0.020	0.000	0.000	0.001	0.001	0.041	0.201	0.109	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	0.039	0.098	0.000	0.000	0.000	0.000	0.021	0.030	0.071	0.168

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	0.007	0.003	0.000	0.005	0.020	0.074	0.002	0.002	0.041	0.015
2	0.010	0.009	0.008	0.005	0.004	0.024	0.105	0.046	0.000	0.017	0.396	0.033
3	0.001	0.001	0.022	0.013	0.000	0.001	0.000	0.000	0.000	0.019	0.051	0.004
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)	0.006	0.008	0.007	0.004	0.002	0.014	0.063	0.060	0.001	0.009	0.218	0.024

Year	2010				2011				2012
Season	1	2	3	4	1	2	3	4	1
AGE									
0	*	*	0.000	0.000	*	*	0.000	0.000	*
1	0.000	0.027	0.052	0.047	0.000	0.000	0.019	0.013	0.000
2	0.000	0.187	0.283	0.247	0.000	0.001	0.014	0.019	0.000
3	0.000	0.052	0.075	0.002	0.000	0.000	0.011	0.000	0.000
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.000	0.107	0.168	0.147	0.000	0.001	0.017	0.016	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 1983-2012 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season AGE	1	2	3	4
0	*	*	*	11.093
1	10.377	*	9.719	9.119
2	9.253	*	8.779	8.471
3	9.253	*	8.779	8.471

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2012 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season AGE	1	2	3	4
0	*	*	*	*
1	2.141	*	*	*
2	1.514	*	*	*
3	1.514	*	*	*

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season AGE	1	2	3	4
0	*	*	2.341	*
1	*	*	1.452	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season AGE	1	2	3	4
0	*	*	2.309	*
1	*	*	1.750	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2011 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season AGE	1	2	3	4
0	*	*	*	*
1	*	*	*	*
2	*	*	1.500	*
3	*	*	1.500	*

Table 5.3.5 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Weighting factors for computing survivors:
Fleet no: 1 (commercial q134)

Year 1983-2012 (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	*	*	*	1.071
1	1.360	*	3.216	2.065
2	2.162	*	1.662	1.242
3	1.251	*	0.832	0.781

Weighting factors for computing survivors:
Fleet no: 2 (ibtsq1)

Year 1983-2012 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	*	*	*	*	*	*	*	*	*	*
1	1.771	*	*	*	1.771	*	*	*	1.771	*	*	*
2	1.795	*	*	*	1.795	*	*	*	1.795	*	*	*
3	1.056	*	*	*	1.056	*	*	*	1.056	*	*	*

Weighting factors for computing survivors:
Fleet no: 3 (egfsq3)

Year 1992-2011 (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	*	*	1.305	*
1	*	*	2.304	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 4 (sgfsq3)

Year 1998-2011 (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	*	*	1.715	*
1	*	*	2.500	*
2	*	*	*	*
3	*	*	*	*

Weighting factors for computing survivors:
Fleet no: 5 (ibtsq3)

Year 1991-2011 (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	*	*	0.903	*

Table 5.3.6 Norway pout IV & IIIaN (Skagerrak). Stock summary table. (SXSA May 2012).

(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	85094	462487	1439616	457.6	0.901
1984	46218	443566	898251	393.0	1.285
1985	31331	201566	477657	205.1	1.334
1986	62105	108799	500147	174.3	1.112
1987	16597	127387	460352	149.3	0.906
1988	49486	148178	395829	109.3	0.661
1989	53150	111491	553659	166.4	0.833
1990	47391	157863	523678	163.3	0.761
1991	92225	179276	738878	186.6	0.894
1992	39638	229003	806805	296.8	0.934
1993	28505	260001	483395	183.1	0.840
1994	116122	143592	689657	182.0	1.073
1995	36542	172093	921186	236.8	0.587
1996	87246	347822	790427	163.8	0.449
1997	24234	244469	822507	169.7	0.590
1998	34164	307475	486639	57.7	0.299
1999	83554	178906	667775	94.5	0.651
2000	28255	210770	809037	184.4	0.583
2001	25820	275125	458804	65.6	0.266
2002	17496	186952	358696	80.0	0.513
2003	7774	125996	224901	27.1	0.248
2004	9043	96549	155113	13.5	0.157
2005	34986	62523	243979	1.9	0.000
2006	18555	89993	377869	46.6	0.290
2007	30844	156557	359879	5.7	0.025
2008	58515	152368	555462	36.1	0.139
2009	83168	211730	876950	54.5	0.252
2010	8418	350490	824715	126.0	0.422
2011	18241	374134	397866	6.5	0.034
2012		168629			
Arit mean	**43,956**	**209,526**	**596,542**		**0.588**
Geomean	**34,933**				

Table 5.6.1 NORWAY POUT IV and IIIaN (Skagerrak). Input data to forecast May 2011.

Basis: HCR with quarter 1 to 4 2011 (assessment year) and quarter 1 2012 observed exploitation pattern (F=0) and 2012 (forecast year) quarter 3 to quarter 4 fishing pattern scaled to the average 2008-2010 seasonal exploitation pattern (standardized with the 2008-2010 Fbar to F(1,2)=1), and quarter 2 2012 F=0 because the fishery is closed in first half year 2012. Recruitment in forecast year is assumed to the 25% percentile = 24234 millions (of the long term geometric mean 34933 millions) in the 3rd quarter of the year.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2011	1	0	0	0.000	0.000	0.000	0.29	0
2011	1	1	4713	0.000	0.009	0.015	0.29	0.2
2011	1	2	12851	0.000	0.026	0.030	0.39	1
2011	1	3	944	0.000	0.043	0.038	0.44	1
2011	2	0	0	0.000	0.000	0.000	0.29	0
2011	2	1	3527	0.001	0.014	0.020	0.29	0
2011	2	2	8701	0.000	0.025	0.038	0.39	0
2011	2	3	608	0.000	0.038	0.052	0.44	0
2011	3	0	18241	0.000	0.004	0.007	0.29	0
2011	3	1	2638	0.019	0.028	0.022	0.29	0
2011	3	2	5887	0.014	0.038	0.038	0.39	0
2011	3	3	391	0.011	0.051	0.052	0.44	0
2011	4	0	13649	0.000	0.006	0.009	0.29	0
2011	4	1	1936	0.013	0.028	0.031	0.29	0
2011	4	2	3929	0.019	0.040	0.036	0.39	0
2011	4	3	249	0.000	0.058	0.052	0.44	0

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	10212	0.000	0.009	0.016	0.29	0.2
2012	1	2	1429	0.000	0.026	0.030	0.39	1
2012	1	3	2610	0.000	0.043	0.038	0.44	1
2012	2	0	0	0.000	0.000	0.000	0.29	0
2012	2	1	0	0.000	0.014	0.017	0.29	0
2012	2	2	0	0.000	0.025	0.031	0.39	0
2012	2	3	0	0.000	0.038	0.046	0.44	0
2012	3	0	24234	0.001	0.004	0.007	0.29	0
2012	3	1	0	0.143	0.028	0.026	0.29	0
2012	3	2	0	0.999	0.038	0.035	0.39	0
2012	3	3	0	0.127	0.051	0.050	0.44	0
2012	4	0	0	0.074	0.006	0.009	0.29	0
2012	4	1	0	0.234	0.028	0.029	0.29	0
2012	4	2	0	0.349	0.040	0.036	0.39	0
2012	4	3	0	0.007	0.058	0.057	0.44	0

Table 5.6.2 NORWAY POUT IV and IIIaN (Skagerrak). Results of the short term forecast (May 2011) with different levels of fishing mortality. Shaded scenarios are not considered consistent with the precautionary approach of B(MSY)=Bpa..

Results of the short term forecast for Norway pout May 2012.

Basis: HCR with 2011 quarter 1-4 assessment year and 2012 quarter 1 forecast year observed fishing mortality (F) and 2012 quarter 3-4 fishing pattern scaled to the average 2008-2010 seasonal exploitation pattern (standardized with the 2008-2010 Fbar to F(1,2)=1). For 2012 quarter 2 fishing mortality has been set to 0 because of closure of the fishery in the first half year 2012.

Recruitment in forecast year is assumed to the 25% percentile = 24 234 millions (of the long term geometric mean 34 933) in the 3rd quarter of the year.

Basis: F (2011)=F(1,2)=0.034; R(2012) = 25 % percentile of long term recruitment (1983-2011) = ~ 24 billion (3rd quarter); SSB (2012) = 175 kt;

Rationale	**Landings 2012**	**Basis**	**F 2012**	**SSB 2013**	**%SSB change[1)]**
MSY approach	0	MSY $B_{escapement}$	0.00	141	- 19
Precautionary approach	0	B_{pa}	0.00	141	- 19
Zero Catch	0	No fishery	0	141	- 19
Status quo					
	50	Fixed TAC Strat.	0.60	111	-37
	31	Fixed F Strat.	0.35	122	- 30
	86	B_{lim}	1.12	90	- 49

Weights in '000 tonnes.

1) SSB 2013 relative to SSB 2012.

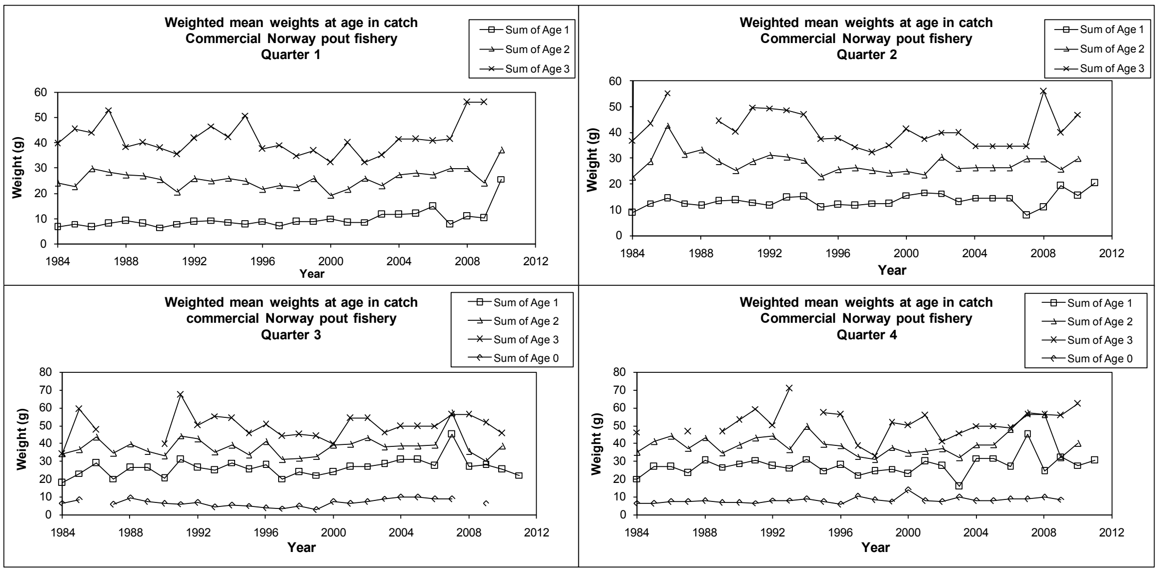


Figure 5.2.1. NORWAY POUT IV and IIIaN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1982-2011.

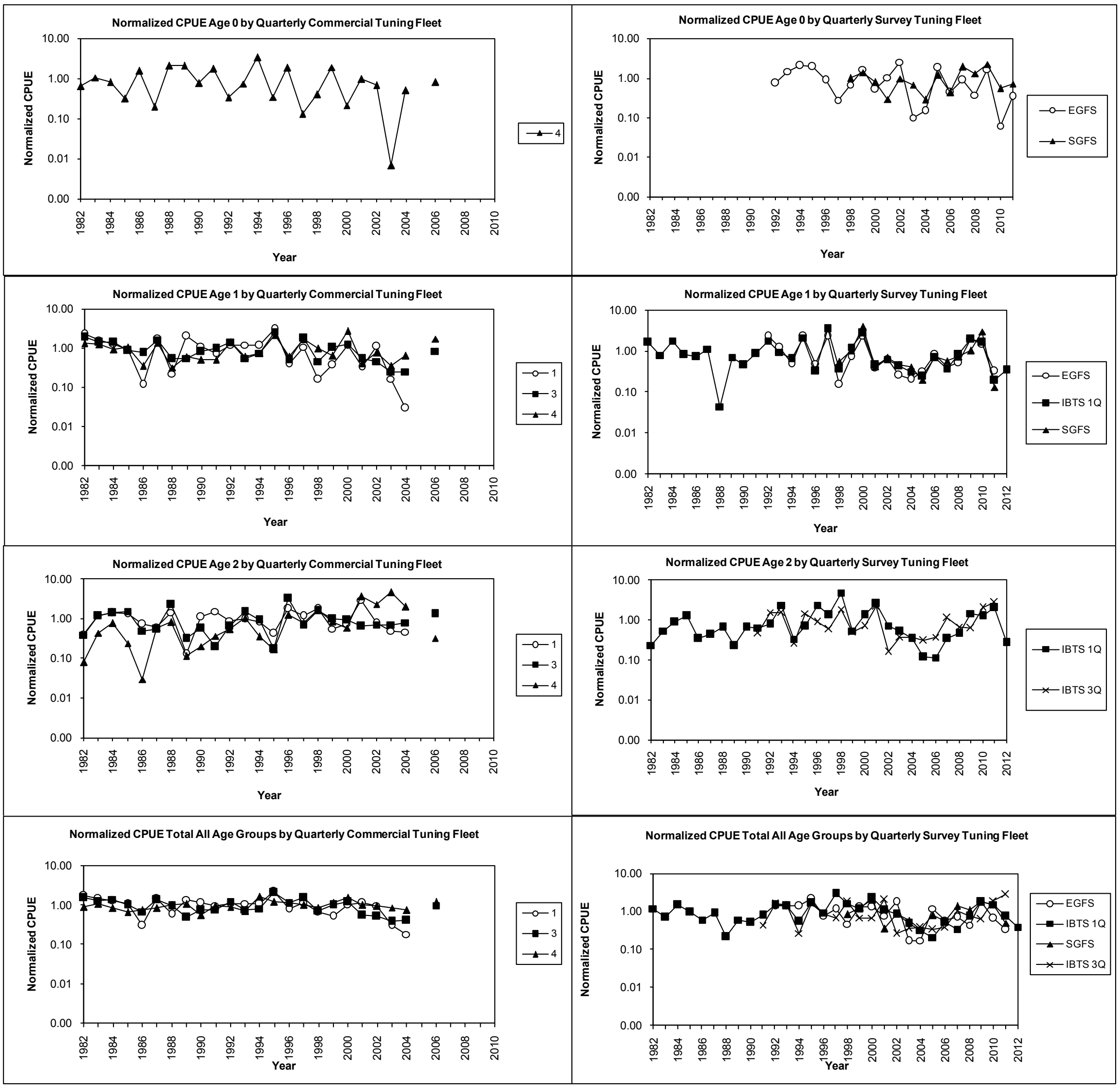


Figure 5.2.2NORWAY POUT IV and IIIaN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly commercial tuning fleet and survey tuning fleet used in the Norway poutSX-SA assessment for each age group and all age groups together.

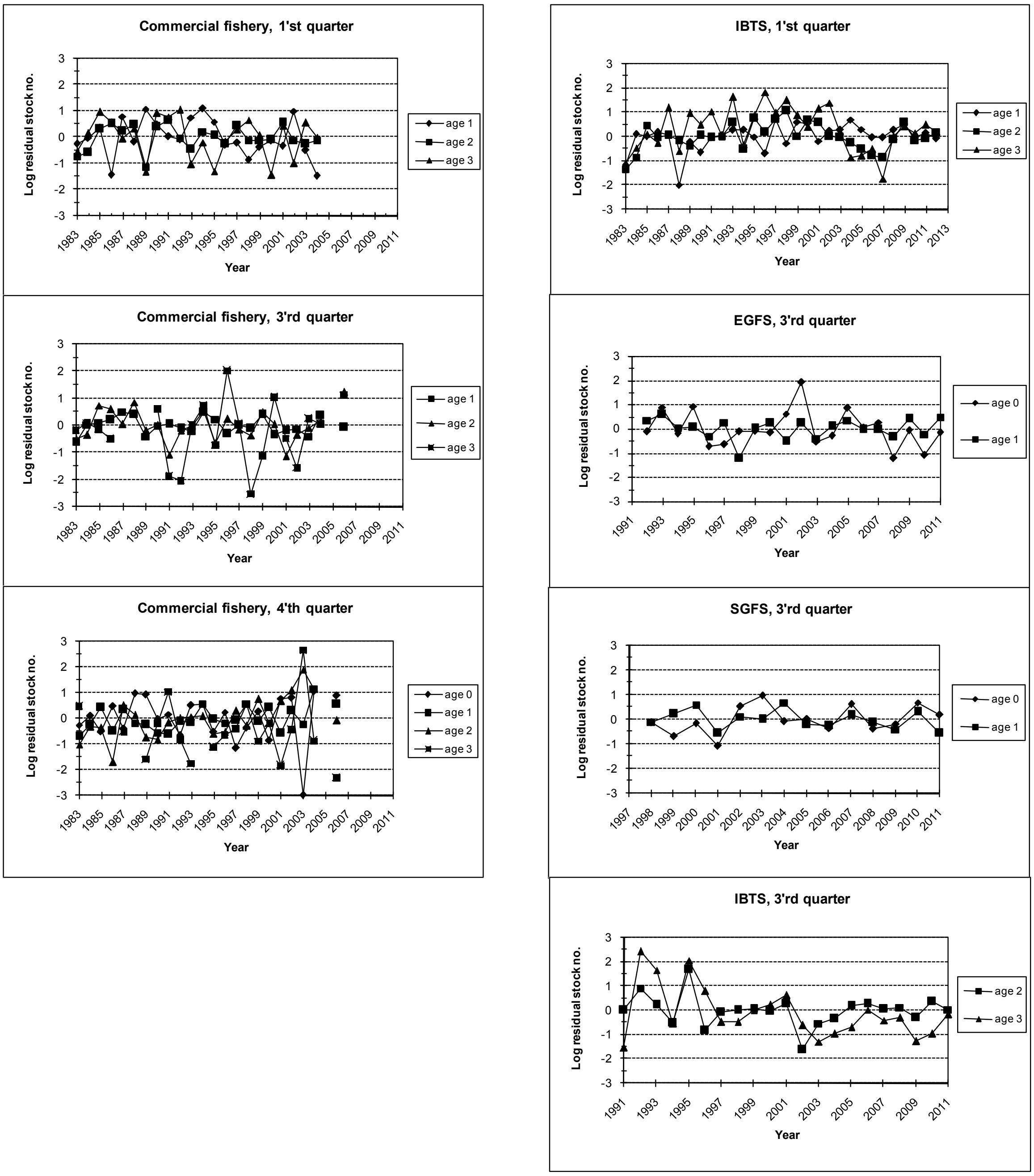


Figure 5.3.1 **Norway pout IV & IIIaN (Skagerrak). Log residual stock numbers (log (Nhat/N)) per age group. SXSA divided by fleet and season.**

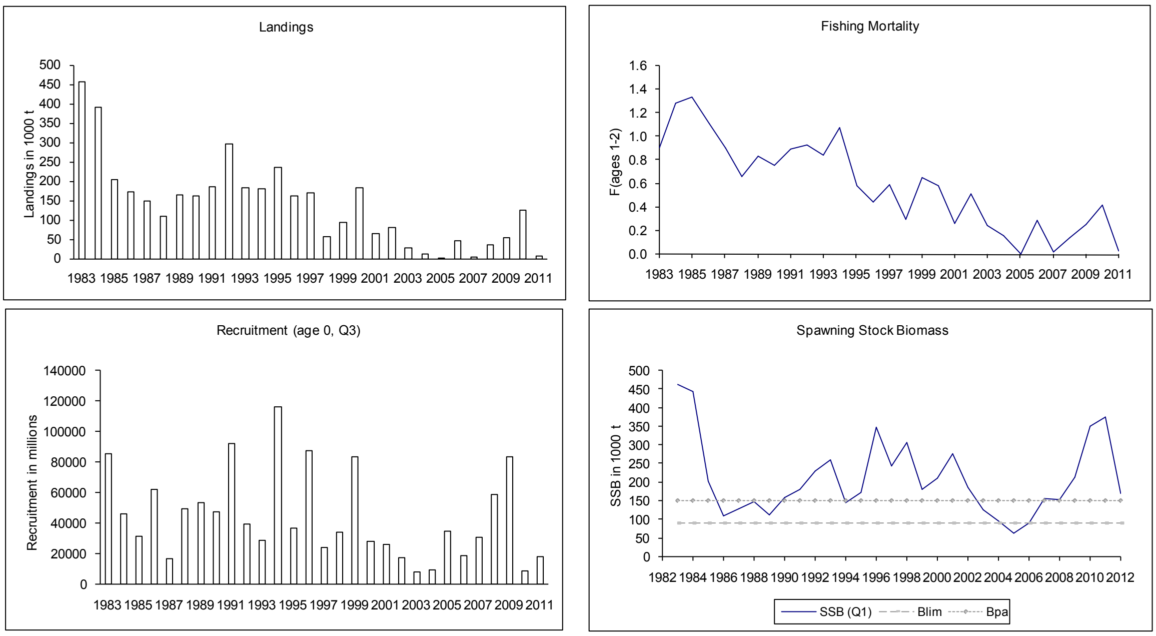


Figure 5.3.2 Norway Pout IV and IIIaN (Skagerrak). Stock Summary Plots. SXSA baseline run May 2012.

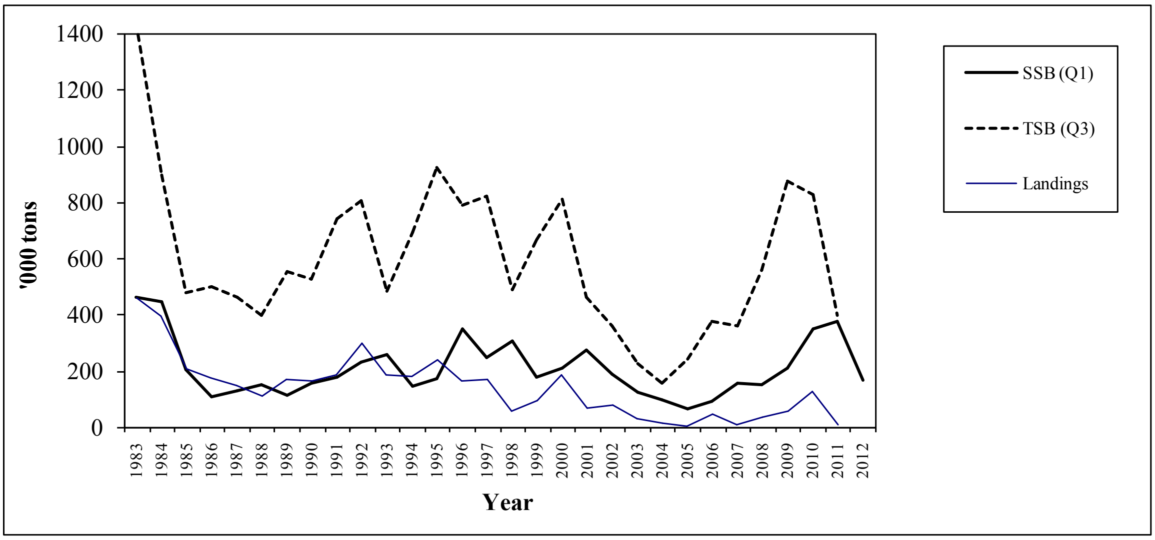


Figure 5.3.3 Norway pout IV & IIIaN (Skagerrak). Trends in yield, SSB and TSB during the period 1983-2012.

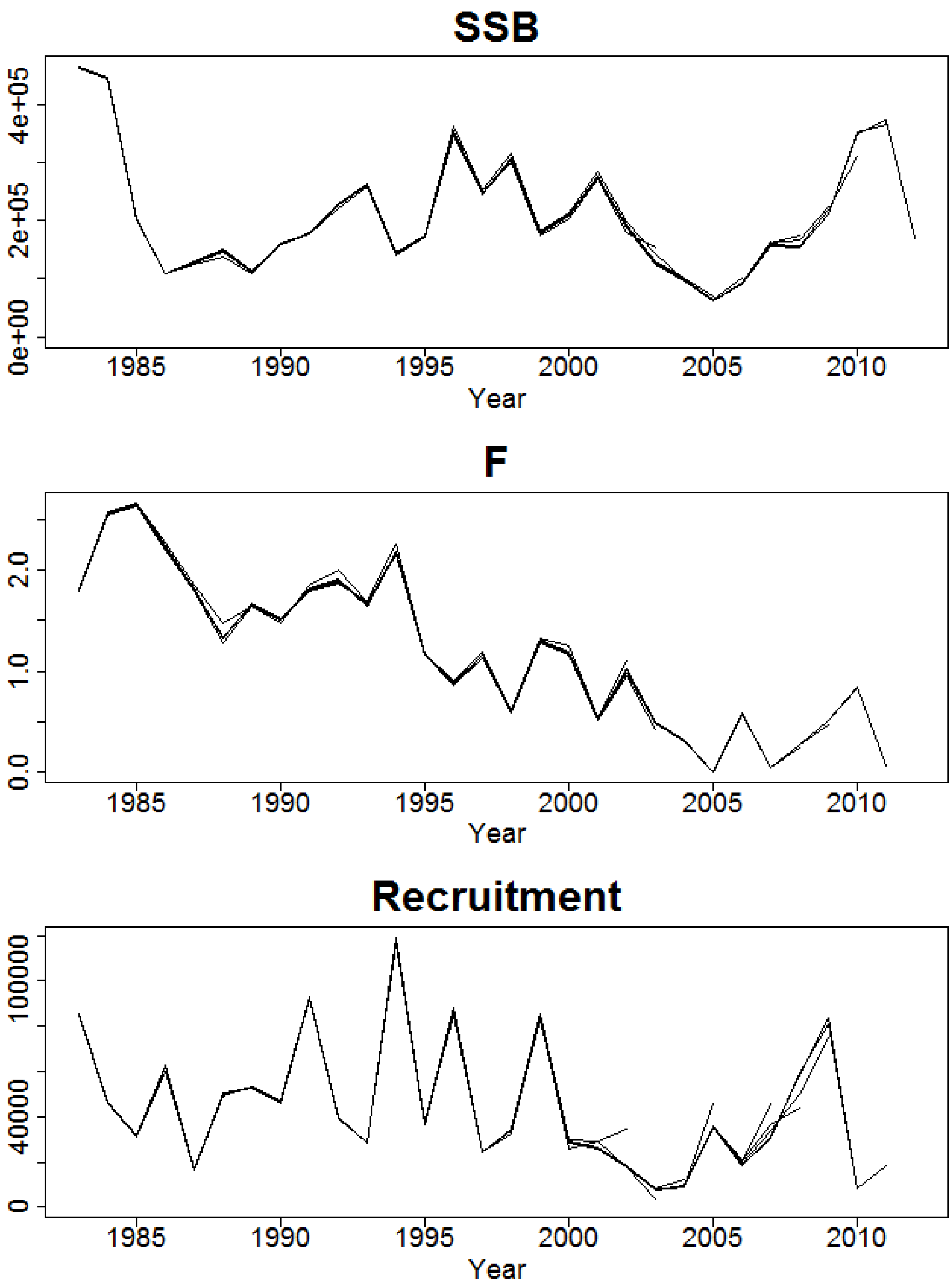


Figure 5.3.4 Norway pout IV & IIIaN (Skagerrak). Retrospective plots of final SXSA assessment May 2012, with terminal assessment year ranging from 2003-2011.

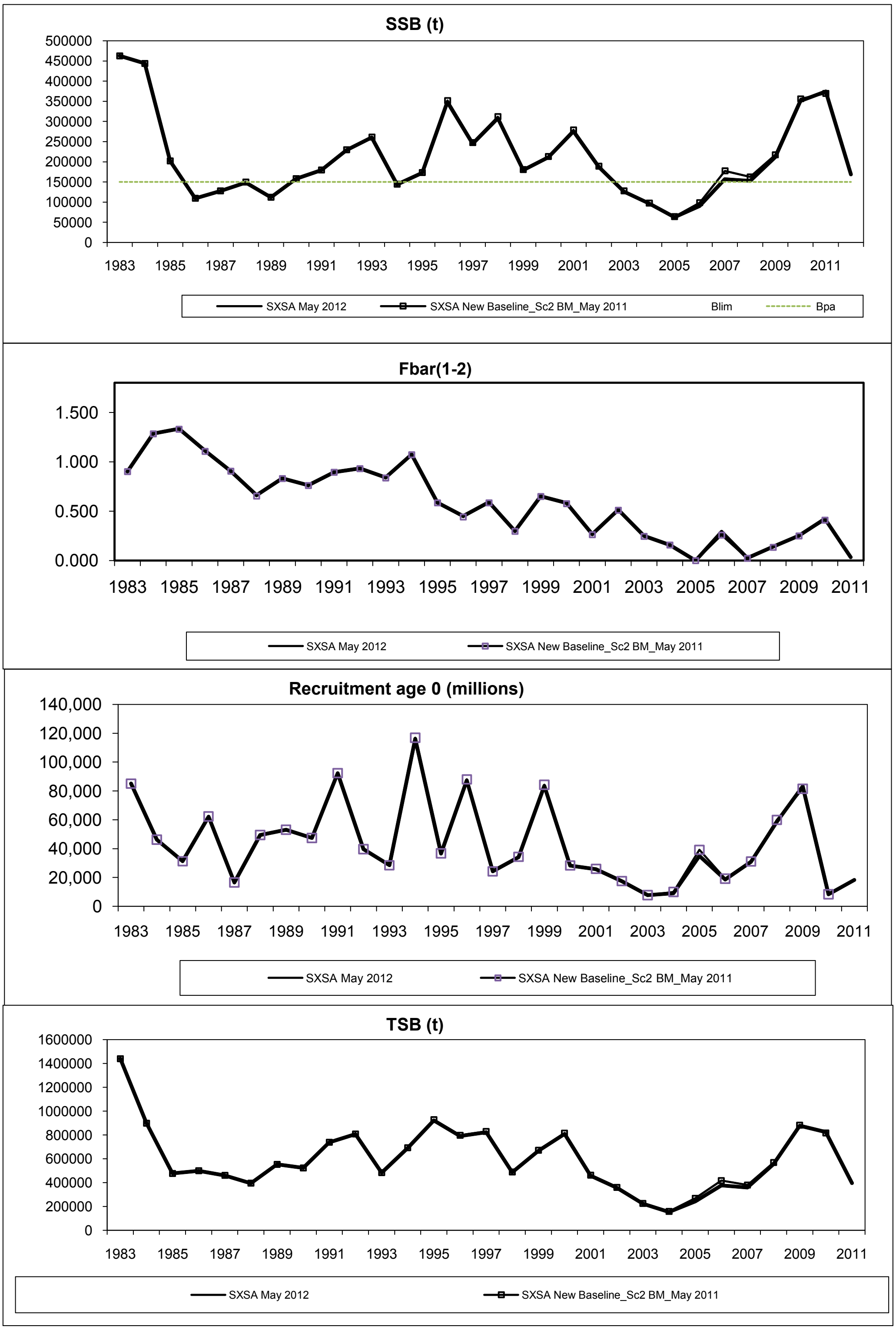


Figure 5.3.5 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2012 SXSA with the new benchmark baseline assessment SXSA May 2011 Scenario 2.

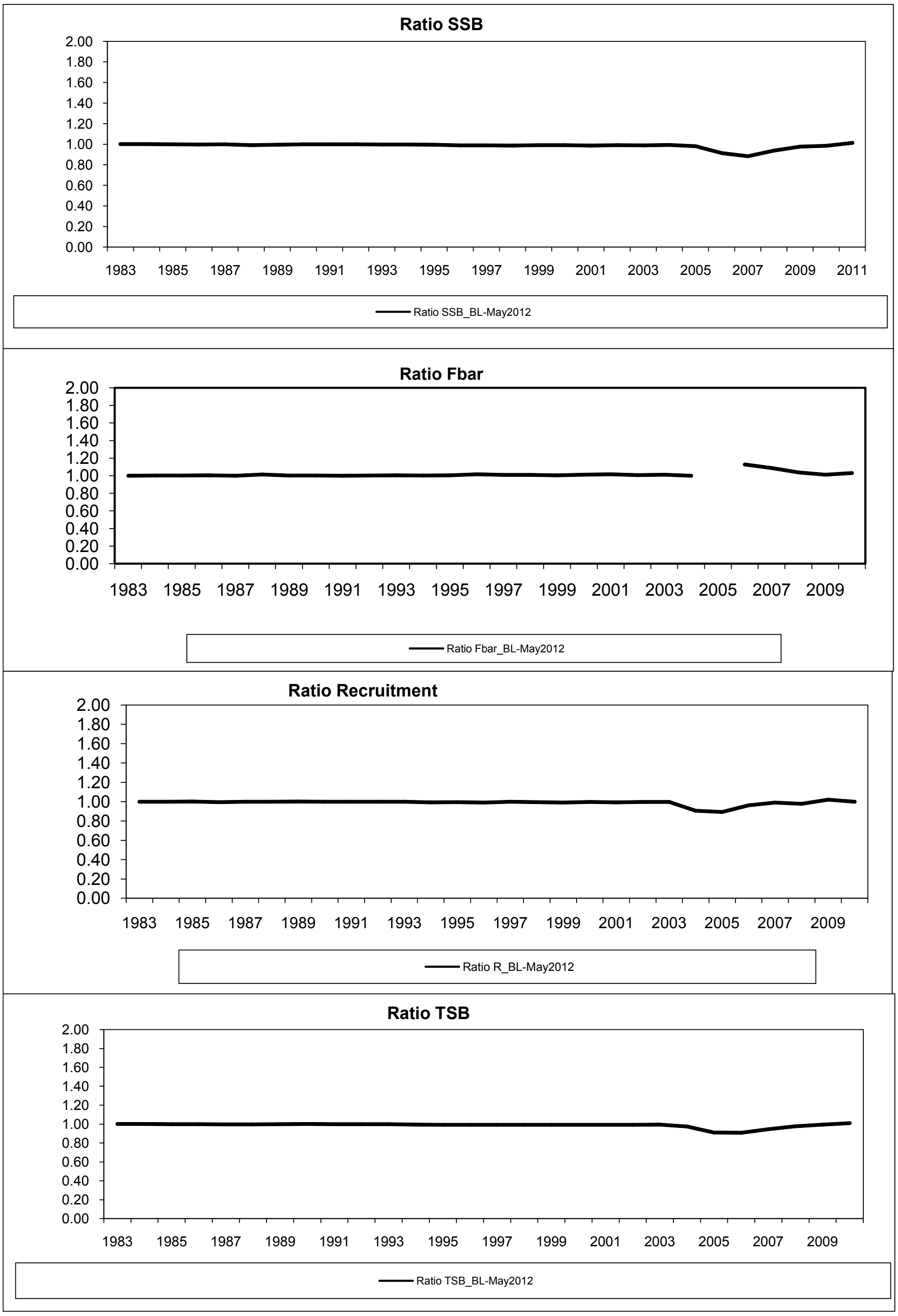


Figure 5.3.6 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2012 SXSA with the new benchmark baseline assessment SXSA May 2011 Scenario 2: Ratios.

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 this year and hardly reliable Fbar values for the last years, the group investigated the input data and found that last years' catches of age 6 and plus are very low and based on very few samples.

The age composition in the catches by country in the last three years are shown in section 6.3.4 and the assessment run with SPALY settings is shown in section 6.3.7.

Another 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 2012.

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 the last years, due to high sole abundances in the Eastern Channel, this fleet is mainly targeting Sole and fish plaice mainly as a by-catch.

The second offshore fleet consists mainly of French large otter trawlers from Boulogne, 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 is usually 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 – 38% of the total recently. In 2011, the beginning of the year remains predominant with the first semester corresponding to 58% of the total landings (see text table below).

Quarter	Landings	Cum, Landings	Cum, %
I	1154	1154	33
II	886	2040	58
III	803	2843	80
IV	694	3537	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 2011 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.

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.

6.1.4 Management

There are no explicit management objectives for this stock.

The TACs have been set to 5050t for 2007-2008, 4646t for 2009, 4274t for 2010 and 4665t for 2011 **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 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. The area's are Kattegat, part of IIIa not covered by Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned 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 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. (see section 1.2.1 for complete list).

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 2011 landings of 3549t (2787t attributed to the resident stock and 750t 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 (56%) of the total VIId landings in 2011 followed by Belgium (29%) and UK (13%) 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 2003-2011 are available from France, Belgium and UK although sampling levels are not high. Discard at age were uploaded in InterCatch for the first time this year and Figure 6.2.1.1 shows the age structure of sampled discards and estimated discards by metiers.

As shown in previous year report, although the series may appear long enough (2003-2011),but, 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.

An average total mortality Z of 1.03 is estimated from catch curves slopes (figure 6.2.1.2).

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 2011 are 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 weight 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 remained stable since then.

6.3 Data analyses

6.3.1 Reviews of last years assessment

In 2011, RGNSSK stated that:

1) Assessment type: Update
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: Last year assessment accepted ONLY for trends. Settings in XSA assessment were the same as 2010. Retrospective patterns in F (underestimation) and SSB (overestimation) seem minor.

6) Stock status: Trends only, reference points no longer valid for advice. SSB (3,945t) < Blim (5400t)<Bpa (8,000t) and Fpa (0.45) < Fbar (0.46) < Flim (0.54). F is stable for the last 5 years. SSB increasing tend in the last 3 years after a stepped decline in the previous 10 years. F declining trend after a peak in recruitment in 2009.

7) Management Plan: No explicit management objectives for this stock. The TAC for 2011 is set at 4,665t.

General comments

The assessment is only accepted for trends avoid using absolute quantities for SSB.

Absolute values for landings could be valid because, the absolute values are known in the historic period. The stock annex indicates that no short-term forecast has been provided since 2005, this is not true. The elements of plaice biology tacked on at the end of the stock annex should be incorporated into the document.

The WG recognizes that there are stock identification problems with this stock. Report Page 311, 6.2.1, bottom of section: “total fish mortality” should be “total mortality”.

Technical comments

There are some weights at age issues for older ages (Figure 6.2.3.1).

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.

Conclusions

The RG agrees with the WG conclusions for this stock. An integrated plaice assessment for all stocks from the English Channel to the Baltic should be explored.

Suggestions for future benchmarks:

Reconstruct the discards time series.

Model the weight at age to avoid overlap of ages 7 and older.

Try the SCA model used in North Sea Plaice that estimates discards and abundance in an integrated way.

Given the pattern in the log-catchability residuals, run the XSA splitting the UB BTS and FR GF surveys, one piece up to 1999 and the other run from 2000 onwards. Analyze if the goodness of fit improves. Having undesirable residuals is not, in principle, a justification to split the indices, is there a qualitative justification (changes in catchability of the indices) to do it?

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

Last years assessment included exploratory SURBA and SURBAR runs. 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 year’s assessment SURBAR runs were not executed.

6.3.4 Impact of the plus group

The effect of setting the plus-group at different ages was studied by running XSA with either a plus group at age 10 or at 7. The proportion of fish older than 7 found in the catches has decreased in the recent years (Fig. 6.3.4.1) for all countries supplying age data. This can lead to inconsistencies in the resultant XSA numbers at age matrix that affect the estimate of SSB such as in 2011 (fig. 6.3.4.2).

Setting the plus group to 7 reduce the retrospective patterns and is considered to improve the quality of the assessment.

6.3.5 Exploratory SAM analyses

SAM runs were made as explanatory analysis. SAM assumed to be less sensitive to the plus-group definition.

Figure 6.3.5.1 shows that runs including both plus group definitions were very similar and trends were very similar to XSA run with a plus group set to 7 with a decrease of the fishing mortality from the late 90’s to its lowest level of the time-series and an increase of the SSB in the latest years. Trends in the residuals already observed in XSA residuals are also present in SAM runs.

6.3.6 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 6.3.6.1 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 is the first semester. A part of the annual dynamic of the stock seems to be missing in the survey indices.

The adjustment of the plus group from age 10 to 7 has reduced consequently the retrospective bias and is considered to improve the quality of the assessment.

6.3.7 Final assessment

The settings in the XSA assessment:

Year of assessment:		2011	2012
Assessment model:		XSA	XSA
Assessment software		FLR library	FLR library
Fleets:			
BE Beam Trawlers Age range		2–10	2–5
UK Beam Trawl Survey	Age range	1–6	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:		1–10+	1–7+
Landings data:		1980–2009	1980–2010
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 7	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 6.3.5.4. Retrospective patterns for the final run are shown in Figure 6.3.6.2

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 2010 year class used for predictions was calculated as the geometric mean recruitment over the period 1999-2009, applying the observed fishing mortality of age 1 in 2011 to get the number of age 2 in 2012.

The 2011 and 2012 year classes were estimated using the average recruitment calculated over the period 1999–2009. 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 beginning 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
2009	2	23245	**10205**	10205
20010	1	-	**12652**	GM (1999-09)

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 2012 is XSA survivors estimates. Age 1 and 2 are taken from the long term geometric mean (1999-2009).

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 2012 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 $F_{MSY\text{-}proxy}$,(see section 6.8) assuming that F is at $F_{MSY\text{-}proxy}$ level after 3 years and using the formula provided by ICES 2012:

$$F_{y+1} = (1-\omega)F_{\mathrm{SQ}} + \omega F_{\mathrm{MSY-proxy}}$$

Where $\omega = \min[\frac{y-Y+1}{n};\ 1]$

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 2012 in VIId (including component from IV and VIIe) of 3415t (the agreed TAC is 4625t for both VIId and VIIe) and a catch of 3449t in 2013. it will result in a spawning biomass resident in VIId in 2013 and 2014 of 7468t and 8592t , 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 2013 of 3742. It will result in a spawning biomass resident in VIId in 2013 and 2014 of 7468t and 8395t , respectively. In 2015 $F_{MSY\text{-}proxy}$ is nearly reached with a Fbar at 0.24.

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 software for three alternative stock-recruit models are presented in Figure 6.8.1-5 and Table 8.8.1. 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 2012, 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.
- 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.

EU Council Regulation (EC) N°43/2012 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 in 2012 and consequently on plaice that is caught as by catch in this fishery.

Sources

Burt, G., D. Goldsmith, and M. Armstrong. 2006. A summary of demersal fish tagging data maintained and published by Cefas. Sci. Ser. Tech Rep., Cefas Lowestoft, 135: 40pp.

Hunter, E. J. D. Metcalfe, G. P. Arnold and J. D. Reynolds. 2004. Impacts of migratory behaviour on population structure in North Sea plaice. *Journal of Animal Ecology* 73, 377–385.

Kell L.T., R. Scott, and E. Hunter. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51, 287– 299.

ICES 2012. Report of the Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). ICES CM 2012/ACOM:36

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

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

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.

2012-05-03 15:00:36 units= thousands

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

Table 6.2.2.2. Plaice in VIId. Landings in numbers (thousands) by quarter for 2010, not taking into account the first quarter removal.

		1	2	3	4	5	6	7+
Quarter	1	4	331	490	184	139	21	19
	2	18	1304	962	266	97	9	33
	3	36	1064	753	292	90	13	26
	4	7	835	614	224	106	9	19

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

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

Table 6.2.5.1. Plaice in VIId. Tuning fleets

UK	BTS		
1 988	2011		
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

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

FR	GFS		
1988	2011		
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	

Table 6.2.5.1.(cont.) Plaice in VIId. Tuning fleets

BE	CBT								
1981	2011								
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

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 2012-05-03 15:00:36

CPUE data from indices

Catch data for 32 years. 1980 to 2011. Ages 1 to 7.

   fleet first age last age first year last year alpha beta
1 BE CBT         2        5       1981      2011     0    1
2 UK BTS         4        6       1988      2011   0.5 0.75
3 FR GFS         2        3       1988      2011  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   2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
  all    1    1    1    1    1    1    1    1    1    1

 Fishing mortalities
   year
age  2002  2003  2004  2005  2006  2007  2008  2009  2010  2011
  1 0.063 0.054 0.095 0.037 0.059 0.067 0.038 0.031 0.024 0.044
  2 0.561 0.421 0.529 0.400 0.403 0.447 0.400 0.397 0.336 0.174
  3 1.010 1.299 0.746 0.745 0.602 0.603 0.539 0.735 0.624 0.390
  4 1.281 0.911 0.539 0.591 0.659 0.564 0.509 0.616 0.594 0.493
  5 1.144 0.853 0.392 0.485 0.472 0.662 0.388 0.410 0.275 0.386
  6 0.506 0.787 0.851 0.328 0.406 0.423 0.432 0.413 0.356 0.068
  7 0.506 0.787 0.851 0.328 0.406 0.423 0.432 0.413 0.356 0.068
```

Table 6.3.5.1. (cont.) Plaice in VIId. XSA diagnostics

XSA population number (NA)

	age						
year	1	2	3	4	5	6	7
2002	15547	12289	6593	1991	1766	1596	758
2003	12979	13209	6345	2174	500	509	631
2004	11273	11130	7845	1566	791	193	437
2005	9389	9281	5934	3367	827	484	780
2006	9369	8187	5632	2550	1686	461	633
2007	12800	7993	4950	2792	1193	952	470
2008	10160	10831	4626	2451	1437	557	640
2009	16181	8851	6567	2441	1334	882	881
2010	26316	14193	5383	2850	1193	801	974
2011	1614	23246	9175	2609	1424	820	1546

Estimated population abundance at 1st Jan 2012

	age						
year	1	2	3	4	5	6	7
2012	0	1398	17671	5621	1442	876	693

Fleet: BE CBT

Log catchability residuals.

	year									
age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
2	-0.095	-0.182	0.413	-1.336	0.356	0.461	0.298	-0.019	-2.053	0.279
3	0.363	-0.309	0.123	0.066	-0.046	0.045	-0.414	-0.110	-0.418	0.484
4	0.497	0.115	0.375	0.272	0.188	-0.164	-0.306	-0.430	-0.022	-0.048
5	-0.087	0.180	-0.222	0.048	-0.774	-0.020	-0.379	-0.736	0.337	-0.050

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
2	0.903	1.184	0.379	0.831	-1.773	-0.311	NA	-0.960	-1.527	-1.489
3	0.881	0.614	-0.099	0.150	0.119	-0.088	-1.496	-0.283	0.000	-0.902
4	0.223	-0.028	-0.247	0.761	0.236	0.276	0.588	0.284	0.466	-1.102
5	0.289	-0.191	0.132	0.454	0.449	0.557	1.377	0.599	0.738	-0.427

	year										
age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	0.321	0.233	0.112	0.106	0.053	0.385	0.847	0.596	0.993	0.732	0.265
3	0.930	0.480	0.530	0.221	-0.207	-0.295	-0.267	0.008	-0.046	0.235	-0.269
4	0.224	0.508	0.202	-0.226	-0.271	-0.152	-0.464	-0.030	-0.915	-0.219	-0.589
5	-0.066	0.517	0.296	-0.271	0.047	-0.319	0.090	-0.515	-0.611	-0.458	-0.982

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	-7.3073	-5.8195	-5.4773	-5.4563
S.E_Logq	0.8606	0.4809	0.4259	0.5063

Fleet: UK BTS

Log catchability residuals.

	year											
age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
4	-0.256	0.288	-0.565	-0.108	0.356	-0.501	0.259	-0.312	-1.377	-1.377	-0.274	-0.743
5	0.473	-0.247	-0.016	-0.278	0.597	0.067	0.314	-0.404	-0.602	-0.994	-0.897	-0.540
6	0.117	0.105	0.051	0.007	0.190	-0.047	-0.031	-0.034	-0.109	-0.432	-0.045	-0.050

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
4	0.388	0.370	0.644	0.140	0.396	0.771	-0.047	-0.030	-0.196	0.517	0.794	0.863
5	0.243	0.711	-0.170	0.793	-0.526	0.657	-0.173	-0.134	-0.188	0.231	0.194	0.889
6	0.066	0.170	0.201	0.041	-0.334	0.214	-0.095	0.106	0.050	0.272	0.186	0.371

```
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 -6.1301 -5.9454 -5.9454
S.E_Logq   0.6115  0.5246  0.1786
Fleet:  FR GFS

 Log catchability residuals.

   year
age  1988   1989   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999  2000
  2 0.267 -0.403 -1.613 -0.916 -0.589 -0.014 -0.654 -0.634 -1.208 -0.398 -0.107 -0.314 1.024
  3 0.104 -0.834 -0.362 -0.786  0.230  0.453 -1.300 -0.349 -2.015  0.421 -0.440  0.330 0.332

    2001   2002 2003  2004  2005  2006  2007  2008   2009  2010  2011
2 -0.530 0.109 0.283 0.538 0.894 0.798 0.719 1.178  0.424 0.706 0.44
3 -0.221 0.714 0.042 0.591 1.282 0.628 0.704 0.352 -0.157 0.051 0.23

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 -7.0760 -7.3164
S.E_Logq   0.7373  0.7169Table 6.3.5.1. (cont.) Plaice in VIId. XSA diagnostics
Fleet:  IN YFS
 Log catchability residuals.

   year
age  1987  1988  1989  1990   1991  1992 1993 1994  1995   1996   1997  1998
  1 0.198 0.315 0.067 0.039 -0.254 0.575 0.51 0.25 0.653 -0.441 -0.495 0.472

age  1999   2000  2001  2002   2003  2004   2005   2006
  1 0.168 -0.275 0.137 0.215 -1.137 0.391 -0.986 -0.402

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                1
Mean_Logq -9.8480
S.E_Logq   0.4972

Terminal year survivor and F summaries:

 Age 1 Year class = 2010

source
survivors         N scaledWts
     1398         1         1

 Age 2 Year class = 2009

source
       survivors N scaledWts
BE CBT     23032 1     0.307
FR GFS     27435 1     0.414
fshk        6878 1     0.279

 Age 3 Year class = 2008

source
       survivors N scaledWts
BE CBT      5157 2     0.526
FR GFS      8570 2     0.322
fshk        3100 1     0.152

 Age 4 Year class = 2007

source
       survivors N scaledWts
BE CBT      1104 3     0.580
UK BTS      3418 1     0.185
FR GFS      1754 2     0.118
fshk        1141 1     0.118
```

Table 6.3.5.1. (cont.) Plaice in VIId. XSA diagnostics

Age 5 Year class = 2006

source

	survivors	N	scaledWts
BE CBT	516	4	0.529
UK BTS	2074	2	0.322
FR GFS	1257	2	0.053
fshk	740	1	0.096

Age 6 Year class = 2005

source

	survivors	N	scaledWts
BE CBT	420	4	0.267
UK BTS	983	3	0.633
FR GFS	1132	2	0.031
IN YFS	464	1	0.024
fshk	92	1	0.046

Table 6.3.5.2. Plaice in VIId. Fishing mortality (F) at age

Plaice in VIId (run: XSAAEDB01/X01) : harvest

2012-05-03 15:00:36 units= f age

year	1	2	3	4	5	6	7
1980	0.003	0.210	0.316	0.534	0.909	0.589	0.589
1981	0.002	0.148	0.814	0.954	0.532	0.770	0.770
1982	0.016	0.183	0.544	0.945	0.804	0.814	0.814
1983	0.007	0.198	0.560	0.965	0.660	0.522	0.522
1984	0.020	0.148	0.676	1.082	0.824	0.907	0.907
1985	0.007	0.383	0.674	1.040	0.374	0.628	0.628
1986	0.016	0.267	0.763	0.844	0.903	1.162	1.162
1987	0.001	0.227	0.573	0.834	0.684	0.658	0.658
1988	0.001	0.244	0.742	0.704	0.611	0.637	0.637
1989	0.076	0.218	0.461	0.807	0.933	0.678	0.678
1990	0.125	0.281	0.781	0.664	0.724	0.724	0.724
1991	0.103	0.625	0.982	0.949	0.541	0.805	0.805
1992	0.085	0.552	0.948	0.755	0.603	0.419	0.419
1993	0.080	0.503	0.547	0.594	0.487	0.452	0.452
1994	0.103	0.506	0.811	0.901	0.908	0.778	0.778
1995	0.150	0.461	0.680	0.747	0.639	0.581	0.581
1996	0.053	0.350	0.600	0.721	0.898	0.748	0.748
1997	0.022	0.225	0.849	1.578	1.681	1.931	1.931
1998	0.048	0.189	0.658	1.021	1.060	0.991	0.991
1999	0.057	0.211	0.768	1.273	0.907	1.209	1.209
2000	0.113	0.734	0.562	0.784	0.643	0.432	0.432
2001	0.189	0.415	0.867	0.547	0.558	0.313	0.313
2002	0.063	0.561	1.010	1.281	1.144	0.506	0.506
2003	0.054	0.421	1.299	0.911	0.853	0.787	0.787
2004	0.095	0.529	0.746	0.539	0.392	0.851	0.851
2005	0.037	0.400	0.745	0.591	0.485	0.328	0.328
2006	0.059	0.403	0.602	0.659	0.472	0.406	0.406
2007	0.067	0.447	0.603	0.564	0.662	0.423	0.423
2008	0.038	0.400	0.539	0.509	0.388	0.432	0.432
2009	0.031	0.397	0.735	0.616	0.410	0.413	0.413
2010	0.024	0.336	0.624	0.594	0.275	0.356	0.356
2011	**0.044**	**0.174**	**0.390**	**0.493**	**0.386**	**0.068**	**0.068**

Table 6.3.5.3. Plaice in VIId. Stock number at age

Plaice in VIId (run: XSAAEDB01/X01) : stock.n
2012-05-02 12:38:55 units= NA

year	age 1	2	3	4	5	6	7
1980	18250	12975	4177	922	571	119	312
1981	8555	16463	9518	2756	489	208	462
1982	17555	7726	12841	3817	960	260	335
1983	14047	15632	5819	6744	1343	389	551
1984	18787	12623	11599	3008	2325	628	547
1985	21564	16667	9849	5336	923	923	673
1986	43634	19377	10280	4541	1707	574	374
1987	23818	38836	13429	4337	1767	626	1111
1988	19121	21528	27998	6852	1704	807	1245
1989	11857	17286	15268	12058	3067	837	1055
1990	14652	9943	12583	8715	4867	1092	1160
1991	16609	11705	6789	5213	4061	2134	809
1992	21504	13562	5667	2301	1825	2140	2277
1993	10171	17874	7067	1987	979	904	1674
1994	13376	8499	9781	3701	993	544	1509
1995	19577	10922	4637	3933	1360	363	1404
1996	22648	15248	6235	2126	1687	650	1160
1997	26803	19429	9724	3097	935	622	874
1998	10358	23730	14035	3764	578	158	480
1999	14107	8931	17773	6577	1227	181	331
2000	13652	12060	6544	7459	1666	448	423
2001	16401	11038	5237	3374	3081	793	567
2002	15547	12289	6593	1991	1766	1596	758
2003	12979	13209	6345	2174	500	509	631
2004	11273	11130	7845	1566	791	193	437
2005	9389	9281	5934	3367	827	484	780
2006	9369	8187	5632	2550	1686	461	633
2007	12800	7993	4950	2792	1193	952	470
2008	10160	10831	4626	2451	1437	557	640
2009	16181	8851	6567	2441	1334	882	881
2010	26316	14193	5383	2850	1193	801	974
2011	1614	23246	9175	2609	1424	820	1546

Table 6.3.5.4. Plaice in VIId. Summary table

	recruitment	ssb	catch	landings	tsb	fbar3-6	Y/ssb
1980	18250	3170	2060	2060	10922	0.587	0.65
1981	8555	4026	3706	3706	9454	0.767	0.92
1982	17555	4753	3781	3781	9883	0.777	0.80
1983	14047	5106	3919	3919	9904	0.677	0.77
1984	18787	4495	4010	4010	9188	0.872	0.89
1985	21564	4983	4680	4680	10490	0.679	0.94
1986	43634	5718	5311	5311	15080	0.918	0.93
1987	23818	8504	6502	6502	21760	0.687	0.76
1988	19121	8580	8098	8098	16696	0.673	0.94
1989	11857	9104	6807	6807	14380	0.720	0.75
1990	14652	9546	7031	7031	14760	0.723	0.74
1991	16609	6357	6072	6072	11858	0.819	0.96
1992	21504	6065	4925	4925	11670	0.681	0.81
1993	10171	4710	4143	4143	10742	0.520	0.88
1994	13376	4814	4757	4757	9769	0.849	0.99
1995	19577	4518	3987	3987	10010	0.661	0.88
1996	22648	4090	4191	4191	11889	0.742	1.02
1997	26803	4206	4872	4872	10326	1.510	1.16
1998	10358	4888	4467	4467	11584	0.932	0.91
1999	14107	5395	4951	4951	9588	1.039	0.92
2000	13652	4034	4294	4294	7550	0.605	1.06
2001	16401	4561	4083	4083	8739	0.571	0.90
2002	15547	4415	4256	4256	9054	0.985	0.96
2003	12979	2798	3665	3665	7051	0.962	1.31
2004	11273	2885	3183	3183	7570	0.632	1.10
2005	9389	3324	2722	2722	6603	0.537	0.82
2006	9369	3321	2643	2643	6530	0.535	0.80
2007	12800	3174	2889	2889	6948	0.563	0.91
2008	10160	3222	2763	2763	7780	0.467	0.86
2009	16181	4013	2889	2889	6596	0.543	0.72
2010	26316	3874	3204	3204	7613	0.462	0.83
2011	**1614**	**6302**	**2787**	**2787**	**13122**	**0.334**	**0.44**

Table 6.6.1. Plaice in VIId. Input to catch forecast

Age	Stock	Mat	M	F
1	12652	0	0,1	0,02
2	10957	0,15	0,1	0,2
3	7757	0,53	0,1	0,38
4	5621	0,96	0,1	0,37
5	1441	1	0,1	0,23
6	876	1	0,1	0,18
7	2000	1	0,1	0,18

Table 6.6.2.1 Plaice in VIId. Management option table following ICES 2012 recomendations

year	2012	2013	2014	2015
landings with Q1 removal	2620	2646	2623	2750
Total landings VIId (including component from IV and VIIe)	3415	3449	3420	3585
Fbar	0,29	0,27	0,24	0,23
ssb	6591	7468	8592	10129
Changes in TAC	-	1%	-1%	5%
Changes in SSB		13%	15%	18%

Table 6.6.2.2 Plaice in VIId. Management option table (TAC = average landings for 3 past years)

year	2012	2013	2014	2015
landings with Q1 removal	2620	2870	2759	2750
Total landings VIId (including component from IV and VIIe)	3415	3742	3597	3585
Fbar	0,29	0,3	0,26	0,24
ssb	6591	7468	8395	9762
Changes in TAC	-	10%	-4%	0%
Changes in SSB		13%	12%	16%

Table 6.8.1. Eastern Channel Plaice. Results of stochastic stock recruit fits for three different models (Ricker, Beverton-Holt and Smooth hockeystick/segmented regression) and per-recruit analyses.

Ricker

1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0,87634	0,44580	9,57298	5,09959	1,15880	0,36797	5,52812	0,11499	50,43020
Mean	0,99578	0,50224	13,08950	6,24077	1,19372	0,39210	6,00231	0,12253	52,46558
5%ile	0,55745	0,26845	5,08788	3,42699	0,96667	0,11694	3,73355	0,03654	50,54204
25%ile	0,71123	0,35763	6,81381	4,19087	1,08885	0,28282	4,83199	0,08838	51,03005
50%ile	0,86702	0,44712	8,81633	5,00080	1,18203	0,39123	5,77567	0,12226	51,89160
75%ile	1,09551	0,56646	12,57923	6,13301	1,29148	0,50565	6,96186	0,15802	53,25673
95%ile	1,79570	0,86921	29,63713	11,18260	1,46005	0,65821	9,05680	0,20569	56,17356
CV	0,52247	0,48686	1,58091	1,07961	0,12965	0,41730	0,27914	0,41730	0,03695
N	995	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000

Beverton-Holt

1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0,99672	0,20092	40,78030	7,59599	0,37626	0,86738	28,08150	4,17681	51,05900
Mean	1,40196	0,23260	215,34156	11,74705	0,38848	0,88945	44,26922	9,77477	52,92549
5%ile	0,55291	0,02007	11,17830	3,64532	0,10217	0,72208	15,69915	0,60449	51,17281
25%ile	0,75814	0,12870	21,85328	5,27553	0,25806	0,80874	20,48810	1,94381	51,62880
50%ile	1,00529	0,19578	44,12750	7,42169	0,39146	0,87613	26,99165	4,00323	52,48410
75%ile	1,50344	0,29734	132,87475	11,92885	0,51572	0,95660	40,94370	8,23103	53,53020
95%ile	5,00000	0,52810	923,78155	30,03479	0,67303	1,10081	103,41540	29,57847	56,17792
CV	0,79523	0,80972	3,11797	1,97709	0,44683	0,12970	2,64320	4,40147	0,03501
N	945	999	999	999	1 000	1 000	1 000	1 000	1 000

Smooth hockeystick

1000/1000 Iterations resulted in feasible parameter estimates

	Fcrash	Fmsy	Bmsy	MSY	ADMB Alpha	ADMB Beta	Unscaled Alpha	Unscaled Beta	AICc
Deterministic	0,6552	0,2637	20,0429	5,2285	0,52318	1,00624	1,72748	4,99976	48,6336
Mean	0,701	0,3554	87,31742	5,97052	0,540124815	1,06203546	1,78343106	5,2769884	51,2072369
5%ile	0,4441	0,0224	4,711726	3,52632	0,44885855	0,7178899	1,4820795	3,56701	48,915795
25%ile	0,5444	0,1588	8,163978	4,48469	0,4926435	0,9074235	1,6266525	4,5087625	49,5634
50%ile	0,6422	0,2834	16,3615	5,42693	0,529351	1,027765	1,747855	5,10671	50,7326
75%ile	0,7793	0,5064	41,30378	6,89872	0,57523875	1,173205	1,8993775	5,829355	52,199225
95%ile	1,1643	0,8524	504,2338	10,4996	0,6642798	1,505429	2,193382	7,480075	55,27609
CV	0,3579	0,7952	2,086788	0,36004	0,131538735	0,2224289	0,131538783	0,222428938	0,04187193
N	1000	1000	1000	1000	1000	1000	1000	1000	1000

Per recruit

	F35	F40	F01	Fmax	Bmsypr	MSYpr
Deterministic	0,1397	0,1186	0,143994	0,26366	1,1603	0,302681
Mean	0,1425	0,1218	0,184713	0,99143	4,701267663	0,32365986
5%ile	0,0019	0,0015	0,002204	0,02409	0,27729845	0,21405825
25%ile	0,0837	0,0687	0,078457	0,19382	0,45357825	0,254342
50%ile	0,1495	0,1268	0,149961	0,38552	0,903495	0,292708
75%ile	0,2044	0,1757	0,268812	1,40911	2,2504475	0,35390025
95%ile	0,2706	0,2342	0,473007	3	26,603185	0,54160865
CV	0,59	0,599	0,793231	1,16688	2,084204516	0,3274117
N	1000	1000	1000	767	1000	1000

Combining all SRRs

Percentage	Fmsy	Fcrash
5%	0,0258	0,4923
25%	0,1852	0,6374
50%	0,3228	0,8088
75%	0,4876	1,0929
95%	0,8044	2,1879

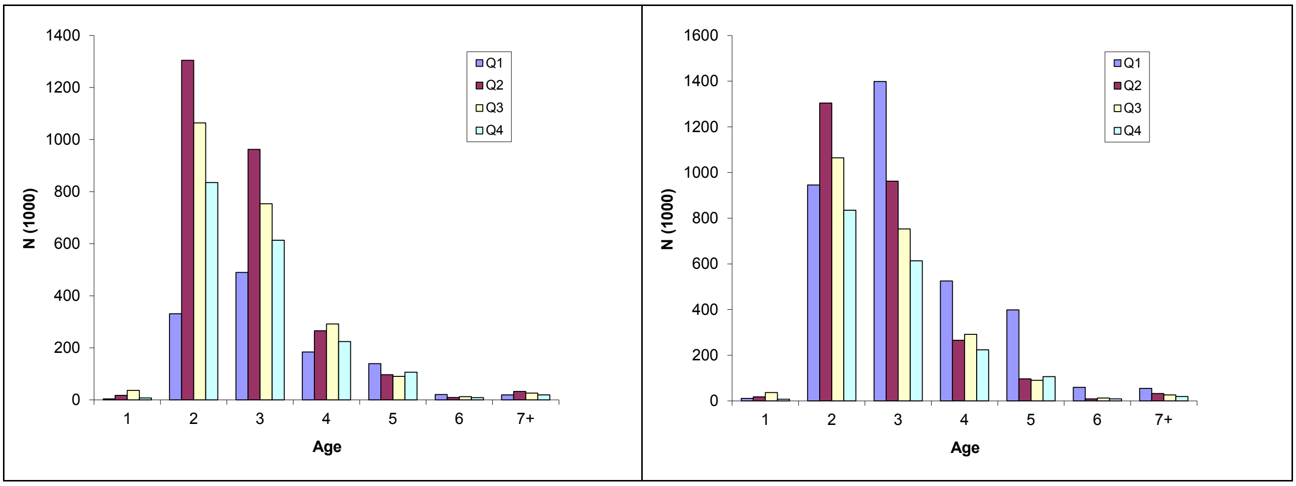


Figure 6.1.2.1. Plaice in VIId. 2010 Age distribution in the landings per quarter, after Q1 removals (left panel) and total landings from VIId (right panel).

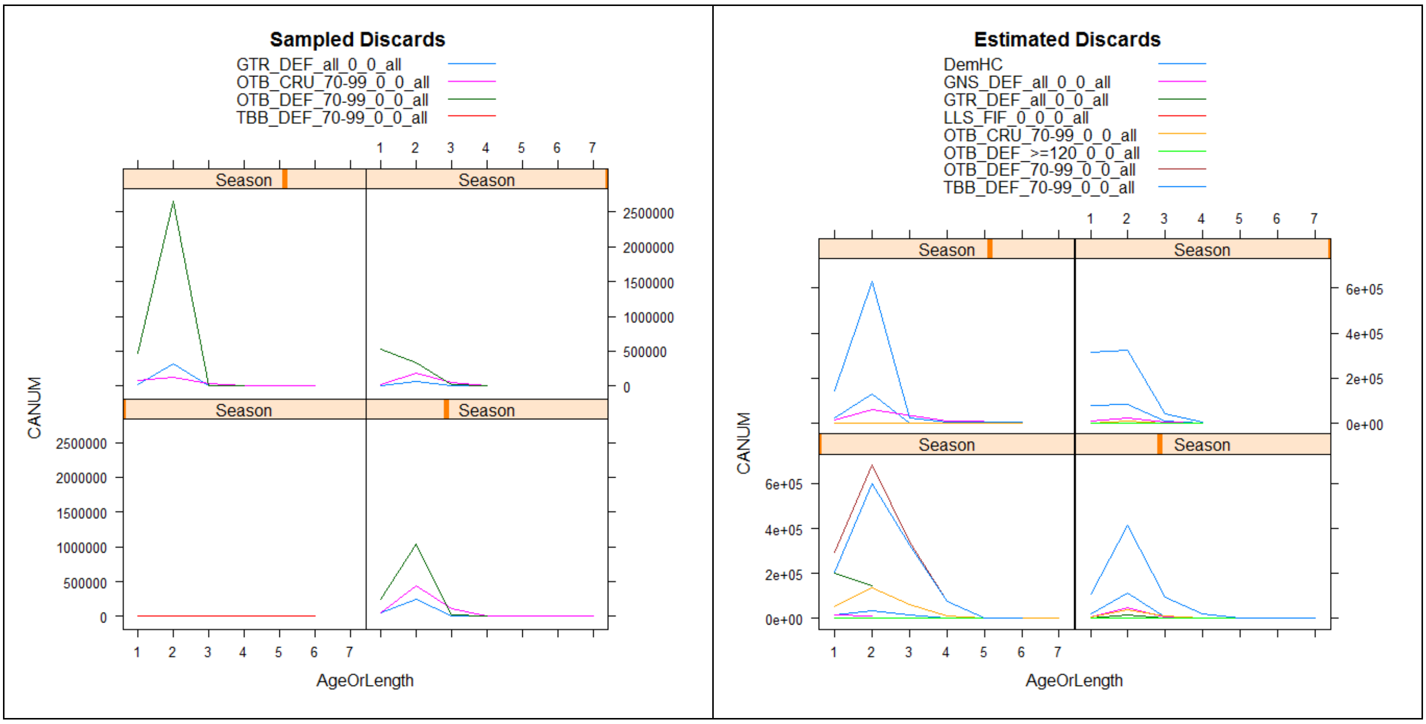


Figure 6.2.1.1 - Plaice VIId - Age structure and numbers of discards by metiers. Sampled Discards (left panel) are the age and numbers submitted by all countries in Inter Catch. Estimated (right panel) are the age and numbers estimated using the discard allocation scheme using Inter Catch

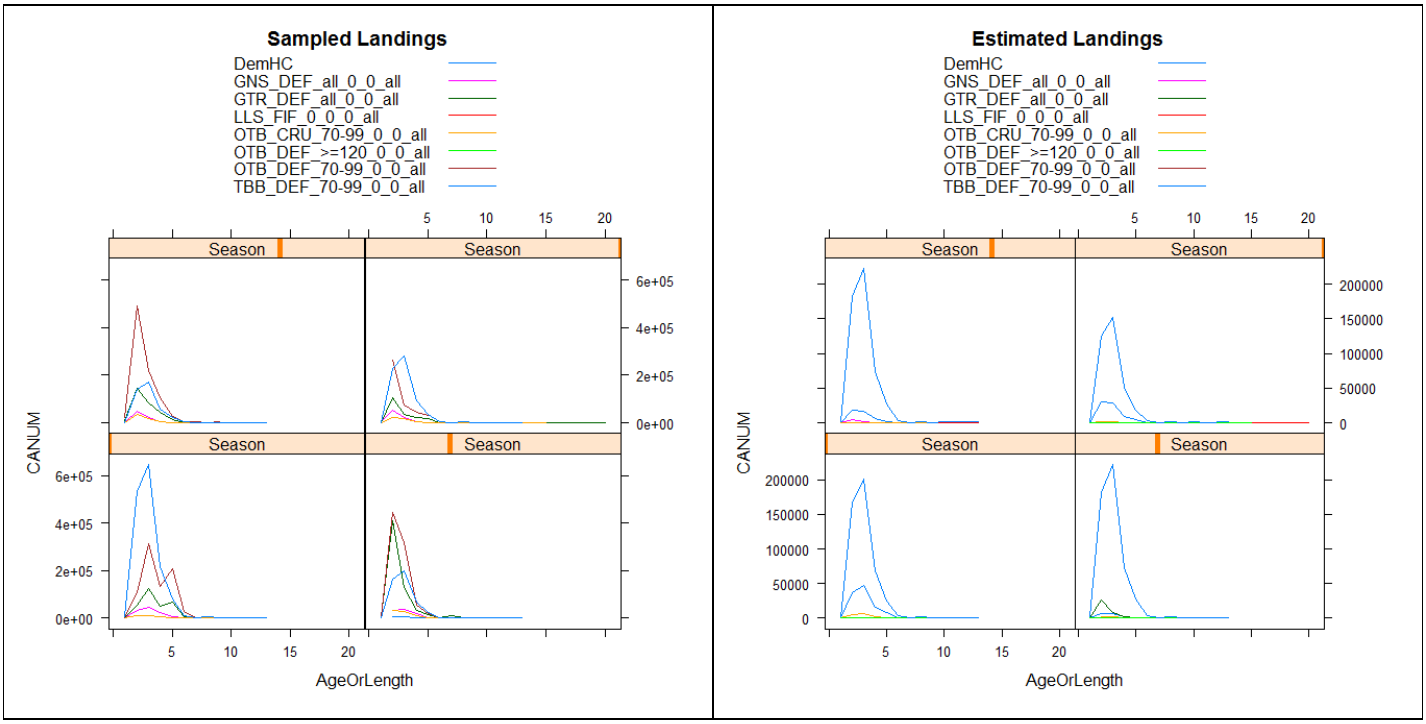
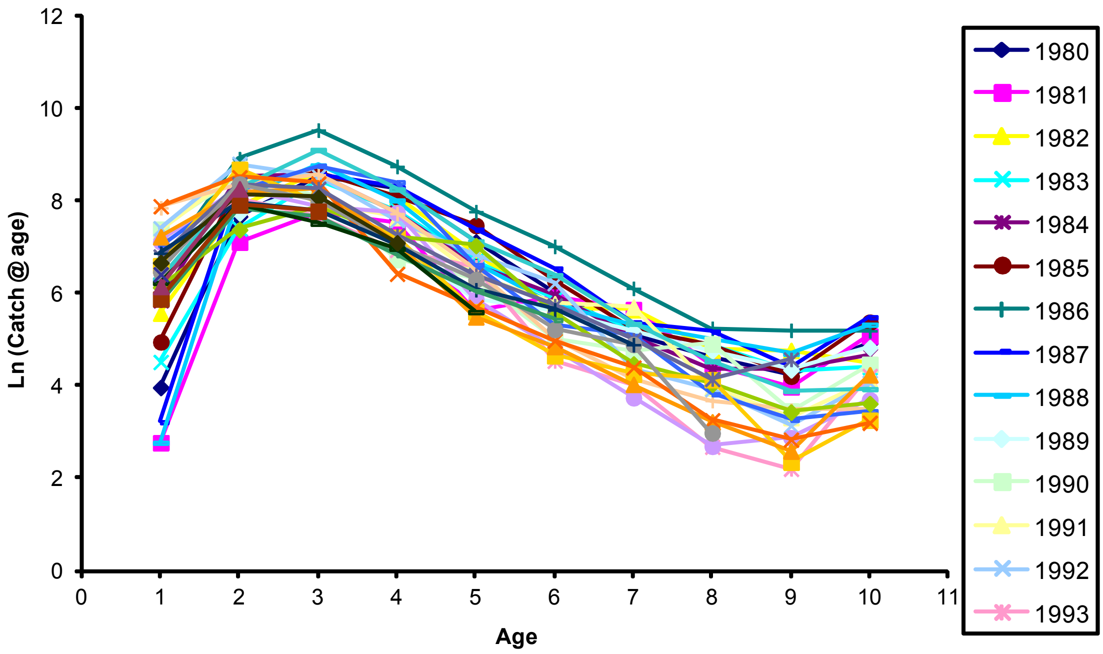


Figure 6.2.1.1 - Plaice VIId - Age structure and numbers of landings by metiers. Sampled Discards (left panel) are the age and numbers submitted by all countries in Inter Catch. Estimated (right panel) are the age and numbers estimated using the discard allocation scheme using Inter Catch



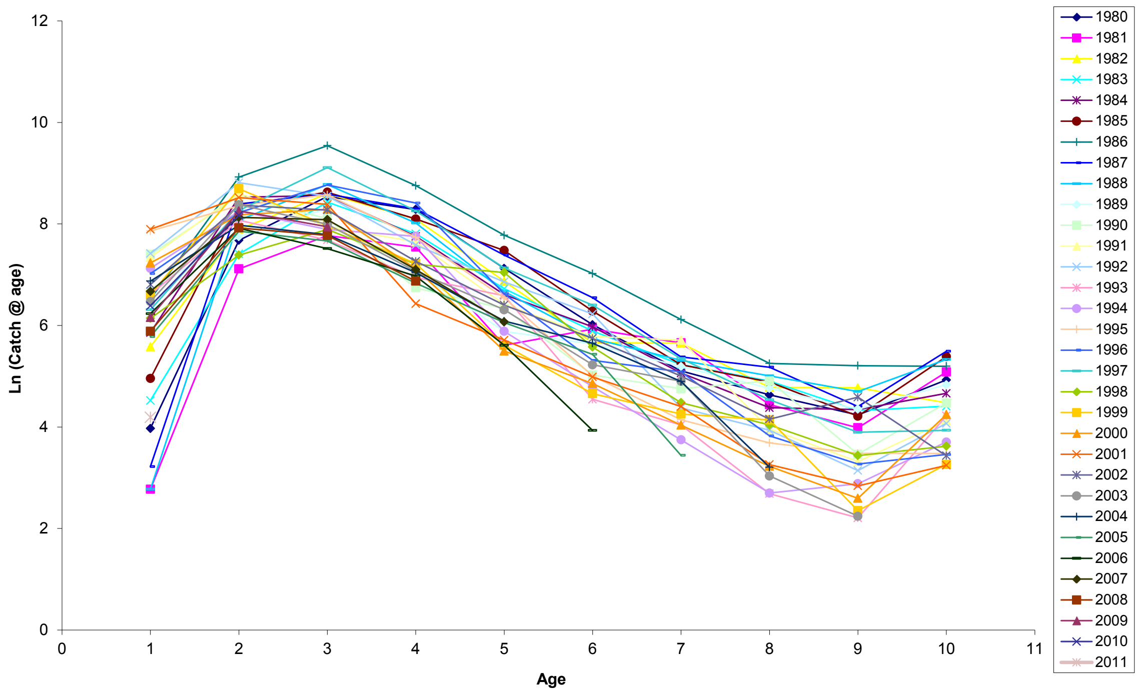


Figure 6.2.1.2a. Plaice in VIId. Catch curves by year class.

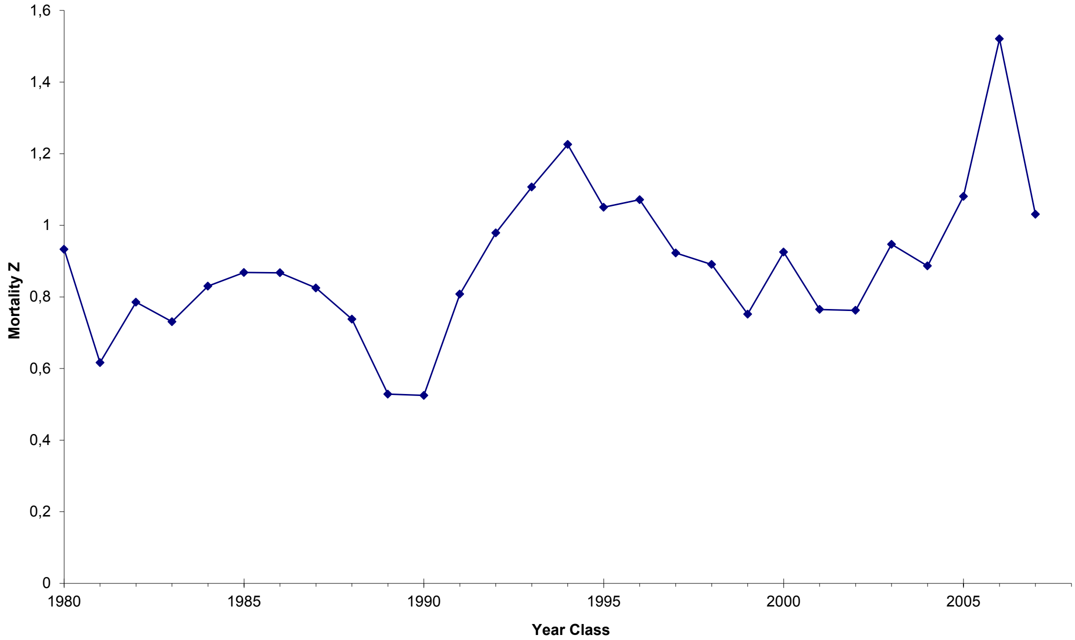


Figure 6.2.1.2b. Plaice in VIId. Evolution of total mortality.

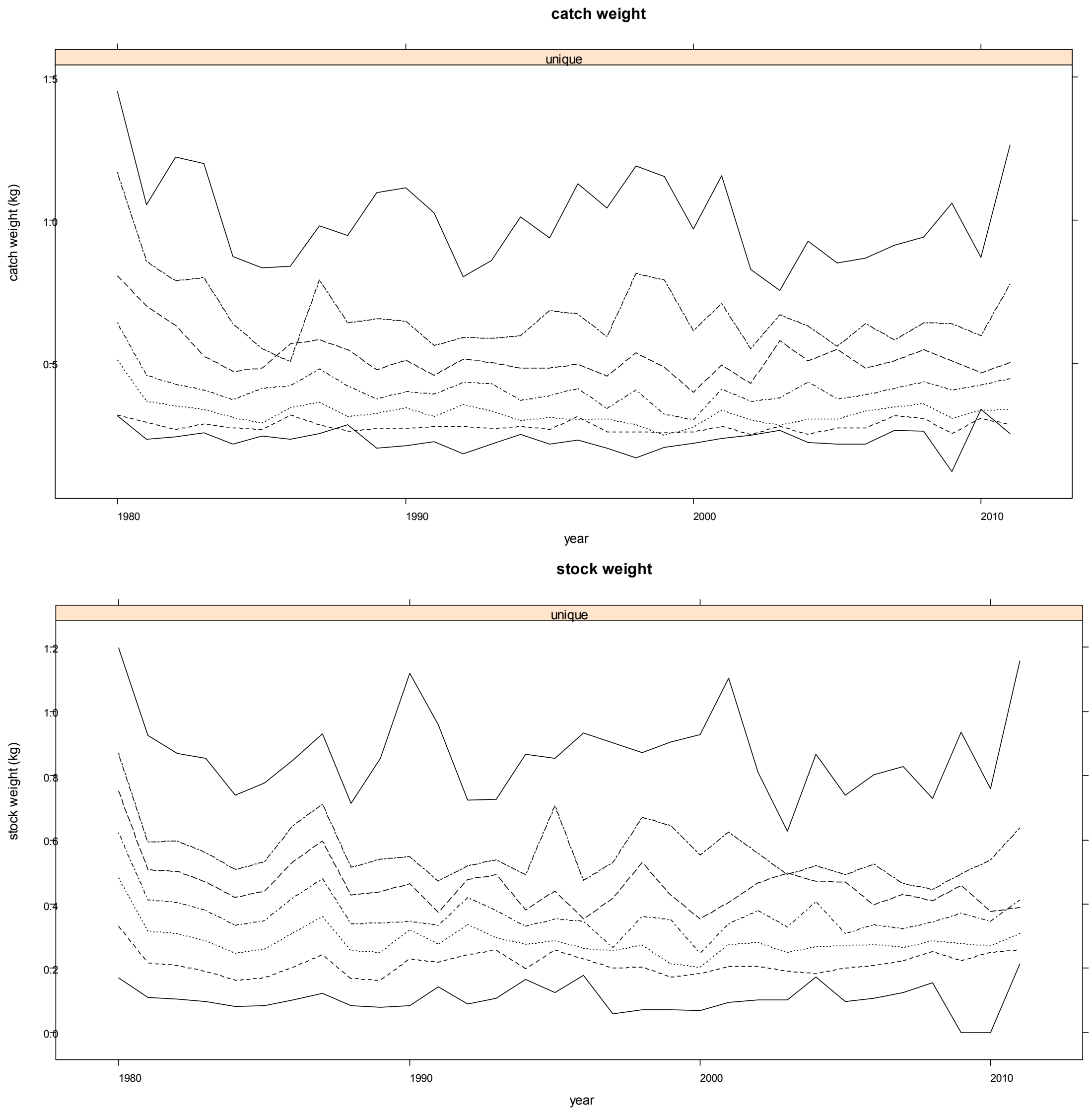


Figure 6.2.3.1. Plaice in VIId. Stock and Catch weight

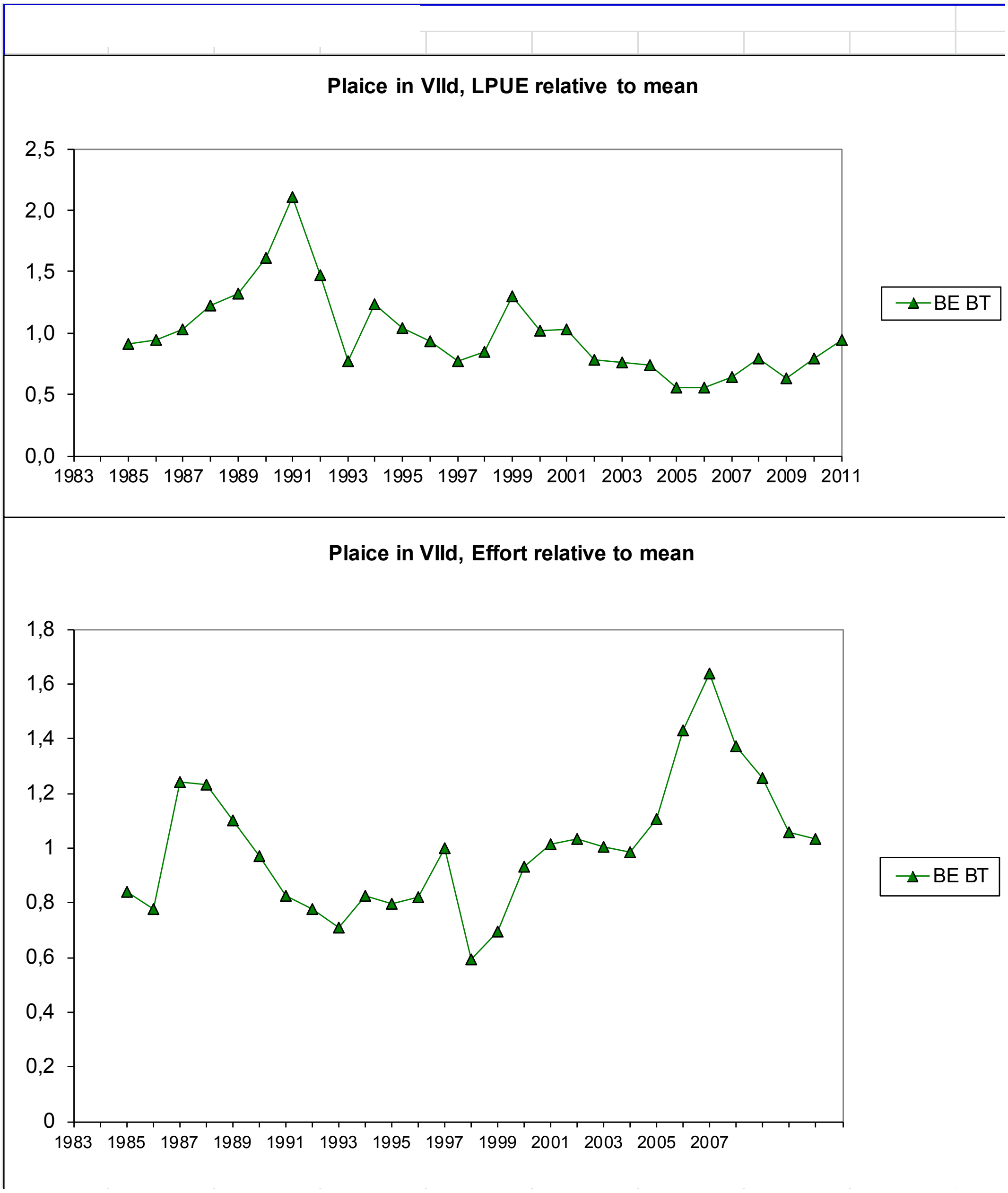


Figure 6.2.5.1 - Plaice in VIId. LPUE and effort

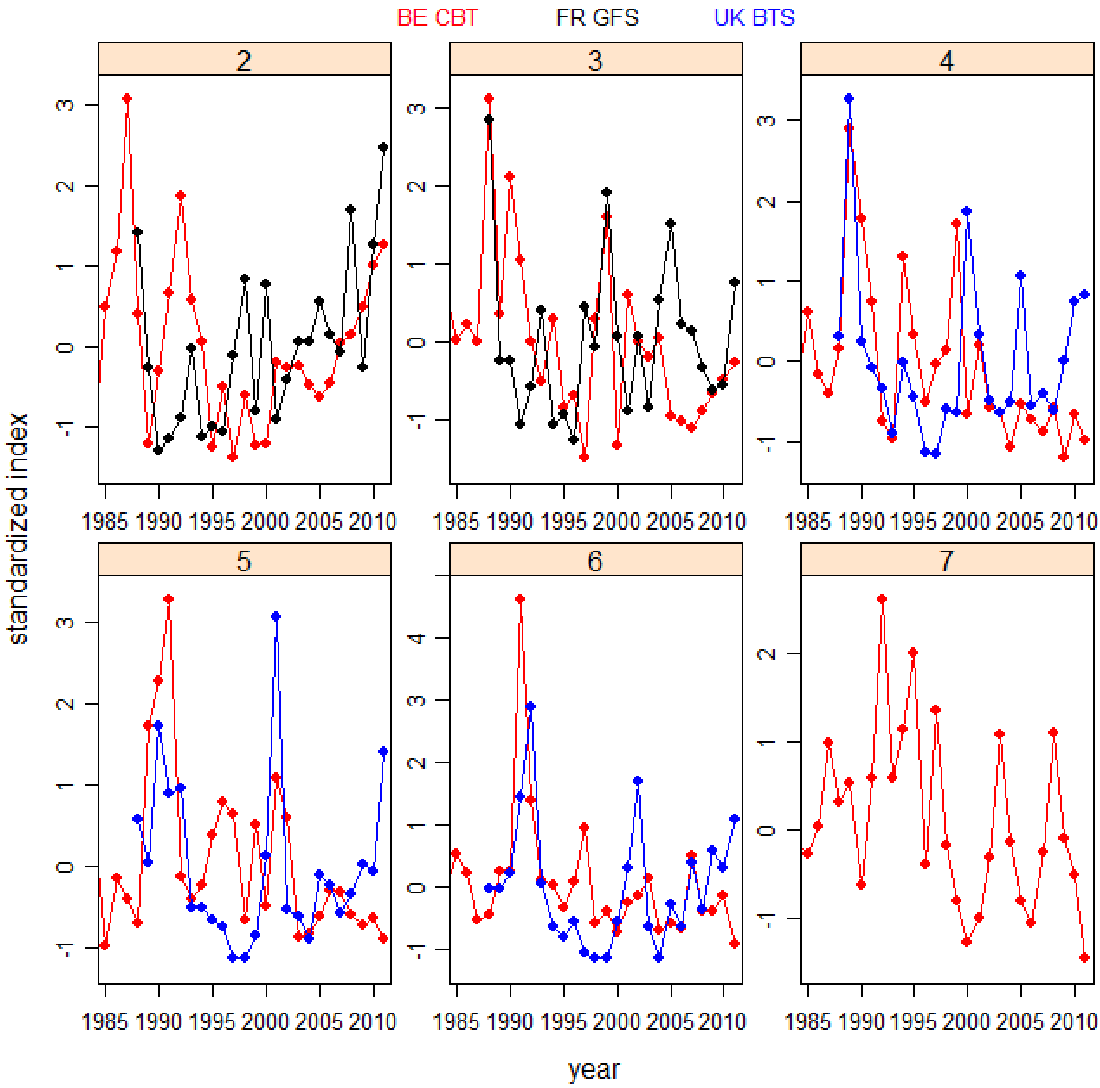


Figure 6.2.5.2. Plaice in VIId. Between survey consistency. Mean standardised indices by surveys for each age

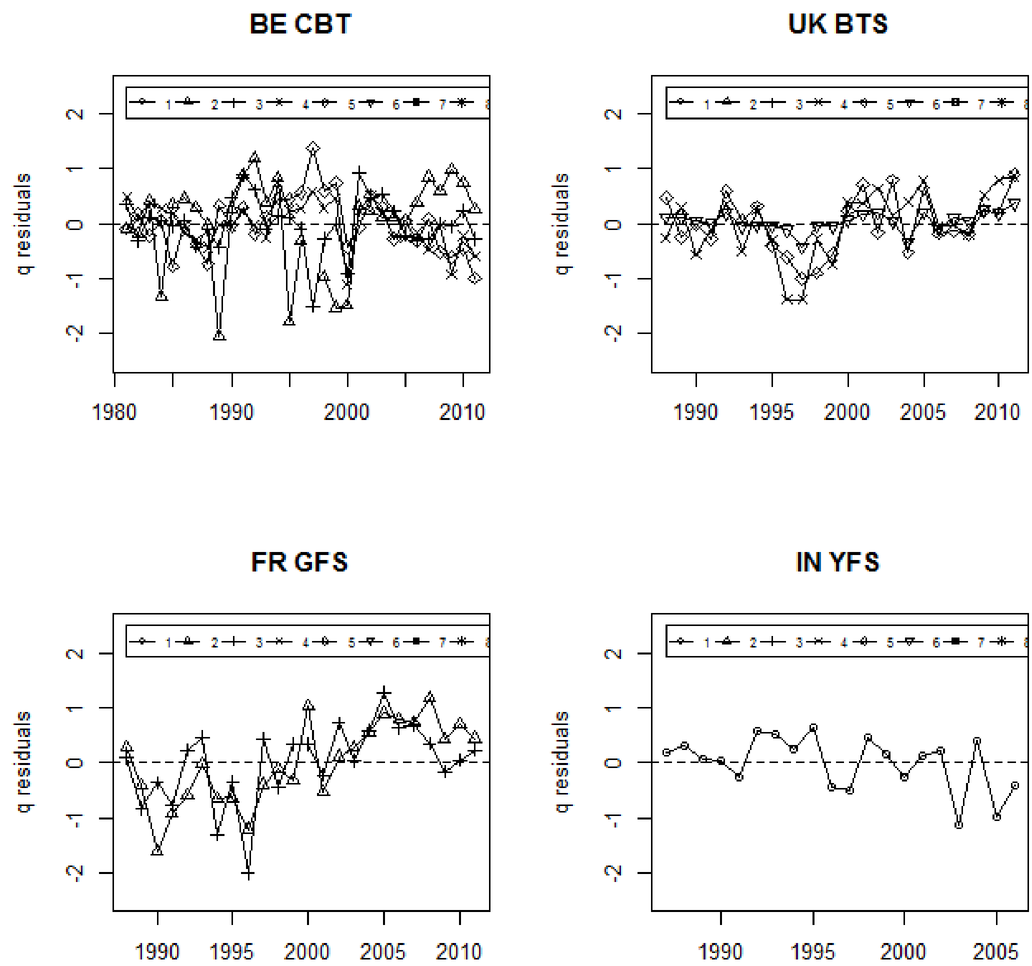


Figure 6.3.2.2. Plaice in VIId. Log q residuals for the single fleet runs (XSA settings and F shrinkage = 1.0)

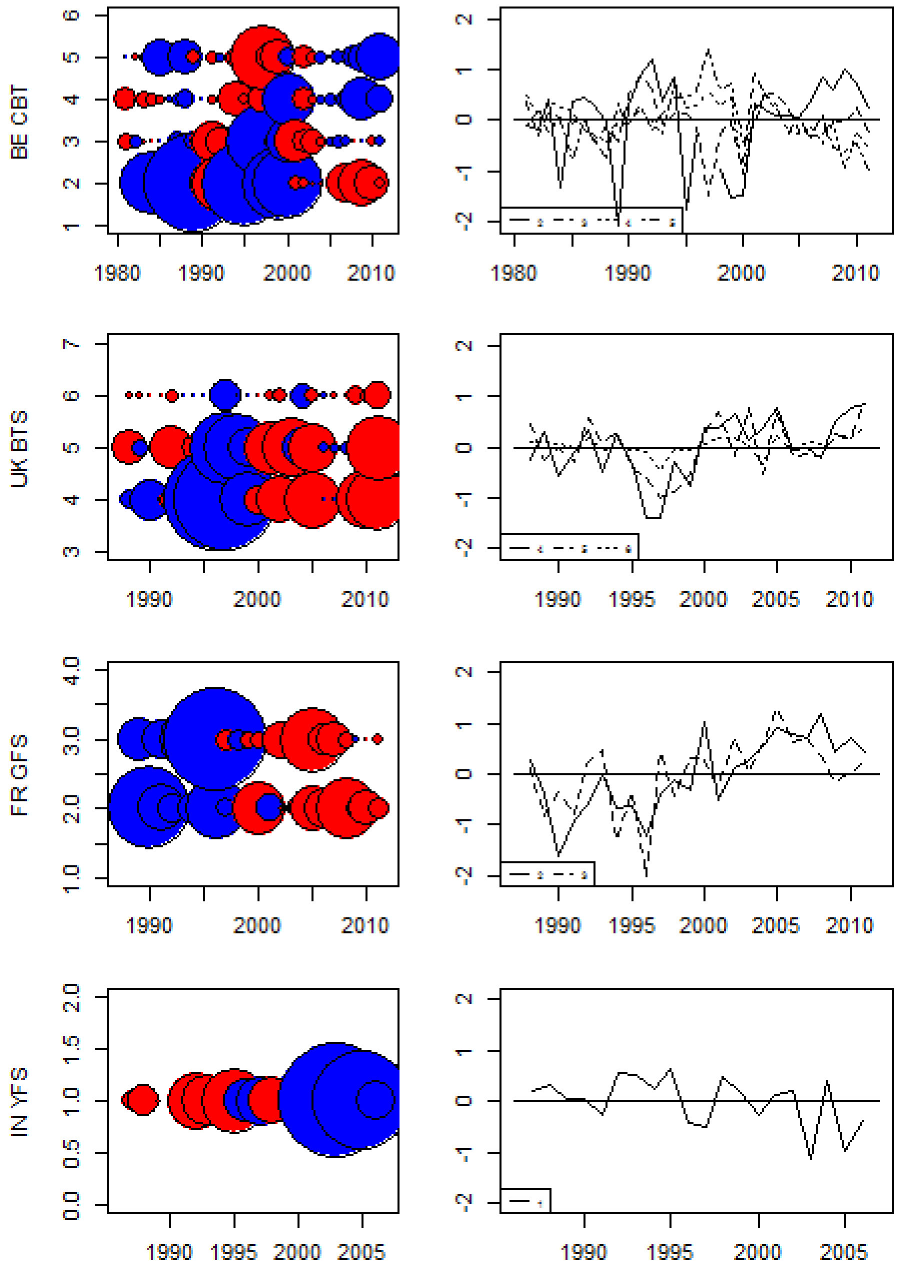


Figure 6.3.2.3. Plaice in VIId. Log q residuals. All fleets combined. Settings as proposed section 6.3.5.

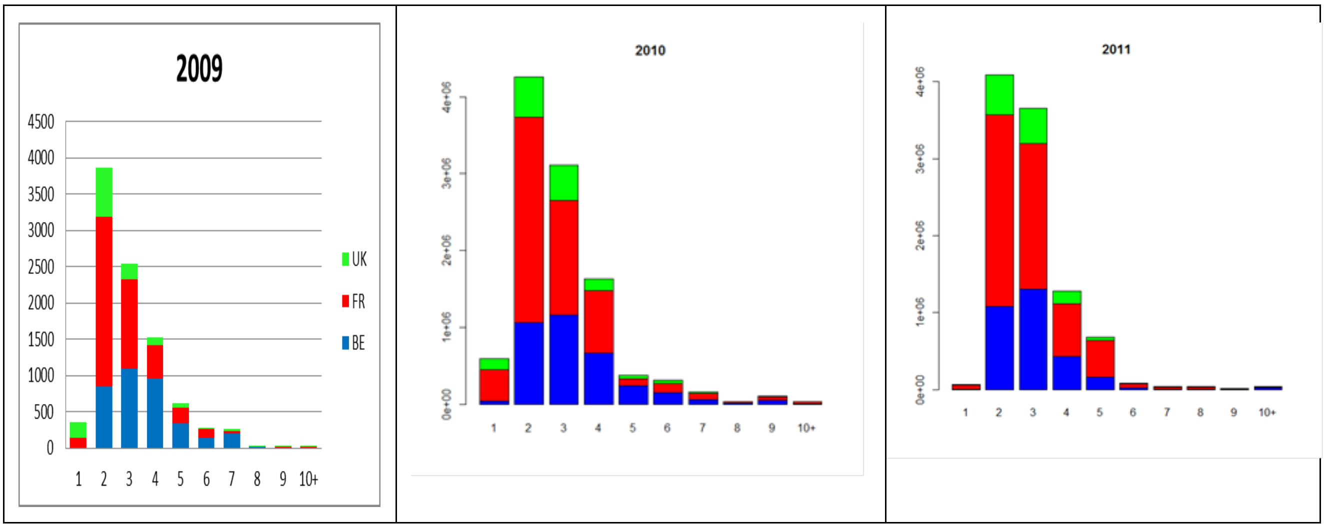


Figure 6.3.4.1. age composition in the catches by country from 2009 to 2010

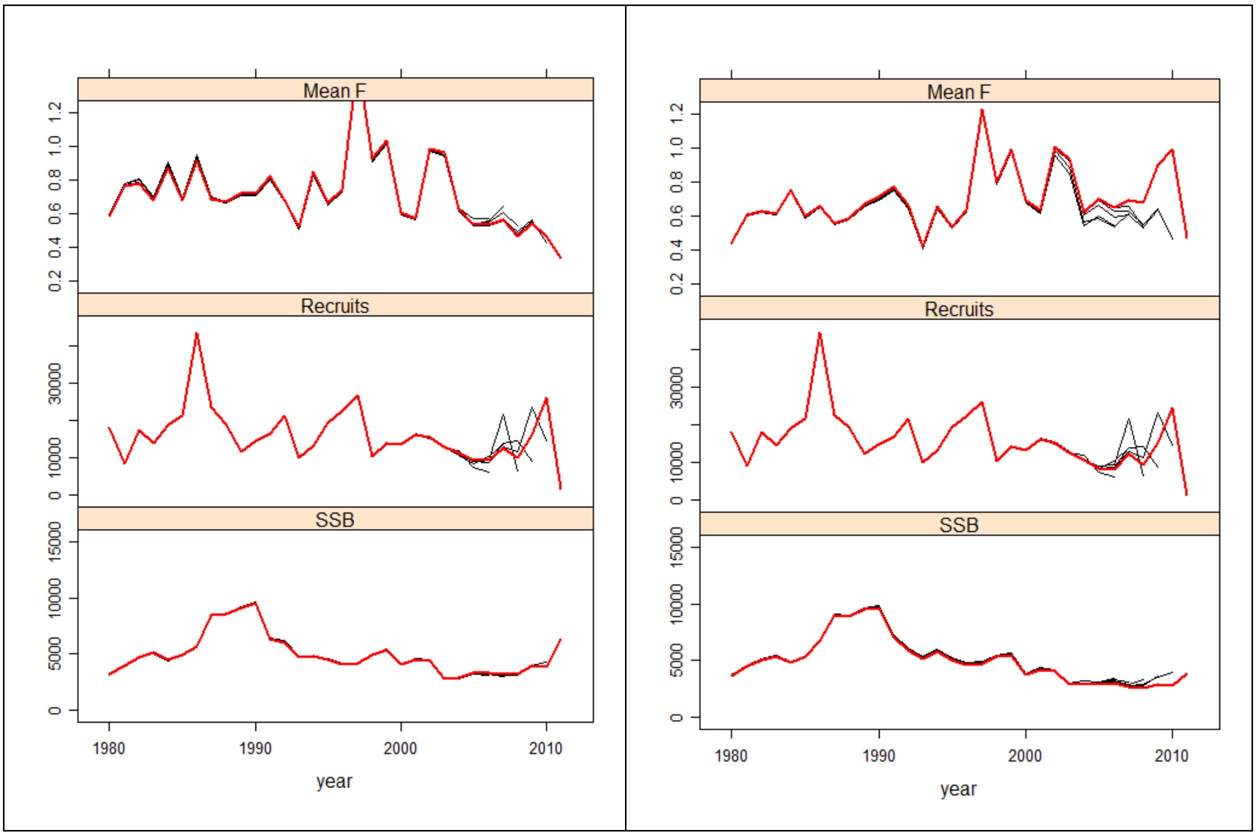


Figure 6.3.4.2. Retrospective analysis setting plus group to 7 (left panel) and to age 10 (right panel)

Figure 6.3.5.1. SAM runs with plus-group defined to 7 (overlying red lines) and plus group set to 10 (black line and shaded area) SSB (top left panel), Fbar (top right panel) Recruits (bottom left panel) and residuals (bottom right panel)

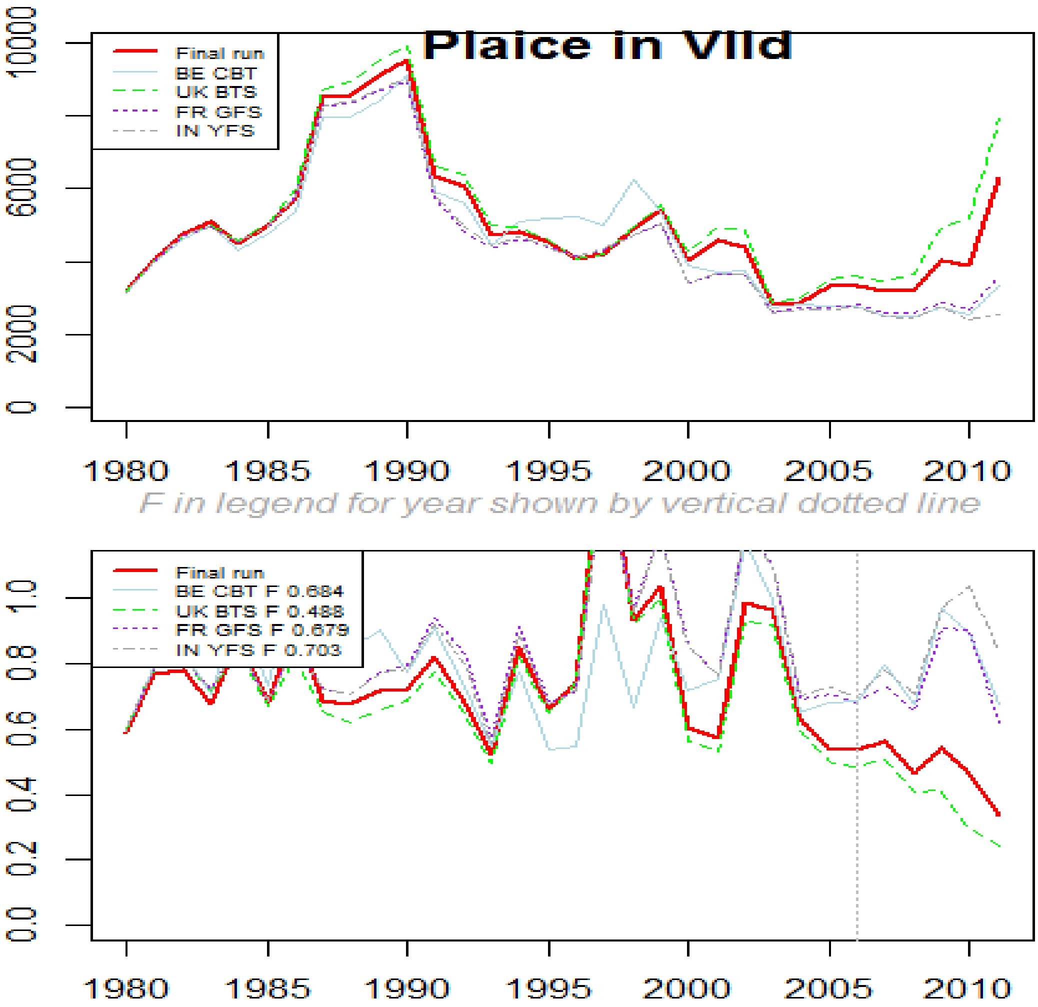


Figure 6.3.6.1. Plaice in VIId. Individual fleet historical performance.

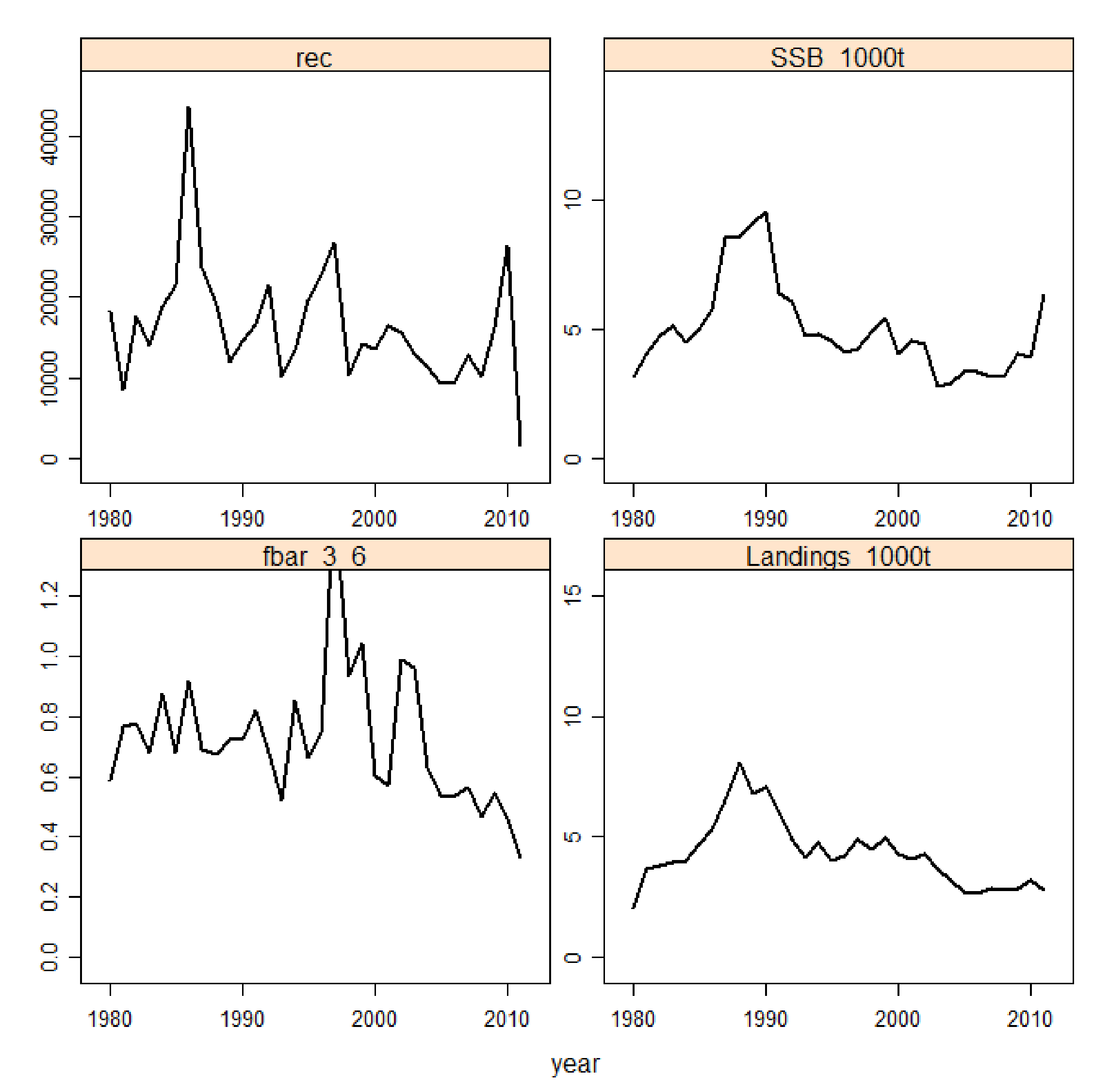


Figure 6.3.5.4. Plaice in VIId. Summary of assessment results

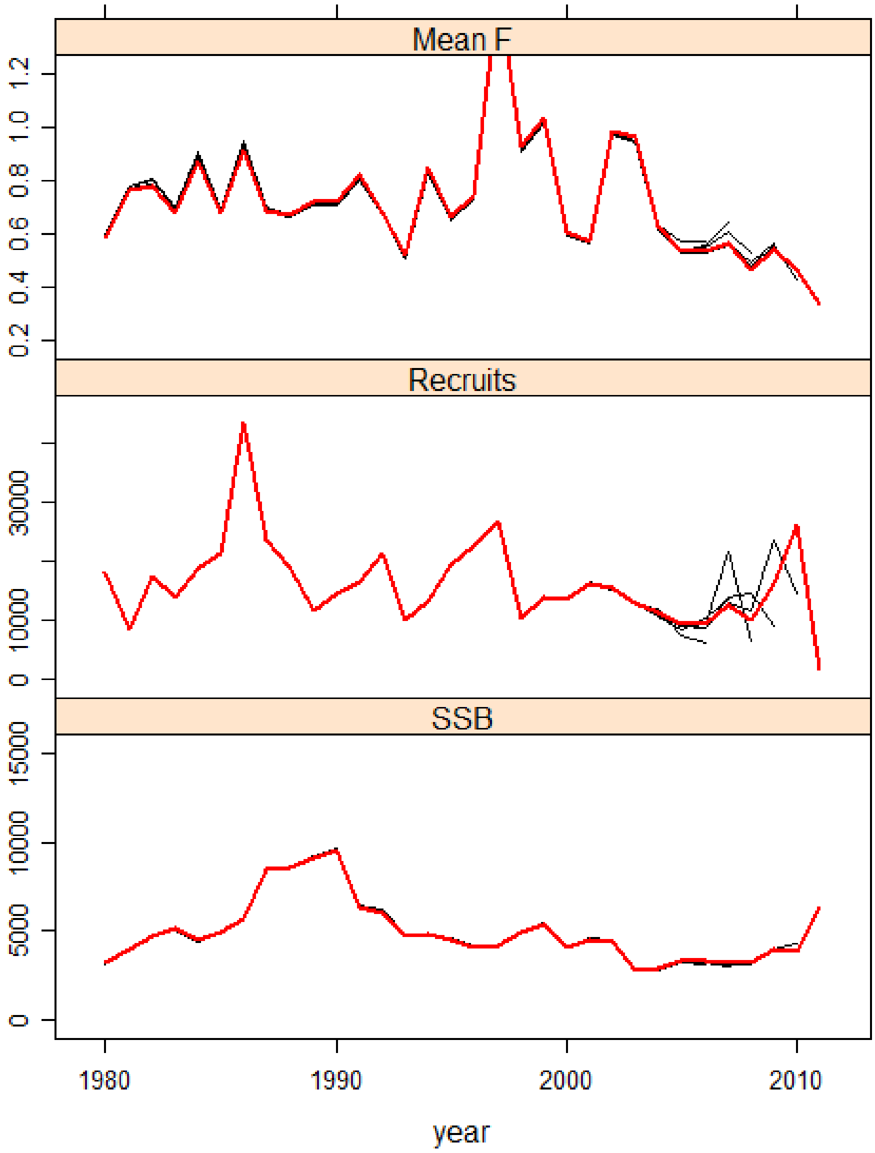


Figure 6.3.6.2. Plaice in VIId. Retrospective patterns for the final run

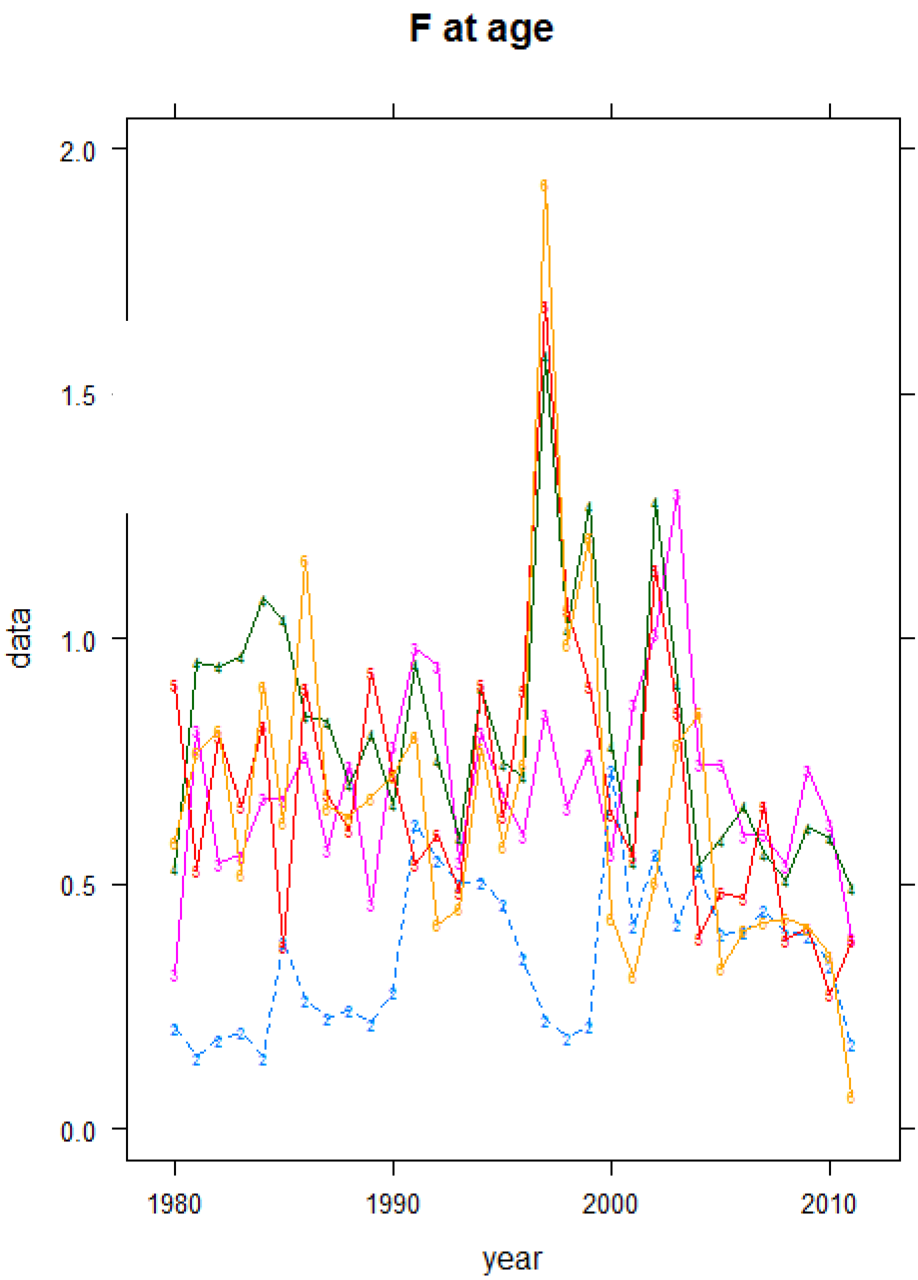


Figure 6.6.1 Plaice in VIId. Exploitation patterns over the last 6 years

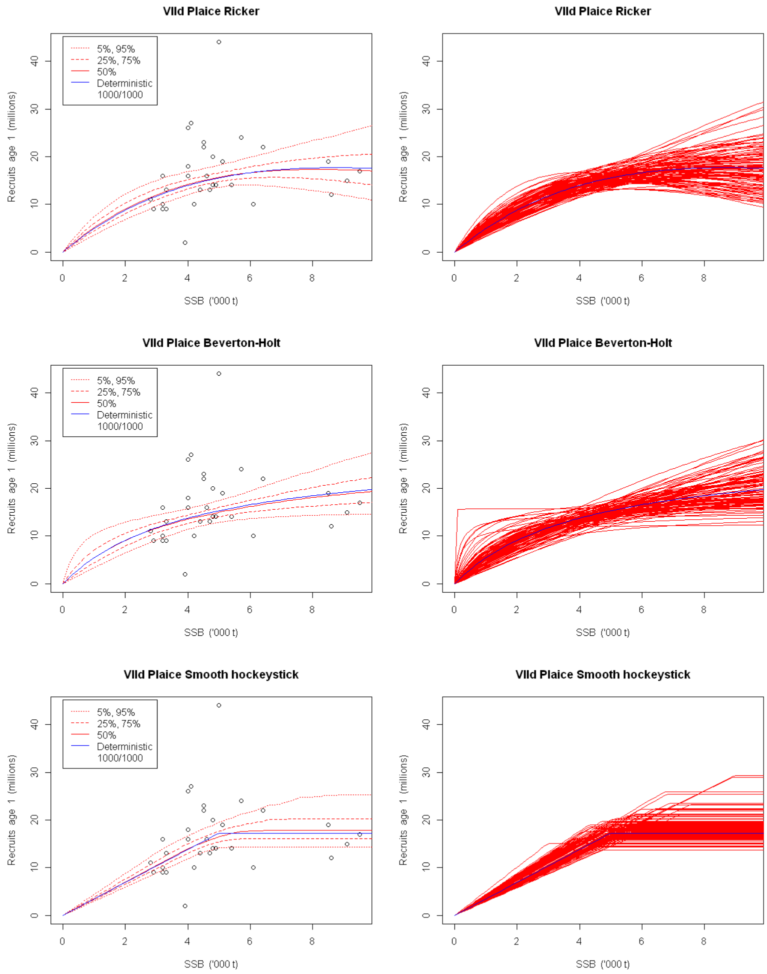


Figure 6.8.1 Eastern Channel Plaice. Stochastic stock recruit fits for three different models: Ricker (top), Beverthon-Holt (middle) and smooth hockeystick (segmented regression, bottom)

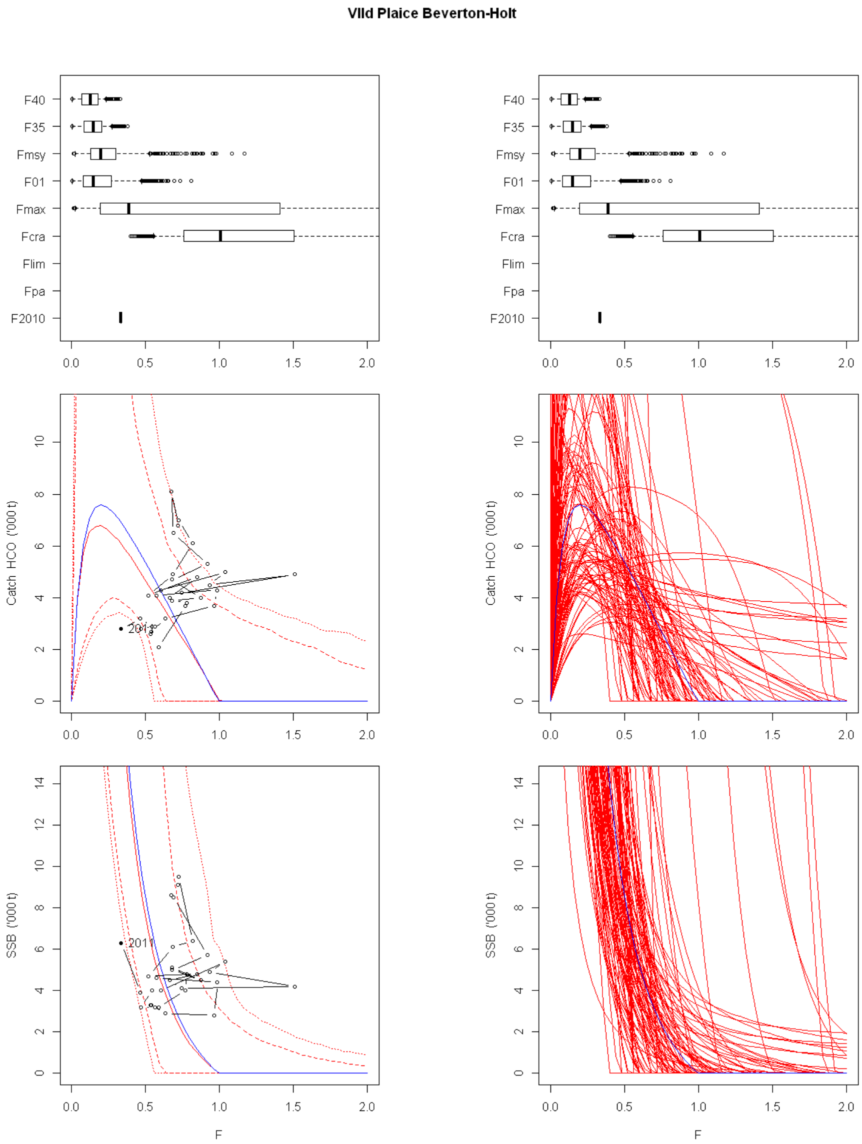


Figure 6.8.2 Eastern Channel plaice. Stochastic equilibrium analyses based on Beverthon-Holt stock recruit fits and resultant distributions of biological reference points.

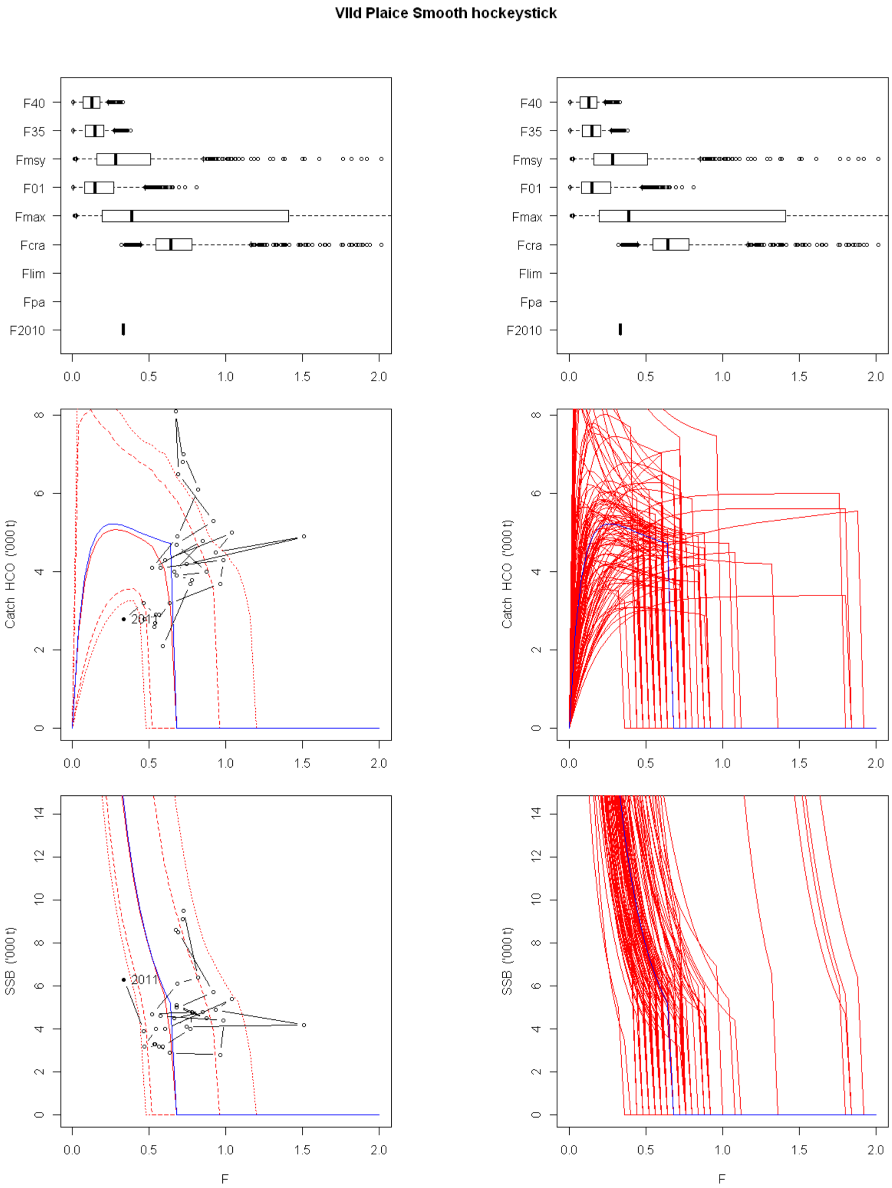


Figure 6.8.3 Eastern Channel plaice. Stochastic equilibrium analyses based on Hockeystick stock recruit fits and resultant distributions of biological reference points.

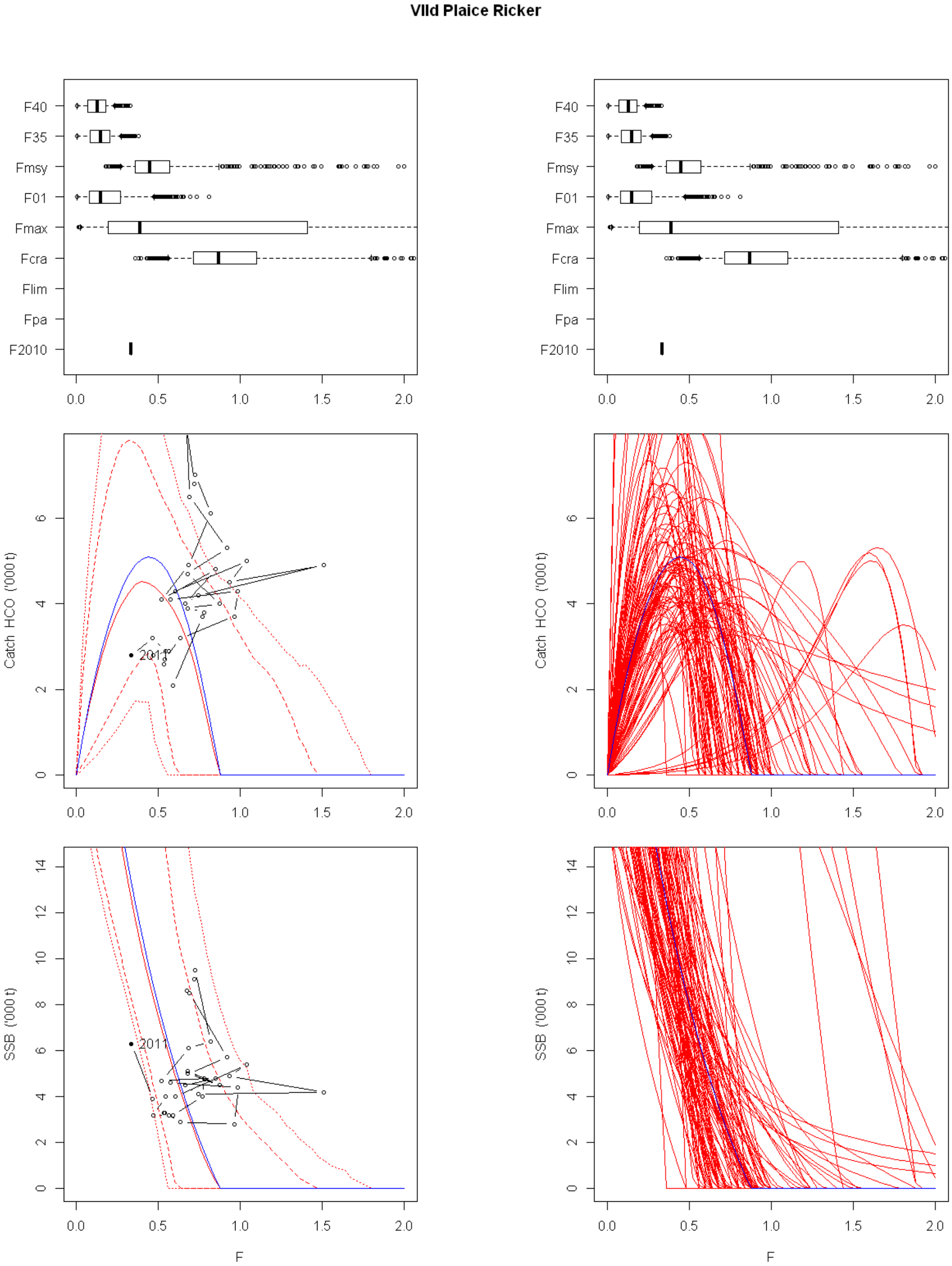


Figure 6.8.4 Eastern Channel plaice. Stochastic equilibrium analyses based on Ricker stock recruit fits and resultant distributions of biological reference points.

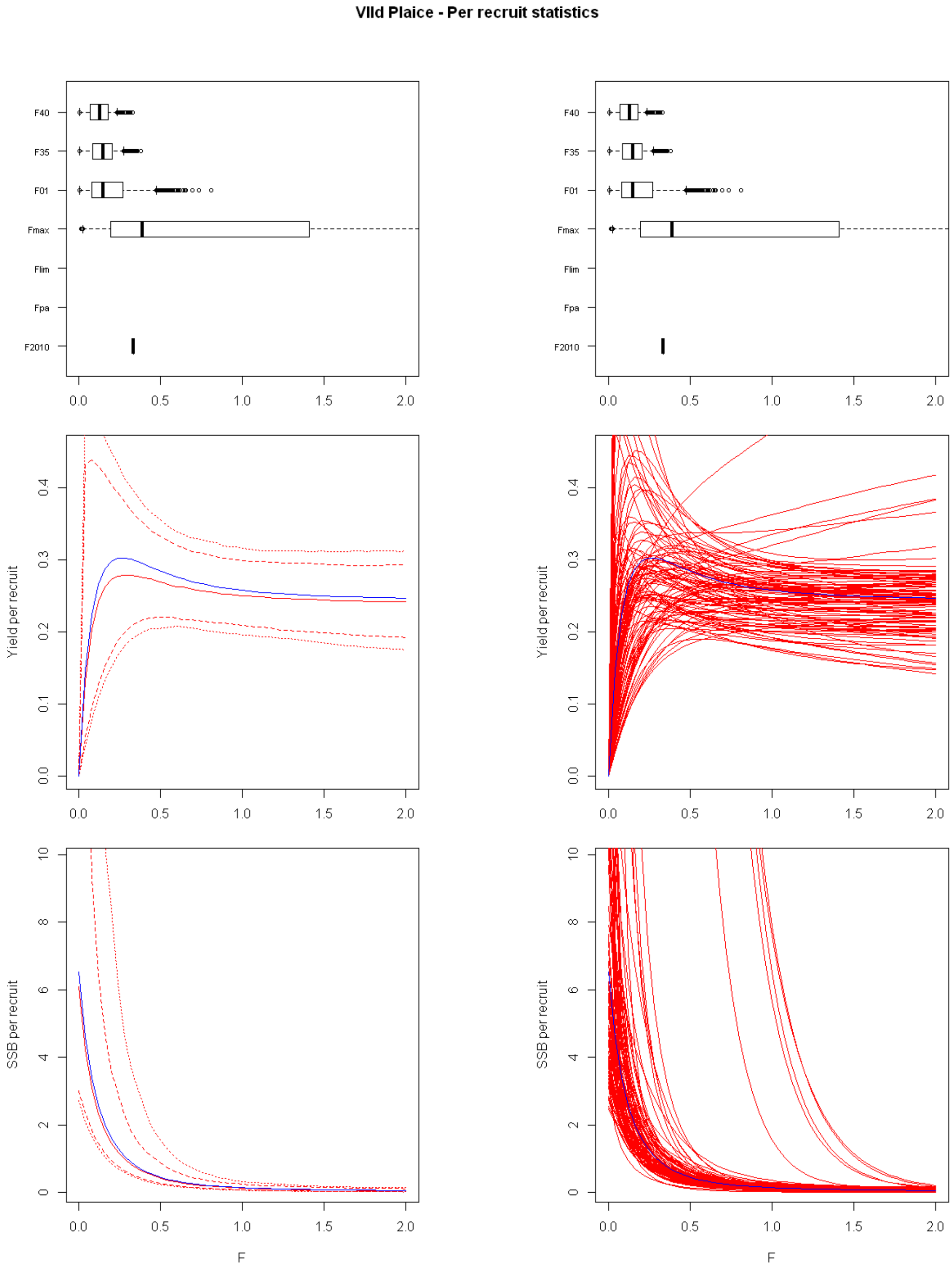


Figure 6.8.5 Eastern Channel plaice. Stochastic equilibrium per-recruit analyses and resultant distributions of biological reference points.

7 Plaice in IIIa

Significant changes have been provided to the assessment of this stock in 2012. There hasn't been produced a final assessment since 2005. The WG has repeatedly noted that the assessment of this stock suffers from a number of issues, mainly dealing with (i) catch at age information and (ii) survey spatial coverage. Catch at age issues relate both to the fisheries mainly taking place in the south-western entrance of Skagerrak where some mixing may occur with North Sea plaice, and to large intrinsic variability in growth within the distributional area, which may not be sufficiently covered by the sampling. Survey issues arise from the survey stations exclusively sampling the Eastern side of the stock distribution where only limited fishing occurs (cf. the extended analyses presented to ICES WGNSSK 2011).

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.

These results were reviewed by WGNSSK. Given that formal review and agreement of the changes suggested by WKPESTO were still lacking, WGNSSK decided to produce both the old setup (combined assessment Skagerrak-Kattegat, this section) and the new setups (Kattegat, 22 and 23 assessment and North Sea-Skagerrak assessment, section 18). In addition, an EU-Norway request dealing with the same issues is also being prepared.

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.

Closed areas were implemented by Denmark and Sweden in the Southeast Kattegat and North of Oresund from the fourth quarter of 2008, with the aim of protecting spawning cod. Two areas are closed on a permanent basis while one large area is closed during the first quarter only.

Beam trawling is forbidden in the Kattegat. Female plaice must be released back in the sea during the period 15 January – 30 April.

Changes in fleet dynamics

Plaice fishing in Kattegat has continuously decreased and dropped to very low levels. Implementation of a number of changes in the regulatory systems in the Kattegat and Skagerrak between 2007 and 2008 (see also 7.1.4 and 7.2.4) as well as continuous reductions in the allowed days at sea to protect Kattegat cod have significantly changed the fishing patterns of the Danish and Swedish fleets.

A detailed description of the fishing effort in area IIIa is available in Bailey and Rätz (2011)[1]. Total fishing effort in Kattegat has decreased by 40% since 2002. By far the largest part of the fishing effort is now operated with the regulated gear TR2 (towed gears with mesh size 70 to 100mm), while large (>100mm) mesh size trawl fishery (TR1) has almost disappeared (less than 3% of the total effort in 2009 compared to 14% in 2000.

Fisheries Science Partnerships

No Fisheries Science Partnerships are applicable for this stock, but a national Danish Project involving both DTU Aqua and Danish Fishermen Association has been ongoing over 2011-2012, aiming at addressing the shortcomings of this stock assessment and thereby supporting MSC certification for the Danish plaice fisheries in area IIIa.

7.1.2 ICES Advice

In 2007, after a series of years without an accepted assessment, ICES noted that there were indications that the biomass and recruitment had increased. There were no indications that the current catch level was detrimental to the stock and therefore the advice for 2008 had been not to increase the catches above the most recent (2006) highest catch at 9400 t. In 2008 and 2009 the data available had given no reason to change the advice from 2007, which had then been rolled over.

In 2010, ICES advice shifted to the MSY framework, and the basis for advice was that the landings in 2011 should be less than 8 000 t, the average of landings over 2007-2009. In 2011, that MSY framework was revised, and ICES advised on the basis of precautionary considerations that catches in 2012 should be reduced. ICES underlined though that this advice did not take into account the mixing with the increasing North Sea plaice stock in the Skagerrak.

7.1.3 Management

There are no explicit management objectives for this stock.

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).

In 2012, the TAC was rolled over to the same level as 2011.

Effort in plaice IIIa fisheries has been regulated through the implementation of a days-at-sea regulation for the cod recovery plan and fishing effort limitation of the

[1] https://stecf.jrc.ec.europa.eu/c/document_library/get_file?p_l_id=53310&folderId=44891&name=DLFE-9402.pdf

long term management plans (EC Council Regulation No. 2056/2001; EC Council Regulation No 676/2007; EC Council Regulation 40/2008) (cf section 2.XX)

In 2007, a rights-based regulation system was introduced in Denmark for the allocation of national quotas. Before that year the quotas were split into 14-days rations which were continuously adjusted to the amount of quota left. In 2007 this system was changed to a complex system were individual rights are attached to the vessels and not to the owners (FKA - Vessel Quota Share), with specific provisions for coastal and recreational fisheries. It is acknowledged that this complex system may have dramatically affected the structure of Danish fisheries, as can be seen from effort trends (Bailey and Rätz, 2011).

7.2 Data available

7.2.1 Catch

The official landings reported to ICES are given in Table 7.1.1. The annual landings used by the Working Group, available since 1972, are given by country for Kattegat and Skagerrak separately in Tables 7.1.2 and 7.1.3. In 2011, 93% of the landings were taken by Denmark.

At the start of this period, landings were mostly taken in the Kattegat but from the mid-1970s, an increasing proportion of the landings has been taken in Skagerrak, and the Kattegat fishery is now negligible (4.2% of total landings in 2011). This may be partly linked to the general decline in the cod fisheries in the Kattegat and a shift towards mainly *Nephrops* fishery, but also to a perceived decline of abundance compared to historical levels (Cardinale et al., 2009, 2010) .

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).

As in previous years, InterCatch was used to raise catch-at-age information. However in 2012 the raising procedure was changed, as for most other demersal stocks from WGNSSK, as information was now made available by DCF metier (see section 1).

Landings at age information is available from Denmark only, and this was used to raise to international landings.. There are almost no landings from age 1 plaice, and in consequence the landings-at-age data starts at age 2. (Figure 7.2.2).

Discards time series in area IIIa from Denmark and Sweden over 2002-2011 were made available to the WG (second semester 2004 data missing for Sweden). The total amount was estimated between 1 500 to 2 600 tonnes by year, corresponding to 15-25 % of the catch in weight (Table 7.2.3). Slightly more discards were reported for 2011, but it is considered to be an effect of the improved recording of catches in 2011, using DCF métiers and InterCatch database allowing allocating observed discards ratio to landings without discards estimates, rather than to reflect actual changes in discards patterns.

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 (Figure 7.2.3). This is considered as the main cause of the lack of year class signal in the catch-at-age matrix.

Since 2004, Denmark and Sweden have put a significant amount of effort into increasing the quality of age reading for plaice in IIIa through a series of workshops and otolith exchanges between age readers. Significant improvement in the consistency have been reached, although some uncertainties remain, particularly for Kattegat plaice and for fish older than 6.

It is therefore acknowledged that the variability of growth is a more important source of uncertainty in the catch matrix than the age reading process in itself. It is not expected that with the current sampling levels, which are consistent with the Data Collection Framework requirements, significant precision improvements can be gained.

7.2.2 Weight at age

Weight at age in landings is presented in Table 7.2.2 and Figure 7.2.4. The procedure for calculating mean weights was revised in 2006 and is described in the Stock Annex. Weight at age in discards is presented in Table 7.2.5 and Figure 7.2.5. The mean weight at age measured in the plus group in 2011 were abnormally low, but this issue was not investigated further. This could indicate a lower sampling level for the older ages, and the adequacy of the plusgroup should be considered during a future benchmark.

7.2.3 Maturity and natural mortality

Natural mortality is assumed constant for all years and is set at 0.1 for all ages.

The maturity ogive was revised during the 2006 WG, and uses a fixed value per age based on 1994-2005 average of IBTS 1st quarter data. (Table 7.2.7)

7.2.4 Catch, effort and research vessel data

The description of tuning fleets is given in the Stock Annex.

As stated above, there is no evidence of issues with regards to misreporting in this stock. However, the general issues described for this stock also apply for the tuning indices. Spatial distribution is increasingly concentrated on the Skagerrak, and the catches may include an unknown level of individuals belonging to the North Sea stock due to fishing close to the borderline. Second, Danish fisheries have been through dramatic changes over the last decade, with among other the introduction of days at sea, FKA (Vessel Quota Share), closed areas etc. This may have affected the whole structure of the plaice fishery. In particular, the number of active vessels recorded in Danish seining and gillnetting in area IIIa has continuously fallen, and was in 2010 less than half of its amount in 2002.

The LPUE from the Danish seiners has continuously increased over the period, potentially indicating significant technical creep but also increased abundance in the area. Highest CPUE are observed at the western entrance. (Figure 7.2.6 and 7.2.7).

In 2007 the WG discussed the limited spatial coverage of the four surveys with regards to main fishing grounds. The Danish Kattegat Survey (KASU) only covers the Kattegat, and the IBTS sampling in Skagerrak is mostly limited to the Eastern part around Skagen in Northern Denmark, while most of the fisheries take place in the North Western area close to the North Sea border. No improvements have been brought to this yet, but the issues are being considered.

7.2.5 Feedbacks from PGCCDBS about data issues

PGCCDBS commented on the two main issues for that stock.

1) No survey coverage where the fisheries are. The Western Skagerrak represents by far the huge majority of the catches but there is no survey there, while there is 4 surveys in Kattegat which represent <5% of catches. There is an urgent need to a better coverage through survey or reference fleet. PGCCDBS recommends that this is followed up more closely by DTU Aqua and by the ICES IBTS and BTS groups to investigate the possibility to extend the existing surveys to the Western Skagerrak.
2) 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. PGCCDBS recommends to pass this on to SIMWG, and that this is followed up by PGCCDBS, DTU-Aqua, IMARES, IMR, CEFAS, IFREMER

7.3 Data analyses

7.3.1 Comments from the technical review group 2011

The review group had the following comments

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret.

No final assessment. Last analytical assessment that was accepted was in 2004.

Assessment has never been benchmarked under the new ICES benchmark system. Last changes to assessment methodology were in 2006.

Technical comments

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.

Exploratory SAM assessment was presented in the report but only stock trends were presented, it would be good to assess the goodness of the fit .In the report it was argue that the confidence intervals were wide but what really matters is if the fit is good. If the fit is acceptable it would be an alternative to XSA.

Conclusions

The RG agrees with the WG conclusions for this stock. An analytical assessment on a single stock in area IIIa is likely not appropriate and an integrated plaice assessment for all stocks from the English Channel to the Baltic should be explored.

Suggestions for future benchmarks:

Revise maturity parameters.

Landings weight at age is very noisy (Figure 7.2.4) it would be recommendable to revise the procedure to calculate it.

Given the problems with catch at age try length based assessment models or biomass dynamic models.

Investigate technological creep in Danish seiners. Try effort standardization techniques to remove technological creep effect. If the effect can not be removed do not use it as tuning index.

The WGNSSK 2012 has taken note of these comments and agrees with them. New goodness of fit of the SAM model have been included. The suggestion of an integrated assessment has been launched by WKPESTO in March 2012 (see also section 18).

7.3.2 Catch-at-age matrix

The Landings-at-age matrix is shown on the figure 7.2.2. The matrix shows clearly a limited ability to track down the cohorts over time, especially in the Skagerrak.

7.3.3 Catch curve cohort trends

Log Catch curves by cohort (figure 7.3.1) show an increasing steepness over the period 2000-2005, when the proportion of fish older than 6 years decreased in the catches. This pattern seems to be less pronounced over the last years.

7.3.4 Tuning series

The commercial tuning series show the same limited internal consistency as the catch at age matrix, with limited tracking of the cohorts (Figure 7.3.2) whereas the surveys are more internally consistent (Figures 7.3.3. and 7.3.4).

However, the four surveys are not entirely consistent with each other, and convey different signals about the dynamics of the stock. As a general abundance index in weight (Figure 7.3.5), the spring surveys notice a decline in total CPUE since 2005, while the autumn surveys show a stable or even increasing stock. With regards to indices by age, the commercial indices do not show particular signals and are mostly noisy (Figure 7.3.6). The autumn surveys have some consistencies in showing some larger year classes (the most recent being 2006), and would indicate that the recent year classes have been lower (Figure 7.3.7). The spring surveys indicate a number of larger year classes over the last decade, but also some potential decrease for the most recent years (Figure 7.3.8).

7.4 Exploratory analysis

This year (similar to last year), the WG decided not to present a final assessment, but to run exploratory assessments using all tuning series and following the settings described in the Stock Annex. It is to be noted that discards have not yet been included in the assessment analyses, as no benchmark has been held for this stock since 2006 where the discards time series was first collated. It was also considered that adding discards would not improve significantly the ongoing issues in the plaice IIIa assessment.

7.4.1 Exploratory XSA

The pattern in the residual plot (Figure 7.3.9) indicates a conflict between the scientific surveys and the commercial catch at age matrixes.

The retrospective plot of the assessment (Figure 7.3.10) shows that the dramatic variability in Fbar and the strong retrospective pattern in the estimates of recruitment and SSB has not improved over the recent years.

7.4.2 Exploratory SAM

An exploratory SAM was also run, using the same input files. As could be expected from the large uncertainty linked to the input data, the model is not very informative and confidence intervals are wide (Figures 7.3.11-7.3.12). There is also an issue evident from the retrospective pattern, that the F estimates around the decade 1990-2000 have been systematically revised upwards, and the SSB estimates downwards (Figure 7.3.13). Globally, the perception from this assessment is though broadly in line with the information from the surveys, indicating that the spawning stock biomass is at a stable level due to decreasing fishing pressure and a number of large year classes around the period 2000-2006. However, there is indication that the most recent recruitments have not been as large.

7.4.3 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 IIIa (areas 8 and 9) are comparable to the ones from the Eastern North Sea, with equal amount of responses indicating “same” or “more” abundance, which is an increase compared to last year. Recruitment is also considered “moderate” to “high” in both areas.

This picture corresponds globally to the perception of the spring surveys in Kattegat, which indicate also lower abundance of the recent year classes compared to the previous decade.

7.6 Recruitment estimates

Not available

7.7 Short-term forecasts

Not performed

7.8 Medium-term forecasts - none

7.9 Biological reference points

	ICES considers that:	ICES proposed that:
Precautionary Approach reference points	B_{lim} cannot be accurately defined.	B_{pa} = 24 000 t.
	F_{lim} cannot be accurately defined.	F_{pa} = 0.73.
Target reference points		F_y undefined.

Technical basis

	$\mathbf{B}_{pa}$ = smoothed $\mathbf{B}_{loss}$ (no sign of impairment).
	$\mathbf{F}_{pa}$ = $\mathbf{F}_{med}$.

7.10 Quality of the assessment

The exploratory analyses indicated that in spite of continuous research activity, the uncertainty in data cannot be easily resolved.

The issues are primarily related to (i) catch at age information and (ii) survey spatial coverage. The catch at age issues relate both to the fisheries mainly taking place in the South-Western entrance of Skagerrak where some mixing may occur with North Sea plaice, and to large intrinsic variability in growth within the distributional area, which cannot be easily monitored with the current sampling levels. The survey issues arise from the survey stations sampling exclusively the Eastern side of the stock distribution where only limited fishing occurs.

The WGNSSK considers that these issues will remain and that the plaice IIIa assessment in its present form will neither be able to provide a reliable basis for advice in the future. The WG has therefore acknowledged the work performed by ICES WKPESTO (2012), recognizing that the current stock boundaries may not be fully appropriate (see section 18).

It is also to be noted that discards have not yet been included in the assessment analyses, as no benchmark has been held for this stock since 2006 where the discards time series was collated in the first place. At that time, it was also considered that adding discards would not improve significantly the ongoing issues in the plaice IIIa assessment. It is however considered now that the time series has become long and reliable enough to be included in the assessment, particularly if new assessment set up with splitted areas are to form the basis for advice in the future.

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.

However, the landings have increased again in 2010 (mainly in the most western area), while the surveys indicates that there has not been large year classes in the last five years in the Eastern part of the area. It is therefore possible that the increased Western landings are driven to some extent by the increased abundance of the North Sea stock which would distribute beyond the Skagerrak border, while the resident populations in the Kattegat are declining. (cf ICES WKPESTO, 2012 and section 18)

7.12 Management Considerations

Because the stock identity at the Western border of the stock is largely unknown, it is difficult to consider appropriate management of the fishery under the current stock management divisions. The plaice stock in the North Sea is estimated to be increasing to very large levels, and it is therefore likely that the abundance at the western border of the IIIa area may have increased as well. On the other hand, abundance in the

Eastern part of the area appears to potentially decline through less abundant recent year classes, although it is difficult to disentangle the effects of decreasing plaice abundance and decreasing of cod fisheries to explain the decrease of plaice landings in the Kattegat.

The WG recommends therefore additional review and consideration of the work initiated by ICES WKPESTO (2012) and continued further during the WG (see section 18), considering this as the only achievable alternative to improve the basis for advice under the current conditions of available scientific knowledge.

In addition, the WG strongly recommends that a scientific survey is set up by Denmark to monitor the abundance of plaice in the major fisheries grounds not covered by the current surveys, and in particular in the Western Skagerrak. No improvements have been brought to this yet, but the issues are being considered.

Additional considerations are given for this stock. Plaice is now mainly taken in a directed fishery, but is also taken as a by-catch in a mixed cod-*Nephrops*- plaice fishery. North Sea cod, which is estimated to be below $\mathbf{B}_{lim}$, has a stock area that includes the Skagerrak (Division IIIaN). Kattegat cod is also well below $\mathbf{B}_{lim}$ (Division IIIa South). Management of plaice in IIIa must therefore take account for state of the cod stocks.

7.13 References

Bailey, N., and Rätz, H. (Ed.), 2011. Report of the STECF SGMOS-10-05 Working Group on Fishing Effort Regimes Regarding Annexes IIA, IIB and IIC of TAC & Quota Regulations, Celtic Sea and Bay of Biscay. 27 September – 1 October 2010, Edinburgh, Scotland.

Cardinale, M., Bartolino, V., Llope, M., Maiorano, L., Sköld M., Hagberg., J., 2010. Historical spatial baselines in conservation and management of marine resources. Fish Fish 12, 289–298.

Cardinale, M., Hagberg, J., Svëdang, H., Bartolino, V., Gedamke, T., Hjelm, J., Börjesson, P., Norén, F., 2009. Fishing through time: population dynamics of plaice (*Pleuronectes platessa*) in the Kattegat–Skagerrak over a century. Popul. Ecol., 52, 251-262.

ICES. 2012b. Report of the Workshop on the Evaluation of Plaice Stocks (WKPESTO), 28 February - 1 March 2012, ICES Headquarters, Copenhagen. ICES CM 2012/ACOM:32. 39 pp

Table 7.1.1 Plaice in IIIa. Official landings in tonnes as reported to ICES and WG estimates, 1972-2011

Year	Denmark		Sweden		Germany		Belgium		Norway		Netherlands		Total			
	Official	WG est.	Official	WG est.	Official	WG est.	Official	WG est.	Official	WG est.	Official	WG est.	Official	Unalloc.	WG est.	TAC
1972	20 368	20 599		418	77	77			3	3			20 448	649	21 097	
1973	13 877	13 892		311	48	48			6	6			13 931	326	14 257	
1974	15 063	14 830		325	52	52			5	5			15 120	92	15 212	
1975	15 045	15 046	437	373	39	39			6	6			15 527	-63	15 464	
1976	18 738	18 738	385	228	32	32	717	717	6	6			19 878	-157	19 721	
1977	24 323	24 466	442	442	32	32	846	846	6	6			25 649	143	25 792	
1978	26 156	26 068	476	405	100	100	371	371	9	9			27 112	-159	26 953	
1979	20 885	20 766	400	400	38	38	763	763	9	9			22 095	-119	21 976	
1980	15 215	15 096	384	384	40	40	914	914	11	11			16 564	-119	16 445	
1981	12 142	11 918	366	366	42	42	263	263	13	13			12 826	-224	12 602	
1982	10 598	10 506	384	384	19	19	127	127	11	11			11 139	-92	11 047	
1983	10 204	10 108	489	489	36	36	133	133	14	14			10 876	-96	10 780	
1984	10 873	10 812	699	699	31	31	27	27	22	22			11 652	-61	11 591	
1985	12 740	12 625	699	699	4	4	136	136	18	18			13 597	-115	13 482	
1986	13 128	13 115	404	404	2	2	505	505	26	26			14 065	-13	14 052	
1987	14 209	14 173	548	548	3	3	907	907	27	27			15 694	-36	15 658	19 250
1988	11 610	11 602	491	491		0	716	716	41	41			12 858	-8	12 850	19 750
1989	6 992	7 023	455	455		0	230	230	33	33			7 710	31	7 741	19 000
1990	10 557	10 559	981	981		2	471	471	69	69			12 078	4	12 082	13 000
1991	7 565	7 546	737	737		34	315	315	68	68			8 685	15	8 700	11 300
1992	10 591	10 582	589	589		117	537	537	106	106			11 823	108	11 931	14 000
1993	10 420	10 419	462	462	120	37	326	326	79	79			11 407	-84	11 323	14 000
1994	10 339	10 330	542	542	37	37	325	325	91	91			11 334	-9	11 325	14 000
1995	9 722	9 722	470	470	48	48	302	302	224	224			10 766	0	10 766	14 000
1996	9 593	9 641	465	465	31	11			428	428			10 517	28	10 545	14 000
1997	9 505	9 504	499	499	39	39			249	249			10 292	-1	10 291	14 000
1998	7 918	7 918	393	393	22	21			98	181			8 431	82	8 513	14 000
1999	7 983	7 983	373	394	27	27			336	336			8 719	21	8 740	14 000
2000	8 324	8 324	401	414	15	15			86	163			8 826	90	8 916	14 000
2001	11 114	11 114	357	385	1	0			181	61			11 653	-93	11 560	11 750
2002	8 275	8 276	322	338	29	29			163	58			8 789	-88	8 701	12 800
2003	6 884	6884	377	396	14	14			341	341	1 494	1 584	9 110	109	9 219	16 600
2004	7 135	7 135	317	244	77	77			106	106	1 455	1 511	9 090	-17	9 073	11 173
2005	5 605	5 619	244	244	21	47			80	116	814	915	6 764	177	6 941	9 500
2006	7 687	7 689	350	350	34	34			327	142	1 167	1 190	9 565	-160	9 405	9 600
2007	6 661	6 664	331	331	31	31			99	100	1 625	1 659	8 747	38	8 785	10 625
2008	7 766	7 767	356	355	23	11			79	79	433	403	8 657	-42	8 615	11 688
2009	6 188	6 183	176	176	18	18			60	60	306	255	6 748	-56	6 692	11 688
2010	7 278	7 520	193	177	17	17		73	49	49	1 520	1 332	9 057	111	9 168	11 641
2011	7 802	8 072	218	218	16	13		185	215	215		6	8 251	458	8 709	9 938
2012																9 938

Table 7.1.2. Plaice in Kattegat. Landings in tonnes Working Group estimates, 1972-2011

Year	Denmark	Sweden	Germany	Belgium	Norway	Total	TAC
1972	15 504	348	77			15 929	
1973	10 021	231	48			10 300	
1974	11 401	255	52			11 708	
1975	10 158	296	39			10 493	
1976	9 487	177	32			9 696	
1977	11 611	300	32			11 943	
1978	12 685	312	100			13 097	
1979	9 721	333	38			10 092	
1980	5 582	313	40			5 935	
1981	3 803	256	42			4 101	
1982	2 717	238	19			2 974	
1983	3 280	334	36			3 650	
1984	3 252	388	31			3 671	
1985	2 979	403	4			3 386	
1986	2 470	202	2			2 674	
1987	2 846	307	3			3 156	
1988	1 820	210	0			2 030	
1989	1 609	135	0			1 744	
1990	1 830	202	2			2 034	
1991	1 737	265	19			2 021	
1992	2 068	208	101			2 377	2.8
1993	1 294	175	0			1 469	2.8
1994	1 547	227	0			1 774	2.8
1995	1 254	133	0			1 387	2.8
1996	2 337	205	0			2 542	2.8
1997	2 198	255	25			2 478	2.8
1998	1 786	185	10			1 981	2.8
1999	1 510	161	20			1 691	2.8
2000	1 644	184	10			1 838	2.8
2001	2 069	260				2 329	2.3
2002	1 806	198	26			2 030	1.6
2003	2 037	253	6			2 296	3
2004	1 395	137	77			1 609	1.8
2005	1 104	100	47			1 251	1.9
2006	1 355	175	20			1 550	1.9
2007	1 198	172	10			1 380	2.1
2008	866	136	6			1 008	2.3
2009	570	84	5			659	2.3
2010	428	66	3			497	2.3
2011	328	40	0			368	2

* years 1972-1990 landings refers to IIIA

Table 7.1.3. Plaice in Skagerrak. Landings in tonnes. Working Group estimates, 1972-2011. TAC in thousands tonnes

Year	Denmark	Sweden	Germany	Belgium	Norway	Netherlands	Total	TAC
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	9.3

Table 7.2.1. Plaice IIIa. Landings at age (thousand) ; Plaice in IIIa (Kattegat Skagerrak)

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1978	489	15692	39531	24919	8011	620	63	63	108
1979	1105	9789	29655	20807	7646	2514	170	75	105
1980	362	4772	16353	12575	6033	2393	949	203	104
1981	190	4048	13098	10970	4306	1427	546	213	216
1982	526	2067	9204	10602	5554	1851	758	301	161
1983	1481	9715	8630	8026	2673	925	531	257	202
1984	2154	12620	11140	4463	2183	985	904	695	457
1985	1400	8641	21798	6232	1715	698	260	197	324
1986	375	4366	14749	19193	4477	633	274	154	239
1987	623	4227	12400	17710	10205	2089	373	242	315
1988	101	3052	12037	13783	6860	2745	946	322	292
1989	1012	3844	7102	6255	2708	1171	549	254	372
1990	3147	8748	8623	9718	3222	981	481	349	428
1991	2309	8611	9583	4663	2893	892	306	156	224
1992	904	3858	11759	17427	4297	1033	296	115	142
1993	1038	3505	10088	13233	6891	1657	376	104	116
1994	1411	6919	8016	9859	8002	2780	448	111	93
1995	446	2277	6606	11530	6622	4929	853	137	116
1996	4527	5353	7971	5283	4751	1812	1355	151	68
1997	529	4733	6379	9465	5104	3072	1369	849	150
1998	563	6710	8219	6856	2971	791	385	234	234
1999	687	2704	8432	8520	7419	1301	380	77	149
2000	1223	3937	8302	11212	3599	888	139	17	36
2001	3981	9172	9399	11001	4744	410	102	19	47
2002	364	5008	8861	7528	4843	1766	448	51	29
2003	3481	4686	9098	9279	4330	969	138	19	16
2004	1724	17816	4271	4056	1994	265	97	11	18
2005	3775	4853	9688	3389	1754	768	169	63	19
2006	1288	13064	9241	7045	1293	673	216	38	28
2007	4788	8085	8282	4398	3407	512	140	61	31
2008	1627	7164	8859	5735	2499	1516	90	98	94
2009	1319	8239	7112	2963	1058	222	107	2	6
2010	1678	9616	11376	3447	999	321	146	125	44
2011	3710	4827	7146	5846	1886	293	151	72	28

Table 7.2.2. Plaice IIIa. Mean weight at age in landings (kg)

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10+**
1978	0.236	0.248	0.268	0.322	0.417	0.598	0.752	0.818	0.875
1979	0.222	0.255	0.267	0.297	0.378	0.451	0.655	0.922	1.033
1980	0.261	0.274	0.306	0.345	0.414	0.579	0.640	0.753	0.859
1981	0.230	0.263	0.296	0.357	0.432	0.537	0.671	0.813	0.951
1982	0.270	0.301	0.286	0.318	0.386	0.544	0.704	0.813	0.934
1983	0.285	0.274	0.293	0.356	0.423	0.483	0.531	0.647	1.090
1984	0.282	0.299	0.304	0.372	0.403	0.406	0.383	0.360	0.605
1985	0.278	0.282	0.308	0.354	0.437	0.544	0.680	0.737	0.832
1986	0.250	0.277	0.284	0.310	0.384	0.531	0.707	0.850	0.983
1987	0.322	0.280	0.281	0.292	0.363	0.527	0.711	0.904	1.065
1988	0.252	0.267	0.268	0.290	0.350	0.475	0.567	0.755	1.025
1989	0.274	0.263	0.282	0.320	0.376	0.466	0.635	0.741	0.937
1990	0.292	0.288	0.294	0.337	0.397	0.498	0.684	0.775	1.078
1991	0.263	0.270	0.259	0.274	0.365	0.492	0.584	0.670	1.003
1992	0.309	0.310	0.272	0.280	0.336	0.500	0.646	0.817	0.943
1993	0.267	0.272	0.271	0.295	0.338	0.441	0.566	0.712	1.020
1994	0.275	0.263	0.272	0.289	0.330	0.381	0.516	0.658	0.892
1995	0.263	0.301	0.303	0.289	0.328	0.368	0.499	0.736	0.871
1996	0.266	0.268	0.294	0.384	0.399	0.436	0.430	0.561	0.928
1997	0.300	0.294	0.283	0.299	0.341	0.410	0.465	0.445	0.586
1998	0.260	0.250	0.280	0.327	0.398	0.464	0.515	0.587	0.702
1999	0.271	0.271	0.290	0.290	0.294	0.336	0.370	0.656	0.643
2000	0.257	0.262	0.276	0.302	0.355	0.388	0.517	0.857	0.968
2001	0.257	0.272	0.290	0.322	0.310	0.425	0.589	0.836	0.777
2002	0.246	0.271	0.270	0.287	0.338	0.402	0.595	0.794	1.149
2003	0.243	0.252	0.271	0.290	0.298	0.400	0.464	0.605	0.845
2004	0.240	0.276	0.320	0.347	0.378	0.523	0.786	0.844	0.693
2005	0.244	0.260	0.292	0.327	0.348	0.381	0.513	0.664	1.092
2006	0.246	0.267	0.289	0.342	0.335	0.355	0.456	0.587	0.873
2007	0.245	0.286	0.316	0.317	0.348	0.363	0.527	0.509	0.929
2008	0.267	0.292	0.294	0.329	0.396	0.457	0.549	0.522	0.502
2009	0.242	0.284	0.323	0.373	0.479	0.531	0.669	0.878	0.957
2010	0.269	0.303	0.328	0.387	0.46	0.459	0.408	0.445	0.551
2011	0.293	0.315	0.351	0.414	0.45	0.53	0.59	0.48	0.449

Table 7.2.3. Plaice IIIa. Reported Discards in weight (tonnes)

Year	Denmark	Sweden	Total
2002	2002	486	2488
2003	2089	584	2673
2004	1628	273	1901
2005	1363	302	1665
2006	1282	347	1629
2007	1401	484	1885
2008	1201	330	1531
2009	1288	215	1503
2010	1112	225	1337
2011	1730	181	1911

Table 7.2.4. Plaice IIIa. Discard numbers ('000) (Reported only until 2010, Reported+Estimated 2011)

	Age									
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2002	4	2592	7175	5886	3001	944	226	64	7	3
2003	4	2600	10159	5452	2506	954	251	65	6	2
2004	4	1664	4839	5506	2058	793	225	40	4	1
2005	4	814	4733	4579	2018	745	213	55	11	1
2006	6	739	3650	5247	1812	723	179	40	3	0
2007	5	1046	5131	4403	2151	797	229	57	26	10
2008	5	741	5049	4187	1913	660	206	48	11	6
2009	7	581	3601	4495	1839	606	187	44	7	0
2010	0	690	2915	4149	2212	272	29	2	5	0
2011	17	1816	7363	3147	1243	488	233	39	19	4

Table 7.2.5. Plaice IIIa. Discard mean weight (kg)

	Age										
Year	0	1	2	3	4	5	6	7	8	9	10
2002	0.033	0.065	0.117	0.136	0.147	0.167	0.258	0.272	0.320	0.316	0.300
2003	0.030	0.061	0.116	0.135	0.147	0.157	0.234	0.268	0.300	0.300	0.300
2004	0.030	0.076	0.111	0.135	0.151	0.160	0.180	0.284	0.300	0.300	0.300
2005	0.030	0.078	0.110	0.132	0.151	0.159	0.177	0.213	0.164	0.300	0.440
2006	0.030	0.081	0.115	0.135	0.153	0.164	0.206	0.250	0.271	0.300	0.300
2007	0.030	0.085	0.121	0.143	0.160	0.174	0.177	0.198	0.227	0.239	0.205
2008	0.030	0.070	0.093	0.130	0.155	0.177	0.173	0.280	0.210	0.146	0.154
2009	0.029	0.071	0.110	0.135	0.162	0.184	0.181	0.325	0.284	0.300	0.205
2010	0.000	0.079	0.109	0.137	0.166	0.164	0.217	0.151	0.115	0.000	0.249
2011	0.011	0.079	0.124	0.156	0.204	0.232	0.185	0.237	0.217	0.202	0.184

Table 7.2.6. Plaice IIIa. Mean weight at age in stock (kg)

	Age								
Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1978	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1979	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1980	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1981	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1982	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1983	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1984	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1985	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1986	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1987	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1988	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1989	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1990	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1991	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1992	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1993	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1994	0.091	0.159	0.253	0.295	0.341	0.399	0.426	0.509	0.635
1995	0.081	0.192	0.306	0.26	0.334	0.385	0.403	0.567	0.695
1996	0.099	0.17	0.287	0.327	0.312	0.317	0.311	0.424	0.443
1997	0.123	0.165	0.243	0.299	0.353	0.495	0.572	0.544	0.689
1998	0.063	0.133	0.223	0.297	0.386	0.451	0.43	0.392	0.501
1999	0.09	0.133	0.208	0.294	0.319	0.346	0.414	0.618	0.849
2000	0.064	0.133	0.196	0.295	0.318	0.316	0.845	0.8	0.926
2001	0.085	0.145	0.234	0.299	0.288	0.382	0.655	0.781	0.699
2002	0.064	0.122	0.162	0.304	0.328	0.372	0.389	0.769	0.932
2003	0.092	0.133	0.179	0.287	0.294	0.348	0.415	0.557	0.782
2004	0.065	0.12	0.169	0.34	0.368	0.473	0.68	0.809	0.969
2005	0.083	0.129	0.214	0.301	0.326	0.349	0.455	0.537	0.73
2006	0.075	0.132	0.215	0.333	0.315	0.415	0.515	0.56	0.826
2007	0.066	0.129	0.212	0.309	0.357	0.44	0.504	0.45	0.909
2008	0.056	0.125	0.197	0.318	0.374	0.462	0.597	0.732	1.022
2009	0.059	0.115	0.191	0.343	0.401	0.605	0.747	1.048	1.135
2010	0.063	0.146	0.251	0.319	0.365	0.337	0.319	0.662	0.816
2011	0.07	0.119	0.178	0.337	0.42	0.373	0.28	0.67	0.249

Table 7.2.7. Plaice IIIa. Maturity

Year	age						
	2	3	4	5	6	7	8	9
all	0.54	0.74	0.88	0.92	0.94	1	1	1

Table 7.2.8. Plaice IIIa. Tuning fleets.

[1] "Final Tuning File"									
106									
DK Gillnetters									
1995	2011								
1	1	0	1						
2	10								
236150	41004	162022	481951	1218991	661753	725503	138092	21132	15729
199512	159746	347956	526608	521810	494928	203666	147976	14233	4957
206792	41993	443102	393385	459126	314599	249657	142019	58770	15011
169842	22639	248607	449714	564524	254092	76487	42318	27666	31299
193717	47487	109450	503992	623875	772756	155731	50526	14452	14580
174610	30628	158975	516760	642735	302086	85045	16696	2099	4582
263858	170611	265684	492485	1059222	629625	66119	19361	2947	5080
199439	25874	322449	386538	366741	362332	224494	70754	11011	8426
170502	138544	168218	436703	518599	301809	105409	18907	2335	2511
152678	45145	756831	293827	284613	156901	30654	13285	1506	3642
119359	113387	162549	537575	255771	138559	66752	18560	8054	1921
163118	34391	525195	530686	466561	95788	47550	23536	6328	1710
127209	51305	177146	433268	383912	341224	42487	13976	5308	1360
162827	91680	677422	671484	536109	274896	142787	8049	6317	4531
162329	57592	587305	853890	412443	172438	27419	16721	537	734
97567	7389	169095	351497	210391	78895	31498	10389	5230	2060
93990	20567	143818	437263	585323	277935	27357	15248	2902	143
DK Seiners									
1995	2011								
1	1	0	1						
2	10								
848990	155505	483163	1237122	2102300	1537781	1039883	145632	22771	19269
829741	671949	1146592	1643737	877448	817287	295731	209090	20906	7373
760695	99282	1097581	1727655	2229125	1100779	739059	319951	250184	29125
726990	113924	1884590	2083633	1781242	779096	207230	96901	56672	58032
822345	197769	601501	2398479	2485717	2164017	319256	89023	19404	39372
920377	291648	1236918	2880342	4216432	1227383	377336	53683	2629	4390
1026524	1545624	3602553	3074242	3346357	1336759	127829	30600	6680	9428
887462	108998	1717074	3300009	2939239	1745286	567066	132372	11880	7025
699429	985829	1658716	3194559	3065635	1240986	234046	40482	4406	3225
641455	582551	5697194	1385089	1168507	587432	82853	14087	2057	3006
514275	1476819	1663149	2875087	892939	442738	170333	32412	8271	2719
449215	369650	3752667	2660569	1929726	346736	173716	52471	10513	2232
416847	1130631	2175839	2741921	1129860	837340	108032	26929	10781	2858
492237	1046295	3871426	3011190	1774239	624904	432156	15886	17151	8606
511145	596521	4092247	2836371	1068803	412662	86203	28744	625	2875
475751	653898	3686158	4260548	1159981	251079	88761	32855	26749	6737
384931	1851067	2647108	3156171	2246343	674788	121347	69931	42043	7546

KASU_Q4						
1994	2011					
1	1	0.83	1			
1	6					
1	0.88	10.52	5.88	0.37	0.99	0.03
1	1.68	10.33	3.77	0.19	1.1	0.06
1	2.53	40.5	13.3	0.44	0.49	0.1
1	11.09	11.47	4.35	1.26	0.65	0.36
1	18.78	15.51	5.4	3.65	0	0.11
1	101.33	52.58	8.08	1.37	0.71	0.66
1	105.68	133.42	15.94	0.54	0.46	0.46
1	52.93	99.92	29.79	1.71	0.49	0.85
1	67.57	26.27	37.38	17.79	1.69	0.15
1	43.68	64.18	15.49	6.5	3.51	0.36
1	15.63	74.63	80.93	10.41	13.82	13.26
1	112.77	41.53	7.23	1.41	0.1	0.08
1	56.24	73.38	69.35	17.41	6.76	2.56
1	40.93	48.52	12.45	3.06	0.44	0
1	30.86	109.16	53.12	15.14	2.17	0.11
1	28.46	70.64	21.07	2.47	0.81	0
1	26.38	27.13	16.62	15.22	1.74	3.27
1	46.62	42.06	19.62	8.54	3.16	2.41
KASU_Q1						
1996	2011					
1	1	0.25	0.33			
1	6					
1	2.59	22.47	26.16	6.22	1.82	0.82
1	0.05	11.49	19.45	4.39	1.75	0.68
1	-9	-9	-9	-9	-9	-9
1	4.87	26.93	23.26	2.95	1.3	0.16
1	32.72	204.49	50.43	9.43	1.95	1.72
1	11.47	127.73	73.92	6.67	1.7	1.33
1	21.72	47.59	81.22	33.06	2.06	0.47
1	10.16	166.86	47.6	46.42	8.84	0.21
1	7.25	79.27	81.99	32.82	13.93	4.9
1	13.37	163.34	111.95	23.44	5.7	1.58
1	16.12	151.51	218.94	35.68	5.69	0.47
1	7.65	112.75	117.87	38.84	7.09	1.14
1	21.15	41.16	47.95	16.03	4.08	1.15
1	3.37	74.03	134.36	28.69	6	2.43
1	39.09	57.49	39.43	8.34	1.85	0.39
1	12.8	106.57	60.31	16.95	11.05	1.64
IBTS_Q1_backshifted						
1990	2011					
1	1	0.99	1			
1	6					
1	9.554	21.086	11.194	3.709	0.295	0.088
1	9.212	18.694	12.317	2.863	0.381	0.108
1	14.576	13.391	13.409	12.098	4.634	0.54
1	19.294	13.749	3.902	2.334	2.544	0.575
1	10.119	21.41	8.92	2.432	1.742	0.79
1	47.736	30.494	9.762	3.343	0.736	0.354
1	20.889	46.748	9.572	3.344	0.181	0.07
1	15.734	17.19	9.503	3.281	0.769	0.231
1	44.596	19.46	5.919	5.676	0.312	0.187
1	131.436	72.726	14.978	5.36	3.372	0.314
1	55.159	91.759	20.406	3.222	2.088	0.786
1	15.572	66.061	44.183	10.796	1.928	1.624
1	95.55	50.848	46.2	33.622	6.34	1.046
1	40.786	116.248	33.615	27.507	25.388	1.609
1	117.052	85.371	51.22	21.276	31.614	9.206
1	37.977	97.566	22.756	13.041	4.176	13.95
1	52.122	83.733	83.427	27.317	15.665	6.024
1	49.271	45.786	20.573	7.57	5.683	2.521
1	17.027	29.409	7.752	3.149	1.358	0.683
1	12.013	48.48	33.335	13.619	4.103	1.144
1	11.031	23.831	31.575	17.747	8.786	6.78
1	5.286	10.372	4.975	1.312	0.561	0
IBTS_Q3						
1997	2011					
1	1	0.83	1			
1	6					
1	16.285	17.279	8.629	2.229	0.79	0.448
1	27.919	19.972	5.258	3.661	0.427	0
1	77.47	59.446	14.35	1.529	1.7	0.314
1	-9	-9	-9	-9	-9	-9
1	19.306	109.311	63.618	9.133	3.775	1.031
1	66.305	54.15	33.273	24.383	4.117	0.445
1	14.976	40.931	6.951	9.842	9.284	1.109
1	51.948	39.985	41.405	3.77	5.493	3.956
1	17.764	60.044	13.524	15.779	3.687	3.701
1	24.39	59.548	72.108	18.138	13.092	6.993
1	29.698	49.557	30.19	16.019	5.784	3.276
1	5.107	98.317	33.392	21.079	6.317	1.484
1	13.459	53.647	105.145	15.318	3.393	0.944
1	9.325	22.314	32.623	41.558	6.59	2.976
1	16.587	27.704	37.319	19.479	10.927	5.579

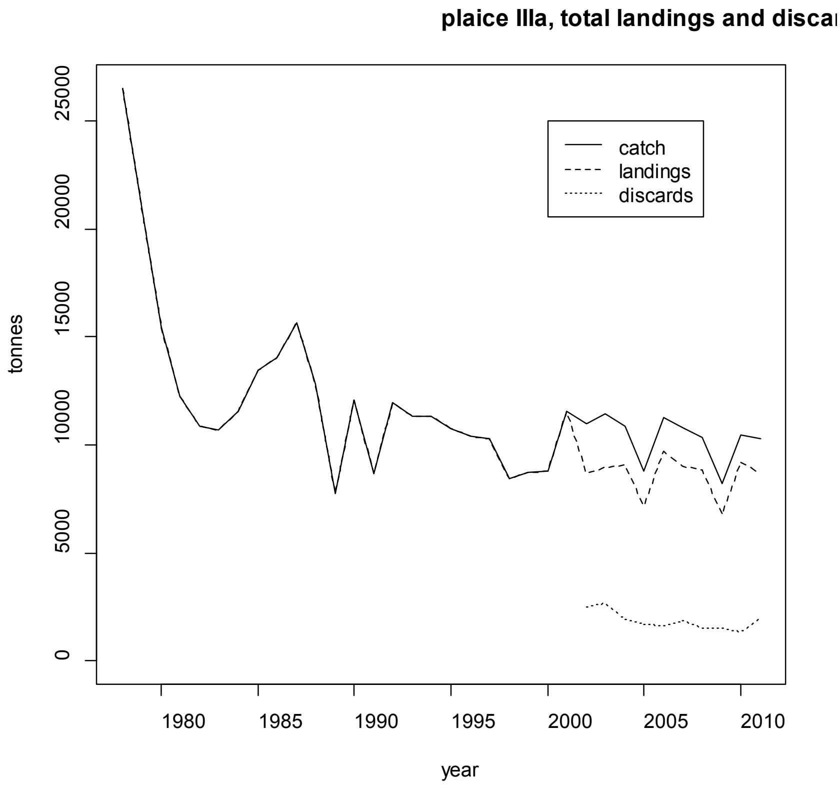


Figure 7.1.1. Plaice IIIa. Upper : Total landings and discards, 1978-2010. Lower : Landings by area and combined TAC

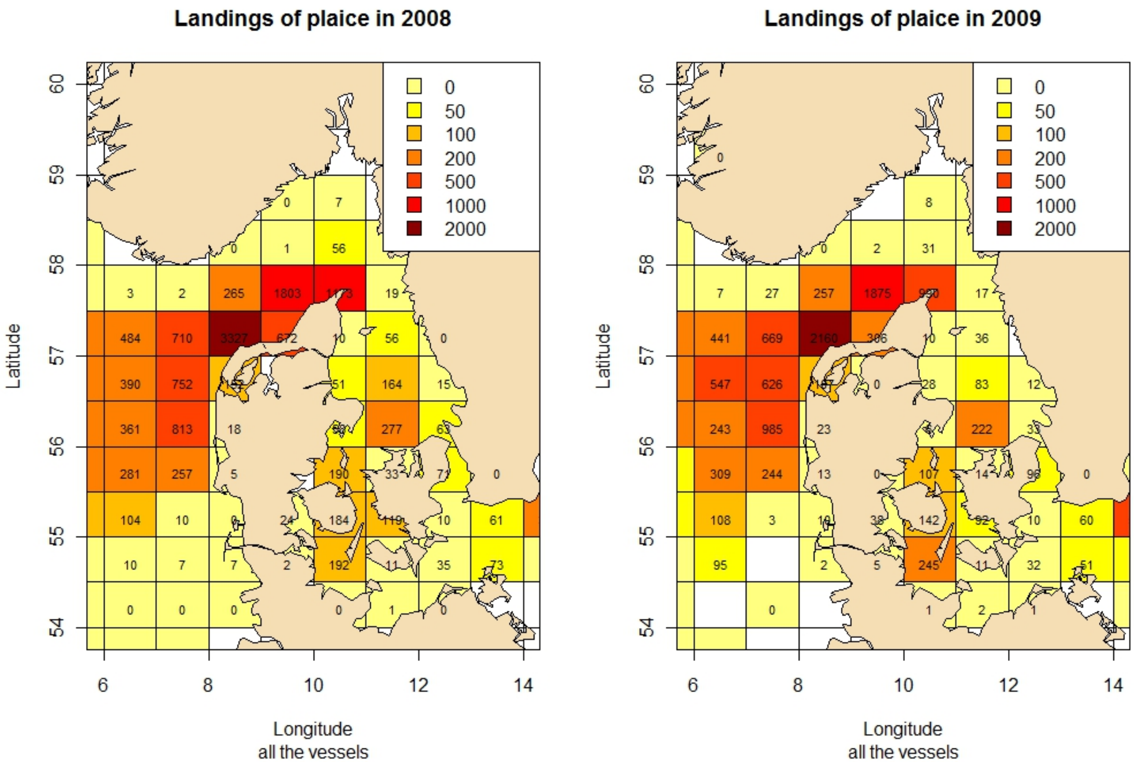


Figure 7.2.1. Annual distribution of Danish plaice landings in 2008 and 2009.

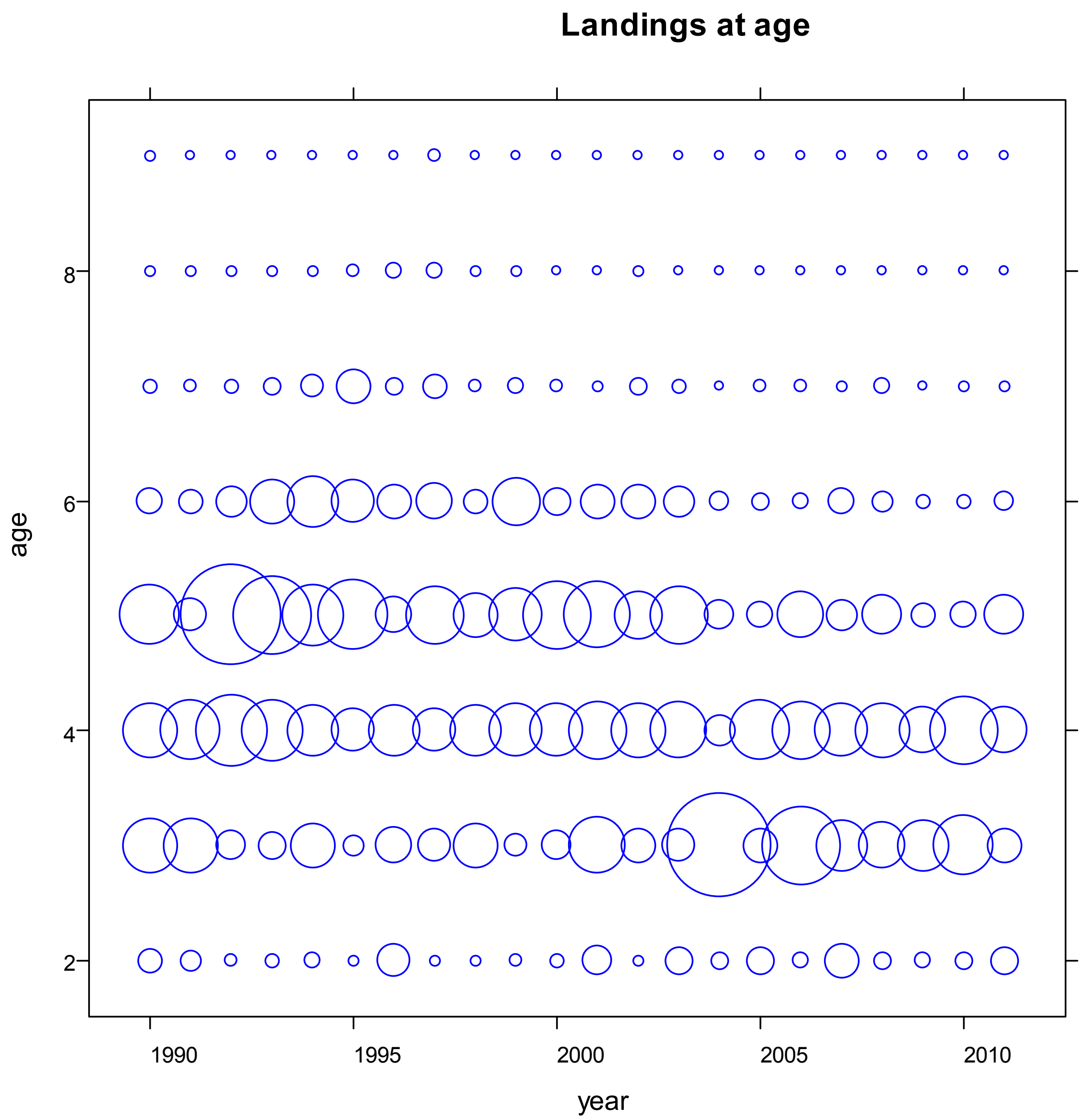


Figure 7.2.2. Plaice IIIa. Relative landings at age.

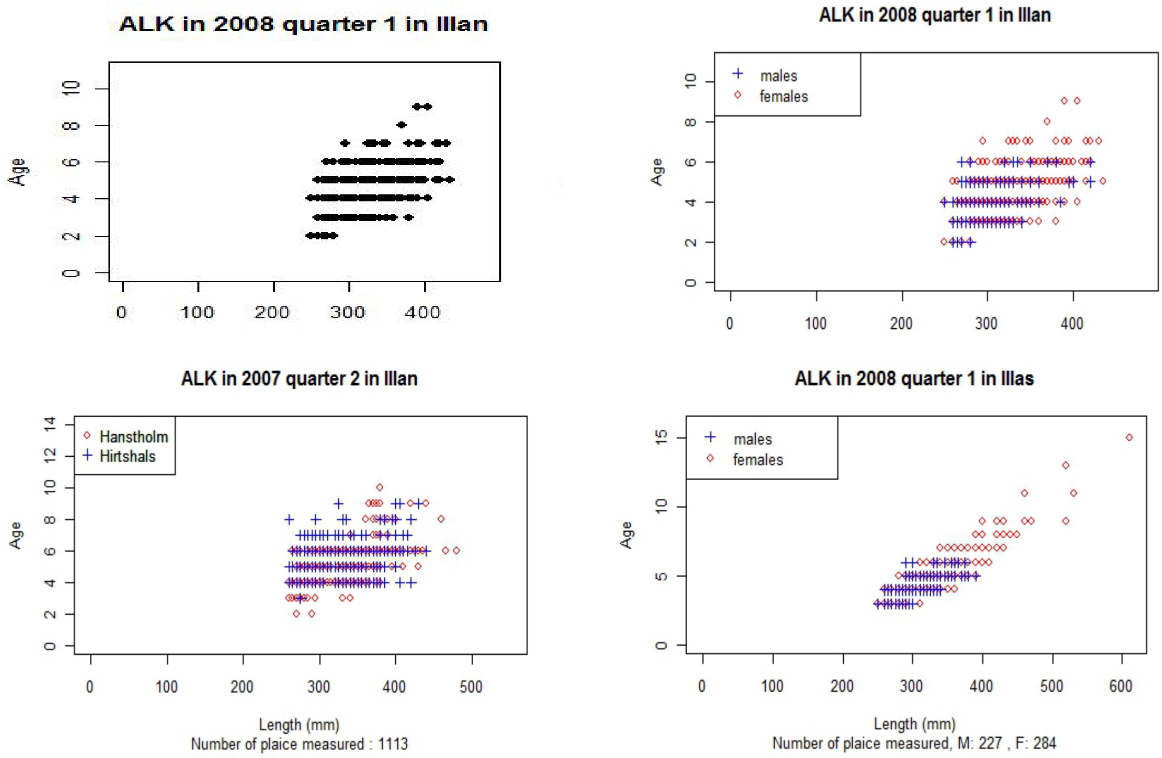


Figure 7.2.3. Example of Age-length key analysis. Ages overlap across length distribution, and there is no strong effect linked to either sex or sampling harbor.

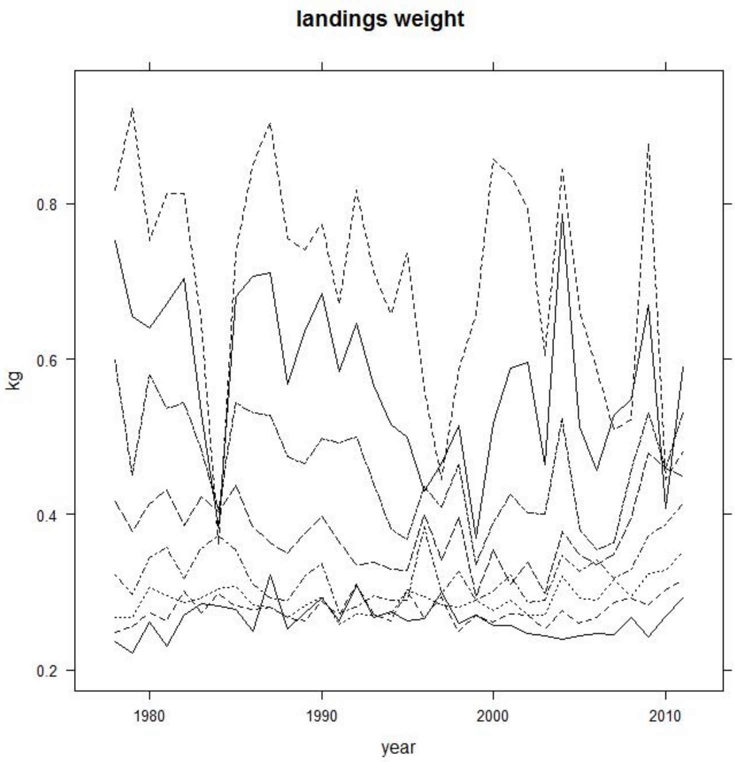


Figure 7.2.4. Landings weight at age

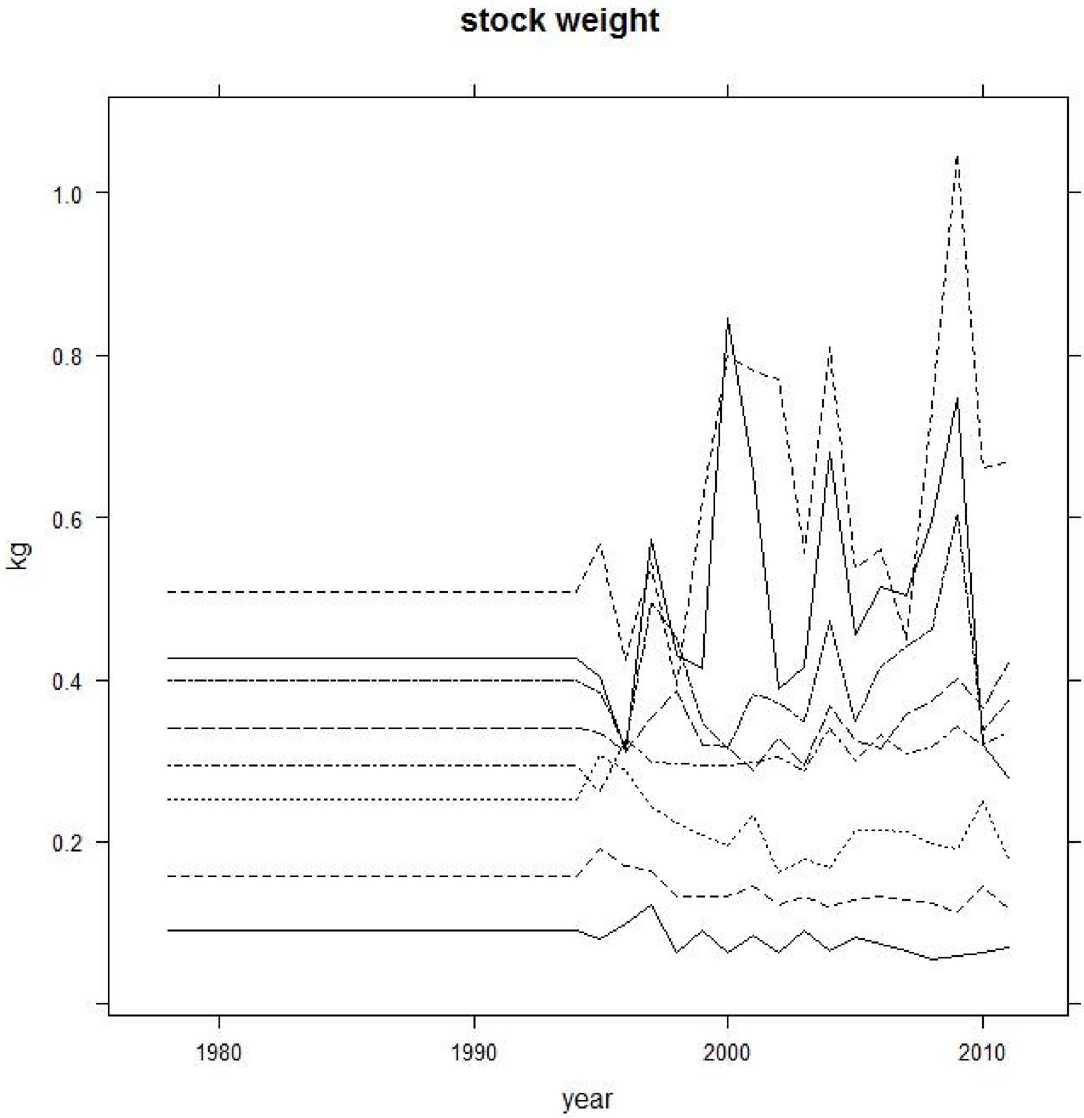


Figure 7.2.5. Stock weight at age

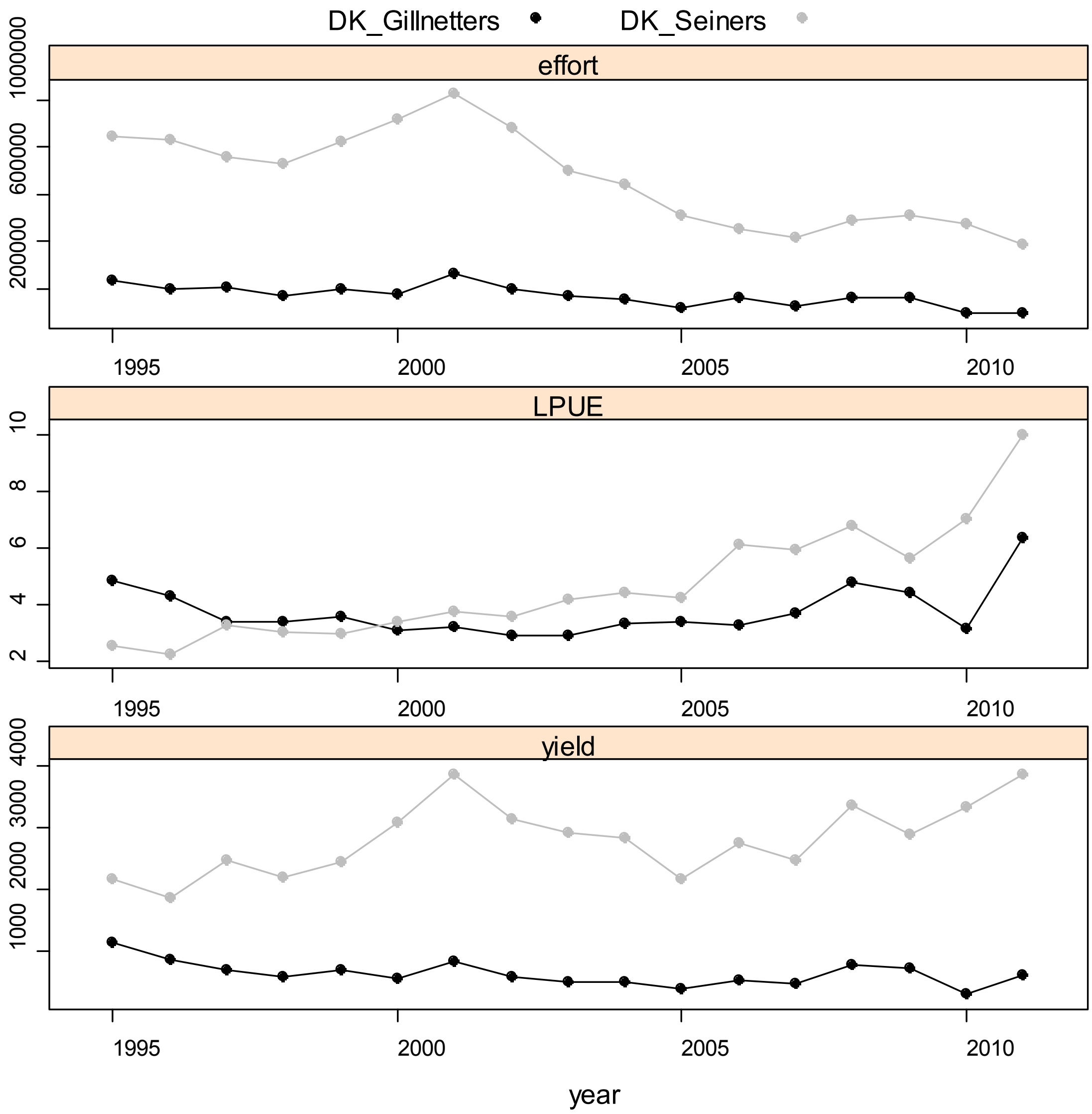


Figure 7.2.6. Plaice IIIa. Effort, landing and LPUE for the Danish commercial tuning fleets.

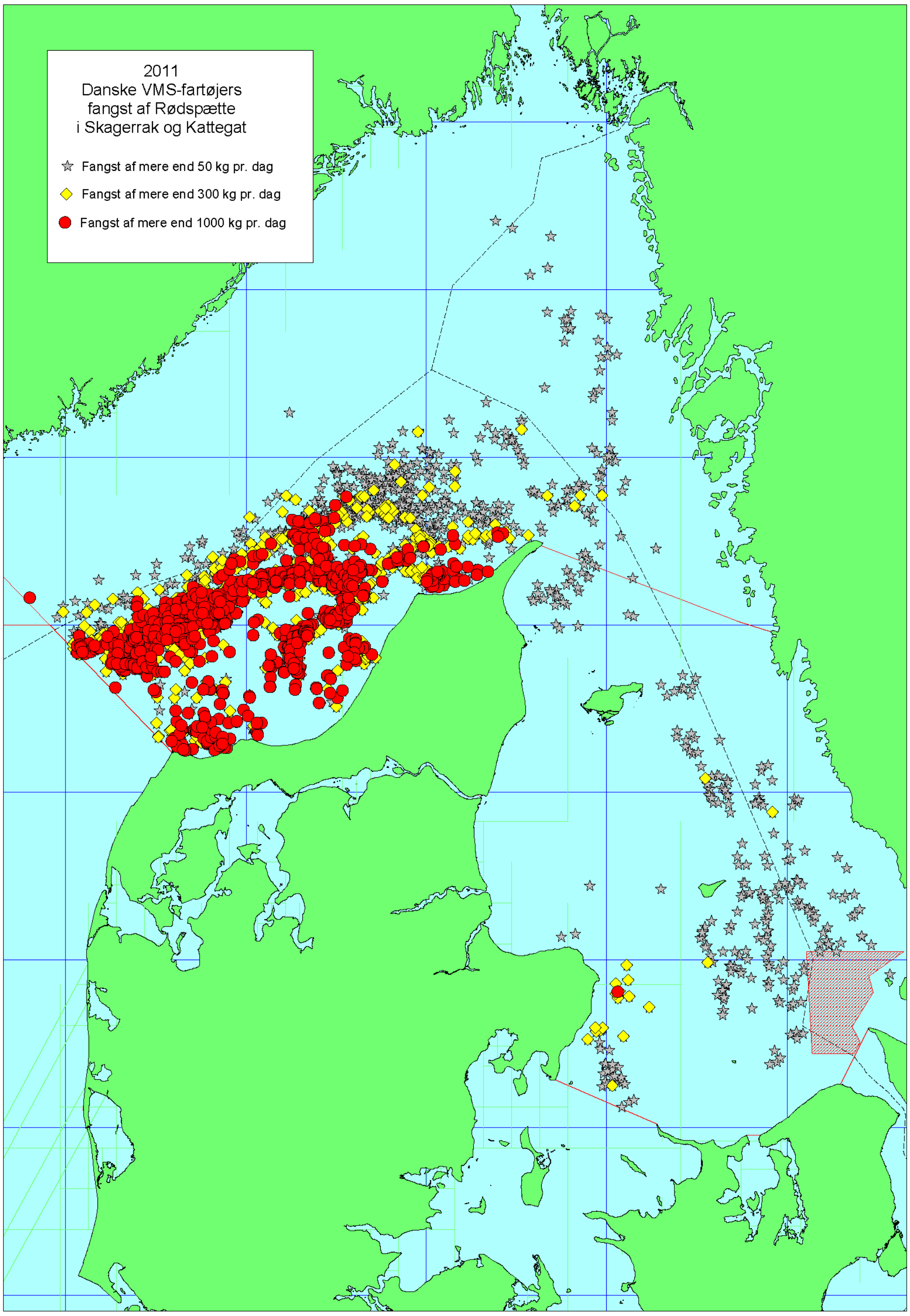


Figure 7.2.7. Plaice IIIa. 2011 landings per day in the Danish fishery (vessel equipped with VMS only). Source : Danish AgriFish Agency.

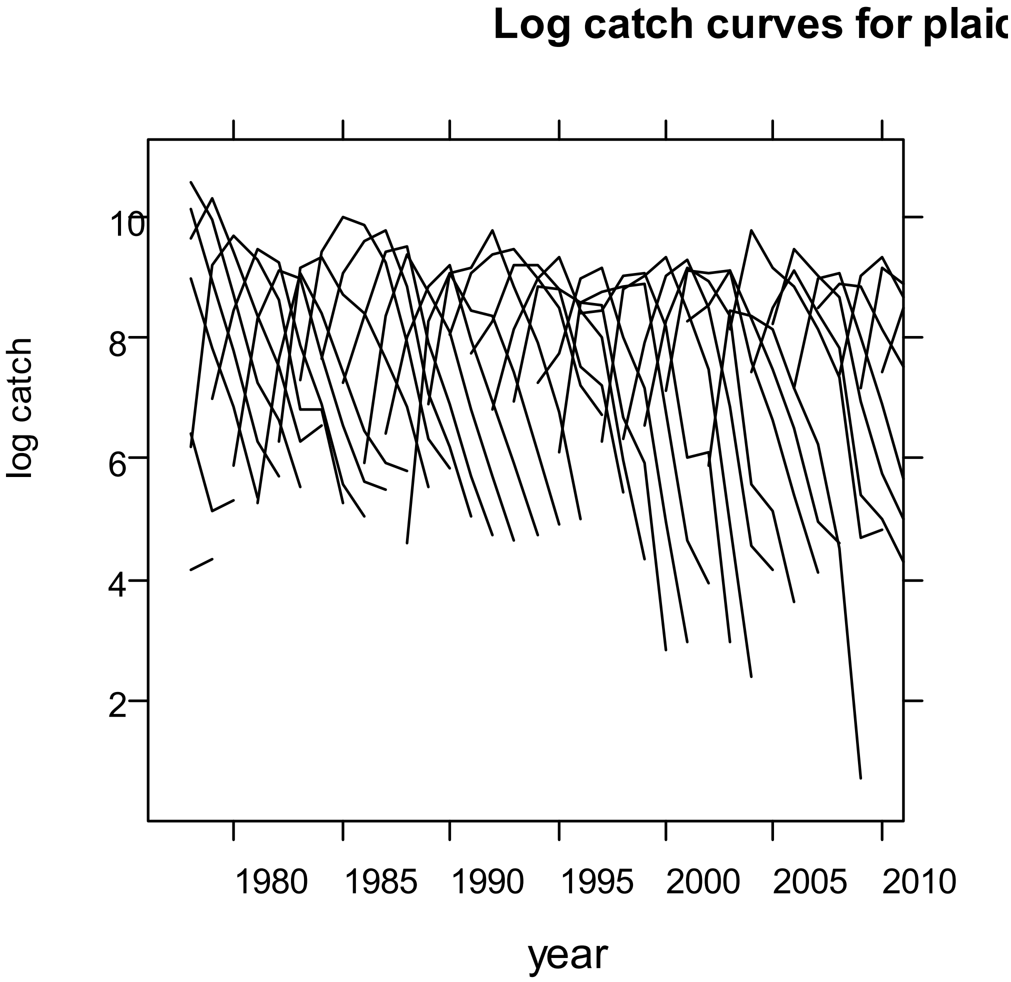
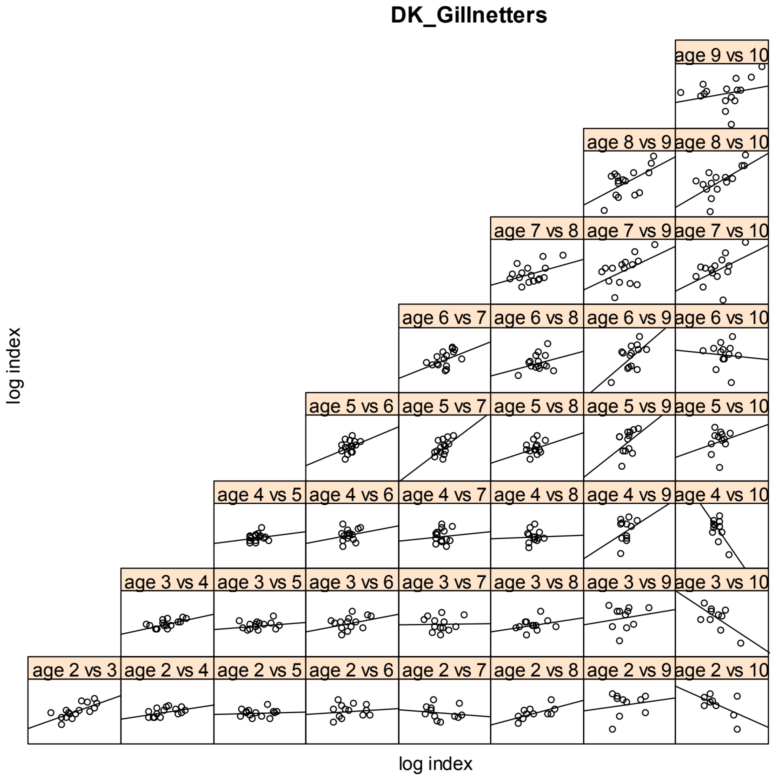


Figure 7.3.1. Plaice IIIa. Log catch curves by cohort in the landings at age



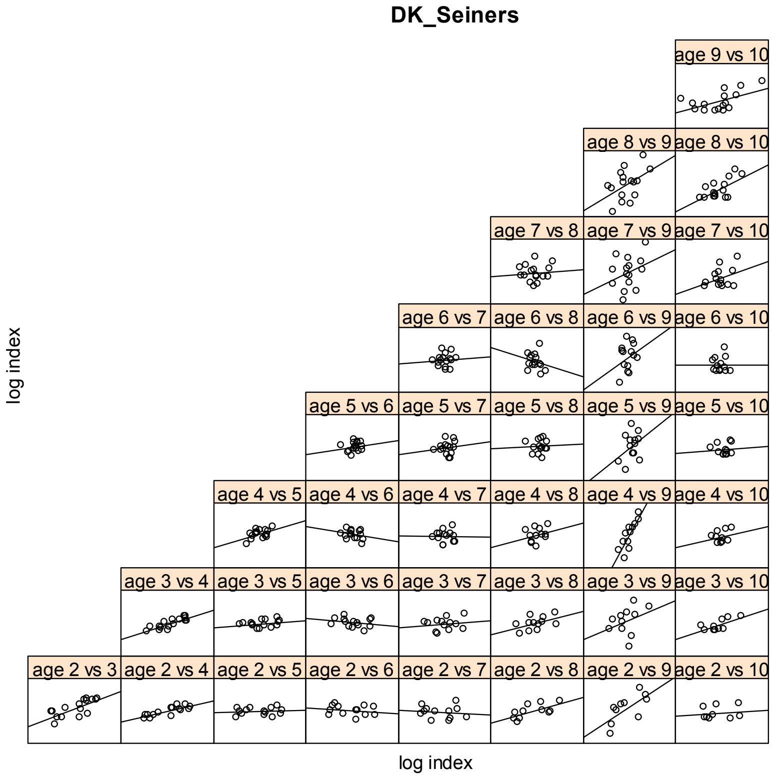


Figure 7.3.2. Plaice IIIa. Internal consistency for the commercial tuning fleets: matrix scatterplots and Log cohort abundance. Up : DK_Gillnetters. Bottom: DK_Seiners.

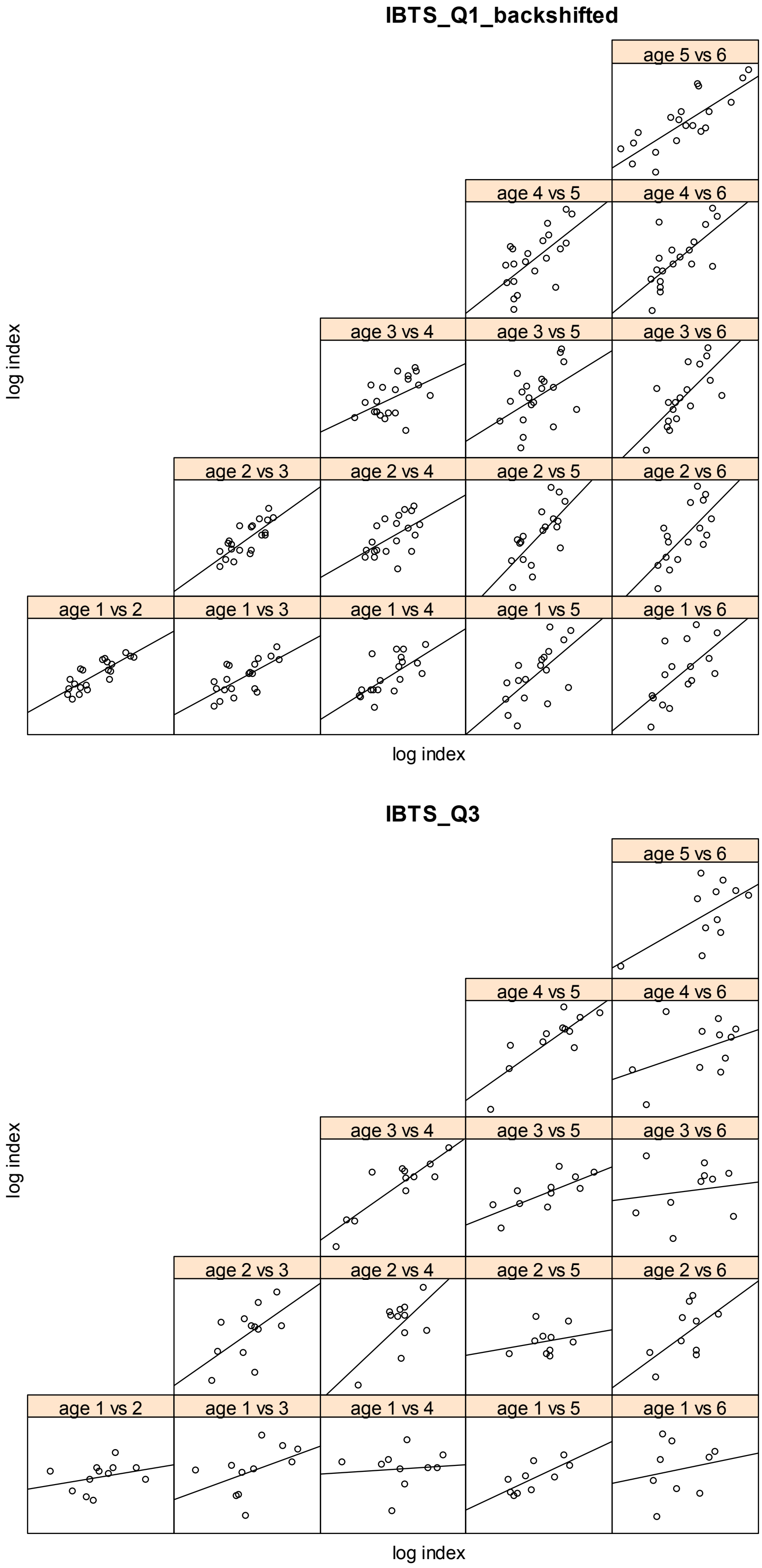


Figure 7.3.3. Plaice IIIa. Internal consistency for the IBTS survey: matrix scatterplots and Log cohort abundance. Top : IBTS Q1 backshifted. Bottom: IBTS Q3.

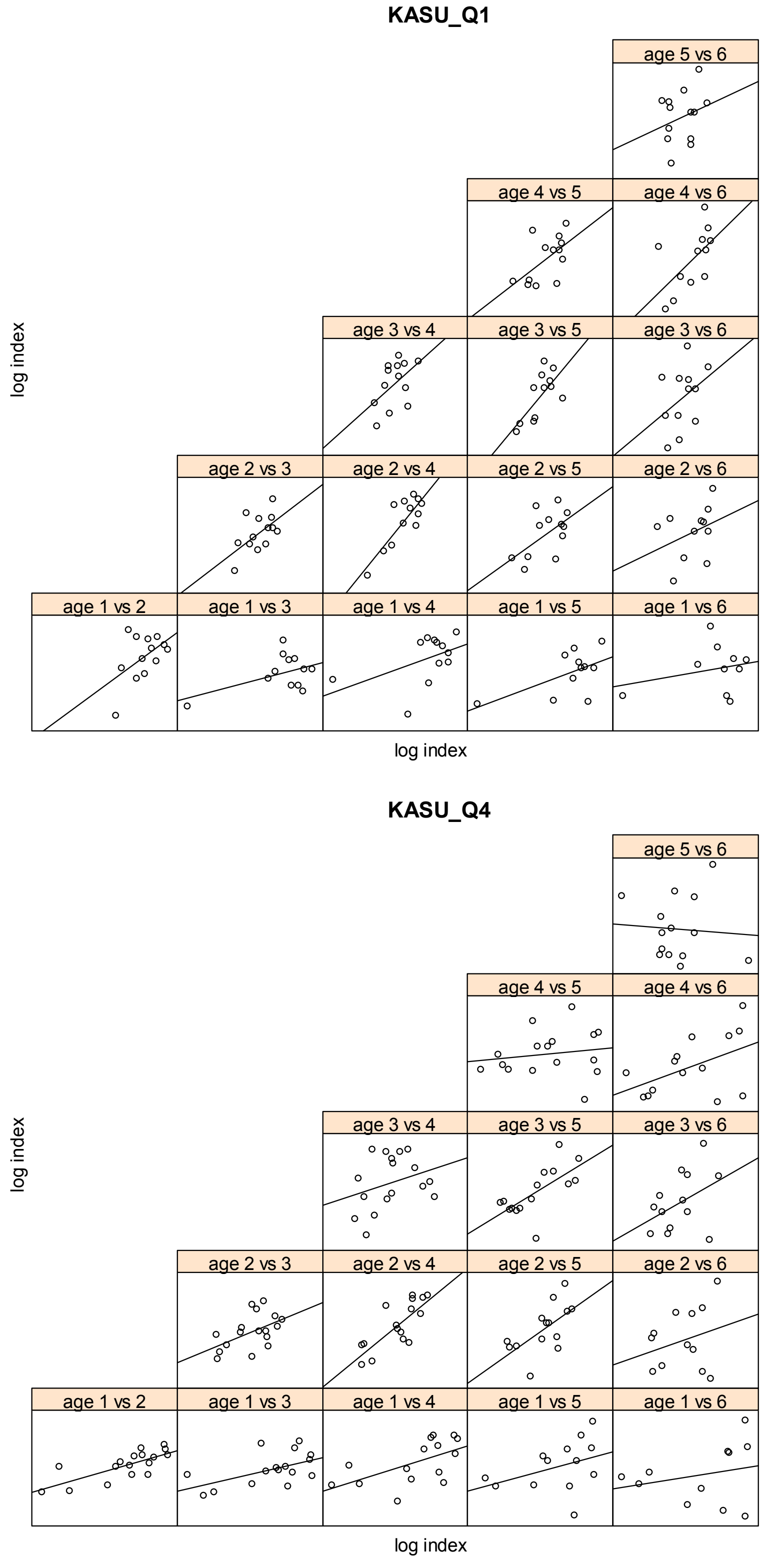


Figure 7.3.4 Internal consistency for the KASU survey: matrix scatterplots and Log cohort abundance. Top : KASU Q1. Bottom: KASU Q4.

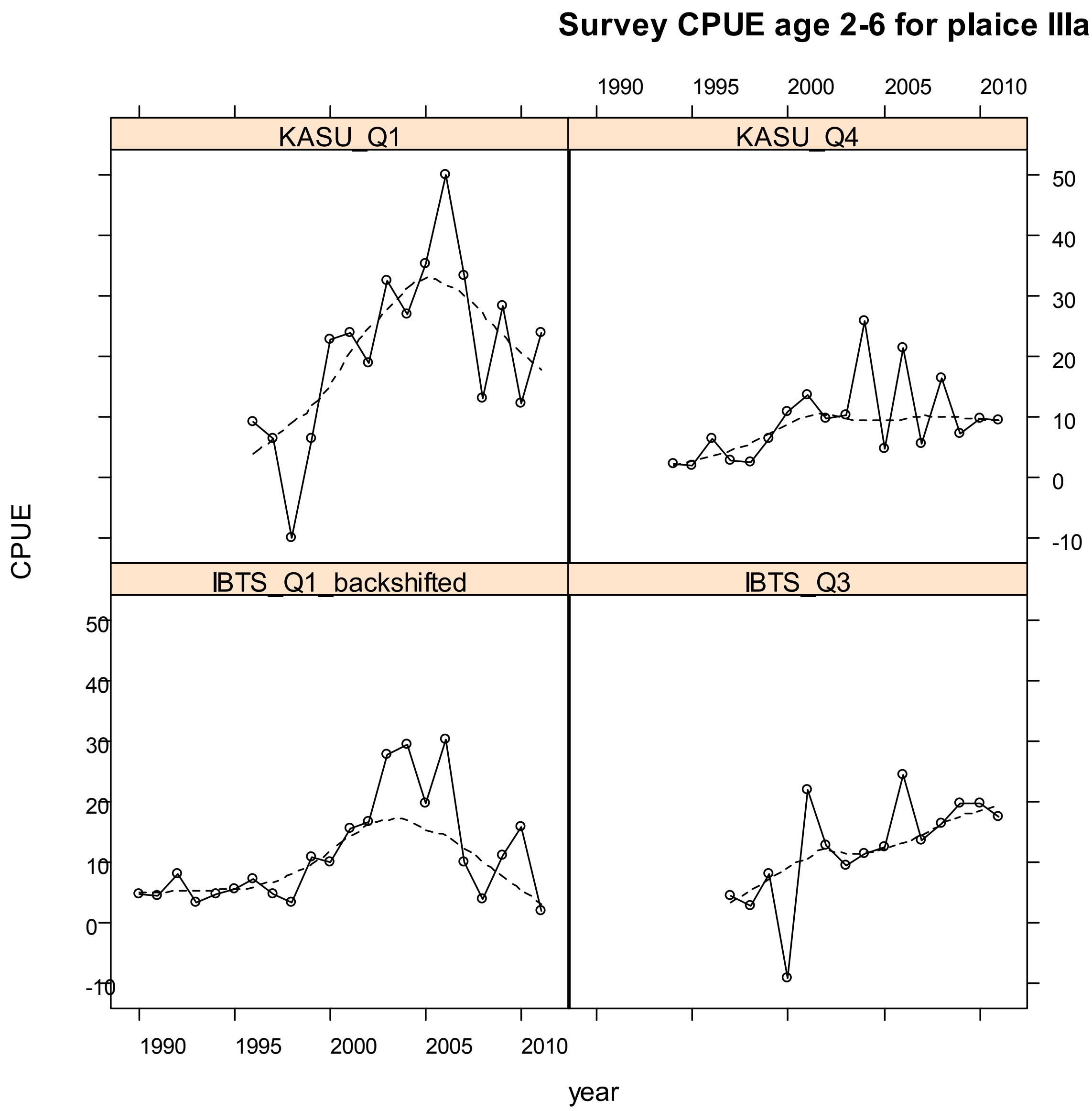


Figure 7.3.5. Plaice IIIa. CPUE (kg/half-hour) for the four surveys

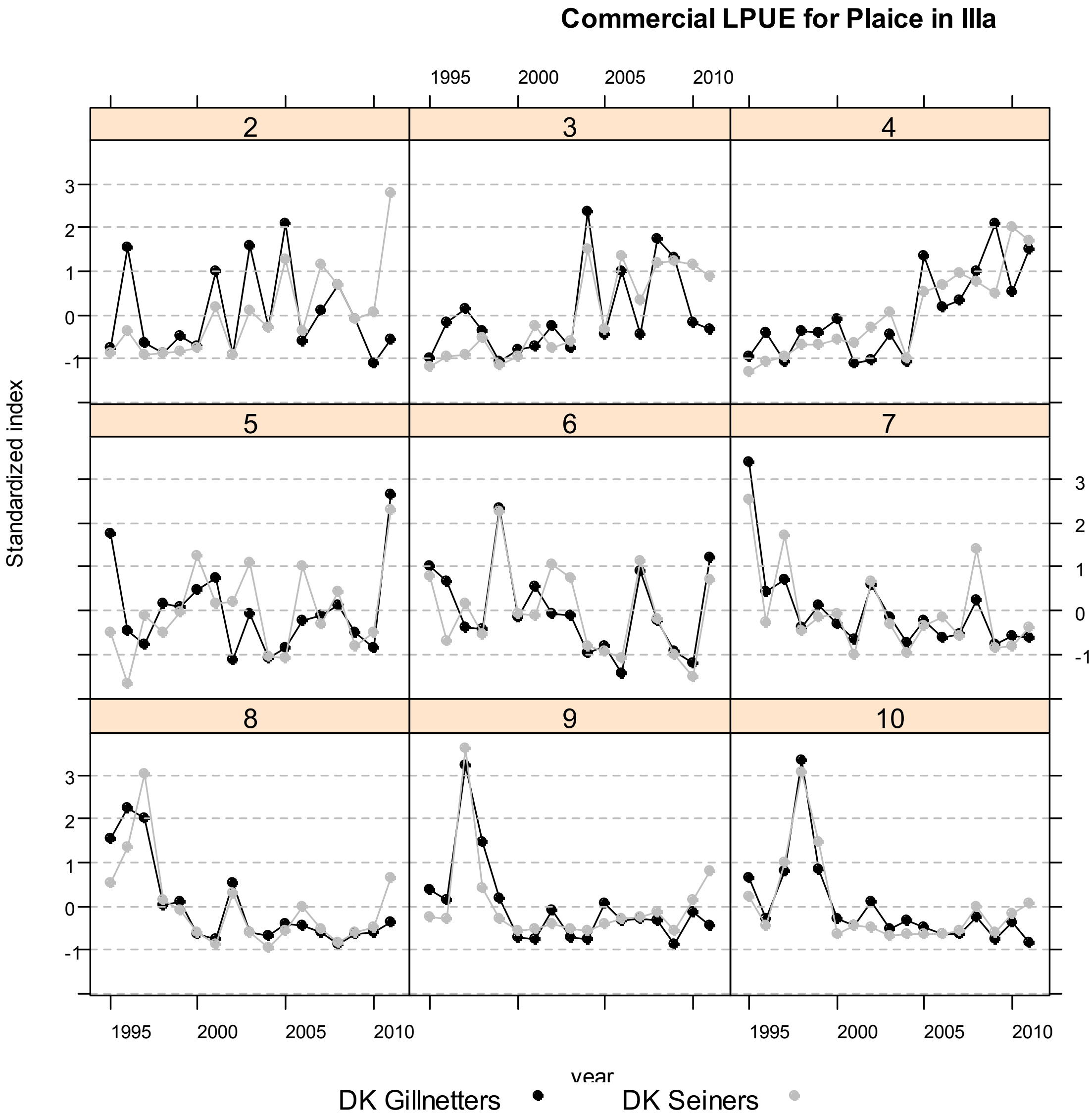


Figure 7.3.6. Plaice IIIa. Standardised Abundance index from commercial tuning series.

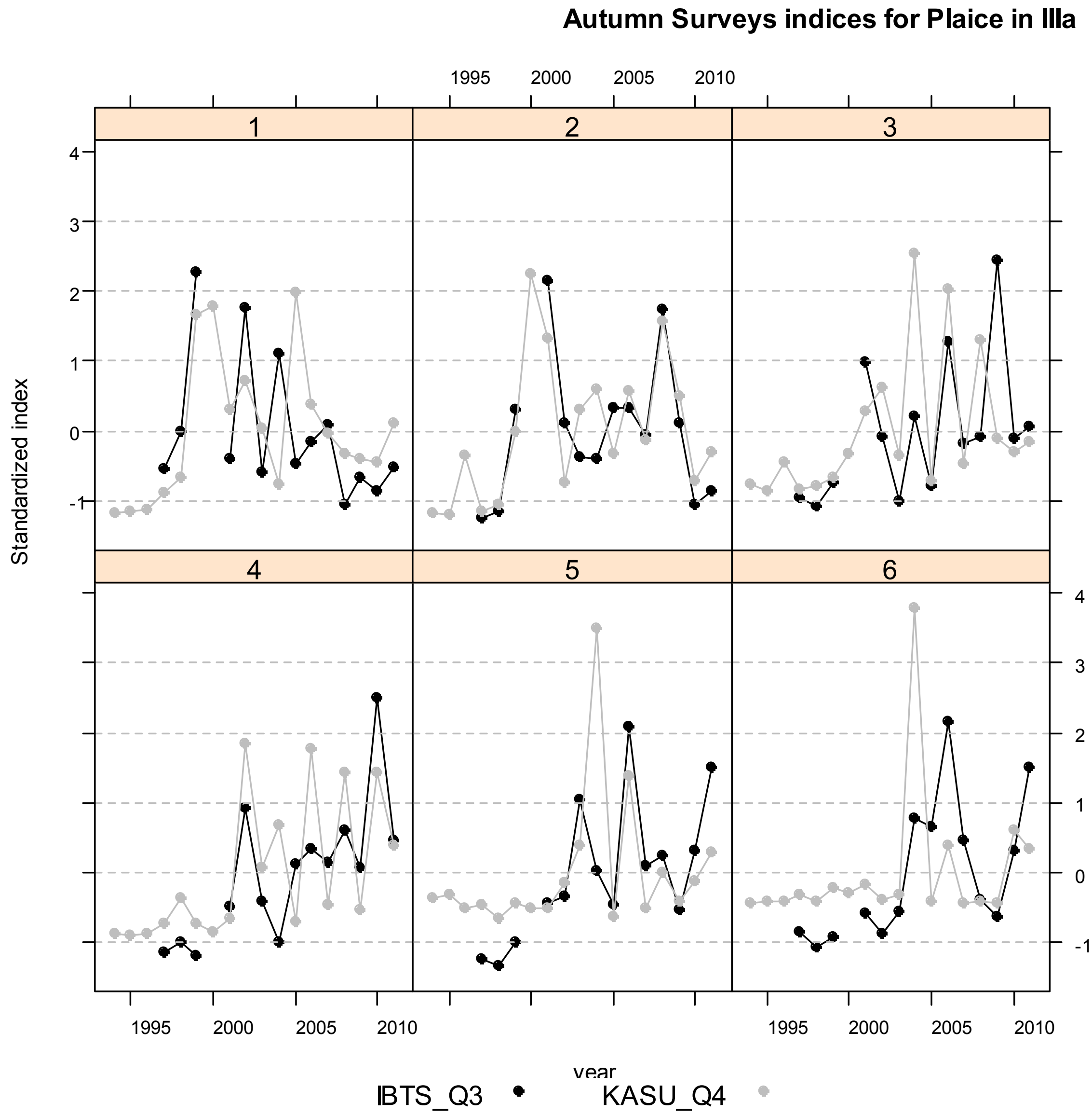


Figure 7.3.7. Plaice IIIa. Standardised Abundance index from Autumn surveys tuning series.

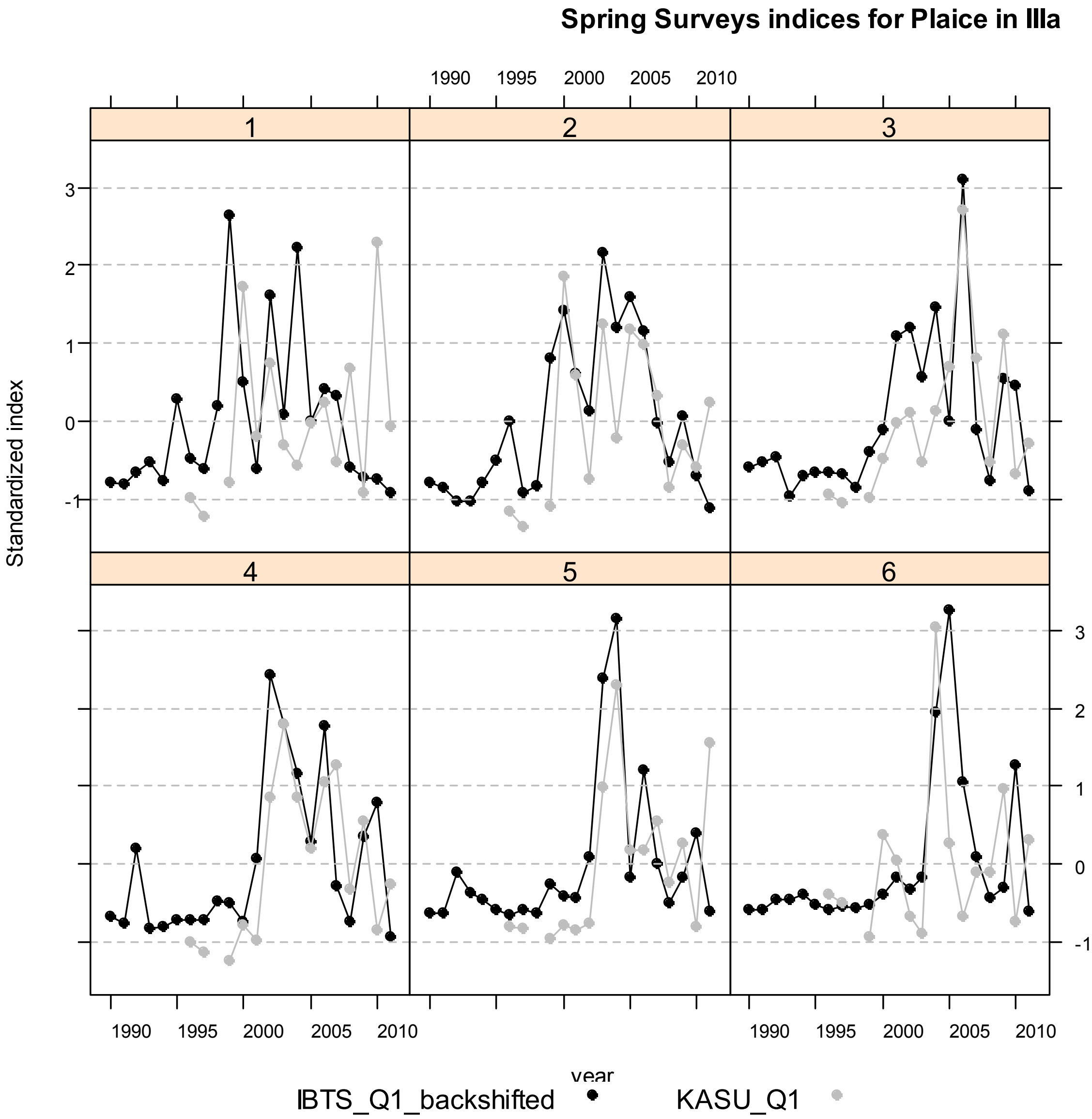


Figure 7.3.8. Plaice IIIa. Standardised Abundance index from Spring surveys tuning series.

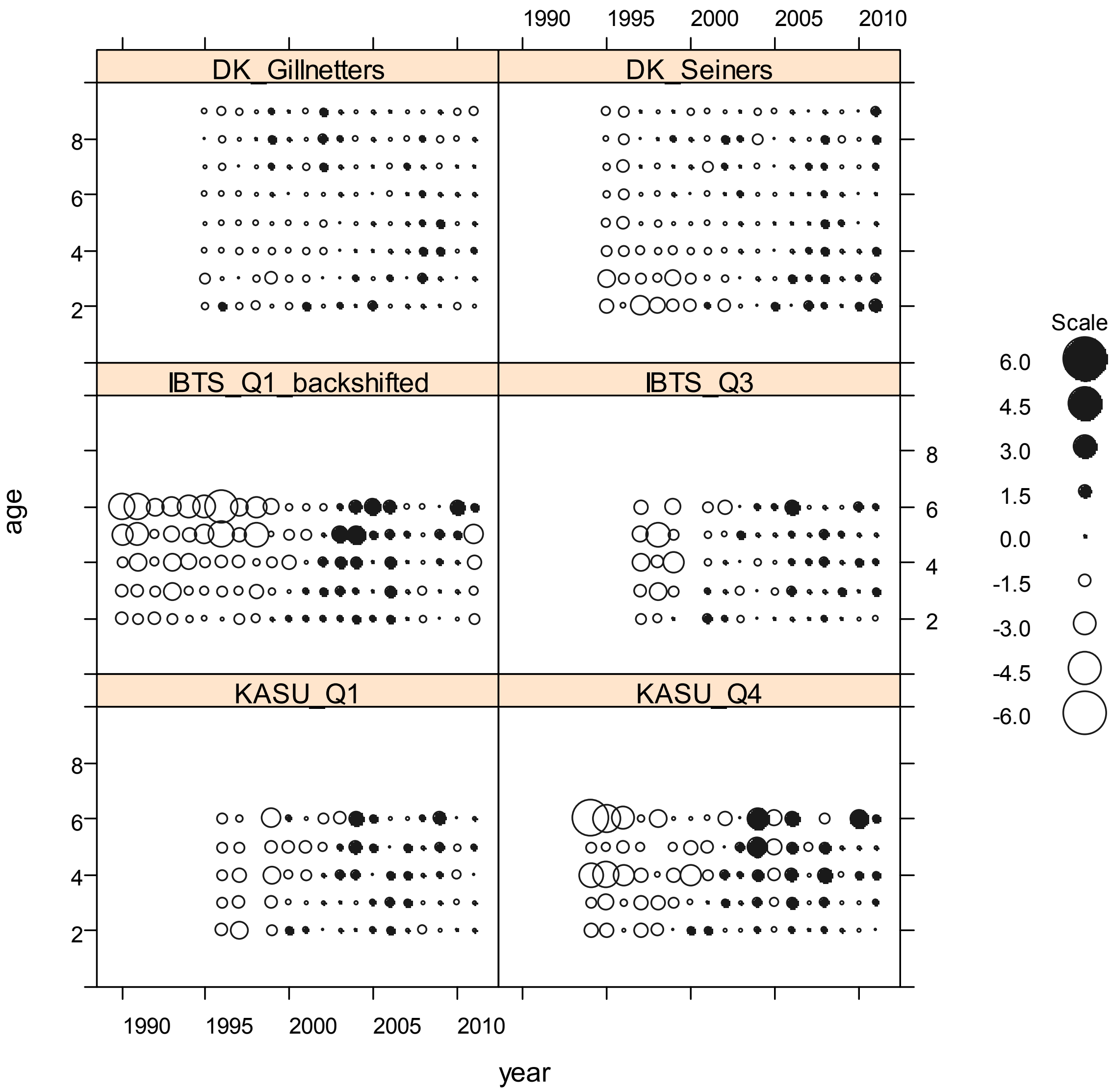


Figure 7.3.9. Plaice IIIa. Log catchability residuals for combined XSA

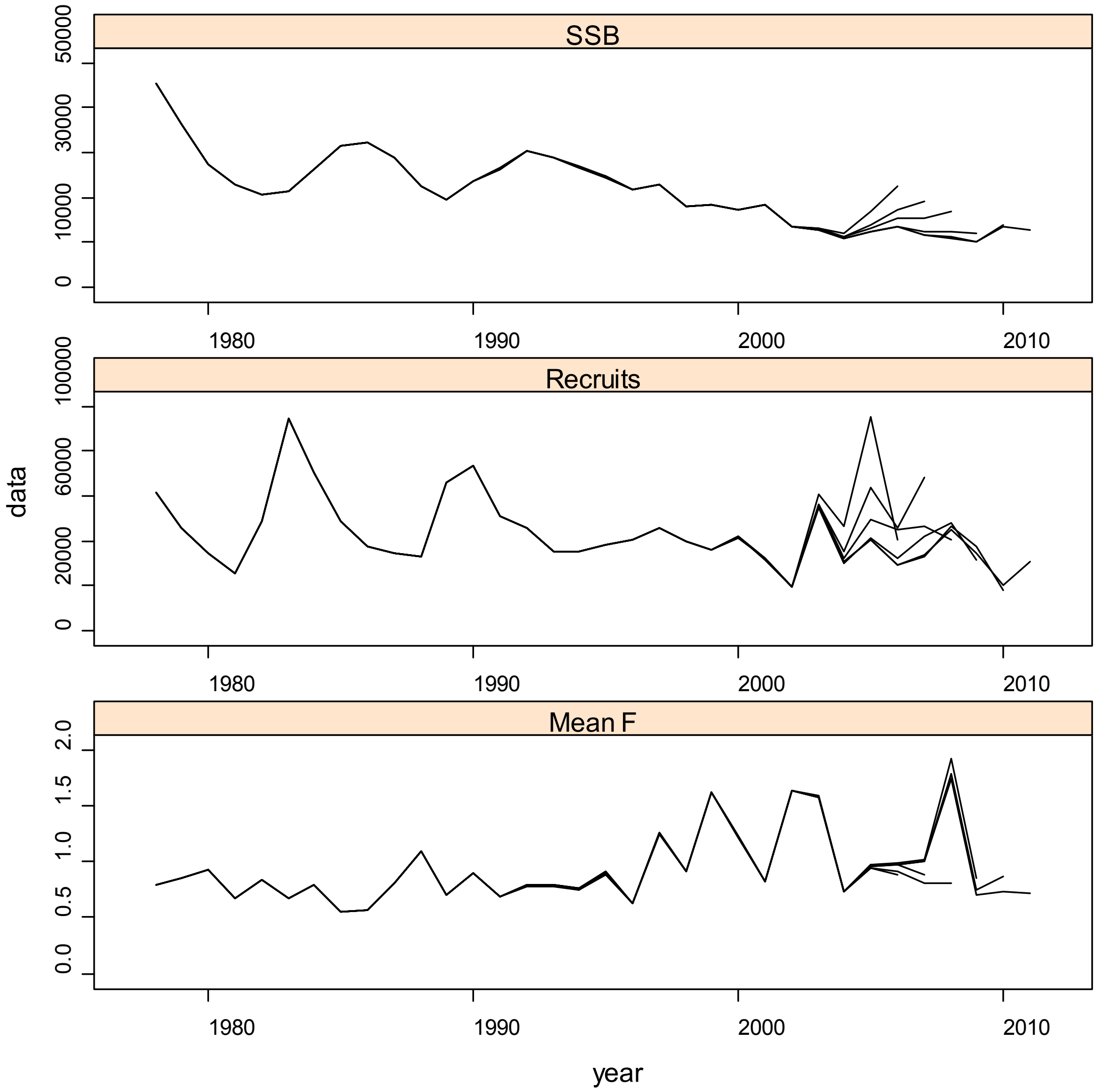


Figure 7.3.10. Plaice IIIa. XSA exploratory run retrospective pattern.

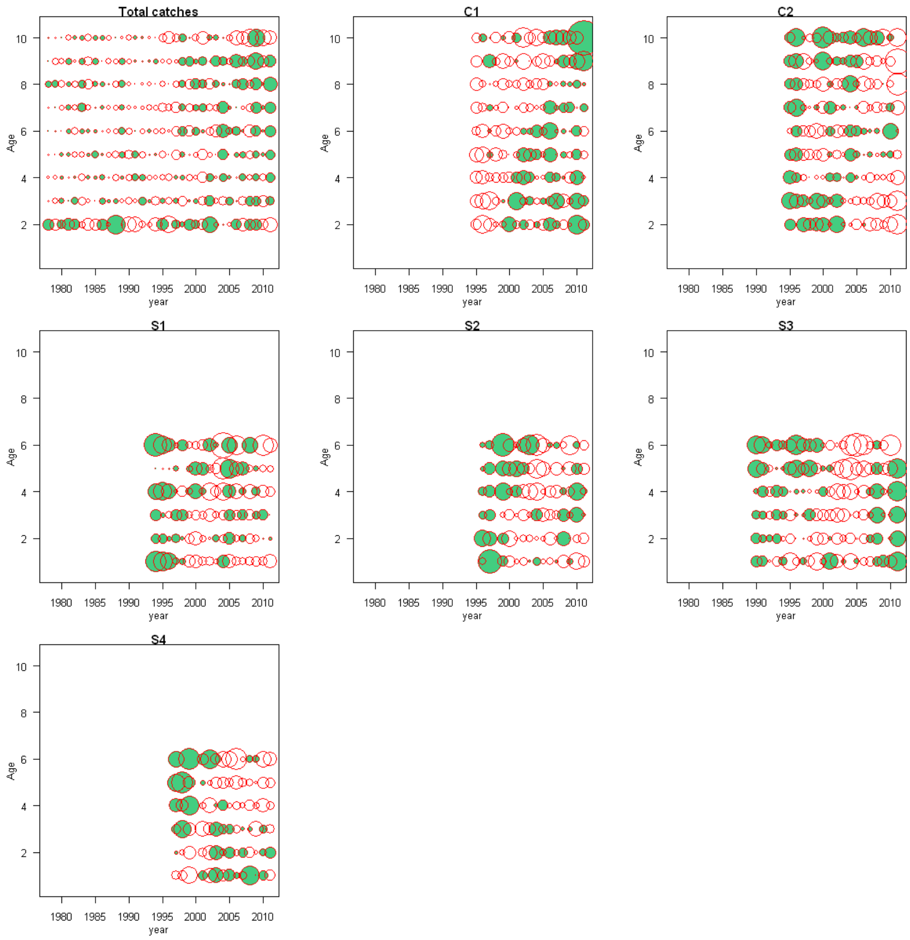


Figure 7.3.11. Plaice IIIa. Normalized residuals for the SAM base run. Red circles indicate a positive residual and filled green circle indicate a negative residual.

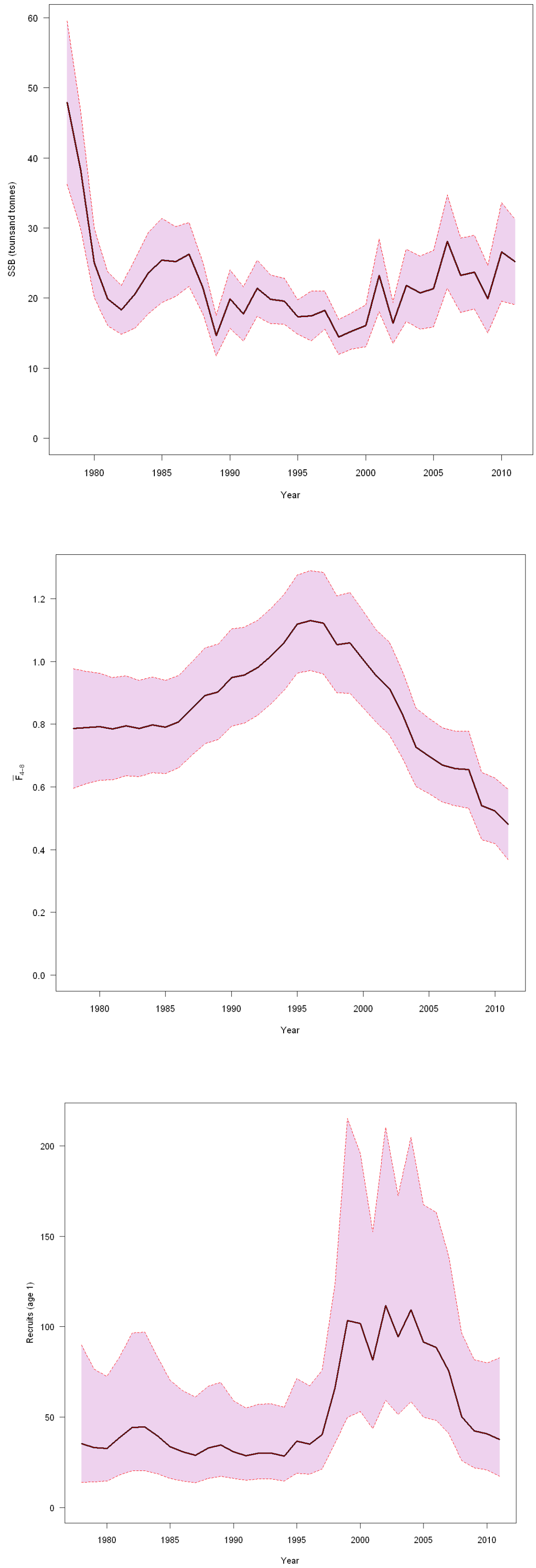
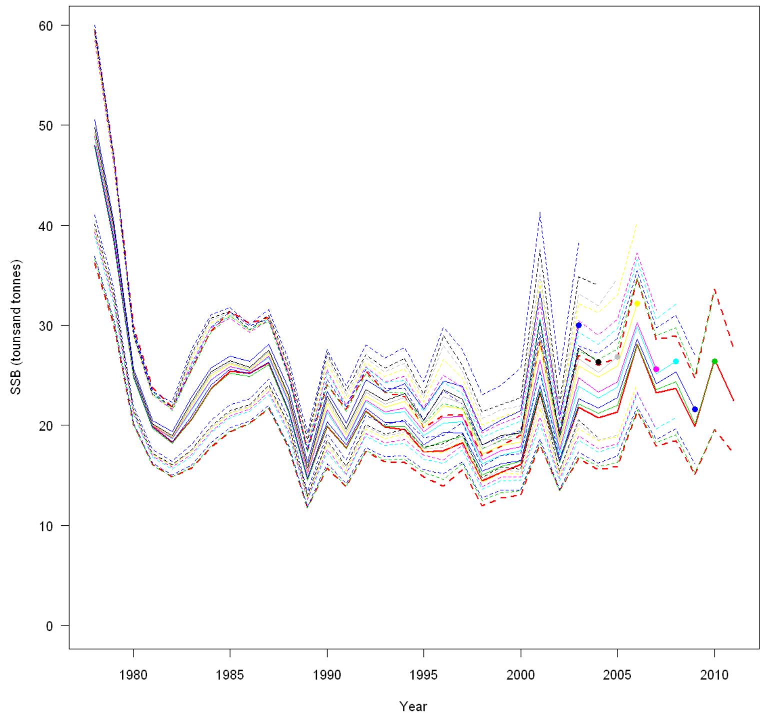


Figure 7.3.12. Plaice IIIa. Estimates from SAM with 95% confidence intervals using same inputs as XSA. Upperleft: Spawning stock biomass. Upper-right: Average fishing mortalities (ages 4-8). Lower: Number of one year old cods entering the population.



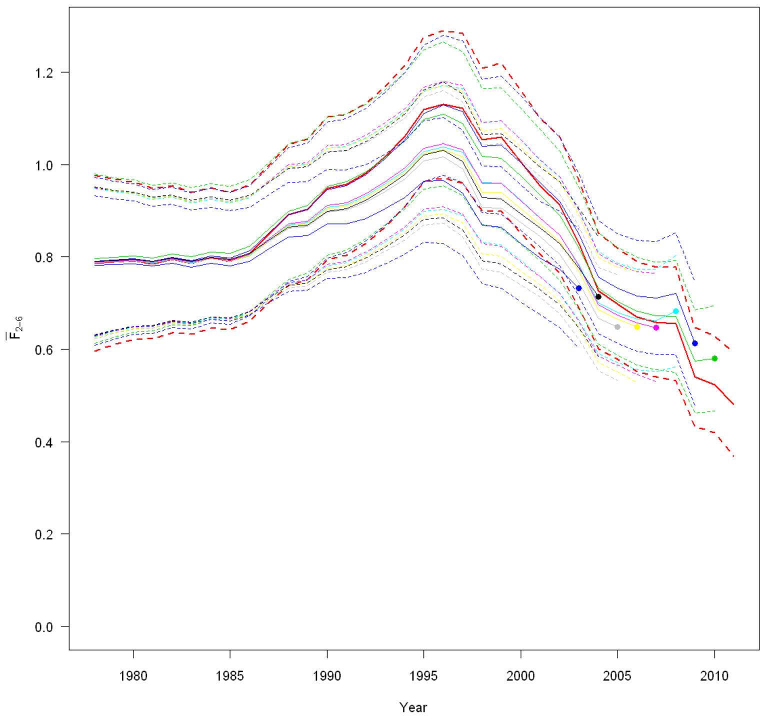


Figure 7.3.13. Plaice IIIa. Retrospective pattern from the SAM assessment with 95% confidence intervals using same inputs as XSA. Upper: Spawning stock biomass. Lower: Fbar 4-8

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 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2011. All available information on ecosystem aspects can be found in the Stock Annex.

8.1.2 Fisheries

No new information on fisheries aspects was presented at the working group in 2011. All available information can be found in the Stock Annex

8.1.3 ICES Advice

The information in this section is taken from the ACOM summary sheet 2011, section 6.4.7:

ICES advises on the basis of the first stage of the EU management plan (Council Regulation No. 676/2007) that landings in 2012 should be no more than 84 410 t. ICES notes that according to the management plan, transitional arrangements to the second stage of the plan should be established since both North Sea plaice and sole have now been within safe biological limits for two consecutive years.

Single-stock exploitation boundaries

Exploitation boundaries in relation to existing management plans

"Following the first stage of the EU management plan would imply increasing F to the target value of 0.3, with a maximum TAC increase of 15%. For 2012 the latter applies, resulting in a TAC of 84 410 t (F = 0.29). This is expected to increase the SSB to 587 600 t in 2013..".

Exploitation boundaries in relation to precautionary limits

"The fishing mortality in 2012 should be no more than Fpa (0.6) corresponding to landings of less than 155 500 t in 2012. This is expected to keep SSB above Bpa in 2013."

Advice for mixed fisheries management

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 and 2010.

Fisheries in Division IIIa (Skagerrak–Kattegat), in Subarea IV (North Sea), and in Division VIId (Eastern Channel) should in 2009 be managed according to the following rules, which should be applied simultaneously:

Demersal fisheries

- *should minimize bycatch or discards of cod;*
- *should implement TACs or other restrictions that will curtail fishing mortality for those stocks mentioned above for which reduction in fishing pressure is advised;*
- *should be exploited within the precautionary exploitation limits or where appropriate on the basis of management plan results for all other stocks (see text table above);*
- *where stocks extend beyond this area, e.g. into Division VI (saithe and anglerfish) or are widely migratory (Northern hake), should take into account the exploitation of the stocks in these areas so that the overall exploitation remains within precautionary limits;*
- *should have no landings of angel shark and minimum bycatch of spurdog, porbeagle, and common skate and undulate ray.*

Mixed fisheries management options should be based on the expected catch in specific combinations of effort in the various fisheries, taking into consideration the advice given above. The distributions of effort across fisheries should be responsive to objectives set by managers, which is also the basis for the scientific advice presented above.

Key points highlighted in the ACOM 2010 summary 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. The current combined sole and plaice long term management plan specifically reduces effort as a management measure and is likely to continue to do so in the immediate future given the slower rate of recovery of the sole stock. This reduction in fishing effort is reflected in reductions in estimated fishing mortality.

The assessment is considered to be uncertain, partly because discards form a substantial part of the total catch and cannot be well estimated from the low number of annual sampling trips, but most importantly due to the large differences in abundance observed in the different regions of the North Sea. The TAC constraint in the EU management plan is designed to allow for the uncertainty in the assessment.

8.1.4 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.

8.2 Data available

8.2.1 Catch

Total landings of plaice in the North Sea in 2011 (Table 8.2.1) were estimated by the WG at 67386 t, an increase of 6712 t from the 2010 landings, but 6014 t (8%) less than the 73400 t TAC for 2011.

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. The decision was made to remove these landings from the assessment of the eastern channel stock. At the previous assessment working group (WGNSSK 2011) test runs were carried out including these removed landings in the assessment of the North Sea stock. The impact was found to be minimal, given that as a percentage of the total catch, these eastern channel landings, available back to 1980, account for less than 1% each year. From 2012 onwards 50% of the Q1 eastern channel (VIId) plaice landings (table 8.2.5) will be included in the assessment of the North Sea plaice stock. The total catch at age including these are presented in table 8.2.6.

To reconstruct the number of plaice discards at age before 2000, catch numbers at age are calculated from fishing mortality at age corrected for discard fractions, using a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07 Appendix 1). The discards time series used in the assessment was derived from Dutch, Danish, German and UK discards observations for 2000–2009, as is described in the stock annex. The Dutch discards data for 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. For 2011, estimates were derived solely from the self-sampling data. There is an ongoing 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.

Figure 8.2.1 presents a time series of landings, catches and discards from these different sources.

8.2.2 Age compositions

The landing numbers at age are presented in Table 8.2.2. The discard numbers at age were calculated using the discards raising procedures described in the stock annex. The discard numbers at age are presented in Table 8.2.3. Catch numbers-at-age are presented as the sum of landings numbers at age and discards numbers at age in Table 8.2.4. Catch-at-age, landings-at-age and discards-at-age matrices are presented in figures 8.2.2 and 8.2.3.

8.2.3 Weight at age

Stock weights at age are presented in Table 8.2.7. Stock weight at age has varied considerably over time, especially for the older ages. There has been a long-term decline in the observed stock weight at age (Figure 8.2.4). Discard, landing, and catch weights at age are presented in Table 8.2.8, 8.2.9 and 8.2.10 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.

8.2.4 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 8.2.11) is used for the estimation of SSB in North Sea plaice.

8.2.5 Discard mortality

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; Chopin et al. 1996). We refer to the stock annex for plaice in ICES Area IV for more details on discard mortality.

8.2.6 Catch, effort and research vessel data

Three different survey indices can been used as tuning fleets (Table 8.2.12 and Figure 8.2.5):

- Beam Trawl Survey RV Isis (BTS-Isis)
- Beam Trawl Survey RV Tridens (BTS-Tridens)
- Sole Net Survey in September-October (SNS)

Traditionally, for the Sole Net Survey (SNS & SNSQ2) ages 1 to 3 are used for tuning the North Sea plaice assessment and 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). However the consistency at young ages is fairly poor for the BTS-Tridens survey.

An additional survey index is used for recruitment estimates (Table 8.2.13):

- Demersal Fish Survey (DFS)

At th eprevious year's assessment working group (WGNSSK 2011) the Belgian data for this index was not available for the estimates in 2010. This year both the 2010 and 2011 Belgian data were available, hence the international index 2010 value has been updated.

Commercial LPUE series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are (Table 8.2.14):

- The Dutch beam trawl fleet
- The UK beam trawl fleet excluding all flag vessels

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 commercial LPUE data of the Dutch beam trawl-fleet, which dominates the fishery, will most likely be biased due to (individual) quota restrictions and increased fuel prices, which caused fishermen to leave productive fishing grounds in the more northern region. A method that corrects for such spatial changes in effort has been developed (WGNSSK 2009 WD 1 Quirijns and Poos). 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 2008, WD 1), by area and fleet component, can be used as indication of stock development. This series has not been updated since 2009 due to discrepancies in the effort data.

Plaice LPUE, corrected for directed fishing under a TAC constraint, of the Dutch fleet shows a substantial decrease in the years 1990–1997, after which overall LPUE remains more or less at the same level. In 2004 the Dutch LPUE in the more northern and central North Sea has increased substantially. In 2008 an increase in the more southern North Sea also becomes evident The LPUE pattern of the Dutch fleet appears to correspond well with the stock dynamics of the XSA assessment.

WKFLAT 2009 recommended to include the LPUE index in to the assessment process, but to exclude LPUE series the final assessment run upon which management advice is based.

8.2.7 Intercatch

This year, all most countries submitted landings and discard estimates by métier and quarter. Because of time constraints and some incomplete data, InterCatch was only used for raising the landings, while discards were raised following the usual procedure. In future years and new raising scheme will be developed to make the best possible use of the data available by country, métier and quarter.

The use of intercatch as a tool for raising ladings and discards for Plaice in Area IV is summarized in the 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 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.**
Ple-nsea (plaice in area IV)	In parallel with another tool	Another tested tool for international discards raising has been used; We are still getting used to intercatch and need to develop a proper raising scheme for the new level of detail in the data.	Comparison not made	InterCatch has not been properly tested

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 2.13. All other post-analyses were done using FLR packages.

8.3.1 Reviews of last year’s assessment

General comments

The assessment was well done and the report was very thorough.

As pointed out by last year reviewer it would be very helpful to have a brief description of the SCA model in the stock annex or the report’s section. For example it is not clear to me how discard data is used by the model to estimate the discards. Or, are discards estimates only based on tuning indices?

- Full details of this model can be found in Aarts and Poos (2009).

Model diagnostics and sensitivity analyses illustrate some of the problems associated with this stock and the WG does an excellent job explaining possible reasons for these issues.

Technical comments

- Discard uncertainty is still the major issue for this assessment.
- A very thorough technical review of this stock took place at last year's RGNS 2010. The WG addressed all of the comments in an efficient manner and offered solutions moving forward for some of the issues surrounding sampling of effort and discards.
- Given that the splitting of tuning indices has an observed justification, not only the non suitability of the residuals, it would be interesting to analyze the goodness of the fit more in deep, log catchability residuals, retrospective patterns. This run could be a candidate to substitute current assessment.
- Further tests were conducted this year which showed limited improvement in the log catchability residuals. It is proposed that in advance of the next working group, time-tapered weighting should be applied on the SNS and BTS Tridens indices.
- Does SCA estimate uncertainty in discards? Apart of comparing point estimates of SCA with estimates derived from observers- and self-sampling it would be interesting to compare the observers- and self-sampling estimates with the confidence intervals of the SCA estimates.
- Due to time contraints this was not possible at WGNSSK 2012. This will be before the next working group meeting.
- The Annex indicates that "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." 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 is a topic that will be addressed at the next benchmark of the stock.
- Bolle et al. 2005 indicate that over 50,000 North Sea plaice were tagged in the 20th century. Can any of these data be used within a conventional tag-recovery model to directly estimate natural mortality?
- Can tag returns be used to support the hypothesis that movement of young plaice out of the area of the SNS to the area of the BTS (The WG offers this as a possible explanation for patterns observed in the XSA catchability residuals).
- Unfortunately not, though the latest review of the plaice box (Beare *et al* 2010) provides enough support of this hypothesis.

8.3.2 Exploratory catch-at-age-based analyses

The following exploratory analyses have been carried out:

1. Explore sensitivity to splitting the tuning indices of the Sole Net Survey and the BTS-Tridens.
2. Stock assessment using the statistical catch-at-age model as described in Aarts & Poos (2009).

1. Splitting of SNS and BTS-Tridens tuning indices

In recent years, the XSA catchability residuals exhibit pronounced trends for ages 1-3: they are consistently negative for the SNS and consistently positive for BTS-Tridens. This is likely to be explained by a movement of young plaice out of the area of the SNS into the area of the BTS (Beare et al. 2010). Juvenile plaice have been distributed more offshore in recent years. Surveys in the Wadden Sea have shown that 1-group plaice are almost absent from the area where they were very abundant in earlier years. This could be linked to environmental changes in the productivity or changes in the temperature of the southern North Sea, but these links have not been shown conclusively. The distribution of the SNS overlaps largely with the Wadden Sea, and the SNS receives high weightings in XSA in the tuning of trends of plaice of age groups 1-3 due to its historically stronger correlation with the VPA. The expected net effect of these changes in catchability would be an underestimation of recruitment strength. This is also seen in the retrospective pattern of recruitment in recent assessments of the stock.

Following initial tests at the previous working group, further analyses investigating the sensitivity of the assessment output to this were conducted. Various combinations of division (splitting) of the SNS and BTS-Tridens tuning indices were examined (see text table below). In all cases indices were split at year 200 (<2000 and >=2000) as opposed to year 2004 as done previously. Previous splitting indices were based on the pattern of residuals for the indices, but further examination of available data and the plaice box report (Beare et al.) suggest 2000 to be a more appropriate year to separate present from past distribution of plaice juveniles.

Run name	Description
Original	All three indices in full, following stock annex
SplitSNS	Only the SNS index split*
SplitBoth	Both SNS and BTS-Tridens split*
SplitNew	Both SNS and BTS-Tridens split*, only >=2000 BTS-Tridens index retained
SplitOld	SNS index split*, only ages 4-9 of BTS-Tridens used (no need to split)
SplitOldrecYng	SNS split*, BTS-Tridens divided into two indices: full time series ages 4-9 and >=2000 ages 1-3

***All splits divide indices into <2000 and >=2000**

Assessment runs have been done with these split tuning indices (Figure 8.3.1). Splitting the indices raises SSB slightly in all cases except *SplitOld*. IN this case removing the young ages in the BTS-Tridens index lowers the estimated recruits significantly in the recent period and the general lower level of year class strength leads to lower SSB. In general splitting the indices has a very limited impact on F, though in most cases this leads to an estimation of higher recruitment in the last two years.

It was decided that while splitting the indices is not the ultimate solution to this problem, it remains clear that recruitment is probably underestimated by the model. This will be taken into account when determining the level of recruitment to use in the short term forecast.

1. *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 (2009-2011), 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 assessment

The settings for the final assessment that is used for the catch option table is given below:

Year	2011
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + GE fleets
Fleets (years; ages)	BTS-Isis 1985–2011; 1–8 BTS-Tridens 1996–2011; 1–9 SNS 1982–2011 (excl. 2003); 1–3
Plus group	10
First tuning year	1982
Last data year	2011
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 41 iterations. The log catchability residuals for the tuning fleets in the final run are dominated in the younger ages by negative values for the SNS tuning index in the most recent period, and positive values for the BTS-Tridens (Figure 8.3.4). This is potentially due to a shift in the location of juvenile plaice offshore, away from the SNS survey area towards the BTS-Tridens survey area. However, the importance of the SNS survey in estimating recruits in previous years results in this survey still carrying a much higher weighting for age 1 estimates than the BTS-Tridens. The high BTS-Tridens tuning index for 1 year old individuals leads to a high residual in the XSA assessment for this age in the survey in recent years.

Fishing mortality and stock numbers are shown in Tables 8.3.2 and 8.3.3. respectively. The SSB in 2011 was estimated at 476 kt. Mean F(ages 2–6) for 2011 was estimated at 0.23. Recruitment of the 2010 year class, age 1 in 2011, was estimated to be higher than average at 1.266 million in the XSA.

Retrospective analyses of the XSA presented in Figure 8.3.5 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 is likely the result of the increase of younger individuals in the more northern region (surveyed by the Tridens but not by the higher weighted SNS), that have aged and therefore only recently have a high impact on the estimation of the stock size. The retrospective pattern of recruits shows a tendency 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 getting a higher weighting than is perhaps appropriate due to historically better representing the level of recruitment).

8.4 Historic Stock Trends

Table 8.4.1. and 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 then, the estimates of fishing mortality have been fluctuating strongly. However, overall F has been lower since 2004, rapidly decreasing down to 0.21 in 2009, stable at this level in 2010 and starting to increase (by design, given that both Fmsy and Fmp are higher than this) in 2011 to 0.23. The peaks during 1997–1998 and 2001 have been mainly caused by peaks in F(discards). The F(human consumption) is estimated to decline since 1997, with little inter-annual variability. Over the last five years SSB has been rapidly increasing and is currently (2011) estimated at 476 kt, slightly down from the 501kt estimated for 2010, which was the highest estimate of the whole time series. The inter-annual variability in recruitment is relatively small, except for a limited number of strong year classes. Previously only year classes 1963, 1981, 1985 and 1996 were considered to be strong. Including discard data in the assessment alters the recruitment estimates and indicates that 1984, 1986, 1987 were also relatively strong year classes and that the 1985 year class was by far the strongest year class on record. Recruitment shows a periodic change with relatively poor recruitment in the 1960s and relatively strong recruitment in the 1980s. The recruitment level in the 1990s appears to be somewhat

lower than in the 1980s. The 1996 and 2001 year classes are estimated to be relatively strong, while the year classes since 2002 appear weak to average. Recent recruitment levels have been fluctuating slightly above the long term geometric mean.

The Fishers' North Sea Stock Survey (FNSSS) again took place in 2011. 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 2010 to 2011. Most respondents reported similar or higher abundances of fish, although the proportions reporting higher levels were somewhat less than in 2010.

Overall, less than half (44%) reported that plaice overall were 'more' or 'much more' abundant in 2011 than in 2010. This is a large decline from the 68% who reported this last year and is in line with the results of the assessment which suggest a slight decrease in SSB over this period. About one-third reported 'no change' in the abundance of plaice, more than in 2010. About three-quarters of respondents overall reported catching 'all sizes' of plaice in 2011, while of the remainder, twice as many reported 'mostly large' plaice as 'mostly small'. Overall, more than half (61%) of respondents reported 'no change' in the level of discarding of plaice, with about one-quarter each reporting lower and higher levels of discarding. The proportion reporting 'more' or 'much more' discarding of plaice was significantly lower in 2011 than in 2010, a similar trend to that observed last year. The vast majority of respondents overall reported 'moderate' or 'high' levels of recruitment of plaice in 2010. Across individual areas the proportions reporting 'high' levels of recruitment of plaice in 2011 were highest in the central, north and western North Sea (areas 1, 2, 3, 4 in FNSSS). Overall the perceptions of the fishing industry reflect the high abundances of plaice estimated during WGNSSK 2012, as well as the trend of lowering discard ratios.

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 2011 (age 1 in 2012) the values predicted by the DFS survey in RCT3 differs considerably (an order of magnitude) from the VPA mean and has a high prediction standard error (Table 8.5.2.). Therefore the geometric mean, higher than the RCT3 estimate, was accepted for the short-term forecasts. For year class 2010 (age 2 in 2012), the estimates from SNS 0-group, BTS 1-group and the VPA mean were relatively comparable, received high weightings and had relatively low standard errors. Estimates from the DFS 0-group and SNS 1-group differed from the other predictors, and had higher prediction standard errors, but received lower weightings for the overall mean. However, the WG decided to use the geometric mean rather than the RCT3 estimate for the 2010 year class, as this was higher. This choice for the higher recruitment estimate was influenced by the retrospective upward revisions of recruitment in recent years.

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 2012	XSA Survivors	RCT3	GM 1957–2009	Accepted estimate
2010	2	**1 033 366**	968 826	680 918	XSA survivors
2011	1		849 355	**922 293**	GM 1957–2009
2012	0			**922 293**	GM 1957–2009

8.6 Short-term forecasts

Short-term prognoses have been carried out in FLR using FLCore (2.3). 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. 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 2 and older are XSA survivor estimates. Numbers at age 1 and recruitment of the 2010 year class are taken from the long-term geometric mean (1957-2008). Input to the short term forecast is presented in table 8.6.1. The management options are given in Tables 8.6.2A-B. Two management options are considered, each with a different assumed F value in the intermediate year: A) F is assumed to be equal to the estimate for F in the previous year ("F-status quo" or F_{sq}), B) F is set such that the landings in the intermediate year equal the TAC for that year. In previous years 0.9*F_{sq} has also been used as an option, matching the planned decrease in F following the management plan. However since F is now below the management plan target and is likely to increase, this option was no longer considered necessary. The table below shows the predicted F values in the intermediate year, SSB for 2012 and the corresponding landings for 2011, given the different assumptions about F in the intermediate year in the two scenarios.

Scenario	Assumption	F_{2012}	SSB_{2013}	$Landings_{2012}$
A	$F_{2012} = F_{2011}$ (Fsq)	0.23	628143 t	78501 t
B	$Landings_{2011} = TAC_{2011}$	0.25	618592 t	84410 t

The detailed tables for forecasts based on the two scenarios are given in Table 8.6.3A-B. ICES interprets the F for the intermediate year as the estimate of F for the year in which the assessment is carried out. Using this ICES rule of application scenario A is used as the basis for the forecast for advice.

Yield and SSB, per recruit, under the condition of the current exploitation pattern are given in Figure 8.6.1 and Table 8.6.4. F_{max} is estimated at 0.19.

8.7 Medium-term forecasts

No medium term projections were done for this stock.

8.8 Biological reference points

8.8.1 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 (although the WG acknowledges that, since the noisy discards estimates have been included, the uncertainty of the estimates of stock status is much greater than that, see Dickey-Collas et al. 2008). $\mathbf{F_{lim}}$ 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.

8.8.2 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.

8.9 Quality of the assessment

Large differences are found in the trends in tuning series over the last eight years for age groups 1-3. The more northern BTS-Tridens index indicates more positive trends than BTS-Isis and particularly the SNS. This suggests a large spatial heterogeneity of the stock which is either explained by increased northwards migration or a higher survival in the more northern region due to an overall decrease in fishery induced mortality. The spatial difference of the stock trends is corroborated by the area disaggregated LPUE estimates from the Dutch beam trawl fleet. However, the historic development of the stock abundance as estimated by XSA shows good correspondence with the development of the average commercial LPUE of the Dutch beam trawl fleet.

A strong retrospective analysis of the assessment shows considerable recurring bias (Figure 8.3.4), though this has decreased in the most recent years. This retrospective pattern is the result of the high 2006-2008 tuning indices in general, and the fact that the cohorts being estimated stronger by BTS Tridens than the other surveys now reach the age where the index receives a higher weighting in the assessment.

The assessment presented by the WG incorporates discards. WGNSSK noted in 2002 (ICES 2003) that not considering discard catches in stock assessments could introduce bias and affect estimates of F and stock biomass, particularly when discard patterns vary over time (see also Dickey-Collas et. al. 2007). Currently fleet level discard estimates are available for the past nine years. However, total sampling effort of the discards is low, and data is sparse. Also, samples may not always be available from relevant fleets and fisheries within a country. Particularly the UK and Dutch >100mm fishery, comprising >20% of the landings is poorly sampled. Discard observation time series are lengthening allowing for better analysis of raising methods for discards data and estimation of previous discards patterns. Also, a new self-sampling discards programme has been initiated by the Dutch in 2009, aiming to improve the overall coverage of discards sampling in the biggest fleet fishing this stock.

8.10 Status of the Stock

SSB in 2010 is estimated around 461 thousand tonnes which is well above Bpa (230 000 t). Fishing mortality is estimated to have remained constant from 2009 to 2010 at a value of 0.24 (both below Fpa = 0.60), and is currently below 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 2012 at Fsq are 71.5 kt, which is higher than to the projected landings for 2011 at Fsq (68.7 kt) which in turn is higher than the estimated landings of 2010 (62 kt). Projected discards for 2012 are somewhat lower than the projected discards for 2011 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.

8.11 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.

8.11.1 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 was perceived as slightly lower, bringing it just under Bpa (SSB in 2011 and 2012 are perceived at and 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.

8.11.2 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.

8.11.3 Technical measures

Plaice is mainly taken by beam trawlers in a mixed fishery with sole 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 high discards of plaice which are selected from 17 cm with a minimum landing size of 27 cm. Recent discards estimates indicate fluctuations around 50% discards in weight. 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) and the relatively stable TAC for sole 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. The most recent EU funded evaluation by Beare *et al.* (2010) reported the Plaice Box as having very little negative or positive impact on the plaice stock

Fishing effort has been substantially reduced since 1995. The reduction in fishing effort appears to be reflected in recent estimates of fishing mortality. There are indications that technical efficiency has increased in this fishery, but these may have been counteracted by decreases in fishing efficiency resulting from reduced fishing speed in an attempt to reduce fuel consumption.

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 mean age in the landings is currently around age 4, but used to be nearer to age 5 in the beginning of the time series. This change may be caused by the high exploitation levels, but also by the shift in the spatial distribution of fishing effort towards inshore waters and by the shift in the spatial distribution of the fish. A lower exploitation level is expected to improve the survival of plaice, which could enhance the stability in the catches.

A shift in the age and size at maturation of plaice has been observed (Grift *et al.* 2003): 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 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 diminishes after maturation.

WGNSSK held a specific plaice sub-group during its 2011 meeting, aiming at clarifying the knowledge base of the identification and connectivity of the various plaice stocks or sub-populations distributed from the Baltic to the English Channel, and suggesting paths towards a more integrated regional assessment. There are indeed clear similarities in the issues experienced in the assessment of plaice stocks in areas VIIe and VIId, and in area IIIa. It is considered that the evaluation of the resident stocks in these small areas is hampered by their connectivity with the much larger stock of plaice in the North Sea (which itself may comprise more than one sub-population), which takes place both through migratory migrations in and out the small areas and through larval drift and homing behavior of juveniles. This issues was addressed, primarily with regards to plaice in the Skaggerak and Kategat, in 2012 at the WKPESTO working group. Stock structure within the North Sea itself remains uncertain.

8.12 References

Aarts, G. and Poos, J. J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science, 66.

Beare, D.J., Rijnsdorp, A.D., Kooten, T. van, Fock, H., Witbaard, R., Meesters, H.W.G., and Quirijns, F.J. (2010) Study for the revision of the plaice box - Draft Final Report. IMARES Report C002/10

Beek, F.A. van, Leeuwen, P.I. van, and Rijnsdorp, A.D. (1990) On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research 26: 151-160.

Bult, T.P., and Schelvis-Smit, A.A.M. (2007) Een verkenning van de mogelijkheden van outriggen door vissers uitgevoerd, in het kader van het Advies van de "Task Force Duurzame Noordzeevisserij". IMARES Report C022.07, 34 pp.

Chopin, F, Inoue, Y and Arimoto, T (1996) Development of a catch mortality model. Fisheries Research 25: 377-382.

Dickey-Collas, M., Pastoors, M.A., and van Keeken, O.A. (2007). Precisely wrong or vaguely right: simulations of noisy discard data and trends in fishing effort being included in the stock assessment of North Sea plaice. – ICES Journal of Marine Science, 64: 1641–1649.

ICES. 2010. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), Copenhagen, Denmark. ICES Document CM 2010/ACOM: 13.

ICES. 2011. Report of the Workshop on Implementing the ICES Fmsy Framework (WKFRAME-2), Copenhagen, Denmark. ICES Document CM 2011/ACOM: 33. 109 pp.

Miller, D. C. M. and Poos, J. J. 2010. Combined Ex post and ex ante evaluation of the long term management plan for sole and plaice in the North Sea, including responses to ICES review. ICES Document CM 2010/ACOM: 62. 109 pp.

Simmonds, E.J., Campbell, A. Skagen, D. Roel B.A. and Kelly, C. 2011. Development of a stock recruit model for simulating stock dynamics for uncertain situations; The example of NEA Mackerel (Scomber scombrus). ICES J Mar Sci. 68: p 848-859

Simmonds, E.J., Miller, D.C.M., Bartelings, H., Vanhee, W. 2010. Report of the Sub Group on Management Objectives and Strategies (SGMOS 10-06). Part b) Impact assessment of North Sea plaice and sole multi-annual plan. EUR 24629 EN, ISBN 978-92-79-18743-8. pp. 124.

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													84410

*** Official estimates not available.**

Table 8.2.2 . North Sea Plaice. landed numbers-at-age

Plaice in IV . landings.n
2012-04-29 12:42:33 units= thousands

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0	4315	59818	44718	31771	8885	11029	9028	4973	10859
1958	0	7129	22205	62047	34112	19594	8178	8000	6110	13148
1959	0	16556	30427	25489	41099	22936	13873	6408	6596	16180
1960	0	5959	61876	51022	21321	27329	14186	9013	5087	15153
1961	0	2264	33392	67906	32699	12759	14680	9748	5996	14660
1962	0	2147	35876	66779	50060	20628	9060	9035	5257	12801
1963	0	4340	21471	76926	54364	31799	12848	6833	7047	16592
1964	0	14708	40486	64735	57408	37091	15819	6595	3980	16886
1965	0	9858	42202	53188	43674	30151	18361	8554	4213	17587
1966	0	4144	65009	51488	36667	27370	16500	10784	6467	14928
1967	0	5982	30304	112917	41383	22053	16175	8004	6728	11175
1968	0	9474	40698	38140	123619	17139	10341	10102	3925	13365
1969	3	15017	45187	36084	35585	102014	10410	6086	8192	16092
1970	76	17294	51174	56153	40686	35074	78886	6311	4185	14840
1971	19	29591	48282	33475	26059	22903	16913	29730	6414	16910
1972	2233	36528	62199	52906	23043	16998	14380	10903	18585	15651
1973	1268	31733	59099	73065	42255	13817	8885	9848	6084	23978
1974	2223	23120	55548	42125	41075	19666	8005	6321	5568	21980
1975	981	28124	61623	31262	25419	21188	11873	5923	4106	19695
1976	2820	33643	77649	96398	13779	9904	9120	6391	2947	12552
1977	3220	56969	43289	66013	83705	9142	5912	5022	4061	9191
1978	1143	60578	62343	54341	50102	35510	5940	3352	2419	7468
1979	1318	58031	118863	48962	47886	39932	24228	4161	2807	9288
1980	979	64904	133741	77523	24974	17982	13761	8458	1864	5377
1981	253	100927	122296	57604	35745	12414	9564	8092	4874	5903
1982	3334	47776	209007	69544	28655	16726	7589	5470	4482	8653
1983	1214	119695	115034	99076	29359	12906	8216	4193	3013	8287
1984	108	63252	274209	53549	37468	13661	6465	5544	2720	6565
1985	121	73552	144316	185203	32520	15544	6871	3650	2698	5798
1986	1674	67125	163717	93801	84479	24049	9299	4490	2733	6950
1987	0	85123	115951	111239	64758	34728	11452	4341	2154	5478
1988	0	15146	250675	74335	47380	25091	16774	5381	3162	6233
1989	1261	46757	105929	231414	52909	19247	10567	7561	2120	5580
1990	1550	32533	97766	110997	159814	26757	8129	4216	3451	3808
1991	1461	43266	83603	116155	72961	77557	14910	5233	3141	5591
1992	3410	43954	85120	72494	72703	33406	29547	6970	3200	6928
1993	3461	53949	98375	72286	51405	29001	13472	11272	3645	5883
1994	1394	45148	101617	80236	38542	20388	15323	6399	5368	5433
1995	7751	36575	81398	78370	36499	17953	9772	4366	2336	3753
1996	1104	42496	64382	46359	32130	14460	10605	4528	2624	4892
1997	892	42855	86948	43669	22541	13518	6362	3632	2179	4181
1998	196	30401	68920	56329	16713	6432	4986	2506	1761	3119
1999	549	8689	155971	39857	24112	6829	2783	2246	1521	3093
2000	2634	15819	39550	164330	14993	9343	2130	1030	940	2097
2001	4509	35886	52480	48238	89949	6836	4418	1127	637	2309
2002	1233	15596	58262	48361	36551	37877	4644	1788	742	1586
2003	694	42594	47802	48894	27126	15999	17069	1608	650	859
2004	543	10317	102332	35165	20527	11293	4787	4555	412	540
2005	2937	16685	26069	82278	17039	9533	5332	2614	2223	613
2006	355	18987	67465	25254	42525	6555	4967	2053	1235	1319
2007	1286	19205	37309	47053	14971	17142	2459	1856	543	1259
2008	380	10970	42865	37970	29476	5700	6752	912	673	896
2009	1492	10726	50436	33911	20969	16551	2987	3967	556	763
2010	2026	17947	39555	58341	21827	11739	9414	1763	2429	1243
2011	238	10354	42255	57233	48186	13549	6561	7055	1238	2816

Table 8.2.3 . North Sea Plaice. Discards numbers-at-age

Plaice in IV . discards.n

2012-05-01 16:53:13 units= thousands

age

year	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

Table 8.2.4 . North Sea Plaice. Catch numbers-at-age

```
Plaice in IV . catch.n
 2012-04-29 12:43:04  units= thousands
      age
year        1       2      3      4      5      6     7     8     9    10
  1957   32356   49911  69038  45627  32732   8910 11029  9028  4973 10859
  1958   66199   80681  45860  64619  36249  19659  8178  8000  6110 13148
  1959  116086  144327  76829  36896  45836  23042 13873  6408  6596 16180
  1960   73939  173852 106824  52019  22388  27848 14186  9013  5087 15153
  1961   75578  146873 122406  68444  34311  12889 14680  9748  5996 14660
  1962   51265  183468 123475  88495  50859  20814  9060  9035  5257 12801
  1963   90913  140523 151249  86890  56476  31987 12848  6833  7047 16592
  1964   66035  167982 104642  98560  60419  37414 15819  6595  3980 16886
  1965   43708  435879 101464  56592  44597  30418 18361  8554  4213 17587
  1966   38496  167269 414367  65887  38069  27495 16500 10784  6467 14928
  1967   20199  139527 117836 265413  42006  22313 16175  8004  6728 11175
  1968   73971   81666  87037  64670 146055  17197 10341 10102  3925 13365
  1969   85195   82395  61934  55418  36358 104038 10410  6086  8192 16092
  1970  123645  169774  78921  57440  45747  35235 78886  6311  4185 14840
  1971   69356  126559  90636  36150  26485  22984 16913 29730  6414 16910
  1972   72235   91998  96098  58620  23610  17071 14380 10903 18585 15651
  1973  133620   81548  63107  73738  43544  13884  8885  9848  6084 23978
  1974  213362  331531  59200  42410  41686  19775  8005  6321  5568 21980
  1975  245950  308254 252159  36069  25672  21311 11873  5923  4106 19695
  1976  186699  174564 148703 114411  13953   9945  9120  6391  2947 12552
  1977  259848  160665 122606  99565  93022   9271  5912  5022  4061  9191
  1978  228015  214691  89600  65116  51346  36080  5940  3352  2419  7468
  1979  294484  273115 176441  67344  48475  40242 24228  4161  2807  9288
  1980  227350  187465 134673  78210  25167  18068 13761  8458  1864  5377
  1981  134395  294168 124146  57977  36176  12469  9564  8092  4874  5903
  1982  414641  252348 213631  70653  28871  16824  7589  5470  4482  8653
  1983  262614  556026 145750 101311  30163  12978  8216  4193  3013  8287
  1984  310783  376742 326860  78078  38960  13730  6465  5544  2720  6565
  1985  405506  302760 179882 187424  32720  15622  6871  3650  2698  5798
  1986 1119019  558090 212227 120271  85930  24195  9299  4490  2733  6950
  1987  361519 1459325 296920 112666  66106  34976 11452  4341  2154  5478
  1988  348597  623255 710060 135502  48262  25268 16774  5381  3162  6233
  1989  214552  532602 299105 317172  60133  19362 10567  7561  2120  5580
  1990  146864  311831 266440 139099 164825  26934  8129  4216  3451  3808
  1991  184587  344841 225170 156894  78489  78496 14910  5233  3141  5591
  1992  142165  263573 179701 106842  77010  34286 29547  6970  3200  6928
  1993   99832  208032 146463  84252  53040  29217 13472 11272  3645  5883
  1994   63516  140851 137320  81274  39364  20532 15323  6399  5368  5433
  1995  126614  119251  97151  79230  37162  18073  9772  4366  2336  3753
  1996  112354  373561  91988  50289  32581  14576 10605  4528  2624  4892
  1997  129545  553773 280776  44257  22812  13626  6362  3632  2179  4181
  1998  104734  676651 260551 109683  17010   6465  4986  2506  1761  3119
  1999  127870  217090 387740  94726  24390   6887  2783  2246  1521  3093
  2000  106102  187032  90642 229301  16223   9584  2393  1197   940  2097
  2001   34855  388338 239380 122982 144225   6988  4463  1128   637  2309
  2002  311055  193170 134508  60474  38122  38538  4751  1789   742  1586
  2003   68412  560235 100384  68024  30969  16385 22820  1609   650   859
  2004  233479  189878 218078  41779  21574  11525  4824  4556   412   540
  2005   96522  341429  69366 101718  21137  15501  5479  2615  2223   613
  2006  220856  242801 174628  34383  44849   6804  5699  2247  1235  1319
  2007   78525  222980 103848  56052  15707  24114  2629  3500   543  1259
  2008  135719  262359  77862  42538  31120   6028 15597  1797   673   896
  2009  150131  202683 116499  43076  22942  17657  3123  7187   556   763
  2010  167940  195859  97834  80923  24499  13465 11487  2044  2429  1243
  2011  117534  160708 102780  93680  60975  16469  6704  9328  1238  2816
```

Table 8.2.5. 50% of Q1 plaice landings in the eastern Channel (VIId). Assumed to be migrants from the North Sea stock (see text). Landing numbers-at-age.

Plaice in IV. 50% of Q1 VIId catches.

	age			units=	thousands					
year	1	2	3	4	5	6	7	8	9	10
1980	0	237	288	136	127.5	19	12	11.5	1	24
1981	0	219.5	1349	605	75.5	40.5	14	10.5	14.5	46.5
1982	0	124.5	1372	833	198	52.5	26	16.5	5	20.5
1983	0	272	635	1490.5	241.5	58	24.5	31.5	1	23.5
1984	0	167.5	1451.5	710	486.5	136	64	26.5	8.5	23
1985	0	513	1230.5	1231.5	107	156	44.5	25.5	35.5	11.5
1986	0	438	1396.5	924	379	143.5	68.5	18	5	8
1987	0	762.5	1490.5	875.5	326.5	110	119.5	39.5	27.5	18
1988	0	449.5	3735.5	1236	290	138	118.5	32.5	27.5	40
1989	0	326	1435	2384.5	694	150.5	78	46	21	45.5
1990	0	236	1736	1509.5	936	204.5	65.5	52.5	46	53.5
1991	0	525.5	1081.5	1141.5	633	429.5	77	31	29	28.5
1992	0	555.5	883.5	434.5	308.5	267	188.5	52	30	27.5
1993	0	682	758	317.5	141	119.5	90	74	26.5	35.5
1994	0	325.5	1383.5	785	220.5	107	84	69	71	72
1995	0	389	582.5	738.5	239.5	58.5	75	58	31	59.5
1996	0	434.5	716	390.5	373	125	48.5	45.5	42.5	80.5
1997	0	399.5	1458.5	843	274	189.5	124.5	49	28	76.5
1998	0	393.5	1687	868.5	136.5	37.5	43.5	22	15.5	48
1999	0	109	2338.5	1504	267	38.5	22.5	23	8	18
2000	0	191	1236	2603.5	692.5	121	30.5	9.5	14.5	28
2001	0	454.5	1147.5	606	563	82.5	18.5	5.5	3	15
2002	0	1680.5	926.5	414.5	323.5	219.5	55.5	17	5.5	18.5
2003	0	428	983.5	483	116	84	94.5	22.5	13.5	16.5
2004	0	473	1190.5	210.5	111.5	36	34.5	30.5	9	12
2005	0	132.5	702	655.5	122	51	28	24	14.5	12.5
2006	0	340.5	543.5	337.5	211.5	44.5	21	22.5	23	16
2007	0	131	522.5	475	243.5	186.5	51	14.5	5	22
2008	0	366	545.5	455	143.5	75.5	88.5	1.5	2	3
2009	0	373	690	163.5	116.5	53	32	9.5	3	11
2010	0	346.5	603	342	88.5	67.5	24	14	6	9.5
2011	5.5	472.5	699.5	262.5	199	30	6	11	2	8.5

Table 8.2.6. North Sea plaice. Catch numbers-at-age including 50% of Q1 landings in the eastern channel (VIId). Final catch estimates used in the assessment of the stock.

Plaice in IV (+ 50% Q1 VIId) . catch.n
2012-05-01 16:53:27 units= thousands

year	age 1	2	3	4	5	6	7	8	9	10
1957	32356	49911	69038	45627	32732	8910	11029	9028	4973	10859
1958	66199	80681	45860	64619	36249	19659	8178	8000	6110	13148
1959	116086	144327	76829	36896	45836	23042	13873	6408	6596	16180
1960	73939	173852	106824	52019	22388	27848	14186	9013	5087	15153
1961	75578	146873	122406	68444	34311	12889	14680	9748	5996	14660
1962	51265	183468	123475	88495	50859	20814	9060	9035	5257	12801
1963	90913	140523	151249	86890	56476	31987	12848	6833	7047	16592
1964	66035	167982	104642	98560	60419	37414	15819	6595	3980	16886
1965	43708	435879	101464	56592	44597	30418	18361	8554	4213	17587
1966	38496	167269	414367	65887	38069	27495	16500	10784	6467	14928
1967	20199	139527	117836	265413	42006	22313	16175	8004	6728	11175
1968	73971	81666	87037	64670	146055	17197	10341	10102	3925	13365
1969	85195	82395	61934	55418	36358	104038	10410	6086	8192	16092
1970	123645	169774	78921	57440	45747	35235	78886	6311	4185	14840
1971	69356	126559	90636	36150	26485	22984	16913	29730	6414	16910
1972	72235	91998	96098	58620	23610	17071	14380	10903	18585	15651
1973	133620	81548	63107	73738	43544	13884	8885	9848	6084	23978
1974	213362	331531	59200	42410	41686	19775	8005	6321	5568	21980
1975	245950	308254	252159	36069	25672	21311	11873	5923	4106	19695
1976	186699	174564	148703	114411	13953	9945	9120	6391	2947	12552
1977	259848	160665	122606	99565	93022	9271	5912	5022	4061	9191
1978	228015	214691	89600	65116	51346	36080	5940	3352	2419	7468
1979	294484	273115	176441	67344	48475	40242	24228	4161	2807	9288
1980	227350	187702	134961	78346	25295	18087	13773	8470	1865	5401
1981	134395	294388	125495	58582	36252	12510	9578	8103	4889	5950
1982	414641	252473	215003	71486	29069	16877	7615	5487	4487	8674
1983	262614	556298	146385	102802	30405	13036	8241	4225	3014	8311
1984	310783	376910	328312	78788	39447	13866	6529	5571	2729	6588
1985	405506	303273	181113	188656	32827	15778	6916	3676	2734	5810
1986	1119019	558528	213624	121195	86309	24339	9368	4508	2738	6958
1987	361519	1460088	298411	113542	66433	35086	11572	4381	2182	5496
1988	348597	623705	713796	136738	48552	25406	16893	5414	3190	6273
1989	214552	532928	300540	319557	60827	19513	10645	7607	2141	5626
1990	146864	312067	268176	140609	165761	27139	8195	4269	3497	3862
1991	184587	345367	226252	158036	79122	78926	14987	5264	3170	5620
1992	142165	264129	180585	107277	77319	34553	29736	7022	3230	6956
1993	99832	208714	147221	84570	53181	29337	13562	11346	3672	5919
1994	63516	141177	138704	82059	39585	20639	15407	6468	5439	5505
1995	126614	119640	97734	79969	37402	18132	9847	4424	2367	3813
1996	112354	373996	92704	50680	32954	14701	10654	4574	2667	4973
1997	129545	554173	282235	45100	23086	13816	6487	3681	2207	4258
1998	104734	677045	262238	110552	17147	6503	5030	2528	1777	3167
1999	127870	217199	390079	96230	24657	6926	2806	2269	1529	3111
2000	106102	187223	91878	231905	16916	9705	2424	1207	955	2125
2001	34855	388793	240528	123588	144788	7071	4482	1134	640	2324
2002	311055	194851	135435	60889	38446	38758	4807	1806	748	1605
2003	68412	560663	101368	68507	31085	16469	22915	1632	664	876
2004	233479	190351	219269	41990	21686	11561	4859	4587	421	552
2005	96522	341562	70068	102374	21259	15552	5507	2639	2238	626
2006	220856	243142	175172	34721	45061	6849	5720	2270	1258	1335
2007	78525	223111	104371	56527	15951	24301	2680	3515	548	1281
2008	135719	262725	78408	42993	31264	6104	15686	1799	675	899
2009	150131	203056	117189	43240	23059	17710	3155	7197	559	774
2010	167940	196206	98437	81265	24588	13533	11511	2058	2435	1253
2011	117540	161181	103480	93943	61174	16499	6710	9339	1240	2825

Table 8.2.7. North Sea plaice. Stock weight-at-age

Plaice in IV . stock.wt

2012-05-01 16:53:41 units= kg

year	1	2	3	4	5	6	7	8	9	10
	age									
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

Table 8.2.8. North Sea plaice. Landings weight-at-age

Plaice in IV . landings.wt
2012-05-01 16:53:55 units= kg

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.183	0.223	0.287	0.392	0.506	0.592	0.654	0.440	1.108
1958	0.000	0.211	0.235	0.275	0.358	0.482	0.546	0.654	0.707	1.055
1959	0.000	0.223	0.251	0.299	0.370	0.483	0.605	0.637	0.766	1.021
1960	0.000	0.201	0.238	0.291	0.389	0.488	0.605	0.688	0.729	1.101
1961	0.000	0.194	0.237	0.307	0.418	0.517	0.613	0.681	0.825	1.088
1962	0.000	0.204	0.240	0.290	0.387	0.523	0.551	0.669	0.751	1.090
1963	0.000	0.258	0.292	0.325	0.407	0.543	0.636	0.680	0.729	1.048
1964	0.000	0.252	0.275	0.314	0.391	0.491	0.633	0.705	0.743	1.012
1965	0.000	0.243	0.284	0.323	0.387	0.474	0.542	0.667	0.730	0.892
1966	0.000	0.236	0.275	0.354	0.444	0.493	0.569	0.635	0.703	0.950
1967	0.000	0.237	0.285	0.328	0.433	0.558	0.609	0.675	0.753	0.998
1968	0.000	0.275	0.307	0.341	0.377	0.532	0.607	0.613	0.706	0.937
1969	0.230	0.311	0.328	0.352	0.380	0.436	0.606	0.693	0.696	0.945
1970	0.307	0.279	0.310	0.347	0.408	0.432	0.486	0.655	0.725	0.869
1971	0.264	0.329	0.368	0.416	0.463	0.531	0.560	0.627	0.722	0.920
1972	0.253	0.304	0.362	0.440	0.507	0.556	0.625	0.664	0.693	0.965
1973	0.286	0.332	0.361	0.426	0.511	0.566	0.636	0.659	0.711	0.884
1974	0.296	0.322	0.367	0.420	0.494	0.574	0.631	0.719	0.733	0.960
1975	0.265	0.319	0.351	0.446	0.526	0.624	0.676	0.747	0.832	1.082
1976	0.272	0.302	0.347	0.385	0.526	0.609	0.657	0.723	0.760	1.005
1977	0.254	0.324	0.354	0.381	0.419	0.557	0.648	0.722	0.716	0.980
1978	0.235	0.304	0.356	0.383	0.422	0.473	0.587	0.662	0.748	0.916
1979	0.235	0.310	0.348	0.387	0.428	0.473	0.549	0.674	0.795	0.959
1980	0.241	0.290	0.349	0.407	0.480	0.553	0.596	0.672	0.783	1.027
1981	0.241	0.279	0.335	0.423	0.514	0.567	0.614	0.653	0.737	1.023
1982	0.280	0.263	0.313	0.426	0.517	0.611	0.667	0.716	0.742	0.988
1983	0.199	0.248	0.298	0.380	0.511	0.599	0.672	0.765	0.809	0.976
1984	0.229	0.259	0.278	0.369	0.483	0.603	0.672	0.713	0.823	1.017
1985	0.242	0.259	0.284	0.330	0.452	0.565	0.664	0.714	0.787	1.000
1986	0.218	0.266	0.300	0.343	0.420	0.482	0.667	0.742	0.843	1.001
1987	0.219	0.246	0.297	0.347	0.397	0.498	0.576	0.720	0.820	0.978
1988	0.217	0.250	0.274	0.346	0.446	0.504	0.598	0.688	0.800	0.998
1989	0.232	0.275	0.304	0.327	0.386	0.524	0.593	0.659	0.779	0.926
1990	0.267	0.280	0.293	0.312	0.360	0.440	0.588	0.681	0.749	0.986
1991	0.219	0.276	0.283	0.295	0.352	0.438	0.509	0.647	0.720	0.887
1992	0.247	0.259	0.285	0.313	0.335	0.418	0.522	0.595	0.703	0.875
1993	0.244	0.267	0.283	0.319	0.348	0.414	0.507	0.617	0.705	0.837
1994	0.223	0.256	0.278	0.330	0.387	0.437	0.489	0.595	0.713	0.881
1995	0.270	0.275	0.299	0.336	0.400	0.451	0.525	0.607	0.730	0.902
1996	0.237	0.276	0.303	0.350	0.414	0.479	0.492	0.581	0.710	0.845
1997	0.206	0.268	0.310	0.360	0.452	0.519	0.597	0.610	0.676	0.913
1998	0.149	0.255	0.305	0.387	0.488	0.596	0.622	0.683	0.688	0.896
1999	0.241	0.248	0.275	0.349	0.447	0.537	0.619	0.670	0.739	0.797
2000	0.221	0.258	0.275	0.304	0.418	0.484	0.662	0.687	0.727	0.858
2001	0.236	0.264	0.289	0.306	0.361	0.477	0.586	0.701	0.787	0.793
2002	0.232	0.259	0.283	0.310	0.341	0.436	0.501	0.678	0.746	0.882
2003	0.227	0.248	0.281	0.319	0.363	0.405	0.477	0.640	0.750	0.838
2004	0.212	0.245	0.280	0.325	0.394	0.433	0.505	0.552	0.789	0.861
2005	0.267	0.262	0.277	0.327	0.385	0.427	0.463	0.545	0.603	0.889
2006	0.257	0.272	0.289	0.338	0.399	0.409	0.475	0.489	0.533	0.754
2007	0.262	0.267	0.303	0.346	0.378	0.452	0.539	0.481	0.591	0.617
2008	0.247	0.265	0.306	0.342	0.403	0.453	0.538	0.726	0.640	0.637
2009	0.183	0.273	0.326	0.375	0.435	0.501	0.553	0.632	0.695	0.824
2010	0.209	0.266	0.307	0.349	0.418	0.470	0.509	0.619	0.679	0.640
2011	0.207	0.215	0.264	0.323	0.393	0.484	0.572	0.492	0.529	0.763

Table 8.2.9. North Sea plaice. Discards weight-at-age

Plaice in IV . discards.wt
2012-05-01 16:54:09 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

Table 8.2.10. North Sea plaice. Catch weight-at-age

Plaice in IV . catch.wt
2012-05-01 16:54:23 units= kg

year	1	2	3	4	5	6	7	8	9	10
1957	0.044	0.111	0.213	0.284	0.387	0.506	0.592	0.654	0.440	1.108
1958	0.047	0.106	0.195	0.272	0.349	0.481	0.546	0.654	0.707	1.055
1959	0.051	0.120	0.193	0.264	0.352	0.482	0.605	0.637	0.766	1.021
1960	0.045	0.115	0.205	0.289	0.380	0.483	0.605	0.688	0.729	1.101
1961	0.044	0.101	0.181	0.306	0.408	0.514	0.613	0.681	0.825	1.088
1962	0.042	0.099	0.180	0.266	0.384	0.520	0.551	0.669	0.751	1.090
1963	0.048	0.110	0.175	0.309	0.399	0.541	0.636	0.680	0.729	1.048
1964	0.032	0.126	0.205	0.272	0.382	0.488	0.633	0.705	0.743	1.012
1965	0.038	0.076	0.215	0.315	0.384	0.471	0.542	0.667	0.730	0.892
1966	0.038	0.104	0.149	0.319	0.435	0.492	0.569	0.635	0.703	0.950
1967	0.036	0.111	0.191	0.237	0.430	0.554	0.609	0.675	0.753	0.998
1968	0.060	0.117	0.226	0.279	0.348	0.531	0.607	0.613	0.706	0.937
1969	0.052	0.176	0.283	0.294	0.376	0.432	0.606	0.693	0.696	0.945
1970	0.049	0.131	0.264	0.343	0.385	0.430	0.486	0.655	0.725	0.869
1971	0.057	0.161	0.281	0.400	0.459	0.529	0.560	0.627	0.722	0.920
1972	0.067	0.209	0.295	0.418	0.500	0.555	0.625	0.664	0.693	0.965
1973	0.045	0.209	0.350	0.423	0.502	0.565	0.636	0.659	0.711	0.884
1974	0.057	0.121	0.355	0.419	0.490	0.573	0.631	0.719	0.733	0.960
1975	0.069	0.153	0.208	0.414	0.523	0.621	0.676	0.747	0.832	1.082
1976	0.088	0.182	0.265	0.355	0.522	0.607	0.657	0.723	0.760	1.005
1977	0.071	0.218	0.245	0.318	0.397	0.552	0.648	0.722	0.716	0.980
1978	0.070	0.188	0.307	0.353	0.417	0.469	0.587	0.662	0.748	0.916
1979	0.067	0.190	0.295	0.337	0.426	0.471	0.549	0.674	0.795	0.959
1980	0.056	0.198	0.348	0.405	0.478	0.550	0.596	0.672	0.783	1.027
1981	0.048	0.184	0.332	0.422	0.510	0.565	0.614	0.653	0.737	1.023
1982	0.056	0.152	0.310	0.423	0.515	0.609	0.667	0.716	0.742	0.988
1983	0.052	0.152	0.273	0.376	0.503	0.598	0.672	0.765	0.809	0.976
1984	0.053	0.149	0.261	0.320	0.472	0.600	0.672	0.713	0.823	1.017
1985	0.054	0.168	0.263	0.328	0.451	0.564	0.664	0.714	0.787	1.000
1986	0.049	0.141	0.273	0.311	0.416	0.481	0.667	0.742	0.843	1.001
1987	0.043	0.113	0.217	0.345	0.394	0.496	0.576	0.720	0.820	0.978
1988	0.043	0.102	0.196	0.274	0.442	0.502	0.598	0.688	0.800	0.998
1989	0.047	0.117	0.213	0.288	0.363	0.521	0.593	0.659	0.779	0.926
1990	0.053	0.129	0.208	0.287	0.356	0.439	0.588	0.681	0.749	0.986
1991	0.056	0.148	0.207	0.267	0.341	0.436	0.509	0.647	0.720	0.887
1992	0.055	0.145	0.223	0.273	0.328	0.413	0.522	0.595	0.703	0.875
1993	0.063	0.159	0.246	0.302	0.344	0.412	0.507	0.617	0.705	0.837
1994	0.064	0.177	0.252	0.328	0.383	0.436	0.489	0.595	0.713	0.881
1995	0.071	0.183	0.281	0.335	0.397	0.450	0.525	0.607	0.730	0.902
1996	0.054	0.140	0.266	0.339	0.411	0.477	0.492	0.581	0.710	0.845
1997	0.045	0.129	0.219	0.358	0.450	0.517	0.597	0.610	0.676	0.913
1998	0.047	0.094	0.206	0.296	0.484	0.593	0.622	0.683	0.688	0.896
1999	0.054	0.103	0.197	0.262	0.444	0.533	0.619	0.670	0.739	0.797
2000	0.063	0.123	0.206	0.268	0.405	0.472	0.612	0.592	0.727	0.858
2001	0.090	0.135	0.194	0.229	0.300	0.472	0.580	0.701	0.787	0.793
2002	0.057	0.131	0.221	0.287	0.335	0.433	0.490	0.678	0.746	0.882
2003	0.066	0.123	0.227	0.282	0.343	0.401	0.413	0.640	0.750	0.838
2004	0.054	0.124	0.220	0.304	0.385	0.429	0.503	0.551	0.789	0.861
2005	0.067	0.116	0.212	0.299	0.353	0.342	0.457	0.544	0.603	0.889
2006	0.060	0.139	0.212	0.301	0.388	0.401	0.441	0.466	0.533	0.754
2007	0.058	0.112	0.224	0.319	0.370	0.380	0.520	0.350	0.591	0.617
2008	0.057	0.122	0.243	0.326	0.392	0.441	0.359	0.463	0.640	0.637
2009	0.061	0.125	0.235	0.338	0.415	0.483	0.538	0.448	0.695	0.824
2010	0.062	0.131	0.219	0.308	0.393	0.435	0.455	0.566	0.679	0.640
2011	0.047	0.111	0.204	0.264	0.351	0.433	0.565	0.424	0.529	0.763

Table 8.2.11. North Sea plaice. Natural mortality at age and maturity ate age vector used in assessments

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	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 8.2.12 North Sea plaice. Survey tuning indices.

North Sea plaice. Survey tuning indices

2012-05-01 16:46:56[1] units= NA

BTS-Isis (ages 1-8 used in assessment)

	Effort	1	2	3	4	5	6	7	8	9
1985	1	137	173.9	36.06	11.00	1.273	0.973	0.336	0.155	0.091
1986	1	667	131.7	50.17	9.21	3.780	0.400	0.418	0.147	0.070
1987	1	226	764.2	33.84	4.88	1.842	0.607	0.252	0.134	0.078
1988	1	680	147.0	182.31	9.99	2.810	0.814	0.458	0.036	0.112
1989	1	468	319.3	38.66	47.30	5.850	0.833	0.311	0.661	0.132
1990	1	185	146.1	79.34	26.35	5.469	0.758	0.189	0.383	0.239
1991	1	291	159.4	33.95	13.57	4.313	5.659	0.239	0.204	0.092
1992	1	361	174.5	29.25	5.96	3.748	2.871	1.186	0.346	0.050
1993	1	189	283.4	62.78	8.27	1.128	1.130	0.584	0.464	0.155
1994	1	193	77.1	34.46	10.59	2.667	0.600	0.800	0.895	0.373
1995	1	266	40.6	13.22	7.53	1.110	0.806	0.330	1.051	0.202
1996	1	310	206.9	21.47	4.47	3.134	0.838	0.044	0.161	0.122
1997	1	1047	59.2	17.18	2.67	0.257	0.358	0.157	0.111	0.000
1998	1	348	402.7	44.96	8.29	1.224	0.339	0.149	0.213	0.072
1999	1	293	121.6	171.25	3.39	1.956	0.127	0.130	0.027	0.030
2000	1	267	69.3	29.35	22.36	0.570	0.162	0.502	0.027	0.012
2001	1	207	72.2	17.84	9.17	8.716	0.270	0.131	0.038	0.040
2002	1	519	44.5	14.90	4.99	2.539	1.321	0.085	0.128	0.000
2003	1	133	159.1	10.06	5.55	1.426	1.133	0.638	0.111	0.096
2004	1	234	39.6	61.91	6.15	2.464	1.492	0.952	2.842	0.000
2005	1	163	66.2	6.76	12.79	1.084	1.164	0.290	0.152	0.492
2006	1	129	36.4	18.11	2.98	5.890	0.867	0.757	0.040	0.269
2007	1	312	67.2	19.71	14.42	2.942	6.085	0.684	0.831	0.156
2008	1	222	120.7	30.11	9.07	7.205	0.618	1.715	0.292	0.229
2009	1	409	105.2	45.98	13.01	4.029	3.474	0.574	2.128	0.278
2010	1	261	84.3	34.24	20.18	4.662	2.162	3.464	0.207	2.547
2011	1	486	148.2	55.30	20.07	12.904	3.945	2.243	2.263	0.232

BTS-Tridens (all ages used in assessment)

	Effort	1	2	3	4	5	6	7	8	9
1996	1	1.643	6.02	4.45	2.90	2.04	1.57	0.721	0.415	0.190
1997	1	0.221	7.12	9.13	3.25	2.10	1.52	0.401	0.819	0.354
1998	1	0.228	32.25	9.57	4.87	2.20	1.27	0.929	0.762	0.304
1999	1	2.692	7.71	35.23	5.56	2.50	1.93	0.633	0.761	0.309
2000	1	4.795	13.45	12.91	16.96	2.88	1.72	0.933	0.805	0.218
2001	1	2.154	8.61	9.90	6.68	7.36	1.05	0.592	0.418	0.505
2002	1	18.553	12.91	9.54	6.41	4.18	4.42	0.743	0.741	0.394
2003	1	3.975	41.69	13.38	9.06	5.08	2.81	3.920	0.703	0.740
2004	1	5.985	15.78	31.49	9.43	4.32	2.44	1.242	2.500	0.409
2005	1	6.876	23.37	12.23	17.67	2.82	6.87	1.565	0.567	3.574
2006	1	6.725	32.19	25.73	11.37	10.92	1.99	3.897	0.864	0.723
2007	1	26.571	23.73	19.55	23.18	4.90	10.15	1.974	3.786	0.323
2008	1	17.467	50.46	25.59	18.39	18.97	6.24	12.747	2.657	6.749
2009	1	12.110	41.69	43.33	19.13	12.05	11.77	3.081	10.119	1.567
2010	1	26.180	35.72	34.56	30.09	13.41	5.70	12.234	2.744	6.362
2011	1	41.881	71.48	41.59	28.46	31.67	14.28	5.501	11.881	1.172

Table 8.2.12 North Sea plaice. Survey tuning indices. (Cont'd)

SNS (ages 1-3 from 1982 onwards used in the assessment)

	Effort	1	2	3	4	5
1970	1	9311	9732	3273	770	170
1971	1	13538	28164	1415	101	50
1972	1	13207	10780	4478	89	84
1973	1	65643	5133	1578	461	15
1974	1	15366	16509	1129	160	82
1975	1	11628	8168	9556	65	15
1976	1	8537	2403	868	236	0
1977	1	18537	3424	1737	590	213
1978	1	14012	12678	345	135	45
1979	1	21495	9829	1575	161	17
1980	1	59174	12882	491	180	24
1981	1	24756	18785	834	38	32
1982	1	69993	8642	1261	88	8
1983	1	33974	13909	249	71	6
1984	1	44965	10413	2467	42	0
1985	1	28101	13848	1598	328	17
1986	1	93552	7580	1152	145	30
1987	1	33402	32991	1227	200	30
1988	1	36609	14421	13153	1350	88
1989	1	34276	17810	4373	7126	289
1990	1	25037	7496	3160	816	422
1991	1	57221	11247	1518	1077	128
1992	1	46798	13842	2268	613	176
1993	1	22098	9686	1006	98	60
1994	1	19188	4977	856	76	23
1995	1	24767	2796	381	97	38
1996	1	23015	10268	1185	45	47
1997	1	95901	4473	497	32	0
1998	1	33666	30242	5014	50	10
1999	1	32951	10272	13783	1058	17
2000	1	22855	2493	891	983	17
2001	1	11511	2898	370	176	691
2002	1	30809	1103	265	65	69
2003	1	NA	NA	NA	NA	NA
2004	1	18202	1350	1081	51	27
2005	1	10118	1819	142	366	8
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

Table 8.2.13. North Sea plaice. DFS index catches (numbers per hour), used only for RCT3. Note: a 10 year average previously used as an estimate for the 2010 Belgian data has been replaced with the now available data (i.e. 2010 value has been revised).

DFS

	Effort	age 0	age 1
1981	1	605.96	169.78
1982	1	433.67	299.36
1983	1	431.72	163.53
1984	1	261.80	124.19
1985	1	716.29	103.27
1986	1	200.11	288.27
1987	1	516.84	195.87
1988	1	318.36	116.45
1989	1	435.70	125.72
1990	1	465.47	130.13
1991	1	498.49	152.35
1992	1	351.59	137.08
1993	1	262.26	75.16
1994	1	445.66	30.60
1995	1	184.51	37.74
1996	1	572.80	116.89
1997	1	149.19	209.92
1998	1	NA	NA
1999	1	NA	NA
2000	1	183.83	11.31
2001	1	500.43	5.90
2002	1	210.70	17.79
2003	1	359.59	11.31
2004	1	243.15	14.97
2005	1	129.25	NA
2006	1	232.28	NA
2007	1	175.65	NA
2008	1	186.87	NA
2009	1	235.55	NA
2010	1	195.35	NA
2011	1	161.19	NA

Table 8.2.14 North Sea plaice. Commercial tuning fleets (not used in the final assessment)

North Sea plaice. Commercial tuning fleets (not used in the final assessment)
2011-05-07 14:04:10[1]

NL Beam Trawl

		2	3	4	5	6	7	8	9
1989	72.5	557.8	1016	1820	318.1	132.9	72.3	37.45	13.06
1990	71.1	308.8	844	701	1076.2	171.4	51.8	25.18	16.33
1991	68.5	401.5	619	776	448.1	497.7	100.4	28.53	16.60
1992	71.1	341.4	623	448	382.1	171.9	133.4	34.66	13.97
1993	76.9	358.3	605	407	256.2	142.8	78.5	46.96	13.33
1994	81.4	370.9	591	441	188.8	97.5	75.8	35.21	23.70
1995	81.2	277.3	536	417	178.0	81.0	42.1	19.08	11.47
1996	72.1	368.9	383	290	193.9	73.7	50.5	18.95	13.09
1997	72.0	320.8	634	252	95.6	60.2	28.0	13.54	6.39
1998	70.2	217.8	463	381	91.0	32.6	19.4	9.53	4.47
1999	67.3	64.5	1134	271	164.3	44.6	14.8	12.38	7.52
2000	64.6	138.9	263	1118	89.6	60.1	11.4	5.20	3.31
2001	61.4	264.3	367	321	664.6	44.7	28.6	6.35	3.19
2002	56.7	177.0	575	383	250.8	292.2	18.5	9.96	2.75
2003	51.6	372.8	387	406	186.4	103.8	129.1	6.03	5.02
2004	48.1	102.5	925	228	150.5	73.8	30.6	44.51	1.95
2005	49.1	154.2	222	727	96.2	59.2	34.1	14.81	23.54
2006	44.1	245.7	593	190	452.9	45.9	50.7	16.30	28.55
2007	42.9	201.6	416	464	109.7	208.1	23.1	26.62	7.53
2008	30.2	186.9	624	420	337.4	44.6	80.9	11.69	5.86

English Beam trawl excl Flag-vessels

		4	5	6	7	8	9	10	11	12
1990	102.3	27.0	92.7	17.46	11.08	7.06	8.23	2.45	1.662	0.958
1991	123.6	21.9	28.6	53.39	10.72	6.77	3.45	4.94	1.828	1.481
1992	151.5	19.2	29.3	18.40	24.25	6.39	3.68	3.20	3.281	1.096
1993	146.6	23.4	20.9	17.26	6.30	12.80	4.33	2.73	2.435	1.739
1994	131.4	23.1	22.0	13.49	9.53	4.51	6.47	3.28	1.438	1.218
1995	105.0	34.0	15.8	14.05	9.71	5.90	3.16	3.60	2.733	1.362
1996	82.9	13.3	19.0	10.74	10.08	6.55	4.68	2.50	3.305	1.966
1997	76.3	16.4	11.1	13.97	7.85	8.99	6.62	2.77	1.940	3.001
1998	68.8	23.6	13.0	8.97	8.69	5.04	6.03	4.61	1.948	1.599
1999	68.6	14.7	15.2	6.66	4.77	5.35	3.76	3.27	2.813	1.429
2000	57.8	63.2	15.0	9.95	4.41	2.44	3.48	1.87	1.782	2.526
2001	54.1	14.7	45.0	8.89	6.21	2.48	1.72	2.07	0.906	1.682
2002	30.6	23.4	20.8	29.61	5.13	4.12	1.41	1.73	1.503	1.340

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 2012-05-01 16:56:24

CPUE data from indices

Catch data for 55 years. 1957 to 2011. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-Isis	1	8	1985	2011	0.66	0.75
2	BTS-Tridens	1	9	1996	2011	0.66	0.75
3	SNS	1	3	1982	2011	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

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.210	0.146	0.215	0.141	0.285	0.073	0.152	0.164	0.211	0.103
2	0.590	0.624	0.662	0.490	0.548	0.458	0.330	0.315	0.299	0.286
3	0.528	0.621	0.469	0.481	0.444	0.425	0.256	0.214	0.221	0.227
4	0.632	0.492	0.501	0.370	0.412	0.222	0.276	0.196	0.202	0.303
5	0.682	0.689	0.252	0.452	0.245	0.300	0.165	0.209	0.146	0.206
6	0.466	0.622	0.523	0.257	0.227	0.181	0.160	0.119	0.163	0.124
7	0.529	0.490	0.330	0.449	0.127	0.117	0.153	0.104	0.095	0.102
8	0.266	0.303	0.151	0.268	0.299	0.097	0.097	0.087	0.083	0.094
9	0.172	0.132	0.106	0.092	0.176	0.097	0.022	0.035	0.035	0.059
10	0.172	0.132	0.106	0.092	0.176	0.097	0.022	0.035	0.035	0.059

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10
2002	1729930	459528	347048	136577	81732	109472	12302	8138	4982	10669
2003	528876	1269420	230450	185192	65661	37383	62187	6558	5646	7437
2004	1270058	413472	615300	112096	102403	29843	18160	34472	4382	5738
2005	770698	927104	193057	348171	61486	72030	16006	11809	26828	7495
2006	937388	605542	513974	108035	217657	35413	50381	9245	8175	8659
2007	1168187	638099	316633	298434	64726	154081	25528	40146	6206	14488
2008	1014800	982324	365146	187221	216264	43393	116303	20549	32982	43901
2009	1040634	789129	638932	255814	128508	165945	33458	90314	16882	23359
2010	929247	798796	520880	466656	190339	94345	133307	27273	74873	38501
2011	1265612	681068	536143	377676	344946	148837	72494	109671	22720	51714

Estimated population abundance at 1st Jan 2012

year \ age	1	2	3	4	5	6	7	8	9	10
2012	0	1033388	462953	386712	252390	253947	118989	59219	90362	19381

```
 Fleet:  BTS-Isis

 Log catchability residuals.

   year
age   1985   1986   1987   1988   1989   1990   1991   1992   1993   1994   1995   1996
1997   1998   1999   2000   2001   2002   2003   2004   2005   2006   2007   2008
  1 -1.221 -0.567 -0.814  0.404  0.417 -0.409  0.221  0.578  0.320  0.480 -0.194 -0.161
0.523  0.504  0.265 -0.020  0.281  0.146 -0.078 -0.340 -0.252 -0.584 -0.067 -0.213
  2  0.334 -0.270  0.585 -0.267  0.608  0.132  0.398  0.652  1.224  0.314 -0.226  0.460 -
0.748  0.418  0.317 -0.385 -0.298 -0.334 -0.051 -0.293 -0.709 -0.840 -0.343 -0.278
  3 -0.053  0.400 -0.249  0.527 -0.283  0.513  0.001  0.064  0.941  0.413 -0.129  0.478 -
0.490  0.634  0.797 -0.005 -0.217 -0.567 -0.485  0.244 -0.804 -0.824 -0.268 -0.106
  4 -0.290 -0.140 -0.543 -0.110  0.490  0.571  0.092 -0.385  0.134  0.527  0.296  0.180 -
0.190  0.502 -0.146  0.016  0.243 -0.070 -0.367  0.244 -0.250 -0.506 -0.080 -0.039
  5 -0.560  0.020 -0.353  0.288  0.670 -0.350 -0.003  0.233 -0.660  0.307 -0.328  0.835 -
1.238  0.365  0.502 -0.518  0.486  0.366  0.013 -0.192 -0.362 -0.079  0.478  0.072
  6  0.299 -0.630 -0.701 -0.021  0.165 -0.328  0.816  0.547  0.205 -0.171  0.164  0.517 -
0.167  0.046 -0.911 -0.990 -0.348 -0.389  0.642  1.073 -0.243  0.151  0.596 -0.439
  7  0.066  0.103 -0.224 -0.232 -0.262 -0.675 -0.740 -0.058 -0.579  0.799 -0.015 -1.928 -
0.440 -0.345 -0.436  0.922 -0.653 -0.902 -0.534  0.985  0.006 -0.408  0.163 -0.409
  8 -0.111 -0.051 -0.413 -1.150  0.859  0.538  0.104  0.402 -0.481  0.194  1.871  0.016 -
0.272  0.453 -1.472 -1.659 -1.334 -0.265 -0.165  1.311 -0.464 -1.532 -0.109 -0.486
   year
age   2009   2010   2011
  1  0.384  0.081  0.317
  2 -0.207 -0.453  0.262
  3 -0.272 -0.357  0.097
  4 -0.047 -0.205  0.072
  5  0.042 -0.249  0.217
  6 -0.082  0.040  0.157
  7 -0.292  0.117  0.297
  8  0.014 -1.122 -0.114


 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 -8.0387 -8.4229 -9.0464 -9.6308 -10.1946 -10.5375 -10.5375 -10.5375
S.E_Logq   0.4509  0.4968  0.4686  0.3097   0.4624   0.5107   0.5912   0.8380


 Fleet:  BTS-Tridens

 Log catchability residuals.

   year
age   1996   1997   1998   1999   2000   2001   2002   2003   2004   2005   2006   2007
2008   2009   2010   2011
  1 -1.438 -3.976 -2.862 -0.462 -0.077 -0.318  0.778  0.378 -0.041  0.546  0.429  1.434
1.210  0.828  1.744  1.829
  2 -1.372 -1.162 -0.403 -0.736 -0.320 -0.720  0.134  0.314  0.491 -0.045  0.742  0.321
0.554  0.572  0.393  1.237
  3 -0.516 -0.543 -0.332 -0.204 -0.246 -0.225 -0.432  0.381  0.148  0.369  0.108  0.305
0.312  0.250  0.233  0.393
  4 -0.479 -0.220 -0.257  0.121 -0.488 -0.301 -0.047 -0.104  0.444 -0.154  0.605  0.167
0.441  0.111 -0.032  0.194
  5 -0.416  0.045  0.132 -0.074  0.282 -0.503  0.045  0.462 -0.452 -0.225 -0.283  0.167
0.220  0.318 -0.013  0.294
  6 -0.171 -0.031  0.058  0.496  0.058 -0.297 -0.494  0.236  0.252  0.219 -0.334 -0.205
0.561 -0.175 -0.305  0.131
  7 -0.445 -0.815  0.173 -0.166  0.229 -0.458 -0.046 -0.031 -0.062  0.379 -0.082 -0.090
0.284  0.076  0.066 -0.119
  8 -0.350  0.414  0.415  0.554  0.423 -0.248  0.178  0.368 -0.130 -0.460  0.228  0.094
0.410  0.260  0.149  0.231
  9 -0.280  0.248  0.071  0.067 -0.243  0.224 -0.029  0.449  0.091  0.436  0.086 -0.499
0.816  0.035 -0.053 -0.535
```

```
 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 -12.0026 -10.1274 -9.6268 -9.4035 -9.3743 -9.2248 -9.2248 -9.2248 -9.2248
S.E_Logq    1.5961   0.7253  0.3450  0.3225  0.2994  0.3046  0.3028  0.3033  0.3487


 Fleet:  SNS

 Log catchability residuals.

   year
age  1982   1983  1984   1985   1986   1987   1988  1989  1990  1991  1992  1993  1994
1995   1996   1997  1998  1999   2000   2001   2002 2003   2004   2005   2006   2007
  1 0.432  0.145 0.507 -0.373 -0.102 -0.294 -0.087 0.233 0.019 1.024 0.965 0.604 0.601 -
0.136 -0.332  0.563 0.600 0.509 -0.049 -0.176 -0.249   NA -0.462 -0.602 -0.512 -0.728
  2 0.691  0.380 0.547  0.878 -0.051  0.517  0.485 0.796 0.236 0.820 1.191 0.921 0.647
0.172  0.531 -0.257 0.903 0.920 -0.636 -0.440 -0.957   NA -0.599 -1.229 -0.908 -0.718
  3 0.370 -1.099 0.419  0.386  0.181 -0.011  1.453 1.093 0.845 0.448 1.062 0.363 0.273 -
0.120  1.136 -0.478 1.996 1.833  0.056 -0.537 -1.041   NA -0.249 -1.112 -1.120 -1.660
   year
age   2008   2009   2010   2011
  1 -0.496 -0.501 -0.574 -0.529
  2 -1.004 -1.086 -1.219 -1.529
  3 -0.723 -1.254 -0.972 -1.538


 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 -3.5613 -4.5891 -5.6939
S.E_Logq   0.5037  0.8241  1.0039


 Terminal year survivor and F summaries:



Age =  1 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2010

Fleet =  BTS-Isis
                      1
Survivors   1418986.000
Raw weights       4.279


Fleet =  BTS-Tridens
                      1
Survivors   6437111.000
Raw weights       0.333


Fleet =  fshk
                    1
Survivors   576619.00
Raw weights      0.25


Fleet =  SNS
                     1
Survivors   608553.000
Raw weights      3.439


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "1418986"    "0.459"   "Inf"     "Inf"     "1" "0.515"     "0.076"
[2,] "BTS-Tridens" "6437111"    "1.645"   "Inf"     "Inf"     "1" "0.04"      "0.017"
[3,] "fshk"        "576619"     "1.9"     "Inf"     "Inf"     "1" "0.03"      "0.177"
[4,] "SNS"         "608553"     "0.512"   "Inf"     "Inf"     "1" "0.414"     "0.169"


 Weighted prediction:

     Suvivors  Int.s.e. Ext.s.e. Var.Ratio F
[1,] "1033388" ""       ""       ""        "0.103"
```

```
Age =  2 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2009

Fleet =  BTS-Isis
                     2          1
Survivors   601760.000 501755.000
Raw weights      2.935      2.885


Fleet =  BTS-Tridens
                      2           1
Survivors   1595689.000 2649304.000
Raw weights       1.344       0.225


Fleet =  fshk
                    2
Survivors   320105.00
Raw weights      0.25


Fleet =  SNS
                     2          1
Survivors   100363.000 260875.000
Raw weights      1.069      2.319


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "549912"     "0.342"   "0.091"   "0.266"   "2" "0.528"     "0.246"
[2,] "BTS-Tridens" "1715933"    "0.683"   "0.178"   "0.261"   "2" "0.142"     "0.086"
[3,] "fshk"        "320105"     "1.733"   "Inf"     "Inf"     "1" "0.023"     "0.391"
[4,] "SNS"         "192976"     "0.439"   "0.444"   "1.011"   "2" "0.307"     "0.585"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "462953" ""       ""       ""        "0.286"


Age =  3 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2008

Fleet =  BTS-Isis
                    3          2          1
Survivors   426275.0 245797.00 567455.000
Raw weights      3.5      2.31      2.379


Fleet =  BTS-Tridens
                     3          2          1
Survivors   572830.000 572929.000 884769.000
Raw weights      6.301      1.058      0.185


Fleet =  fshk
                    3
Survivors   267898.00
Raw weights      0.25


Fleet =  SNS
                    3           2          1
Survivors   83082.000 114327.000 234270.000
Raw weights     0.765      0.842      1.911


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "396571"     "0.282"   "0.228"   "0.809"   "3" "0.42"      "0.222"
[2,] "BTS-Tridens" "578993"     "0.318"   "0.048"   "0.151"   "3" "0.387"     "0.157"
[3,] "fshk"        "267898"     "1.786"   "Inf"     "Inf"     "1" "0.013"     "0.313"
[4,] "SNS"         "157513"     "0.409"   "0.316"   "0.773"   "3" "0.18"      "0.485"


 Weighted prediction:
```

```
     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "386712" ""       ""       ""        "0.227"


Age =  4 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2007

Fleet =  BTS-Isis
                    4          3         2          1
Survivors   271238.000 176650.000 2.052e+05 203869.000
Raw weights      7.425      2.598 1.687e+00      1.759


Fleet =  BTS-Tridens
                    4          3          2          1
Survivors   306550.000 318564.000 446993.000 846323.000
Raw weights      6.682      4.678      0.772      0.137


Fleet =  fshk
                   4
Survivors   297962.00
Raw weights      0.25


Fleet =  SNS
                   3         2          1
Survivors   95502.000 85155.000 153753.000
Raw weights     0.568     0.614      1.414


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "232302"     "0.215"   "0.103"   "0.479"   "4" "0.471"     "0.325"
[2,] "BTS-Tridens" "322184"     "0.232"   "0.079"   "0.341"   "4" "0.429"     "0.245"
[3,] "fshk"        "297962"     "1.719"   "Inf"     "Inf"     "1" "0.009"     "0.262"
[4,] "SNS"         "120464"     "0.409"   "0.191"   "0.467"   "3" "0.091"     "0.555"

 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "252390" ""       ""       ""        "0.303"


Age =  5 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2006

Fleet =  BTS-Isis
                    5          4          3          2          1
Survivors   315437.000 206867.000 193542.000 192284.000 237457.000
Raw weights      3.669      6.682      2.355      1.507      1.699


Fleet =  BTS-Tridens
                    5          4          3         2           1
Survivors   340859.000 245812.000 325936.000 441927.00 1064914.000
Raw weights      8.539      6.014      4.241      0.69       0.132


Fleet =  fshk
                   5
Survivors   244561.00
Raw weights      0.25
Fleet =  SNS
                   3         2          1
Survivors   72485.000 93004.000 122586.000
Raw weights     0.515     0.549      1.366


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "227536"     "0.198"   "0.094"   "0.475"   "5" "0.416"     "0.228"
[2,] "BTS-Tridens" "310565"     "0.188"   "0.094"   "0.5"     "5" "0.513"     "0.172"
[3,] "fshk"        "244561"     "1.804"   "Inf"     "Inf"     "1" "0.007"     "0.213"
[4,] "SNS"         "103039"     "0.407"   "0.151"   "0.371"   "3" "0.064"     "0.448"
```

```
 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "253947" ""       ""       ""        "0.206"


Age =  6 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2005

Fleet =  BTS-Isis
                     6          5           4           3          2          1
Survivors   139231.000 92738.000 113504.000 107010.000 84454.000 66337.000
Raw weights      3.267     3.443      6.312      2.134     1.201     1.097


Fleet =  BTS-Tridens
                     6           5           4           3          2           1
Survivors   135654.000 117468.000 132918.000 162484.000 164094.00 182655.000
Raw weights      8.959      8.014      5.681      3.843      0.55      0.085


Fleet =  fshk
                   6
Survivors   84424.00
Raw weights     0.25


Fleet =  SNS
                    3         2         1
Survivors   57715.000 58030.000 71290.000
Raw weights     0.466     0.438     0.881


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "106582"     "0.191"   "0.085"   "0.445"   "6" "0.374"     "0.137"
[2,] "BTS-Tridens" "133444"     "0.163"   "0.048"   "0.294"   "6" "0.582"     "0.111"
[3,] "fshk"        "84424"      "1.88"    "Inf"     "Inf"     "1" "0.005"     "0.171"
[4,] "SNS"         "64145"      "0.421"   "0.074"   "0.176"   "3" "0.038"     "0.219"

 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "118989" ""       ""       ""        "0.124"


Age =  7 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2004

Fleet =  BTS-Isis
                    7         6         5         4         3         2         1
Survivors   79667.000 61601.000 61764.000 56974.000 45303.000 25566.000 46010.000
Raw weights     2.201     2.834     2.805     4.744     1.354     0.696     0.734


Fleet =  BTS-Tridens
                    7         6         5         4         3          2          1
Survivors   52576.000 43663.000 81345.000 91999.000 80307.000 124375.000 102176.000
Raw weights     8.779     7.774     6.528     4.269     2.437      0.319      0.057


Fleet =  fshk
                   7
Survivors   50302.00
Raw weights     0.25


Fleet =  SNS
                    3         2        1
Survivors   11263.000 23873.000 32443.00
Raw weights     0.296     0.254     0.59


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "57573"      "0.193"   "0.095"   "0.492"   "7" "0.328"     "0.105"
[2,] "BTS-Tridens" "62341"      "0.151"   "0.121"   "0.801"   "7" "0.643"     "0.097"
[3,] "fshk"        "50302"      "1.9"     "Inf"     "Inf"     "1" "0.005"     "0.119"
[4,] "SNS"         "23023"      "0.419"   "0.311"   "0.742"   "3" "0.024"     "0.245"
```

```
 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "59219"  ""       ""       ""        "0.102"


Age =  8 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2003

Fleet =  BTS-Isis
                    8          7          6          5          4          3          2          1
Survivors   80581.00 101576.000 83220.000 97076.000 83388.000 39650.000 44471.000 64316.000
Raw weights     1.18      2.019      2.717      2.811      5.018      1.406      0.767      0.751


Fleet =  BTS-Tridens
                     8          7          6           5           4           3          2          1
Survivors   113841.000 96533.000 75857.000 112557.000 106807.000 100617.000 86340.000 86733.000
Raw weights      7.212      8.051      7.453       6.542       4.516       2.532      0.351      0.058


Fleet =  fshk
                   8
Survivors   62673.00
Raw weights     0.25


Fleet =  SNS
                     3          2          1
Survivors   29491.000 26437.000 56918.000
Raw weights     0.307      0.279      0.603


     Fleet         Est.Suvivors Int. s.e. Ext. s.e. Var Ratio N   Scaled Wgts Estimated F
[1,] "BTS-Isis"    "78802"      "0.187"   "0.102"   "0.545"   "8" "0.304"     "0.107"
[2,] "BTS-Tridens" "98966"      "0.139"   "0.056"   "0.403"   "8" "0.67"      "0.086"
[3,] "fshk"        "62673"      "1.908"   "Inf"     "Inf"     "1" "0.005"     "0.133"
[4,] "SNS"         "40118"      "0.419"   "0.252"   "0.601"   "3" "0.022"     "0.2"


 Weighted prediction:

     Suvivors Int.s.e. Ext.s.e. Var.Ratio F
[1,] "90362"  ""       ""       ""        "0.094"


Age =  9 .  Catchability constand w.r.t. time and dependant on age
 Year class =  2002

Fleet =  BTS-Isis
                   8         7         6         5         4        3         2         1
Survivors   6307.000 14477.000 12499.000 31241.000 11686.000 8670.000 14452.000 17929.000
Raw weights    1.124     1.906     2.463     2.226     3.286    0.887     0.408     0.427


Fleet =  BTS-Tridens
                    9           8           7           8           5           4           3
2        1
Survivors      11345.000  22499.000  20910.000  33975.000  22910.000  35491.000  28040.000
31655.000 28269.000
Raw weights      7.105       6.874       7.604       6.756       5.181       2.957       1.598
0.187     0.033
```

```
Fleet =  fshk
                  9
Survivors   6525.00
Raw weights    0.25


Fleet =  SNS
                   3         2
Survivors   6375.000 10649.000
Raw weights    0.194     0.148
```

	Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
[1,]	"BTS-Isis"	"13754"	"0.201"	"0.168"	"0.836"	"8"	"0.247"	"0.082"
[2,]	"BTS-Tridens"	"22050"	"0.136"	"0.131"	"0.963"	"9"	"0.742"	"0.052"
[3,]	"fshk"	"6525"	"1.942"	"Inf"	"Inf"	"1"	"0.005"	"0.166"
[4,]	"SNS"	"7963"	"0.683"	"0.254"	"0.372"	"2"	"0.007"	"0.138"

Weighted prediction:

	Suvivors	Int.s.e.	Ext.s.e.	Var.Ratio	F
[1,]	"19381"	""	""	""	"0.059"

Table 8.3.2. North Sea plaice. Fishing mortality estimates in final XSA run

Plaice in IV . harvest
2012-05-01 16:55:55 units= f

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.077	0.229	0.255	0.304	0.347	0.208	0.274	0.314	0.290	0.290
1958	0.105	0.250	0.302	0.358	0.374	0.321	0.268	0.291	0.323	0.323
1959	0.152	0.310	0.355	0.376	0.412	0.383	0.350	0.309	0.367	0.367
1960	0.108	0.318	0.353	0.384	0.366	0.419	0.383	0.359	0.383	0.383
1961	0.097	0.289	0.344	0.357	0.417	0.330	0.361	0.437	0.381	0.381
1962	0.096	0.319	0.373	0.398	0.434	0.426	0.362	0.350	0.395	0.395
1963	0.149	0.364	0.418	0.434	0.423	0.474	0.450	0.452	0.448	0.448
1964	0.032	0.399	0.448	0.469	0.540	0.488	0.403	0.390	0.459	0.459
1965	0.068	0.267	0.397	0.412	0.355	0.508	0.417	0.352	0.410	0.410
1966	0.071	0.356	0.388	0.430	0.477	0.343	0.506	0.409	0.435	0.435
1967	0.054	0.352	0.405	0.408	0.476	0.504	0.310	0.435	0.428	0.428
1968	0.197	0.287	0.344	0.361	0.366	0.323	0.410	0.289	0.351	0.351
1969	0.149	0.313	0.327	0.341	0.315	0.428	0.295	0.399	0.356	0.356
1970	0.223	0.435	0.492	0.505	0.462	0.504	0.594	0.261	0.467	0.467
1971	0.196	0.332	0.388	0.388	0.407	0.395	0.428	0.412	0.407	0.407
1972	0.232	0.381	0.401	0.413	0.419	0.443	0.408	0.478	0.434	0.434
1973	0.113	0.394	0.433	0.542	0.545	0.413	0.387	0.480	0.475	0.475
1974	0.221	0.399	0.491	0.515	0.596	0.452	0.394	0.465	0.486	0.486
1975	0.355	0.501	0.531	0.557	0.600	0.618	0.477	0.503	0.553	0.553
1976	0.333	0.407	0.426	0.432	0.383	0.433	0.518	0.452	0.445	0.445
1977	0.323	0.471	0.495	0.499	0.665	0.420	0.441	0.533	0.513	0.513
1978	0.304	0.428	0.464	0.471	0.461	0.519	0.461	0.426	0.469	0.469
1979	0.424	0.636	0.664	0.673	0.683	0.707	0.703	0.605	0.677	0.677
1980	0.237	0.466	0.664	0.622	0.508	0.517	0.493	0.501	0.530	0.530
1981	0.178	0.482	0.577	0.602	0.581	0.450	0.505	0.534	0.536	0.536
1982	0.241	0.516	0.692	0.676	0.603	0.520	0.481	0.538	0.566	0.566
1983	0.236	0.518	0.568	0.750	0.606	0.528	0.459	0.476	0.566	0.566
1984	0.299	0.549	0.584	0.606	0.641	0.545	0.486	0.571	0.572	0.572
1985	0.261	0.472	0.492	0.701	0.484	0.507	0.509	0.493	0.541	0.541
1986	0.283	0.606	0.633	0.636	0.720	0.713	0.567	0.651	0.745	0.745
1987	0.214	0.637	0.677	0.732	0.772	0.642	0.790	0.502	0.675	0.675
1988	0.231	0.608	0.657	0.675	0.714	0.678	0.653	0.975	0.743	0.743
1989	0.210	0.578	0.590	0.616	0.642	0.622	0.597	0.613	1.278	1.278
1990	0.161	0.472	0.572	0.538	0.670	0.586	0.511	0.449	0.562	0.562
1991	0.237	0.604	0.660	0.698	0.586	0.696	0.666	0.642	0.625	0.625
1992	0.212	0.551	0.653	0.674	0.790	0.485	0.543	0.674	0.942	0.942
1993	0.219	0.483	0.604	0.648	0.748	0.703	0.316	0.363	0.811	0.811
1994	0.162	0.484	0.610	0.715	0.637	0.648	0.896	0.218	0.264	0.264
1995	0.121	0.457	0.646	0.767	0.746	0.600	0.656	0.616	0.103	0.103
1996	0.096	0.545	0.685	0.735	0.744	0.656	0.764	0.646	0.838	0.838
1997	0.065	0.791	0.927	0.752	0.790	0.717	0.602	0.576	0.661	0.661
1998	0.153	0.492	0.994	1.082	0.638	0.470	0.549	0.440	0.537	0.537
1999	0.173	0.475	0.519	1.173	0.655	0.508	0.337	0.453	0.461	0.461
2000	0.120	0.365	0.334	0.592	0.568	0.515	0.296	0.211	0.310	0.310
2001	0.070	0.725	0.984	0.891	0.815	0.436	0.421	0.196	0.148	0.148
2002	0.210	0.590	0.528	0.632	0.682	0.466	0.529	0.266	0.172	0.172
2003	0.146	0.624	0.621	0.492	0.689	0.622	0.490	0.303	0.132	0.132
2004	0.215	0.662	0.469	0.501	0.252	0.523	0.330	0.151	0.106	0.106
2005	0.141	0.490	0.481	0.370	0.452	0.257	0.449	0.268	0.092	0.092
2006	0.285	0.548	0.444	0.412	0.245	0.227	0.127	0.299	0.176	0.176
2007	0.073	0.458	0.425	0.222	0.300	0.181	0.117	0.097	0.097	0.097
2008	0.152	0.330	0.256	0.276	0.165	0.160	0.153	0.097	0.022	0.022
2009	0.164	0.315	0.214	0.196	0.209	0.119	0.104	0.087	0.035	0.035
2010	0.211	0.299	0.221	0.202	0.146	0.163	0.095	0.083	0.035	0.035
2011	0.103	0.286	0.227	0.303	0.206	0.124	0.102	0.094	0.059	0.059

Table 8.3.3. North Sea plaice. Stock number estimates in the final XSA runs

Plaice in IV . stock.n

2012-05-01 16:56:08 units= NA

age

year	1	2	3	4	5	6	7	8	9	10
1957	457973	256778	322069	182986	117504	49780	48438	35192	20763	45210
1958	698110	383614	184865	225749	122171	75186	36568	33338	23255	49887
1959	863386	568706	270362	123650	142799	76063	49331	25309	22555	55137
1960	757299	670799	377298	171551	76786	85609	46907	31440	16805	49877
1961	860577	614899	441591	239780	105744	48183	50972	28949	19875	48420
1962	589154	706790	416674	283132	151856	63044	31337	32158	16921	41052
1963	688367	484324	465010	259569	172010	89026	37245	19737	20503	48075
1964	2231503	536381	304565	276886	152215	101919	50127	21480	11359	47991
1965	694575	1956333	325548	176043	156783	80258	56631	30309	13162	54735
1966	586779	586901	1355542	198053	105458	99441	43686	33776	19288	44345
1967	401297	494321	371939	832387	116532	59210	63824	23833	20304	33590
1968	434281	343895	314558	224455	500707	65485	32351	42364	13952	47349
1969	648875	322590	233486	201832	141579	314126	42895	19436	28724	56233
1970	650583	506087	213515	152353	129910	93521	185269	28911	11797	41653
1971	410282	471057	296432	118125	83216	74031	51105	92600	20156	52939
1972	366625	305265	305843	182007	72497	50104	45123	30154	55508	46557
1973	1312107	263024	188704	185327	108926	43139	29097	27151	16913	66366
1974	1132775	1060140	160423	110717	97549	57140	25827	17877	15199	59733
1975	864859	822021	643892	88844	59840	48613	32892	15755	10163	48505
1976	693092	548602	450575	342757	46079	29725	23715	18468	8621	36569
1977	989338	449542	330345	266247	201308	28422	17436	12783	10631	23948
1978	914118	648015	253933	182282	146201	93666	16898	10153	6790	20871
1979	895153	610233	382127	144538	102995	83446	50432	9640	5999	19730
1980	1133652	529846	292367	177927	66724	47083	37226	22586	4765	13732
1981	868626	809508	300877	136166	86470	36313	25398	20582	12380	14994
1982	2035162	658124	452443	152870	67483	43758	20958	13870	10916	20994
1983	1312130	1447072	355336	204870	70323	33410	23540	11720	7331	20111
1984	1263687	937458	780198	182275	87586	34708	17830	13460	6585	15816
1985	1853892	847805	489719	393652	89984	41728	18216	9923	6880	14550
1986	4775439	1291741	478644	270836	176736	50195	22748	9904	5482	13840
1987	1970104	3256552	637528	229890	129779	77818	22266	11672	4673	11700
1988	1776234	1438737	1557771	293001	100008	54235	37037	9140	6394	12492
1989	1189264	1275608	708536	730546	135049	44307	24907	17444	3120	8111
1990	1039262	872002	647281	355228	357053	64337	21529	12411	8548	9392
1991	918015	800662	492173	330587	187672	165398	32399	11685	7169	12640
1992	781976	655070	395946	230119	148799	94549	74582	15060	5566	11889
1993	532656	572330	341484	186489	106175	61091	52684	39199	6947	11120
1994	445836	387004	319331	168947	88296	45484	27371	34770	24676	24910
1995	1167369	342990	215884	157003	74813	42239	21523	10111	25308	40717
1996	1296449	935840	196546	102373	65993	32115	20972	10108	4940	9145
1997	2160323	1066201	491027	89659	44422	28366	15075	8842	4795	9197
1998	777736	1831514	437593	175830	38226	18235	12525	7470	4499	7979
1999	845152	604098	1013198	146502	53937	18278	10314	6548	4354	8822
2000	987140	643092	340005	545725	41024	25350	9950	6663	3767	8357
2001	544499	792274	403801	220252	273197	21029	13706	6698	4881	17694
2002	1729930	459528	347048	136577	81732	109472	12302	8138	4982	10669
2003	528876	1269420	230450	185192	65661	37383	62187	6558	5646	7437
2004	1270058	413472	615300	112096	102403	29843	18160	34472	4382	5738
2005	770698	927104	193057	348171	61486	72030	16006	11809	26828	7495
2006	937388	605542	513974	108035	217657	35413	50381	9245	8175	8659
2007	1168187	638099	316633	298434	64726	154081	25528	40146	6206	14488
2008	1014800	982324	365146	187221	216264	43393	116303	20549	32982	43901
2009	1040634	789129	638932	255814	128508	165945	33458	90314	16882	23359
2010	929247	798796	520880	466656	190339	94345	133307	27273	74873	38501
2011	1265612	681068	536143	377676	344946	148837	72494	109671	22720	51714

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	457973	273010	78443	70563	7880	0.27	0.22	0.12	0.26
1958	698110	287066	88191	73354	14837	0.32	0.24	0.19	0.26
1959	863386	296272	109164	79300	29864	0.37	0.24	0.24	0.27
1960	757299	307214	117334	87541	29793	0.37	0.27	0.23	0.28
1961	860577	319935	118474	85984	32490	0.35	0.24	0.27	0.27
1962	589154	371317	125375	87472	37903	0.39	0.25	0.29	0.24
1963	688367	368352	148376	107118	41258	0.42	0.27	0.36	0.29
1964	2231503	361210	147571	110540	37031	0.47	0.30	0.32	0.31
1965	694575	343910	140223	97143	43080	0.39	0.28	0.25	0.28
1966	586779	359196	166552	101834	64718	0.40	0.24	0.34	0.28
1967	401297	412585	163365	108819	54546	0.43	0.25	0.32	0.26
1968	434281	400993	139521	111534	27987	0.34	0.21	0.22	0.28
1969	648875	376358	142820	121651	21169	0.34	0.25	0.17	0.32
1970	650583	332878	159982	130342	29640	0.48	0.35	0.28	0.39
1971	410282	314682	136939	113944	22995	0.38	0.29	0.22	0.36
1972	366625	316599	142475	122843	19632	0.41	0.33	0.19	0.39
1973	1312107	266580	143783	130429	13354	0.47	0.41	0.13	0.49
1974	1132775	278457	157485	112540	44945	0.49	0.41	0.20	0.40
1975	864859	291454	195235	108536	86699	0.56	0.37	0.43	0.37
1976	693092	307725	166917	113670	53247	0.42	0.30	0.27	0.37
1977	989338	314439	176689	119188	57501	0.51	0.34	0.31	0.38
1978	914118	301354	159639	113984	45655	0.47	0.36	0.22	0.38
1979	895153	295823	213282	145347	67935	0.67	0.49	0.36	0.49
1980	1133652	270485	171485	140405	31080	0.56	0.49	0.15	0.52
1981	868626	261847	173596	140565	33031	0.54	0.47	0.16	0.54
1982	2035162	262324	204508	155381	49127	0.60	0.51	0.22	0.59
1983	1312130	314080	219386	144903	74483	0.59	0.48	0.26	0.46
1984	1263687	322798	227848	157032	70816	0.59	0.43	0.28	0.49
1985	1853892	345749	221419	160870	60549	0.53	0.44	0.23	0.47
1986	4775439	372196	296472	166519	129953	0.66	0.50	0.34	0.45
1987	1970104	450011	345628	155104	190524	0.69	0.48	0.51	0.34
1988	1776234	391842	312684	156261	156423	0.67	0.40	0.51	0.40
1989	1189264	417266	279112	171319	107793	0.61	0.38	0.45	0.41
1990	1039262	381455	229016	157791	71225	0.57	0.38	0.39	0.41
1991	918015	351693	230278	149343	80935	0.65	0.41	0.47	0.42
1992	781976	286209	183326	126277	57049	0.63	0.42	0.40	0.44
1993	532656	249472	153043	118027	35016	0.64	0.50	0.28	0.47
1994	445836	227759	135227	111442	23785	0.62	0.52	0.24	0.49
1995	1167369	220049	121063	99235	21828	0.64	0.55	0.21	0.45
1996	1296449	182046	134647	82598	52049	0.67	0.52	0.34	0.45
1997	2160323	207638	184297	84152	100145	0.80	0.52	0.68	0.41
1998	777736	228183	176282	72531	103751	0.74	0.39	0.60	0.32
1999	845152	203386	152696	81720	70976	0.67	0.38	0.38	0.40
2000	987140	230353	126783	82472	44311	0.47	0.33	0.26	0.36
2001	544499	270908	183182	82873	100309	0.77	0.32	0.71	0.31
2002	1729930	198554	125777	71387	54390	0.58	0.38	0.42	0.36
2003	528876	226326	144964	67172	77792	0.61	0.38	0.45	0.30
2004	1270058	206665	116536	62070	54466	0.48	0.29	0.44	0.30
2005	770698	243515	110133	56257	53876	0.41	0.21	0.38	0.23
2006	937388	252277	120299	58453	61846	0.38	0.19	0.39	0.23
2007	1168187	259858	89783	50348	39435	0.32	0.16	0.34	0.19
2008	1014800	359399	95309	49434	45875	0.24	0.14	0.22	0.14
2009	1040634	400115	100671	55446	45225	0.21	0.11	0.21	0.14
2010	929247	500793	106980	61163	45817	0.21	0.11	0.20	0.12
2011	1265612	476063	108523	67963	40560	0.23	0.11	0.20	0.14

Table 8.5.1. North Sea plaice. Input table for RCT3 analysis.

Plaice	NorthSea							
	Age1	Age2	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1972	1312107	1060140	7757.5	65642.5	16508.9	-11	-11	-11
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	606
1982	1312130	937458	24401.9	33974.2	10412.8	-11	-11	433.7
1983	1263687	847805	32941.9	44964.5	13847.8	-11	173.9	431.7
1984	1853892	1291741	7918.3	28100.5	7580.4	136.8	131.7	261.8
1985	4775439	3256552	47256.4	93551.9	32991.1	667.4	764.2	716.3
1986	1970104	1438737	8819.9	33402.4	14421.1	225.8	147	200.1
1987	1776234	1275608	21334.9	36608.6	17810.2	680.2	319.3	516.8
1988	1189264	872002	15669.7	34276.3	7496	467.9	146.1	318.4
1989	1039262	800662	24585.3	25036.6	11247.2	185.3	159.4	435.7
1990	918015	655070	368.5	57221.3	13841.8	291.4	174.5	465.5
1991	781976	572330	7256.7	46798.2	9685.6	360.9	283.4	498.5
1992	532656	387004	472.5	22098.3	4976.6	189	77.1	351.6
1993	445836	342990	234.3	19188.4	2796.4	193.3	40.6	262.3
1994	1167369	935840	26781.3	24767	10268.2	265.6	206.9	445.7
1995	1296449	1066201	12541.3	23015.4	4472.7	310.3	59.2	184.5
1996	2160323	1831514	84041.8	95900.9	30242.2	1046.8	402.7	572.8
1997	777736	604098	7344.1	33665.7	10272.1	347.6	121.6	149.2
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	183.8
2001	1729930	1269420	99628	30809.2	-11	519.2	159.1	500.4
2002	528876	413472	1202	-11	1349.7	132.8	39.6	210.7
2003	1270058	927104	-11	18201.6	1818.9	233.7	66.2	359.6
2004	770698	605542	3537.2	10118.4	1571	163	36.4	243.2
2005	937388	638099	7390.6	12164.2	2133.9	128.6	67.2	129.3
2006	1168187	982324	1124.2	14174.5	2700.4	312	120.7	232.3
2007	1014800	789129	40580.9	14705.8	2018.7	221.6	105.2	175.7
2008	-11	-11	50179.3	14860	1811.5	409	84.3	186.9
2009	-11	-11	53258.8	11946.9	1142.515	261	148.2	235.6
2010	-11	-11	49347.24	18348.6	-11	486	-11	195.4
2011	-11	-11	-11	-11	-11	-11	-11	161.2

Table 8.5.2. North Sea plaice. RCT3 results for age 1.

```
Analysis by RCT3 ver4.0

Plaice
Data for 6 surveys over 40 years : 1972 - 2011
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	0.3851	10.597	0.5464	0.4305	35	NA	NA	NA	NA
SNS1	1.1769	1.931	0.5935	0.3739	35	NA	NA	NA	NA
SNS2	0.7842	6.996	0.5708	0.4027	35	NA	NA	NA	NA
BTS1	1.6632	4.529	0.7386	0.3548	24	NA	NA	NA	NA
BTS2	0.9012	9.614	0.4609	0.5754	25	NA	NA	NA	NA
DFS0	2.1783	1.390	0.9244	0.2601	25	5.083	12.46	1.022	0.1698
VPA Mean	NA	NA	NA	NA	36	NA	13.90	0.462	0.8302

	WAP	logWAP	int.se
yearclass:2011	849355	13.65	0.421

Table 8.5.3. North Sea plaice. RCT3 results for age 2.

```
Analysis by RCT3 ver4.0
Plaice
Data for 6 surveys over 40 years : 1972 - 2011
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
     SNS0 0.3568   10.5324 0.4726  0.5034 35  10.807      14.39  0.5039     0.27778
     SNS1 1.1605    1.7886 0.5774  0.3907 35   9.817      13.18  0.6060     0.19209
     SNS2 0.8478    6.1307 0.6457  0.3457 35      NA         NA      NA          NA
     BTS1 1.5414    4.9394 0.6663  0.3887 24   6.186      14.48  0.7256     0.13399
     BTS2 0.8936    9.3693 0.4710  0.5490 25      NA         NA      NA          NA
     DFS0 2.1994    0.9803 0.9474  0.2377 25   5.275      12.58  1.0280     0.06674
 VPA Mean     NA        NA     NA      NA 36      NA      13.59  0.4627     0.32940

                  WAP logWAP int.se

yearclass:2010 968826  13.78 0.2656
```

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	2012	0.170	0.17	0.00	922294	0.06	0.20	0.06	0.05	0.0	0.1
2	2	2012	0.319	0.30	0.02	1033366	0.12	0.25	0.11	0.11	0.5	0.1
3	3	2012	0.235	0.14	0.10	462935	0.22	0.30	0.16	0.19	0.5	0.1
4	4	2012	0.249	0.07	0.18	386689	0.30	0.35	0.19	0.30	1.0	0.1
5	5	2012	0.199	0.03	0.17	252374	0.39	0.42	0.19	0.36	1.0	0.1
6	6	2012	0.144	0.02	0.13	253930	0.45	0.48	0.20	0.43	1.0	0.1
7	7	2012	0.107	0.01	0.10	118979	0.52	0.54	0.21	0.45	1.0	0.1
8	8	2012	0.094	0.03	0.07	59212	0.48	0.58	0.22	0.51	1.0	0.1
9	9	2012	0.046	0.00	0.05	90351	0.63	0.63	0.00	0.55	1.0	0.1
10	10	2012	0.046	0.00	0.05	63486	0.74	0.74	0.00	0.61	1.0	0.1
11	1	2013	0.170	0.17	0.00	922294	0.06	0.20	0.06	0.05	0.0	0.1
12	2	2013	0.319	0.30	0.02	NA	0.12	0.25	0.11	0.11	0.5	0.1
13	3	2013	0.235	0.14	0.10	NA	0.22	0.30	0.16	0.19	0.5	0.1
14	4	2013	0.249	0.07	0.18	NA	0.30	0.35	0.19	0.30	1.0	0.1
15	5	2013	0.199	0.03	0.17	NA	0.39	0.42	0.19	0.36	1.0	0.1
16	6	2013	0.144	0.02	0.13	NA	0.45	0.48	0.20	0.43	1.0	0.1
17	7	2013	0.107	0.01	0.10	NA	0.52	0.54	0.21	0.45	1.0	0.1
18	8	2013	0.094	0.03	0.07	NA	0.48	0.58	0.22	0.51	1.0	0.1
19	9	2013	0.046	0.00	0.05	NA	0.63	0.63	0.00	0.55	1.0	0.1
20	10	2013	0.046	0.00	0.05	NA	0.74	0.74	0.00	0.61	1.0	0.1
21	1	2014	0.170	0.17	0.00	922294	0.06	0.20	0.06	0.05	0.0	0.1
22	2	2014	0.319	0.30	0.02	NA	0.12	0.25	0.11	0.11	0.5	0.1
23	3	2014	0.235	0.14	0.10	NA	0.22	0.30	0.16	0.19	0.5	0.1
24	4	2014	0.249	0.07	0.18	NA	0.30	0.35	0.19	0.30	1.0	0.1
25	5	2014	0.199	0.03	0.17	NA	0.39	0.42	0.19	0.36	1.0	0.1
26	6	2014	0.144	0.02	0.13	NA	0.45	0.48	0.20	0.43	1.0	0.1
27	7	2014	0.107	0.01	0.10	NA	0.52	0.54	0.21	0.45	1.0	0.1
28	8	2014	0.094	0.03	0.07	NA	0.48	0.58	0.22	0.51	1.0	0.1
29	9	2014	0.046	0.00	0.05	NA	0.63	0.63	0.00	0.55	1.0	0.1
30	10	2014	0.046	0.00	0.05	NA	0.74	0.74	0.00	0.61	1.0	0.1

Table 8.6.2A. North Sea plaice. Results from the short term forecast assuming $F_{2012} = F_{2011}$ (rescaled)

```
   year fmult  f2-6 f_dis2-3 f_hc2-6 landings discards  catch ssb2012
25 2012     1 0.229     0.22    0.12    78501    51192 129797  589341
   year fmult  f2-6 f_dis2-3 f_hc2-6 landings discards  catch    ssb ssb2014
2  2013   0.2 0.046     0.04    0.02    17952    10121  28098 628143  792171
5  2013   0.3 0.069     0.06    0.04    26679    14993  41709 628143  778131
8  2013   0.4 0.092     0.09    0.05    35244    19744  55036 628143  764386
11 2013   0.5 0.115     0.11    0.06    43651    24377  68087 628143  750931
14 2013   0.6 0.138     0.13    0.07    51903    28894  80867 628143  737758
17 2013   0.7 0.160     0.15    0.08    60003    33300  93384 628143  724860
20 2013   0.8 0.183     0.17    0.10    67954    37597 105643 628143  712232
23 2013   0.9 0.206     0.19    0.11    75760    41788 117651 628143  699867
26 2013   1.0 0.229     0.22    0.12    83424    45876 129412 628143  687760
29 2013   1.1 0.252     0.24    0.13    90948    49862 140933 628143  675904
32 2013   1.2 0.275     0.26    0.14    98336    53751 152220 628143  664293
35 2013   1.3 0.298     0.28    0.16   105590    57545 163277 628143  652923
38 2013   1.4 0.321     0.30    0.17   112713    61246 174110 628143  641787
41 2013   1.5 0.344     0.32    0.18   119707    64856 184724 628143  630880
44 2013   1.6 0.367     0.35    0.19   126577    68378 195125 628143  620198
47 2013   1.7 0.390     0.37    0.20   133323    71815 205316 628143  609734
50 2013   1.8 0.413     0.39    0.21   139948    75168 215303 628143  599484
53 2013   1.9 0.436     0.41    0.23   146456    78439 225091 628143  589444
56 2013   2.0 0.458     0.43    0.24   152848    81632 234684 628143  579607
```

Table 8.6.3A. North Sea plaice. Detailed STF table by age, assuming $F_{2012} = F_{2011}$, rescaled.

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.	discards.	stock.wt	mat	M	catch.n	catch	landings.	landings	discards.	discards	SSB	TSB
1	2012	0.17	0.17	0	922294	0.06	0.2	0.06	0.05	0	0.1	137058	7783	1100	220	135958	7568	0	44270
2	2012	0.319	0.3	0.02	1E+06	0.12	0.25	0.11	0.11	0.5	0.1	269524	32877	19322	4852	250202	28023	56835	113670
3	2012	0.235	0.14	0.1	462935	0.22	0.3	0.16	0.19	0.5	0.1	92440	20267	38804	11600	53636	8653	43207	86415
4	2012	0.249	0.07	0.18	386689	0.3	0.35	0.19	0.3	1	0.1	81178	24616	57425	20055	23753	4513	115105	115105
5	2012	0.199	0.03	0.17	252374	0.39	0.42	0.19	0.36	1	0.1	43432	16784	37593	15619	5839	1133	91612	91612
6	2012	0.144	0.02	0.13	253930	0.45	0.48	0.2	0.43	1	0.1	32477	14622	28504	13819	3973	801	109698	109698
7	2012	0.107	0.01	0.1	118979	0.52	0.54	0.21	0.45	1	0.1	11510	5977	10572	5758	938	194	53858	53858
8	2012	0.094	0.03	0.07	59212	0.48	0.58	0.22	0.51	1	0.1	5040	2415	3650	2121	1390	307	30277	30277
9	2012	0.046	0	0.05	90351	0.63	0.63	0	0.55	1	0.1	3856	2445	3856	2445	0	0	50085	50085
10	2012	0.046	0	0.05	63486	0.74	0.74	0	0.61	1	0.1	2709	2011	2709	2011	0	0	38665	38665
1	2013	0.17	0.17	0	922294	0.06	0.2	0.06	0.05	0	0.1	137058	7783	1100	220	135958	7568	0	44270
2	2013	0.319	0.3	0.02	704391	0.12	0.25	0.11	0.11	0.5	0.1	183720	22410	13171	3307	170549	19101	38741	77483
3	2013	0.235	0.14	0.1	679435	0.22	0.3	0.16	0.19	0.5	0.1	135671	29745	56951	17025	78719	12700	63414	126828
4	2013	0.249	0.07	0.18	331158	0.3	0.35	0.19	0.3	1	0.1	69520	21081	49179	17175	20342	3865	98575	98575
5	2013	0.199	0.03	0.17	272864	0.39	0.42	0.19	0.36	1	0.1	46958	18147	40646	16888	6313	1225	99050	99050
6	2013	0.144	0.02	0.13	187129	0.45	0.48	0.2	0.43	1	0.1	23933	10776	21006	10184	2928	590	80840	80840
7	2013	0.107	0.01	0.1	198922	0.52	0.54	0.21	0.45	1	0.1	19243	9992	17675	9627	1568	325	90045	90045
8	2013	0.094	0.03	0.07	96722	0.48	0.58	0.22	0.51	1	0.1	8233	3945	5962	3465	2270	501	49457	49457
9	2013	0.046	0	0.05	48789	0.63	0.63	0	0.55	1	0.1	2082	1320	2082	1320	0	0	27045	27045
10	2013	0.046	0	0.05	132957	0.74	0.74	0	0.61	1	0.1	5674	4213	5674	4213	0	0	80975	80975
1	2014	0.17	0.17	0	922294	0.06	0.2	0.06	0.05	0	0.1	137058	7783	1100	220	135958	7568	0	44270
2	2014	0.319	0.3	0.02	704391	0.12	0.25	0.11	0.11	0.5	0.1	183720	22410	13171	3307	170549	19101	38741	77483
3	2014	0.235	0.14	0.1	463135	0.22	0.3	0.16	0.19	0.5	0.1	92480	20275	38821	11605	53659	8657	43226	86452
4	2014	0.249	0.07	0.18	486030	0.3	0.35	0.19	0.3	1	0.1	102033	30940	72178	25207	29855	5672	144675	144675
5	2014	0.199	0.03	0.17	233679	0.39	0.42	0.19	0.36	1	0.1	40215	15541	34809	14462	5406	1049	84825	84825
6	2014	0.144	0.02	0.13	202322	0.45	0.48	0.2	0.43	1	0.1	25877	11650	22711	11011	3165	638	87403	87403
7	2014	0.107	0.01	0.1	146592	0.52	0.54	0.21	0.45	1	0.1	14181	7364	13025	7095	1156	239	66357	66357
8	2014	0.094	0.03	0.07	161711	0.48	0.58	0.22	0.51	1	0.1	13764	6596	9968	5793	3796	838	82688	82688
9	2014	0.046	0	0.05	79696	0.63	0.63	0	0.55	1	0.1	3401	2156	3401	2156	0	0	44178	44178
10	2014	0.046	0	0.05	157078	0.74	0.74	0	0.61	1	0.1	6704	4977	6704	4977	0	0	95666	95666

Table 8.6.3B. North Sea plaice. Detailed STF table by age, forecast assuming a F for 2012 such that the landings in 2012 equal the TAC for 2012

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M	catch.n	catch	landings.n	landings	discards.n	discards	SSB	TSB
1	2012	0.184	0.18	0	922294	0.06	0.2	0.06	0.05	0	0.1	147521	8377	1184	237	146337	8146	0	44270
2	2012	0.346	0.32	0.02	1033366	0.12	0.25	0.11	0.11	0.5	0.1	288471	35188	20681	5193	267790	29993	56835	113670
3	2012	0.255	0.15	0.11	462935	0.22	0.3	0.16	0.19	0.5	0.1	99248	21759	41662	12454	57586	9291	43207	86415
4	2012	0.269	0.08	0.19	386689	0.3	0.35	0.19	0.3	1	0.1	87112	26416	61623	21521	25489	4843	115105	115105
5	2012	0.216	0.03	0.19	252374	0.39	0.42	0.19	0.36	1	0.1	46695	18045	40417	16793	6277	1218	91612	91612
6	2012	0.156	0.02	0.14	253930	0.45	0.48	0.2	0.43	1	0.1	34991	15754	30711	14889	4280	863	109698	109698
7	2012	0.116	0.01	0.11	118979	0.52	0.54	0.21	0.45	1	0.1	12419	6449	11407	6213	1012	210	53858	53858
8	2012	0.101	0.03	0.07	59212	0.48	0.58	0.22	0.51	1	0.1	5441	2607	3940	2290	1500	331	30277	30277
9	2012	0.05	0	0.05	90351	0.63	0.63	0	0.55	1	0.1	4171	2644	4171	2644	0	0	50085	50085
10	2012	0.05	0	0.05	63486	0.74	0.74	0	0.61	1	0.1	2931	2176	2931	2176	0	0	38665	38665
1	2013	0.17	0.17	0	922294	0.06	0.2	0.06	0.05	0	0.1	137058	7783	1100	220	135958	7568	0	44270
2	2013	0.319	0.3	0.02	694472	0.12	0.25	0.11	0.11	0.5	0.1	181133	22095	12986	3261	168148	18833	38196	76392
3	2013	0.235	0.14	0.1	661528	0.22	0.3	0.16	0.19	0.5	0.1	132095	28961	55450	16576	76645	12365	61743	123485
4	2013	0.249	0.07	0.18	324712	0.3	0.35	0.19	0.3	1	0.1	68167	20671	48221	16841	19946	3790	96656	96656
5	2013	0.199	0.03	0.17	267247	0.39	0.42	0.19	0.36	1	0.1	45992	17773	39809	16540	6183	1199	97011	97011
6	2013	0.144	0.02	0.13	184038	0.45	0.48	0.2	0.43	1	0.1	23538	10598	20659	10016	2879	581	79505	79505
7	2013	0.107	0.01	0.1	196538	0.52	0.54	0.21	0.45	1	0.1	19013	9873	17463	9512	1550	321	88966	88966
8	2013	0.094	0.03	0.07	95860	0.48	0.58	0.22	0.51	1	0.1	8159	3910	5909	3434	2250	497	49016	49016
9	2013	0.046	0	0.05	48408	0.63	0.63	0	0.55	1	0.1	2066	1310	2066	1310	0	0	26834	26834
10	2013	0.046	0	0.05	132448	0.74	0.74	0	0.61	1	0.1	5653	4196	5653	4196	0	0	80665	80665
1	2014	0.17	0.17	0	922294	0.06	0.2	0.06	0.05	0	0.1	137058	7783	1100	220	135958	7568	0	44270
2	2014	0.319	0.3	0.02	704391	0.12	0.25	0.11	0.11	0.5	0.1	183720	22410	13171	3307	170549	19101	38741	77483
3	2014	0.235	0.14	0.1	456614	0.22	0.3	0.16	0.19	0.5	0.1	91177	19990	38274	11442	52903	8535	42617	85235
4	2014	0.249	0.07	0.18	473220	0.3	0.35	0.19	0.3	1	0.1	99344	30125	70275	24543	29068	5523	140862	140862
5	2014	0.199	0.03	0.17	229130	0.39	0.42	0.19	0.36	1	0.1	39432	15238	34131	14181	5301	1028	83174	83174
6	2014	0.144	0.02	0.13	198157	0.45	0.48	0.2	0.43	1	0.1	25344	11411	22244	10784	3100	625	85604	85604
7	2014	0.107	0.01	0.1	144171	0.52	0.54	0.21	0.45	1	0.1	13947	7242	12810	6978	1137	235	65261	65261
8	2014	0.094	0.03	0.07	159773	0.48	0.58	0.22	0.51	1	0.1	13599	6517	9849	5724	3750	828	81697	81697
9	2014	0.046	0	0.05	78986	0.63	0.63	0	0.55	1	0.1	3371	2137	3371	2137	0	0	43784	43784
10	2014	0.046	0	0.05	156309	0.74	0.74	0	0.61	1	0.1	6671	4953	6671	4953	0	0	95197	95197

Table 8.6.4. North Sea plaice. Yield and spawning biomass per recruit reference points following 2012 assessment.

	Fish Mort	Yield/R	SSB/R
	Ages 2-6		
Average last 3 years	0.22	0.10	1.01
Fmax	0.19	0.10	1.19
F0.1	0.14	0.09	1.62

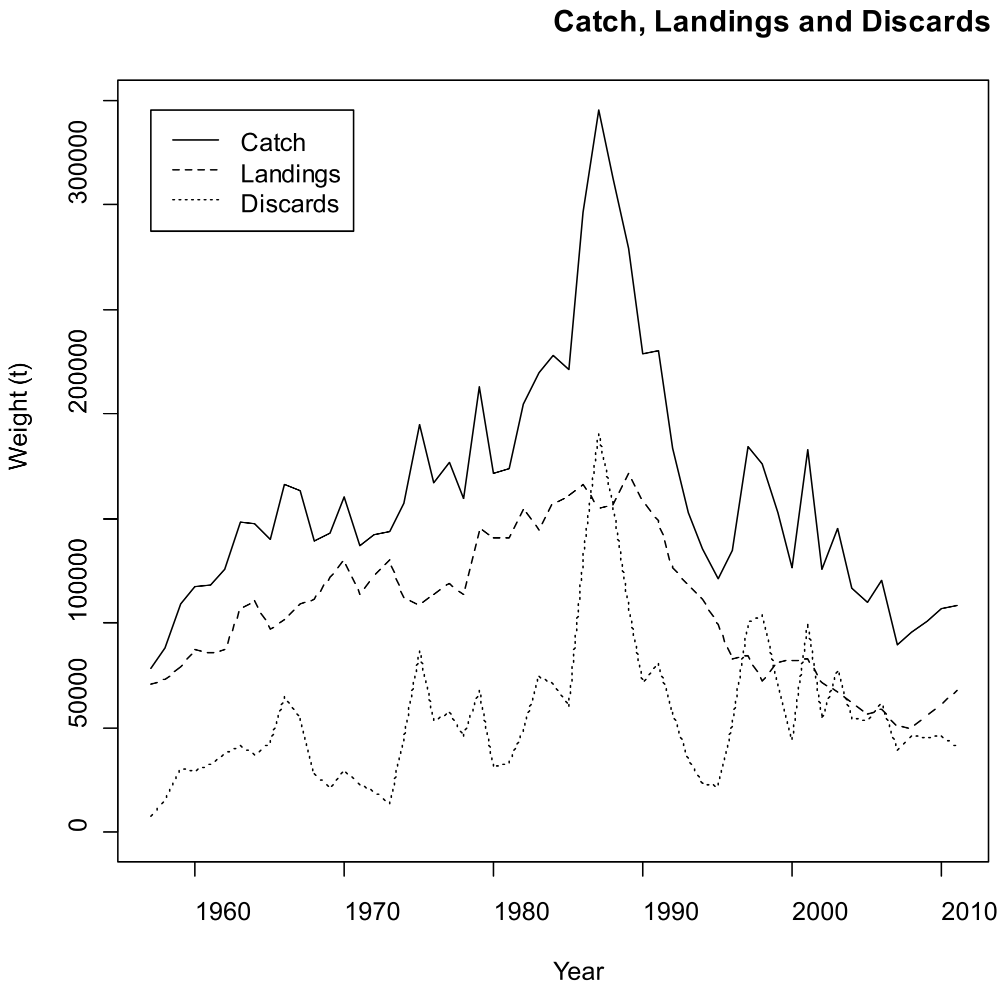


Figure 8.2.1 North Sea plaice. Time series of catch (solid line), landings (dashed line) and discards (dotted line) estimates.

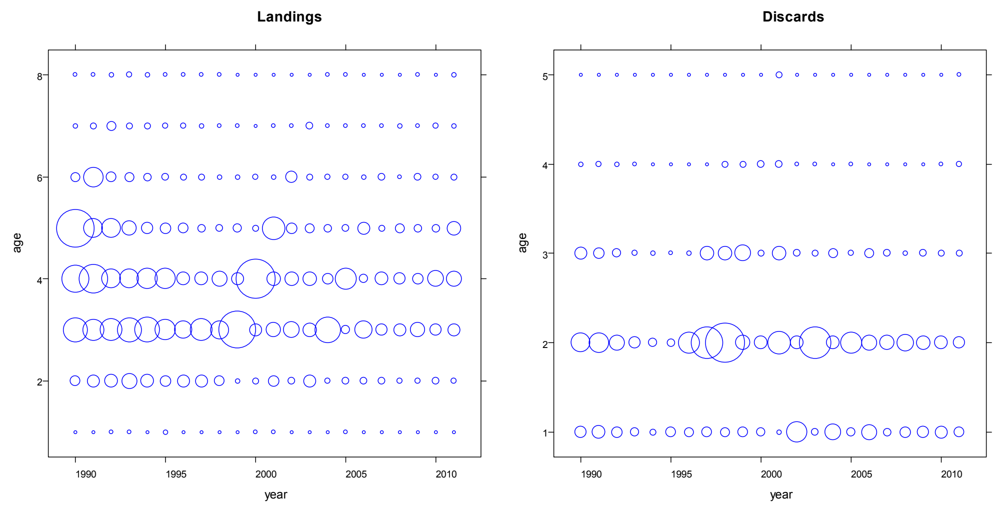


Figure 8.2.2 North Sea plaice. Landing numbers-at-age (left) and discards numbers-at-age (right).

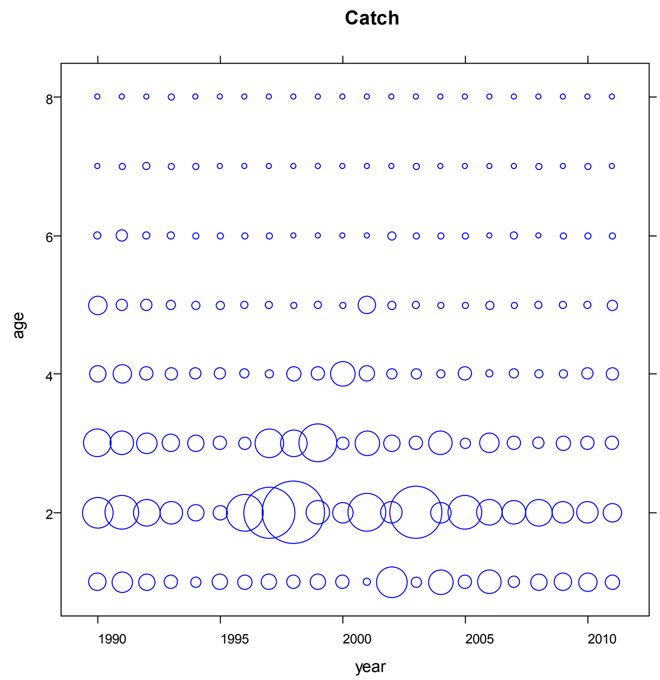


Figure 8.2.3 North Sea plaice. Catch numbers-at-age.

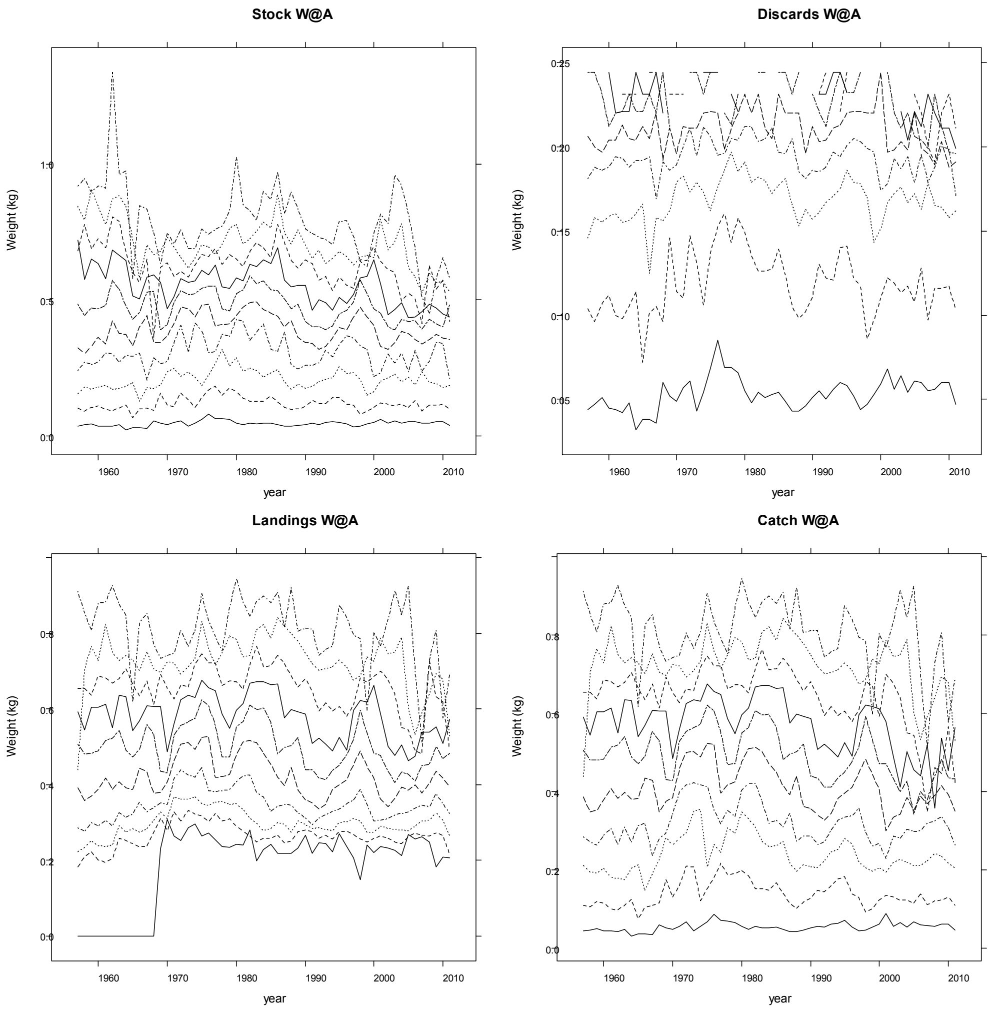


Figure 8.2.4 North Sea plaice. Stock weight-at-age (top left), discards weight-at-age (top right), landings weight-at-age (bottom left) and catch weight-at-age (bottom right)..

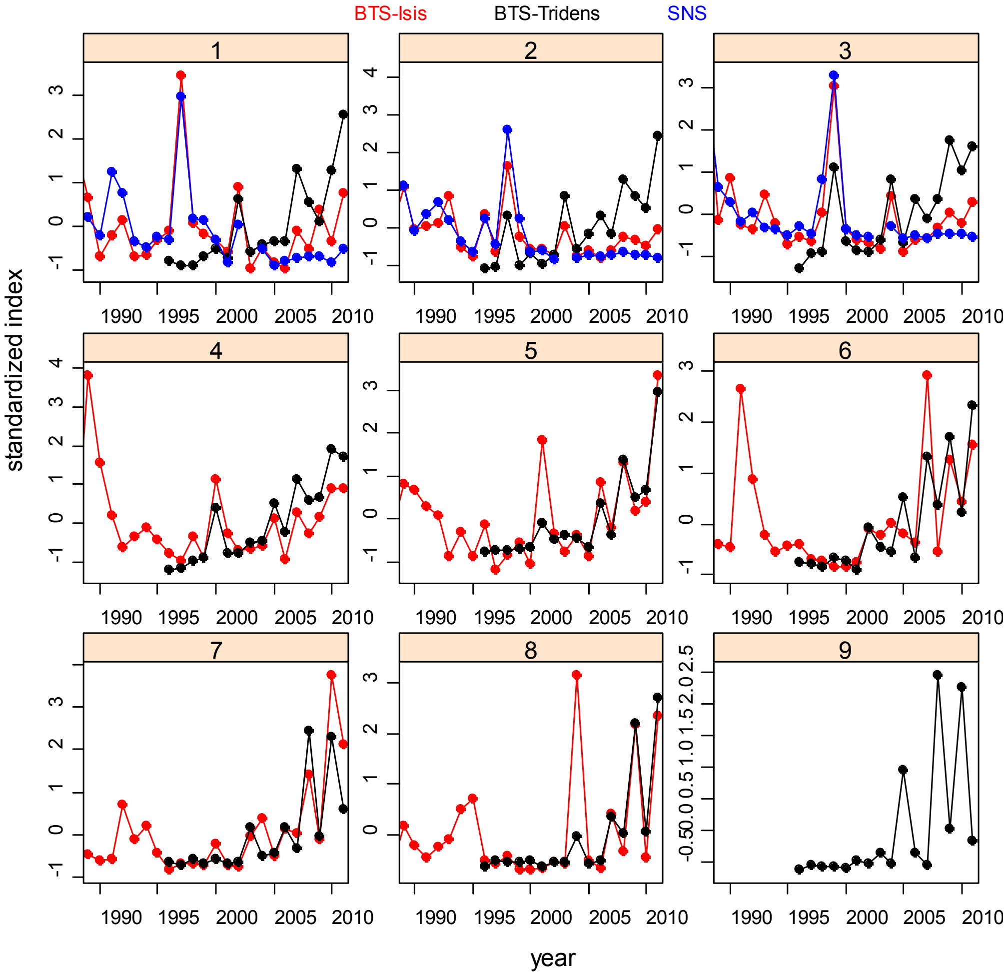


Figure 8.2.5 North Sea plaice. Standardized survey tuning indices used for tuning XSA: BTS-Isis (red), BTS-Tridens (black) and SNS (blue). Note: only ages used in the assessment are presented.

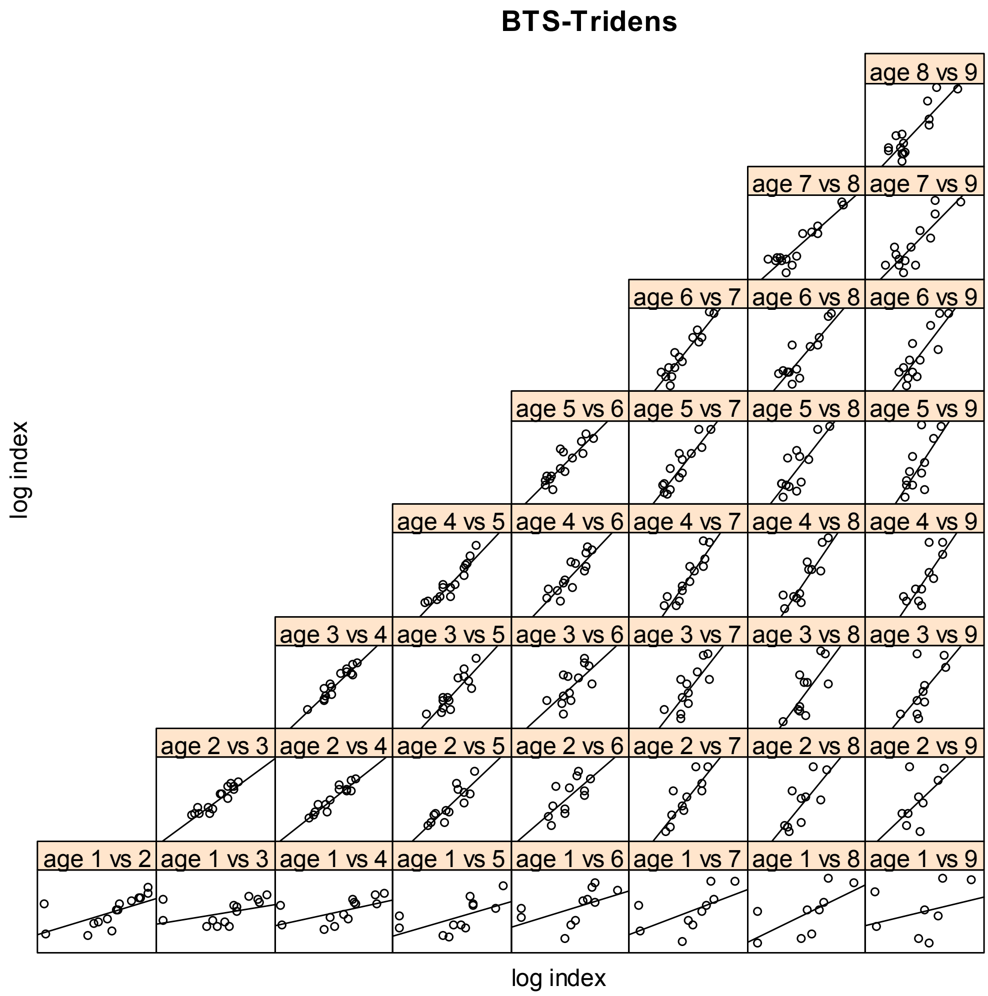


Figure 8.2.6 North Sea plaice. Internal consistency plot for the BTS-Tridens survey.

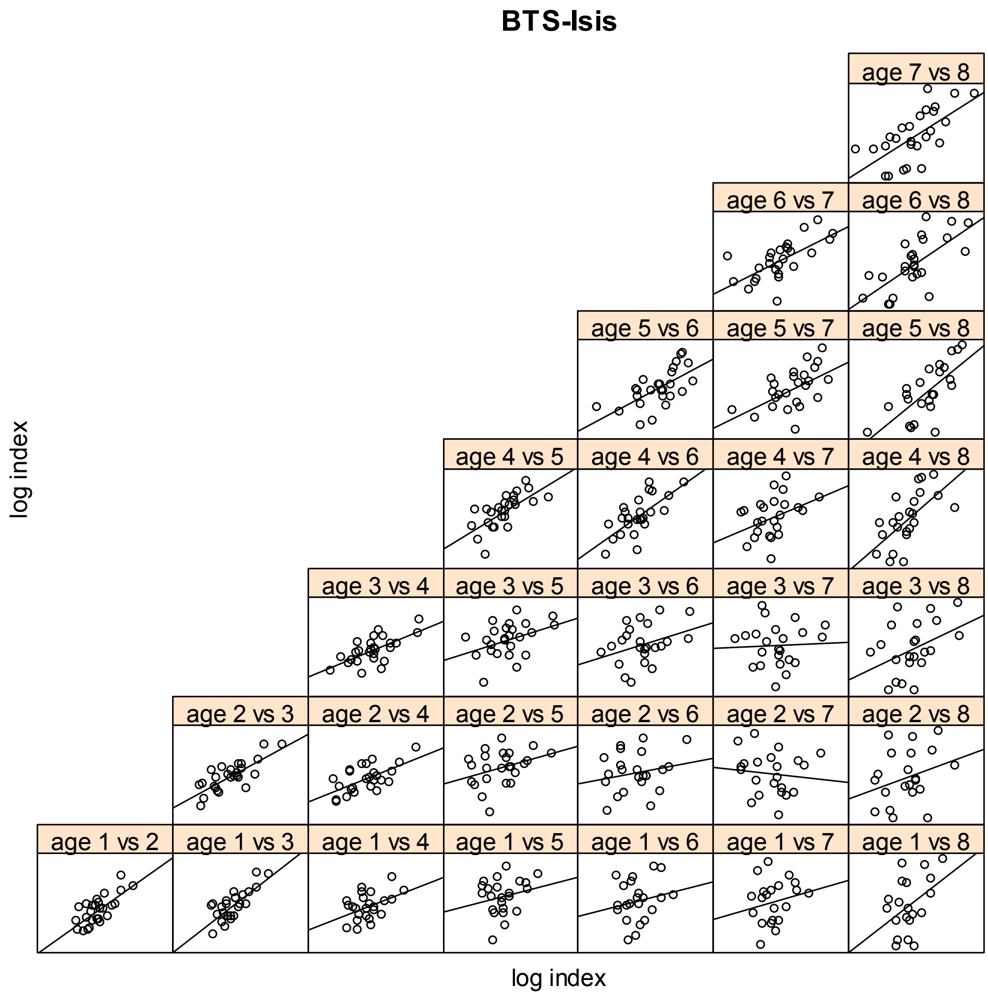


Figure 8.2.7. North Sea plaice. Internal consistency plot for the BTS-Isis survey.

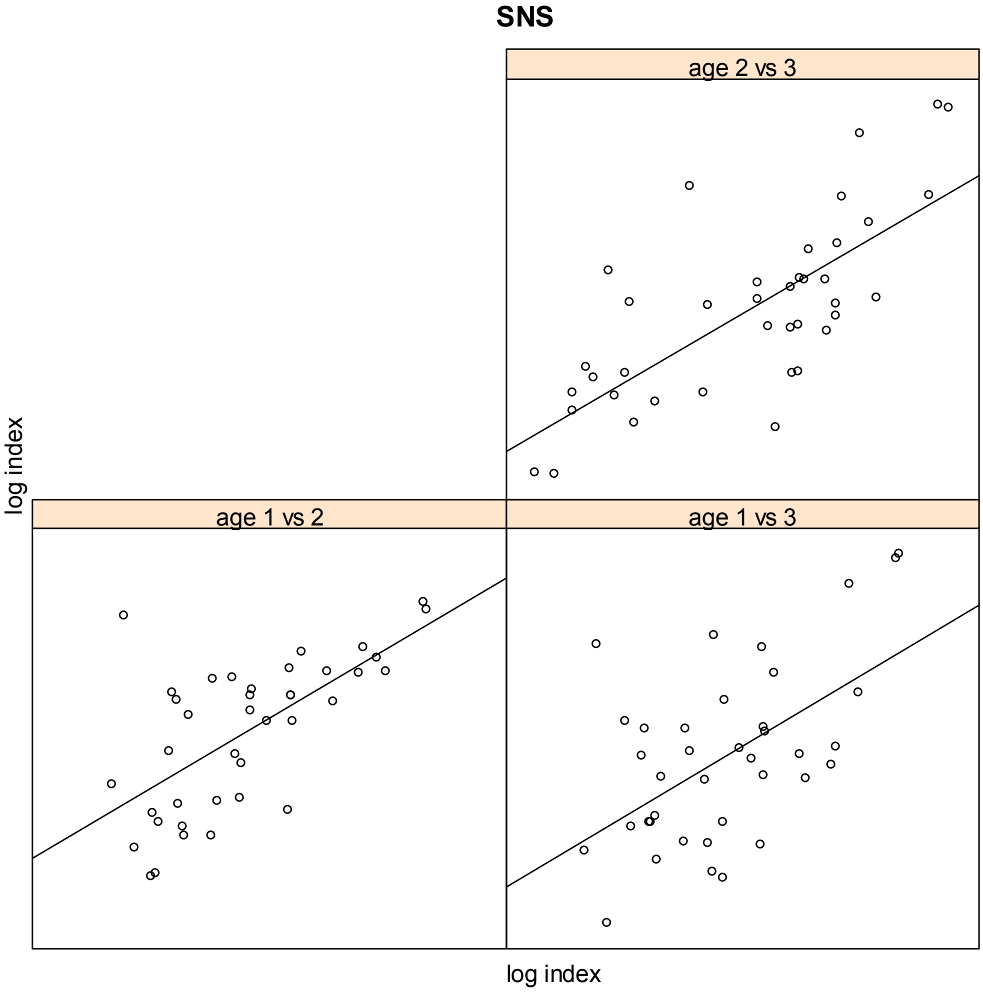


Figure 8.2.8. North Sea plaice. Internal consistency plot for the SNS survey.

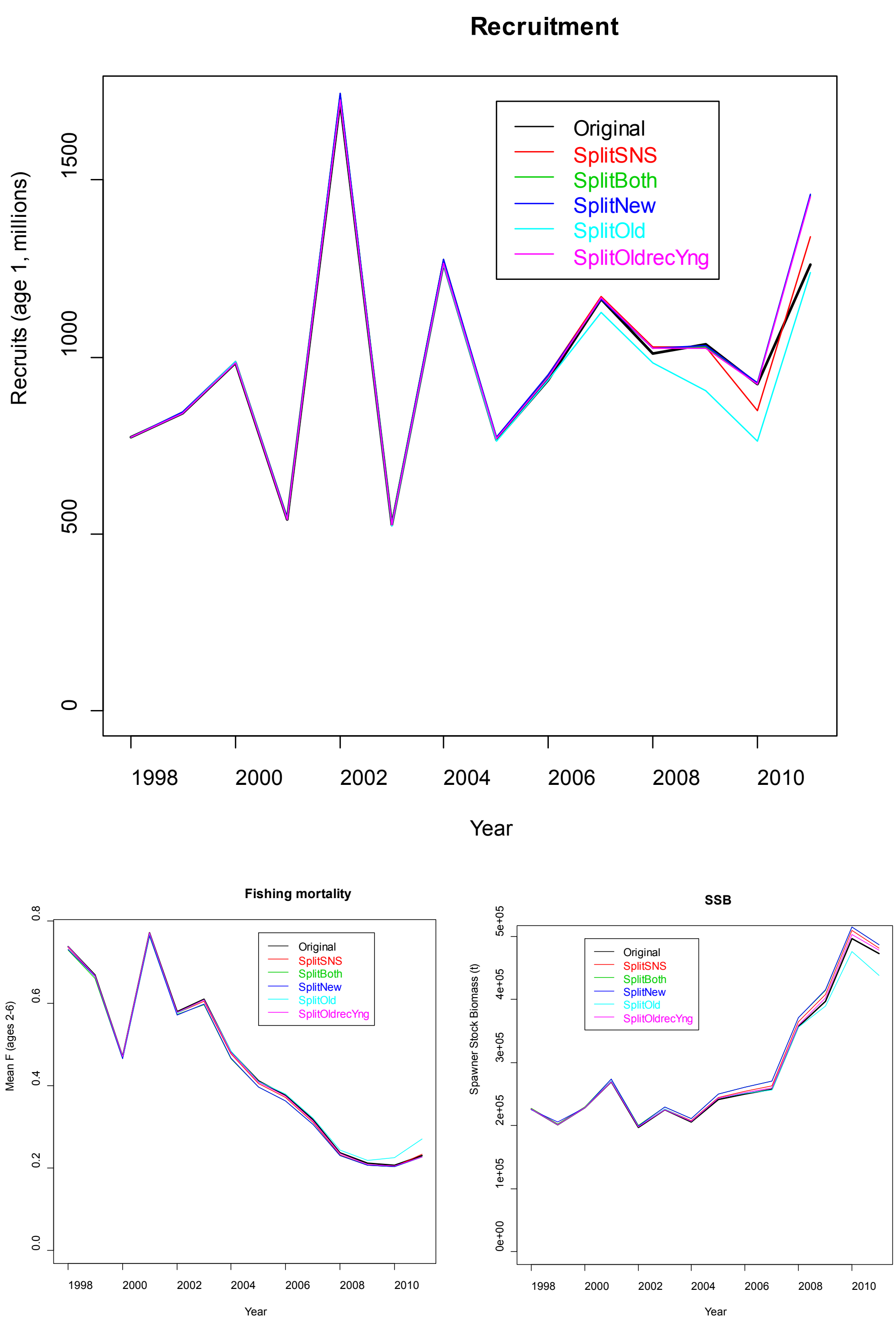


Figure 8.3.1. North Sea plaice. Sensitivity of the assessment with respect to assumptions on catchability of indices over time (by splitting the SNS and/or BTS Tridens indices at the year 200 – see text for details). XSA results with respect to recruitment (top), F (bottom left) and SSB (bottom right) estimates. Note: some lines may be hidden due to near identical outputs.

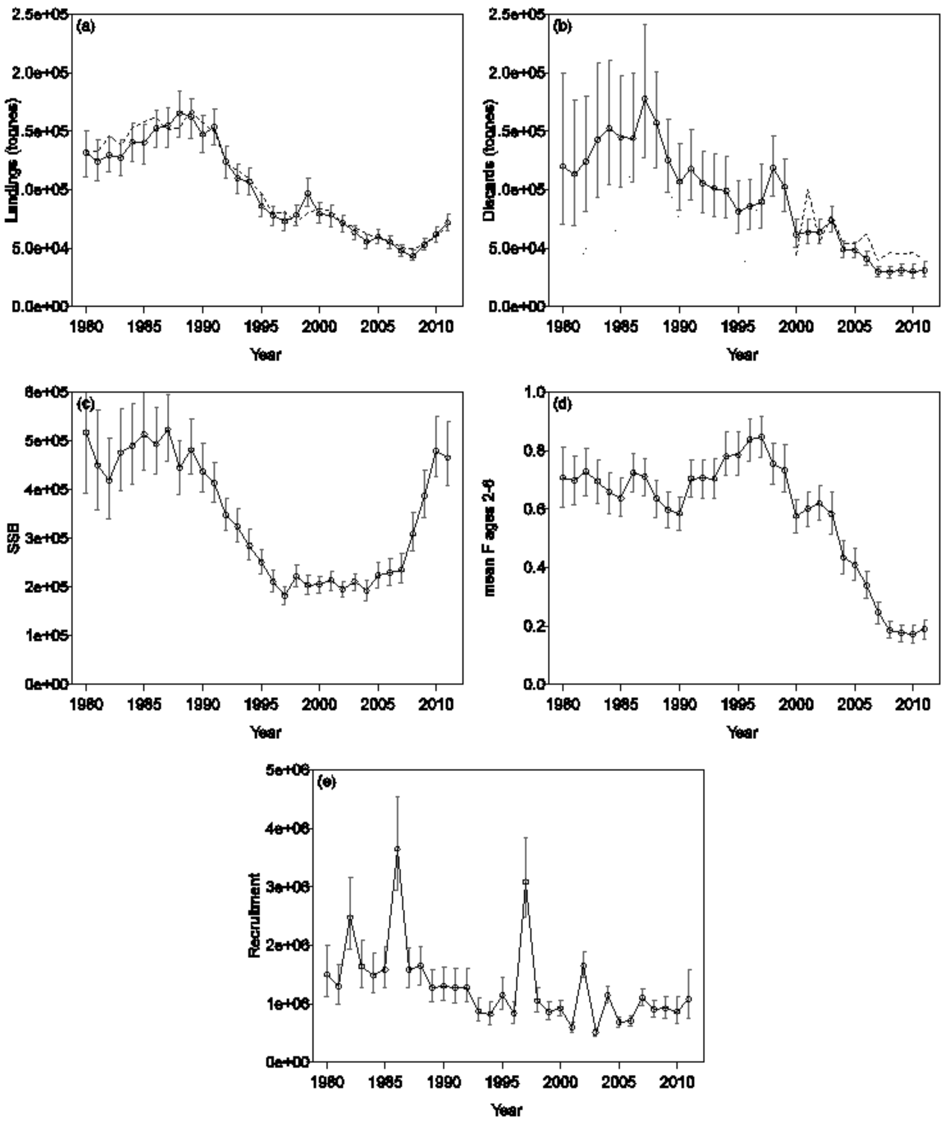


Figure 8.3.2 North Sea plaice. SCA (see Aarts & Poos 2009) assessment results: (a) Estimated Landings, (b) Discard estimates, (c) SSB, (d) Mean F (ages 2-6), and (e) Recruitment. Horizontal bars indicate 95% confidence levels.

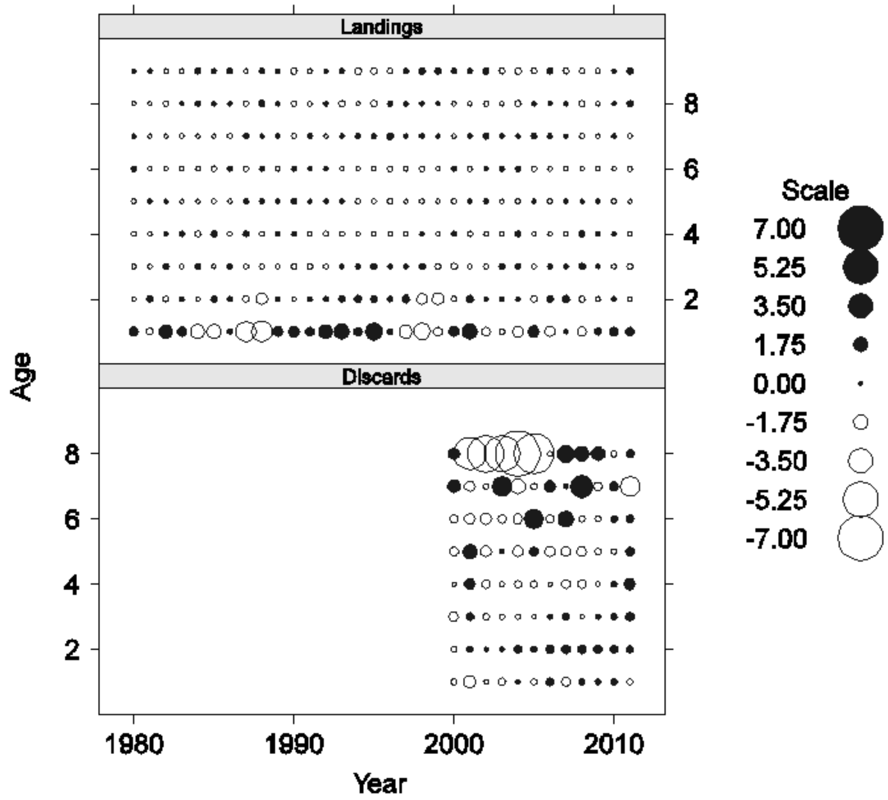


Figure 8.3.3. North Sea plaice. Log catchability residuals for the landings and discard estimates from the SCA model (Aarts and Poos 2009).

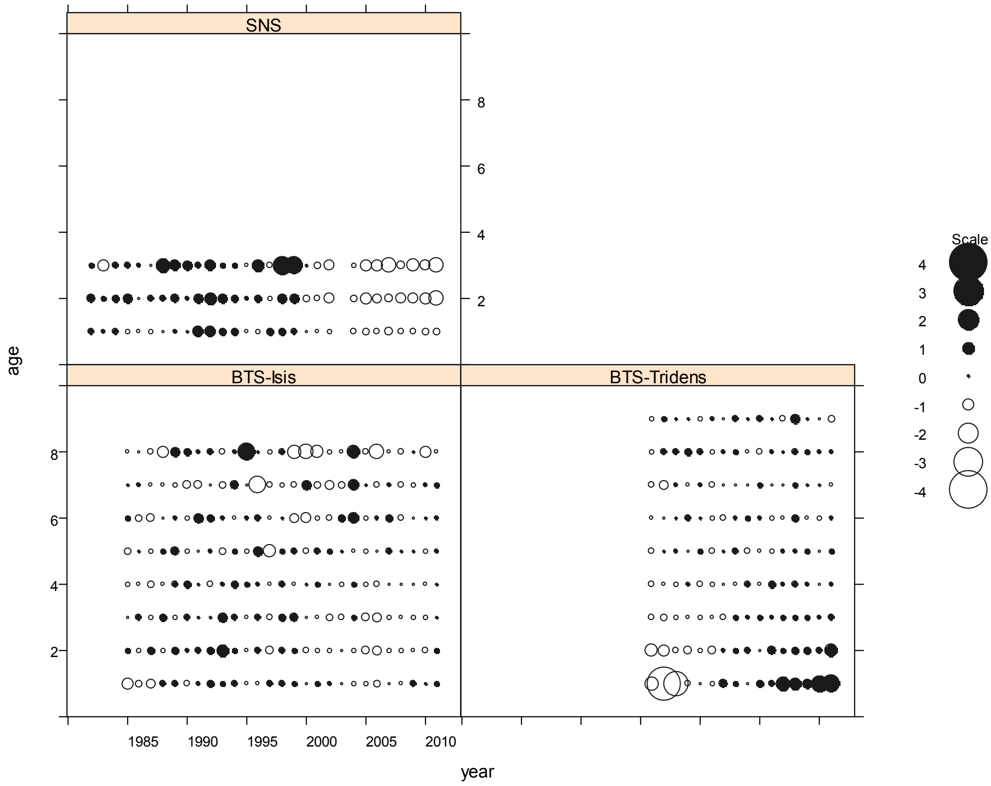


Figure 8.3.4. North Sea plaice. Log catchability residuals for the final XSA run from the three tuning series.

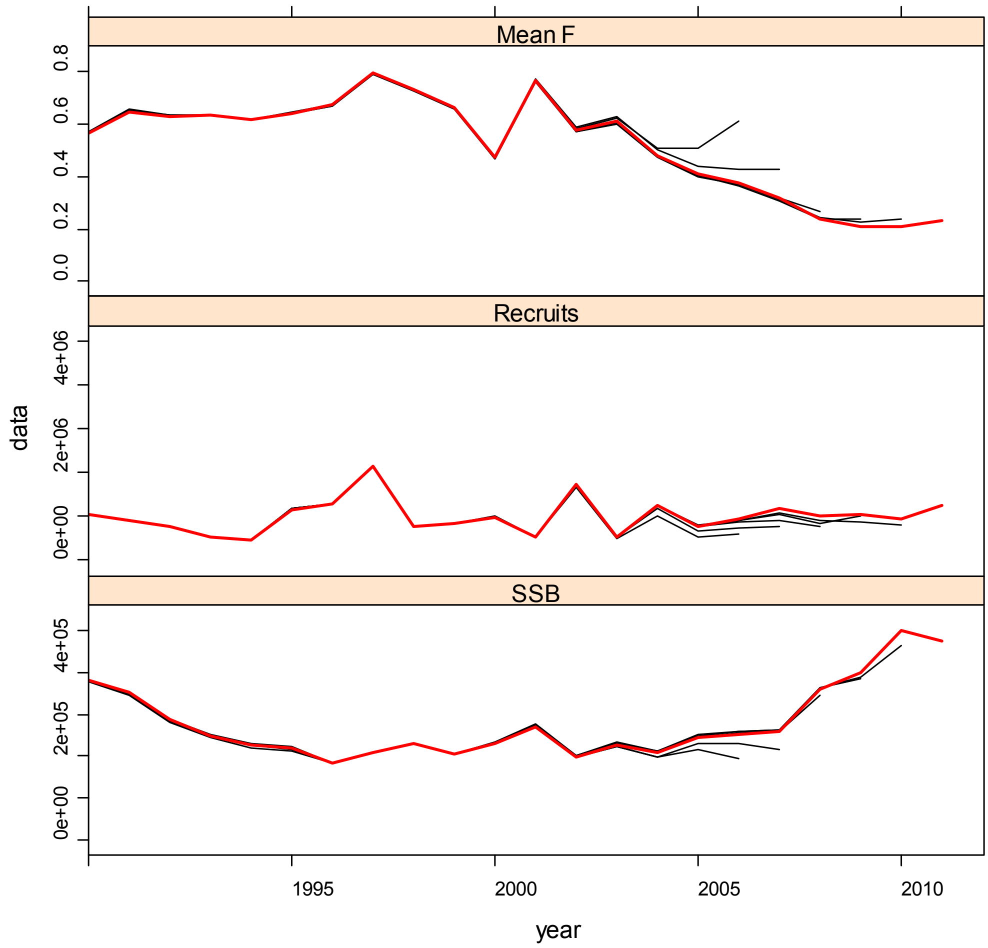


Figure 8.3.5. North Sea plaice. Retrospective pattern of the final XSA run with respect to SSB, recruitment and F.

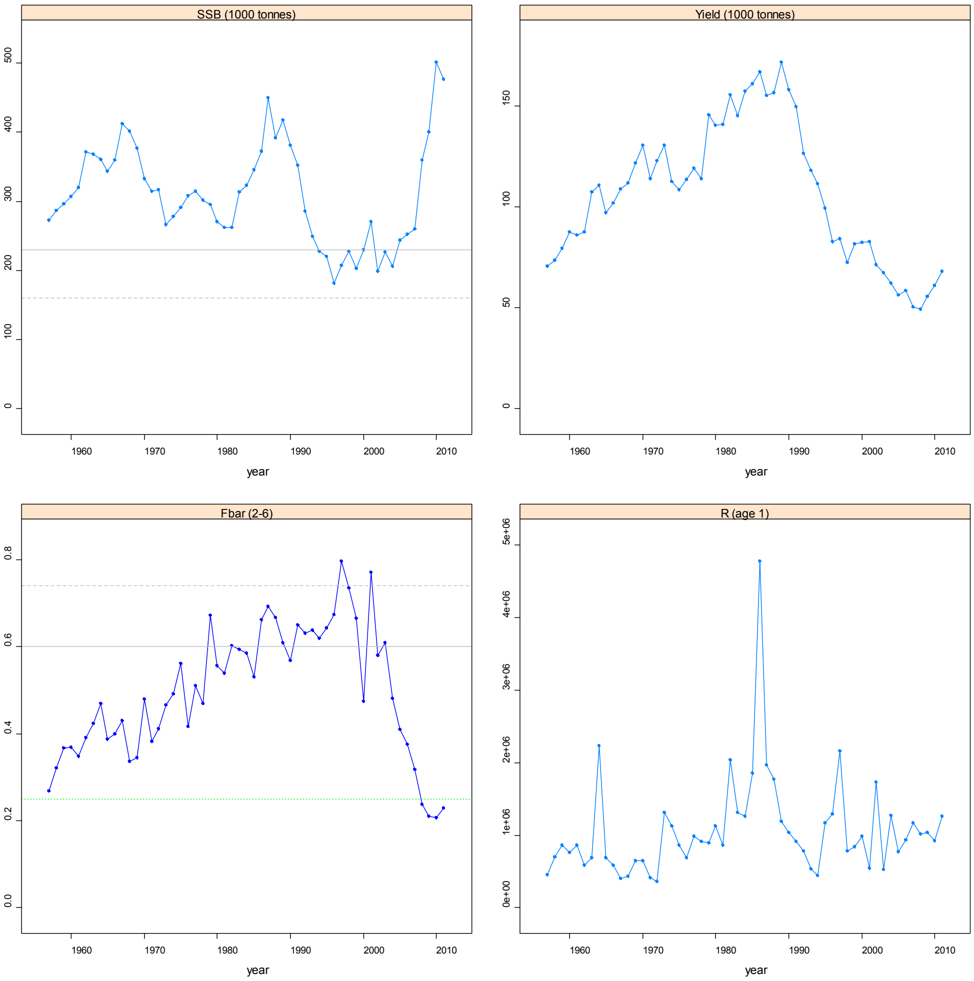


Figure 8.4.1. North Sea plaice. Stock summary figure, time series on SSB (drawn line indicates B_{pa}, dashed line indicates B_{lim}), Yield, Fishing mortality (drawn grey line indicates F_{pa}, dashed grey line indicates F_{lim}, green dashed line indicates MP target F), and recruitment at age 1.

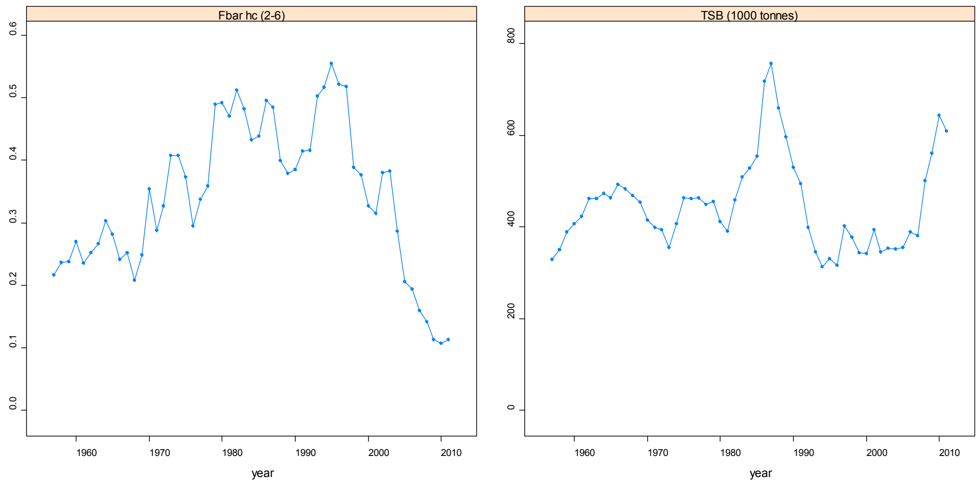


Figure 8.4.2. North Sea plaice. Stock summary figure. Time series on human consumption (left) fishing mortality and total stock biomass (right)

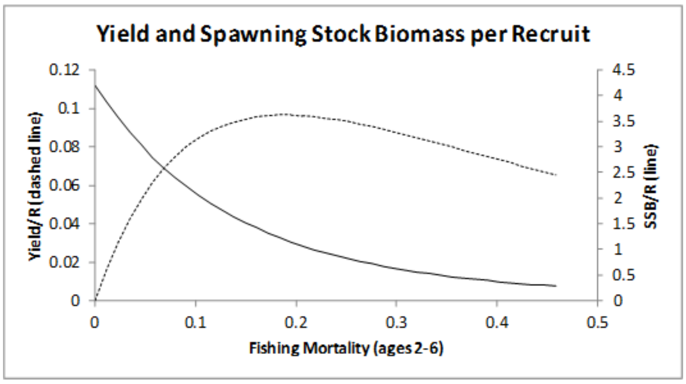


Figure 8.6.1 North Sea plaice. Yield and SSB per recruit following the latest assessment of the stock.

9 Sole in Subarea VIId

The assessment of sole in subarea 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 2012.

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.

Apart for 2010, the TAC was not restrictive for France, Belgium nor UK since 1997.

9.1.3 ICES advice

In 2011 the stock status was presented as follows:

Fishing mortality	2007	2008	2009
F_{MSY}	Above	Above	Above
F_{PA}/F_{lim}	Between	Between	Between
Spawning Stock Biomass (SSB)	2008	2009	2010
MSY $B_{trigger}$	Above	Above	Above
B_{PA}/B_{lim}	Above	Above	Above

In 2011 the ICES advice was as follows:

MSY approach

Following the ICES MSY framework implies fishing mortality to be reduced to 0.29 resulting in landings of less than 3690 t in 2011. This is expected to lead to a record high SSB of 14 200 t in 2012

*Following the transition scheme towards the ICES MSY framework implies that (0.8*F(2010) + 0.2*Fmsy) is 0.44, which is above Fpa.Therefore, fishing mortality should be reduced to 0.4 (= Fpa), resulting in landings of less than 4840 t in 2011. This is expected to lead to an SSB of 12 900 t in 2012.*

PA approach

The fishing mortality in 2011 should be no more than Fpa corresponding to landings of less than 4840 t in 2011. This is expected to keep SSB above Bpa in 2012.

In 2012 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

In 2012 the ICES advice 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.

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 2011 and 2012 are 4852t and 5580t 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 permitted to catch sole are 80mm for beam trawling and 80mm 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.

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. 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 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. (see section 1.2.1 for complete list).

9.2 Data available

9.2.1 Catch

Belgian and UK landings submitted to the Working Group for 2010 were both revised upward by 1% to 1308t and 677t respectively. The 2010 values for the numbers at age were therefore also updated. Total landings for 2010 now amount to 4409t instead of 4391t

The 2011 landings used by the Working Group were 4133t (Table 9.2.1) which is 15% below the agreed TAC of 4852t and 29% below the predicted landings at a status quo fishing mortality in 2011 (5839t). The advice for 2012 was based on a TAC constrain for 2011.The contribution of France, Belgium and the UK to the landings in 2011 is 53%, 30% and 17% 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 return rates of 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 and 2011 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 13% 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 and France have provided data this year under the ICES InterCatch format on a metier basis. Allocation has been made according the agreed scheme by the Working group, e.g. allocation first by quarter and metier, then over quarters by metier and finally over quarters over all metiers. The only deviation was that the French metier DRB_all_0_0_all was allocated only age distributions from active gear (beam and otter trawl) by quarter.

9.2.2 Age compositions

Quarterly data for 2011 were available for landing numbers and weight at age, for the French, Belgian, and UK fleets. These comprise 100% of the international landings. The annual age compositions of the landings are presented in Table 9.2.2. The quarterly age composition (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 weight at age in the stock in Table 9.2.5. 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 are assumed at fixed values (0.1) for all ages in time.

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 9.2.1a-c. Revisions have been made to the UK effort and LPUE series for 2010. 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 four 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 are predominantly fishing in the most favourable area which is subdivision VIId at the moment. 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 2011 is the second lowest value of the time series.

Information has been provided on effort and LPUE from the recent period of 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 2009-2011 were 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 and 2011, before the next working group. It appears that for the 3 main French fleets (Gill/trammel nets, Otter trawls and Beam trawls), effort further went down in the last years.

Belgian and UK beam trawl LPUE have been fluctuating around the mean with no strong trend until catch rates have been increasing up to 2005. Since then the UK beam trawl has decreased to the levels of the early 2000s. After a small decline since 2005, the Belgian beam trawl LPUE reached again 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 2010 for the UK beam trawl series was 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 number corrections, the RG did not report any major deficiencies for the sole assessment in the Eastern English Channel. It was however noted that the status quo forecast assumed a 20% TAC overshoot which was unlikely to be the case taking into account the available information of the last 13 year. In the ADGNS it was decided that a TAC constraint in 2011 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 2011 (TAC2011=4852t; Landings2011= 4133t).

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 (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 9.2.2. 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 component. Internal consistency plots for the 2 commercial fleets and the UK beam trawl survey are presented in Figure 9.2.3-5. The internal consistency of the Belgian beam trawl fleet appears 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 9.3.1a-b and the XSA tuning diagnostics are given in Table 9.3.1.

In general, estimates between fleets are consistent for all ages (Figure 9.3.2), apart from the estimates from the FR-YFS for ages 2, 3, 4, 5 and 10. In this year's assessment the estimates for the recruiting year class 2010 were estimated by the UK beam trawl survey and the French component of the Young Fish Survey which have both an equal weighting of about 50% to the final survivor estimates. It should be noted that both surveys, (UK(E&W)-BTS) and (FR-YFS) are estimating this year class with similar strength to be above average (see also section 9.4).

At age 2, the 2009 year-class is predominantly estimated by the commercial UK beam trawl fleet and UK beam trawl survey, with a weighting of 41% and 40% respectively. Both tuning fleets estimating the survivors of that year class rather similar (44707 and 35350). The Belgian commercial beam trawl fleet estimating this year class at around the same strength (37860) with a weighting of 10%. The French component of the Young Fish Survey estimates this year class to be very weak (8666) but only accounts for 7% of the final survivor estimate (see also section 9.4).

F shrinkage gets low weights for all ages (< 2%). The weighting of the 3 surveys decreases for the older ages as the commercial fleets are given more weight (Figure 9.3.2).

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 similar estimated by 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 similar 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 2010) is an above average value for the time series. (Table 9.3.1 and Table 9.3.4). As both surveys (UK-BTS and FR-YFS) estimate the 2010 year class rather similar as above average, the Working Group decided that the final XSA survivor estimate of 39385 fish at age 1 could be accepted for any forecasts.

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:

	2012 assessment		
Fleets	Years	Ages	α-β
BE-CBT commercial	86-11	2-10	0-1
UK(E&W)-CBT commercial	86-11	2-10	0-1
UK(E&W)-BTS survey	88-11	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	87-11	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 9.3.3. The high fishing mortality at age 4 in 2010 (0.80) and age 5 (0.79) was investigated in depth for possible errors in raw data or raising procedures. No errors were found.

Retrospective patterns for the final run are shown in Figure 9.3.4. There is good consistency between estimates in successive years. However, the retrospective show a massive downward revision of the 2008 year class (age 1 in 2009). 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. The strength of the 2008 year class is estimated in this year's assessment to be 39186 fish at age 1. The 2009 year class has been revised upward by 173%.

Fishing mortality for 2010 has been revised upward by 7% SSB downward by 9% respectively.

9.4 Historical Stock Trends

Trends in landings, SSB, F(3-8) and recruitment are presented Table 9.3.4 and Figure 9.3.3.

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 6 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 10 years.

The spawning stock biomass has been stable for most of the time series. Since 2001 SSB has increased due to average and above average year classes to well above B_{pa} (8000 t).

9.5 Recruitment estimates

The 2009 year class in 2010 was estimated to be around 49 million fish at age 1, which is above average and 72% higher 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 2010 year class in 2011 was estimated by XSA to be 44 million one year olds which is above average.

As both surveys (UK-BTS and FR-YFS) estimate the 2010 year class as above average, the Working Group decided that the XSA survivor estimate for this year class was used for further prediction.

The long term GM recruitment (24 million, 1982-2009) was assumed for the 2011 and subsequent year classes.

RCT3 runs, including the French Young fish survey-index for age 0 (not included in the XSA) have been conducted for comparison with XSA results. The input is presented in Table 9.5.1 and the results in Tables 9.5.2a and b.

Although the RCT3 results for the 2011 year class are not used for prediction, it should be noted that the French Young fish survey (FR-YFS) at age 0 indicates an above average 2010 year class.

The working group estimates of year class strength used for prediction can be summarised as follows:

Year class	At age in 2012	**XSA**	**GM 82-09**	**RCT3**	Accepted Estimate
2009	3	<u>35375</u>	15718	-	XSA
2010	2	<u>39395</u>	20727	23886*	XSA
2011	1	-	<u>23798</u>	24847	GM 1982-09
2012 & 2013	recruits	-	<u>23798</u>	-	GM 1982-09

* 26398 reduced with fishing mortality and natural mortality

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 2009-2011.

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 13 years. This year's *status quo* assumption for 2012 again resulted in a much higher landings (6670t) than the agreed TAC of 5580t (Table 9.6.2a). The working group therefore decided to use a TAC constrain for the intermediate year 2012. The Results are presented in Table 9.6.2b (management options) and Table 9.6.3 (detailed output).

Assuming a TAC constrain for 2012 of 5580t, implies a fishing mortality in 2012 of 0.38. The assumed catch using a status quo fishing mortality in 2013 is 7210t. The corresponding SSB's in 2013 and 2014 are 17400t and 14600t respectively.

Assuming a TAC constrain for 2012 and a status quo F in 2013, the proportional contributions of recent year classes to the landings in 2013 and SSB in 2014 are given in Table 9.6.4. The assumed GM recruitment accounts for 7 % of the landings in 2013 and 21 % of the 2014 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 2013 are 4500t and 9500t. There is less then 5% probability that at current fishing mortality SSB will fall below the B_{pa} of 8000t in 2014.

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 TAC constrain in 2012, 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 (0.48 = $F_{sq,}$; 0.38 = $F_{TAC2012}$).

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	0.48	
$F_{TAC\ constain}$	0.38	

9.9 Quality of the assessment

- Revisions in 2010 landings for Belgium and UK (E&W) together with the income of 2 commercial tuning series to estimate the 2009 year class (see section 9.2.5) resulted in an upward revision of fishing mortality in 2010 by 7% and a downward revision of SSB by 9%. The XSA recruitment estimate in 2010 was revised upward by 173% mainly due to the availability in this year's assessment of survivor estimates of two commercial fleets.
- The trends and estimates of fishing mortality, SSB and recruitment were consistent with last year's assessment apart from the upward revision of the 2009 year class (see above).
- Except year classes 2002, 2003, 2006 and 2007, all year classes from 1998 are estimated to be at or above long term average which explains the increase in SSB since 1998.
- Information available on discards suggest 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 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.
- 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 op recruitment have been adjusted by several assessments in the past e.g. where adjustment were made of the XSA recruitment by RCT3 estimates in the 2010 assessment.
- There has been misreporting from adjacent areas. The Working group has addressed this by modifying landings data accordingly. Since 2002 the UK(E&W) beam trawl landings from two rectangles 28E8 and 29E8 (in VIId) were reallocated 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 done 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 rec-

tangles 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 F_{pa}. In the last 5 years fishing mortality has increased to values between F_{pa} (0.4) and F_{lim} (0.57).

The spawning stock biomass has been stable for most of the time series and SSB is presently well above B_{pa}. The strong 2004 and 2005 year class increased SSB to around record high level of the time series in 2008. The strong 2008, 2009 and 2010 year classes could even increase SSB in the future.

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, 2009 and 2010 year classes.
- EU Council Regulation (EC) N°43/2012 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 in 2012.
- 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

* Unallocated mainly due to misreporting

** Preliminary

Table 9.2.2 - Sole VIId - Landing numbers at age (kg)

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
1	155	0	24	49	49	9	95	163	1245	383
2	2625	852	1977	3693	1251	3117	2162	3484	2851	7166
3	5256	3452	3157	5211	5296	3730	7174	3220	5580	4105
4	1727	3930	2610	1646	3195	3271	1602	4399	1151	4160
5	570	897	1900	1027	904	2053	1159	1434	1496	604
6	653	735	742	1860	768	1042	856	840	301	996
7	549	627	457	144	1056	1090	388	571	390	257
8	240	333	317	158	155	784	255	201	260	247
9	122	108	136	156	190	111	256	166	129	258
10	83	89	99	69	212	163	83	224	126	92
+gp	202	193	238	128	372	459	275	282	489	382
0 TOTALNUM	12182	11216	11657	14141	13448	15829	14305	14984	14018	18650
TONSLAND	3190	3458	3575	3837	3932	4791	3853	3805	3647	4351
SOPCOF %	97	99	99	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
1	105	85	31	838	9	24	33	168	138	168
2	4046	5028	694	2977	1825	1489	1376	3268	3586	6042
3	8789	6442	6203	4375	7764	6068	5609	8506	4852	6194
4	1888	5444	5902	4765	3035	5008	2704	3307	4395	1595
5	1993	1008	3404	2968	3206	2082	1636	1311	1076	2491
6	288	563	584	1980	1823	1670	609	869	505	728
7	368	162	567	375	1283	916	558	350	319	290
8	135	188	109	278	271	775	441	672	148	128
9	171	116	147	88	319	239	354	351	328	56
10	95	62	93	106	112	169	239	192	150	81
+gp	231	129	258	241	344	267	301	359	248	265
0 TOTALNUM	18109	19227	17992	18991	19991	18707	13860	19353	15745	18038
TONSLAND	4072	4299	4383	4420	4797	4764	3363	4135	3476	4025
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
1	707	379	1030	206	608	175	149	231	139	0
2	7011	10957	4254	3468	7370	6511	2702	3006	5276	4636
3	7513	5086	8623	4034	3753	7316	8516	4418	4453	6230
4	3767	3178	2545	5458	2821	2990	4145	7092	3289	2884
5	1414	1805	2272	1543	3433	1500	1267	2378	3083	1510
6	655	671	1108	1143	1103	2038	849	798	1327	1432
7	298	588	371	633	796	751	751	615	328	554
8	129	198	448	218	403	467	356	642	267	179
9	97	70	94	283	191	257	164	277	336	148
10	57	88	88	127	208	162	134	251	99	105
+gp	197	245	233	271	307	230	247	451	290	222
0 TOTALNUM	21845	23265	21066	17384	20993	22397	19280	20159	18887	17900
TONSLAND	4733	5038	4826	4383	4833	5166	4517	5266	4409	4133
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 9.2.3 - Sole VIId - Quaterly landings composition for 2011

	Q1		Q2		Q3		Q4	
Age	Numbers	Weights	Numbers	Weights	Numbers	Weights	Numbers	Weights
1	0.0	0.137	0.0	0.000	0.4	0.123	0.0	0.000
2	868.3	0.199	471.0	0.142	2053.0	0.169	1240.8	0.174
3	2155.2	0.252	1451.0	0.189	1406.9	0.223	1215.7	0.210
4	1161.5	0.299	799.5	0.244	431.8	0.261	492.0	0.257
5	660.6	0.327	510.0	0.277	189.4	0.319	149.8	0.315
6	558.4	0.337	453.4	0.318	152.6	0.356	267.5	0.322
7	186.7	0.376	199.4	0.336	71.0	0.370	97.6	0.343
8	81.8	0.320	51.3	0.375	22.0	0.442	23.9	0.487
9	51.8	0.432	45.7	0.386	13.6	0.379	37.0	0.347
10	35.7	0.527	28.4	0.501	18.1	0.374	22.7	0.432
11	26.2	0.651	18.2	0.412	6.1	0.376	5.6	0.555
12	28.9	0.367	17.3	0.563	17.7	0.507	13.0	0.705
13	8.8	0.404	7.5	0.496	0.8	0.569	19.5	0.399
14	5.8	0.393	2.0	0.624	0.9	0.579	0.0	0.000
15+	11.4	0.902	16.5	0.555	6.8	0.690	7.3	0.692

Nominal landings (t)	1389.0	969.4	950.6	823.7

Table 9.2.4 - Sole VIId - Catch weights at age (kg)

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 2 Catch weights at age (kg)

	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	AGE										
	1	0.102	0.000	0.100	0.090	0.135	0.095	0.102	0.106	0.12	0.114
	2	0.171	0.173	0.178	0.182	0.180	0.175	0.152	0.154	0.178	0.161
	3	0.225	0.230	0.234	0.230	0.212	0.236	0.226	0.192	0.238	0.208
	4	0.312	0.302	0.314	0.281	0.306	0.295	0.278	0.271	0.289	0.266
	5	0.386	0.404	0.380	0.368	0.363	0.353	0.36	0.293	0.349	0.354
	6	0.428	0.436	0.436	0.394	0.387	0.407	0.409	0.358	0.339	0.394
	7	0.439	0.435	0.417	0.516	0.437	0.411	0.459	0.388	0.47	0.421
	8	0.509	0.524	0.538	0.543	0.520	0.482	0.514	0.472	0.465	0.43
	9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487	0.434
	10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518	0.478
	+gp	0.6729	0.6283	0.7135	0.8005	0.6015	0.6176	0.6647	0.7014	0.5621	0.5656
0	SOPCOFAC	0.9713	0.991	0.9884	0.998	1.0006	1.0004	1.0001	0.9994	0.9995	1.0001

Table 2 Catch weights at age (kg)

	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	AGE										
	1	0.103	0.085	0.099	0.129	0.142	0.139	0.132	0.130	0.145	0.108
	2	0.153	0.147	0.150	0.176	0.165	0.153	0.159	0.151	0.142	0.152
	3	0.203	0.197	0.186	0.179	0.178	0.188	0.172	0.189	0.176	0.211
	4	0.267	0.247	0.235	0.230	0.229	0.233	0.235	0.215	0.223	0.283
	5	0.290	0.335	0.288	0.255	0.269	0.292	0.286	0.260	0.332	0.288
	6	0.403	0.384	0.355	0.333	0.324	0.343	0.343	0.280	0.377	0.334
	7	0.391	0.537	0.381	0.357	0.361	0.390	0.383	0.290	0.424	0.367
	8	0.462	0.553	0.505	0.385	0.405	0.404	0.417	0.341	0.427	0.374
	9	0.459	0.515	0.484	0.490	0.435	0.503	0.484	0.358	0.384	0.493
	10	0.463	0.766	0.496	0.494	0.465	0.474	0.435	0.374	0.459	0.511
	+gp	0.5661	0.6666	0.6156	0.6536	0.5854	0.6509	0.6162	0.5354	0.68	0.5445
0	SOPCOFAC	1.0001	1.0002	1.0001	0.9997	0.9999	1	1.0013	0.9992	1.0009	1.0005

Table 2 Catch weights at age (kg)

	YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	AGE										
	1	0.120	0.114	0.120	0.135	0.139	0.163	0.148	0.143	0.124	0.123
	2	0.162	0.170	0.179	0.172	0.162	0.190	0.164	0.177	0.161	0.161
	3	0.204	0.208	0.205	0.208	0.192	0.202	0.201	0.203	0.195	0.204
	4	0.253	0.257	0.255	0.253	0.249	0.227	0.244	0.260	0.239	0.252
	5	0.316	0.277	0.296	0.303	0.284	0.276	0.262	0.279	0.287	0.295
	6	0.375	0.357	0.304	0.337	0.328	0.294	0.321	0.358	0.340	0.326
	7	0.376	0.381	0.348	0.368	0.353	0.315	0.435	0.321	0.342	0.342
	8	0.393	0.438	0.403	0.433	0.402	0.378	0.411	0.464	0.355	0.399
	9	0.469	0.482	0.492	0.570	0.457	0.441	0.377	0.406	0.512	0.352
	10	0.420	0.494	0.509	0.445	0.450	0.439	0.498	0.476	0.438	0.441
	+gp	0.5308	0.5274	0.525	0.5369	0.557	0.5206	0.5127	0.6185	0.4504	0.5216
0	SOPCOFAC	0.9995	1.0002	0.9983	0.9989	1	1.0026	0.9991	1.0009	0.9998	1.0004

Table 9.2.5 - Sole VIId - Stock weights at age (kg)

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 3 Stock weights at age (kg)

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
1	0.059	0.070	0.067	0.065	0.070	0.072	0.05	0.05	0.05	0.05
2	0.114	0.135	0.131	0.129	0.136	0.139	0.145	0.113	0.138	0.138
3	0.167	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232	0.225
4	0.217	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305	0.279
5	0.263	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.4	0.38
6	0.306	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361	0.384
7	0.347	0.406	0.403	0.436	0.403	0.417	0.477	0.48	0.476	0.41
8	0.384	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535	0.449
9	0.418	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571	0.474
10	0.4500	0.5220	0.5290	0.6110	0.5120	0.5360	0.636	0.536	0.507	0.451
+gp	0.53	0.6008	0.6265	0.7798	0.5761	0.6156	0.7498	0.7135	0.5765	0.6203

Table 3 Stock weights at age (kg)

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.144	0.130	0.116	0.126	0.155	0.139	0.140	0.128	0.122	0.127
3	0.199	0.189	0.161	0.129	0.176	0.165	0.158	0.180	0.148	0.157
4	0.277	0.246	0.215	0.220	0.258	0.220	0.233	0.205	0.208	0.216
5	0.305	0.366	0.273	0.234	0.286	0.264	0.299	0.253	0.402	0.226
6	0.454	0.377	0.316	0.333	0.308	0.317	0.374	0.277	0.440	0.223
7	0.405	0.545	0.368	0.357	0.366	0.376	0.363	0.298	0.395	0.231
8	0.459	0.560	0.530	0.330	0.391	0.404	0.357	0.324	0.554	0.253
9	0.430	0.559	0.461	0.614	0.438	0.563	0.450	0.336	0.443	0.256
10	0.528	0.813	0.470	0.382	0.466	0.494	0.372	0.323	0.420	0.301
+gp	0.5269	0.5664	0.6122	0.6292	0.6304	0.6536	0.5768	0.5118	0.6822	0.4204

Table 3 Stock weights at age (kg)

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
AGE										
1	0.050	0.050	0.050	0.144	0.141	0.139	0.131	0.141	0.143	0.050
2	0.136	0.151	0.137	0.157	0.161	0.163	0.158	0.169	0.149	0.142
3	0.179	0.207	0.185	0.203	0.185	0.195	0.191	0.186	0.185	0.189
4	0.209	0.249	0.236	0.241	0.246	0.239	0.250	0.243	0.210	0.244
5	0.258	0.314	0.265	0.267	0.272	0.286	0.294	0.278	0.267	0.277
6	0.254	0.376	0.267	0.309	0.326	0.297	0.368	0.352	0.316	0.318
7	0.301	0.399	0.273	0.349	0.339	0.340	0.401	0.341	0.341	0.336
8	0.234	0.418	0.331	0.401	0.394	0.400	0.476	0.430	0.326	0.375
9	0.326	0.446	0.504	0.608	0.416	0.433	0.463	0.449	0.440	0.386
10	0.404	0.444	0.409	0.425	0.461	0.446	0.402	0.456	0.416	0.501
+gp	0.4170	0.5032	0.4501	0.5602	0.5553	0.5182	0.5663	0.6598	0.4192	0.5147

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*	2.96	34.80

[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	30.13	29.78

[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 - 2011WG

105

BE-CBT

1980	**2011**		
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

UK(E&W)-CBT

1986	**2011**		
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	**224.1**	**119.8**	**58.8**	**16.3**	**36.7**	**10.7**	**2.5**	**2.5**	**2.5**	0.8	2.1	0.6	0.1	0.8

Table 9.2.7 - Sole VIId - tuning files - continued

Bolded numbers = used in XSA

UK(E&W)-BTS-Q3

1988	**2011**					
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**

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	**2011**		
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**	

Table 9.3.1 - Sole VIId - XSA diagnostics

26/04/2012 19:34

Extended Survivors Analysis

Sole in Division VIId - 2012 WG.

CPUE data from file SOL7DTUN.txt

Catch data for 30 years. 1982 to 2011. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BE-CBT	1986	2011	2	10	0	1
UK(E&W)-CBT	1986	2011	2	10	0	1
UK(E&W)-BTS-Q3	1988	2011	1	6	0.5	0.75
UK(E&W)-YFS	1987	2011	1	1	0.5	0.75
FR-YFS	1987	2011	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 79 iterations

Regression weights

1	1	1	1	1	1	1	1	1	

Fishing mortalities

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.016	0.019	0.058	0.006	0.015	0.01	0.007	0.006	0.003	0
2	0.371	0.327	0.274	0.249	0.29	0.2	0.194	0.181	0.171	0.117
3	0.511	0.446	0.41	0.401	0.413	0.461	0.385	0.488	0.392	0.279
4	0.483	0.373	0.372	0.437	0.48	0.599	0.457	0.566	0.73	0.42
5	0.493	0.398	0.443	0.359	0.48	0.449	0.485	0.457	0.455	0.788
6	0.253	0.407	0.403	0.37	0.418	0.517	0.437	0.57	0.442	0.351
7	0.288	0.337	0.366	0.376	0.423	0.495	0.323	0.578	0.429	0.297
8	0.237	0.282	0.411	0.338	0.387	0.418	0.408	0.446	0.471	0.391
9	0.253	0.174	0.187	0.438	0.494	0.406	0.225	0.569	0.393	0.46
10	0.323	0.34	0.307	0.367	0.592	0.915	0.34	0.555	0.36	0.182

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7	8	9	10
2002	4.64E+04	2.38E+04	1.97E+04	1.03E+04	3.82E+03	3.08E+03	1.25E+03	6.44E+02	4.57E+02	2.17E+02
2003	2.10E+04	4.13E+04	1.49E+04	1.07E+04	5.78E+03	2.11E+03	2.16E+03	8.48E+02	4.60E+02	3.21E+02
2004	1.93E+04	1.87E+04	2.70E+04	8.62E+03	6.68E+03	3.51E+03	1.27E+03	1.40E+03	5.79E+02	3.50E+02
2005	3.42E+04	1.65E+04	1.28E+04	1.62E+04	5.37E+03	3.88E+03	2.12E+03	7.98E+02	8.39E+02	4.35E+02
2006	4.24E+04	3.08E+04	1.17E+04	7.79E+03	9.47E+03	3.40E+03	2.43E+03	1.32E+03	5.15E+02	4.90E+02
2007	1.80E+04	3.78E+04	2.08E+04	6.97E+03	4.36E+03	5.31E+03	2.02E+03	1.44E+03	8.10E+02	2.84E+02
2008	2.13E+04	1.61E+04	2.80E+04	1.19E+04	3.47E+03	2.52E+03	2.86E+03	1.12E+03	8.57E+02	4.89E+02
2009	3.92E+04	1.91E+04	1.20E+04	1.72E+04	6.81E+03	1.93E+03	1.47E+03	1.88E+03	6.71E+02	6.19E+02
2010	4.87E+04	3.52E+04	1.44E+04	6.68E+03	8.86E+03	3.90E+03	9.88E+02	7.47E+02	1.09E+03	3.44E+02
2011	4.35E+04	4.40E+04	2.69E+04	8.84E+03	2.91E+03	5.08E+03	2.27E+03	5.82E+02	4.22E+02	6.64E+02

Estimated population abundance at 1st Jan 2011

0.00E+00	3.94E+04	3.54E+04	1.84E+04	5.25E+03	1.20E+03	3.24E+03	1.53E+03	3.56E+02	2.41E+02

Taper weighted geometric mean of the VPA populations:

2.49E+04	2.16E+04	1.60E+04	8.74E+03	4.73E+03	2.79E+03	1.61E+03	9.62E+02	6.12E+02	3.86E+02

Standard error of the weighted Log(VPA populations) :

0.4037	0.3934	0.3597	0.4137	0.4423	0.4595	0.4755	0.4821	0.4671	0.5011

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Log catchability residuals.

Fleet : BE-CBT

Age	1986	1987	1988	1989	1990	1991
1	No data for this fleet at this age					
2	-0.01	0.54	-0.77	-2.6	1.08	-0.81
3	0.72	-0.21	-0.44	-0.01	0.09	0.83
4	0.19	0.36	-0.72	-0.4	-0.14	0.07
5	-0.09	0.58	-0.23	1.01	-0.08	-0.04
6	-0.11	0.91	-0.22	0.28	-0.17	0.66
7	-0.17	0.62	0.05	0.35	0.56	0.08
8	0.03	-0.06	-0.74	-0.07	-0.24	-0.02
9	0.74	0.29	-0.7	-0.31	0.34	-0.64
10	0.09	2.14	1.34	-2.03	-0.07	0.54

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	No data for this fleet at this age									
2	-0.07	1.27	-0.34	-0.8	-0.16	-0.77	-0.38	0.34	0.02	0.44
3	0.09	0.25	-0.03	-0.3	-0.06	0.38	-0.22	0.03	0.42	0.03
4	0.4	-0.04	0.56	-0.34	0.27	0.35	0.27	0.52	0.34	-0.35
5	0.25	-0.03	0.27	-0.07	-0.12	0.46	-0.15	0.47	-0.31	0.12
6	-0.48	-0.83	0.42	0.08	0.13	0.16	-0.26	-0.07	0.09	0.72
7	-0.2	0.02	0.06	-0.01	0.26	0.24	-0.2	0	-0.21	0.17
8	-0.14	-0.22	0.32	-1.06	-0.02	-0.18	0.09	-0.18	0.52	-0.63
9	-0.03	0.71	-0.14	0.21	-0.09	0.08	-0.03	0.03	-0.23	-0.61
10	-0.63	-0.56	1.42	-0.71	1.16	-0.89	-0.06	-0.5	-0.31	-1.31

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	No data for this fleet at this age									
2	0.81	0.42	0.51	0.96	0.2	0.04	-0.88	0.49	0.4	0.07
3	0.08	0.13	-0.36	0.07	-0.24	-0.38	-0.85	-0.04	0.12	-0.1
4	-0.12	-0.01	-0.23	-0.2	0.02	-0.21	-0.05	-0.38	-0.23	0.05
5	-0.27	-0.12	0.24	-0.65	-0.42	-0.59	-0.14	0.02	-0.26	0.11
6	-0.82	0.46	-0.1	-0.56	0.06	-0.28	-0.32	0.33	0.36	-0.44
7	-0.21	-0.38	-0.55	-0.26	0.18	-0.36	-0.16	0.16	0.43	-0.46
8	-0.32	-0.14	-0.49	-0.05	-0.15	0.16	-0.04	-0.26	-0.04	-0.13
9	-0.57	-1.46	-0.83	-0.72	0.22	-0.06	-0.46	-0.09	0.28	0.25
10	0.35	0.14	0.24	-0.94	0.26	0.31	0.02	-0.07	0.17	-0.6

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	-7.0295	-5.8109	-5.6789	-5.5606	-5.7516	-5.6933	-5.6933	-5.6933	-5.6933
S.E(Log q)	0.8033	0.3502	0.322	0.366	0.4465	0.3035	0.3559	0.5221	0.8918

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	0.84	0.478	7.52	0.26	26	0.68	-7.03
3	1.45	-1.683	4.05	0.36	26	0.49	-5.81
4	0.95	0.343	5.86	0.64	26	0.31	-5.68
5	1.16	-0.813	5.09	0.52	26	0.43	-5.56
6	1.12	-0.548	5.48	0.45	26	0.51	-5.75
7	1.06	-0.424	5.59	0.68	26	0.33	-5.69
8	1.21	-1.394	5.63	0.65	26	0.38	-5.85
9	1.27	-1	5.68	0.37	26	0.63	-5.84
10	-3.58	-5.689	7.01	0.06	26	2.13	-5.71
1							

Fleet : UK(E&W)-CBT

Age	1986	1987	1988	1989	1990	1991
1	No data for this fleet at this age					
2	-0.39	0.36	0.56	-0.07	-0.23	-0.11
3	0.51	-0.07	0.34	-0.03	0.1	-0.28
4	0.52	0.4	-0.05	0.23	-0.13	0.05
5	0.27	0.52	0.4	-0.5	0	-1.23
6	0.4	-0.27	0.27	0.12	-0.38	-0.25
7	0.66	-0.28	-0.14	0.22	-0.28	-0.94
8	-0.76	0.41	0.3	-0.26	0.02	-0.6
9	0.08	-0.74	0.11	-0.32	-0.18	0.16
10	0.01	-1.36	0.51	0.36	0.55	0

Age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	No data for this fleet at this age									
2	-0.43	-0.38	-1.23	-0.21	0.23	0.11	-0.02	0.33	-0.15	0.03
3	-0.11	-0.52	-0.11	-0.65	-0.51	0.15	-0.27	0.1	0.24	-0.15
4	-0.43	-0.2	-0.32	-0.08	-0.8	-0.24	-0.06	0.13	0.17	-0.1
5	0.48	-0.36	-0.05	-0.15	-0.07	-0.54	0.13	0.17	0.26	0.22
6	-0.6	0.08	0	0.04	-0.25	0.21	-0.1	0.3	0.26	0.25
7	-0.18	-0.55	0.51	-0.16	-0.1	-0.13	0.2	0.22	0.45	0.2
8	-0.4	-0.11	-0.16	0.42	-0.19	0.13	0.1	0.18	0.24	0.64
9	0.42	0.02	0.4	0.22	0.25	-0.1	0.21	-0.04	0.53	0.18
10	-0.24	-0.44	0.46	0.44	0.23	0.27	0.39	-0.26	0.13	0.19

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	No data for this fleet at this age									
2	0.32	0.12	-0.03	0.3	0.54	-0.39	0.15	0.61	-0.28	0.23
3	0.27	-0.02	0.37	0	0.79	0.26	0.41	-0.38	0.04	-0.48
4	0.16	-0.16	0.01	0.49	0.06	0.4	0.06	0.13	-0.17	-0.06
5	0.16	-0.23	-0.08	0	0.5	-0.26	-0.07	0.13	0.24	0.06
6	-0.01	-0.09	-0.1	0.37	-0.29	0.66	-0.28	-0.43	-0.04	0.12
7	0.12	0.09	-0.25	0.34	0.01	0.23	-0.05	-0.28	0.36	-0.26
8	0.55	0.24	0.31	0.59	-0.13	0.52	-0.07	0.17	0.24	-0.32
9	-0.23	-0.18	-0.34	0.48	0.45	0.17	-0.94	0.01	0.41	0.04
10	-0.12	0.29	-0.08	0.77	0.04	-0.51	0.04	0.68	0.49	-0.52

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	-6.4918	-5.829	-5.7896	-5.9206	-5.9172	-5.9957	-5.9957	-5.9957	-5.9957
S.E(Log q)	0.3969	0.3512	0.2906	0.3799	0.2949	0.3498	0.3737	0.361	0.4711

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	1.08	-0.35	6.22	0.46	26	0.44	-6.49
3	1	-0.023	5.81	0.52	26	0.36	-5.83
4	0.9	0.799	6.13	0.71	26	0.26	-5.79
5	0.73	2.31	6.62	0.75	26	0.26	-5.92
6	0.77	2.441	6.37	0.83	26	0.21	-5.92
7	0.8	1.708	6.28	0.76	26	0.27	-6
8	0.8	1.834	6.11	0.77	26	0.28	-5.92
9	0.82	1.497	6.04	0.74	26	0.29	-5.96
10	0.92	0.467	5.91	0.61	26	0.43	-5.91
1							

Fleet : UK(E&W)-BTS

Age	1986	1987	1988	1989	1990	1991
1	99.99	99.99	0.26	-0.46	0.12	0.04
2	99.99	99.99	1	0.17	-0.79	0.08
3	99.99	99.99	0.62	0.59	-0.51	-0.4
4	99.99	99.99	-0.3	-0.06	0.03	0.04
5	99.99	99.99	0.42	0.15	-0.15	-0.24
6	99.99	99.99	0.02	-0.88	-0.35	0.01
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	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	-1.78	-2.11	-0.31	-0.29	-0.29	1.02	-0.8	1.47	0.31	0.33
2	-0.39	0.05	-1.05	-0.25	-0.28	-0.31	0.34	0.07	0.52	0.34
3	0.09	0.02	0.09	-1.01	-0.37	-0.15	-0.5	0.74	0.21	0.4
4	-0.64	0.59	-0.02	-0.34	-0.8	-0.27	-0.24	0.57	0.6	-0.13
5	-0.09	-0.01	0.38	-0.44	-0.31	-1.23	0.13	0.99	0.29	0.48
6	0.27	0.26	-0.93	0.14	-0.13	-0.66	-1.17	1.22	0.51	0.21
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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	1.03	0.23	0.47	1.09	-0.5	-0.75	-0.59	1.15	0.28	0.1
2	-0.03	0.31	-0.14	-0.56	0.6	0.05	-0.31	0.23	0.42	-0.08
3	-0.09	-0.12	-0.12	-0.37	-0.29	0.69	-0.24	0.39	0.12	0.22
4	0.45	0.01	-0.22	-0.02	0.19	-0.14	0.63	0.21	0.34	-0.49
5	-1.07	0.23	0.02	0.31	-0.03	-0.14	-1.27	0.98	0.41	0.19
6	0.01	-0.38	0.3	0.21	-0.85	0.15	-0.03	0.1	1.11	0.86
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	-8.2423	-7.3209	-7.7273	-8.0943	-8.1213	-8.1619
S.E(Log q)	0.8674	0.4554	0.4346	0.3921	0.5763	0.6097

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	0.5	2.11	9.23	0.45	24	0.4	-8.24
2	0.79	1.1	7.9	0.55	24	0.36	-7.32
3	0.9	0.453	7.94	0.46	24	0.4	-7.73
4	0.77	1.561	8.32	0.68	24	0.29	-8.09
5	0.83	0.778	8.19	0.48	24	0.48	-8.12
6	0.83	0.737	8.12	0.46	24	0.51	-8.16
1							

Fleet : UK(E&W)-YFS

Age	1986	1987	1988	1989	1990	1991
1	99.99	0.65	0.1	-0.57	-0.41	0.48
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	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	-0.39	0.19	0.43	0.85	-0.78	-0.49	-0.06	-0.16	0.18	-1.52
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	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.31	0.05	0.79	0.59	-0.23	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	-9.5691
S.E(Log q)	0.5846

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	1.27	-0.581	9.41	0.2	20	0.76	-9.56

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Fleet : FR-YFS

Age		1986	1987	1988	1989	1990	1991
	1	99.99	-0.27	-0.24	0	0.39	0.27
	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		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	1	-0.25	-1.54	1.15	0.57	-0.05	-2.05	-0.41	0.47	0.17	1.7
	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		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
	1	-1.25	0.61	-0.04	1.05	0.86	-0.63	-1.09	2.14	-1.41	-0.13
	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	-11.6258
S.E(Log q)	0.9975

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	0.74	0.688	11.24	0.23	25	0.74	-11.63

Terminal year survivor and F summaries :

Age 1 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	1	0	0	0	0	0	0
UK(E&W)-CBT	1	0	0	0	0	0	0
UK(E&W)-BTS-Q3	43536	0.885	0	0	1	0.569	0
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	34505	1.017	0	0	1	0.431	0
F shrinkage mean	0	2				0	0

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
39385	0.67	0.12	2	0.172	0

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 2 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	37860	0.819	0	0	1	0.101	0.11
UK(E&W)-CBT	44707	0.404	0	0	1	0.414	0.094
UK(E&W)-BTS-Q3	35350	0.412	0.146	0.36	2	0.4	0.118
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	8666	1.017	0	0	1	0.065	0.411
F shrinkage mean	19124	2				0.019	0.207

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
35375	0.26	0.18	6	0.704	0.117

Age 3 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	17795	0.328	0.175	0.53	2	0.274	0.287
UK(E&W)-CBT	12255	0.269	0.098	0.36	2	0.39	0.394
UK(E&W)-BTS-Q3	27331	0.303	0.196	0.65	3	0.302	0.196
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	156016	1.017	0	0	1	0.024	0.037
F shrinkage mean	11055	2				0.01	0.429

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
18382	0.17	0.18	9	1.072	0.279

Age 4 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	5791	0.237	0.071	0.3	3	0.314	0.388
UK(E&W)-CBT	5714	0.206	0.174	0.85	3	0.403	0.392
UK(E&W)-BTS-Q3	4353	0.248	0.193	0.78	4	0.264	0.489
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	1772	1.017	0	0	1	0.011	0.935
F shrinkage mean	3584	2				0.008	0.568

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
5252	0.13	0.09	12	0.678	0.42

Age 5 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	1147	0.222	0.117	0.53	4	0.361	0.812
UK(E&W)-CBT	1114	0.203	0.099	0.49	4	0.398	0.828
UK(E&W)-BTS-Q3	1428	0.256	0.138	0.54	5	0.222	0.696
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	639	1.017	0	0	1	0.006	1.178
F shrinkage mean	2414	2				0.014	0.467

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1198	0.13	0.07	15	0.512	0.788

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 6 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	2145	0.206	0.095	0.46	5	0.314	0.492
UK(E&W)-CBT	3729	0.178	0.077	0.43	5	0.472	0.311
UK(E&W)-BTS-Q3	4549	0.248	0.177	0.71	6	0.191	0.262
UK(E&W)-YFS	2581	0.604	0	0	1	0.011	0.424
FR-YFS	7623	1.017	0	0	1	0.004	0.164
F shrinkage mean	2219	2				0.007	0.479

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3238	0.12	0.09	19	0.757	0.351

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2004

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	1242	0.187	0.138	0.74	6	0.409	0.354
UK(E&W)-CBT	1457	0.169	0.087	0.51	6	0.454	0.309
UK(E&W)-BTS-Q3	3559	0.247	0.095	0.39	6	0.121	0.138
UK(E&W)-YFS	2760	0.604	0	0	1	0.007	0.175
FR-YFS	4374	1.017	0	0	1	0.002	0.114
F shrinkage mean	924	2				0.007	0.451

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
1526	0.11	0.09	21	0.82	0.297

Age 8 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	394	0.185	0.115	0.62	7	0.453	0.359
UK(E&W)-CBT	339	0.175	0.15	0.86	7	0.46	0.407
UK(E&W)-BTS-Q3	252	0.255	0.231	0.91	6	0.073	0.516
UK(E&W)-YFS	786	0.604	0	0	1	0.004	0.196
FR-YFS	341	1.017	0	0	1	0.001	0.405
F shrinkage mean	319	2				0.008	0.427

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
356	0.12	0.08	23	0.659	0.391

Age 9 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	247	0.186	0.086	0.46	8	0.409	0.451
UK(E&W)-CBT	237	0.175	0.073	0.41	8	0.52	0.467
UK(E&W)-BTS-Q3	230	0.245	0.083	0.34	6	0.056	0.477
UK(E&W)-YFS	253	0.604	0	0	1	0.003	0.442
FR-YFS	442	1.017	0	0	1	0.001	0.276
F shrinkage mean	271	2				0.01	0.419

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
241	0.12	0.04	25	0.351	0.46

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2001

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	420	0.182	0.089	0.49	9	0.38	0.214
UK(E&W)-CBT	571	0.169	0.143	0.85	9	0.556	0.161
UK(E&W)-BTS-Q3	537	0.245	0.089	0.36	6	0.051	0.171
UK(E&W)-YFS	685	0.604	0	0	1	0.003	0.136
FR-YFS	143	1.017	0	0	1	0.001	0.53
F shrinkage mean	172	2				0.009	0.459

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
501	0.12	0.08	27	0.643	0.182

Table 9.3.2 - Sole VIId - Fishing mortality (F) at age

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 8 Fishing mortality (F) at age

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AGE										
1	0.0129	0	0.0012	0.004	0.002	0.0009	0.0039	0.0103	0.03	0.0116
2	0.1865	0.0820	0.1139	0.2224	0.12	0.1522	0.2602	0.1719	0.2222	0.2154
3	0.3118	0.3538	0.4309	0.433	0.5022	0.5449	0.5416	0.6715	0.4033	0.5041
4	0.4853	0.3601	0.4379	0.3716	0.4576	0.5894	0.4214	0.6677	0.4751	0.5265
5	0.2290	0.4441	0.2635	0.2731	0.3191	0.5312	0.3774	0.7309	0.4415	0.4349
6	0.2269	0.4568	0.7156	0.3947	0.3004	0.6517	0.3901	0.4577	0.2875	0.5249
7	0.4667	0.3151	0.5073	0.2539	0.3619	0.7979	0.475	0.4334	0.3536	0.3773
8	0.4092	0.5087	0.2319	0.291	0.4213	0.4428	0.3793	0.4279	0.3188	0.3523
9	0.3452	0.2897	0.3557	0.1531	0.5959	0.5355	0.2244	0.4032	0.4761	0.5307
10	0.3363	0.4041	0.4161	0.2738	0.2856	1.4801	0.8803	0.2788	0.5389	0.6551
+gp	0.3363	0.4041	0.4161	0.2738	0.2856	1.4801	0.8803	0.2788	0.5389	0.6551
0 FBAR 3- 8	0.3548	0.4064	0.4312	0.3362	0.3938	0.593	0.4308	0.5649	0.38	0.4533

Table 8 Fishing mortality (F) at age

YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
AGE										
1	0.0033	0.0053	0.0012	0.0464	0.0005	0.0009	0.0019	0.0067	0.0046	0.0067
2	0.1467	0.1916	0.0495	0.1398	0.1215	0.0962	0.0594	0.2371	0.1740	0.2554
3	0.3942	0.3259	0.3396	0.4361	0.5666	0.6439	0.5458	0.5409	0.5780	0.4507
4	0.4053	0.4017	0.4945	0.4205	0.5432	0.7840	0.5890	0.6406	0.5273	0.3345
5	0.4571	0.3494	0.4179	0.4393	0.4922	0.7919	0.5617	0.5618	0.3897	0.5707
6	0.3384	0.1996	0.3116	0.4057	0.4691	0.4558	0.4949	0.5841	0.3870	0.4406
7	0.3311	0.2882	0.2822	0.3004	0.4437	0.4041	0.2398	0.5221	0.3884	0.3566
8	0.3093	0.2506	0.2855	0.1944	0.3283	0.4666	0.3078	0.4474	0.3862	0.2363
9	0.3903	0.4220	0.2825	0.3493	0.3176	0.4761	0.3568	0.3814	0.3629	0.2196
10	0.3354	0.2123	0.6258	0.3012	0.8870	0.2470	1.1205	0.2971	0.2475	0.1271
+gp	0.3354	0.2123	0.6258	0.3012	0.8870	0.2470	1.1205	0.2971	0.2475	0.1271
0 FBAR 3- 8	0.3726	0.3026	0.3552	0.3661	0.4739	0.5910	0.4565	0.5495	0.4428	0.3983

Table 8 Fishing mortality (F) at age

YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	FBAR 09-11
AGE											
1	0.0161	0.0191	0.0576	0.0063	0.0152	0.0103	0.0074	0.0062	0.0030	0.0000	0.0031
2	0.3706	0.3267	0.2739	0.2493	0.2901	0.1997	0.1937	0.1806	0.1713	0.1175	0.1564
3	0.5107	0.4457	0.4095	0.4007	0.4134	0.4609	0.3850	0.4883	0.3916	0.2794	0.3864
4	0.4825	0.3733	0.3719	0.4370	0.4795	0.5992	0.4567	0.5661	0.7297	0.4202	0.5720
5	0.4929	0.3981	0.4425	0.3593	0.4796	0.4487	0.4851	0.4572	0.4554	0.7878	0.5668
6	0.2531	0.4066	0.4031	0.3703	0.4178	0.5171	0.4373	0.5702	0.4424	0.3511	0.4546
7	0.2883	0.3366	0.3662	0.3760	0.4230	0.4947	0.3227	0.5784	0.4295	0.2967	0.4349
8	0.2365	0.2816	0.4109	0.3385	0.3874	0.4177	0.4084	0.4459	0.4712	0.3909	0.4360
9	0.2527	0.1744	0.1871	0.4382	0.4944	0.4057	0.2247	0.5686	0.3931	0.4600	0.4739
10	0.3233	0.3400	0.3074	0.3670	0.5917	0.9148	0.3401	0.5553	0.3603	0.1819	0.3658
+gp	0.3233	0.3400	0.3074	0.3670	0.5917	0.9148	0.3401	0.5553	0.3603	0.1819	
0 FBAR 3- 8	0.3774	0.3737	0.4007	0.3803	0.4335	0.4897	0.4159	0.5177	0.4866	0.4210	

Table 9.3.3 - Sole VIId - Stock numbers at age

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	AGE										
	1	12732	21335	21540	12905	25700	10975	25735	16795	44274	34843
	2	16220	11373	19305	19467	11630	23208	9922	23195	15042	38876
	3	20625	12180	9480	15587	14102	9333	18034	6921	17674	10899
	4	4722	13663	7737	5575	9147	7722	4897	9494	3200	10684
	5	2928	2630	8624	4518	3479	5237	3876	2907	4406	1800
	6	3382	2107	1526	5996	3111	2288	2786	2404	1267	2564
	7	1547	2439	1207	675	3656	2085	1079	1707	1376	860
	8	751	878	1610	658	474	2304	849	607	1001	874
	9	439	451	478	1155	445	281	1339	526	358	659
	10	305	281	306	303	897	222	149	968	318	201
	+gp	741	608	732	560	1570	617	490	1215	1228	831
0	TOTAL	64393	67945	72545	67399	74211	64272	69156	66740	90143	103091

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
	AGE										
	1	33614	16789	26538	19413	18863	27766	18024	26262	31286	26483
	2	31163	30316	15111	23983	16769	17059	25101	16277	23603	28178
	3	28360	24349	22648	13013	18869	13437	14019	21403	11619	17946
	4	5957	17301	15904	14592	7613	9688	6386	7350	11275	5898
	5	5710	3594	10476	8776	8671	4001	4002	3206	3505	6021
	6	1054	3271	2293	6241	5118	4796	1640	2065	1654	2148
	7	1372	680	2424	1519	3764	2897	2751	905	1042	1016
	8	533	892	461	1654	1018	2185	1750	1959	486	639
	9	556	354	628	314	1232	663	1240	1164	1133	299
	10	351	341	210	428	200	812	373	785	719	713
	+gp	850	707	580	971	610	1279	465	1464	1186	2330
0	TOTAL	109521	98594	97273	90905	82726	84583	75751	82839	87508	91671

Table 10 Stock number at age (start of year) Numbers*10**-3

	YEAR	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	GMST 82-09	AMST 82-09
	AGE													
	1	46424	21030	19344	34218	42420	18007	21295	39186	48739	43527	0*	23798	25493
	2	23803	41333	18668	16523	30766	37805	16127	19127	35237	43969	39385	20727	22141
	3	19749	14868	26977	12845	11652	20827	28014	12022	14447	26865	35375	15718	16695
	4	10346	10723	8616	16208	7786	6973	11886	17248	6676	8837	18382	8819	9592
	5	3820	5778	6679	5375	9473	4361	3465	6812	8860	2912	5252	4703	5148
	6	3079	2111	3511	3883	3396	5306	2519	1930	3902	5084	1198	2696	2980
	7	1251	2163	1272	2123	2426	2023	2863	1472	988	2268	3238	1622	1807
	8	644	848	1398	798	1319	1438	1116	1876	747	582	1526	988	1108
	9	457	460	579	839	515	810	857	671	1087	422	356	607	675
	10	217	321	350	435	490	284	489	619	344	664	241	380	432
	+gp	747	891	923	924	719	400	898	1107	1004	1401	1557		
0	TOTAL	110536	100527	88317	94170	110961	98237	89530	102071	122031	136531	106512		

* Replaced with GM (23798) in prediction

Table 9.3.4 - Sole VIId - Summary

Run title : Sole in Division VIId - 2012 WG.

At 26/04/2012 19:35

Table 16 Summary (without SOP correction)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1982	12732	10413	7813	3190	0.4083	0.3548
1983	21335	12597	9568	3458	0.3614	0.4064
1984	21540	12945	8973	3575	0.3984	0.4312
1985	12905	13319	9969	3837	0.3849	0.3362
1986	25700	13964	10583	3932	0.3715	0.3938
1987	10975	13017	9000	4791	0.5323	0.5930
1988	25735	12824	10098	3853	0.3815	0.4308
1989	16795	11838	8377	3805	0.4542	0.5649
1990	44274	13850	9560	3647	0.3815	0.3800
1991	34843	15872	8765	4351	0.4964	0.4533
1992	33614	17355	11187	4072	0.3640	0.3726
1993	16789	17933	13152	4299	0.3269	0.3026
1994	26538	15610	12530	4383	0.3498	0.3552
1995	19413	15069	11077	4420	0.3990	0.3661
1996	18863	15677	12134	4797	0.3953	0.4739
1997	27766	14267	10508	4764	0.4534	0.5910
1998	18024	12517	8101	3363	0.4151	0.4565
1999	26262	12437	9041	4135	0.4574	0.5495
2000	31286	12939	8495	3476	0.4092	0.4428
2001	26483	12501	7598	4025	0.5297	0.3983
2002	46424	14099	8540	4733	0.5542	0.3774
2003	21030	17662	10369	5038	0.4859	0.3737
2004	19344	14917	11392	4826	0.4236	0.4007
2005	34218	18943	11422	4383	0.3837	0.3803
2006	42420	20870	9936	4833	0.4864	0.4335
2007	18007	19165	10499	5166	0.4920	0.4897
2008	21295	18387	13049	4517	0.3462	0.4159
2009	39186	20381	11624	5266	0.453	0.5177
2010	48739	21516	9296	4409	0.4743	0.4866
2011	43527	20274	11854	4133	0.3487	0.421
2012	23798[1]	24158[2]	15470[2]			0.3825[3]
Arith. Mean	26869	15439	10150	4249	0.4239	0.4316
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

[1] Geometric mean 1982-2009

[2] From forecast

[3] TAC constraint (5580t in 2012)

Table 9.5.1 - Sole VIId – RCT3 input

Yearclass	XSA (Age 1)	XSA (Age 2)	FR-YF0	FR-YF1	BTS1	BTS2
1981	12732	11373	3.33	0.07	-11	-11
1982	21335	19305	1.04	0.02	-11	-11
1983	21540	19467	0.79	-11	-11	-11
1984	12905	11630	-11	-11	-11	-11
1985	25700	23208	-11	-11	-11	-11
1986	10975	9922	-11	0.07	-11	14.20
1987	25735	23195	0.75	0.17	8.20	15.40
1988	16795	15042	0.04	0.14	2.60	3.70
1989	44274	38876	17.43	0.54	12.10	22.80
1990	34843	31163	0.57	0.38	8.90	12.00
1991	33614	30316	1.04	0.22	1.40	17.50
1992	16789	15111	0.48	0.03	0.50	3.20
1993	26538	23983	0.27	0.70	4.80	10.60
1994	19413	16769	4.04	0.28	3.50	7.30
1995	18863	17059	3.50	0.15	3.50	7.30
1996	27766	25101	0.28	0.03	19.00	21.20
1997	18024	16277	0.07	0.10	2.00	9.44
1998	26262	23603	10.52	0.35	28.14	22.03
1999	31286	28178	2.84	0.31	10.49	21.01
2000	26483	23803	2.41	1.21	9.09	11.42
2001	46424	41333	4.32	0.11	31.76	28.48
2002	21030	18668	0.94	0.32	6.47	8.49
2003	19344	16523	0.21	0.15	7.35	5.04
2004	34218	30766	7.29	0.82	25.00	29.20
2005	42420	37805	0.05	0.83	6.30	21.86
2006	18007	16127	1.04	0.08	2.14	6.50
2007	21295	19127	0.03	0.06	2.90	13.3
2008	-11	-11	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	-11
2011	-11	-11	2.78	-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   31 years :  1981 - 2011

 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 =   2009

          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    1.31   8.91   1.03   .102     24   1.24   10.54    1.101     .039
 FR-YF1    3.36   9.29    .62   .280     24    .10    9.61     .665     .106
 BTS1       .61   8.94    .41   .405     21   2.83   10.66     .447     .234
 BTS2       .89   7.82    .37   .514     22   3.20   10.67     .402     .289

                                         VPA Mean =   10.06     .375     .333
 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    1.31   8.91   1.03   .102     24    .18    9.15    1.116     .052
 FR-YF1    3.36   9.29    .62   .280     24    .28   10.22     .660     .150
 BTS1       .61   8.94    .41   .405     21   2.56   10.50     .442     .334
 BTS2
                                         VPA Mean =   10.06     .375     .464
 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    1.31   8.91   1.03   .102     24   1.33   10.66(42617)    1.104
.103
 FR-YF1
 BTS1
 BTS2
                                         VPA Mean =   10.06(23389)     .375
.897

 Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class     Average      WAP     Std     Std    Ratio             VPA
          Prediction           Error   Error

 2009       31162     10.35     .22     .19      .75
 2010       26398     10.18     .26     .18      .49
 2011       24847     10.12     .35     .18      .26
```

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   31 years :  1981 - 2011

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 =   2009

         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    1.34   8.77   1.06   .097     24   1.24   10.44    1.132     .036
FR-YF1    3.36   9.17    .62   .278     24    .10    9.49     .668     .104
BTS1       .61   8.81    .41   .399     21   2.83   10.55     .455     .224
BTS2       .88   7.74    .35   .529     22   3.20   10.55     .390     .304

                                       VPA Mean =    9.95     .374     .332

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    1.34   8.77   1.06   .097     24    .18    9.02( 8267)    1.147     .050
FR-YF1    3.36   9.17    .62   .278     24    .28   10.11(24588)     .662     .151
BTS1       .61   8.81    .41   .399     21   2.56    10.39(32533)    .449     .327
BTS2

                                       VPA Mean =    9.95(20952)     .374
.472

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    1.34   8.77   1.06   .097     24   1.33   10.56    1.134     .098
FR-YF1
BTS1
BTS2

                                       VPA Mean =    9.95     .374     .902


Year     Weighted      Log      Int      Ext      Var     VPA       Log
Class     Average      WAP      Std      Std     Ratio              VPA
         Prediction            Error    Error

2009       27933     10.24      .22      .19      .75
2010       23595     10.07      .26      .18      .48
2011       22202     10.01      .36      .18      .26
```

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	23798	0.38	WS1	0.111	0.48
N2	39385	0.67	WS2	0.153	0.09
N3	35375	0.26	WS3	0.187	0.01
N4	18382	0.18	WS4	0.232	0.08
N5	5252	0.13	WS5	0.274	0.02
N6	1198	0.13	WS6	0.329	0.06
N7	3238	0.12	WS7	0.339	0.01
N8	1526	0.11	WS8	0.377	0.14
N9	356	0.12	WS9	0.425	0.08
N10	241	0.12	WS10	0.458	0.09
N11	1557	0.12	WS11	0.531	0.23
H.cons selectivity			Weight in the HC catch		
sH1	0.0031	0.19	WH1	0.130	0.09
sH2	0.1565	0.22	WH2	0.166	0.06
sH3	0.3864	0.27	WH3	0.201	0.02
sH4	0.5720	0.27	WH4	0.250	0.04
sH5	0.5668	0.34	WH5	0.287	0.03
sH6	0.4546	0.24	WH6	0.341	0.05
sH7	0.4349	0.32	WH7	0.335	0.04
sH8	0.4360	0.09	WH8	0.406	0.14
sH9	0.4739	0.19	WH9	0.423	0.19
sH10	0.3658	0.51	WH10	0.452	0.05
sH11	0.3658	0.51	WH11	0.530	0.16
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		
HF12	1	0.09	K12	1	0.1
HF13	1	0.09	K13	1	0.1
HF14	1	0.09	K14	1	0.1
Recruitment in 2007 and 2008					
R13	23798	0.38			
R14	23798	0.38			

Table 9.6.2a Sole in VIId - Management option table

MFDP version 1a
Run: SOL7D_fin_SQ
Sole in VIId
Time and date: 12:40 28/04/2012
Fbar age range: 3-8

F - status quo

2012 Biomass	SSB	FMult	FBar	Landings
24158	15470	1.0000	0.4751	6670

2013 Biomass	SSB	FMult	FBar	Landings	2014 Biomass	SSB
22160	16219	0.0000	0.0000	0	26968	21017
.	16219	0.1000	0.0475	824	26096	20146
.	16219	0.2000	0.0950	1610	25265	19316
.	16219	0.3000	0.1425	2360	24472	18523
.	16219	0.4000	0.1900	3077	23715	17768
.	16219	0.5000	0.2376	3761	22993	17046
.	16219	0.6000	0.2851	4415	22303	16358
.	16219	0.7000	0.3326	5040	21645	15701
.	16219	0.8000	0.3801	5636	21017	15074
.	16219	0.9000	0.4276	6207	20417	14475
.	16219	1.0000	0.4751	6752	19844	13903
.	16219	1.1000	0.5226	7273	19297	13357
.	16219	1.2000	0.5701	7771	18775	12836
.	16219	1.3000	0.6176	8247	18275	12337
.	16219	1.4000	0.6652	8703	17798	11861
.	16219	1.5000	0.7127	9139	17342	11406
.	16219	1.6000	0.7602	9556	16906	10971
.	16219	1.7000	0.8077	9955	16489	10555
.	16219	1.8000	0.8552	10337	16090	10157
.	16219	1.9000	0.9027	10703	15709	9777
.	16219	2.0000	0.9502	11053	15344	9413

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.84

.	16219	0.8400	0.3991	5868	20774	14831

Fmult corresponding to Fmsy = 0.61

.	16219	0.6100	0.2898	4479	22236	16291

Fmult corresponding to Fmsy transition = 0.78

.	16219	0.7800	0.3706	5519	21140	15197

Bpa/Btrigger = 8 000 t

Table 9.6.2b Sole in VIId - Management option table

MFDP version 1a

TAC constrain

Run: SOL7D_fin_TAC
Sole in VIId
Time and date: 12:48 28/04/2012
Fbar age range: 3-8

2012 Biomass	SSB	FMult	FBar	Landings
24158	15470	0.8051	0.3825	5580

2013 Biomass	SSB	FMult	FBar	Landings	2014 Biomass	SSB
23312	17369	0.0000	0.0000	0	28185	22234
.	17369	0.1000	0.0475	881	27253	21302
.	17369	0.2000	0.0950	1722	26364	20415
.	17369	0.3000	0.1425	2525	25516	19568
.	17369	0.4000	0.1900	3291	24708	18761
.	17369	0.5000	0.2376	4022	23936	17990
.	17369	0.6000	0.2851	4720	23201	17255
.	17369	0.7000	0.3326	5387	22498	16554
.	17369	0.8000	0.3801	6024	21828	15885
.	17369	0.9000	0.4276	6633	21189	15246
.	17369	1.0000	0.4751	7214	20578	14637
.	17369	1.1000	0.5226	7770	19995	14055
.	17369	1.2000	0.5701	8301	19438	13499
.	17369	1.3000	0.6176	8808	18906	12968
.	17369	1.4000	0.6652	9294	18398	12461
.	17369	1.5000	0.7127	9758	17913	11977
.	17369	1.6000	0.7602	10202	17449	11514
.	17369	1.7000	0.8077	10627	17006	11071
.	17369	1.8000	0.8552	11033	16582	10649
.	17369	1.9000	0.9027	11422	16177	10245
.	17369	2.0000	0.9502	11795	15789	9858

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.84

.	17369	0.8400	0.3991	6271	21569	15626

Fmult corresponding to Fmsy = 0.61

.	17369	0.6100	0.2898	4788	23129	17184

Fmult corresponding to Fmsy transition = 0.78

.	17369	0.7800	0.3706	5899	21960	16016

Bpa/Btrigger = 8 000 t

Table 9.6.3 Sole in VIId. Detailed results

MFDP version 1a
Run: SOL7D_fin_TAC **TAC constrain**
Time and date: 12:48 28/04/2012
Fbar age range: 3-8

Year: 2012 F multiplier: 0.8051 Fbar: 0.3825

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0025	56	7	23798	2650	0	0	0	0
2	0.1260	4441	739	39385	6039	0	0	0	0
3	0.3111	9024	1811	35375	6603	35375	6603	35375	6603
4	0.4605	6480	1622	18382	4271	18382	4271	18382	4271
5	0.4563	1838	528	5252	1439	5252	1439	5252	1439
6	0.3660	350	120	1198	394	1198	394	1198	394
7	0.3501	913	306	3238	1099	3238	1099	3238	1099
8	0.3510	431	175	1526	575	1526	575	1526	575
9	0.3815	108	46	356	151	356	151	356	151
10	0.2945	59	26	241	110	241	110	241	110
11	0.2945	379	201	1557	827	1557	827	1557	827
Total		24079	5580	130308	24158	67125	15470	67125	15470

Year: 2013 F multiplier: 1 Fbar: 0.4751

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0031	69	9	23798	2650	0	0	0	0
2	0.1565	2965	493	21480	3294	0	0	0	0
3	0.3864	9614	1929	31419	5865	31419	5865	31419	5865
4	0.5720	9767	2445	23450	5448	23450	5448	23450	5448
5	0.5668	4341	1246	10495	2876	10495	2876	10495	2876
6	0.4546	1051	359	3011	990	3011	990	3011	990
7	0.4349	253	85	752	255	752	255	752	255
8	0.4360	697	283	2064	778	2064	778	2064	778
9	0.4739	350	148	972	413	972	413	972	413
10	0.3658	64	29	220	101	220	101	220	101
11	0.3658	354	188	1212	644	1212	644	1212	644
Total		29526	7214	118873	23312	73595	17369	73595	17369

Year: 2014 F multiplier: 1 Fbar: 0.4751

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0031	69	9	23798	2650	0	0	0	0
2	0.1565	2963	493	21467	3292	0	0	0	0
3	0.3864	5086	1021	16621	3103	16621	3103	16621	3103
4	0.5720	8045	2014	19317	4488	19317	4488	19317	4488
5	0.5668	4954	1422	11976	3281	11976	3281	11976	3281
6	0.4546	1880	642	5387	1771	5387	1771	5387	1771
7	0.4349	582	195	1729	587	1729	587	1729	587
8	0.4360	149	60	440	166	440	166	440	166
9	0.4739	436	184	1208	513	1208	513	1208	513
10	0.3658	160	72	548	251	548	251	548	251
11	0.3658	263	139	899	477	899	477	899	477
Total		24587	6251	103390	20578	58125	14637	58125	14637

Input units are thousands and kg - output in tonnes

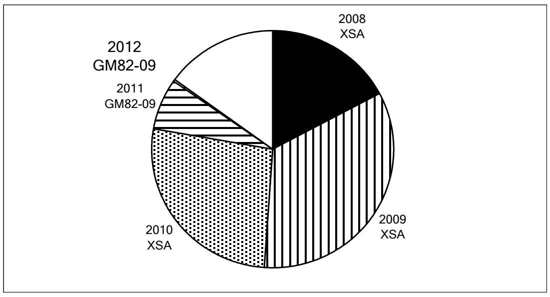
Table 9.6.4 **Sole VIId**
Stock numbers of recruits and their source for recent year classes used in predictions, and the relative (%) contributions to landings and SSB (by weight) of these year classes

Year-class	2008	2009	2010	2011	2012
Stock No. (thousands) of 1 year-olds	39186	48739	43527	23798	23798
Source	XSA	XSA	XSA	GM82-09	GM82-09
Status Quo F:					
% in 2012 landings	29.1	32.4	13.2	0.1	-
% in 2013 landings	17.3	33.9	26.7	6.8	0.1
% in 2012 SSB	27.6	42.7	0.0	0.0	-
% in 2013 SSB	16.6	31.4	33.8	0.0	0.0
% in 2014 SSB	12.1	22.4	30.7	21.2	0.0

GM : geometric mean recruitment

Sole VIId : Year-class % contribution to

a) 2013 landings



b) 2014 SSB

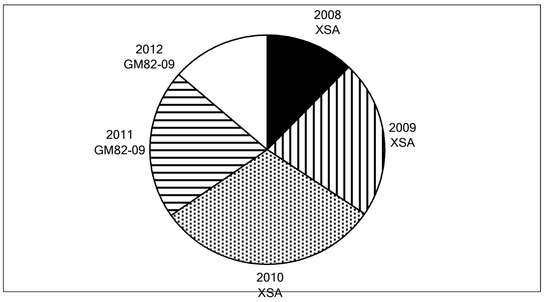


Table 9.7.1 - Sole in VIId Yield per recruit summary table

MFYPR version 2a
Run: S7d_Yield_fin
Time and date: 13:28 28/04/2012
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0.0000	0.0000	0.0000	0.0000	10.5083	3.7620	8.6035	3.5120	8.6035	3.5120
0.1000	0.0475	0.2580	0.0923	7.9310	2.5054	6.0264	2.2554	6.0264	2.2554
0.2000	0.0950	0.4010	0.1332	6.5050	1.8412	4.6007	1.5912	4.6007	1.5912
0.3000	0.1425	0.4903	0.1528	5.6145	1.4461	3.7105	1.1961	3.7105	1.1961
0.4000	0.1900	0.5508	0.1625	5.0126	1.1920	3.1088	0.9421	3.1088	0.9421
0.5000	0.2376	0.5942	0.1672	4.5819	1.0191	2.6785	0.7692	2.6785	0.7692
0.6000	0.2851	0.6267	0.1693	4.2601	0.8960	2.3570	0.6462	2.3570	0.6462
0.7000	0.3326	0.6519	0.1700	4.0114	0.8052	2.1085	0.5555	2.1085	0.5555
0.8000	0.3801	0.6720	0.1700	3.8135	0.7362	1.9109	0.4864	1.9109	0.4864
0.9000	0.4276	0.6883	0.1695	3.6526	0.6822	1.7502	0.4325	1.7502	0.4325
1.0000	0.4751	0.7020	0.1689	3.5190	0.6392	1.6169	0.3895	1.6169	0.3895
1.1000	0.5226	0.7135	0.1681	3.4062	0.6041	1.5044	0.3545	1.5044	0.3545
1.2000	0.5701	0.7234	0.1673	3.3097	0.5750	1.4082	0.3254	1.4082	0.3254
1.3000	0.6176	0.7320	0.1664	3.2260	0.5506	1.3248	0.3010	1.3248	0.3010
1.4000	0.6652	0.7396	0.1656	3.1526	0.5297	1.2517	0.2802	1.2517	0.2802
1.5000	0.7127	0.7463	0.1648	3.0877	0.5117	1.1870	0.2623	1.1870	0.2623
1.6000	0.7602	0.7523	0.1641	3.0297	0.4960	1.1293	0.2466	1.1293	0.2466
1.7000	0.8077	0.7578	0.1633	2.9775	0.4822	1.0774	0.2328	1.0774	0.2328
1.8000	0.8552	0.7627	0.1627	2.9303	0.4699	1.0304	0.2206	1.0304	0.2206
1.9000	0.9027	0.7672	0.1620	2.8872	0.4589	0.9876	0.2097	0.9876	0.2097
2.0000	0.9502	0.7713	0.1614	2.8478	0.4490	0.9485	0.1998	0.9485	0.1998

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 9.2.1a

Sole VIId - Effort series

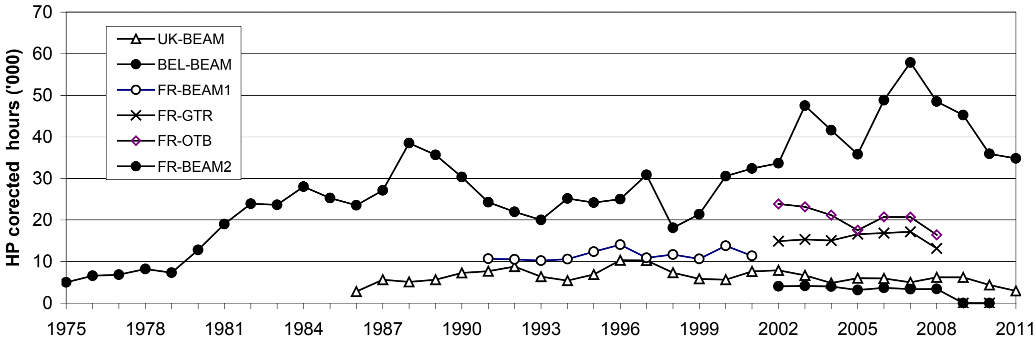


Figure 9.2.1b

Sole VIId - Relative Effort series

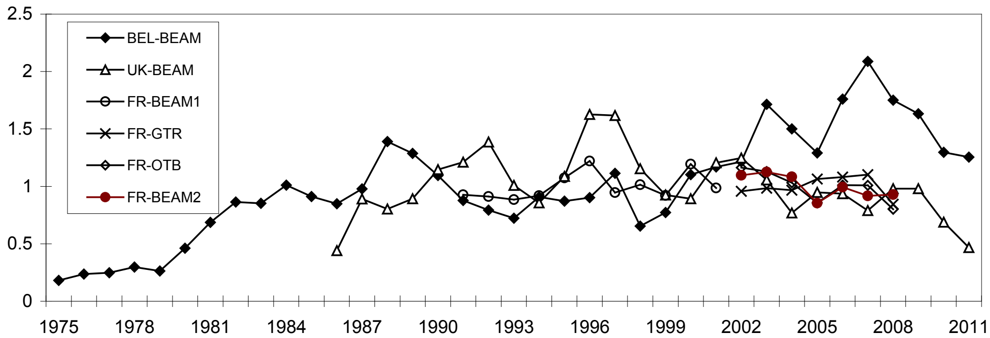
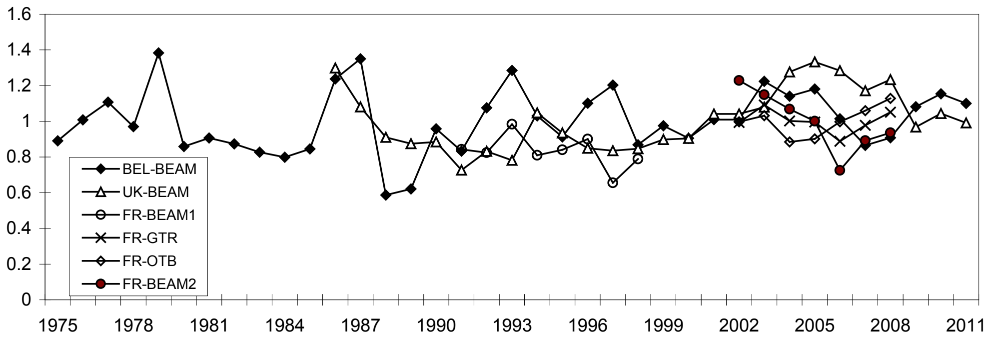


Figure 9.2.1c

Sole VIId - Relative LPUE series



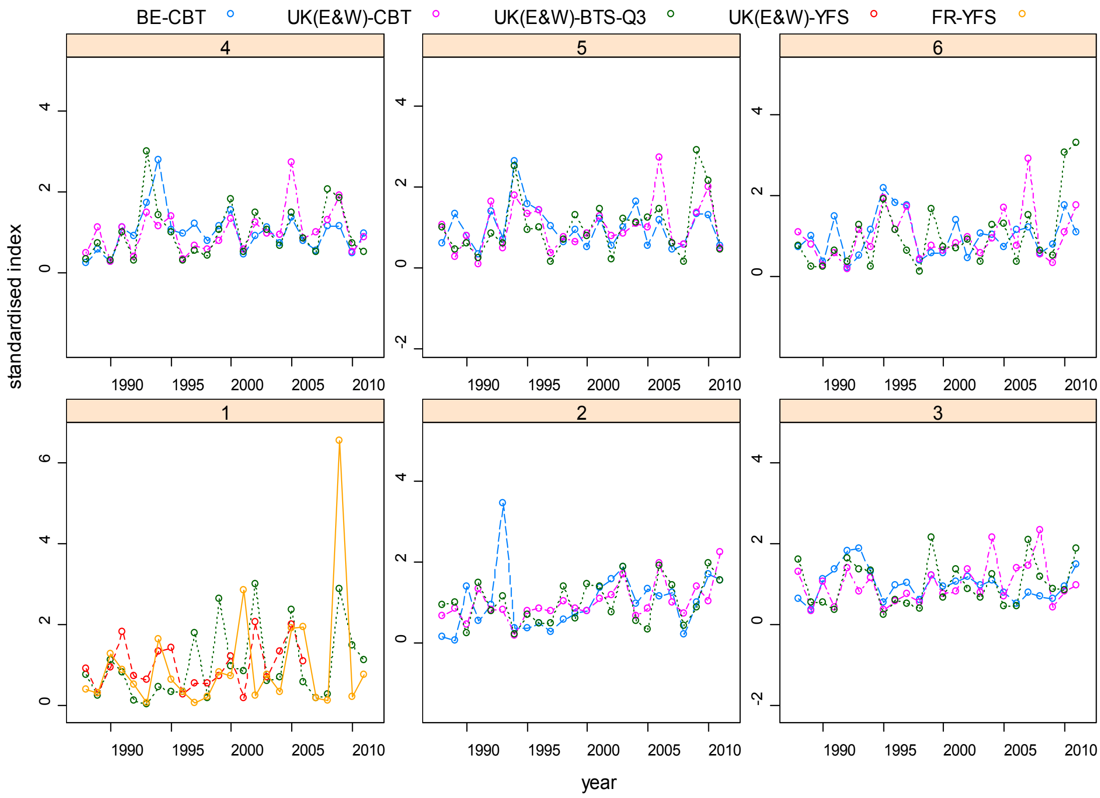


Figure 9.2.2 Sole in VIId. Standardized tuning indices used for tuning XSA: BE-CBT (blue), UK(E&W)-CBT (pink), UK-BTS (green) UK(E&W)YFS (red) and FR-YFS (orange).

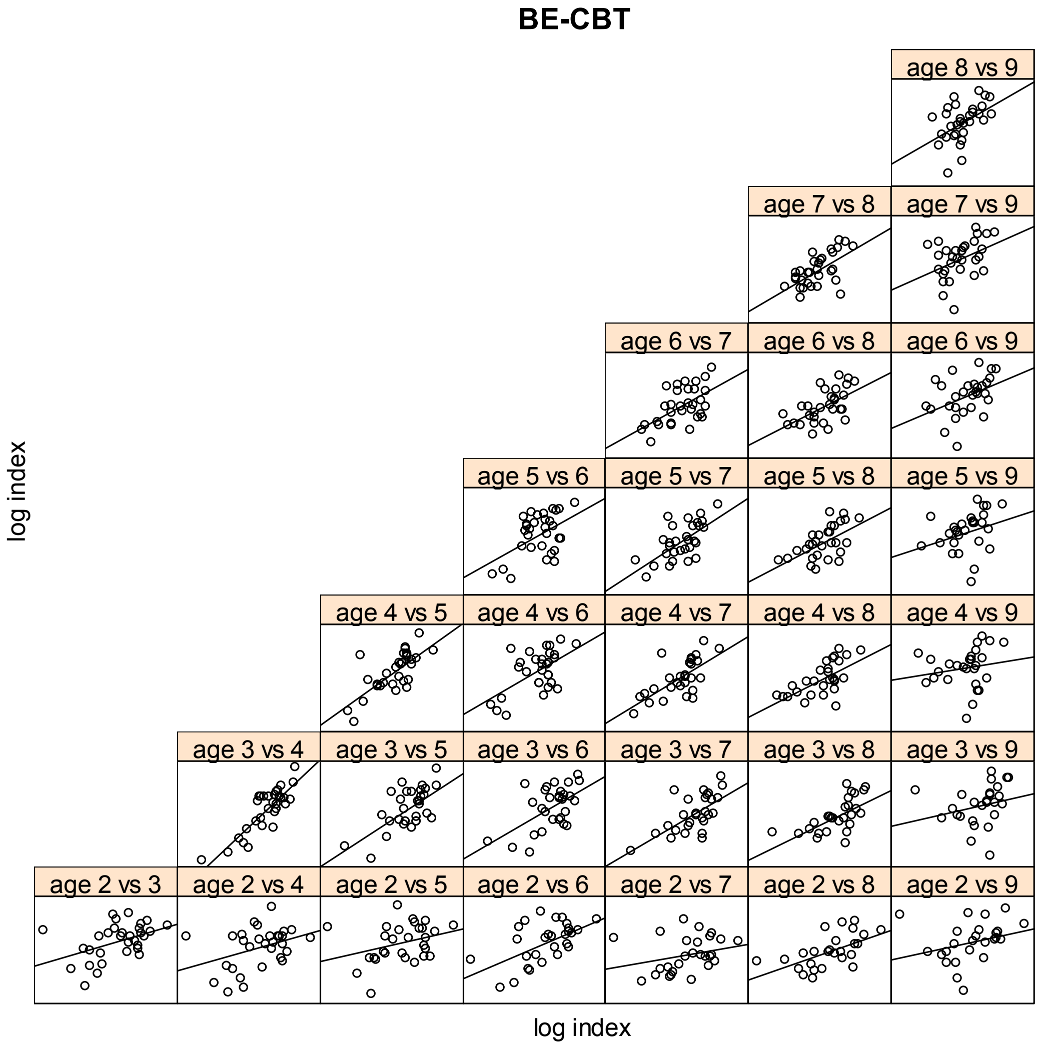


Figure 9.2.3 Sole in VIId. Internal concistency plot for the Belgian commercial fleet (BE-CBT).

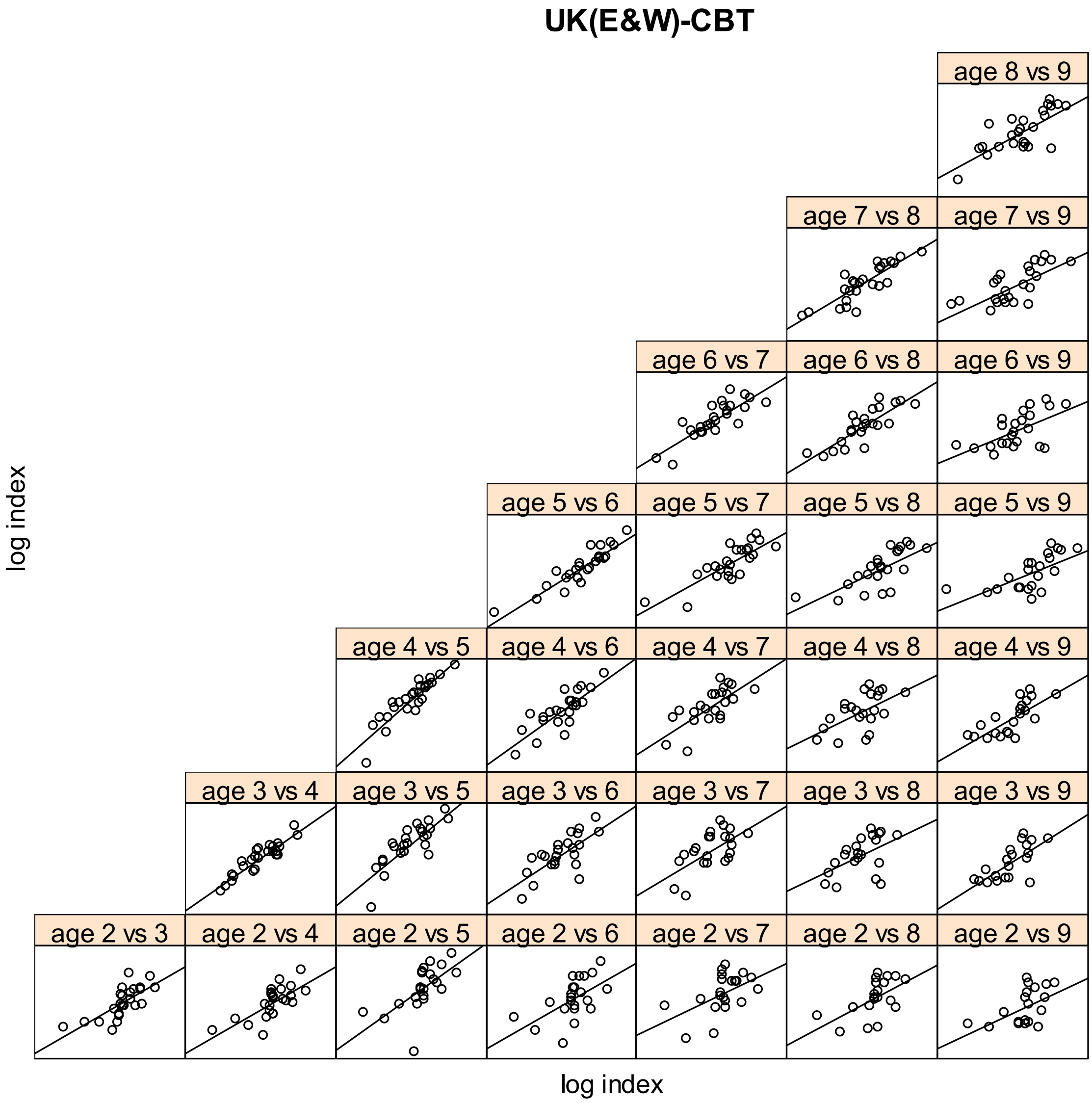


Figure 9.2.4 Sole in VIId. Internal concistency plot for the UK commercial fleet (UK(E&W)-CBT).

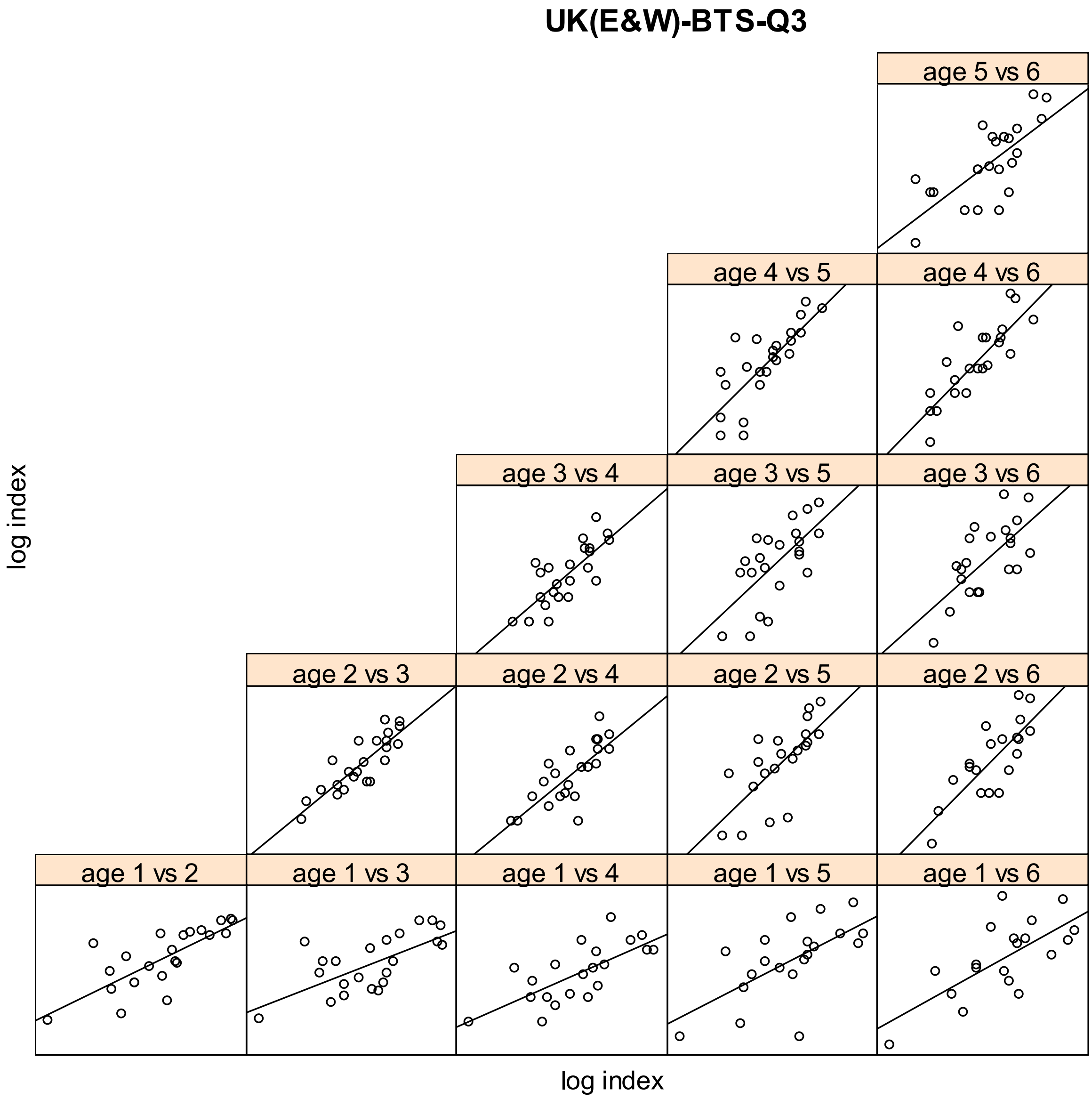


Figure 9.2.5 Sole in VIId. Internal concistency plot for the UK beam trawl survey (UK(E&W)-BTS).

Figure 9.3.1a - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

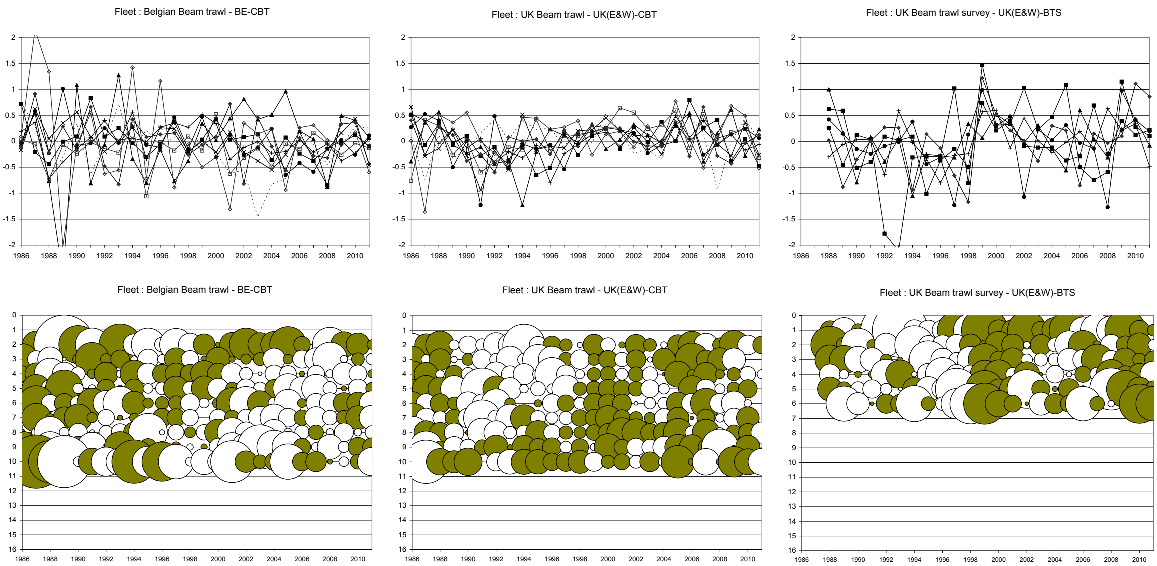


Figure 9.3.1b - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

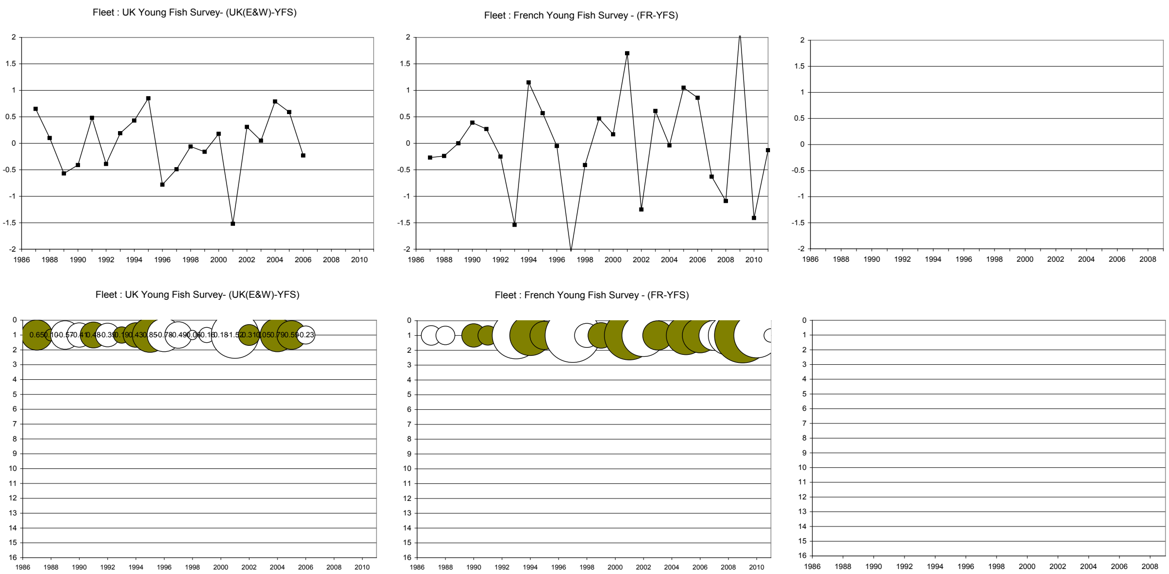
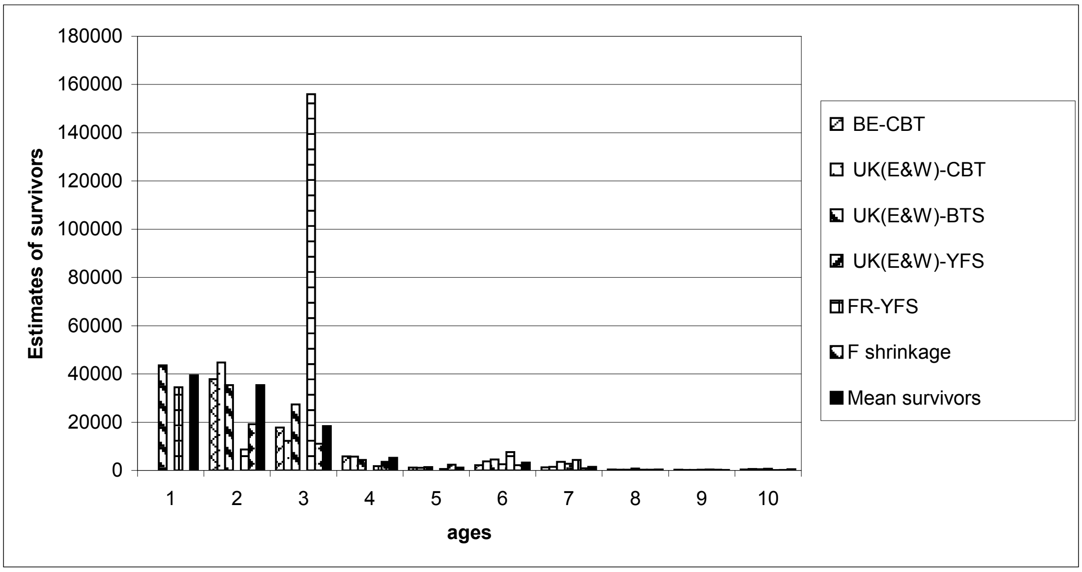


Figure 9.3.2 Sole in VIId. Estimates of survivors from different fleets and shrinkage, as well as their different weighting in the final XSA-run



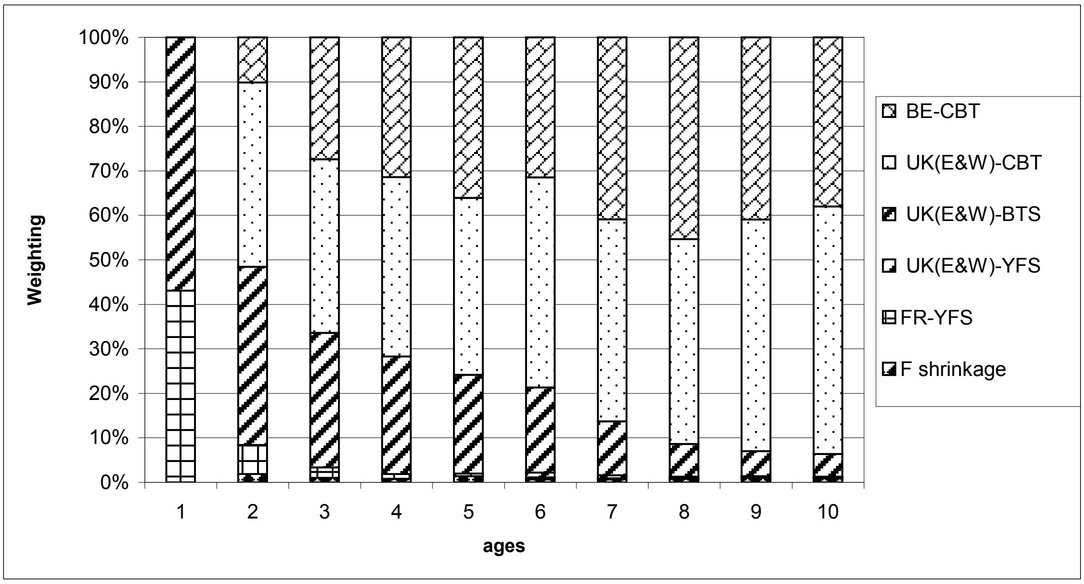


Figure 9.3.3 Sole in VIId. Summary plots

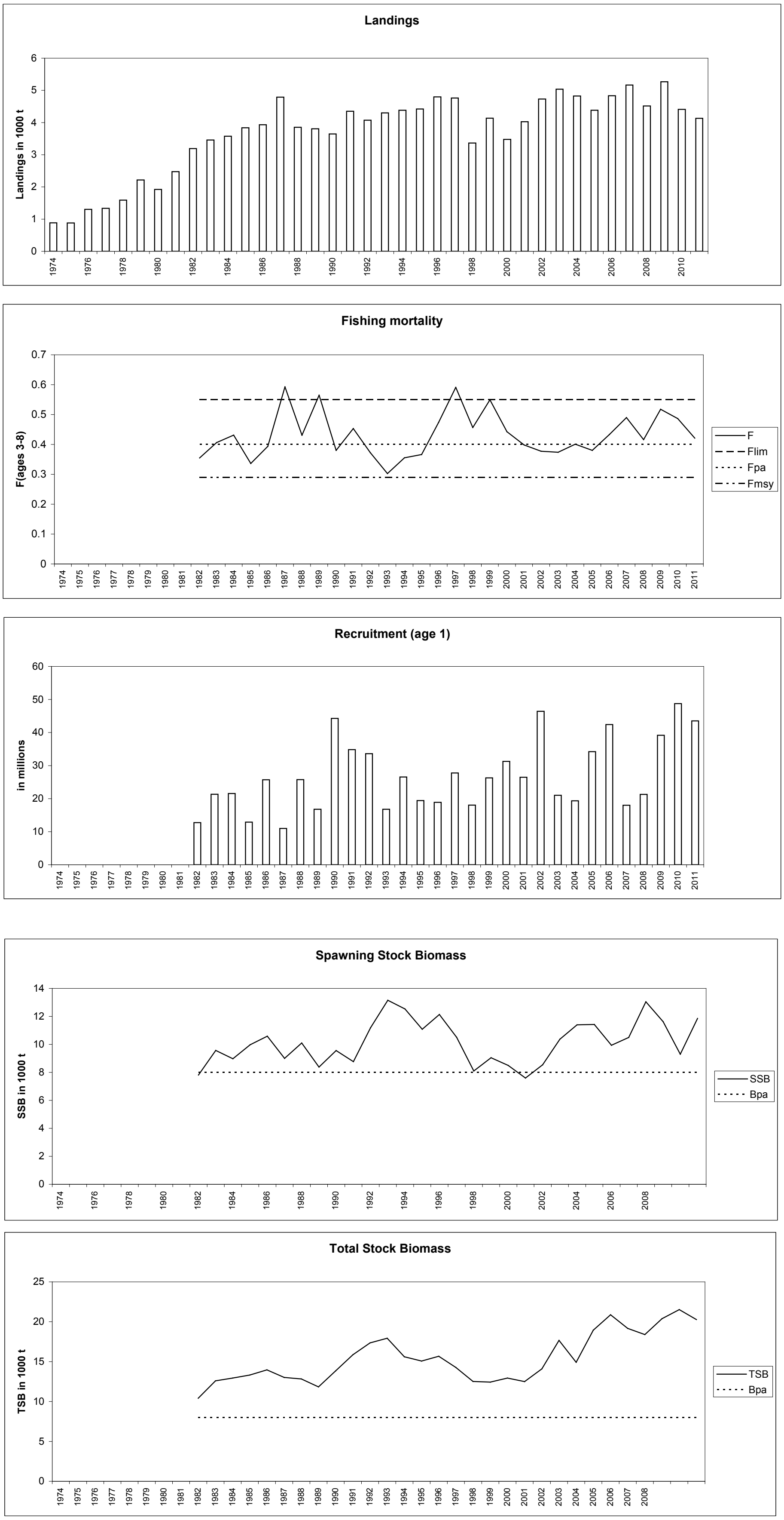


Figure 9.3.4 - Sole VIId retrospective XSA analysys (shinkage SE=2.0)

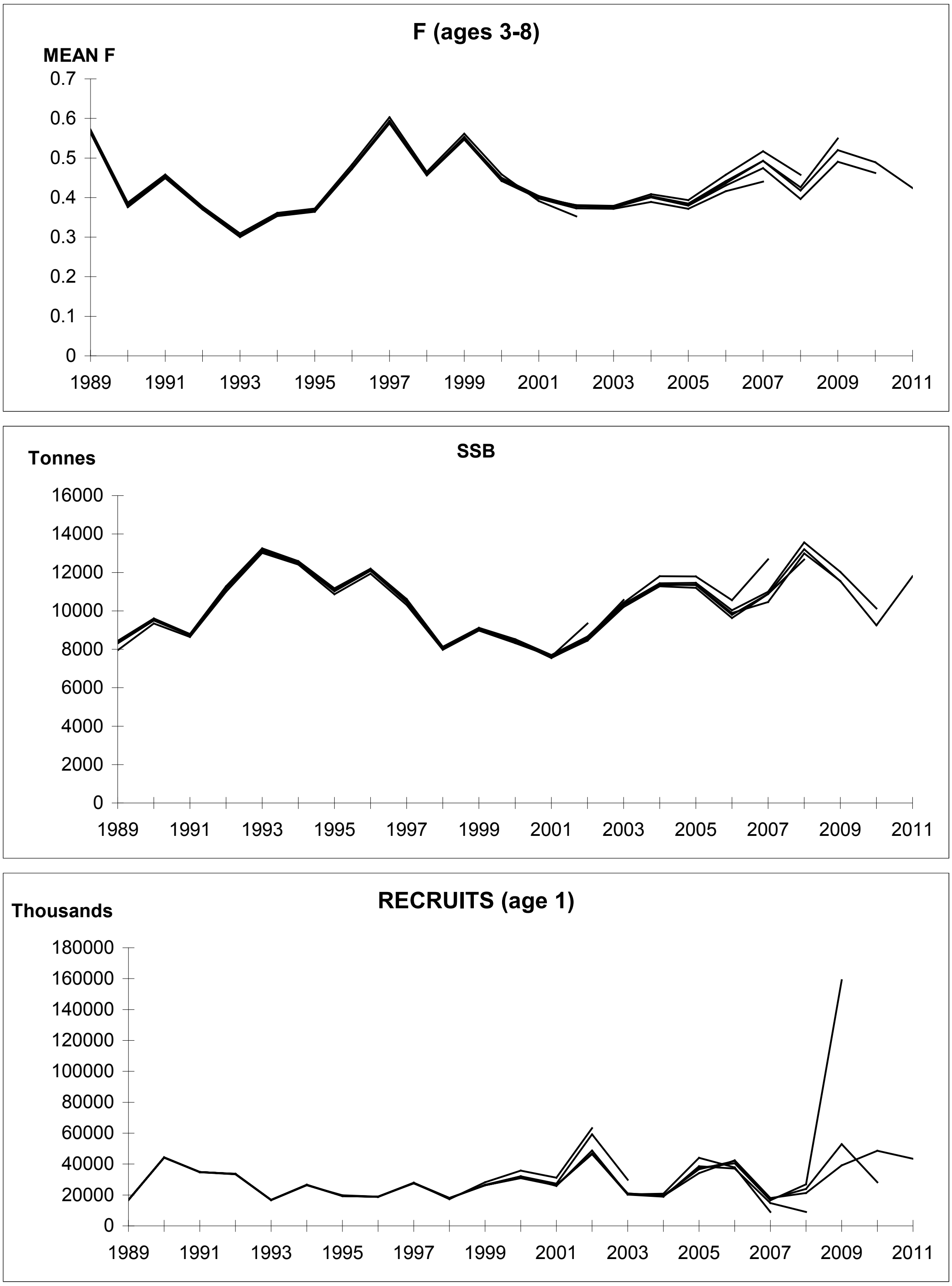
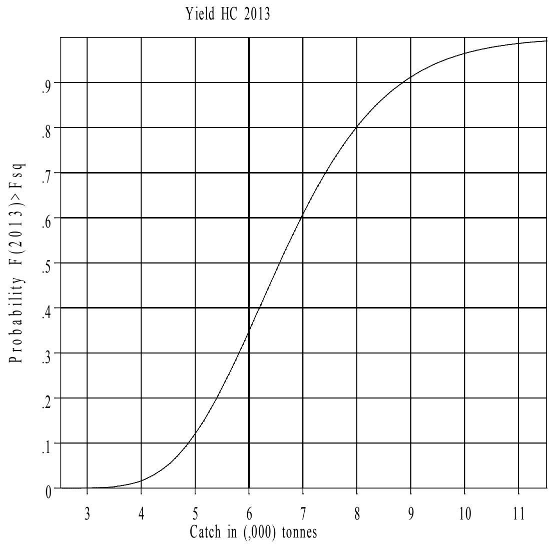
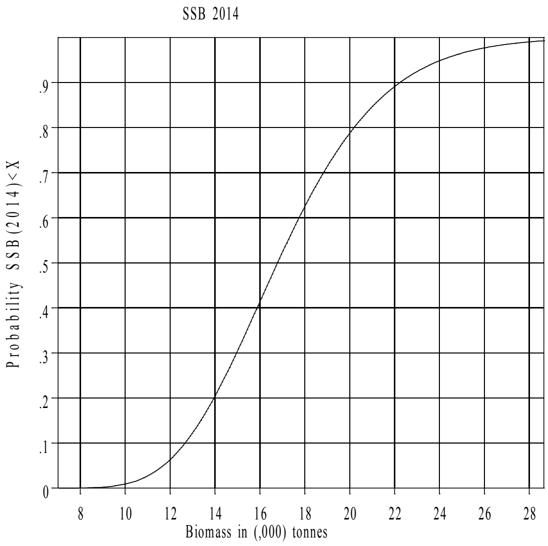


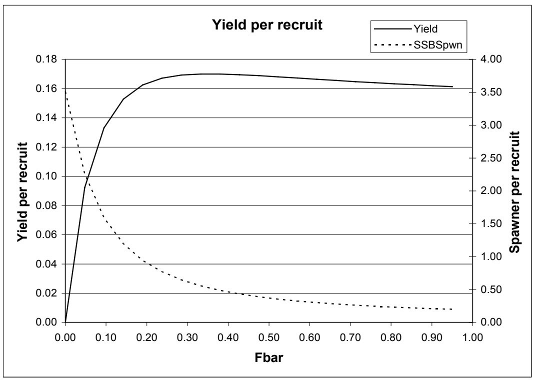
Figure Sole 9.6.1 - Sole VIId - Probability profiles for short term forecast.

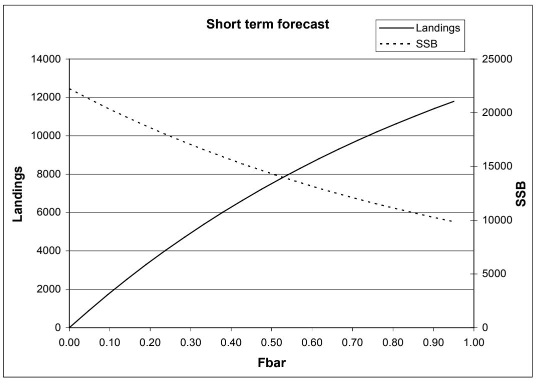




Data from file:C:\Sensitivity\Pie & profile\SOL7D_2012WG.SEN on 28/04/2012 at 15

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: 13:28 28/04/2012

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_TAC
Sole in VIId
Time and date: 12:48 28/04/2012
Fbar age range: 3-8

Input units are thousands and kg - output in tonnes

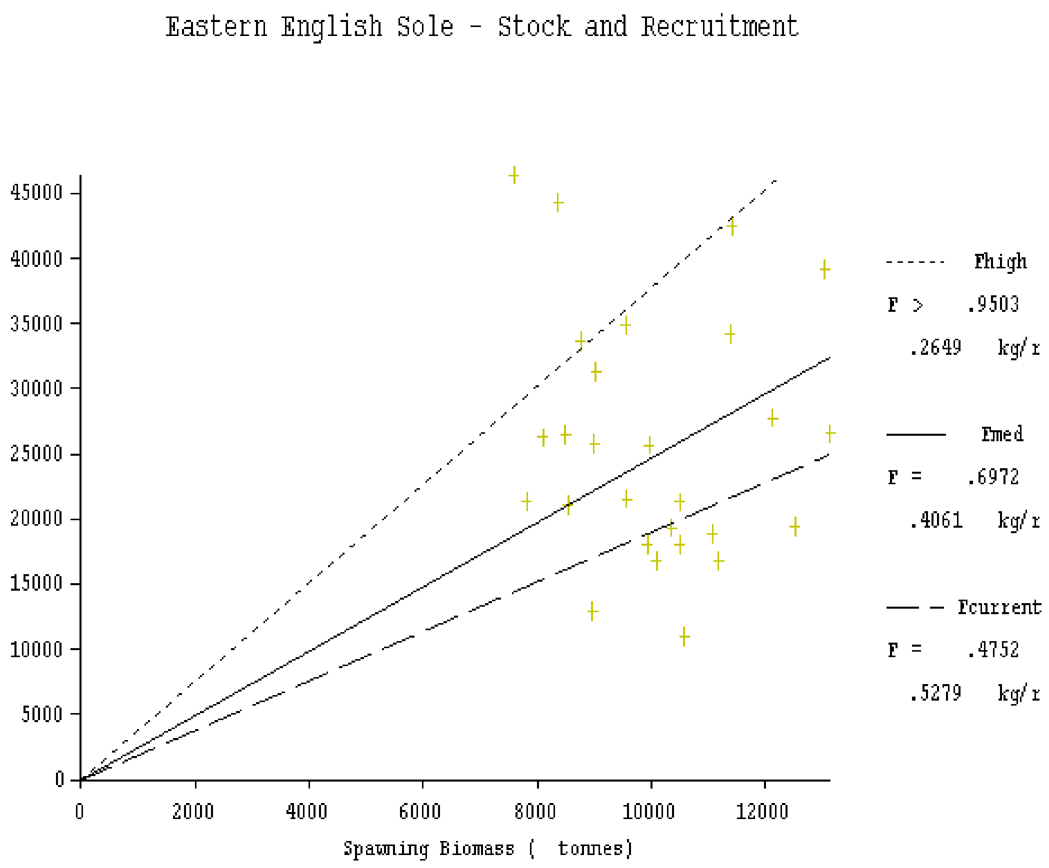
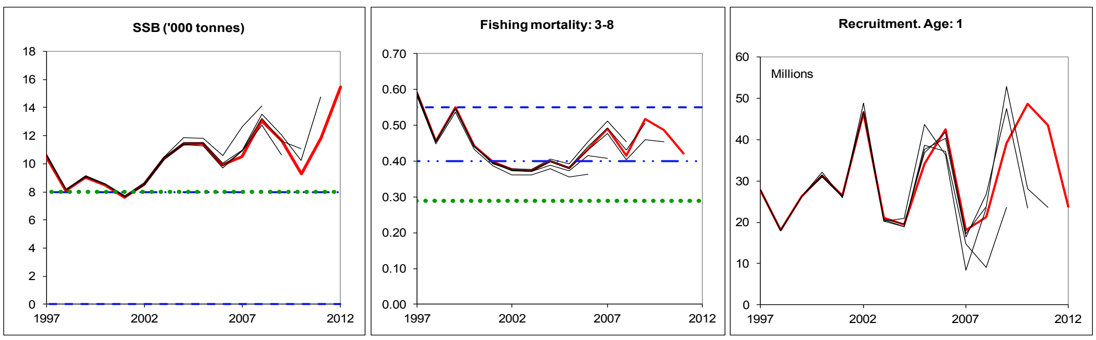


Figure 9.9.1 - Sole VIId Stock/recruitment plot

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 2011, which is not customary for this fleet considering the relatively high value of this species in the mixed fishery. Only 11 485 tonnes of their quota of 14 100 tonnes were utilised which represents only 81%. Part of the reason for this was that catch rates were relatively low in the gillnet fishery. Another reason was that part of the Dutch beam trawl fleet (28 vessels) changed gear to pulse trawl, for which the vessels were kept on shore to be rebuilt for a number of weeks. In the following three to four months they experiences a 'testing' phase with this new gear during which fishing success was relatively low. Finally, after this phase the general impression by the fishermen was that the rate of sole in their catches increased in comparison to their previously experienced catches with beam trawl.

10.1.3 ICES Advice for 2012

The information in this section is taken from the Advice summary sheet 2011, section 6.4.10.

During the autumn update the recruitment indices for 2011 were found to indicate stronger recruitment. The revised forecasts lead to a higher TAC being recommended by STECF - 16 200kt

Advice for 2012

ICES advises on the basis of the first stage of the EU management plan (Council Regulation No. 676/2007) that landings in 2012 should be no more than 15 700 t. ICES notes that according to the management plan, transitional arrangements to the second stage of the plan should be established since both North Sea sole and plaice have now been within safe biological limits for two consecutive years.

Management plan

Both the North Sea sole and plaice 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. Transitional arrangements for stage two (Article 5) should amend the objectives and the procedures for setting TACs and effort limitations, but these have not been decided on yet. Therefore, ICES advice is limited to the procedures defined for stage one.

Following the first stage of the EU management plan would imply a 10% reduction of F to 0.31, resulting in a TAC of 15 700 t in 2012 and implying a 10% reduction in fishing effort. This is expected to lead to an SSB of 45 600 t in 2013. The TAC increase of 11% is within the 15% bounds of the management plan TAC change constraints.

Following the second stage of the EU management plan would imply decreasing F to 0.2 (Article 4), resulting in a TAC of 11 000 t in 2012. This is expected to lead to an SSB of 50 100 t in 2013.

ICES has evaluated this management plan and considers it can be accepted as precautionary.

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 - 2011.

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.

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 and in 2011 approximately 80-90% 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). 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, gaps in the discard sampling programs result in incomplete time series. The inclusion of discards in the assessment of this stock may be considered further in future benchmarks.

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 3.7 in 2009, (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 estimations 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 6 in 2011. Log catch ratios and catch curves for sole ages 2 to 9 are summarised in Figures 10.2.2 A and B (1957 to 2011).

InterCatch

For WGNSSK 2012, InterCatch was used for raising the landings for the first time (see 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.
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 and WGNSSK2012. 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.). A very slight decrease in fishing effort (≈ 1%) was recorded for 2011.

The lpue estimated for 2011 (345 kg hpday^{-1}) was substantially above the 1997-2010 mean (261 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).

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 2.13.0.

Reviews of last year's assessment

Comments made in 2011 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 NS sole fishery is a mixed demersal fishery for flatfish. The minimum legal size of 24cm is appropriate for sole but may result in substantial discards of undersize plaice. Currently discards of North Sea sole are considered minimal at <20% and are not included in the assessment. However, as the working group points out the shift/concentration of fishing effort to the south may increase the discards of juveniles. This could subsequently have an impact on the assessment outputs and should be monitored.

WGNSSK 2012 reply: We agree with this comment, however discards were not included during the meeting. There remain significant time series and raising issues with regards to sole discard estimates and the data are not yet currently suitable for inclusion in the assessment. This issue will certainly be examined at the next benchmark of this stock.

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.

As with the Sole in Division IIIa a knife-edge maturity at age 3 is used for the assessment. This does not account for changes in maturity or size at maturity resulting from variability in the environmental factors. The 50% probability of maturation at age has *decreased from 29to 25cm. Consequently SSB is considered artificial. Natural mortality has also been fixed at 0.1 since the beginning of the time series, except for 1963 when it was changed to accommodate a severe winter. Recently there have been several cold years that may affect natural mortality the have not been considered. These changes/variability are not captured by the current assessment inputs.*

WGNSSK 2012 reply: It is acknowledged that the current SSB estimate is 'artificial'. An attempt was made to construct a more relevant maturity ogive during WKFLAT 2010 but there were insufficient data available for this purpose. With regards to the temperature induced mortality, it was not just the 2009-2010 and 2010-2011 winters wich were relatively cold, but also the 1995-1996 and 1996–1997 winters. It would require quite some effort to implement temperature based mortalities into the assessment as at present no fixed relationship has been established.

Technical comments

Benchmark assessment in 2010 explored a variety of input data combinations. The WKFLAT 2010 decided that XSA should continue to be used for providing advice, but SAM should be run concurrently. They also recommended replacing XSA with SAM after the next benchmark if no problems are encountered. The results from both models are generally comparable (SSB 2010 - SAM 34100 and XSA 35200). There is good correspondence in trends for all 3 indices of abundance tracking one another throughout the time series. Truncating the NL-BT survey before 1997 appears to have removed the persistent retrospective pattern, especially for F, that has plagued this stock assessment is assessments prior to the 2010 benchmark assessment. Although the XSA model settings have changed over the years, the historical biomass estimates have not changed substantially, therefore the reference points remain valid. The scenarios in the short-term forecasts for Fsq indicate an increase in SSB for both 2011 and 2012 with an increase in landings in 2011. Fishing at the current TAC will reduce F.

Conclusions

The assessment was consistent with previous XSA formulations updated for another year. Changes resulting from the 2010 benchmark workshop seem to have improved the overall performance of this assessment producing un-biased estimates of SSB, F, and recruitment.

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 outputs and time trends to the XSA. SSB, for example, estimated by SAM was 34 400 t in 2011 versus 34 700 t in 2011 for the Final XSA run (see Table 10.4.1).

10.4.2 Exploratory single fleet analyses

Three tuning indices were included in the assessment. When survey data (BTS-ISIS and SNS) were used alone in the assessment the retrospective pattern reverses. Survey data suggest higher Fs, 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 2011 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	2010	2011	2012
Catch at age	Landings	Landings	Landings
Fleets	BTS-Isis 1985–2009 SNS 1970–2009 Nl-BT 1990–2009	BTS-Isis 1985–2010 SNS 1970–2010 Nl-BT 1997–2010	BTS-Isis 1985–2011 SNS 1970–2011 Nl-BT 1997–2011
Plus group	10	10	10
First tuning year	1970	1970	1970
Last data year	2009	2010	2011
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 29 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 2010 was estimated at around 33 500 t (Table 10.4.1) which has increased slightly to around 34 700 t in 2011. Mean F(2–6) was estimated at 0.30 and has been stable since 2008 (see Table 10.4.1). Recruitment of the 2010 year class, age 1 in 2011, was estimated by the XSA at 91 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.

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 2011 landings were estimated to be around 11 500 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 2011 is estimated at around 34 700 t. Recruitment in 2011 of the 2010 year class at the age of 1 was estimated at 91 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 2010 value is 0.30 (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 1957–2008 was around 94 million (geometric mean). For year class 2011 (age 1 in 2012) the value predicted by the RCT3 was 62 621, slightly lower than the geometric mean (Table 10.5.2.). The estimate was based on the estimate of the DFS0 survey which showed such a large standard error (>1) that the geometric mean was accepted for the short-term forecasts.

For year class 2010 (age 2 in 2012), the data are also noisy (high s.e. of the predicted value, Table 10.5.3). 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 2011	XSA thousands	RCT3 thousands	GM(1957–2008) thousands
2010	2	**81 891**	88 852	82 525
2011	1		62 621	**93 669**
2012	Recruit			**93 669**

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). The exploitation pattern 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 and recruitment of the 2009 year-class are taken from the long-term geometric mean (1957–2009: 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 2011; A) F2012 is assumed to be equal to Fsq, F in 2011 rescaled to the average selection pattern from 2009 to 2011; B) F2012 is 0.9 times Fsq, rescaled; and C) F2012 is set such that the landings in 2012 equal the TAC of that same year. The table below shows the predicted F values in the intermediate year, SSB for 2013 and the corresponding landings for 2012, given the different assumptions about F in the intermediate year in the different scenarios.

Scenario	Assumption	F_{2012}	SSB_{2013}	$Landings_{2012}$
A	$F_{2012} = F_{sq}$	0.30	47 145	14 969
B	$F_{2012} = 0.9F_{sq}$	0.27	48 489	13 671
C	F~$Landings_{2012}$= TAC_{2012}	0.33	45 870	16 200

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 2012 and 2013, SSB is expected to increase to 47 100 t in 2013. The landings at Fsq are expected to be around 15 000 t in 2012 which is below the 2012 TAC (16 200t). The landings in 2013 are predicted to be around 15 100 t at Fsq.

Figure 10.5.1 shows the projected contribution of different sources of information to estimates of the landings in 2013 and of the SSB in 2014, when fishing at Fsq. Less than 1/8th of the predicted landings in 2013 will consist of uncertain year classes (2010–2011) relying on assumptions of the forecast (i.e. geometric mean recruitment). The contribution of these assumed year classes to the SSB forecasted in 2014 is slightly higher, approximately 25-30%. 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 and WGNSSK 2012 as no difference was apparent, see also Table 10.6.4 which was updated). Fmax is poorly defined at 0.55.

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 equilibrium analysis approach to determining FMSY, taking into account uncertainty in stock recruitment relationships.

On the basis of these analyses the working group has concluded that F=0.22 is an appropriate value for F_{MSY} for North Sea sole as it results in a high long term yield, with low risk to 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 rather stable SSB in 2011 (34 700t) compared to 2010 (33 500t) due in part the rather stable trend in fishing effort between 2008 and 2011 (see Table 10.2.7).

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 0.30 in 2011 which is below F_{pa} (=0.4). The SSB in 2011 was estimated at about 35 000 t which is above both B_{lim} (25 000t) and equal to B_{pa} (35 000 t). Two weak year classes in 2003 and 2004 were followed by a strong year class in 2005 the impact of which is still being seen in the SSB estimations. Projected landings for 2013 at Fsq are 15 163t, about the same amount as projected landings for 2012 (14 969).

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 was perceived as slightly lower, bringing it just under Bpa (SSB in 2011 and 2012 are perceived at and 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) and the relatively stable TAC for sole 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	Belgium	Denmark	France	Germany	Netherlands	UK (E/W/NI)	Other countries	Total reported	Unallocated landings	WG 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											

Table 10.2.2 Sole in sub-area IV: Overview of landings and discards numbers and weights (kg) per hour and there 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 (thousands)

2011-05-06 11:40:01 units= thousands

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0	1415	10148	12642	3762	2924	6518	1733	509	6288
1958	0	1854	8440	14169	9500	3484	3008	4439	2253	6557
1959	0	3659	12025	10401	8975	5768	1206	2025	2574	5615
1960	0	12042	14133	16798	9308	8367	4846	1593	1056	7901
1961	0	959	49786	19140	12404	4695	3944	4279	836	7254
1962	0	1594	6210	59191	15346	10541	4826	4112	2087	7494
1963	0	676	8339	8555	46201	8490	6658	2423	3393	8384
1964	55	155	2113	5712	3809	17337	3126	1810	818	3015
1965	0	47100	1089	1599	5002	2482	12500	1557	1525	3208
1966	0	12278	133617	990	1181	3689	744	6324	702	2450
1967	0	3686	25683	85127	1954	536	1919	760	5047	2913
1968	1037	17148	13896	24973	48571	462	245	1644	324	6523
1969	396	23922	21451	5326	12388	25139	331	244	1190	5272
1970	1299	6140	25993	8235	1784	3231	11960	246	140	5234
1971	420	33369	14425	12757	4485	1442	2327	7214	192	4594
1972	358	7594	36759	7075	4965	1565	523	1232	4706	2801
1973	703	12228	12783	16187	4025	2324	994	765	1218	5790
1974	101	15380	21540	5487	7061	1922	1585	658	401	4814
1975	264	22954	28535	11717	2088	3830	790	907	508	3445
1976	1041	3542	27966	14013	4819	966	1909	550	425	2663
1977	1747	22328	12073	15306	7440	1779	319	1112	256	2115
1978	27	25031	29292	6129	6639	4250	1738	611	646	1602
1979	9	8179	41170	16060	2996	3222	1747	816	241	1527
1980	637	1209	12511	17781	7297	1450	2197	1409	367	1203
1981	423	29217	3259	6866	8223	3661	948	886	766	908
1982	2660	26435	45746	1843	3535	4789	1678	615	605	1278
1983	389	34408	41386	21189	624	1378	1950	978	386	1176
1984	191	30734	43931	22554	8791	741	854	1043	524	894
1985	165	16618	43213	20286	9403	3556	209	379	637	975
1986	374	9363	18497	17702	7747	5515	2270	110	283	1682
1987	94	29053	22046	8899	6512	3119	1567	903	81	694
1988	10	13219	47182	15232	4381	3882	1551	891	524	317
1989	117	46387	18263	22654	4624	1653	1437	647	458	468
1990	863	11939	104454	9767	9194	3349	1043	1198	554	845
1991	120	13163	25420	77913	6724	3675	1736	719	730	1090
1992	980	6832	44378	16204	38319	2477	3041	741	399	1180
1993	54	50451	16768	31409	13869	24035	1489	1184	461	842
1994	718	7804	87403	13550	18739	5711	11310	464	916	908
1995	4801	12767	16822	68571	6308	7307	1995	6015	295	668
1996	172	18824	16190	16964	27257	3858	4780	943	3305	988
1997	1590	6047	23651	7325	5108	12793	1201	2326	333	1688
1998	244	56648	15141	14934	3496	1941	4768	794	1031	846
1999	287	15762	72470	8187	6111	1212	664	1984	331	812
2000	2351	15073	32738	42803	3288	2477	804	435	931	714
2001	884	25846	21595	19876	16730	1427	834	274	168	724
2002	1055	11053	32852	12290	8215	6448	673	597	89	364
2003	1048	32330	17498	16090	5820	3906	2430	400	128	451
2004	516	14950	47970	9524	7457	2165	901	961	389	389
2005	1156	7417	23141	29523	4262	3948	1524	616	785	401
2006	6814	9690	10109	9340	10640	1572	1533	704	363	538
2007	317	39888	10887	6447	5741	5513	824	729	501	544
2008	1920	6200	36690	5878	2870	2346	2562	439	481	450
2009	1616	10327	10678	26319	3250	1638	1577	1519	309	857
2010	371	11654	13348	8526	13617	1816	907	809	1195	690
2011	44	12008	19814	8390	5077	6444	984	432	283	766

Table 10.2.4 North Sea Sole. Numbers-at-age (x1000) and weights-at-age (kilograms) in the landings by quarter in 2011.

	Quarter 1		Quarter 2		Quarter 3		Quarter 4	
Age	numbers	weight	numbers	weight	numbers	weight	numbers	weight
1	2.9	0.149	7.8	0.046	31.7	0.008	1.2	0.160
2	479.6	0.128	962.8	0.141	3526.6	0.151	7038.8	0.172
3	5137.9	0.198	4358.6	0.179	6322.9	0.184	3995	0.221
4	2871	0.249	2248.5	0.223	1976.9	0.214	1293.5	0.246
5	1176	0.281	1401.4	0.261	1511.5	0.203	987.9	0.228
6	1884.5	0.332	1806.6	0.276	1684.6	0.216	1068.7	0.257
7	218.7	0.299	291.9	0.320	231.7	0.216	241.5	0.244
8	84.5	0.356	114.2	0.360	165.3	0.226	68	0.263
9	86.2	0.307	84.9	0.444	65.8	0.223	45.6	0.348
10	121.5	0.379	250.1	0.394	92.4	0.277	126.2	0.259
11	4.8	0.422	9.4	0.422	3.3	0.316	10.3	0.340
12	4.6	0.567	33	0.264	43.2	0.260	2.7	0.305
13	2.2	0.406	2.9	0.486	3	0.364	8.4	0.383
14	4	0.415	2.4	0.823	8.6	0.412	0	0
15	3.3	1.168	5.3	0.381	8.8	0.549	15.5	0.276

Table 10.2.5 Sole in sub-area IV: Landing weights at age (kg)

2011-05-06 11:42:06 units= kg

	age									
year	1	2	3	4	5	6	7	8	9	10
1957	0	0.154	0.177	0.204	0.248	0.279	0.29	0.335	0.436	0.408
1958	0	0.145	0.178	0.22	0.254	0.273	0.314	0.323	0.388	0.413
1959	0	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.426
1960	0	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.418
1961	0	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.419
1962	0	0.155	0.165	0.208	0.241	0.295	0.32	0.321	0.334	0.412
1963	0	0.163	0.171	0.219	0.258	0.309	0.323	0.387	0.376	0.485
1964	0.153	0.175	0.213	0.252	0.274	0.309	0.327	0.346	0.388	0.48
1965	0	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.48
1966	0	0.177	0.19	0.18	0.301	0.332	0.429	0.399	0.449	0.501
1967	0	0.192	0.201	0.252	0.277	0.389	0.419	0.339	0.424	0.491
1968	0.157	0.189	0.207	0.267	0.327	0.342	0.354	0.455	0.465	0.508
1969	0.152	0.191	0.196	0.255	0.311	0.373	0.553	0.398	0.468	0.523
1970	0.154	0.212	0.218	0.285	0.35	0.404	0.441	0.463	0.443	0.533
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.42	0.49	0.534	0.547
1972	0.169	0.204	0.252	0.334	0.434	0.425	0.532	0.485	0.558	0.629
1973	0.146	0.208	0.238	0.346	0.404	0.448	0.552	0.567	0.509	0.586
1974	0.164	0.192	0.233	0.338	0.418	0.448	0.52	0.559	0.609	0.653
1975	0.129	0.182	0.225	0.32	0.406	0.456	0.529	0.595	0.629	0.669
1976	0.143	0.19	0.222	0.306	0.389	0.441	0.512	0.562	0.667	0.665
1977	0.147	0.188	0.236	0.307	0.369	0.424	0.43	0.52	0.562	0.619
1978	0.152	0.196	0.231	0.314	0.37	0.426	0.466	0.417	0.572	0.666
1979	0.137	0.208	0.246	0.323	0.391	0.448	0.534	0.544	0.609	0.763
1980	0.141	0.199	0.244	0.331	0.371	0.418	0.499	0.55	0.598	0.684
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.63
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.58	0.656
1983	0.134	0.182	0.217	0.301	0.389	0.416	0.467	0.489	0.505	0.642
1984	0.153	0.171	0.221	0.286	0.361	0.386	0.465	0.555	0.575	0.634
1985	0.122	0.187	0.216	0.288	0.357	0.427	0.447	0.544	0.612	0.645
1986	0.135	0.179	0.213	0.299	0.357	0.407	0.485	0.543	0.568	0.61
1987	0.139	0.185	0.205	0.277	0.356	0.378	0.428	0.481	0.393	0.657
1988	0.127	0.175	0.217	0.27	0.354	0.428	0.484	0.521	0.559	0.712
1989	0.118	0.173	0.216	0.288	0.336	0.375	0.456	0.492	0.47	0.611
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.62
1991	0.127	0.186	0.21	0.263	0.315	0.436	0.443	0.467	0.507	0.558
1992	0.146	0.178	0.213	0.258	0.298	0.38	0.409	0.46	0.487	0.556
1993	0.097	0.167	0.196	0.239	0.264	0.3	0.338	0.441	0.496	0.603
1994	0.143	0.18	0.202	0.228	0.257	0.3	0.317	0.432	0.409	0.51
1995	0.151	0.186	0.196	0.247	0.265	0.319	0.344	0.356	0.444	0.591
1996	0.163	0.177	0.202	0.234	0.274	0.285	0.318	0.37	0.39	0.594
1997	0.151	0.18	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.44
1998	0.128	0.182	0.189	0.252	0.262	0.289	0.336	0.292	0.335	0.504
1999	0.163	0.179	0.212	0.229	0.287	0.324	0.354	0.372	0.372	0.453
2000	0.145	0.17	0.2	0.248	0.29	0.299	0.323	0.368	0.402	0.427
2001	0.143	0.185	0.202	0.27	0.275	0.333	0.391	0.414	0.433	0.493
2002	0.14	0.183	0.211	0.243	0.281	0.312	0.366	0.319	0.571	0.536
2003	0.136	0.182	0.214	0.256	0.273	0.317	0.34	0.344	0.503	0.431
2004	0.127	0.18	0.209	0.252	0.263	0.284	0.378	0.367	0.327	0.425
2005	0.172	0.185	0.207	0.243	0.241	0.282	0.265	0.377	0.318	0.401
2006	0.156	0.19	0.22	0.263	0.291	0.322	0.293	0.358	0.397	0.397
2007	0.154	0.18	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.326
2008	0.15	0.181	0.223	0.24	0.265	0.324	0.314	0.297	0.307	0.418
2009	0.138	0.185	0.202	0.256	0.275	0.278	0.325	0.334	0.303	0.398
2010	0.163	0.181	0.22	0.236	0.273	0.308	0.283	0.311	0.361	0.381
2011	0.152	0.162	0.194	0.233	0.242	0.274	0.272	0.293	0.335	0.346

Table 10.2.6 Sole in sub-area IV: Stock weights at age (kg) 2011-05-06 11:42:40 units= kg

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.025	0.070	0.147	0.187	0.208	0.253	0.262	0.355	0.390	0.365
1958	0.025	0.070	0.164	0.205	0.226	0.228	0.297	0.318	0.393	0.422
1959	0.025	0.070	0.159	0.198	0.239	0.271	0.292	0.276	0.303	0.426
1960	0.025	0.070	0.163	0.207	0.234	0.240	0.268	0.242	0.360	0.431
1961	0.025	0.070	0.148	0.206	0.235	0.232	0.259	0.274	0.281	0.396
1962	0.025	0.070	0.148	0.192	0.240	0.301	0.293	0.282	0.273	0.441
1963	0.025	0.070	0.148	0.193	0.243	0.275	0.311	0.363	0.329	0.465
1964	0.025	0.070	0.159	0.214	0.240	0.291	0.305	0.306	0.365	0.474
1965	0.025	0.140	0.198	0.223	0.251	0.297	0.337	0.358	0.526	0.460
1966	0.025	0.070	0.160	0.149	0.389	0.310	0.406	0.377	0.385	0.505
1967	0.025	0.177	0.164	0.235	0.242	0.399	0.362	0.283	0.381	0.459
1968	0.025	0.122	0.171	0.248	0.312	0.280	0.629	0.416	0.410	0.486
1969	0.025	0.137	0.174	0.252	0.324	0.364	0.579	0.415	0.469	0.521
1970	0.025	0.137	0.201	0.275	0.341	0.367	0.423	0.458	0.390	0.554
1971	0.034	0.148	0.213	0.313	0.361	0.410	0.432	0.474	0.483	0.533
1972	0.038	0.155	0.218	0.313	0.419	0.443	0.443	0.443	0.508	0.602
1973	0.039	0.149	0.226	0.322	0.371	0.433	0.452	0.472	0.446	0.536
1974	0.035	0.146	0.218	0.329	0.408	0.429	0.499	0.565	0.542	0.618
1975	0.035	0.148	0.206	0.311	0.403	0.446	0.508	0.582	0.580	0.650
1976	0.035	0.142	0.201	0.301	0.379	0.458	0.508	0.517	0.644	0.665
1977	0.035	0.147	0.202	0.291	0.365	0.409	0.478	0.487	0.531	0.644
1978	0.035	0.139	0.211	0.290	0.365	0.429	0.427	0.385	0.542	0.644
1979	0.045	0.148	0.211	0.300	0.352	0.429	0.521	0.562	0.567	0.743
1980	0.039	0.157	0.200	0.304	0.345	0.394	0.489	0.537	0.579	0.645
1981	0.050	0.137	0.200	0.305	0.364	0.402	0.454	0.522	0.561	0.622
1982	0.050	0.130	0.193	0.270	0.359	0.411	0.429	0.476	0.583	0.642
1983	0.050	0.140	0.200	0.285	0.329	0.435	0.464	0.483	0.510	0.636
1984	0.050	0.133	0.203	0.268	0.348	0.386	0.488	0.591	0.567	0.664
1985	0.050	0.127	0.185	0.267	0.324	0.381	0.380	0.626	0.554	0.642
1986	0.050	0.133	0.191	0.278	0.345	0.423	0.495	0.487	0.587	0.686
1987	0.050	0.154	0.191	0.262	0.357	0.381	0.406	0.454	0.332	0.620
1988	0.050	0.133	0.193	0.260	0.335	0.409	0.417	0.474	0.486	0.654
1989	0.050	0.133	0.195	0.290	0.350	0.340	0.411	0.475	0.419	0.595
1990	0.050	0.148	0.203	0.294	0.357	0.447	0.399	0.494	0.481	0.653
1991	0.050	0.139	0.184	0.254	0.301	0.413	0.447	0.522	0.548	0.573
1992	0.050	0.156	0.194	0.257	0.307	0.398	0.406	0.472	0.500	0.540
1993	0.050	0.128	0.184	0.229	0.265	0.293	0.344	0.482	0.437	0.583
1994	0.050	0.143	0.174	0.209	0.257	0.326	0.349	0.402	0.494	0.459
1995	0.050	0.151	0.179	0.240	0.253	0.321	0.365	0.357	0.545	0.545
1996	0.050	0.147	0.178	0.208	0.274	0.268	0.321	0.375	0.402	0.546
1997	0.050	0.150	0.190	0.225	0.252	0.303	0.319	0.325	0.360	0.424
1998	0.050	0.140	0.173	0.234	0.267	0.281	0.328	0.273	0.336	0.455
1999	0.050	0.131	0.187	0.216	0.259	0.296	0.340	0.322	0.369	0.464
2000	0.050	0.139	0.185	0.226	0.264	0.275	0.287	0.337	0.391	0.376
2001	0.050	0.144	0.185	0.223	0.263	0.319	0.327	0.421	0.410	0.530
2002	0.050	0.145	0.197	0.245	0.267	0.267	0.299	0.308	0.435	0.435
2003	0.050	0.146	0.194	0.240	0.256	0.288	0.330	0.312	0.509	0.470
2004	0.050	0.137	0.195	0.240	0.245	0.305	0.316	0.448	0.356	0.601
2005	0.050	0.150	0.189	0.234	0.237	0.258	0.276	0.396	0.369	0.428
2006	0.050	0.148	0.197	0.250	0.270	0.319	0.286	0.341	0.409	0.456
2007	0.050	0.152	0.179	0.216	0.242	0.245	0.275	0.252	0.257	0.364
2008	0.050	0.154	0.198	0.212	0.239	0.302	0.282	0.231	0.274	0.400
2009	0.050	0.142	0.185	0.232	0.255	0.279	0.283	0.333	0.302	0.390
2010	0.050	0.149	0.200	0.230	0.272	0.307	0.336	0.336	0.361	0.410
2011	0.050	0.141	0.179	0.223	0.261	0.276	0.320	0.360	0.444	0.391

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(new) HP days (10^6)	Lpue(new) kg 1000HP days^{-1}
1997	11894.4	72.0	165.2
1998	17606.2	70.2	250.8
1999	19086.3	67.3	283.6
2000	16750.8	68.4	244.9
2001	16197.3	64.8	250
2002	13789.4	59.1	233.3
2003	14442.8	55.7	259.3
2004	14862.9	51.5	288.6
2005	12775.8	52.4	243.8
2006	8396.6	46.9	179
2007	11085.4	45.1	245.8
2008	9455.6	32.5	290.9
2009	12038	34	354.1
2010	12603	34.3	367.4
2011	11485	33.3	344.9

Table 10.2.8 Sole in subarea IV: Tuning data. BTS and SNS surveys and commercial series from NL beam trawl.

2011-05-06 12:16:09[1] BTS-ISIS units= NA

		1	2	3	4	5	6	7	8	9
1985	1	7.031	7.121	3.695	1.654	0.688	0.276	0	0	0
1986	1	7.168	5.183	1.596	0.987	0.623	0.171	0.158	0	0.018
1987	1	6.973	12.548	1.834	0.563	0.583	0.222	0.228	0.058	0
1988	1	83.111	12.512	2.684	1.032	0.123	0.149	0.132	0.103	0.014
1989	1	9.015	68.084	4.191	4.096	0.677	0.128	0.242	0	0.051
1990	1	37.839	24.487	21.789	0.778	1.081	0.77	0.12	0.115	0.025
1991	1	4.035	28.841	6.872	6.453	0.136	0.135	0.063	0.045	0.013
1992	1	81.625	22.284	10.449	2.529	3.018	0.09	0.162	0.078	0.02
1993	1	6.35	42.345	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	1	7.66	7.121	19.743	0.124	1.636	0.088	0.983	0.009	0
1995	1	28.125	8.458	6.268	5.129	0.363	0.805	0.316	0.734	0.039
1996	1	3.975	7.634	1.955	1.785	2.586	0.326	0.393	0.052	0.264
1997	1	169.343	4.919	2.985	0.739	0.71	0.38	0.096	0.035	0.042
1998	1	17.108	27.422	1.862	1.242	0.073	0.015	0.391	0	0
1999	1	11.96	18.363	15.783	0.584	1.92	0.31	0.218	0.604	0.003
2000	1	14.594	6.144	4.045	1.483	0.263	0.141	0.06	0.007	0.15
2001	1	7.998	9.963	2.156	1.564	0.684	0.074	0.037	0.028	0
2002	1	20.989	4.182	3.428	0.886	0.363	0.361	0.032	0.069	0
2003	1	10.507	9.947	2.459	1.67	0.36	0.187	0.319	0	0.02
2004	1	4.192	4.354	3.553	0.644	0.626	0.118	0.07	0.073	0
2005	1	5.534	3.395	2.377	1.303	0.167	0.171	0.077	0.047	0
2006	1	17.089	2.332	0.278	0.709	0.479	0.151	0.088	0	0.007
2007	1	7.498	19.504	1.464	0.565	0.315	0.537	0.031	0.009	0
2008	1	15.247	9.062	12.298	1.313	0.222	0.279	0.202	0.028	0.047
2009	1	15.95	4.999	2.858	4.791	0.252	0.124	0.272	0.079	0
2010	1	54.81	10.71	2.027	0.774	1.252	0.143	0.122	0.005	0.027
2011	1	26.17	17.39	4.006	1.094	0.778	0.828	0.013	0	0.141

Table 10.2.8 cont.

SNS units= NA

		1	2	3	4
1970	1	5410	734	238	35
1971	1	903	1831	113	3
1972	1	1455	272	149	0
1973	1	5587	935	84	37
1974	1	2348	361	65	0
1975	1	525	865	177	18
1976	1	1399	74	229	27
1977	1	3743	776	104	43
1978	1	1548	1355	294	28
1979	1	94	408	301	78
1980	1	4313	89	109	61
1981	1	3737	1413	50	20
1982	1	5857	1146	228	7
1983	1	2621	1123	121	40
1984	1	2493	1100	318	74
1985	1	3619	716	167	49
1986	1	3705	458	69	31
1987	1	1948	944	65	21
1988	1	11227	594	282	82
1989	1	2831	5005	208	53
1990	1	2856	1120	914	100
1991	1	1254	2529	514	624
1992	1	11114	144	360	195
1993	1	1291	3420	154	213
1994	1	652	498	934	10
1995	1	1362	224	143	411
1996	1	218	349	30	36
1997	1	10279	154	190	27
1998	1	4095	3126	142	99
1999	1	1649	972	456	10
2000	1	1639	126	166	118
2001	1	970	655	107	36
2002	1	7548	379	195	0
2003	1	NA	NA	NA	NA
2004	1	1370	624	393	69
2005	1	568	163	124	0
2006	1	2726	117	25	30
2007	1	849	911	33	40
2008	1	1259	259	325	0
2009	1	1932	344	62	103
2010	1	2637	237	67	42
2011	1	1248	884	21	112

NL Beam Trawl units= NA

	Effort	2	3	4	5	6	7	8	9
1997	80.5	56	229	56	41.4	121.38	6.17	22.36	1.18
1998	89.2	566.9	101	124.7	20.5	12.85	38.06	2.37	3.778
1999	82.3	143.6	670	50.5	54.2	8.87	4.08	18.55	1.616
2000	68.4	180	432	317.9	29.9	23.1	6.65	4.71	9.371
2001	64.8	289	211	231	201.9	11.13	7.81	2.1	1.435
2002	59.1	152.4	420	134.3	102.1	85.99	7.17	6.5	0.914
2003	55.7	465.8	207	223.4	61	50.7	35.22	4.04	1.113
2004	51.5	217.3	723	109.4	98.2	23.11	12.43	10.52	2.621
2005	52.4	96.6	312	401.3	72.4	38.19	17.58	5.52	11.813
2006	46.9	144.8	166	143	175.4	20.34	20.15	11.13	5.736
2007	45.1	737.8	170	99.4	81.1	81.95	7.43	7.23	2.816
2008	32.5	145.1	885	100.2	57.4	39.02	44.15	6.09	5.446
2009	34	254.6	227	562.9	59.2	32.35	27.56	23.38	1.824
2010	34.3	258.2	295	151.9	299.9	30.35	19.74	13.29	21.662
2011	33.3	290.2	474	182.3	98.1	134.98	14.44	8.83	3.964

Table 10.3.1. Sole in sub area IV: XSA diagnostics

FLR XSA Diagnostics 2012-04-30 18:21:15

CPUE data from indices

Catch data for 55 years. 1957 to 2011. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-ISIS	1	9	1985	2011	0.66	0.75
2	SNS	1	4	1970	2011	0.66	0.75
3	NL Beam Trawl	2	9	1997	2011	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

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.006	0.014	0.012	0.026	0.035	0.006	0.028	0.017	0.003	0.001
2	0.232	0.229	0.242	0.217	0.275	0.265	0.137	0.186	0.146	0.101
3	0.626	0.611	0.548	0.632	0.455	0.499	0.370	0.327	0.346	0.351
4	0.646	0.637	0.707	0.686	0.500	0.521	0.488	0.438	0.418	0.339
5	0.728	0.644	0.610	0.710	0.499	0.581	0.410	0.485	0.377	0.417
6	0.656	0.827	0.465	0.676	0.548	0.463	0.440	0.385	0.487	0.274
7	0.468	0.488	0.398	0.617	0.535	0.549	0.360	0.528	0.339	0.471
8	1.011	0.498	0.321	0.460	0.571	0.465	0.564	0.334	0.502	0.239
9	0.560	0.535	1.180	0.419	0.479	0.932	0.566	0.891	0.423	0.290
10	0.560	0.535	1.180	0.419	0.479	0.932	0.566	0.891	0.423	0.290

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10
2002	184631	56071	74208	27161	16700	14090	1893	986	218	888
2003	81869	166057	40221	35897	12886	7297	6616	1073	325	1139
2004	44666	73081	119501	19749	17175	6124	2887	3675	590	584
2005	48057	39925	51906	62499	8810	8448	3481	1755	2411	1227
2006	205913	42384	29070	24954	28468	3917	3888	1700	1002	1478
2007	56682	179836	29133	16688	13695	15638	2049	2060	869	936
2008	72568	50987	124780	16005	8967	6931	8906	1070	1171	1090
2009	101246	63836	40237	78005	8890	5384	4039	5621	551	1516
2010	145457	90074	47938	26251	45546	4953	3313	2155	3641	2094
2011	90550	131262	70417	30679	15643	28259	2754	2135	1180	3186

```
Estimated population abundance at 1st Jan  2012
      age
year   1      2      3      4      5     6      7    8    9  10
  2012 0  81891 107348 44868 19779 9325 19441 1556 1521 799
```

```
 Fleet:  BTS-ISIS
 Log catchability residuals.
```

age	year 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	-0.215	-0.695	-0.132	-0.143	-0.285	0.132	-0.404	0.04	-0.145	0.104	0.441	-0.15	0.633	0.026
2	0.053	-0.535	-0.248	0.532	0.305	0.736	0.377	1.06	0.135	-0.049	0.445	-0.16	-0.07	0.037
3	-0.026	-0.236	-0.496	-0.578	0.555	0.164	0.482	0.373	-0.742	0.442	0.855	0.239	0.067	0.116
4	0.254	-0.251	-0.282	-0.039	0.907	-0.22	-0.181	0.32	0.64	-2.164	0.163	0.808	0.351	0.304
5	-0.022	0.221	0.036	-0.957	0.283	0.425	-1.045	-0.217	1.565	0.307	-0.234	0.446	0.99	-0.977
6	0.151	-0.398	0.094	-0.436	-0.129	1.227	-0.875	-0.506	1.329	-0.906	0.489	0.744	-0.406	-1.785
7	NA	0.265	0.414	0.115	0.518	0.256	-0.742	-0.095	-1.135	-0.033	1.19	0.451	0.199	0.313
8	NA	NA	0.044	0.153	NA	0.474	-0.047	0.026	-0.063	-1.342	0.221	0.455	-0.996	NA
9	NA	-0.108	NA	-0.447	-0.066	-0.32	-0.676	-0.045	0.174	NA	0.913	-0.29	1.525	NA
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
	0.072	-0.112	0.055	-0.218	0.008	-0.045	0.057	-0.399	0.093	0.305	0.079	0.477	0.424	
	0.426	-0.297	-0.169	-0.409	-0.63	-0.626	-0.288	-0.683	-0.011	0.392	-0.392	-0.003	0.073	
	0.676	0.053	-0.2	-0.034	0.236	-0.529	-0.038	-1.729	-0.039	0.543	0.186	-0.32	-0.02	
	0.027	-0.562	0.19	-0.086	0.263	-0.043	-0.505	-0.326	-0.136	0.725	0.401	-0.347	-0.213	
	1.77	0.118	-0.331	-0.299	-0.107	0.135	-0.448	-0.716	-0.346	-0.392	-0.204	-0.311	0.31	
	1.417	0.252	-0.281	0.018	0.139	-0.401	-0.203	0.351	0.175	0.318	-0.279	0.019	-0.117	
	1.502	0.567	-0.45	-0.643	0.42	-0.331	-0.269	-0.303	-0.696	-0.424	0.782	0.045	-1.916	
	1.454	-1.107	0.723	1.16	NA	-0.584	-0.188	NA	-1.997	-0.138	-0.921	-2.604	NA	
	-0.818	0.7	NA	NA	0.698	NA	NA	-1.518	NA	0.291	NA	-1.498	1.188	

```
 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 -8.8606 -9.4370 -9.7194 -9.8544 -10.0576 -9.9451 -9.9451 -9.9451
S.E_Logq   0.4342  0.5247  0.5840  0.6707   0.6898  0.7152  1.0036  0.8565
```

```
 Regression statistics
 Ages with q dependent on year class strength
          slope intercept
Age 1 0.7366305  9.532242
```

```
 Fleet:  SNS
 Log catchability residuals.
```

age	year 1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.29	0.172	-0.007	0.511	-0.013	-0.11	-0.323	0.071	0.387	-0.141	0.089	0.022	0.263	-0.14
2	0.815	0.863	0.073	0.687	-0.595	0.291	-1.292	0.151	0.478	0.347	0.154	0.447	0.238	0.265
3	0.556	0.233	-0.231	0.307	-0.648	-0.013	0.294	0.322	0.513	0.36	0.338	0.836	0.041	-0.667
4	0.119	-2.538	NA	-0.388	NA	-0.672	-0.757	-0.163	0.168	0.416	-0.01	-0.156	0.037	-0.367
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.351	0.452	-0.034	0.192	-0.203	0.105	-0.258	-0.03	-0.012	-0.001	-0.235	-0.196	-0.747	0.144
2	0.29	0.572	-0.145	-0.019	0.3	0.511	0.467	0.759	-1.166	0.435	0.107	-0.37	-0.429	-0.718
3	0.455	-0.131	-0.385	-0.844	0.161	0.544	-0.016	0.88	-0.003	0.087	0.383	0.067	-0.946	0.305
4	0.115	-0.04	-0.486	-0.346	0.654	-0.216	0.954	0.708	0.982	0.611	-1.457	0.864	0.13	0.266
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.275	0.008	-0.292	-0.085	0.257	NA	0.364	-0.18	-0.385	-0.086	-0.041	-0.054	-0.156	-0.223
2	0.682	0.304	-1.368	-0.075	0.006	NA	0.247	-0.508	-0.859	-0.259	-0.347	-0.253	-0.998	-0.09
3	0.535	0.123	-0.149	-0.212	0.091	NA	0.261	0	-1.146	-0.84	-0.098	-0.653	-0.737	0.028
4	1	-0.815	0.132	-0.356	0	NA	0.949	0	-0.264	0.441	0	-0.214	-0.036	0.733

```
 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	-4.7690	-5.5210	-6.0368
S.E_Logq	0.5796	0.4885	0.6907

Regression statistics

Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7498784	5.717573

Fleet: NL Beam Trawl

Log catchability residuals.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	-0.743	-0.068	-0.627	-0.045	0.063	0.064	0.094	0.158	-0.06	0.313	0.491	0.064	0.426	0.076	-0.205
3	-0.228	-0.534	-0.22	0.087	-0.249	0.126	0.026	0.158	0.191	0.061	0.098	0.237	-0.012	0.085	0.176
4	-0.317	-0.106	-0.512	-0.215	0.176	-0.044	0.182	0.097	0.235	0.039	0.088	0.122	0.242	0.011	0.002
5	-0.155	-0.538	-0.093	-0.306	0.163	0.156	-0.138	0.037	0.444	0.062	0.059	0.059	0.133	0.073	0.043
6	0.117	-0.27	-0.421	0.106	-0.447	0.282	0.486	-0.284	-0.009	0.073	0.044	0.105	0.145	0.211	-0.136
7	-0.61	-0.094	-0.525	0.228	-0.061	-0.163	0.187	-0.067	0.191	0.181	-0.17	0.057	0.453	0.231	0.164
8	0.408	-0.69	-0.082	0.384	0.023	0.624	-0.156	-0.51	-0.353	0.43	-0.241	0.287	-0.131	0.34	-0.181
9	-0.291	-0.176	0.229	-0.112	0.069	-0.021	-0.233	0.298	0.072	0.255	-0.118	0.086	-0.114	0.268	-0.365

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	-5.8102	-4.9597	-4.9159	-4.8672	-5.0268	-5.1423	-5.1423	-5.1423
S.E_Logq	0.3349	0.2140	0.2128	0.2269	0.2637	0.2883	0.3860	0.2133

Terminal year survivor and F summaries:

Age 1 Year class =2010

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.361	145601	2010
SNS	0.519	60858	2010
fshk	0.016	2326	2010
nshk	0.105	83357	2010

Age 2 Year class =2009

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.307	115496	2009
SNS	0.174	98136	2009
NL Beam Trawl	0.502	87427	2009
fshk	0.017	50933	2009

Age 3 Year class =2008

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.184	43991	2008
SNS	0.215	46158	2008
NL Beam Trawl	0.583	53503	2008
fshk	0.019	38243	2008

Age 4 Year class =2007

source

	scaledWts	survivors	yrcls

```
BTS-ISIS          0.175     15989  2007
SNS               0.116     41183  2007
NL Beam Trawl     0.687     19818  2007
fshk              0.022     13140  2007

 Age 5 Year class =2006

source
              scaledWts survivors yrcls
BTS-ISIS          0.157     12717  2006
NL Beam Trawl     0.815      9735  2006
fshk              0.028      8003  2006

 Age 6 Year class =2005

source
              scaledWts survivors yrcls
BTS-ISIS          0.150     17299  2005
NL Beam Trawl     0.825     16968  2005
fshk              0.024     10320  2005

 Age 7 Year class =2004

source
              scaledWts survivors yrcls
BTS-ISIS          0.141       229  2004
NL Beam Trawl     0.830      1833  2004
fshk              0.030      1585  2004

 Age 8 Year class =2003

source
              scaledWts survivors yrcls
NL Beam Trawl     0.952      1269  2003
fshk              0.048       651  2003

 Age 9 Year class =2002

source
              scaledWts survivors yrcls
BTS-ISIS          0.101      2620  2002
NL Beam Trawl     0.873       554  2002
fshk              0.026       644  2002
```

Table 10.3.2. Sole in sub area IV: fishing mortality at age

2012-04-30 18:21:13 units= f

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.021	0.127	0.255	0.259	0.228	0.292	0.167	0.241	0.241
1958	0.000	0.017	0.149	0.235	0.276	0.361	0.345	0.295	0.303	0.303
1959	0.000	0.034	0.130	0.246	0.205	0.239	0.182	0.366	0.248	0.248
1960	0.000	0.029	0.158	0.241	0.323	0.267	0.289	0.344	0.294	0.294
1961	0.000	0.018	0.145	0.295	0.252	0.239	0.174	0.397	0.272	0.272
1962	0.000	0.019	0.141	0.229	0.363	0.313	0.367	0.247	0.304	0.304
1963	0.000	0.053	0.179	0.422	0.402	0.509	0.482	0.457	0.479	0.479
1964	0.000	0.020	0.326	0.250	0.486	0.365	0.516	0.325	0.390	0.390
1965	0.000	0.107	0.169	0.388	0.321	0.600	0.432	0.465	0.443	0.443
1966	0.000	0.124	0.437	0.204	0.490	0.368	0.318	0.360	0.349	0.349
1967	0.000	0.113	0.365	0.488	0.683	0.382	0.296	0.549	0.481	0.481
1968	0.011	0.308	0.695	0.643	0.505	0.296	0.268	0.394	0.422	0.422
1969	0.008	0.333	0.690	0.553	0.682	0.472	0.318	0.412	0.489	0.489
1970	0.010	0.152	0.643	0.547	0.319	0.331	0.381	0.367	0.390	0.390
1971	0.011	0.334	0.557	0.672	0.578	0.410	0.374	0.370	0.482	0.482
1972	0.005	0.237	0.659	0.517	0.532	0.359	0.227	0.308	0.390	0.390
1973	0.007	0.207	0.690	0.605	0.555	0.451	0.361	0.531	0.502	0.502
1974	0.001	0.188	0.593	0.638	0.512	0.496	0.562	0.383	0.520	0.520
1975	0.007	0.278	0.551	0.667	0.471	0.512	0.345	0.647	0.507	0.507
1976	0.010	0.107	0.565	0.508	0.564	0.367	0.459	0.382	0.638	0.638
1977	0.013	0.263	0.554	0.614	0.492	0.369	0.177	0.470	0.273	0.273
1978	0.001	0.236	0.573	0.536	0.522	0.513	0.659	0.527	0.486	0.486
1979	0.001	0.225	0.659	0.632	0.484	0.458	0.363	0.661	0.360	0.360
1980	0.004	0.128	0.556	0.590	0.584	0.404	0.576	0.495	0.626	0.626
1981	0.003	0.255	0.524	0.599	0.529	0.579	0.447	0.427	0.485	0.485
1982	0.018	0.232	0.697	0.562	0.629	0.596	0.506	0.517	0.514	0.514
1983	0.003	0.310	0.600	0.724	0.332	0.474	0.456	0.552	0.634	0.634
1984	0.003	0.292	0.721	0.682	0.669	0.727	0.536	0.418	0.574	0.574
1985	0.002	0.319	0.747	0.775	0.600	0.554	0.405	0.428	0.432	0.432
1986	0.002	0.143	0.620	0.698	0.681	0.760	0.739	0.343	0.580	0.580
1987	0.001	0.239	0.510	0.610	0.529	0.569	0.443	0.656	0.406	0.406
1988	0.000	0.237	0.661	0.708	0.611	0.614	0.547	0.430	0.904	0.904
1989	0.001	0.125	0.526	0.687	0.424	0.433	0.426	0.409	0.365	0.365
1990	0.005	0.137	0.403	0.527	0.585	0.550	0.474	0.672	0.651	0.651
1991	0.002	0.091	0.425	0.527	0.750	0.433	0.544	0.621	1.038	1.038
1992	0.003	0.120	0.437	0.468	0.473	0.606	0.684	0.418	0.751	0.751
1993	0.001	0.182	0.424	0.560	0.830	0.543	0.807	0.549	0.441	0.441
1994	0.013	0.141	0.483	0.638	0.683	0.889	0.471	0.558	0.982	0.982
1995	0.054	0.306	0.446	0.772	0.614	0.549	0.805	0.436	0.743	0.743
1996	0.004	0.275	0.698	0.986	0.716	0.852	0.751	1.038	0.403	0.403
1997	0.006	0.154	0.580	0.703	0.820	0.782	0.621	0.922	1.245	1.245
1998	0.002	0.281	0.619	0.795	0.772	0.762	0.671	0.992	1.353	1.353
1999	0.004	0.176	0.612	0.717	0.796	0.591	0.565	0.579	1.524	1.524
2000	0.020	0.241	0.583	0.801	0.626	0.787	0.894	0.798	0.522	0.522
2001	0.015	0.286	0.563	0.757	0.756	0.541	0.590	0.786	0.737	0.737
2002	0.006	0.232	0.626	0.646	0.728	0.656	0.468	1.011	0.560	0.560
2003	0.014	0.229	0.611	0.637	0.644	0.827	0.488	0.498	0.535	0.535
2004	0.012	0.242	0.548	0.707	0.610	0.465	0.398	0.321	1.180	1.180
2005	0.026	0.217	0.632	0.686	0.710	0.676	0.617	0.460	0.419	0.419
2006	0.035	0.275	0.455	0.500	0.499	0.548	0.535	0.571	0.479	0.479
2007	0.006	0.265	0.499	0.521	0.581	0.463	0.549	0.465	0.932	0.932
2008	0.028	0.137	0.370	0.488	0.410	0.440	0.360	0.564	0.566	0.566
2009	0.017	0.186	0.327	0.438	0.485	0.385	0.528	0.334	0.891	0.891
2010	0.003	0.146	0.346	0.418	0.377	0.487	0.339	0.502	0.423	0.423
2011	0.001	0.101	0.351	0.339	0.417	0.274	0.471	0.239	0.290	0.290

Table 10.3.3 Sole in sub area IV: stock numbers at age

2012-04-30 18:21:13 units= NA

year	1	2	3	4	5	6	7	8	9	10
1957	128914	72456	89309	59107	17319	15058	27046	11837	2500	30811
1958	128646	116646	64214	71157	41456	12092	10843	18272	9062	26295
1959	488783	116404	103782	50075	50908	28475	7627	6950	12311	26789
1960	61717	442269	101846	82467	35416	37526	20278	5754	4363	32547
1961	99502	55844	388727	78711	58641	23192	25996	13739	3691	31945
1962	22899	90033	49617	304377	53014	41261	16519	19770	8361	29935
1963	20424	20720	79949	38988	219107	33371	27308	10356	13977	32252
1964	539186	8304	7993	27188	10397	59623	8154	6857	2666	9789
1965	121993	487824	7366	5222	19167	5784	37458	4405	4483	9392
1966	39916	110383	396598	5629	3204	12585	2873	22003	2505	8712
1967	75185	36117	88200	231757	4152	1776	7878	1892	13894	7984
1968	99242	68030	29174	55376	128727	1898	1097	5303	989	19825
1969	50939	88811	45244	13179	26351	70275	1278	760	3235	14267
1970	137953	45714	57604	20534	6859	12060	39674	841	455	16962
1971	42185	123590	35524	27397	10747	4509	7839	24522	527	12563
1972	76411	37771	80087	18422	12655	5458	2708	4879	15326	9089
1973	105157	68799	26953	37499	9939	6728	3450	1953	3243	15346
1974	110007	94481	50620	12228	18533	5164	3877	2176	1040	12422
1975	40846	99442	70860	25314	5845	10053	2844	2001	1343	9065
1976	113320	36707	68144	36974	11759	3303	5453	1822	947	5903
1977	140406	101546	29845	35058	20126	6056	2070	3118	1126	9275
1978	47213	125383	70644	15521	17162	11133	3788	1569	1764	4355
1979	11679	42694	89641	36058	8214	9213	6031	1774	839	5296
1980	151694	10559	30851	41948	17350	4582	5272	3795	829	2702
1981	149004	136652	8404	16015	21042	8757	2767	2680	2094	2471
1982	152575	134422	95856	4504	7959	11218	4442	1602	1582	3327
1983	141599	135525	96484	43219	2322	3839	5595	2423	864	2618
1984	70911	127754	89899	47935	18951	1508	2163	3208	1262	2142
1985	81951	63982	86361	39555	21919	8785	659	1145	1910	2912
1986	159426	73996	42085	37037	16494	10889	4567	398	676	3994
1987	72756	143899	58048	20486	16674	7556	4607	1973	255	2179
1988	458067	65743	102569	31553	10071	8893	3870	2678	926	556
1989	108190	414467	46913	47928	14061	4945	4354	2026	1575	1604
1990	177141	97783	330901	25076	21818	8325	2902	2573	1218	1847
1991	70374	159463	77121	200052	13399	10996	4347	1634	1188	1759
1992	352793	63563	131767	45602	106901	5728	6454	2282	795	2335
1993	69118	318288	51015	77014	25849	60278	2827	2947	1360	2473
1994	56960	62489	240009	30210	39808	10196	31679	1141	1540	1514
1995	95940	50857	49119	134029	14446	18195	3793	17906	591	1330
1996	49345	82243	33873	28443	56047	7071	9513	1535	10480	3121
1997	270749	44486	56511	15249	9600	24786	2729	4061	492	2466
1998	113725	243472	34500	28635	6830	3828	10258	1326	1462	1186
1999	82207	102670	166417	16815	11705	2854	1617	4747	445	1078
2000	123139	74111	77907	81645	7427	4778	1430	831	2408	1838
2001	62897	109184	52720	39352	33160	3592	1967	529	339	1450
2002	184631	56071	74208	27161	16700	14090	1893	986	218	888
2003	81869	166057	40221	35897	12886	7297	6616	1073	325	1139
2004	44666	73081	119501	19749	17175	6124	2887	3675	590	584
2005	48057	39925	51906	62499	8810	8448	3481	1755	2411	1227
2006	205913	42384	29070	24954	28468	3917	3888	1700	1002	1478
2007	56682	179836	29133	16688	13695	15638	2049	2060	869	936
2008	72568	50987	124780	16005	8967	6931	8906	1070	1171	1090
2009	101246	63836	40237	78005	8890	5384	4039	5621	551	1516
2010	145457	90074	47938	26251	45546	4953	3313	2155	3641	2094
2011	90550	131262	70417	30679	15643	28259	2754	2135	1180	3186

Table 10.4.1. Sole in sub area IV: XSA summary

	recruits	ssb	catch	landings	fbar2-6	Y/ssb
1957	128914	55108	12067	12067	0.18	0.22
1958	128646	60920	14287	14287	0.21	0.23
1959	488783	65582	13832	13832	0.17	0.21
1960	61717	73401	18620	18620	0.2	0.25
1961	99502	117104	23566	23566	0.19	0.2
1962	22899	116836	26877	26877	0.21	0.23
1963	20424	113637	26164	26164	0.31	0.23
1964	539186	37132	11342	11342	0.29	0.31
1965	121993	30035	17043	17043	0.32	0.57
1966	39916	84263	33340	33340	0.32	0.4
1967	75185	82987	33439	33439	0.41	0.4
1968	99242	72345	33179	33179	0.49	0.46
1969	50939	55318	27559	27559	0.55	0.5
1970	137953	50739	19685	19685	0.4	0.39
1971	42185	43825	23652	23652	0.51	0.54
1972	76411	47562	21086	21086	0.46	0.44
1973	105157	36913	19309	19309	0.5	0.52
1974	110007	36240	17989	17989	0.49	0.5
1975	40846	38590	20773	20773	0.5	0.54
1976	113320	39042	17326	17326	0.42	0.44
1977	140406	35135	18003	18003	0.46	0.51
1978	47213	36430	20280	20280	0.48	0.56
1979	11679	45127	22598	22598	0.49	0.5
1980	151694	33552	15807	15807	0.45	0.47
1981	149004	23112	15403	15403	0.5	0.67
1982	152575	32911	21579	21579	0.54	0.66
1983	141599	39921	24927	24927	0.49	0.62
1984	70911	43361	26839	26839	0.62	0.62
1985	81951	40883	24248	24248	0.6	0.59
1986	159426	34224	18201	18201	0.58	0.53
1987	72756	29487	17368	17368	0.49	0.59
1988	458067	38707	21590	21590	0.57	0.56
1989	108190	34016	21805	21805	0.44	0.64
1990	177141	90275	35120	35120	0.44	0.39
1991	70374	78033	33513	33513	0.45	0.43
1992	352793	77736	29341	29341	0.42	0.38
1993	69118	55964	31491	31491	0.51	0.56
1994	56960	74600	33002	33002	0.57	0.44
1995	95940	59279	30467	30467	0.54	0.51
1996	49345	38745	22651	22651	0.71	0.58
1997	270749	27510	14901	14901	0.61	0.54
1998	113725	20326	20868	20868	0.65	1.03
1999	82207	41371	23475	23475	0.58	0.57
2000	123139	38462	22641	22641	0.61	0.59
2001	62897	30169	19944	19944	0.58	0.66
2002	184631	30846	16945	16945	0.58	0.55
2003	81869	25036	17920	17920	0.59	0.72
2004	44666	37238	18757	18757	0.51	0.5
2005	48057	31773	16355	16355	0.58	0.51
2006	205913	23677	12594	12594	0.46	0.53
2007	56682	17612	14635	14635	0.47	0.83
2008	72568	35851	14071	14071	0.37	0.39
2009	101246	33083	13952	13952	0.36	0.42
2010	145457	33545	12603	12603	0.35	0.38
2011	90550	34747	11485	11485	0.3	0.33

Table 10.5.1. Sole in sub area IV: RCT3 input table

Yearclass	age1	age2	DFS0	SNS1	SNS2	BTS1
1972	105157	94481	-11	5587	361	-11
1973	110007	99442	-11	2348	864	-11
1974	40846	36707	-11	525	74	-11
1975	113320	101546	168.84	1399	776	-11
1976	140406	125383	82.28	3743	1355	-11
1977	47213	42694	33.8	1548	408	-11
1978	11679	10559	96.87	94	89	-11
1979	151694	136652	392.08	4313	1413	-11
1980	149004	134422	404	3737	1146	-11
1981	152575	135525	293.93	5856	1123	-11
1982	141599	127754	328.52	2621	1100	-11
1983	70911	63982	104.38	2493	716	-11
1984	81951	73996	186.53	3619	458	7.03
1985	159426	143899	315.03	3705	944	7.17
1986	72756	65743	73.22	1948	594	6.97
1987	458067	414467	523.86	1122	5005	83.11
1988	108190	97783	50.07	2831	1120	9.01
1989	177141	159463	77.8	2856	2529	37.84
1990	70374	63563	21.09	1254	144	4.03
1991	352793	318288	391.93	11114	3420	81.63
1992	69118	62489	25.3	1291	498	6.35
1993	56960	50857	25.13	652	224	7.66
1994	95940	82243	69.11	1362	349	28.13
1995	49345	44486	19.07	218	154	3.98
1996	270749	243472	59.62	10279	3126	169.34
1997	113725	102670	44.08	4095	972	17.11
1998	82207	74111	-11	1649	126	11.96
1999	123139	109184	-11	1639	655	14.59
2000	62897	56071	15.51	970	379	8
2001	184631	166057	85.31	7547	-11	20.99
2002	81869	73081	64.97	-11	624	10.51
2003	44666	39925	16.82	1370	163	4.19
2004	48057	42384	40.1	568	117	5.53
2005	205913	179836	46.81	2726	911	17.09
2006	56682	50987	14.69	849	259	7.5
2007	72568	63836	23.51	1259	344	15.25
2008	-11	-11	26.74	1932	237	15.95
2009	-11	-11	39.59	2637	884	54.8
2010	-11	-11	59.33	1248	-11	26.2
2011	-11	-11	17.91	-11	-11	-11

Table 10.5.2. Sole in sub area IV: RCT3 analysis – age 1

```
Analysis by RCT3 ver4.0

Data for 4 surveys over 40 years : 1972 - 2011
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
     DFS0 1.1361     6.600 1.0385  0.3313 31   2.885      9.878  1.1202      0.2714
     SNS1 0.8893     4.773 0.5713  0.6025 35      NA         NA      NA          NA
     SNS2 0.7379     6.796 0.3727  0.7766 35      NA         NA      NA          NA
     BTS1 0.7470     9.618 0.3885  0.7412 24      NA         NA      NA          NA
 VPA Mean     NA        NA     NA      NA 36      NA     11.479  0.6836      0.7286

                  WAP logWAP int.se
yearclass:2011  62621  11.04 0.5835
```

Table 10.5.3. Sole in sub area IV: Output RCT3 – age 2

```
Analysis by RCT3 ver4.0

Data for 4 surveys over 40 years : 1972 - 2011

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

     DFS0 1.1298     6.518 1.0297  0.3352 31   4.083      11.13  1.0824     0.05385

     SNS1 0.7427     5.722 0.3519  0.7998 35   7.129      11.02  0.3687     0.46409

     SNS2 0.7357     6.701 0.3677  0.7812 35      NA         NA      NA          NA

     BTS1 0.7525     9.494 0.3961  0.7348 24   3.266      11.95  0.4264     0.34706

 VPA Mean     NA        NA     NA      NA 36      NA      11.37  0.6836     0.13500


                     WAP logWAP int.se

yearclass:2010 88852  11.39 0.2512
```

Table 10.6.1. Sole in sub area IV: STF Input table (F values presented are for Fsq)

Age year f f.disc f.land stock.n catch.wt landings.wt stock.wt mat M

	age	year	f	f.disc	f.land	stock.n	catch.wt	landings.wt	discards.wt	stock.wt	mat	M
1	1	2012	0.006	0	0.01	93669	0.15	0.15	NaN	0.05	0	0.1
2	2	2012	0.127	0	0.13	81891	0.18	0.18	NaN	0.14	0	0.1
3	3	2012	0.299	0	0.30	107348	0.21	0.21	NaN	0.19	1	0.1
4	4	2012	0.349	0	0.35	44868	0.24	0.24	NaN	0.23	1	0.1
5	5	2012	0.373	0	0.37	19779	0.26	0.26	NaN	0.26	1	0.1
6	6	2012	0.335	0	0.33	9325	0.29	0.29	NaN	0.29	1	0.1
7	7	2012	0.391	0	0.39	19440	0.29	0.29	NaN	0.31	1	0.1
8	8	2012	0.314	0	0.31	1556	0.31	0.31	NaN	0.34	1	0.1
9	9	2012	0.468	0	0.47	1521	0.33	0.33	NaN	0.37	1	0.1
10	10	2012	0.468	0	0.47	2955	0.38	0.38	NaN	0.40	1	0.1
11	1	2013	0.006	0	0.01	93669	0.15	0.15	NaN	0.05	0	0.1
12	2	2013	0.127	0	0.13	NA	0.18	0.18	NaN	0.14	0	0.1
13	3	2013	0.299	0	0.30	NA	0.21	0.21	NaN	0.19	1	0.1
14	4	2013	0.349	0	0.35	NA	0.24	0.24	NaN	0.23	1	0.1
15	5	2013	0.373	0	0.37	NA	0.26	0.26	NaN	0.26	1	0.1
16	6	2013	0.335	0	0.33	NA	0.29	0.29	NaN	0.29	1	0.1
17	7	2013	0.391	0	0.39	NA	0.29	0.29	NaN	0.31	1	0.1
18	8	2013	0.314	0	0.31	NA	0.31	0.31	NaN	0.34	1	0.1
19	9	2013	0.468	0	0.47	NA	0.33	0.33	NaN	0.37	1	0.1
20	10	2013	0.468	0	0.47	NA	0.38	0.38	NaN	0.40	1	0.1
21	1	2014	0.006	0	0.01	93669	0.15	0.15	NaN	0.05	0	0.1
22	2	2014	0.127	0	0.13	NA	0.18	0.18	NaN	0.14	0	0.1
23	3	2014	0.299	0	0.30	NA	0.21	0.21	NaN	0.19	1	0.1
24	4	2014	0.349	0	0.35	NA	0.24	0.24	NaN	0.23	1	0.1
25	5	2014	0.373	0	0.37	NA	0.26	0.26	NaN	0.26	1	0.1
26	6	2014	0.335	0	0.33	NA	0.29	0.29	NaN	0.29	1	0.1
27	7	2014	0.391	0	0.39	NA	0.29	0.29	NaN	0.31	1	0.1
28	8	2014	0.314	0	0.31	NA	0.31	0.31	NaN	0.34	1	0.1
29	9	2014	0.468	0	0.47	NA	0.33	0.33	NaN	0.37	1	0.1
30	10	2014	0.468	0	0.47	NA	0.38	0.38	NaN	0.40	1	0.1

Table 10.6.2. (A) Sole in sub area IV: STF option table, assuming F(2012) = F(sq)

fmult	age	year	unit	season	area	iter	ssb	f2-6	f_dis2-3	f_hc2-6	recruit	catch	landings	discards
1	all	2012	unique	all	unique	1	46654	0.296	0	0.3	93669	14969	14969	0

year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb	ssb2014
2013	0	0	NaN	NaN	0	0	0	47145	63008
2013	0.1	0.03	0	0.03	1738	0	1738	47145	61203
2013	0.2	0.059	0	0.06	3422	0	3422	47145	59455
2013	0.3	0.089	0	0.09	5055	0	5055	47145	57762
2013	0.4	0.119	0	0.12	6637	0	6637	47145	56122
2013	0.5	0.148	0	0.15	8170	0	8170	47145	54534
2013	0.6	0.178	0	0.18	9657	0	9657	47145	52996
2013	0.7	0.208	0	0.21	11098	0	11098	47145	51506
2013	0.8	0.237	0	0.24	12495	0	12495	47145	50063
2013	0.9	0.267	0	0.27	13850	0	13850	47145	48665
2013	1	0.296	0	0.3	15163	0	15163	47145	47310
2013	1.1	0.326	0	0.33	16437	0	16437	47145	45998
2013	1.2	0.356	0	0.36	17672	0	17672	47145	44726
2013	1.3	0.385	0	0.39	18870	0	18870	47145	43494
2013	1.4	0.415	0	0.42	20032	0	20032	47145	42300
2013	1.5	0.445	0	0.44	21159	0	21159	47145	41142
2013	1.6	0.474	0	0.47	22252	0	22252	47145	40021
2013	1.7	0.504	0	0.5	23313	0	23313	47145	38933
2013	1.8	0.534	0	0.53	24342	0	24342	47145	37880
2013	1.9	0.563	0	0.56	25341	0	25341	47145	36858
2013	2	0.593	0	0.59	26310	0	26310	47145	35868

Table 10.6.2. (B) Sole in sub area IV: STF option table, assuming F(2012) = 0.9*F(sq)

year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb2012**	
2012	1	0.267	0	0.27	13671	0	13671	46654	
year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb**	**ssb2014**
2013	0.2	0.059	0	0.06	3510	0	3510	48489	60737
2013	0.3	0.089	0	0.09	5185	0	5185	48489	59000
2013	0.4	0.119	0	0.12	6807	0	6807	48489	57318
2013	0.5	0.148	0	0.15	8380	0	8380	48489	55690
2013	0.6	0.178	0	0.18	9904	0	9904	48489	54112
2013	0.7	0.208	0	0.21	11381	0	11381	48489	52584
2013	0.8	0.237	0	0.24	12814	0	12814	48489	51104
2013	0.9	0.267	0	0.27	14202	0	14202	48489	49671
2013	1	0.296	0	0.3	15549	0	15549	48489	48282
2013	1.1	0.326	0	0.33	16854	0	16854	48489	46937
2013	1.2	0.356	0	0.36	18120	0	18120	48489	45633
2013	1.3	0.385	0	0.39	19348	0	19348	48489	44370
2013	1.4	0.415	0	0.42	20538	0	20538	48489	43146
2013	1.5	0.445	0	0.44	21693	0	21693	48489	41960
2013	1.6	0.474	0	0.47	22813	0	22813	48489	40811
2013	1.7	0.504	0	0.5	23900	0	23900	48489	39697
2013	1.8	0.534	0	0.53	24954	0	24954	48489	38617
2013	1.9	0.563	0	0.56	25976	0	25976	48489	37571
2013	2	0.593	0	0.59	26969	0	26969	48489	36556

Table 10.6.2. (C) Sole in sub area IV: STF option table, assuming F(2012)~Landings for 2012=TAC for 2012

year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb2012	
2012	1	0.325	0	0.33	16200	0	16200	46654	
year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb	ssb2014
2013	0.2	0.059	0	0.06	3339	0	3339	45870	58238
2013	0.3	0.089	0	0.09	4932	0	4932	45870	56587
2013	0.4	0.119	0	0.12	6475	0	6475	45870	54987
2013	0.5	0.148	0	0.15	7972	0	7972	45870	53438
2013	0.6	0.178	0	0.18	9423	0	9423	45870	51937
2013	0.7	0.208	0	0.21	10829	0	10829	45870	50483
2013	0.8	0.237	0	0.24	12193	0	12193	45870	49075
2013	0.9	0.267	0	0.27	13515	0	13515	45870	47710
2013	1	0.296	0	0.3	14798	0	14798	45870	46388
2013	1.1	0.326	0	0.33	16041	0	16041	45870	45107
2013	1.2	0.356	0	0.36	17247	0	17247	45870	43865
2013	1.3	0.385	0	0.39	18417	0	18417	45870	42662
2013	1.4	0.415	0	0.42	19552	0	19552	45870	41496
2013	1.5	0.445	0	0.44	20653	0	20653	45870	40366
2013	1.6	0.474	0	0.47	21721	0	21721	45870	39271
2013	1.7	0.504	0	0.5	22757	0	22757	45870	38209
2013	1.8	0.534	0	0.53	23762	0	23762	45870	37180
2013	1.9	0.563	0	0.56	24738	0	24738	45870	36182
2013	2	0.593	0	0.59	25685	0	25685	45870	35215

Table 10.6.3. (A) Sole in sub area IV: STF detailed, assuming F(2012) = F(sq).

age	year	f	f.disc	f.land	stock.n	catch.wt	landings.v	stock.wt	mat	M	catch.n	catch	landings.r	landings	discards.n	SSB	TSB
1	2012	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	0	4683
2	2012	0.127	0	0.13	81891	0.18	0.18	0.14	0	0.1	9276	1637	9276	1637	0	0	11792
3	2012	0.299	0	0.3	107348	0.21	0.21	0.19	1	0.1	26459	5447	26459	5447	0	20181	20181
4	2012	0.349	0	0.35	44868	0.24	0.24	0.23	1	0.1	12606	3055	12606	3055	0	10245	10245
5	2012	0.373	0	0.37	19779	0.26	0.26	0.26	1	0.1	5884	1554	5884	1554	0	5195	5195
6	2012	0.335	0	0.33	9325	0.29	0.29	0.29	1	0.1	2530	727	2530	727	0	2679	2679
7	2012	0.391	0	0.39	19440	0.29	0.29	0.31	1	0.1	6003	1766	6003	1766	0	6085	6085
8	2012	0.314	0	0.31	1556	0.31	0.31	0.34	1	0.1	400	125	400	125	0	534	534
9	2012	0.468	0	0.47	1521	0.33	0.33	0.37	1	0.1	543	181	543	181	0	561	561
10	2012	0.468	0	0.47	2955	0.38	0.38	0.4	1	0.1	1055	397	1055	397	0	1173	1173
1	2013	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	0	4683
2	2013	0.127	0	0.13	84259	0.18	0.18	0.14	0	0.1	9544	1684	9544	1684	0	0	12133
3	2013	0.299	0	0.3	65288	0.21	0.21	0.19	1	0.1	16092	3313	16092	3313	0	12274	12274
4	2013	0.349	0	0.35	72037	0.24	0.24	0.23	1	0.1	20239	4905	20239	4905	0	16448	16448
5	2013	0.373	0	0.37	28647	0.26	0.26	0.26	1	0.1	8523	2251	8523	2251	0	7525	7525
6	2013	0.335	0	0.33	12319	0.29	0.29	0.29	1	0.1	3343	961	3343	961	0	3540	3540
7	2013	0.391	0	0.39	6038	0.29	0.29	0.31	1	0.1	1864	548	1864	548	0	1890	1890
8	2013	0.314	0	0.31	11901	0.31	0.31	0.34	1	0.1	3059	959	3059	959	0	4082	4082
9	2013	0.468	0	0.47	1029	0.33	0.33	0.37	1	0.1	367	123	367	123	0	380	380
10	2013	0.468	0	0.47	2536	0.38	0.38	0.4	1	0.1	906	341	906	341	0	1007	1007
1	2014	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	0	4683
2	2014	0.127	0	0.13	84259	0.18	0.18	0.14	0	0.1	9544	1684	9544	1684	0	0	12133
3	2014	0.299	0	0.3	67176	0.21	0.21	0.19	1	0.1	16557	3409	16557	3409	0	12629	12629
4	2014	0.349	0	0.35	43812	0.24	0.24	0.23	1	0.1	12309	2983	12309	2983	0	10004	10004
5	2014	0.373	0	0.37	45993	0.26	0.26	0.26	1	0.1	13683	3613	13683	3613	0	12081	12081
6	2014	0.335	0	0.33	17842	0.29	0.29	0.29	1	0.1	4842	1391	4842	1391	0	5127	5127
7	2014	0.391	0	0.39	7977	0.29	0.29	0.31	1	0.1	2463	725	2463	725	0	2497	2497
8	2014	0.314	0	0.31	3697	0.31	0.31	0.34	1	0.1	950	298	950	298	0	1268	1268
9	2014	0.468	0	0.47	7868	0.33	0.33	0.37	1	0.1	2810	938	2810	938	0	2903	2903
10	2014	0.468	0	0.47	2020	0.38	0.38	0.4	1	0.1	721	271	721	271	0	802	802

Table 10.6.3. (B) Sole in sub area IV: STF detailed, assuming F(2012) = 0.9*F(sq).

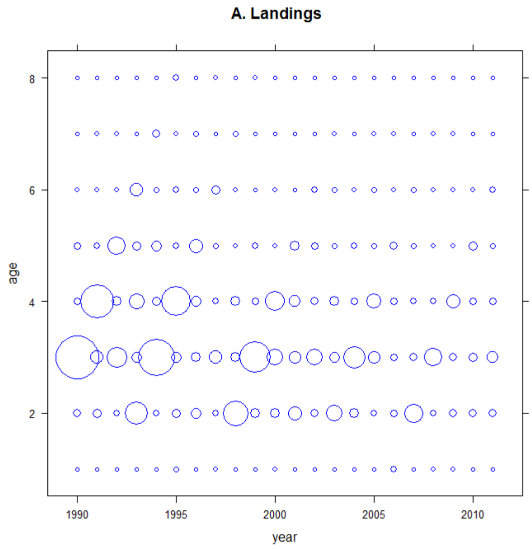
age	year	f	f.land	stock.n	catch.wt	landings.v	stock.wt	mat	M	catch.n	catch	landings.r	landings	SSB	TSB
1	2012	0.005	0.01	93669	0.15	0.15	0.05	0	0.1	470	71	470	71	0	4683
2	2012	0.114	0.11	81891	0.18	0.18	0.14	0	0.1	8399	1482	8399	1482	0	11792
3	2012	0.269	0.27	107348	0.21	0.21	0.19	1	0.1	24148	4971	24148	4971	20181	20181
4	2012	0.314	0.31	44868	0.24	0.24	0.23	1	0.1	11530	2794	11530	2794	10245	10245
5	2012	0.336	0.34	19779	0.26	0.26	0.26	1	0.1	5388	1423	5388	1423	5195	5195
6	2012	0.301	0.3	9325	0.29	0.29	0.29	1	0.1	2313	665	2313	665	2679	2679
7	2012	0.352	0.35	19440	0.29	0.29	0.31	1	0.1	5500	1618	5500	1618	6085	6085
8	2012	0.282	0.28	1556	0.31	0.31	0.34	1	0.1	365	115	365	115	534	534
9	2012	0.421	0.42	1521	0.33	0.33	0.37	1	0.1	499	167	499	167	561	561
10	2012	0.421	0.42	2955	0.38	0.38	0.4	1	0.1	970	365	970	365	1173	1173
1	2013	0.006	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	4683
2	2013	0.127	0.13	84309	0.18	0.18	0.14	0	0.1	9550	1685	9550	1685	0	12140
3	2013	0.299	0.3	66119	0.21	0.21	0.19	1	0.1	16297	3355	16297	3355	12430	12430
4	2013	0.349	0.35	74223	0.24	0.24	0.23	1	0.1	20853	5054	20853	5054	16948	16948
5	2013	0.373	0.37	29663	0.26	0.26	0.26	1	0.1	8825	2330	8825	2330	7792	7792
6	2013	0.335	0.33	12788	0.29	0.29	0.29	1	0.1	3470	997	3470	997	3674	3674
7	2013	0.391	0.39	6244	0.29	0.29	0.31	1	0.1	1928	567	1928	567	1954	1954
8	2013	0.314	0.31	12375	0.31	0.31	0.34	1	0.1	3180	997	3180	997	4245	4245
9	2013	0.468	0.47	1061	0.33	0.33	0.37	1	0.1	379	127	379	127	392	392
10	2013	0.468	0.47	2657	0.38	0.38	0.4	1	0.1	949	357	949	357	1055	1055
1	2014	0.006	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	4683
2	2014	0.127	0.13	84259	0.18	0.18	0.14	0	0.1	9544	1684	9544	1684	0	12133
3	2014	0.299	0.3	67215	0.21	0.21	0.19	1	0.1	16567	3411	16567	3411	12636	12636
4	2014	0.349	0.35	44370	0.24	0.24	0.23	1	0.1	12466	3021	12466	3021	10131	10131
5	2014	0.373	0.37	47389	0.26	0.26	0.26	1	0.1	14098	3723	14098	3723	12447	12447
6	2014	0.335	0.33	18475	0.29	0.29	0.29	1	0.1	5013	1441	5013	1441	5309	5309
7	2014	0.391	0.39	8280	0.29	0.29	0.31	1	0.1	2557	752	2557	752	2592	2592
8	2014	0.314	0.31	3822	0.31	0.31	0.34	1	0.1	982	308	982	308	1311	1311
9	2014	0.468	0.47	8182	0.33	0.33	0.37	1	0.1	2922	975	2922	975	3019	3019
10	2014	0.468	0.47	2107	0.38	0.38	0.4	1	0.1	753	283	753	283	836	836

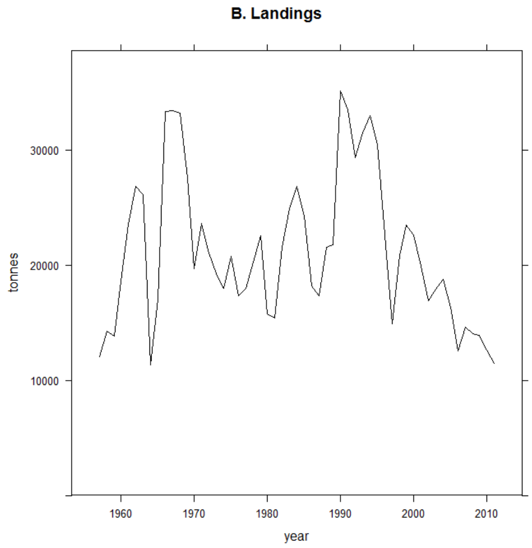
Table 10.6.3. (C) Sole in sub area IV: STF detailed, assuming F(2012) = TAC

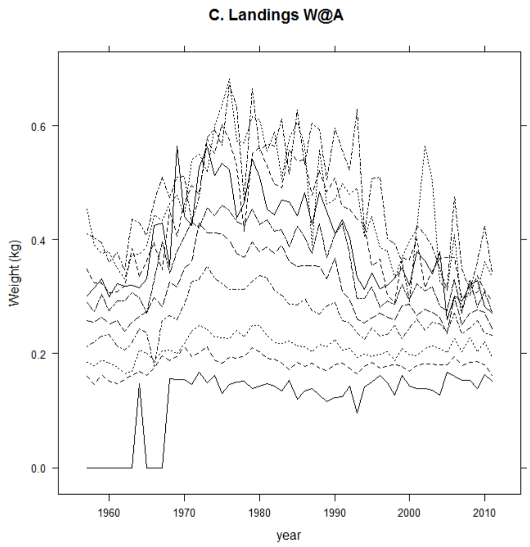
age	year	f	f.disc	f.land	stock.n	catch.wt	landings.v	stock.wt	mat	M	catch.n	catch	landings.r	landings	SSB	TSB
1	2012	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	573	87	573	87	0	4683
2	2012	0.139	0	0.14	81891	0.18	0.18	0.14	0	0.1	10123	1787	10123	1787	0	11792
3	2012	0.328	0	0.33	107348	0.21	0.21	0.19	1	0.1	28654	5899	28654	5899	20181	20181
4	2012	0.383	0	0.38	44868	0.24	0.24	0.23	1	0.1	13623	3301	13623	3301	10245	10245
5	2012	0.41	0	0.41	19779	0.26	0.26	0.26	1	0.1	6352	1677	6352	1677	5195	5195
6	2012	0.367	0	0.37	9325	0.29	0.29	0.29	1	0.1	2736	786	2736	786	2679	2679
7	2012	0.429	0	0.43	19440	0.29	0.29	0.31	1	0.1	6475	1905	6475	1905	6085	6085
8	2012	0.345	0	0.34	1556	0.31	0.31	0.34	1	0.1	433	136	433	136	534	534
9	2012	0.514	0	0.51	1521	0.33	0.33	0.37	1	0.1	584	195	584	195	561	561
10	2012	0.514	0	0.51	2955	0.38	0.38	0.4	1	0.1	1135	427	1135	427	1173	1173
1	2013	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	4683
2	2013	0.127	0	0.13	84211	0.18	0.18	0.14	0	0.1	9538	1683	9538	1683	0	12126
3	2013	0.299	0	0.3	64484	0.21	0.21	0.19	1	0.1	15894	3272	15894	3272	12123	12123
4	2013	0.349	0	0.35	69962	0.24	0.24	0.23	1	0.1	19656	4763	19656	4763	15975	15975
5	2013	0.373	0	0.37	27686	0.26	0.26	0.26	1	0.1	8237	2175	8237	2175	7272	7272
6	2013	0.335	0	0.33	11877	0.29	0.29	0.29	1	0.1	3223	926	3223	926	3413	3413
7	2013	0.391	0	0.39	5844	0.29	0.29	0.31	1	0.1	1804	531	1804	531	1829	1829
8	2013	0.314	0	0.31	11455	0.31	0.31	0.34	1	0.1	2944	923	2944	923	3929	3929
9	2013	0.468	0	0.47	998	0.33	0.33	0.37	1	0.1	356	119	356	119	368	368
10	2013	0.468	0	0.47	2422	0.38	0.38	0.4	1	0.1	865	325	865	325	962	962
1	2014	0.006	0	0.01	93669	0.15	0.15	0.05	0	0.1	522	79	522	79	0	4683
2	2014	0.127	0	0.13	84259	0.18	0.18	0.14	0	0.1	9544	1684	9544	1684	0	12133
3	2014	0.299	0	0.3	67137	0.21	0.21	0.19	1	0.1	16548	3407	16548	3407	12622	12622
4	2014	0.349	0	0.35	43273	0.24	0.24	0.23	1	0.1	12158	2946	12158	2946	9881	9881
5	2014	0.373	0	0.37	44668	0.26	0.26	0.26	1	0.1	13289	3509	13289	3509	11733	11733
6	2014	0.335	0	0.33	17244	0.29	0.29	0.29	1	0.1	4679	1345	4679	1345	4955	4955
7	2014	0.391	0	0.39	7691	0.29	0.29	0.31	1	0.1	2375	699	2375	699	2407	2407
8	2014	0.314	0	0.31	3577	0.31	0.31	0.34	1	0.1	919	288	919	288	1227	1227
9	2014	0.468	0	0.47	7573	0.33	0.33	0.37	1	0.1	2705	903	2705	903	2794	2794
10	2014	0.468	0	0.47	1938	0.38	0.38	0.4	1	0.1	692	260	692	260	769	769

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	0.34	0.16	0.44
Fmax	0.55	0.16	0.28
F0.1	0.10	0.13	1.09
Fmed	0.36	0.16	0.41


A. Landings
age
8
6
4
2
1990
1995
2000
2005
2010
year


B. Landings
tonnes
30000
20000
10000
1960
1970
1980
1990
2000
2010
year



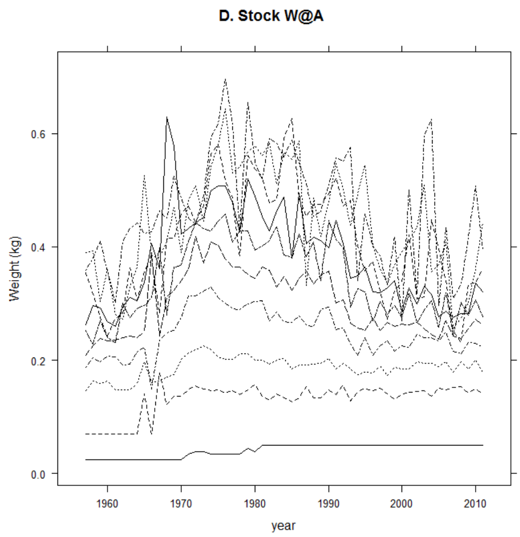
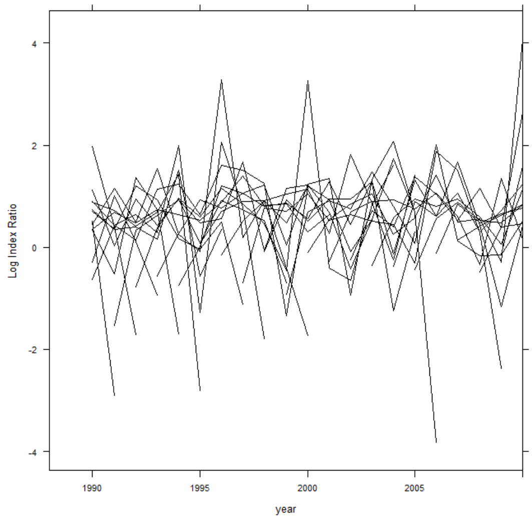


Figure 10.2.1. Sole in SubArea IV. A: bubble plot of landings (n) by age and year; B: time series of landings (total tonnages) 1957-2011; C: time-series of stock-weights by age 1957-2011; D: time-series of landing-weights by age 1957-2011.



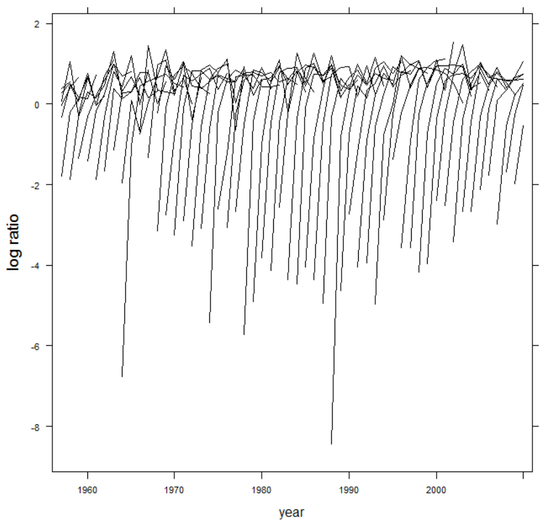


Figure 10.2.2. Sole in Sub-Area IV: Log catch ratios (left) and catch curves (right) from 1957 to 2011.

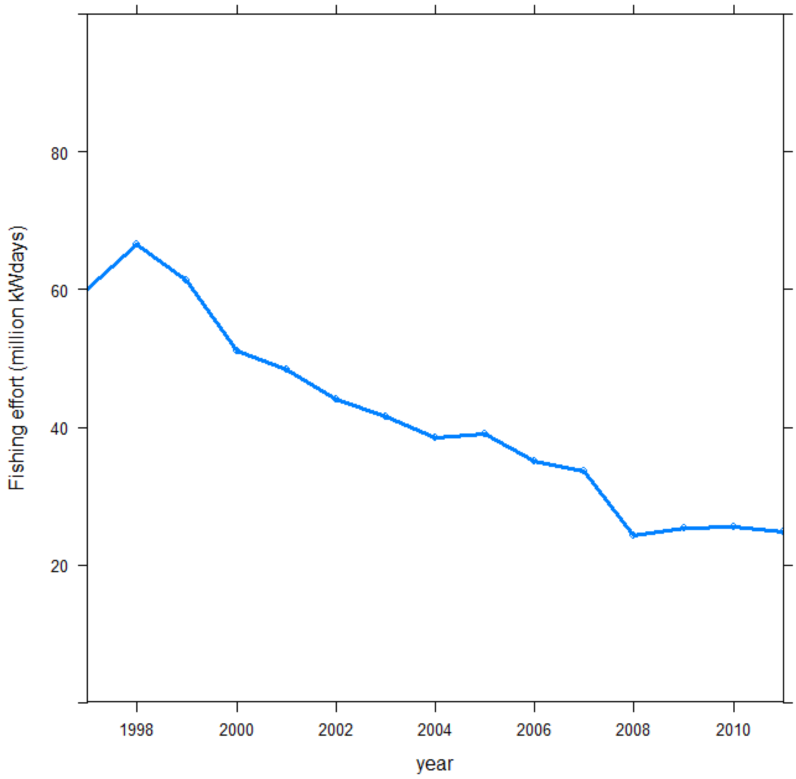


Figure 10.2.3. Sole in Sub-Area IV: Trends in the Dutch beam trawl fleet fishing effort based on days at sea records in the Dutch logbook database from vessels landings into the Netherlands.

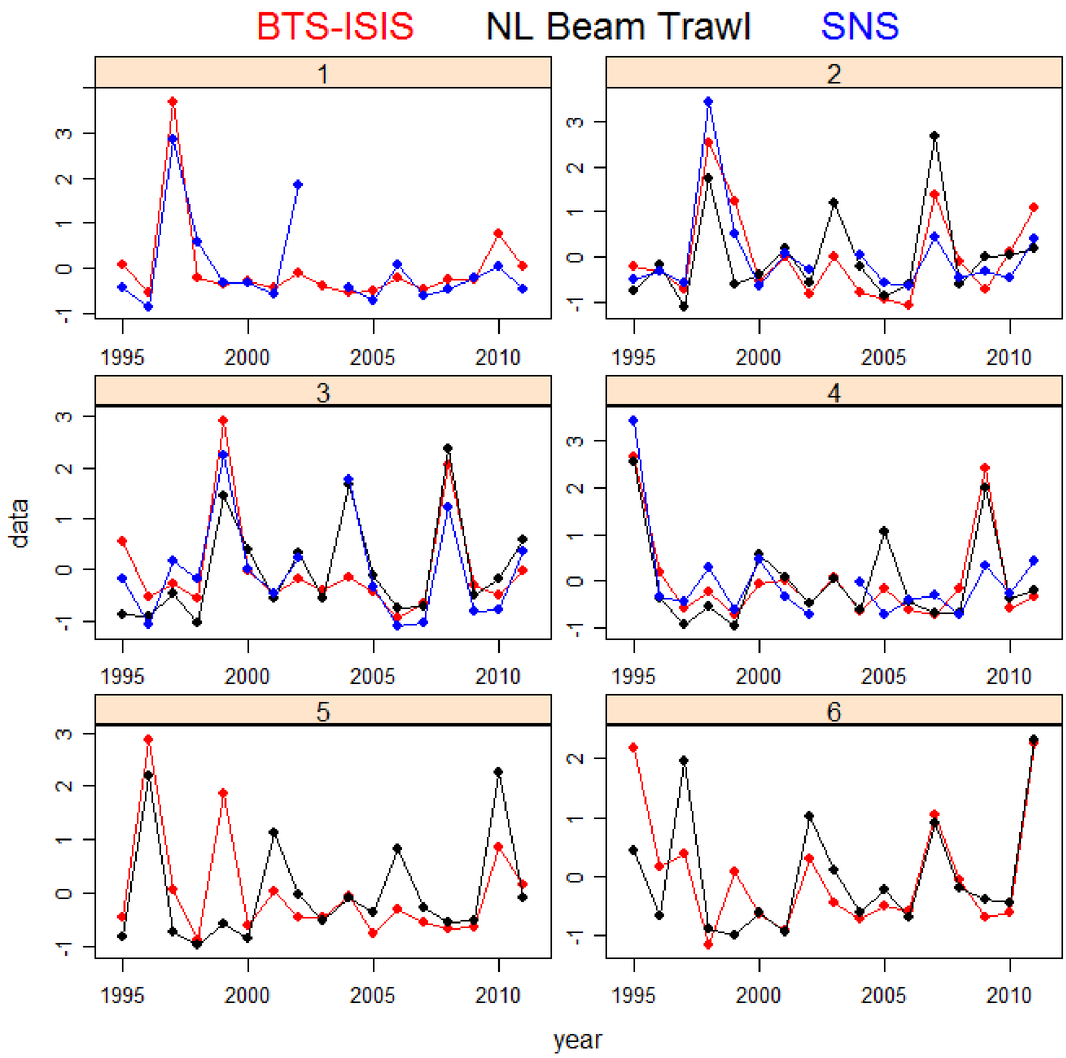


Figure 10.2.4 Sole in sub-area IV. Time series of the standardized indices age 1 to 6 from the three tuning fleets used in the final XSA assessment (BTS-ISIS, SNS and NL beam trawl).

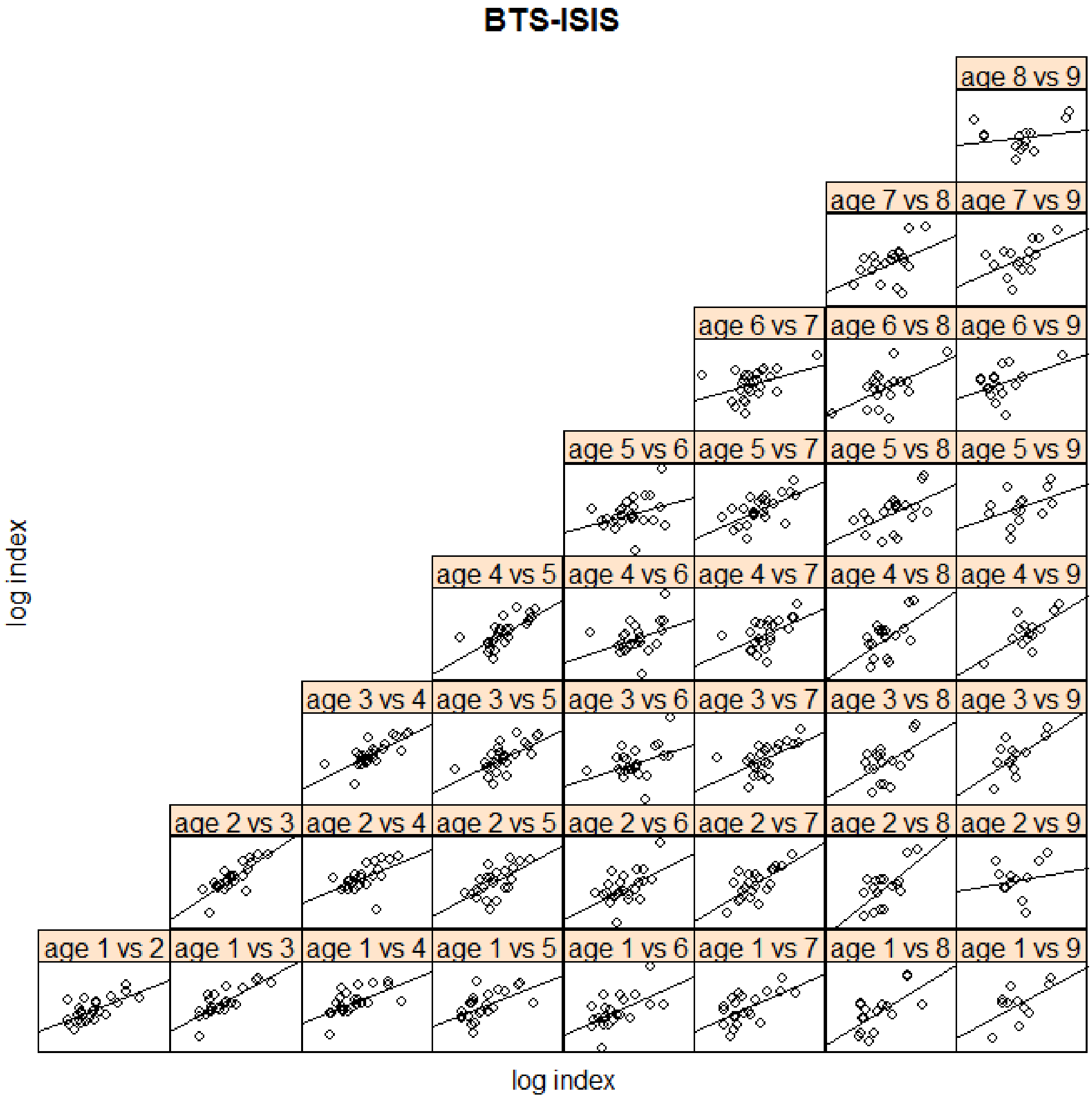


Figure 10.2.5 Sole in sub-area IV. Internal consistency in BTS-ISIS survey tuning index.

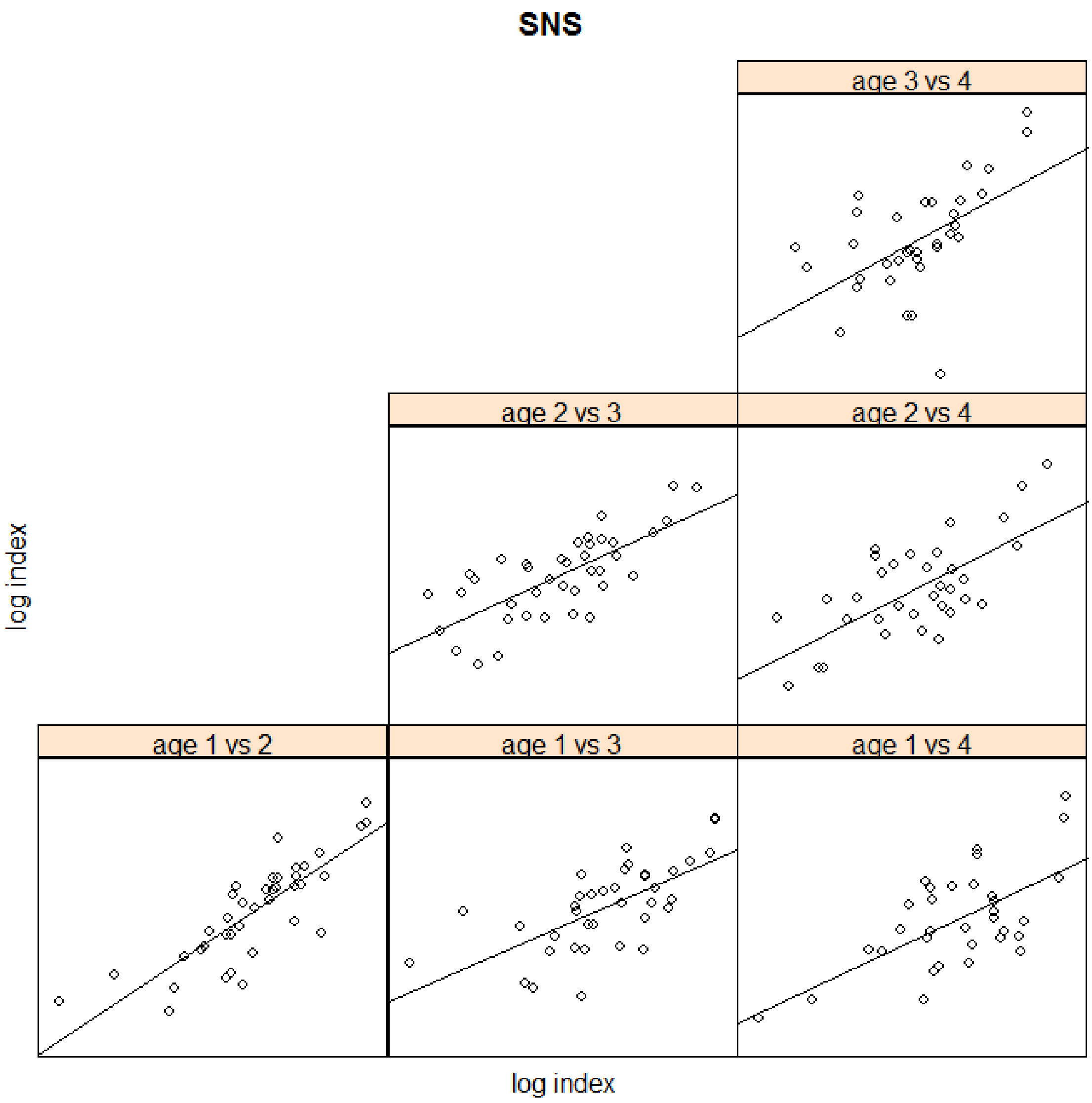


Figure 10.2.6 Sole in sub-area IV. Internal consistency in SNS survey tuning index.

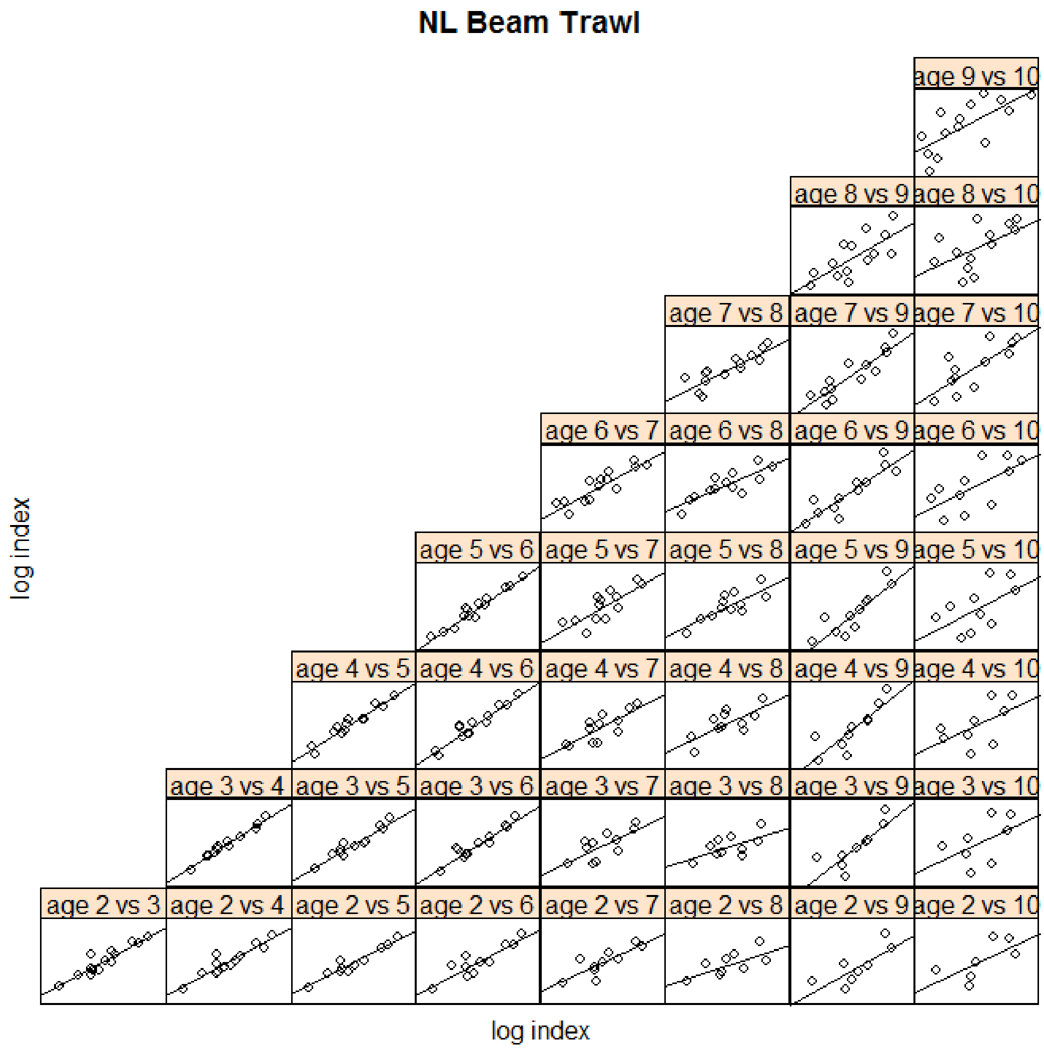


Figure 10.2.7 Sole in sub-area IV. Internal consistency in NL Beam trawl commercial tuning index.

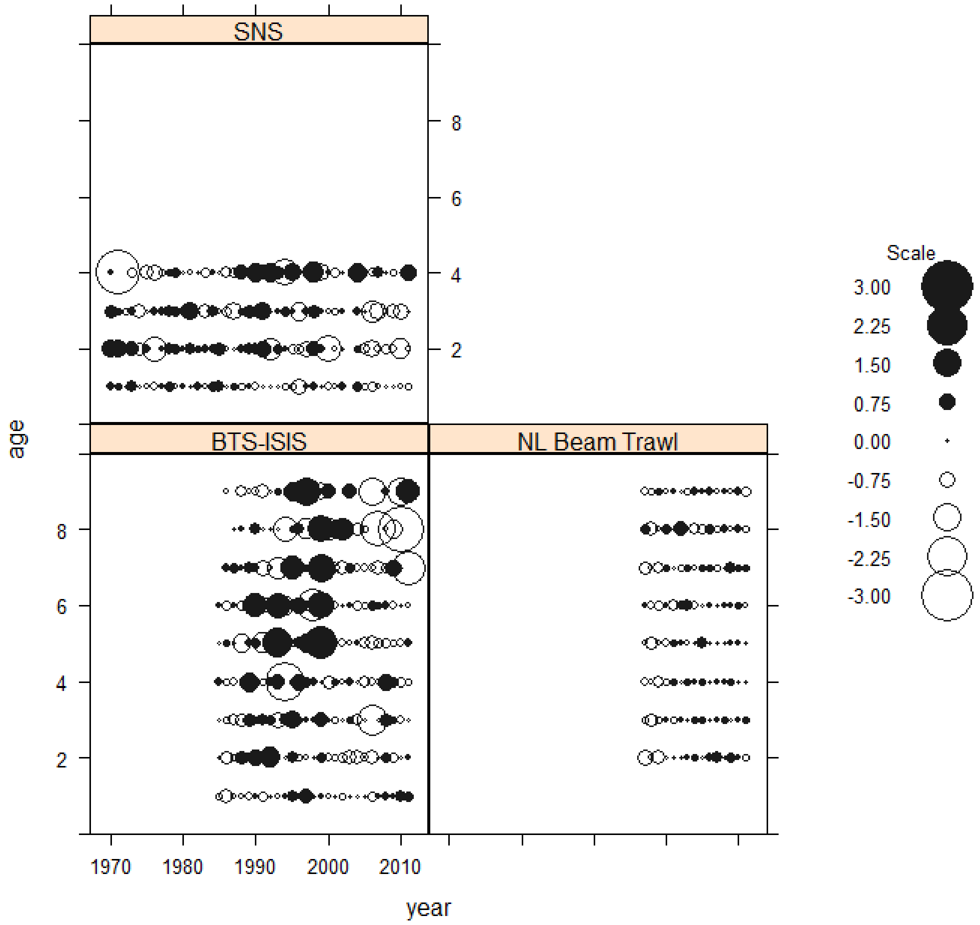


Figure 10.3.1. Sole in sub-area IV. log catchability residuals for the tuning fleets, BTS, SNS and NL beam trawl, in the final run. Closed and dark- circles indicate positive residuals, open circles indicate negative residuals

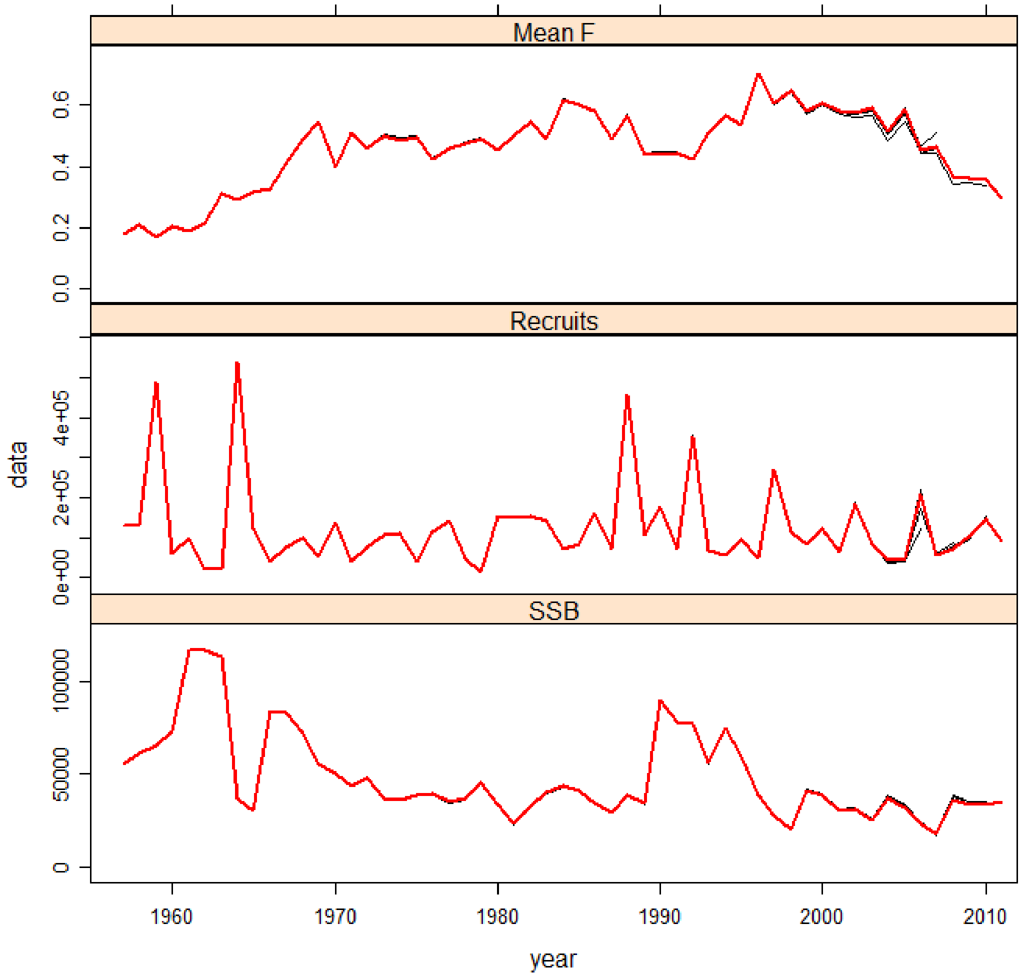


Figure 10.3.2 Sole in sub-area IV. Retrospective analysis of F, SSB and recruitment for 1995–2011 for the final XSA run.

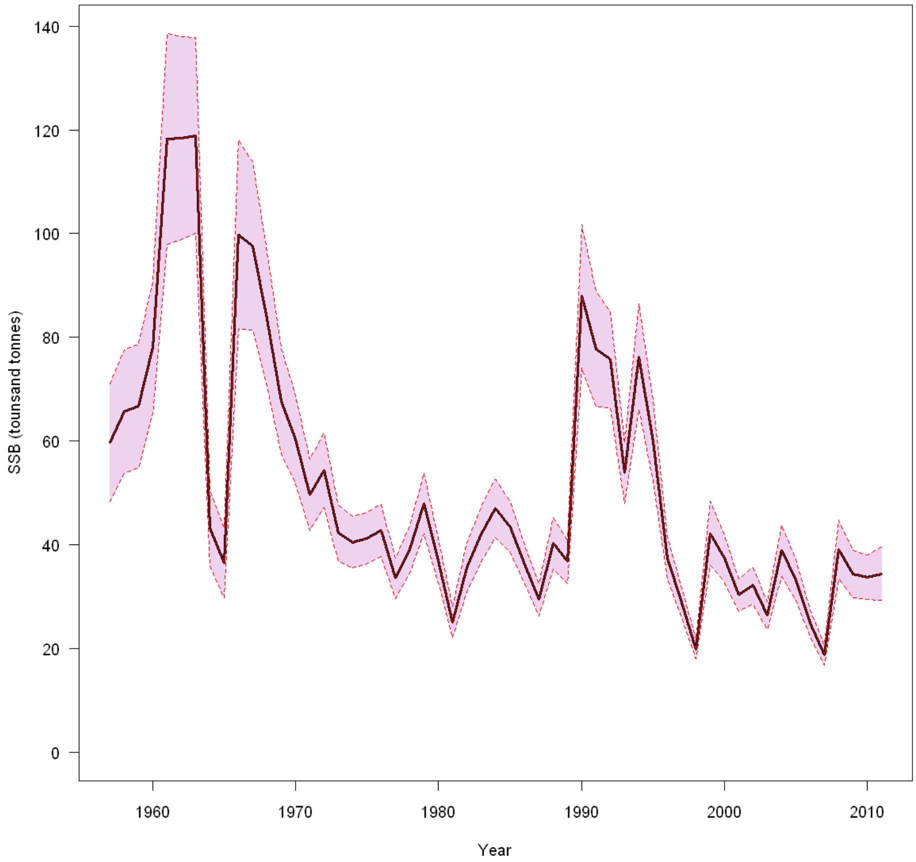


Figure 10.3.3a Sole in sub-area IV: SSB 1957–2011 output by SAM model.

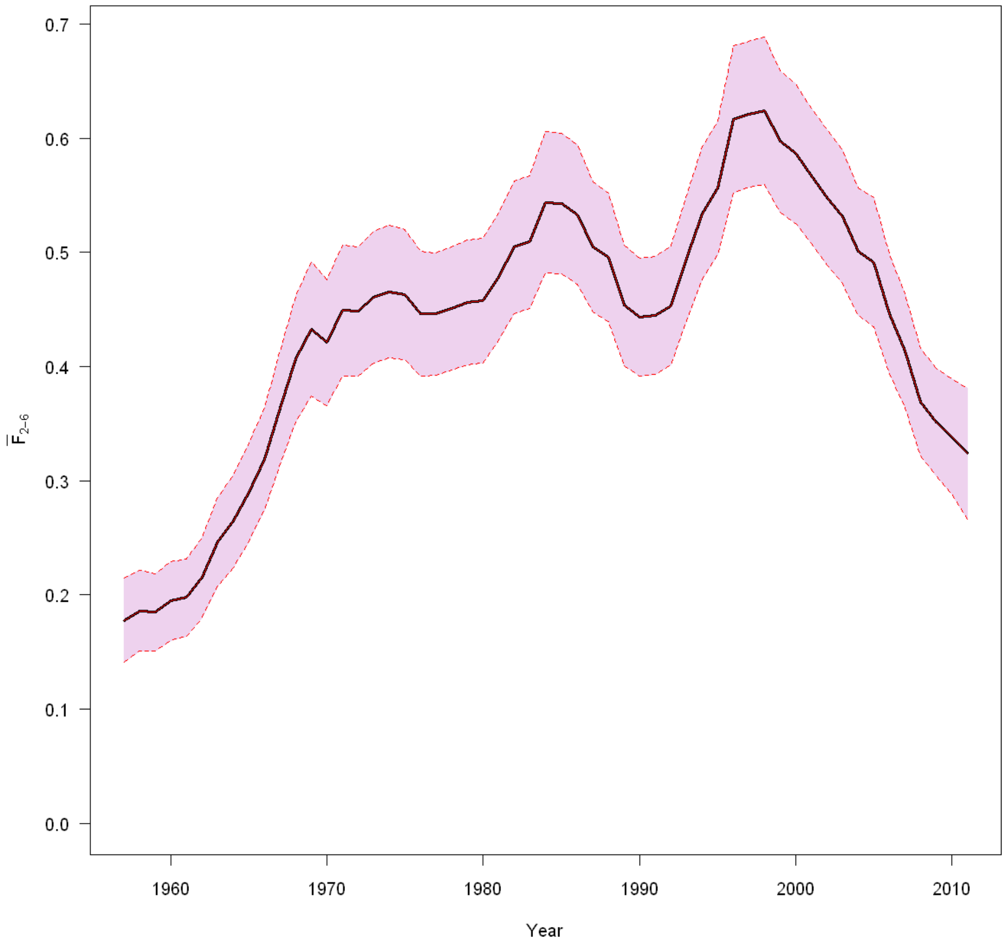


Figure 10.3.3b Sole in sub-area IV: Fishing mortality on ages 2-6 1957–2011 output by SAM model.

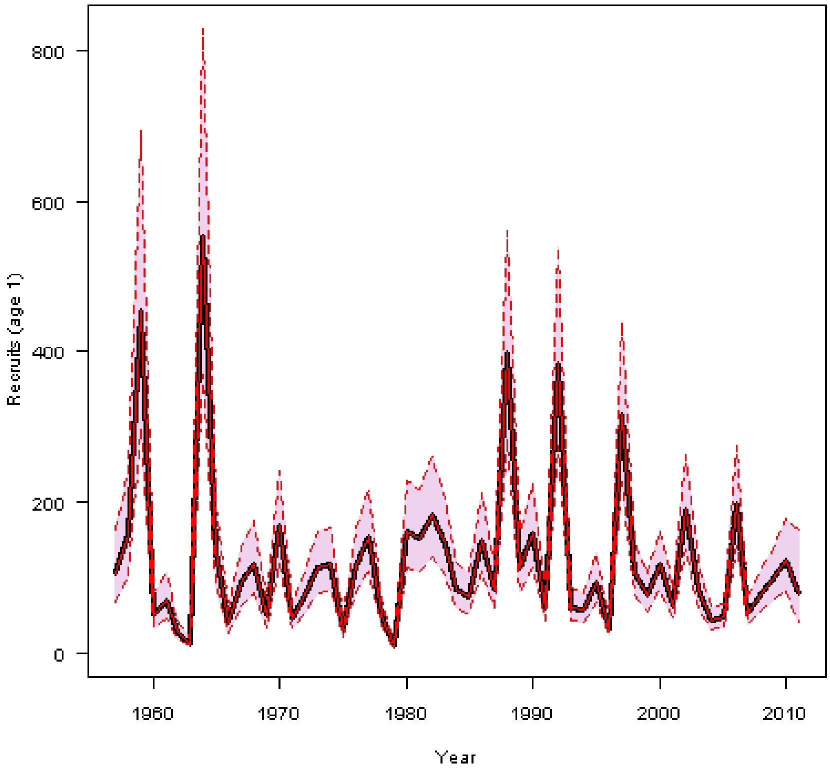


Figure 10.3.3c Sole in sub-area IV: Recruitment 1957–2011 output by SAM model.

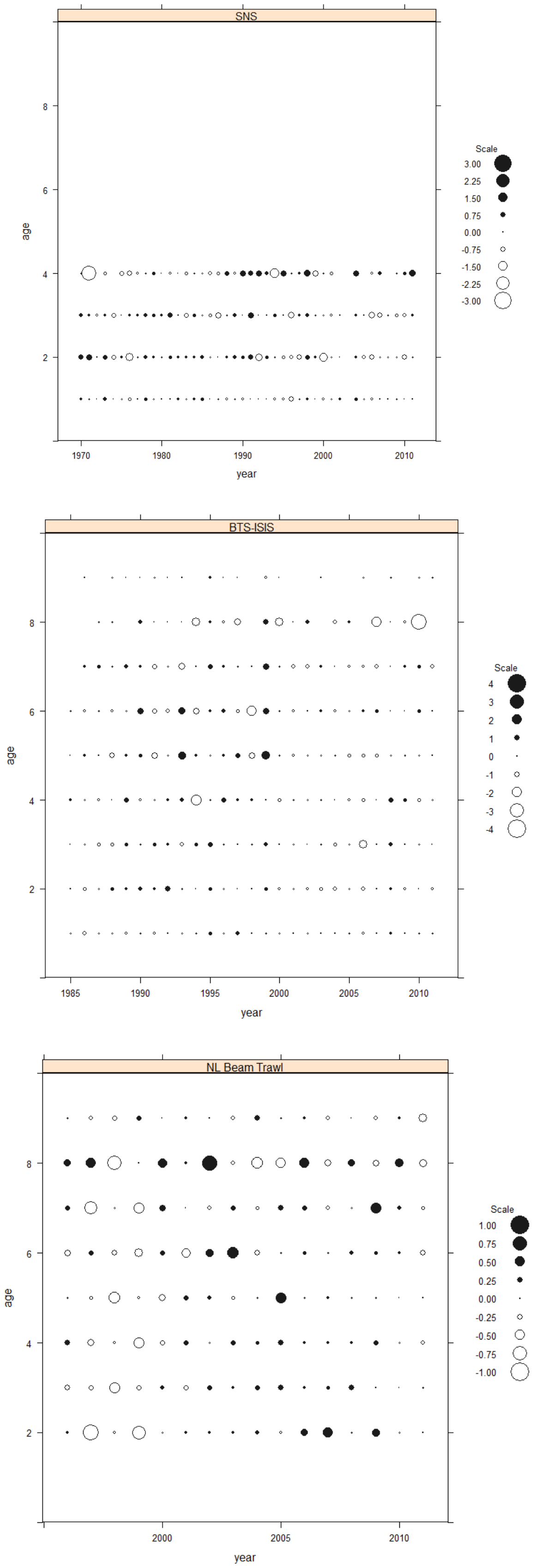
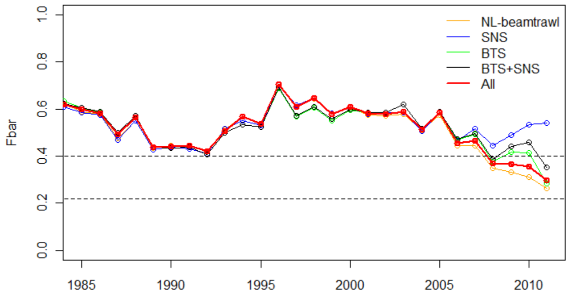


Figure 10.3.4 Sole in sub-area IV. log catchability residuals for the tuning fleets in the single fleet XSA assessments, BTS, SNS and NL beam trawl. Closed and dark- circles indicate positive residuals, open circles indicate negative residuals



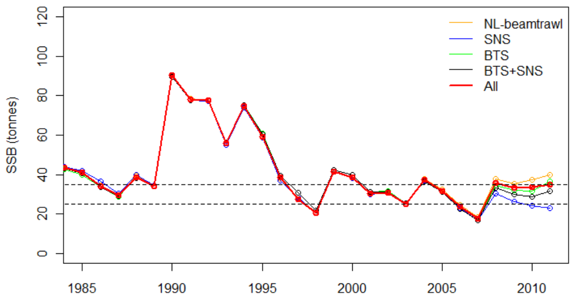


Figure 10.3.5 Sole in sub-area IV. F (left) and SSB (right) estimates for different combinations of the tuning series

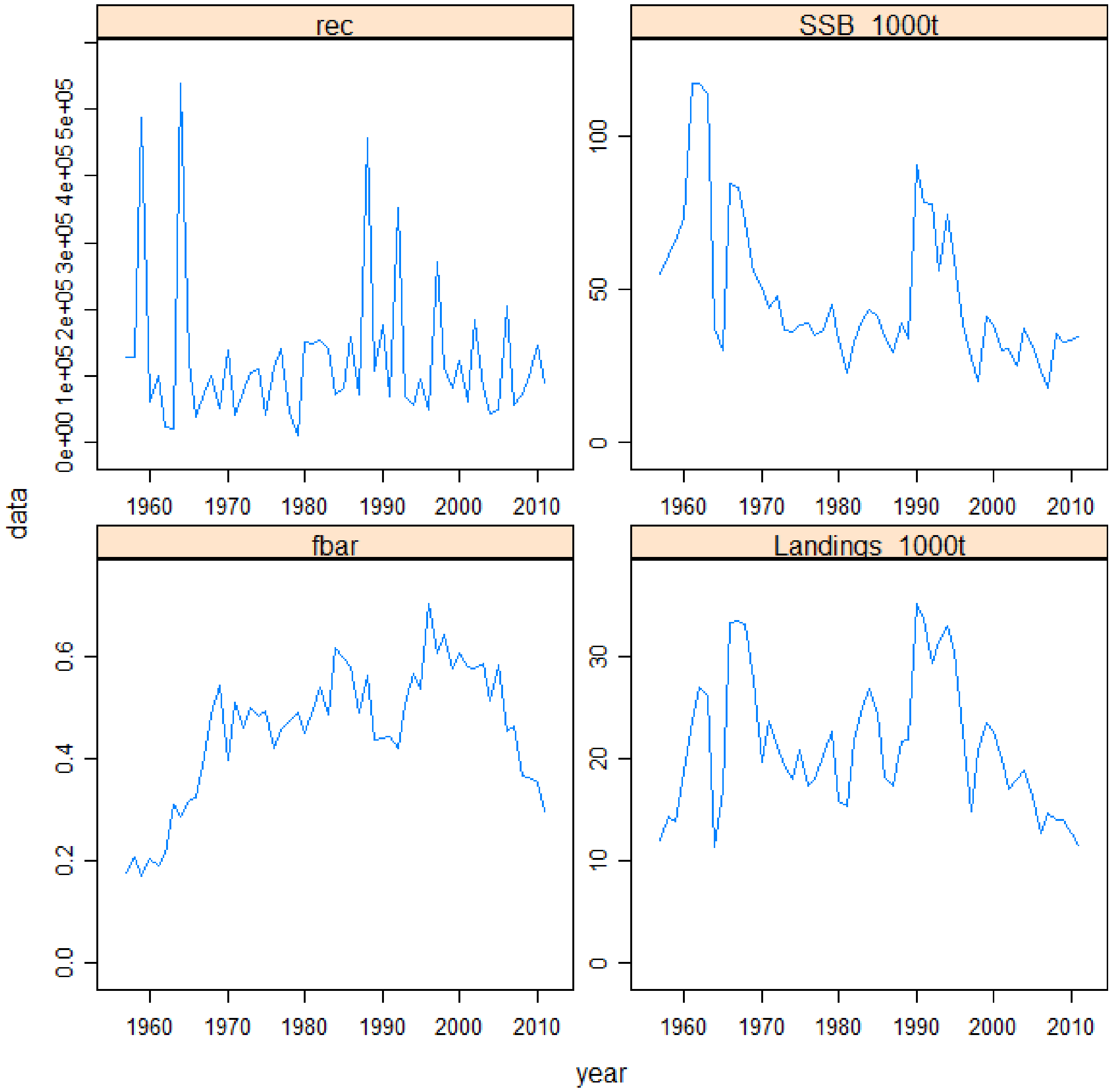


Figure 10.4.1 Sole in sub-area IV 1957-2011. XSA summary plots. Time series of recruitment (top left), SSB (top right), mean fishing mortality one ages 2-6 (bottom left) and landings (bottom right).

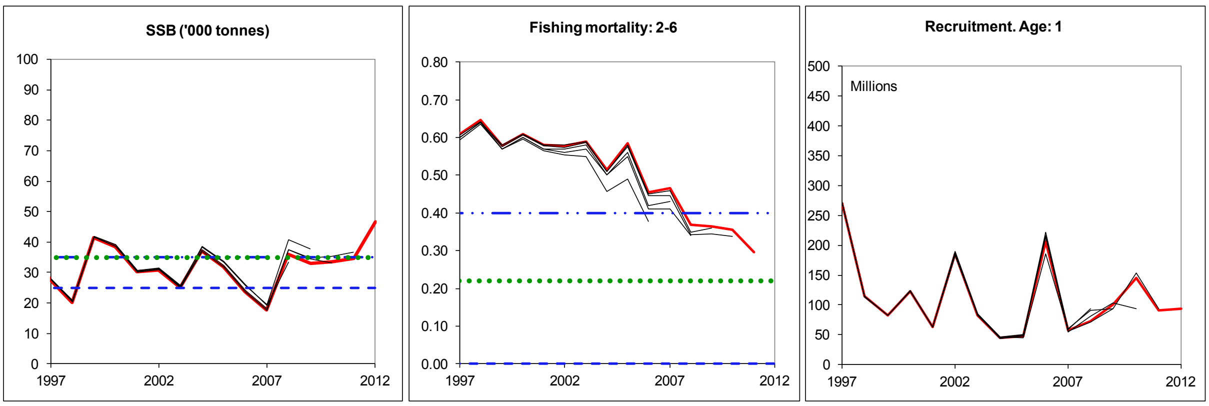
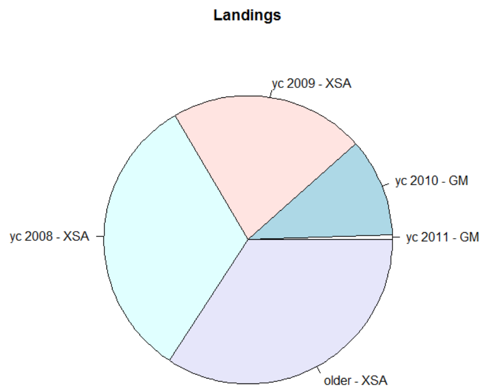


Figure 10.4.2 Sole in Subarea IV (North Sea). Historical assessment results (final year recruitment estimates included).



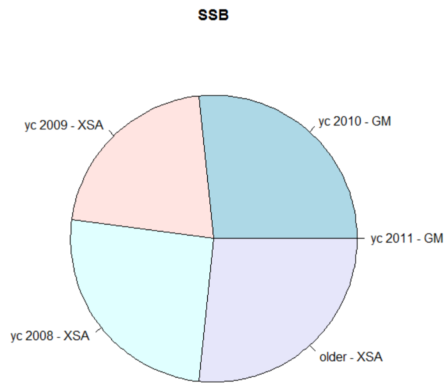
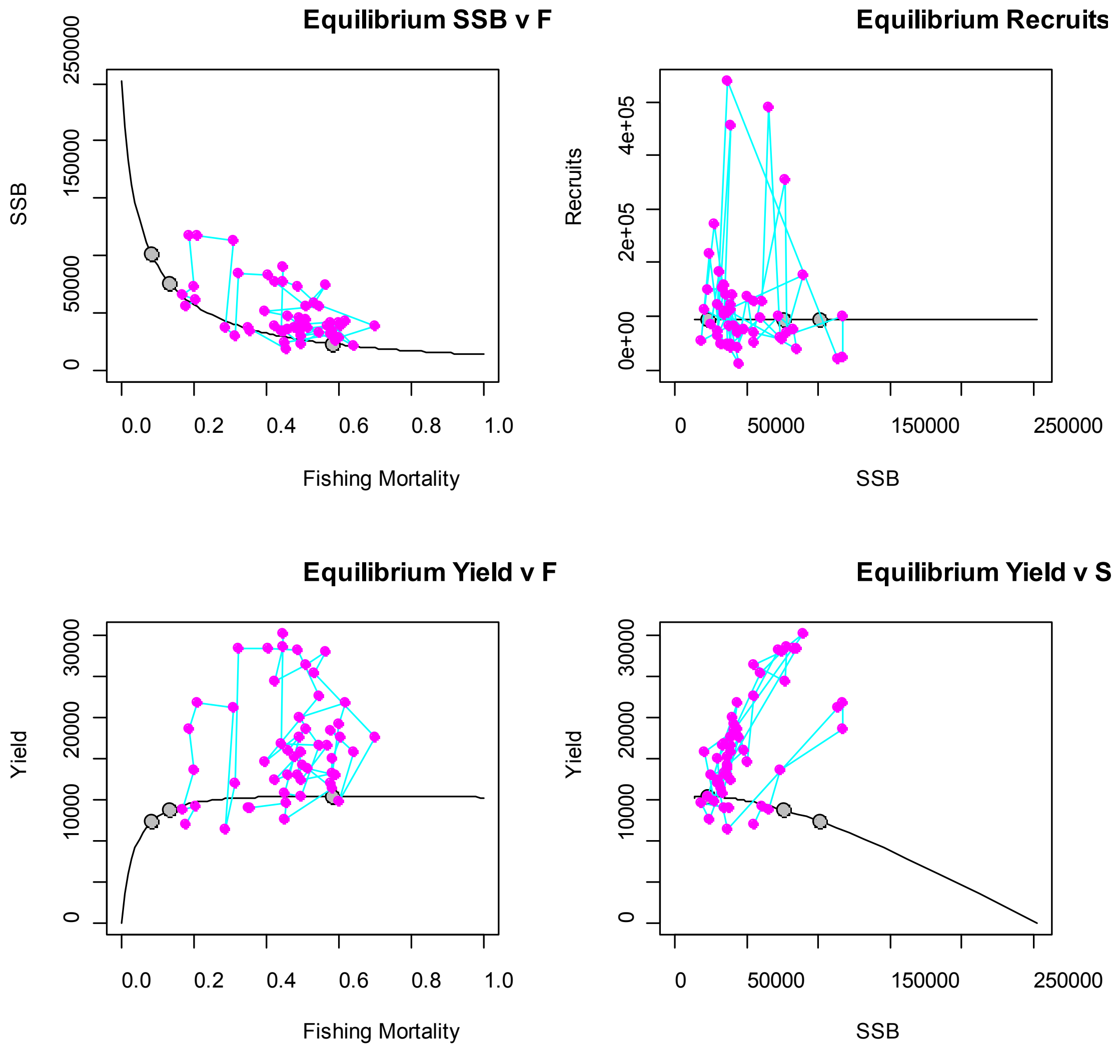


Figure 10.5.1 Sole in sub-area IV. Relative year class contribution to 2014 predicted SSB (left) and 2014 landings (right). Stock numbers of 1 year olds: (2008/XSA) 73000 (2009/XSA) 101000, (2010/XSA) 145000 & (2011/XSA) 91000 and (2012/GM) 94 000.



Yield and spawning biomass per Recruit

F-reference points:

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.34	0.16	0.44
Fmax	0.55	0.16	0.28
F0.1	0.10	0.13	1.09
Fmed	0.36	0.16	0.41

Figure 10.5.2 Sole in sub-area IV. YPR results.

11 Saithe in Subareas IV, VI and Division IIIa

The May 2011 assessment of saithe (Pollachius virens) in Subareas IV and VI and Division IIIa was run as agreed during the benchmark WKBENCH 2011, i.e.with ages 3-5 excluded for the commercial indices (NORTRL_IV22, FRATRB_IV _IV and GER_OTB_IV)).

In October 2011 the AGCREFA 2008 protocol showed that new survey data information in Q3 made reopening of the advice necessary. The review group of the reopening argued for a re-insertion of ages 3-5 in the commercial indices. The WGNSSK decided for 2012 to use the same settings as in the revised assessment from autumn 2011 as basis for advice after the two assessments (inclusion or exclusion of ages 3-5 from the commercial CPUE indices) were presented to the group. Results of the alternative assessment with age 3-5 excluded from the commercial CPUE indices, however, are also presented in this report.

In 2010 no assessment could be conducted due to missing data, so only a 4 year forecast based on the 2009 assessment was done.

11.1 Ecosystem aspects

See stock annex.

11.1.1 Fisheries

See stock annex.

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, since 2009, the EU fleet fishing for saithe has fallen under the effort regime of the EU cod management plan (1342/2008). This may have contributed to a southern shift in geographical distribution for the German fleet (Figure 11.1.1). A change in distribution has been shown for the French freezer trawl fleet (giving the FRATRB_IV _IV) and thereby a change in fishing pattern (Figure 11.1.2). Additional factors for the change in area in the French fleet have also been an area conflict with gillnetters at traditional saithe fishing grounds. A shift in geographical distribution of the catches has also been shown for the Norwegian trawling fleet, markedly in 2009 and 2011, even without such restrictions (Figure 11.1.3).

French and German trawlers are targeting saithe and have large quotas. The discard in these fleets is considered low (less than 5 %). The largest quota is taken by the Norwegian trawlers that have a total ban for discarding, and restricted bycatch allowances. The vessels have to leave the area when the boat quotas are reached, and in addition the fishery is closed if the seasonal quota is reached. The Skagerrak agreement that used to regulate the fisheries in this area is terminated. Precautionary area closures where mixed fisheries is observed in and the southern part of Norwegian and northern part of Danish waters have been an issue, and will be patrolled by the Norwegian coastguard.

In 2011 the landings were estimated to be around 89 704 t in Subarea IV and Division IIIa, 7 400 t in Subarea VI, which both are below the TACs for both area IV and Division IIIa and for Subarea VI (93 600 and 9 570 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, discard numbers have not been used in the assessment. Ages 1 and 2 are mainly distributed close to the shore and are normally very scarce in the main fishing areas for saithe. In the last year some catches of some age 2 fish have been observed. The total level of discards in area IV and IIIa reported from three nations is 4 900 t.

ICES advice for 2013

In November 2011, an update assessment was made with all age groups included in the trawl indexes. The settings from this assessment are used in the current assessment. However, since the NORASS index was not consistent with former years probably due to a vessel effect, the 2011 values for this index was excluded.

Exploitation boundaries in relation to existing management plans

"The EU Norway agreement management plan as updated in December 2008 results in a TAC of 100 684 t. ICES has evaluated the plan and concludes that it is consistent with the precautionary approach in the short term (< 5 years)."

Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential and considering ecosystem effects

"Following the ICES MSY approach implies fishing mortality to be marginally increased to 0.30, resulting in landings of 113 000 t in 2013. This is expected to lead to an SSB of 241 064 in 2014. "

Exploitation boundaries in relation to precautionary limits

"In order to follow the precautionary approach with Fpa=0.4, total landings should be 143.132 kt in 2013."

ICES conclusion on exploitation boundaries

"The stock biomass is close to Bpa and recruitment estimates for the terminal year are uncertain. The forcast is highly sensitive to the recruitment estimate. Because the harvest control rule results in large differences if the stock is estimated to be below or above Bpa, the advice varies greatly. The probability of reopening the advice increased when new survey information become available as year effects in the scientific surveys were encountered in recent years.

Management

The ICES advice applies to the combined areas IIIa, IV, and VI.

Management of saithe is by TAC and technical measures. The agreed TAC for saithe in Subarea IV and Division IIIa for 2011 were 93 318 t, and 9 682 t for Subarea VI. The agreed TAC in 2012 were 79 320 tons for Subarea IV and Division IIIa and 400 t for Subarea VI.

In 2008 EU and Norway renewed the existing agreement on "*a long-term plan for the saithe stock in the Skagerrak, the North Sea and west of Scotland, which is consistent with a precautionary approach and designed to provide for sustainable fisheries and high yields. The plan shall consist of the following elements:*

1. *Every effort shall be made to maintain a minimum level of Spawning Stock biomass (SSB) greater than 106 000 tonnes (B_{lim}).*
2. *Where the SSB is estimated to be above 200 000 tonnes the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of no more than 0.30 for appropriate age groups.*

3. *Where the SSB is estimated to be below 200 000 tonnes but above 106 000 tonnes The TAC shall not exceed a level which, on the basis of a scientific evaluation by ICES, will result in a fishing mortality rate equal to 0.30-0.20*(200 000-SSB)/94 000.*
4. *Where the SSB is estimated by the ICES to be below the minimum level of SSB of 106 000 tonnes the TAC shall be set at a level corresponding to a fishing mortality rate of no more than 0.1.*
5. *Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 15% from the TAC the preceding year the Parties shall fix a TAC that is no more than 15% greater or 15% less than the TAC of the preceding year.*
6. *Notwithstanding paragraph 5 the Parties may where considered appropriate reduce the TAC by more than 15% compared to the TAC of the preceding year.*
7. *A review of this arrangement shall take place no later than 31 December 2012.*
8. *This arrangement enters into force on 1 January 2009."*

11.1.2 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). Given the current low recruitment and the still low growth rates in the stock, a re-evaluation of the management plan reference points should be considered.

11.2 Data available

11.2.1 Catch

Landings by country and TACs are presented in Table 11.2.1. Major revisions were applied to the age structure of the Norwegian 2010 landings. The revised landing data is skewed towards older ages compared to the previous estimate, but total catches are not changed. 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. Working group estimates for area IV (97104 t) are less than 1 % higher than officially reported landings (96587) in 2011.

11.2.2 Age compositions

Age compositions of the landings are presented in Table 11.2.2. Landings-at-age data by fleet were supplied by Germany, France, Norway, Poland, UK (England), Denmark and UK (Scotland) for Area IV and IIIa and only UK (Scotland) for Area VI separately. The differences between the sum-of-products (SOP) and the working group estimate was less than 3 % in 2011. SOP correction was still used. The International catch data were raised using the ICES database Intercatch. Figure 11.2.1 shows that the proportions in the age distribution in later years reflect the strong year classes.

Before upload to Intercatch, the Norwegian catch and weight at age were estimated using ECA (Hirst et al 2004, 2005, and 2012), a software developed in Norway to utilize the different sources of catch sampling information. Implementing the methods in Hirst et al. 2004, 2005 and 2012; a Bayesian hierarchical model has been developed to estimate the catch-at-age of fish, using data on age, length and age-given-length.

ECA has been thoroughly tested and used for estimating Norwegian catch and weights at age of Northeast Arctic cod, haddock and partly saithe since 2006. The Norwegian sampling strategy is to have age and length samples from all major gears in each main area and quarter. The main sampling program is the Norwegian self-sampling program with vessels in a high seas reference fleet and a coastal reference fleet. Additional samples of catches are obtained from the coast guard and IMR. However, the Norwegian sampling effort in the North Sea is below a responsible level and is reflected in the uncertainty of catch at age estimates. A coefficient of variance (CV) above 50% is not uncommon for saithe in area IIIa and IV, but is dependent on gear, area and quarter. A CV of 20-30 % is desirable.

The Norwegian catch at age allocation, performed with the old method, contained an error causing the catch of three year olds in 2010 allocations to be highly overestimated. The 2010 catch data were revised using ECA and the 2011 May assessment was rerun with the revised data. This revision caused major changes in the 2011 May assessment for recruitment (-44%), SSB (+14%), and Fbar (-22%). A comparison of the assessments from May 2011 with the original and revised 2010 age distribution is shown in figure 11.2.3.

11.2.3 Weight at age

The error in the Norwegian 2010 data also affected the weight at age estimate and this was revised. Weights at age in the catch are presented in Table 11.2.3 and Figure 11.2.2. These 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, and slightly higher weight at age is observed for all ages in 2010 and 2011.

11.2.4 Maturity and natural mortality

A natural mortality rate of 0.2 is used for all ages and years, and 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 contionus 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. A yearly update of the maturity ogives may give a more accurate assessment of SSB although the implications for realised spawning potential are unknown.

11.2.5 Catch, effort and research vessel data

In January 2011 a benchmark was set for the assessment of North Sea saithe (WKBENCH 2011), and the conclusion of the benchmark was to include 6 tuning indices in the assessment (3 commercial and 3 surveys).

The commercial fleets are:

- French demersal trawl, age range: 3-9, year range 1990-2010 (“FRATRB_IV ”)
- German bottom trawl, age range: 3-9, year range 1995-2010 (“GEROTB”)

- Norwegian bottom trawl, age range: 3-9, year range 1980-2010 (“NORTRL_IV2”)

  (Part 2 : 1993-2010)

NORTRL_IV2 is the CPUE from large Norwegian saithe trawlers in the North Sea. The index was used in the assessment until 2006, but then removed based on diverging pattern in log-cpue curves and large log catchability residuals from the XSA runs. The residual plots (Figure 11.3.18) does not indicate large problems any more, and the spatial changes in particular in the German fisheries, made WKBENCH include the index again.

Geographical distribution of all three (French, German, Norwegian) trawler fleets were available in 2012 (figure 11.1.1 to 11.1.3) The Norwegian commercial fleet typically fish at the edge of the Haltenbank, but in 2009 and 2011 has shifted more to the edge of the Norwegian trench. There is also a slight temporal change to the 2nd quarter of the year. Since 2009 the EU fleets fishing for saithe has fallen under the effort regime of the EU cod management plan (1342/2008). This may have contributed to a southern shift in geographical distribution and thereby a change in fishing pattern. This can be seen for the German trawl catches that has had a southward shift from 2009, reducing the catches north of 60 deg. The trawl catches from German trawlers are concentrated outside the edge of the continental slope in southern Norway, outside Egersund. This is an area where precautionary zones may be implemented from 2012 due to problems with mixed fisheries. The number of statistical squares representing 90 % of the catches has gone down for the German fleet, which reflects a concentration of the effort.

A shift in geographical distribution is also shown for the French trawl effort in 2009 and 2010, but most of this shift is explained from gear conflicts and increased effort from gillnetters in the northern areas (Figure 11.1.2). The Norwegian trawl catch distribution has shifted southward in 2009 and 2011 (Figure 11.1.3).

The Surveys are:

- Norwegian acoustic survey, age range 3-6, year range 1995-2011 (“NOR-ACU”)
- IBTS quarter 3, age range: 3-5, year range 1991-2011 (“IBTS-Q3”)
- Norwegian Acoustic saithe survey, age range 2-4, year range 2005-2011: “NORASS”

The NORASS is an acoustic survey covering a fraction of the undersea mountains at the Norwegian coast from approximately 59°N to 62°N. At these subsea mountain tops the young (2-4 years) saithe aggregates during spring to feed on *Calanus spp.* that are being concentrated by the eddies around the subsea mountains. The survey was included during BENCHMARK to strengthen data on young saithe and recruiting year classes. In 2011 a change of survey vessels was done in the NORASS survey, without any inter calibration with the vessel used earlier for the index. The 2011 data showed a clear year effect, and was not used in the assessment.

The data available for the working group for the tuning in 2012 is shown in Table 11.2.5.

11.3 Data analyses

All catch-data were loaded and raised using the ICES software Intercatch. The XSA assessment and forecast was run in FLR.

11.3.1 Reviews of last year's assessment

Given the current low recruitment and low growth rates in the stock a re-evaluation of the management plan reference points should be considered.

There will be a re-evaluation of the management plan in 2012. Joint meetings between EU and Norway will take place in May/June 2012 to discuss issues related to the management plan.

There are conflicting trends between the two acoustic surveys (NORACU and NORASS). NORACU shows a significant decline in abundance from 2008 to 2010 for all ages while NORASS indicates an increase for ages 2 and 3 with declines for ages 4 and 5 that is unresolved.

The figure has been misinterpreted by the review group. To follow the cohorts the time shift has to be taken into account. I.e. trends in age 2 have to be compared to age 3 one year later. Trends are less conflicting when taking this into account.

There appear to be some residual patterns in the IBTS Q3 that are not addressed and could result in the exclusion of the index given further analysis.

Year effects have been discovered in IBTS in especially in the last three years (ICES WGNSSK 2011), but also in NORACU. One hypothesis is a change in the distribution of the stock leading to migration in and out of the survey area. The fishing industry doubts whether hauls with half an hour duration with the trawl used for assessment (GOV 47)can lead to representative catches of saithe. However, given the low weight of the IBTS index in the assessment (<10%), this is regarded a minor issue. Next to this IBTS and NORACU don't disagree in the main trends (Figure 11.3.1).

The landings used are not reported landings but estimated ones. It is not said in the section nor in the annex how this landings are estimated. The procedure should be described in future reports. And the reason for the higher discrepancy between reported and estimated landings in 2010 should be investigated.

Landings are reported to the group via the national institutes as for all other stocks. If there are discrepancies between reported landings from national administrations and national institutes, data from the national institutes are used as Working Group estimates. Raising has been done with InterCatch. The report is not the place to describe these things, but the stock annex can be updated.

Using commercial CPUE for hyperstability fisheries can have serious implications for model outputs. In this stock there is evidence that CPUE is remaining high while abundance is declining. The report also discusses changing temporal and spatial fishing patterns and gear which may be another contributing factor to maintaining catch rates at a high level.

Changes in fishing patterns are an issue for this assessment. In especially in 2009 and 2010 changes have occurred for all major fleets (see chapters 11.1.1., 11.2.5 and Figures 11.1.1-11.1.3) . In 2011 the French tuning fleet shows fishing patterns that are more in line with previous observed fishing patterns . During the review of the assessment in autumn it was decided that the commercial indices can still be used also for the younger ages to give information on stock trends (see below). Further analyses do not contradict with this conclusion (see below) especially for ages 4 and 5.

In Figures 11.3.8 and 11.3.9 Surveys and Commercial indices are compared independently, it would be of interest to compare surveys and commercial indices together as both are treated in the same way in the XSA.

Figures stay separately as all indices in one plot are confusing. However, discrepancies between the two data sources are discussed.

In Figure 11.3.10 the text reference is says left and right to distinguish plots but it should be top and bottom. In the main text nothing is said about which gives better retrospective patterns and as the text reference is incorrect I cannot know which is better. The one in the top gives better retrospective pattern, if this does not correspond with the current assessment an explanation would be required.

A better explanation of the figure has been done to ensure readability of the report.

In the section 11.5 "Recruitments Estimates" it is not clear which years use the geometric mean recruitment.

This is now described in a better way.

There has been a significant change in F for the younger ages in the final year (2010) that does not appear in the runs using the old assessment suit of indices and ages.

After the revision of Norwegian landings at age data this discrepancy between both assessments became much lower (see chapter 11.2.2).

Suggestions for future benchmarks.

- **Remove age 3 from the calculation of reference F and update reference points accordingly.**
- **Analyze possible hyperstability of the commercial CPUE series and try to standardize them to remove variations in CPUE not associated with variation in stock abundance.**
- **Try to obtain reliable estimates of discards in order to incorporate them into the assessment.**

The need for an inter-benchmark will be evaluated and suggestions will be taken into account accordingly.

Points for consideration in 2012 from the Review group on saithe assessment in autumn 2011

- **Pre-benchmark settings used as a base.**

The assessment in 2012 has been carried out with the same settings as suggested by the review group in autumn 2011.

- **Hypothesis with regards to hyperstability of the commercial fleets are explored statistically. E.g. by estimating the most appropriate relationship between the converged VPA population numbers against commercial cpue indices, with particular attention of deviation through time.**

First preliminary analyses have been carried out during WGNSSK contrasting XSA estimates with CPUE indices for ages 3 to 5 and for the years up to 2007 (4 years before the terminal year). The French Trawl index (FRATRB_IV _IV) started in 1991, the Norwegian Trawl (NORTRL_IV2) index in 1993 and the German (GER_OTB_IV)) in 1995. Since XSA estimates and tuning indices are not fully independent even for years prior to 2008, the CPUE indices were also contrasted to indices derived from NORACU. For this analysis data up to 2011 could be used.

In general, there were quite strong relationships between XSA estimates prior to 2008 and CPUE indices for age 4 and 5 (Figure 11.3.2). Only for NORTRL_IV2 the relationship for age 4 was weak. For age 3 the relationships were much weaker and there was hardly any relationship with the French CPUE index (FRATRB_IV _IV). Despite for the French index at age 3 there were no strong indications for hyperstability. CPUE indices decreased in line with XSA estimates although there is uncertainty around the relationships and outliers occur. The intercept of the linear regressions did not show serious deviations from zero, despite for the French index at age 3 and to some extent for the Norwegian index at age 4 and 5.

The French index showed quite strong relationships when contrasting it with the NORACU index (Figure 11.3.3). Only for age 3 the CPUE index values were higher than expected from a linear relationship at low NORACU index values. The relationships with the Norwegian index were weaker and more uncertain. In especially for age 3 and 4 hardly any relationship existed. The relationship for age 3 was driven by two higher index values at high NORACU index values. Otherwise the NORTR index did hardly change with changes in NORACU. The relationship for age 5 was stronger and only one data point at a very low NORACU value was considerably higher than expected by a linear relationship.. The relationship between the indexes is generally low for age 3 and the NORACU (R2 for FRATRB_IV: 0.3; NORTRL_IV: 0.23 and GER_OTB_IV: 0.26). A high value is visible in GER_OTB_IV for age 3 in 2010. High age 4 catches in 2011, however, suggest that there was indeed a stronger year class not visible in the NORACU. While the relationship with the German CPUE index was weak for age 4, it was strong for age 5 despite a minor positive deviation at the lowest observed NORACU index value.

Overall, there were no strong indications for a general hyperstability of the commercial CPUE indices when contrasting the commercial CPUE indices with XSA estimates. Index values for age 3 are highly uncertain. There were some indications for hyperstability when contrasting the commercial indices to the NORACU in especially at low NORACU index values. However, it was not possible to judge whether deviations from a linear relationship came due to hyperstability or a decrease in catchability with decreasing abundance in the NORACU. In addition, also the NORACU index has to be considered uncertain and in the latest years strong year effects occurred (ICES WGNSSK 2011; Figure 11.3.4). Therefore, it was concluded by the group that it is not warranted from the results to exclude the commercial indices for ages 3-5 for this assessment. However, caution is needed as the effect of latest changes in fishing patterns could not be taken into account in the comparison with converged XSA estimates. In especially estimates for age 3 have to be treated as very uncertain. Next to this the very poor performance of the commercial indices for some ages should be investigated at the next benchmark potentially leading to the exclusion of some age-index combinations.

- **Survey indices are scrutinized further with the aim trying to find the reason for the apparent increase in year effects in recent years compared with that in the past.**

Norway has investigated the survey design of NORACU and whether changes could explain the year effects observed in the last years. There is no indication that changes in survey design could have led to these changes.

- **The sensitivity of using the 10 as plus group is tested (the true tuning age in the XSA at present is age 9, which has a high catch proportion). If such**

sensitivity test has been made in recent years, documents should at minimum be cited.

The need for an inter-benchmark will be evaluated and suggestions will be taken into account accordingly.

- **Alternative modeling framework that may be able to handle transient year effect properly (e.g. TSA) may need to be explored.**

The need for an inter-benchmark will be evaluated and suggestions will be taken into account accordingly.

- **Analysis related to potential fall 2012 update be performed and procedures suggested (including potential scenario that it should not take place).**

Latest observed year effects in the scientific surveys together with uncertain recruitment estimates make it more likely that an update assessment is needed despite a general good retrospective pattern in the assessment for SSB and F.

11.3.2 Exploratory survey-based analyses

Log-abundance indices by cohort for the tuning series are shown in Figure 11.3.4. The pattern is similar to the pattern in the catch data curves (Figure 11.3.13), with partial recruitment of age 3 for recent cohorts. The curves for the most recent cohorts of the NORTRL_IV1 time series show a pattern that differs from earlier cohorts in the NORTRL_IV2 series and from the curves of the other tuning series (Figure 11.3.4), suggesting higher mean age in the catches from 1993 onwards. This indicates changes in the exploitation pattern or data problems in the Norwegian trawler fleet and led to the exclusion of the series from tuning in 2007. However, the reintroduction of the fleet (part 2, from 1993 onwards) in the tuning was agreed at the benchmark 2011. This conclusion was based on the residuals (Figure 11.3.14) and the fact that other indices might have been more variable or biased in recent years. A strong year effect becomes visible for NORASS age 4 and 5 in 2011. Instead of a decline in the log-abundance index after age 3 as in former years, a strong increase was observed especially for age 4 in 2011 compared to age 3 in 2010. A similar year effect is also visible in NORACU and IBTS, however, to a smaller extent. An increase in the log abundance index from age 3 to age 4 is not unusual for IBTS Q3 and NORACU reflecting partial recruitment at age 3 to the survey area (Figure 11.3.4).

Within-survey correlations for the available tuning series are shown in Figures 11.3.5 – 11.3.10. For all the commercial tuning series the relationship for older ages are strong (Figures 11.3.8 – 11.3.10). The survey-based indexes have a good consistency for younger age groups, i.e. from age 4 to 5 (Figures 11.3.5 – 11.3.7). The relationship between age 3 and age4 one year later is weak for all indexes.

The three scientific survey time series are relatively consistent (Figure 11.3.11). The NORACU and Norwegian part of the IBTS-Q3 are, however, not entirely independent since the age-disaggregation of both indices is based on some of the same age and length samples since 2008. For the NORACU series there is a poor relationship between age 5 and 6, which may be driven by one point in the plot, and therefore of less significance for the assessment (Figure 11.3.6).

The youngfish survey for saithe, NORASS, is the only survey giving index values for 2 year old. However, due to potential vessel effects the 2011 value had to be excluded.

The relative CPUEs in the commercial tuning series are compared in Figure 11.3.12. For age 8 and 9 the consistency between the series is poorer, but the overall trend for the two ages is consistent. Especially there is some discrepancy for age 8 between FRATRB_IV and the two other indices, but the FRATRB_IV is not given a large weight in the XSA compared to the other CPUE indexes, so the discrepancy is of minor concern for the assessment.

In the 2011 assessment, the time series of the “GER_OTB_IV” and “NORTRL_IV2” indicated a very strong 2007 cohort (ICES WGNSSK 2011), while in the “FRATRL_IV” series and in the surveys it appeared medium strong at best (Figure 11.3.11), which gave rise to some uncertainty. The update of the Norwegian age distribution in the 2010 catches has also diminished the year class from this index (Figure 11.3.12) and both data sources are now more in line with each other. During the benchmark 2011 it was decided to exclude the commercial CPUE indices for the younger ages due to the substantial changes in the fishing pattern observed for the German and Norwegian fleets. Therefore, it was assumed that the scientific surveys give more reliable estimates for age 3 - 5 since they are not biased due to spatio-temporal shifts in fishing pattern and potential hyperstability. However, strong year effects also occurred in the scientific surveys in most recent years (Figure 11.3.4). Although the fishing patterns of the trawler fleets have undergone spatial changes, it was concluded in the working group that the indexes should be kept in the assessment. Preliminary analyses do not contradict with this decision (see chapter 11.3.1). An alternative assessment with ages 3-5 excluded from the commercial indexes is presented to evaluate the consequences of this decision for assessment results.

11.3.3 Exploratory catch-at-age-based analyses

Catch curves (log catch-numbers-at-age linked by cohort) for the total catch-at-age matrix are shown in Figure 11.3.13. The plot shows that age 3 is partly recruited to the fishery for recent cohorts, but fully recruited for some of the earlier cohorts. Moreover the catch curves are less steep in recent years compared to earlier. The trend in the gradients is not in agreement with the trend in estimated fishing mortality. This is because catch curve analysis only works if F is stable. The catch curves are assuming that catch equals a proportion of the stock, i.e. that the reduction in catch from one year to the next reflects the reduction in stock numbers. However, if F is increasing, a higher proportion will be taken out of the year class than the year before, and the reduction in catch will therefore be less than the reduction in stock, implying a lower total mortality than the real one when it is based on landings. Thus the effect the first years is opposite of what is expected, and the real total mortality will not be approached before F is stabilized.

11.3.4 Conclusions drawn from exploratory analyses

The catch curves of the total landings data indicate changes in the relative exploitation of age 3 with time. A likely explanation of this apparent change in exploitation pattern is that the proportion of catches taken by Norwegian purse seine decreased significantly in the early 1990s, and purse seiners mainly target young saithe. Next to this estimates for age 3 are the main source of uncertainty in this assessment. Therefore, it may now be more appropriate to use a reference F that does not include age 3. However, younger fish (also age 2) have appeared in trawl catches in 2010. A change of the reference F will affect the biological reference points and is outside the scope of this update assessment.

11.3.5 Sensitivity analysis

Before WKBENCH 2011 the assessment has been to a large extent dominated by the NORACU index. Still, there was a problem in the assessment due to the fact that the commercial indexes are used for age groups where surveys are an alternative. At the benchmark it was decided to include the NORTRL_IV2 index in the assessment, and to reduce the ages used from the commercial indexes (NORTRL_IV2, FRATRL_IV, GER_OTB_IV) from 3-9 to 6-9. Also, the new acoustic index of young saithe (NORASS) was included for ages 3-4.

As a sensitivity analysis during the working group, the assessment was run with both the settings agreed during the benchmark 2011 and the settings from the update-assessment in November 2011 where the full age range was used for the commercial indices again. The working group decided to use the settings from the update assessment in November 2011 (full age-range for the commercial indices) in the current assessment based on preliminary analyses on the behaviour of commercial CPUE indexes (see 11.3.1).Main results of an alternative assessment with ages 3-5 excluded from the commercial indices are presented in Table 11.3.1 (diagnostics).

The log catchability residuals from the alternative XSA-run are shown in Figure 11.3.14, and a retrospective analysis in Figure 11.3.15. The historic stock and fishery trends from the alternative assessment are presented in Figure 11.3.16 and Table 11.3.2.

Overall the final and alternative assessment show very similar trends. However, the general perception of the stock is worse in the alternative assessment. SSB in the terminal year is estimated to be slightly below Btrigger (198 000; Table 11.3.2) while it is above Btrigger in the final assessment (217 000 t; Table 11.4.1). F in the terminal year is estimated to be higher in the alternative assessment (0.36; Table 11.3.2) compared to the final assessment (0.28; Table 11.4.1). However, the retrospective pattern for F is better in the final assessment (Figure 11.3.15 vs Figure 11.3.18).

11.3.6 Final assessment

Settings used in the assessment are shown below. From 2011, SOP correction of catches are used.

Year of assessment:	2009	2010	2011	2011 REOPENING	2012
Assessment model:	XSA	No assessment	XSA	XSA	
Fleets:	FRATRB_IV (age range: 3-9, 1990 onwards)	No assessment	FRATRB_IV (age 6-9, 1990 onwards)	FRATRB_IV (age 3-9, 1990 onwards)	FRATRB_IV (age 3-9, 1990 onwards)
	GER_OTB_IV (age: 3-9, 1995 onwards)	No assessment	GER_OTB_IV (age: 6-9, 1995 onwards)	GER_OTB_IV (age: 3-9, 1995 onwards)	GER_OTB_IV (age: 3-9, 1995 onwards)
	NORACU (age range: 3-6, 1996 onwards)	No assessment	NORACU (age 3-6, 1996 onwards)	NORACU (age 3-6, 1996 onwards)	NORACU (age 3-6, 1996 onwards)
	IBT-Q3 (age range: 3-5, 1992 onwards)	No assessment	IBTS-Q3 (age 3-5, 1992 onwards)	IBTS-Q3 (age 3-5, 1992 onwards)	IBTS-Q3 (age 3-5, 1992 onwards)

			NORTRL_IV 2 (age 6-9, 1993 onwards	NORTRL_IV2 (age 3-9, 1993 onwards	NORTRL_IV2 (age 3-9, 1993 onwards
			NORASS (age 2-4, 2005 onwards)	NORASS (age 2-4, 2005 onwards)	NORASS (age 2-4, 2005 excluding 2011)
Age range:	3-10+	No assessment	3-10+	3-10+	3-10+
Catch data:	1967-2008	No assessment	1967-2010	1967-2010	1967-2011
Fbar:	3-6	No assessment	3-6	3-6	3-6
Time series weights:	Tricubic over 20 years	No assessment	Tricubic over 20 years	Tricubic over 20 years	Tricubic over 20 years
Power model for ages:	No	No assessment	No	No	No
Catchabilit y plateau:	Age 7	No assessment	Age 7	Age 7	Age 7
Survivor est. shrunk towards the mean F:	5 years / 3 ages	No assessment	5 years/ 3 ages	5 years/ 3 ages	5 years/ 3 ages
S.e. of mean (F-shrinkage):	1.0	No assessment	1.0	1.0	1.0
Min. s.e. of population estimates:	0.3	No assessment	0.3	0.3	0.3
Prior weighting:	No	No assessment	No	No	No
Number of iterations before convergenc e:	47	No assessment	53	60	60

Outputs from the final run are given in Table 11.3.3 (diagnostics), Table 11.3.4 (fishing mortality at age), and Table 11.3.5 (population numbers at age).

The log catchability residuals from the final XSA-run are shown in Figure 11.3.17, and a retrospective analysis in Figure 11.3.18.

11.4 Historic Stock Trends

The historic stock and fishery trends from the final assessment are presented in Figure 11.4.1 and Table 11.4.1. The reported landings increased from 1967 to the highest observed landing levels in the mid-1970s. After 1976 the landings decreased rapidly to a stable level between 1979-1981 and increased again from 1981 to 1985. From 1985 the reported landings decreased and levelled off in 1989 to a fairly stable level where they have stayed since. During the last 9 years (2002-2011), TAC levels have been higher than the reported landings. Estimated landings for Subarea IV and Division IIIa in 2011 (not shown in figure) were 90 thousand tons while TAC was 93.6 thousand tons.

The fishing mortality shows the same trends as landings in the period 1967-1985, while it has decreased nearly continuously since 1985 until 2008, dropping below F_{lim} in 1993 and below F_{msy} in 1997. In 2008 and 2009, at relatively stable landings, fishing mortality has increased above F_{msy}, but in the two latest years (after updates) the F is now below F_{msy} again. Estimated SSB increased from 1967 reaching the highest observed level in 1974 after which it decreased to below B_{lim} in 1990. After 1991 SSB increased to above B_{pa} in 2001 until it reached 279 thousand t in 2005, and has decreased again in the latest years and is now close to B_{pa} and MSYBtrigger.

Both the level and the variation in estimated recruitment (at age 3) are higher before about 1985 than after, e.g., the six strongest year classes observed all occurred in the earliest period. Recruitment in 2006, 2008 and 2009 seem to be well below average strength in the assessment. Recruitment has been estimated to increase the last two years, and in 2010 and 2011 the number was estimated to be twice as high as in 2009.

11.5 Recruitment estimates

There are indications of the 2008 year class to be slightly below average in the assessment, which seems in agreement with the commercial indexes. For the 2009 year class there is one observation from the NORASS index which suggest this year class is stronger, but this might be part of a vessel effect in this survey and the 2011 data from this survey is not used. It was therefore decided to use the geometric mean of recruits (age 3 from the final assessment) from the period 1988-2011 as the estimated recruitment for this year class. The reason for excluding data before 1988 is that the recruitment dynamics (level and variation) seems quite different before and after 1988.

11.6 Short-term forecasts

As the assessment 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 (selectivity pattern) is taken to be the mean value of the last three years, and F is scaled to the F corresponding to the TAC in 2012. TAC uptake has been increasing in recent years and as the landings in 2011 are close to TAC. It was decided to use a TAC constraint for the intermediate year (i.e. the fishing mortality for 2012 was determined such that the landings in 2012 match the TAC). 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 – 2011.

The input data for the short term forecast are given in Table 11.6.1.

The management options are given in Table 11.6.2. The adapted fishing mortality in 2012 is expected to lead to landings of about 87 600 tonnes in 2012 and an increase to 235 000 t in the expected spawning stock biomass in the beginning of 2013. A fishing mortality in 2013 according to the EU-Norway management plan that has a TAC restrain to maximum 15 % corresponds to F=0.26, and is expected to lead to landings of 100 684 t in 2013 and an SSB of 252 158 t in 2014. Stock numbers of recruits and their sources for recent year-classes used in the predictions and relative contributions in the landings and SSB is shown in table 11.6.3.

11.7 Medium-term and long-term forecasts

No medium-term or long-term forecasts were carried out.

11.8 Biological reference points

The biological 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

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. In the last 3 years however, the exploitation pattern may have changed again due to effort regulations in the Cod management plan.

11.9 Estimation of F_{MSY}

The estimation of FMSY 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 Fmsy estimates are sensitive to the choice of the stock recruitment relationship and assumptions on what part of the time series is used as input. The hockey stick recruitment curve was chosen as being most appropriate. The median value of the bootstrap estimates was 0.3. This was chosen as Fmsy having in mind that there is a considerable uncertainty around it.

11.10 Quality of the assessment and forecast

The poor reliability of the recruitment (age 3) estimate is a major problem for the saithe assessment. To improve the reliability of the information about year class strength before age 4, IMR in Norway has since 2006 carried out an acoustic recruitment survey for saithe (ages 2-4) along the Norwegian west coast. Information from the 2012 survey (conducted in the last part of May) will give input for RTC3 analysis in October.

Next to this the usage of commercial CPUE indices have the disadvantage that the assessment can be biased when changes in fishing patterns occur. Especially for older ages ,however, there is currently no alternative as the scientific surveys do not cover deeper parts of the North Sea where older ages can be found.

11.11 Status of the Stock

The general perception of the status of the saithe stock is more positive than the perception was last year. The fishing mortality in 2011 is estimated to be belowF_{msy} at 0.28, but the spawning stock is still close to Btrigger .

11.12 Management Considerations

The ICES advice applies to the combined areas IIIa, IV, and VI.

The total landings in 2011 in areas IIIa and IV are still lower than the TAC, as was also the case in the 8 previous years although the uptake has increased in the last three years. Effort regulations may play a role in the priorities of the fishermen in EU, and combined with fuel prices this may explain why a larger part of the TAC is now taken in the southern part of the distribution area. But there are also claims by the Norwegian industry that the abundance of saithe has been reduced in the most recent years, and that young saithe cannot be found at the traditional grounds. Norwegian fishermen are worried that the exploitation pattern has changed due to more pelagic trawling, and that the youngest year classes may be overexploited. On the other hand, the fishers survey (Napier, 2009) shows that the EU fishermen are generally very optimistic about saithe abundance in the North Sea. Reports from Norwegian fishers show concerns about increased landings from pelagic trawling and a possible change in exploitation pattern towards younger year classes. According to a RAC-meeting between scientist and fishers in Hanstholm in April 2012, the industry was worried about the decline in stock weight after 2000. French and German industry representatives confirmed changes in fishingpattern due to effort management and conflicts with gillnetters in VIa especially in 2009 and 2010. The fishing industry representatives see improved stock status in the last two years after a period of low recruitment. Fishing industry is worried about conflicting data-sources and suggests that fishermen knowledge should be used for the interpretation of the data (i.e. commercial CPUE indices). Survey data especially for young year classes before age 3 should be improved.

The stock biomass is close to Bpa and recruitment estimates for the terminal year are uncertain. The forcast is highly sensitive to the recruitment estimate. Because the harvest control rule results in large differences if the stock is estimated below or above Bpa, the advice can vary greatly even with rather small changes in the assessment. Reopening the assessment increases the probability of an update of advice after new survey information become available.

The change in fishery distribution and stock productivity (lower growth and recruitment) imply that a re-evaluation of the management plan is needed. This re-evaluation is envisaged for 2012.

The reported landings have been lower than the TACs during the past nine years, but the reduction of the TAC in recent years have led to a gradually lower difference between landings and TAC.

Bycatch of other demersal fish species occurs in some trawl fisheries for saithe(WGMIXFISH, 2011). Saithe is also taken as unintentional bycatch in other fisheries, and discards may occur, but is at present estimated to be below 5 % of the landings.

In 2008 ICES carried out an evaluation of the management plans agreed between Norway and the European Community (ICES Advice, 2008. Book 6.), and the response is described below:

Recent reductions in recruitment levels and growth rates indicate that the productivity of the saithe stock in the North Sea, Skagerrak, and West of Scotland has declined. Assuming continuation of the current selection pattern and growth rates, annual yields are expected to be relatively stable at about 100 000 t for fishing mortalities between 0.1 and 0.4. A target F below 0.3, or an increase in the upper SSB threshold (i.e., above the current B_{pa} = 200 000t), are likely to give similar yields with lower risks in the medium term.

The 15% TAC change constraint is likely to be invoked in ~50% of the years in which the harvest control rule is applied. TAC constraints more than 15% would require a lower target fishing mortality in order to balance the increased risk to the stock. The equilibrium yield from the saithe stock is fairly insensitive to the TAC constraint.

Given the relatively low productivity of saithe (low mean recruitment and low weight-at-age) in recent times, the limited treatment of measurement errors in the assessment, and implementation errors in the fishery, the harvest control rule must be reviewed again within 2012.

References

ICES, 2010. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH), 31 August - 3 September 2010, ICES Headquarters, Copenhagen, Denmark. ICES CM 2010/ACOM:35 93 pp.

Hirst, D., Aanes, S., Storvik, G. and Tvete, I.F. 2004. Estimating catch at age from market sampling data using a Bayesian hierarchical model. Journal of the Royal statistical society. Series C, applied statistics, 53: 1-14.

Hirst, D., Storvik, G., Aldrin, M., Aanes, S and Huseby, R.B. 2005. Estimating catch-at-age by combining data from different sources. Canadian Journal of Fisheries and Aquatic Sciences 62:1377-1385.

Hirst, D., Storvik, G., Rognebakke, H., Aanes, S., and Vølstad, J.H. Submitted. A modelling approach to the estimation of catch-at-age of commercial fish species.

Napier, I. R. 2010. Fishers North Sea stock survey 2009. NAFC Marine Centre, Shetland, Scotland.

ICES-WKBENCH, 2011. Report of the Benchmark Workshop on Roundfish and Pelagic Stocks. ICES CM 2011/ACOM:38

Table 11.2.1 Nominal landings (in tonnes) of Saithe in Subarea IV and Division IIIa and SubareaVI, 2001-2011, as officially reported to ICES, and WG estimates

SAITHE IV and IIIa

Country	2001	2002	2003	2004*	2005*	2006	2007*	2008*	2009	2010	2011*
Belgium	24	107	45	22	28	16	18	7	27	15	2
Denmark	3575	5668	6954	7991	7498	7471	5458	8069	8802	8019	6325
Faroe Isl.	289	872	495	558	184	62	15	108	-	146	0
France	20472	25441	18001	13628	10768	15739	13043	15302	5445*	4582*	13856
Germany	9479	10999	8956	9589	12401	14390	12790	14141	13689	11192	10234
Greenland	1526[2]*	62	1616	403	-	-	-	-	-	-	0
Ireland	-	-	-	1	-	0	-	81	81	-	0
Netherlands	20	6	11*	3	40	28	5	3	17	3	24
Norway	44397	60013	61735	62783	67365	61268	45395	62055	57708	53031	46778
Poland	727	752	734*	0	1100	-	-	1407	988	654	584
Russia	-	-	-	-	35	2	5	5	13	-	0
Sweden	1627	1863	1876	2249	2114	1695	1380	1639	1363	1545	1331
UK (E/W/NI)	1186	2521	1215	457	1190	9129**	9628**	11701**	12545**	11887**	10148**
UK (Scotland)	5219	6596	5829	5924	7703						
Total reported	88541	114900	107467	103608	110575	109800	87377	114517	100678	91074	89282
Unallocated	1030	1291	-5809	-3646	968	7312	6241	-3084	4851	4026	422
WG estimate	89571	116191	101658	99962	111543	117112	93618	111433	105529	95100	89704
TAC	87000	135000	165000	190000	145000	123250	135900	135900	125934	107000	93600

*Preliminary, [2]Preliminary data reported in Iva, **Scotland+E/W/NI combined

SAITHE VI

Country	2001	2002	2003	2004*	2005*	2006	2007*	2008*	2009	2010	2011*
Faroe Islands	-	-	2	34	21	76	32	23	-	24	5
France	5157	3062	3499	3053	3452	5782	3956	2617	2093	2003	2382
Germany	466	467	54	4	373	532	580	147	298	257	0
Ireland	399	91	170	95	168	243	322	208	208	519	359
Netherlands	-	-	-	-	-	-	-	1	-		0
Norway	31	12	28	16	20	28	377	78	68	249	160
Russia	1	1	6	6	25	7	2	50	4	2	0
Spain	15	4	6	2	3	-	-	-	-		0
UK (E/W/NI)	273	307	263	37	203	2748**	1419**	2887**	3501**	3168**	4399**
UK (Scotland)	2246	1567	1189	1563	4433						
Total reported	8588	5513	5215	4810	8699	9416	6688	6011	6172	6222	7305
Unallocated	-1770	-327	35	-296	-2960	848	98	1223	791	666	95
WG estimate	6818	5186	5250	4514	5739	8568	6786	7234	6963	6840	7400
TAC	9000	14000	17119	20000	15044	12787	14100	14100	13066	11000	9570

*Preliminary **Scotland+E/W/NI combined

SAITHE IV, IIIa and VI

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
WG estimate	96389	121377	106908	104476	117282	125680	100404	118667	112492	101940	97104
TAC	96000	149000	182119	210000	160044	136037	150000	150000	139000	118000	103170

Table 11.2.2 Saithe in Sub-Areas IV, 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	

Table 11.2.3 Saithe in Sub-Areas IV, 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	0.985	1.436	1.944	2.566	3.081	3.494	3.945	4.960
2011	**1.060**	**1.321**	**1.845**	**2.540**	**3.007**	**3.523**	**3.808**	**4.187**

Table 11.2.5 Saithe in Sub-Areas IV,VI and Division IIIa. Tuning data, effort and index values.

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

NORTRL_IV1 units= NA

		3	4	5	6	7	8	9
1980	18317	0.01015	0.0704	0.0359	0.05350	0.04351	0.01425	0.003276
1981	28229	0.00312	0.0299	0.0476	0.01743	0.02373	0.02476	0.004216
1982	47412	0.13971	0.2534	0.0577	0.04455	0.00719	0.00494	0.000401
1983	43099	0.10211	0.1152	0.1897	0.04524	0.05492	0.01116	0.008283
1984	47803	0.43043	0.1533	0.0462	0.07025	0.00906	0.00929	0.002217
1985	66607	0.40668	0.3213	0.0797	0.02356	0.00956	0.00084	0.000691
1986	57468	0.09217	0.5153	0.0625	0.01423	0.00684	0.00212	0.000435
1987	30008	0.08814	0.6150	0.0739	0.00966	0.00783	0.00670	0.006598
1988	18402	0.17020	0.1110	0.1203	0.00766	0.00853	0.00402	0.007282
1989	17781	0.03650	0.1196	0.0470	0.03903	0.01738	0.00866	0.003656
1990	10249	0.07845	0.0762	0.0902	0.05064	0.01981	0.00615	0.001171
1991	28768	0.49875	0.1727	0.0415	0.01801	0.00706	0.00177	0.001947
1992	35621	0.09677	0.2676	0.1132	0.03052	0.01305	0.00463	0.003060

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	34360	0.0312	0.0948	0.1728	0.0365	0.1552	0.04761	0.027154
2010	24101	0.0147	0.0432	0.0732	0.1082	0.0715	0.07576	0.043442
2011	31816	0.0457	0.2196	0.0358	0.0580	0.0232	0.02379	0.053935

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

NORACU units= NA

		3	4	5	6
1995	1	56244	4756	1214	174
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	2490	5225	4891	2899
2011	1	19659	50840	8176	11770

IBTS-Q3 units= NA

		3	4	5
1991	1	1.95	0.402	0.064
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

NORASS units= NA

		2	3	4	5
2005	1	NA	NA	NA	NA
2006	1	15.63	7.66	17.89	1.86
2007	1	9.83	55.47	6.28	20.01
2008	1	5.10	30.89	23.42	2.40
2009	1	7.96	27.68	11.83	4.35
2010	1	18.29	30.79	5.07	1.35
2011	1	49.63	28.86	286.41	17.86

Table 11.3.1 FLR XSA Diagnostics (alternative assessment)

CPUE data from xsa.indices

```
Catch data for 45 years. 1967 to 2011. Ages 3 to 10.

            fleet first age last age first year last year alpha beta
1       FRATRB_IV         6         9       1990      2011     0    1
2      NORTRL_IV2         6         9       1993      2011     0    1
3      GER_OTB_IV         6         9       1995      2011     0    1
4          NORACU         3         6       1996      2011   0.5 0.75
5          IBTSq3         3         5       1992      2011   0.5 0.75
6 NORASS          3         4       2005      2010     0    1


 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    2002 2003  2004  2005  2006  2007 2008  2009 2010 2011
  all 0.751 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1


 Fishing mortalities
    year
age   2002  2003  2004  2005  2006  2007  2008  2009  2010  2011
  3  0.118 0.105 0.060 0.084 0.187 0.189 0.173 0.242 0.091 0.145
  4  0.317 0.169 0.191 0.194 0.245 0.227 0.445 0.372 0.354 0.395
  5  0.258 0.324 0.220 0.342 0.299 0.298 0.380 0.618 0.401 0.464
  6  0.285 0.294 0.279 0.360 0.324 0.293 0.414 0.423 0.488 0.415
  7  0.359 0.384 0.293 0.415 0.413 0.330 0.298 0.491 0.554 0.371
  8  0.368 0.397 0.404 0.370 0.390 0.338 0.342 0.407 0.351 0.537
  9  0.489 0.448 0.580 0.405 0.354 0.194 0.257 0.392 0.458 0.406
  10 0.489 0.448 0.580 0.405 0.354 0.194 0.257 0.392 0.458 0.406


 XSA population number ( NA )
     age
year        3      4      5     6     7     8     9    10
  2002 196998 172341  43040 39717  8923 10691  5329  4592
  2003 129093 143270 102798 27211 24466  5100  6060  3152
  2004 101508  95141  99014 60856 16606 13642  2808  2002
  2005 190535  78299  64334 65054 37689 10140  7456  1513
  2006  64061 143390  52788 37416 37160 20375  5733  5277
  2007 112388  43517  91871 32040 22161 20131 11290  6082
  2008  67446  76193  28407 55815 19566 13041 11749  8426
  2009  47886  46451  39974 15911 30213 11892  7584 10788
  2010  93256  30768  26226 17639  8529 15142  6479 11683
  2011  76468  69697  17682 14376  8869  4015  8731 14738
```

Estimated population abundance at 1st Jan 2012

year \ age	3	4	5	6	7	8	9	10
2012	0	54134	38460	9099	7776	5010	1921	4764

Fleet: FRATRB_IV

Log catchability residuals.

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
6	-0.338	0.263	-0.359	-0.353	0.353	-0.389	0.167	-0.637	0.171	-0.065	0.864
7	0.792	0.495	-0.596	-1.675	-0.002	0.016	0.100	-0.056	-0.848	0.054	0.580
8	-0.345	0.393	-1.212	-1.442	-1.529	0.252	-0.137	-0.755	-0.733	-1.027	0.380
9	-0.028	-0.330	-0.797	-1.204	-1.865	0.095	0.464	0.237	-0.568	-0.583	0.484

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
6	0.450	0.423	-0.697	-0.182	0.196	-0.993	-0.710	0.325	1.010	0.021
7	0.279	0.609	0.274	0.064	0.669	-0.007	-0.588	0.186	-0.432	-0.508
8	-0.759	0.286	0.452	-0.644	-0.631	-1.031	-3.969	-0.958	0.186	-0.074
9	-0.665	-0.272	0.641	0.426	-0.403	-0.877	NA	-0.922	-0.294	-0.258

age \ year	2011
6	-0.131
7	-0.215
8	0.095
9	-0.561

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	6	7	8	9
Mean_Logq	-12.9632	-13.5799	-13.5799	-13.5799
S.E_Logq	0.5109	0.5741	0.9780	0.6198

Fleet: NORTRL_IV2

Log catchability residuals.

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
6	0.580	-0.397	-0.635	0.142	-0.408	0.166	0.132	0.802	-0.351	-0.460	-0.213
7	0.337	-0.431	0.829	0.011	-0.260	-0.053	0.324	0.062	-0.408	-0.450	-0.028
8	0.163	-1.217	0.341	-0.551	-0.428	0.190	0.920	0.157	-0.598	-0.118	-0.177
9	0.366	0.157	0.481	-1.934	-0.674	0.452	0.717	0.304	-0.906	0.191	-0.089

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
6	-0.182	0.058	0.051	0.054	0.211	-0.481	0.532	0.080
7	-0.116	0.179	0.389	-0.009	-0.319	0.186	0.703	-0.541
8	0.288	0.079	0.370	0.253	-0.179	-0.101	0.097	0.349
9	0.554	0.216	0.032	-0.494	-0.385	-0.219	0.437	0.332

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	6	7	8	9
Mean_Logq	-12.2092	-12.0392	-12.0392	-12.0392
S.E_Logq	0.3911	0.3835	0.4644	0.6388

Fleet: GER_OTB_IV

Log catchability residuals.

age \ year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
6	0.265	0.034	-0.664	0.020	0.175	0.604	0.287	0.217	-0.451	-0.301	0.185
7	0.059	0.452	-0.270	-0.086	0.386	0.001	0.674	-0.469	-0.220	-0.486	0.278
8	-0.256	1.138	-0.190	-0.018	-0.471	0.270	0.612	-0.299	-0.557	-0.078	0.225
9	-0.448	0.941	-0.083	0.001	-0.217	-0.035	0.096	-0.256	-0.490	-0.029	0.004

age \ year	2006	2007	2008	2009	2010	2011
6	-0.037	-0.145	0.342	-0.319	-0.021	-0.006
7	0.231	0.031	-0.014	0.071	-0.554	0.326
8	0.150	0.160	-0.064	0.153	-0.335	0.081
9	0.534	-0.196	0.015	0.449	0.155	-0.035

```
 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                6       7       8       9
Mean_Logq -13.0271 -13.2221 -13.2221 -13.2221
S.E_Logq    0.3169   0.3479   0.4109   0.3535


 Fleet:  NORACU

 Log catchability residuals.

   year
age   1996   1997   1998   1999  2000   2001   2002   2003   2004   2005   2006
  3 -0.195 -0.530 -0.047 -0.693 0.427  0.292  0.597  0.815  0.342  0.077  0.290
  4 -0.806 -0.743 -0.019  0.086 0.542 -0.023  0.843  0.519  0.042  0.058 -0.051
  5 -0.337 -0.131 -0.057  0.329 0.578 -0.209  0.231  0.270 -0.033  0.347 -0.377
  6  0.489  0.005  0.143 -0.079 0.834  0.286 -0.575 -0.167 -0.645 -0.200  0.081
   year
age   2007   2008 2009   2010  2011
  3  1.146 -0.747   NA -2.172 0.126
  4 -0.443 -0.414   NA -0.854 0.629
  5  0.116 -0.709   NA -0.458 0.489
  6 -0.984 -0.004   NA -0.071 1.490


 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 -1.2689 -0.5737 -0.8464 -1.3065
S.E_Logq   0.7972  0.5317  0.3756  0.5995

 Fleet:  IBTSq3

 Log catchability residuals.

   year
age   1992   1993   1994   1995   1996   1997   1998   1999   2000  2001   2002
  3 -1.479  0.076 -1.558  0.127 -0.483 -0.887 -1.304 -1.344 -0.432 0.519 -0.004
  4 -0.444 -0.406 -1.253 -0.587 -0.660 -0.657 -0.869 -0.601 -0.029 0.098  0.350
  5 -0.313  0.028 -0.251  0.019 -0.152  0.553 -0.484  0.005 -0.107 0.195 -0.456
   year
age  2003   2004   2005  2006  2007   2008   2009   2010  2011
  3 0.994 -0.147 -0.181 1.151 1.753 -0.030 -0.590 -1.337 0.098
  4 0.670 -0.146  0.047 0.942 0.449  0.071 -0.715 -0.886 0.500
  5 1.027 -0.446  0.520 0.159 0.993 -0.133 -1.007 -0.920 0.344


 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 -9.6136 -9.1420 -9.6453
S.E_Logq   0.9155  0.5918  0.5383


 Fleet:  NORASS

 Log catchability residuals.

   year
age 2005   2006   2007  2008  2009   2010
  3   NA -1.073  0.346 0.264 0.529 -0.102
  4   NA -0.450 -0.313 0.542 0.321 -0.122


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

               3       4
Mean_Logq -7.7716 -8.3246
S.E_Logq   0.6383  0.4222

 Terminal year survivor and F summaries:
```

```
 Age 3 Year class = 2008

source
       survivors N scaledWts
NORACU     61408 1     0.335
IBTSq3     59686 1     0.321
fshk       43728 1     0.344

 Age 4 Year class = 2007

source
                survivors N scaledWts
NORACU              37386 2     0.385
IBTSq3              38501 2     0.318
NORASS     34721 1     0.166
fshk                47503 1     0.131

 Age 5 Year class = 2006

source
                survivors N scaledWts
NORACU               9989 2     0.428
IBTSq3               6986 3     0.250
NORASS      9525 2     0.237
fshk                10866 1     0.086

 Age 6 Year class = 2005

source
                survivors N scaledWts
FRATRB_IV            6824 1     0.076
NORTRL_IV2           8428 1     0.215
GER_OTB_IV           7729 1     0.305
NORACU               9185 3     0.183
IBTSq3               3781 3     0.090
NORASS     10557 2     0.086
fshk                 8348 1     0.044

 Age 7 Year class = 2004

source
                survivors N scaledWts
FRATRB_IV            4294 2     0.167
NORTRL_IV2           4505 2     0.298
GER_OTB_IV           5900 2     0.365
NORACU               4653 3     0.058
IBTSq3               3894 3     0.039
NORASS      8178 2     0.035
fshk                 4313 1     0.039

 Age 8 Year class = 2003

source
                survivors N scaledWts
FRATRB_IV            1782 3     0.101
NORTRL_IV2           2546 3     0.342
GER_OTB_IV           1608 3     0.397
NORACU               1108 3     0.056
IBTSq3               2562 3     0.031
NORASS      1149 2     0.031
fshk                 3069 1     0.042

 Age 9 Year class = 2002

source
                survivors N scaledWts
FRATRB_IV            3306 4     0.119
NORTRL_IV2           5779 4     0.293
GER_OTB_IV           4541 4     0.467
NORACU               5000 4     0.052
IBTSq3              10587 3     0.022
NORASS      3037 1     0.016
fshk                 4264 1     0.032
```

Table 11.3.2. Saithe in Sub-Areas IV,VI and Division IIIa. Historic stock and fishery trends (alternative assessment)

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	429605	265381	265381	1018391	0.329	0.62
1972	171373	474021	261877	261877	903521	0.395	0.55
1973	152852	534465	242499	242499	847459	0.416	0.45
1974	148740	554916	298351	298351	833755	0.556	0.54
1975	181240	472029	271584	271584	743382	0.482	0.58
1976	384113	351616	343967	343967	752448	0.760	0.98
1977	118018	263128	216395	216395	509445	0.615	0.82
1978	92455	268131	155141	155141	463895	0.477	0.58
1979	77655	241080	128360	128360	419186	0.396	0.53
1980	67150	235190	131908	131908	396835	0.443	0.56
1981	172844	241252	132278	132278	495261	0.306	0.55
1982	109977	210508	174351	174351	511859	0.469	0.83
1983	118255	214357	180044	180044	467428	0.548	0.84
1984	205274	176796	200834	200834	466193	0.677	1.14
1985	311946	161100	220869	220869	490974	0.714	1.37
1986	288468	152210	198596	198596	488129	0.819	1.30
1987	113718	154070	167514	167514	386853	0.645	1.09
1988	116015	149616	135172	135172	323382	0.621	0.90
1989	78043	117295	108877	108877	261392	0.672	0.93
1990	119197	106547	103800	103800	266652	0.597	0.97
1991	138531	105555	108048	108048	286987	0.575	1.02
1992	93373	107290	99742	99742	282517	0.629	0.93
1993	152769	112418	111491	111491	330585	0.527	0.99
1994	104293	123288	109622	109622	325620	0.510	0.89
1995	227379	138174	121810	121810	464132	0.413	0.88
1996	112944	153129	114997	114997	447235	0.403	0.75
1997	165207	202107	107327	107327	478158	0.284	0.53
1998	71521	203144	106123	106123	396872	0.342	0.52
1999	143101	215115	110716	110716	416416	0.355	0.51
2000	95835	216099	91322	91322	451460	0.306	0.42
2001	228239	231430	95042	95042	522231	0.275	0.41
2002	196998	231369	115395	115395	561214	0.245	0.50
2003	129093	264476	105569	105569	528117	0.223	0.40
2004	101508	324222	104237	104237	563997	0.188	0.32
2005	190535	330099	124532	124532	582127	0.245	0.38
2006	64061	317702	125681	125681	529999	0.264	0.40
2007	112388	314435	101202	101202	487069	0.252	0.32
2008	67446	301456	119305	119305	464797	0.353	0.40
2009	47886	260422	115747	115747	365852	0.414	0.44
2010	93256	244608	101940	101940	393191	0.333	0.42
2011	**76468**	**197604**	**97104**	**97104**	**363905**	**0.355**	**0.49**

Table 11.3.3. FLR XSA Diagnostics (final assessment).

```
CPUE data from xsa.indices

Catch data for 45 years. 1967 to 2011. Ages 3 to 10.

            fleet first age last age first year last year alpha beta
1       FRATRB_IV         3         9       1990      2011     0    1
2      NORTRL_IV2         3         9       1993      2011     0    1
3      GER_OTB_IV         3         9       1995      2011     0    1
4          NORACU         3         6       1996      2011   0.5 0.75
5          IBTSq3         3         5       1992      2011   0.5 0.75
6 NORASS         3         4       2005      2010     0    1


 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    2002 2003  2004  2005  2006  2007 2008  2009 2010 2011
  all 0.751 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1


 Fishing mortalities
    year
age   2002  2003  2004  2005  2006  2007  2008  2009  2010  2011
  3  0.121 0.106 0.061 0.084 0.187 0.181 0.166 0.210 0.076 0.101
  4  0.315 0.174 0.193 0.198 0.244 0.228 0.420 0.352 0.293 0.314
  5  0.260 0.322 0.227 0.345 0.306 0.296 0.382 0.561 0.370 0.354
  6  0.281 0.296 0.276 0.375 0.328 0.303 0.410 0.428 0.415 0.368
  7  0.345 0.378 0.297 0.409 0.438 0.336 0.311 0.483 0.562 0.292
  8  0.341 0.374 0.395 0.376 0.382 0.369 0.350 0.433 0.343 0.552
  9  0.476 0.401 0.526 0.392 0.362 0.189 0.289 0.406 0.505 0.392
  10 0.476 0.401 0.526 0.392 0.362 0.189 0.289 0.406 0.505 0.392


 XSA population number ( NA )
     age
year        3      4      5     6     7     8     9    10
  2002 193160 173116  42787 40089  9238 11371  5446  4694
  2003 128406 140127 103433 27004 24771  5358  6617  3444
  2004  99937  94579  96441 61375 16436 13891  3019  2155
  2005 191329  77013  63874 62947 38114 10001  7660  1555
  2006  63839 144040  51735 37039 35435 20723  5620  5171
  2007 116790  43335  92404 31178 21852 18719 11575  6236
  2008  70107  79797  28257 56251 18860 12789 10593  7592
  2009  54348  48629  42924 15788 30570 11314  7378 10491
  2010 111206  36059  28010 20055  8429 15434  6006 10822
  2011 107243  84392  22014 15837 10847  3933  8970 15145


 Estimated population abundance at 1st Jan  2012
     age
year   3     4     5     6    7    8    9   10
  2012 0 79330 50492 12646 8972 6629 1854 4960
```

Fleet: FRATRB_IV

Log catchability residuals.

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0.198	-0.501	-0.202	0.500	-0.015	-0.274	-0.955	-0.923	-0.409	-1.153
4	0.138	0.245	0.170	0.127	0.208	-0.333	-0.485	-0.397	-0.549	-0.418
5	0.052	0.073	0.293	0.226	0.282	-0.410	-0.211	-0.044	0.047	-0.008
6	-0.315	0.288	-0.343	-0.318	0.374	-0.373	0.180	-0.627	0.199	-0.054
7	0.811	0.515	-0.573	-1.667	0.041	0.032	0.109	-0.053	-0.845	0.083
8	-0.325	0.411	-1.190	-1.414	-1.526	0.313	-0.123	-0.753	-0.738	-1.033
9	-0.009	-0.310	-0.779	-1.180	-1.831	0.086	0.559	0.247	-0.577	-0.607

age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	-0.178	-0.950	0.200	-0.123	-0.416	-0.597	1.330	1.269	0.371	-0.133
4	-0.288	0.104	0.406	-0.254	-0.349	0.019	0.335	0.055	0.075	0.286
5	0.476	0.642	-0.095	-0.247	-0.357	0.198	-0.401	0.273	-0.777	0.404
6	0.848	0.441	0.434	-0.666	-0.171	0.257	-0.960	-0.657	0.337	1.041
7	0.583	0.243	0.586	0.277	0.094	0.673	0.069	-0.554	0.247	-0.429
8	0.414	-0.760	0.230	0.411	-0.648	-0.597	-1.034	-3.865	-0.917	0.266
9	0.463	-0.626	-0.282	0.550	0.348	-0.418	-0.835	NA	-0.785	-0.242

age	2010	2011
3	-0.267	0.312
4	0.146	0.050
5	0.211	0.036
6	-0.119	-0.227
7	-0.474	-0.434
8	-0.079	0.141
9	-0.143	-0.576

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	-13.4287	-12.5964	-12.5480	-12.9846	-13.5979	-13.5979	-13.5979
S.E_Logq	0.6455	0.2924	0.3342	0.5068	0.5772	0.9645	0.6016

Fleet: NORTRL_IV2

Log catchability residuals.

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
3	1.742	1.202	0.421	0.749	0.201	0.713	-0.417	-0.728	0.825	0.334	-0.254
4	0.609	1.436	1.084	0.315	0.086	0.539	0.435	-0.572	0.674	0.128	-0.609
5	0.521	0.644	0.548	0.297	0.046	0.511	0.535	0.564	0.348	-0.304	-0.146
6	0.616	-0.376	-0.619	0.155	-0.397	0.194	0.143	0.786	-0.359	-0.449	-0.183
7	0.345	-0.389	0.845	0.020	-0.257	-0.049	0.353	0.065	-0.445	-0.474	-0.025
8	0.191	-1.215	0.402	-0.538	-0.426	0.185	0.914	0.191	-0.599	-0.174	-0.218
9	0.390	0.191	0.472	-1.839	-0.664	0.443	0.694	0.283	-0.867	0.182	-0.180

age	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.684	-0.793	0.089	0.291	0.973	0.427	-1.105	0.078
4	-0.677	-0.395	-0.563	-0.282	0.955	0.209	-0.305	0.481
5	-0.483	-0.181	-0.139	-0.390	0.377	0.467	-0.050	-0.532
6	-0.170	0.119	0.084	0.107	0.223	-0.450	0.392	-0.016
7	-0.086	0.183	0.466	0.026	-0.258	0.189	0.737	-0.761
8	0.284	0.114	0.368	0.358	-0.138	-0.021	0.092	0.394
9	0.476	0.201	0.074	-0.503	-0.249	-0.168	0.552	0.317

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	-14.6001	-13.0941	-12.5337	-12.2305	-12.0572	-12.0572	-12.0572
S.E_Logq	0.7455	0.6231	0.4012	0.3794	0.4132	0.4728	0.6159

Fleet: GER_OTB_IV

Log catchability residuals.

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
3	-0.386	-0.420	-0.472	0.150	-1.237	0.244	-0.032	-0.308	-0.299	-0.413
4	0.354	-0.229	0.058	-0.149	-0.089	0.182	0.267	0.248	-0.697	0.143
5	-0.039	0.013	-0.070	-0.284	-0.056	0.261	0.429	0.122	-0.102	-0.326
6	0.281	0.047	-0.654	0.048	0.187	0.589	0.278	0.228	-0.421	-0.289
7	0.075	0.461	-0.267	-0.083	0.415	0.004	0.638	-0.492	-0.217	-0.456
8	-0.195	1.152	-0.188	-0.024	-0.476	0.304	0.611	-0.355	-0.598	-0.082
9	-0.457	1.036	-0.072	-0.007	-0.240	-0.055	0.135	-0.266	-0.581	-0.107

age	2005	2006	2007	2008	2009	2010	2011
3	-0.631	0.445	0.604	0.411	0.142	0.472	0.064
4	-0.877	-0.276	-0.028	0.915	-0.304	0.392	0.166
5	0.127	-0.457	0.211	-0.087	0.014	-0.165	0.346
6	0.246	-0.003	-0.091	0.354	-0.288	-0.160	-0.102
7	0.282	0.308	0.066	0.047	0.075	-0.520	0.107
8	0.260	0.148	0.265	-0.023	0.233	-0.339	0.127
9	-0.010	0.576	-0.205	0.152	0.501	0.270	-0.050

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	-14.6865	-13.3150	-12.9065	-13.0487	-13.2403	-13.2403	-13.2403
S.E_Logq	0.4827	0.4213	0.2369	0.3154	0.3381	0.4250	0.3942

Fleet: NORACU

Log catchability residuals.

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
3	-0.142	-0.486	-0.002	-0.642	0.487	0.344	0.675	0.877	0.414	0.129	0.350
4	-0.759	-0.704	0.009	0.114	0.580	0.025	0.881	0.587	0.093	0.120	-0.013
5	-0.313	-0.095	-0.032	0.337	0.588	-0.185	0.270	0.295	0.030	0.388	-0.320
6	0.506	0.020	0.177	-0.064	0.820	0.281	-0.559	-0.131	-0.629	-0.131	0.120

age	2007	2008	2009	2010	2011
3	1.159	-0.733	NA	-2.302	-0.183
4	-0.394	-0.432	NA	-1.007	0.431
5	0.141	-0.670	NA	-0.511	0.234
6	-0.924	0.012	NA	-0.218	1.391

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	-1.3252	-0.6172	-0.8784	-1.3330
S.E_Logq	0.8354	0.5408	0.3584	0.5736

Fleet: IBTSq3

Log catchability residuals.

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	-1.417	0.137	-1.498	0.192	-0.424	-0.836	-1.252	-1.286	-0.365	0.577	0.080
4	-0.400	-0.364	-1.212	-0.547	-0.613	-0.618	-0.841	-0.572	0.009	0.148	0.389
5	-0.268	0.066	-0.216	0.051	-0.122	0.596	-0.453	0.018	-0.092	0.225	-0.411

age	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	1.063	-0.068	-0.123	1.218	1.773	-0.010	-0.674	-1.459	-0.205
4	0.739	-0.095	0.110	0.980	0.498	0.054	-0.729	-1.038	0.303
5	1.057	-0.378	0.566	0.221	1.024	-0.088	-1.076	-0.967	0.094

```
 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 -9.6764 -9.1861 -9.6831
S.E_Logq   0.9244  0.5974  0.5485


 Fleet:  NORASS

 Log catchability residuals.

   year
age 2005   2006   2007  2008  2009   2010
  3   NA -0.987  0.386 0.304 0.469 -0.204
  4   NA -0.395 -0.248 0.546 0.327 -0.248


 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

                3       4
Mean_Logq -7.8536 -8.3852
S.E_Logq   0.6076  0.4133


 Terminal year survivor and F summaries:

 Age 3 Year class = 2008

source
           survivors N scaledWts
FRATRB_IV     108342 1     0.159
NORTRL_IV2     85754 1     0.190
GER_OTB_IV     84582 1     0.367
NORACU         66050 1     0.092
IBTSq3         64619 1     0.092
fshk           47320 1     0.101

 Age 4 Year class = 2007

source
                survivors N scaledWts
FRATRB_IV           50989 2     0.349
NORTRL_IV2          43423 2     0.134
GER_OTB_IV          68929 2     0.216
NORACU              41418 2     0.112
IBTSq3              41955 2     0.093
NORASS     41193 1     0.058
fshk                51352 1     0.038

 Age 5 Year class = 2006

source
                survivors N scaledWts
FRATRB_IV           13745 3     0.253
NORTRL_IV2           8905 3     0.154
GER_OTB_IV          17501 3     0.273
NORACU              11398 2     0.141
IBTSq3               7953 3     0.074
NORASS     12026 2     0.082
fshk                11424 1     0.023

 Age 6 Year class = 2005

source
                survivors N scaledWts
FRATRB_IV           10542 4     0.201
NORTRL_IV2           9463 4     0.230
GER_OTB_IV           8085 4     0.339
NORACU               9870 3     0.109
IBTSq3               4257 3     0.047
NORASS     12360 2     0.051
fshk                 8668 1     0.022
```

```
 Age 7 Year class = 2004

source
                survivors N scaledWts
FRATRB_IV            6306 5     0.216
NORTRL_IV2           6643 5     0.264
GER_OTB_IV           7028 5     0.389
NORACU               5587 3     0.046
IBTSq3               4977 3     0.030
NORASS     10940 2     0.031
fshk                 4200 1     0.025

 Age 8 Year class = 2003

source
                survivors N scaledWts
FRATRB_IV            1677 6     0.162
NORTRL_IV2           2398 6     0.310
GER_OTB_IV           1631 6     0.397
NORACU               1094 3     0.047
IBTSq3               2587 3     0.023
NORASS      1180 2     0.026
fshk                 2973 1     0.035

 Age 9 Year class = 2002

source
                survivors N scaledWts
FRATRB_IV            4242 7     0.174
NORTRL_IV2           5513 7     0.289
GER_OTB_IV           4782 7     0.427
NORACU               5365 4     0.049
IBTSq3              11459 3     0.018
NORASS      3343 1     0.015
fshk                 4746 1     0.028
```

Table 11.3.4 Fishing mortality at age (final assessment)

	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	0.466	0.656	0.762	0.936	1.030	0.919	0.919
1984	0.572	0.691	0.608	0.836	0.523	0.663	0.680	0.680
1985	0.644	1.044	0.697	0.471	0.460	0.424	0.455	0.455
1986	0.239	1.393	0.952	0.691	0.513	0.424	0.547	0.547
1987	0.362	0.865	0.837	0.518	0.526	0.494	0.517	0.517
1988	0.372	0.598	0.939	0.575	0.695	0.725	0.671	0.671
1989	0.376	0.732	0.692	0.891	0.489	0.644	0.681	0.681
1990	0.476	0.679	0.665	0.572	0.589	0.459	0.544	0.544
1991	0.459	0.788	0.602	0.454	0.420	0.410	0.431	0.431
1992	0.245	0.730	0.980	0.565	0.354	0.299	0.410	0.410
1993	0.319	0.485	0.621	0.690	0.607	0.724	0.690	0.690
1994	0.237	0.670	0.649	0.481	0.459	0.255	0.457	0.457
1995	0.139	0.555	0.560	0.390	0.949	0.706	0.834	0.834
1996	0.114	0.309	0.528	0.652	0.670	0.592	0.493	0.493
1997	0.105	0.298	0.421	0.308	0.483	0.467	0.439	0.439
1998	0.173	0.326	0.446	0.416	0.311	0.426	0.522	0.522
1999	0.075	0.368	0.520	0.433	0.502	0.633	0.651	0.651
2000	0.085	0.192	0.432	0.486	0.287	0.294	0.349	0.349
2001	0.081	0.317	0.409	0.284	0.251	0.258	0.234	0.234
2002	0.121	0.315	0.260	0.281	0.345	0.341	0.476	0.476
2003	0.106	0.174	0.322	0.296	0.378	0.374	0.401	0.401
2004	0.061	0.193	0.227	0.276	0.297	0.395	0.526	0.526
2005	0.084	0.198	0.345	0.375	0.409	0.376	0.392	0.392
2006	0.187	0.244	0.306	0.328	0.438	0.382	0.362	0.362
2007	0.181	0.228	0.296	0.303	0.336	0.369	0.189	0.189
2008	0.166	0.420	0.382	0.410	0.311	0.350	0.289	0.289
2009	0.210	0.352	0.561	0.428	0.483	0.433	0.406	0.406
2010	0.076	0.293	0.370	0.415	0.562	0.343	0.505	0.505
2011	0.101	0.314	0.354	0.368	0.292	0.552	0.392	0.392

Table 11.3.5. Population numbers at age (final assessment)

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	205322	115736	60269	13622	9765	5286	5132
1973	152852	96808	108299	71849	30155	7830	5330	9288
1974	148740	75983	45149	64373	44292	17063	4601	6037
1975	181240	61210	31681	24186	33985	22993	9266	7036
1976	384113	96822	26712	16601	12956	15467	10359	9984
1977	118018	126439	31260	11287	7934	7009	7811	9495
1978	92455	71777	53783	12243	4273	3079	2620	11785
1979	77654	43973	34092	27691	7027	2469	1586	6075
1980	67149	48801	23139	17794	14800	3215	1358	6076
1981	172843	39148	28788	10788	8489	6998	1592	6076
1982	109975	117825	24506	17472	5507	3933	2657	3358
1983	118254	61180	59742	11763	8895	2568	1904	2399
1984	205272	71263	31447	25375	4493	2855	751	1428
1985	311939	94831	29235	14023	9003	2180	1205	2222
1986	288466	134124	27328	11919	7169	4652	1168	2334
1987	113691	186017	27270	8633	4890	3514	2491	1896
1988	115958	64834	64103	9667	4211	2365	1755	1517
1989	78104	65461	29187	20521	4452	1721	937	1078
1990	119074	43924	25769	11965	6892	2236	740	948
1991	138549	60565	18243	10853	5531	3132	1157	1432
1992	93477	71706	22558	8179	5644	2975	1701	1374
1993	152968	59880	28293	6929	3808	3242	1806	2246
1994	104547	91016	30180	12447	2845	1699	1287	2370
1995	226851	67538	38149	12916	6302	1473	1078	1539
1996	113334	161603	31739	17845	7159	1998	595	1380
1997	167055	82777	97147	15321	7615	3000	905	889
1998	72222	123168	50309	52232	9217	3845	1540	745
1999	143779	49754	72776	26380	28217	5528	2057	1499
2000	95458	109184	28183	35440	14008	13990	2403	1642
2001	229185	71762	73744	14985	17851	8610	8535	1291
2002	193160	173116	42787	40089	9238	11371	5446	4694
2003	128406	140127	103433	27004	24771	5358	6617	3444
2004	99937	94579	96441	61375	16436	13891	3019	2155
2005	191329	77013	63874	62947	38114	10001	7660	1555
2006	63839	144040	51735	37039	35435	20723	5620	5171
2007	116790	43335	92404	31178	21852	18719	11575	6236
2008	70107	79797	28257	56251	18860	12789	10593	7592
2009	54348	48629	42924	15788	30570	11314	7378	10491
2010	111206	36059	28010	20055	8429	15434	6006	10822
2011	107243	84392	22014	15837	10847	3933	8970	15145
2012	**0**	**79330**	**50492**	**12646**	**8972**	**6629**	**1854**	**13334**

Table 11.4.1. Saithe in Sub-Areas IV,VI and Division IIIa. Historic stock and fishery trends (final assessment)

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	429605	265381	265381	1018391	0.329	0.62
1972	171373	474021	261877	261877	903521	0.395	0.55
1973	152852	534465	242499	242499	847459	0.416	0.45
1974	148740	554916	298351	298351	833755	0.556	0.54
1975	181240	472029	271584	271584	743382	0.482	0.58
1976	384113	351616	343967	343967	752448	0.760	0.98
1977	118018	263128	216395	216395	509445	0.615	0.82
1978	92455	268131	155141	155141	463895	0.477	0.58
1979	77654	241080	128360	128360	419186	0.396	0.53
1980	67149	235189	131908	131908	396834	0.443	0.56
1981	172843	241251	132278	132278	495259	0.306	0.55
1982	109975	210507	174351	174351	511855	0.469	0.83
1983	118254	214355	180044	180044	467423	0.548	0.84
1984	205272	176792	200834	200834	466186	0.677	1.14
1985	311939	161094	220869	220869	490961	0.714	1.37
1986	288466	152201	198596	198596	488113	0.819	1.30
1987	113691	154053	167514	167514	386814	0.645	1.09
1988	115958	149591	135172	135172	323293	0.621	0.90
1989	78104	117248	108877	108877	261351	0.673	0.93
1990	119074	106459	103800	103800	266490	0.598	0.98
1991	138549	105447	108048	108048	286808	0.576	1.02
1992	93477	107126	99742	99742	282436	0.630	0.93
1993	152968	112181	111491	111491	330605	0.529	0.99
1994	104547	122945	109622	109622	325707	0.509	0.89
1995	226851	138638	121810	121810	464384	0.411	0.88
1996	113334	152714	114997	114997	446879	0.401	0.75
1997	167055	202698	107327	107327	480612	0.283	0.53
1998	72222	204049	106123	106123	399702	0.340	0.52
1999	143779	216957	110716	110716	419862	0.349	0.51
2000	95458	219028	91322	91322	454955	0.299	0.42
2001	229185	234435	95042	95042	526000	0.273	0.41
2002	193160	235782	115395	115395	562889	0.244	0.49
2003	128406	269415	105569	105569	529990	0.224	0.39
2004	99937	324767	104237	104237	561517	0.189	0.32
2005	191329	327674	124532	124532	578452	0.250	0.38
2006	63839	312400	125681	125681	524555	0.266	0.40
2007	116790	310638	101202	101202	486641	0.252	0.33
2008	70107	292133	119305	119305	461620	0.344	0.41
2009	54348	260808	115747	115747	374622	0.388	0.44
2010	111206	248309	101940	101940	422579	0.289	0.41
2011	**107243**	**216972**	**97104**	**97104**	**433227**	**0.284**	**0.45**

Table 11.6.1 Saithe in Sub-Areas IV, VI and Division IIIa. Input data for short term forecast.

age	year	f	stock.n	stock.wt	landings.wt	mat	M
3	2012	0.098	115970	0.91	0.91	0.00	0.2
4	2012	0.241	79330	1.31	1.31	0.15	0.2
5	2012	0.324	50492	1.74	1.74	0.70	0.2
6	2012	0.305	12646	2.35	2.35	0.90	0.2
7	2012	0.337	8972	2.76	2.76	1.00	0.2
8	2012	0.334	6629	3.28	3.28	1.00	0.2
9	2012	0.328	1854	3.70	3.70	1.00	0.2
10	2012	0.328	13334	4.47	4.47	1.00	0.2

Table 11.6.2 Saithe in Sub-Areas IV, VI and Division IIIa. Management option table.

Basis: F(2012) =0.24 estimated from landings constraint 2012 =87.6; R11–13 = GM88–11 =115970; SSB(2013) =235; landings (2012) = 87.550.

Rationale	landings 2013	landings IIIa&IV 2013[1]	landings VI 2013[1]	Basis	F 2013	SSB 2014	% SSB change [2]	% TAC change [3]
Management plan4) § 5	100.684	91.219	9.464	15 % TAC constraint	0.26	252.158	+7.2	+15
F_{MSY}	113.071	102.442	10.628	F_{MSY}*SSB_{2012}/Btrigger	0.3	241.064	+2.5	+29
Fpa	143.132	129.677	13.454	Fpa	0.4	214.379	-8.8	+63
Zero catch	0	0	0	F = 0	0	344.066	+46	-100
Stable F	94.016	85.178	8.837	F2011	0.24	258.152	+9.8	+7.4

Weights in '000 t.

[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 2014 relative to SSB 2013.

[3] Landings 2013 relative to TAC 2012.

[4] Assuming stock status is determined at the beginning of the TAC year.

Table 11.6.3 Saithe in Sub-Areas IV, VI and Division IIIa. Stock numbers 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	2006	2007	2008	2009	2010
Stock no. (thousands) of 3 years old	54348	111206	107243	115970	115970
Source	XSA	XSA	XSA	GM88-09	GM88-09
Status Quo F:					
% in 2012 landings	8.13	25.34	23.15	10.22	-
% in 2013 landings	5.80	17.84	23.70	23.53	9.78
% in 2012 SSB	12.33	28.41	7.18	0	-
% in 2013 SSB	8.96	26.91	26.49	7.19	0.00
% in 2014 SSB	5.57	19.18	24.46	26.56	6.96

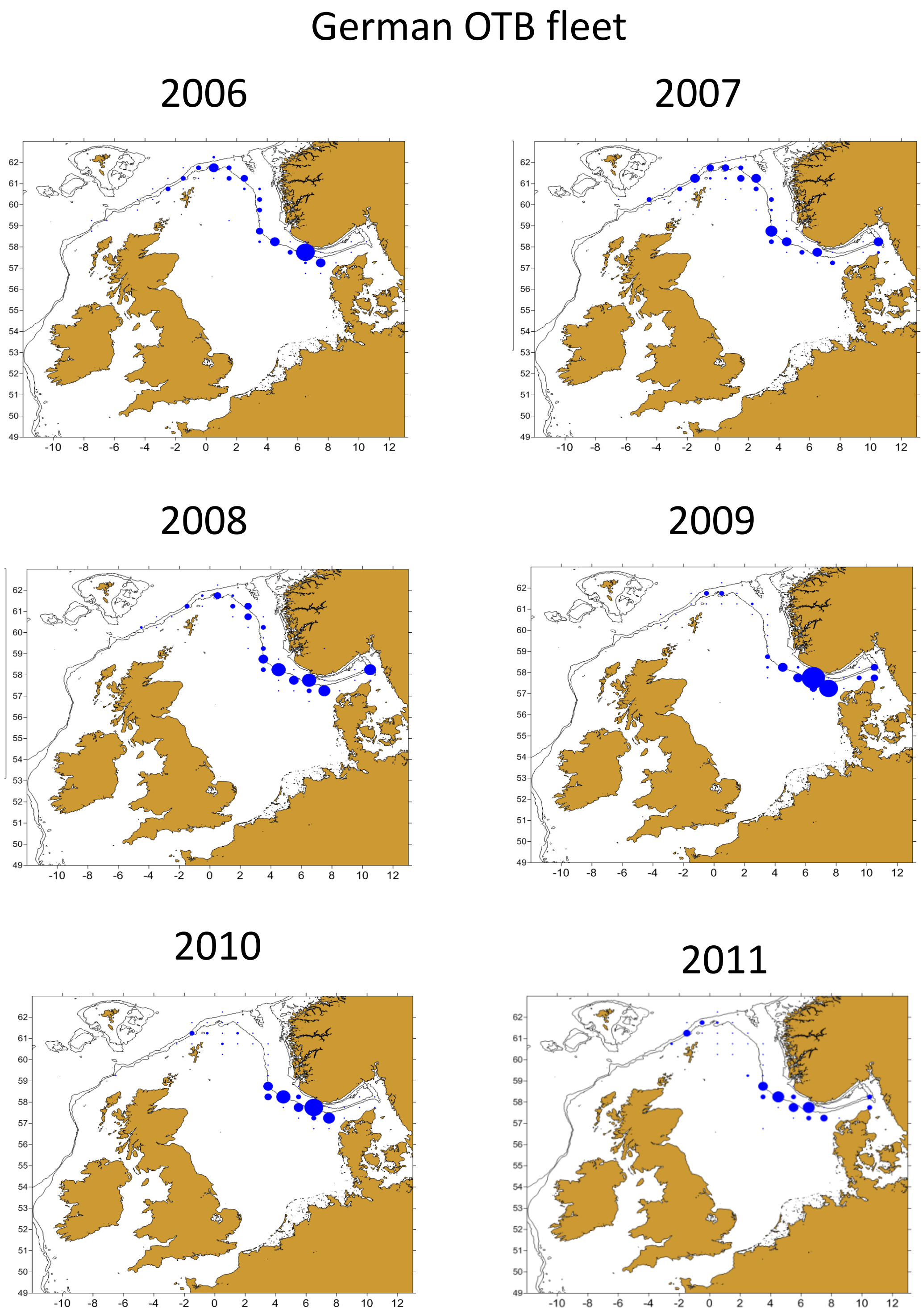


Figure 11.1.1. Spatial distribution of the German trawl catches 2006-2011.

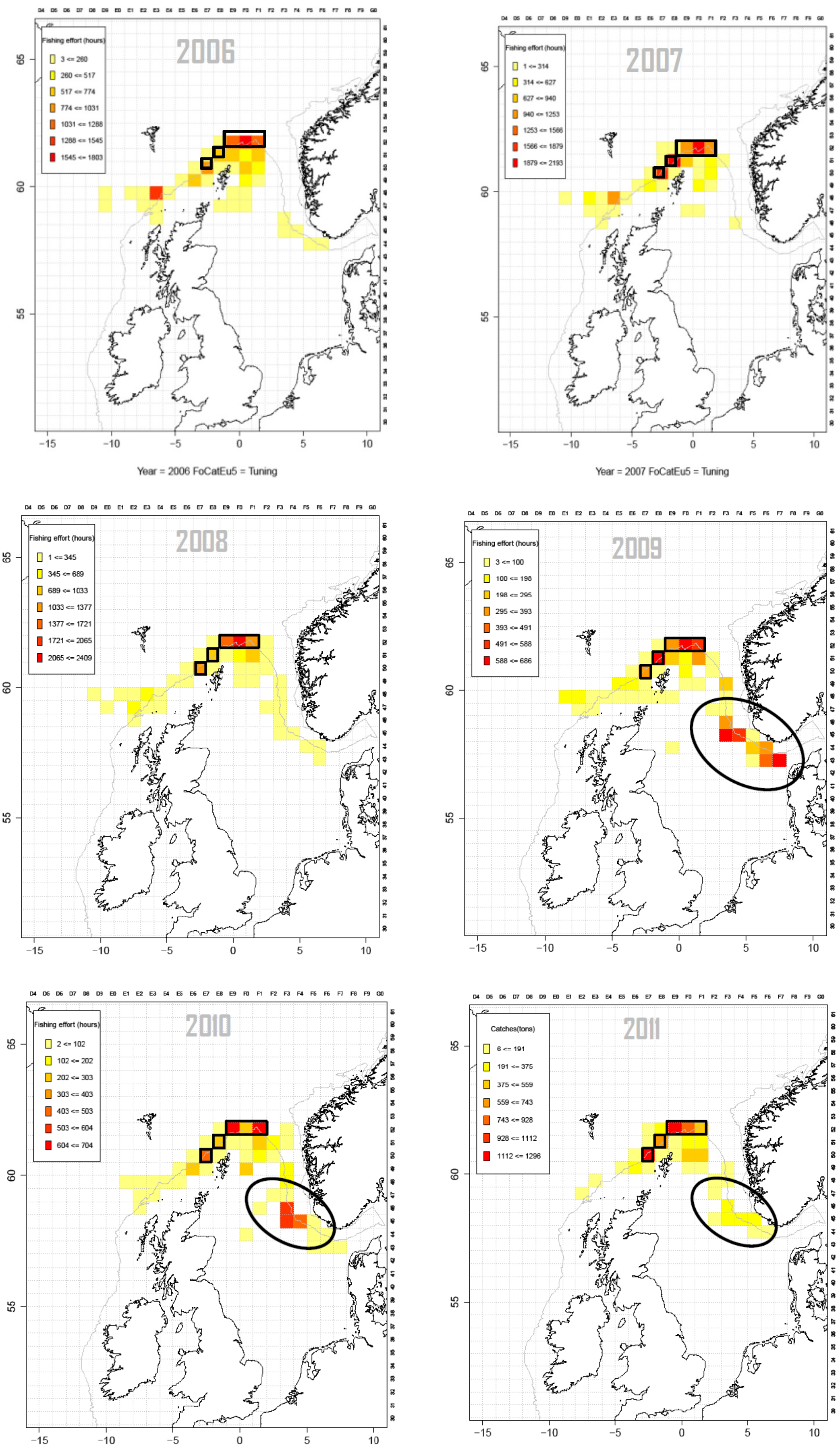


Figure 11.1.2. Spatial distribution of the French trawl effort 2006-2011.

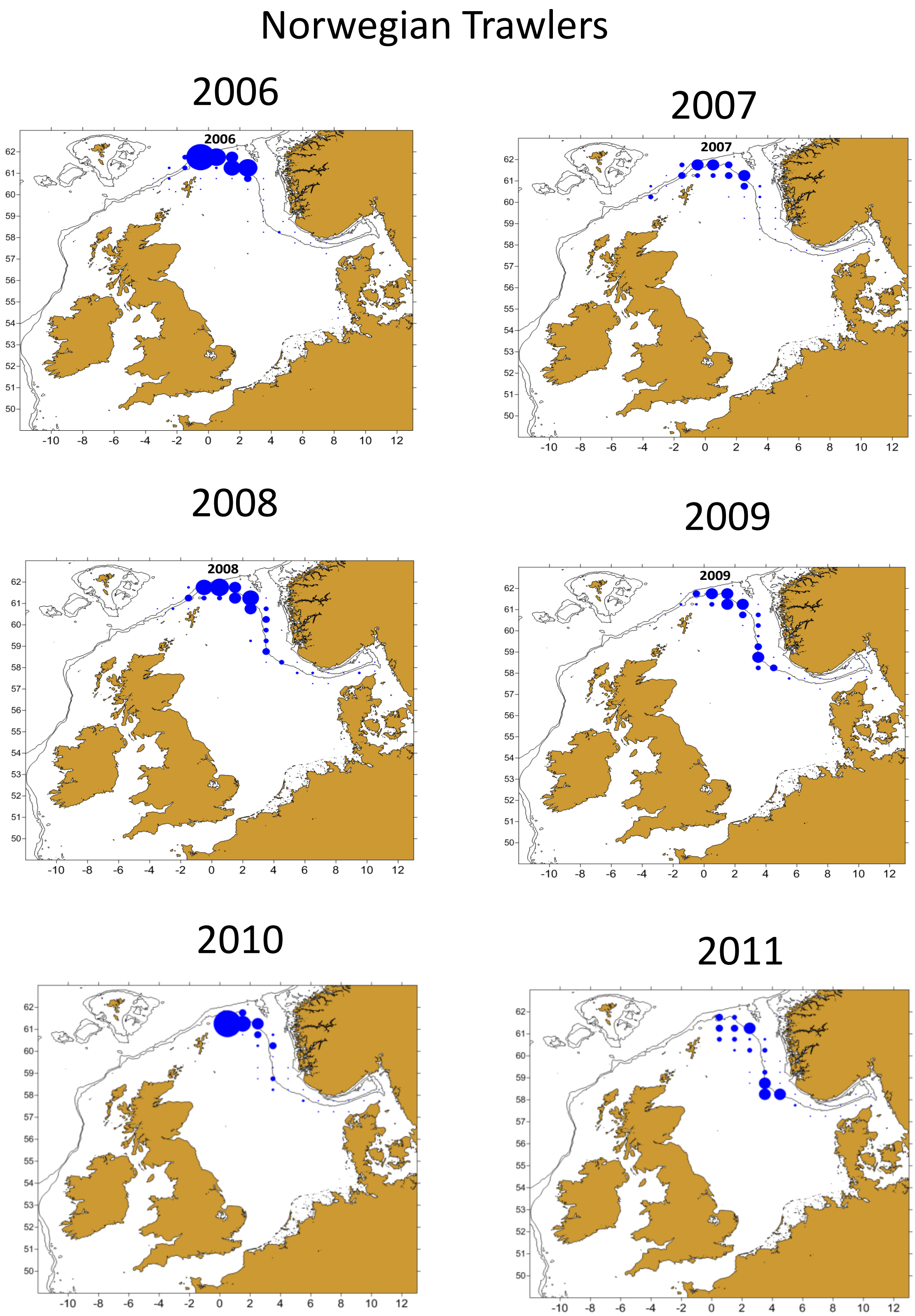


Figure 11.1.3. Spatial distribution of the Norwegian trawl catches 2006-2011.

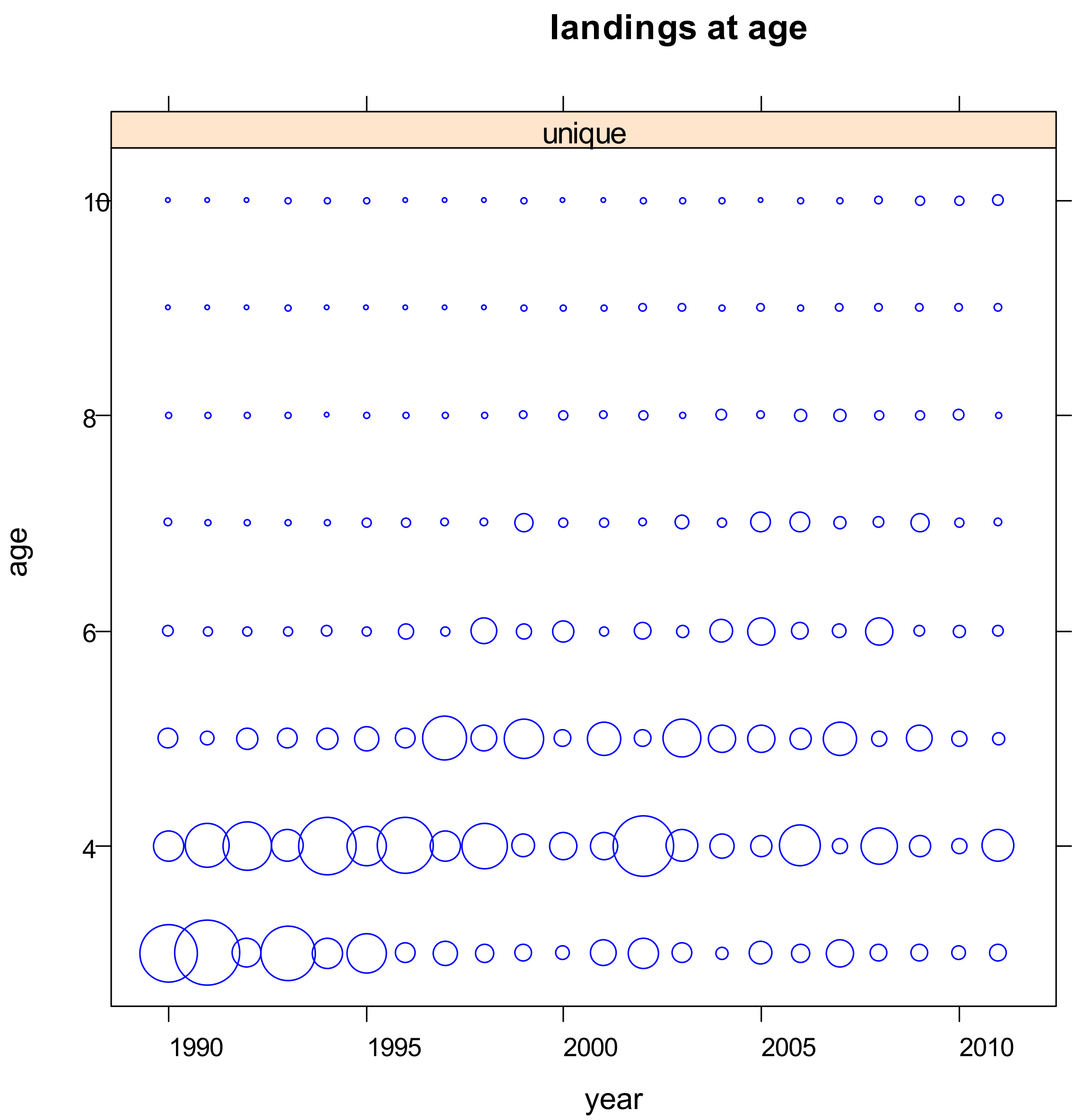


Figure 11.2.1. Saithe in Sub-Area IV, VI and Division IIIa, landings at age.

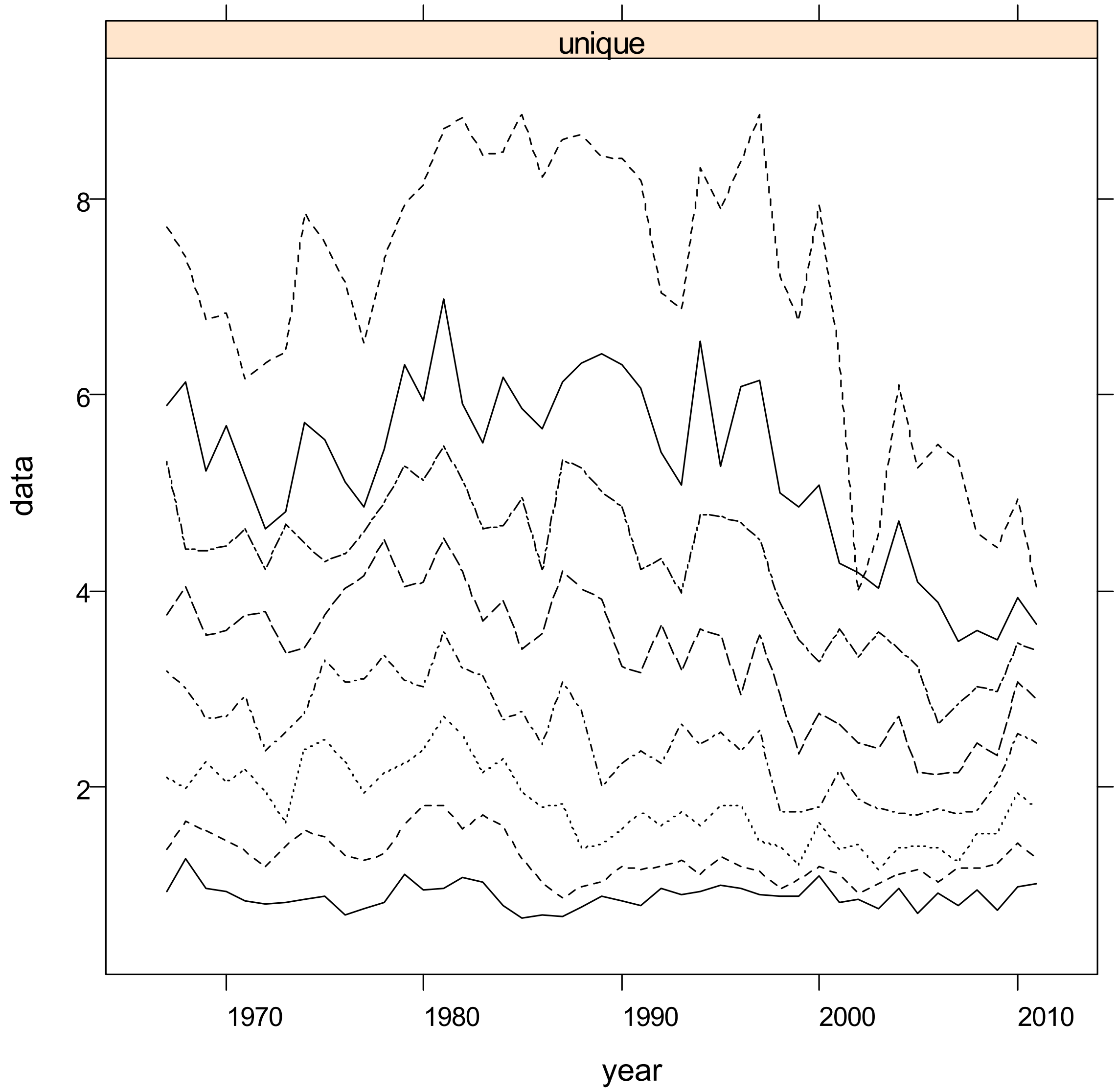


Figure 11.2.2. Weight at age in the landings for age 3-10+. These weights are also used as weight at age in the stock.

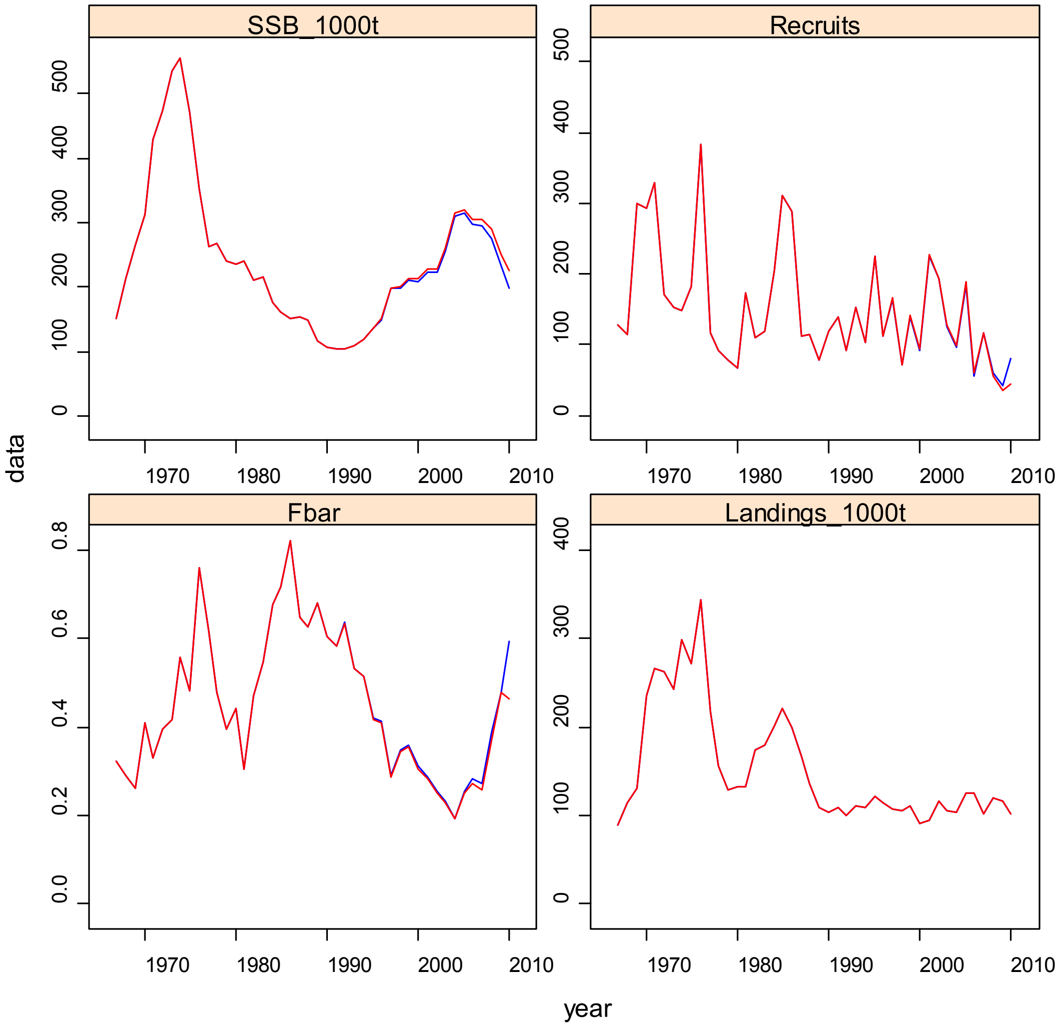


Figure 11.2.3 Sensitivity analysis: The 2011 assessment ran with 2010 catches (blue) and revised Norwegian catches (red line). This test was run with catches as the only differences, all other assessment settings are identical to the assessment run in May 2011.

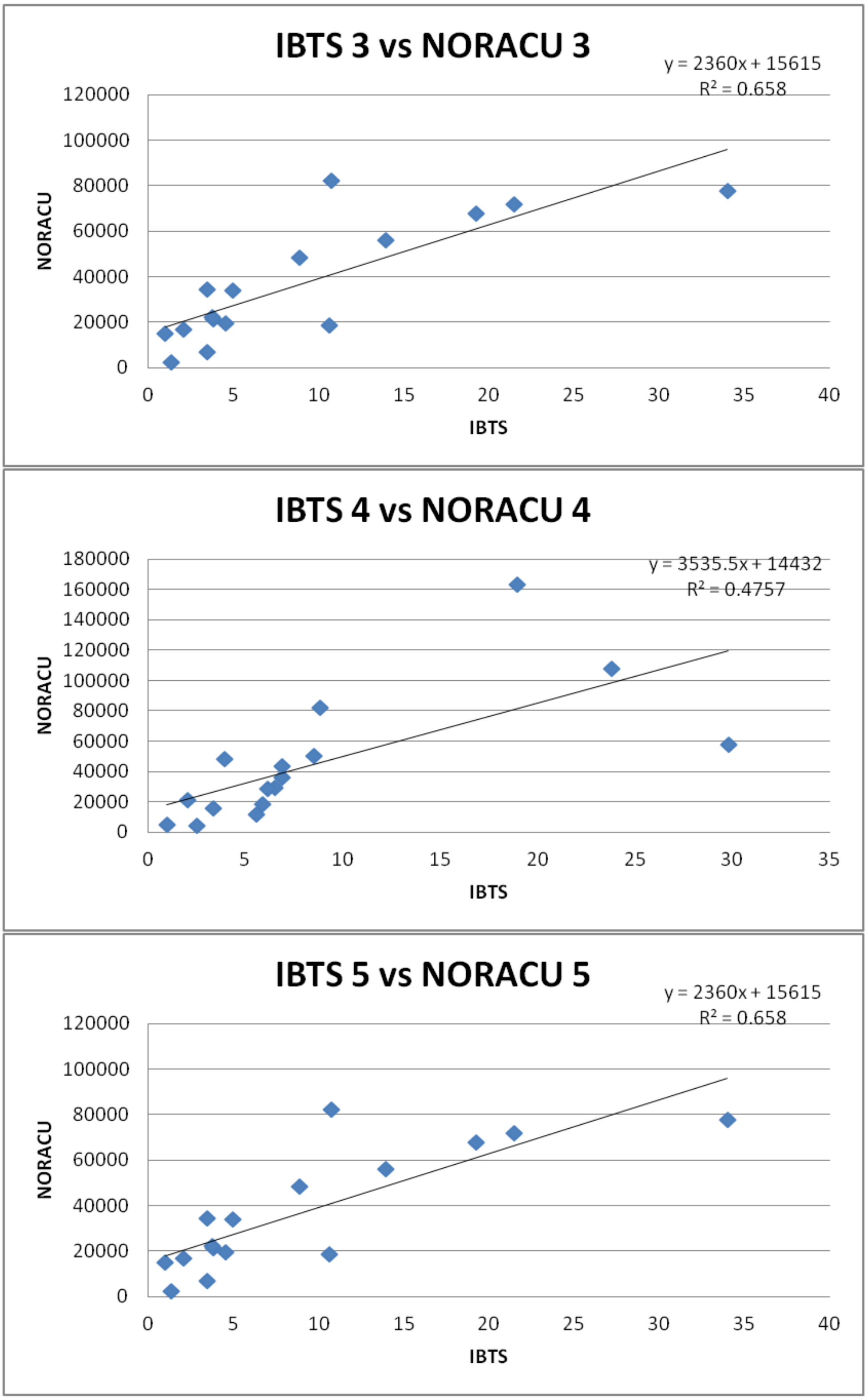


Figure 11.3.1 Relationship between IBTS and NORACU index values

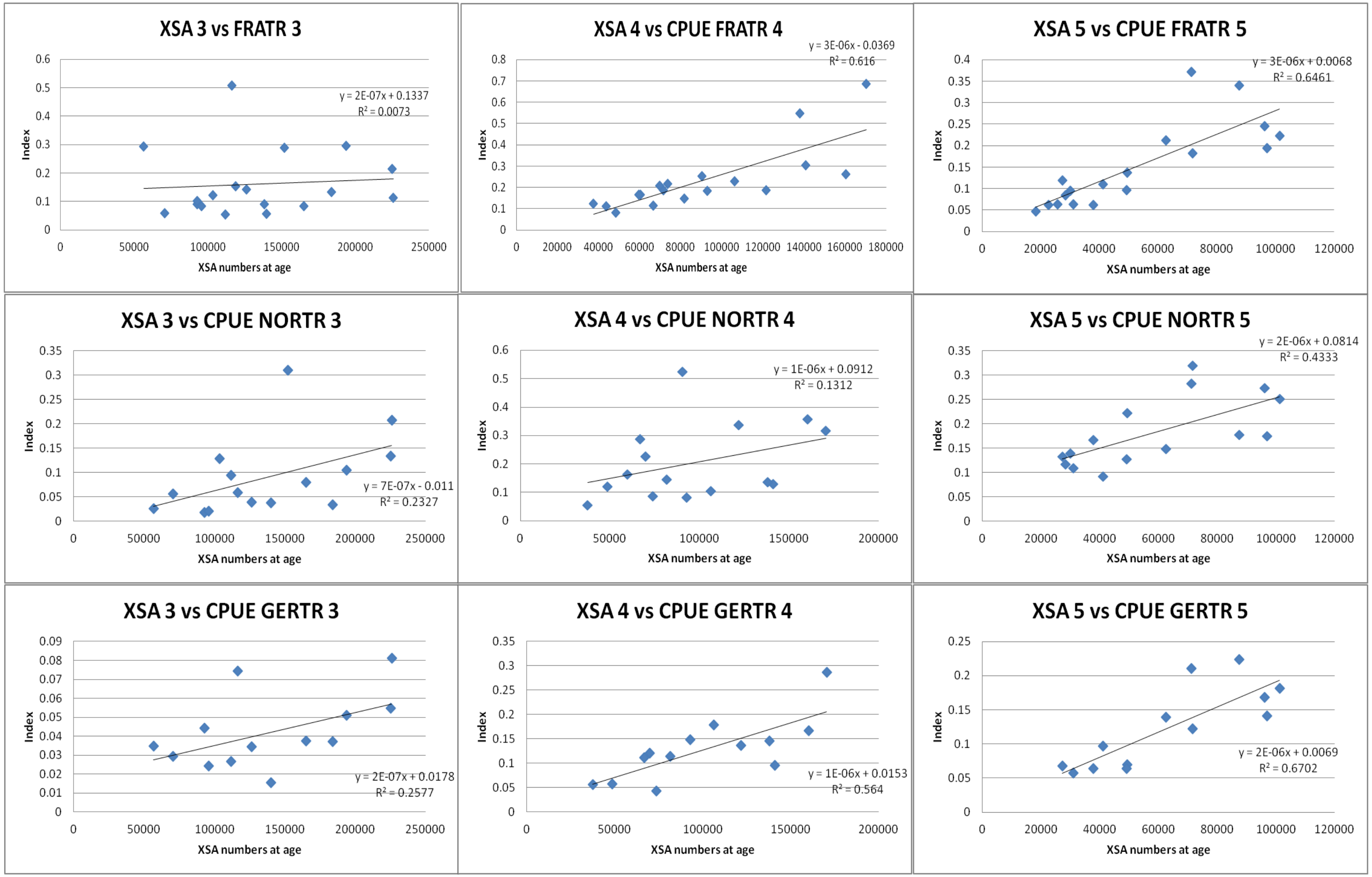


Figure 11.3.2 Relationship between commercial CPUE indices and XSA estimates for years up to 2007.

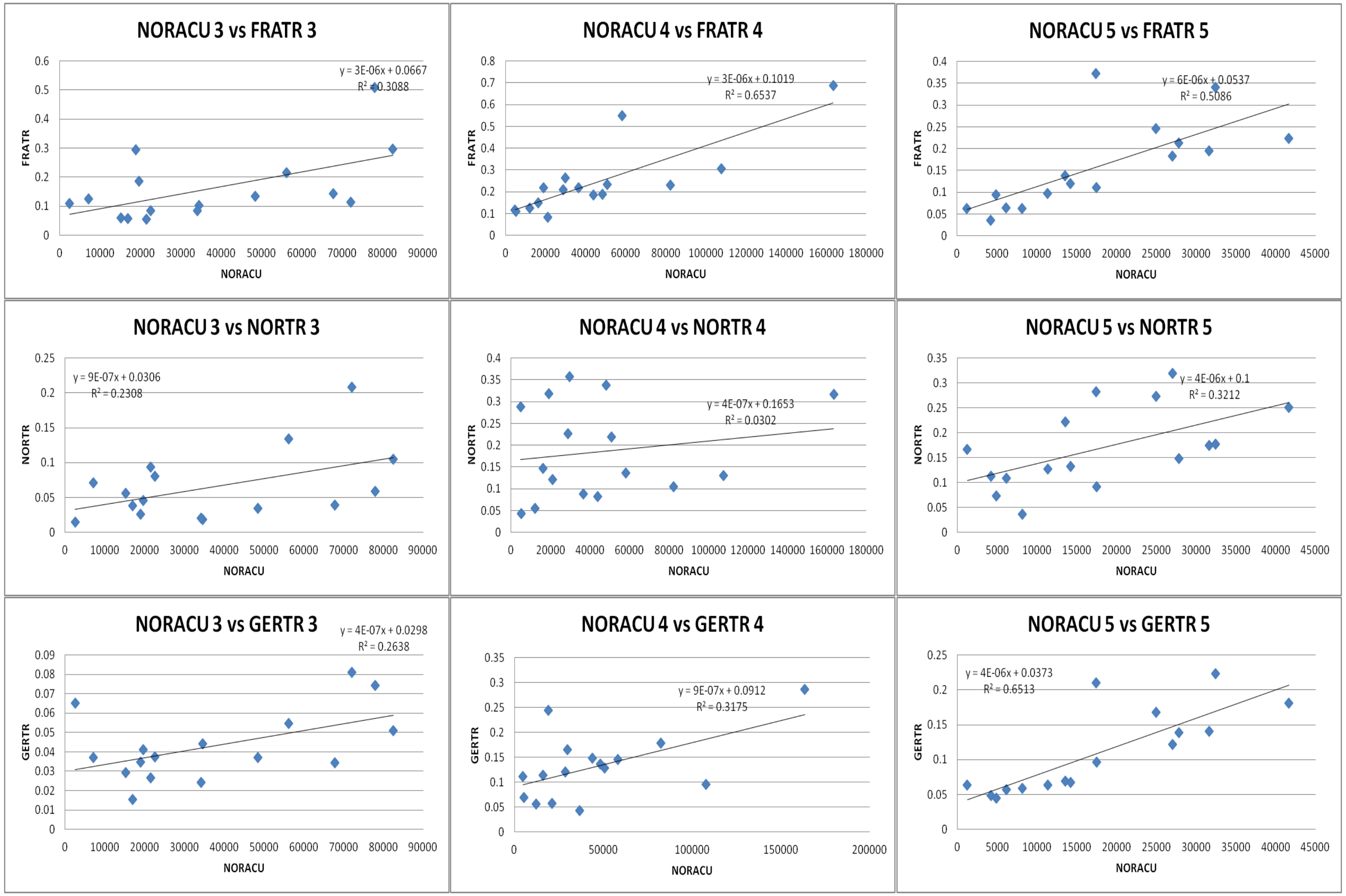


Figure 11.3.3 Relationships between commercial CPUE indices and NORACU survey index.

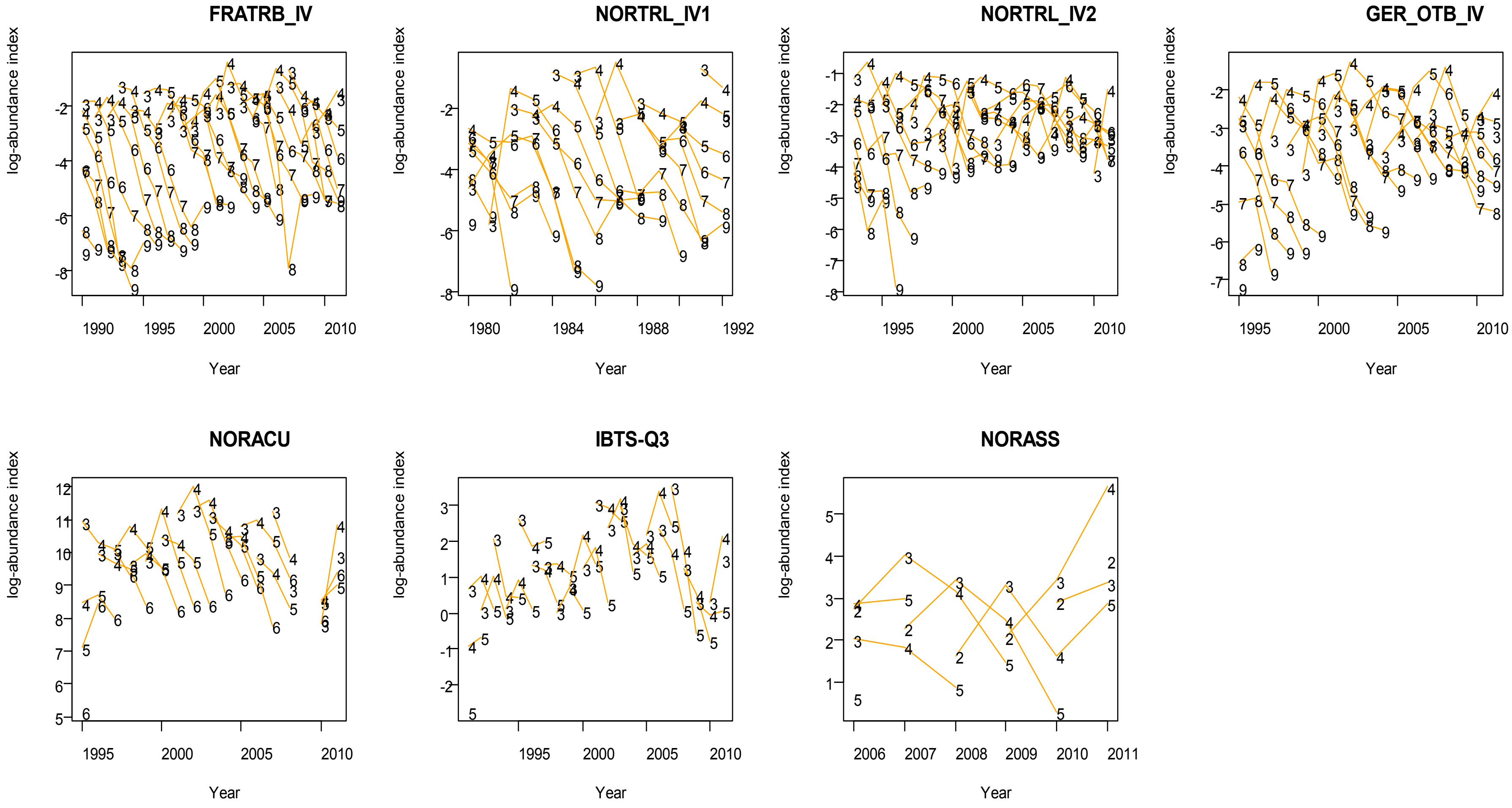


Figure 11.3.4 Saithe in Sub-Area IV, VI and Division IIIa. Log-abundance indices by cohort for each of the available tuning series.

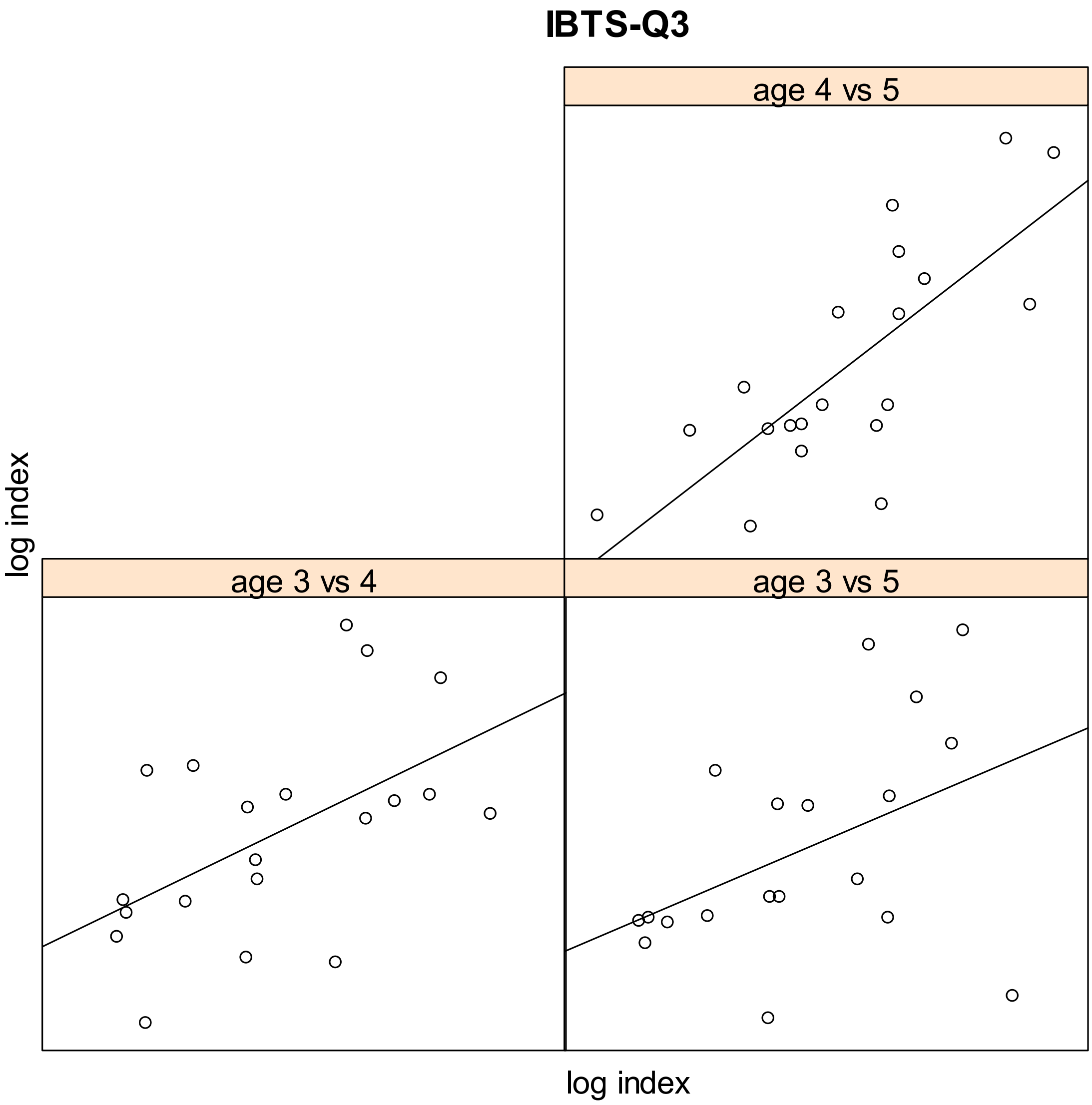


Figure 11.3.5. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for IBTSq3 for the period 1991-2011

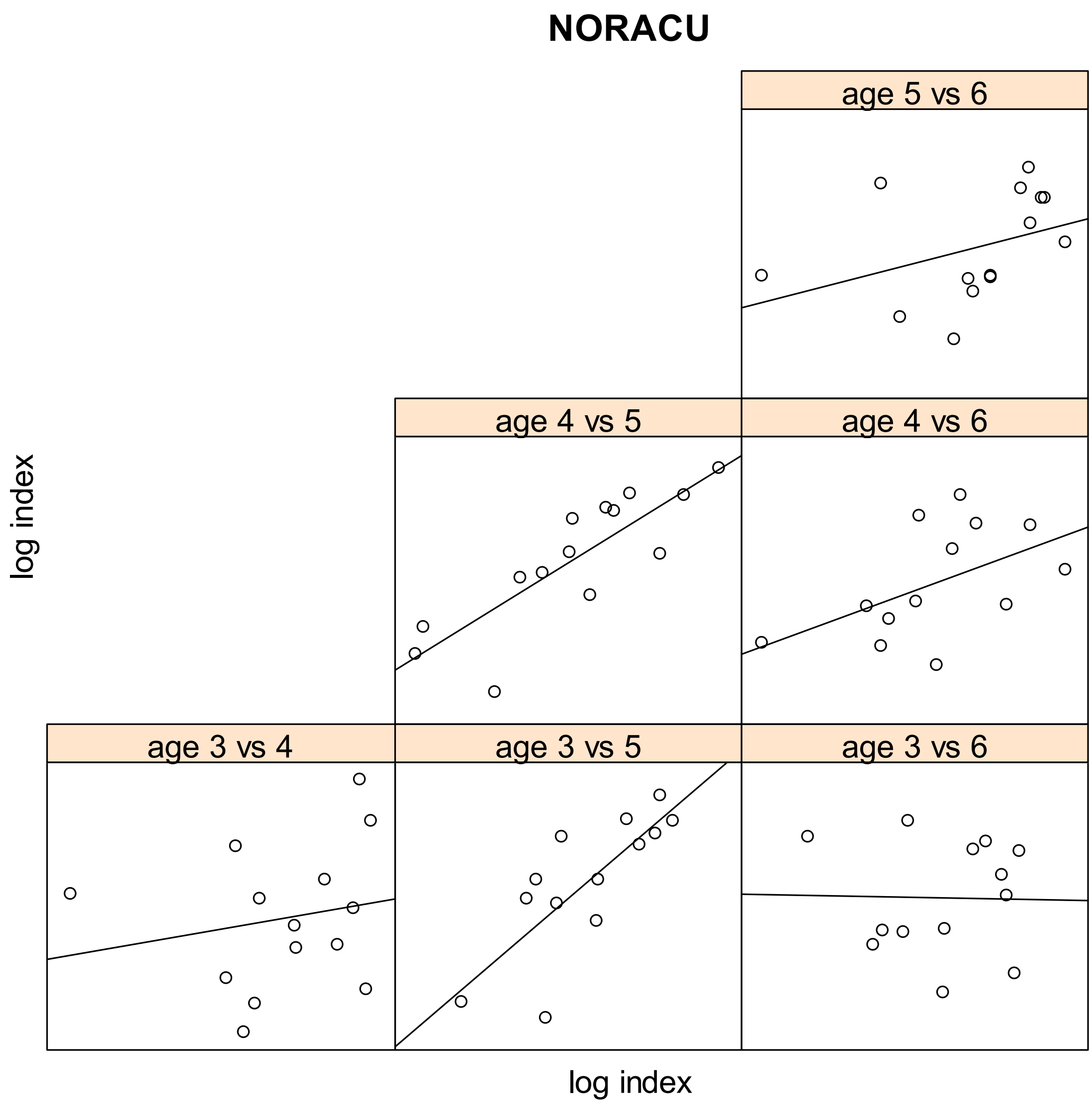


Figure 11.3.6. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NOR-ACU for the period 1991-2011 (the survey was not conducted 2009).

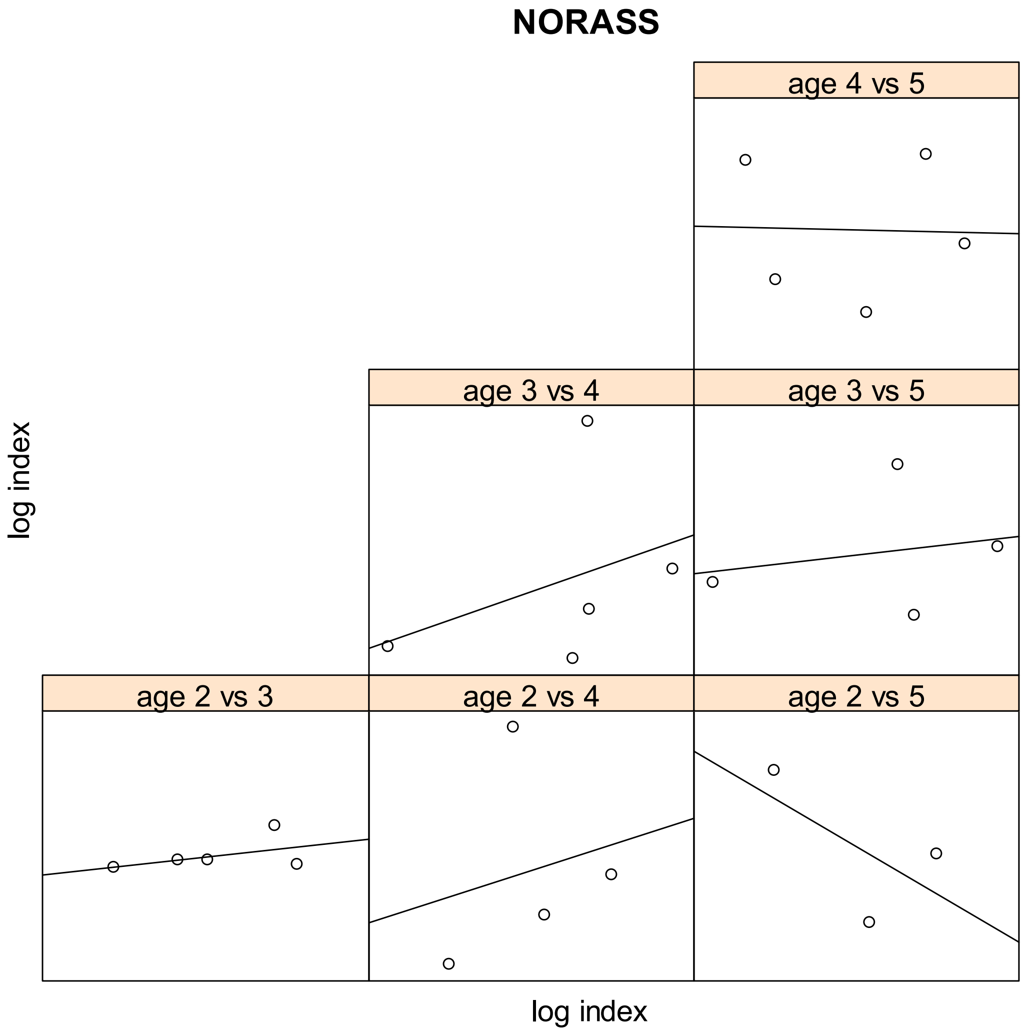


Figure 11.3.7. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NORASS for the period 2006-2011.

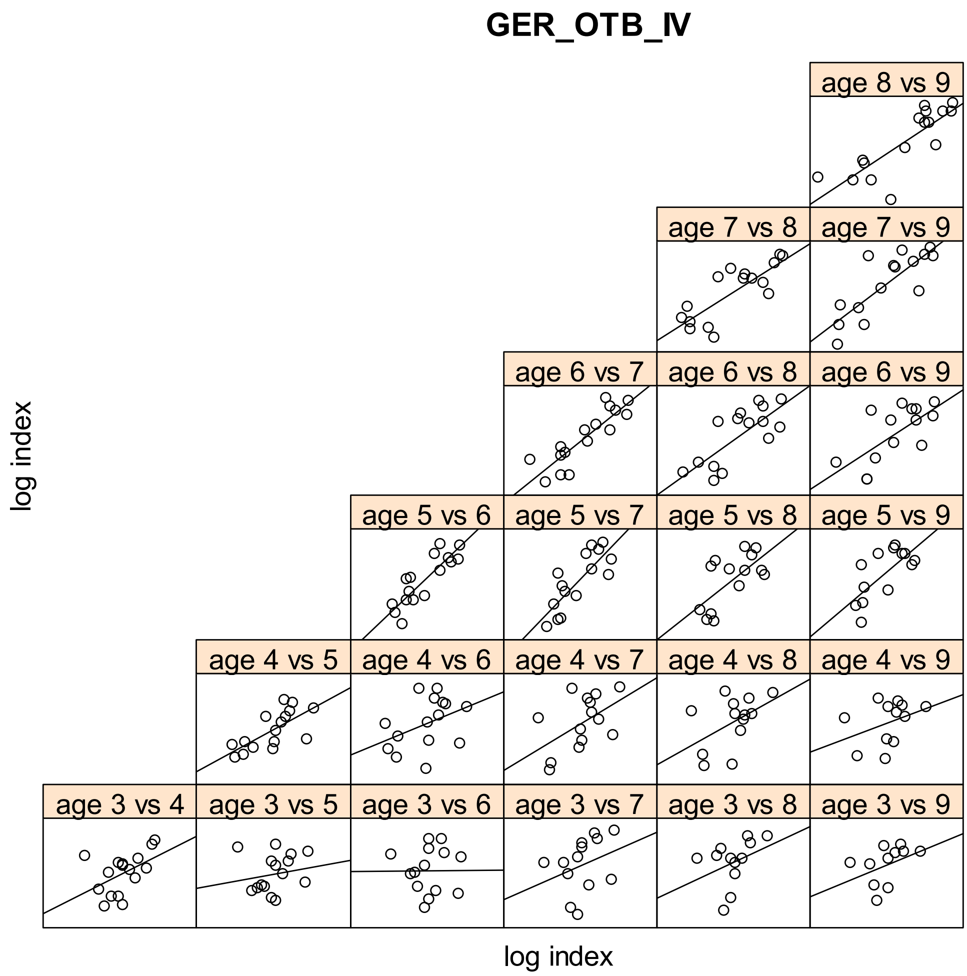


Figure 11.3.8. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for GER_OTB_IV.

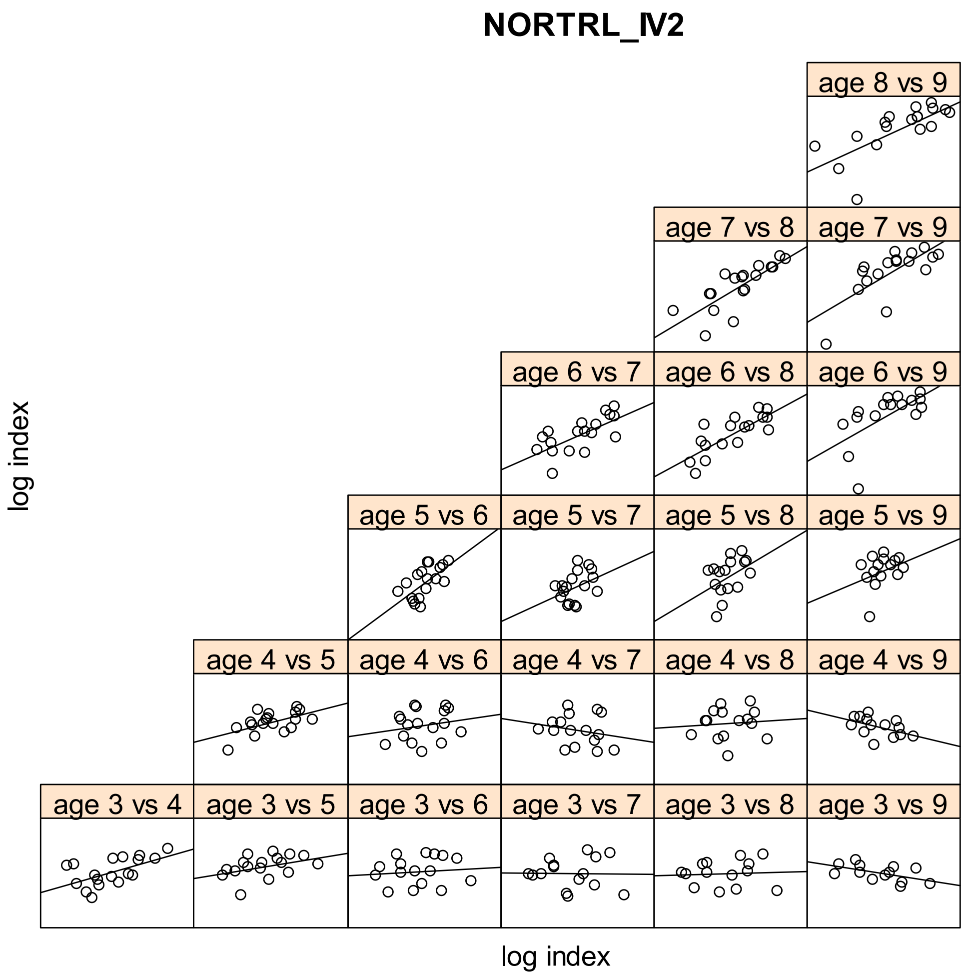


Figure 11.3.9. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NORTRL_IV2.

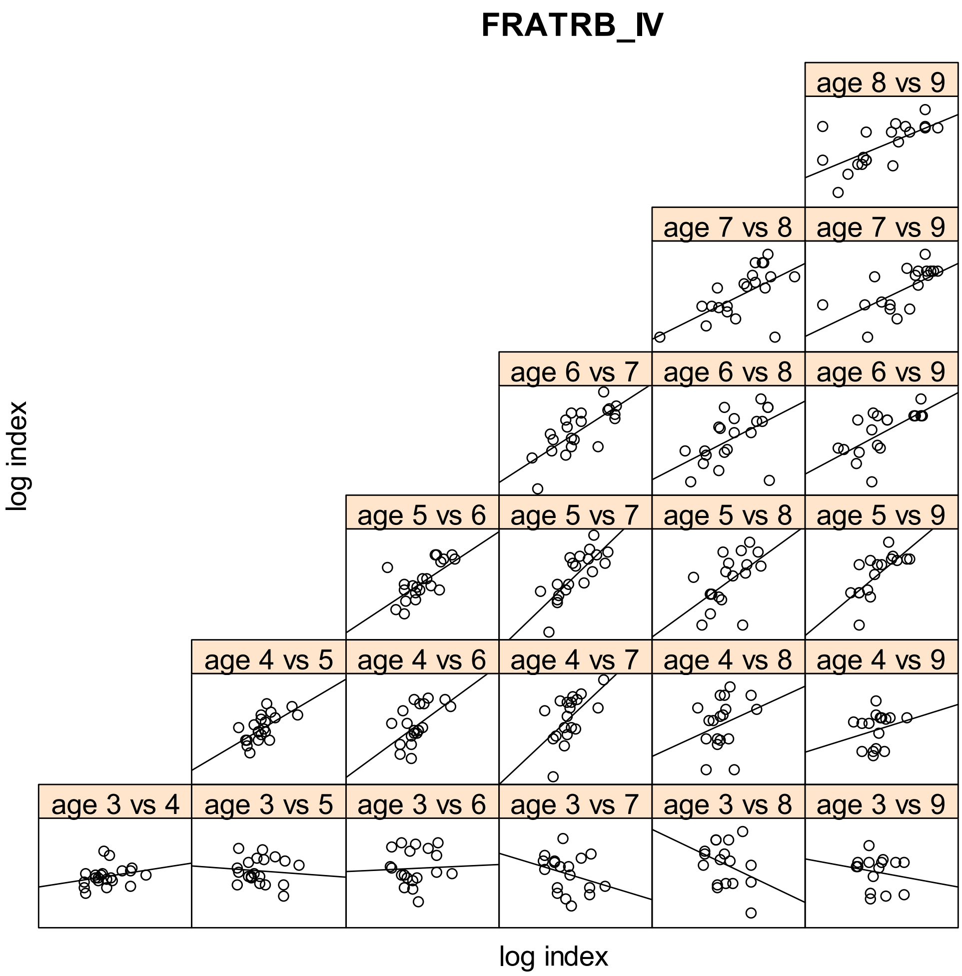


Figure 11.3.10. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for FRATRB_IV.

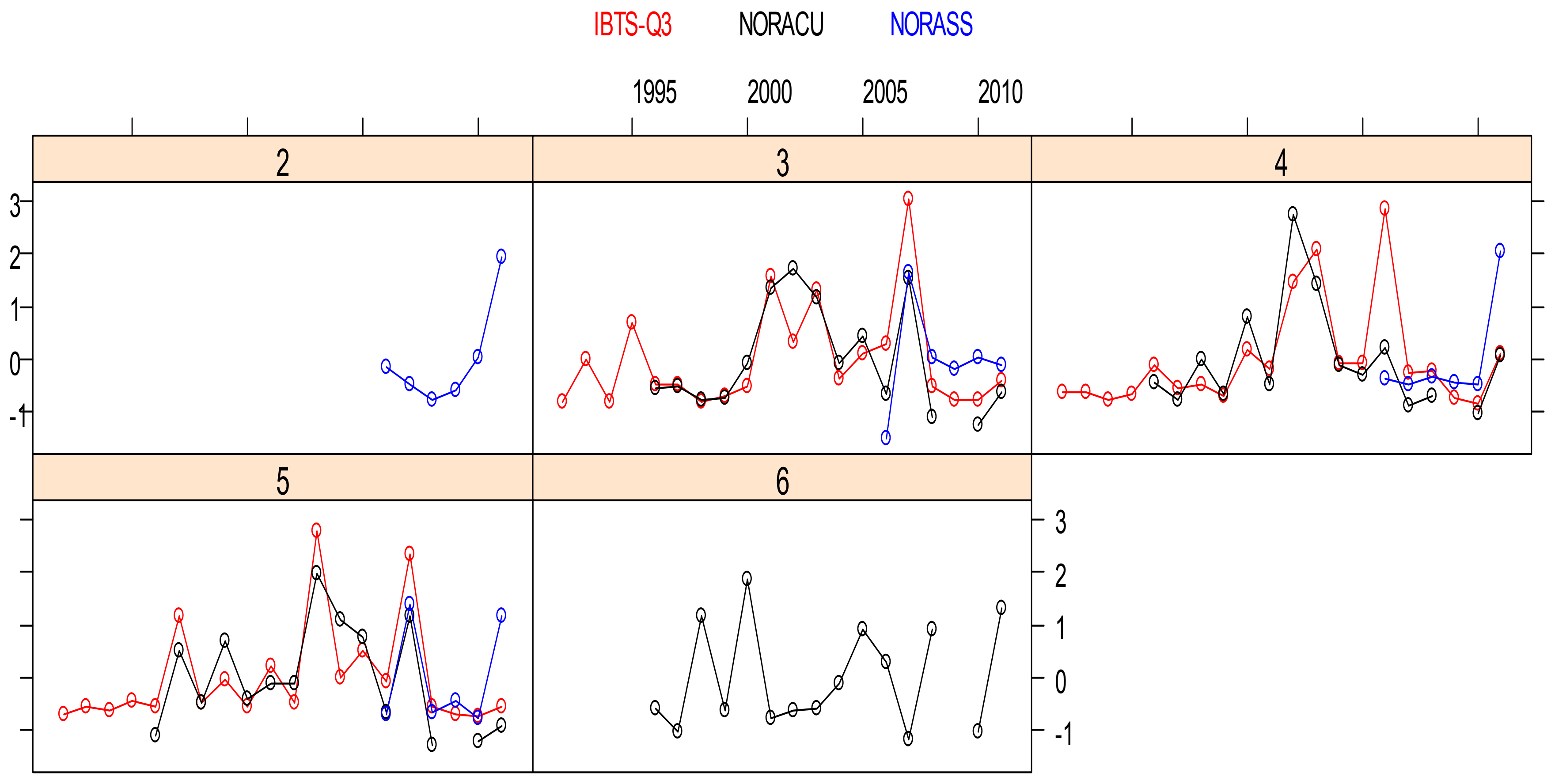


Figure 11.3.11. Saithe in Sub-Area IV, VI and Division IIIa. Standardised indices from the three survey time series.

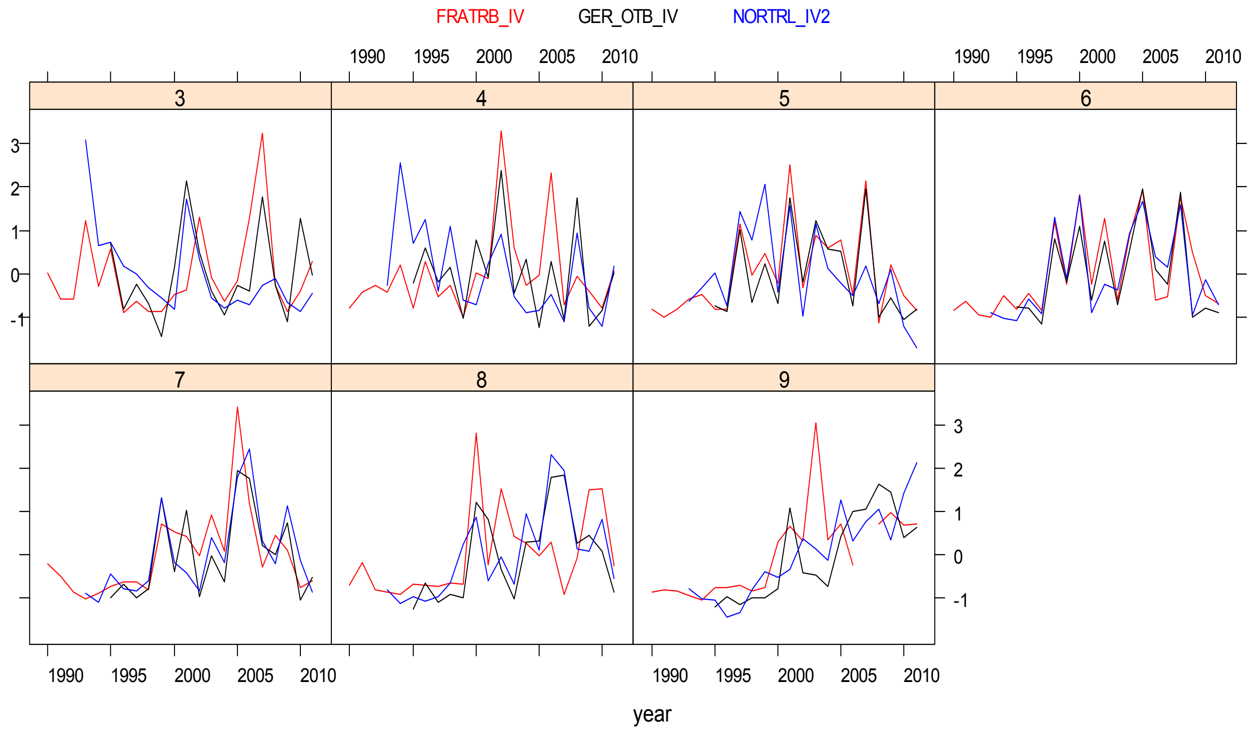


Figure 11.3.12. Saithe in Sub-Area IV, VI and Division IIIa. Standardised indices from the three commercial tuning series.

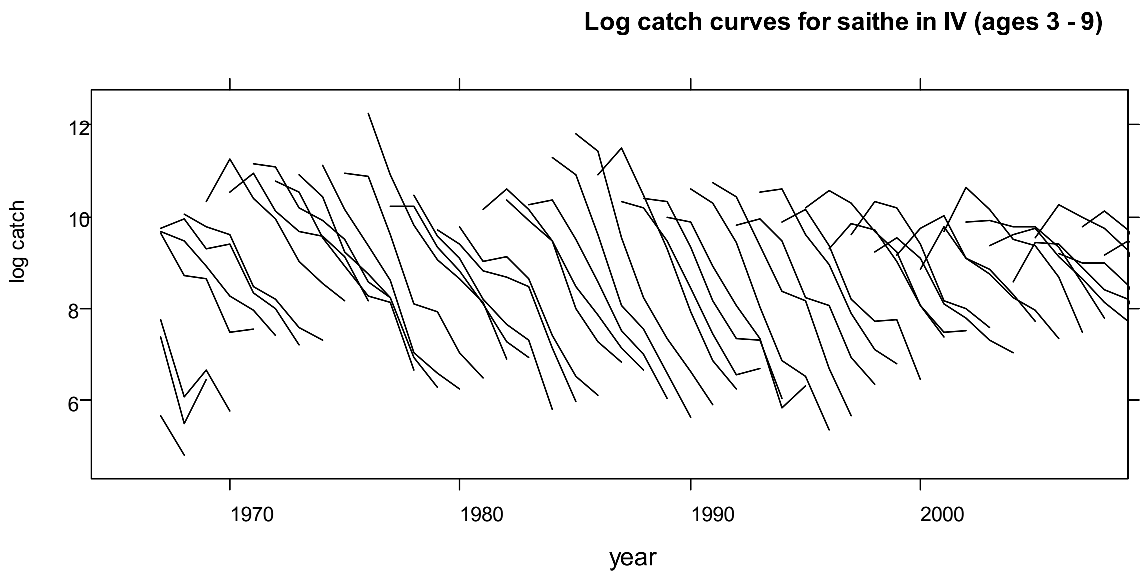


Figure 11.3.13. Saithe in Sub-Area IV, VI and Division IIIa. Log of catch curves for saithe.

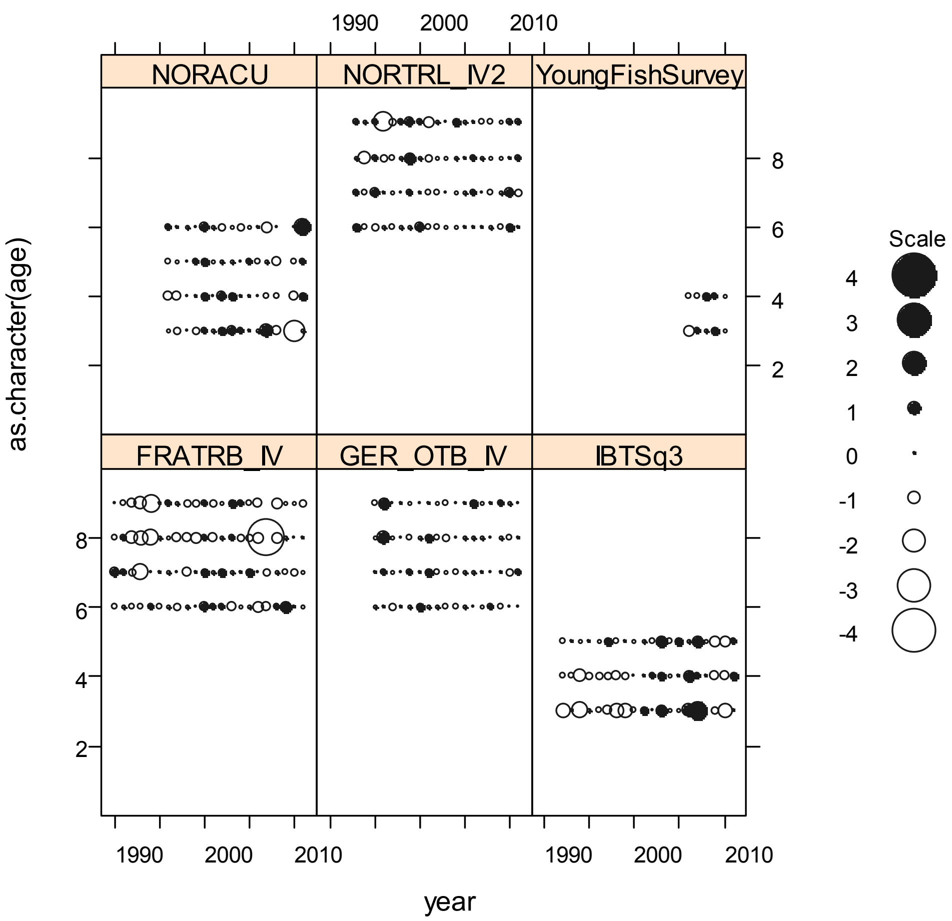


Figure 11.3.14. Log catchability residuals from the alternative XSA shown for each tuning fleet.

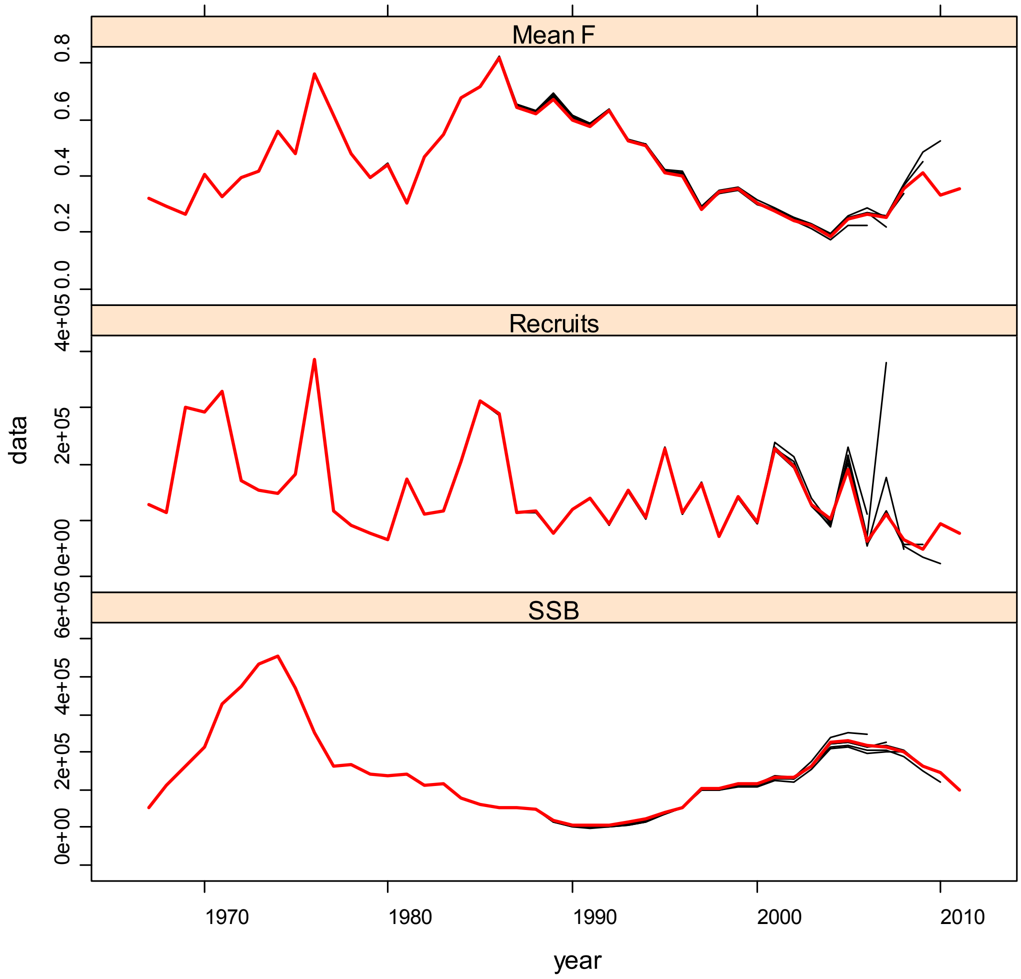


Figure 11.3.15. Retrospective plot for the alternative assessment, showing the retrospective pattern in F_{3-6}, R3 and SSB.

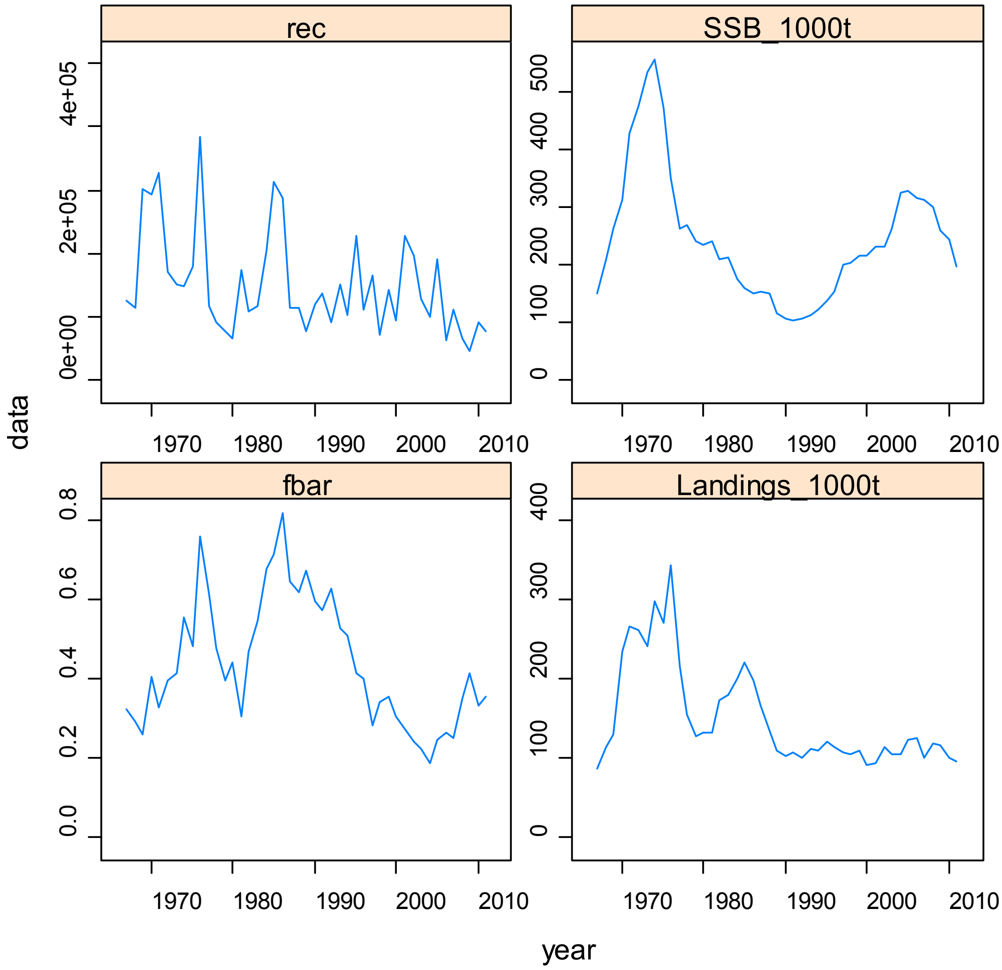


Figure 11.3.16 Stock summary, historical trends in recruitment, SSB, F_{3-6} and landings (alternative assessment).

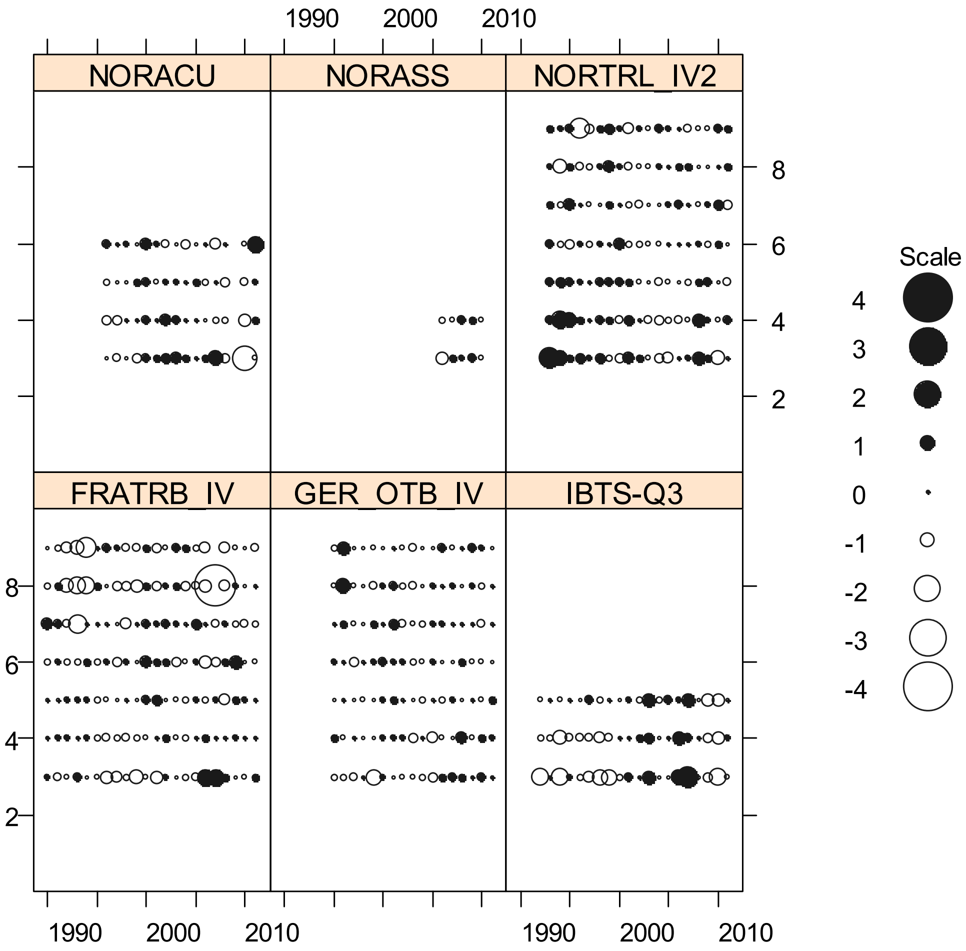


Figure 11.3.17. Log chatchability residuals from the final XSA shown for each tuning fleet.

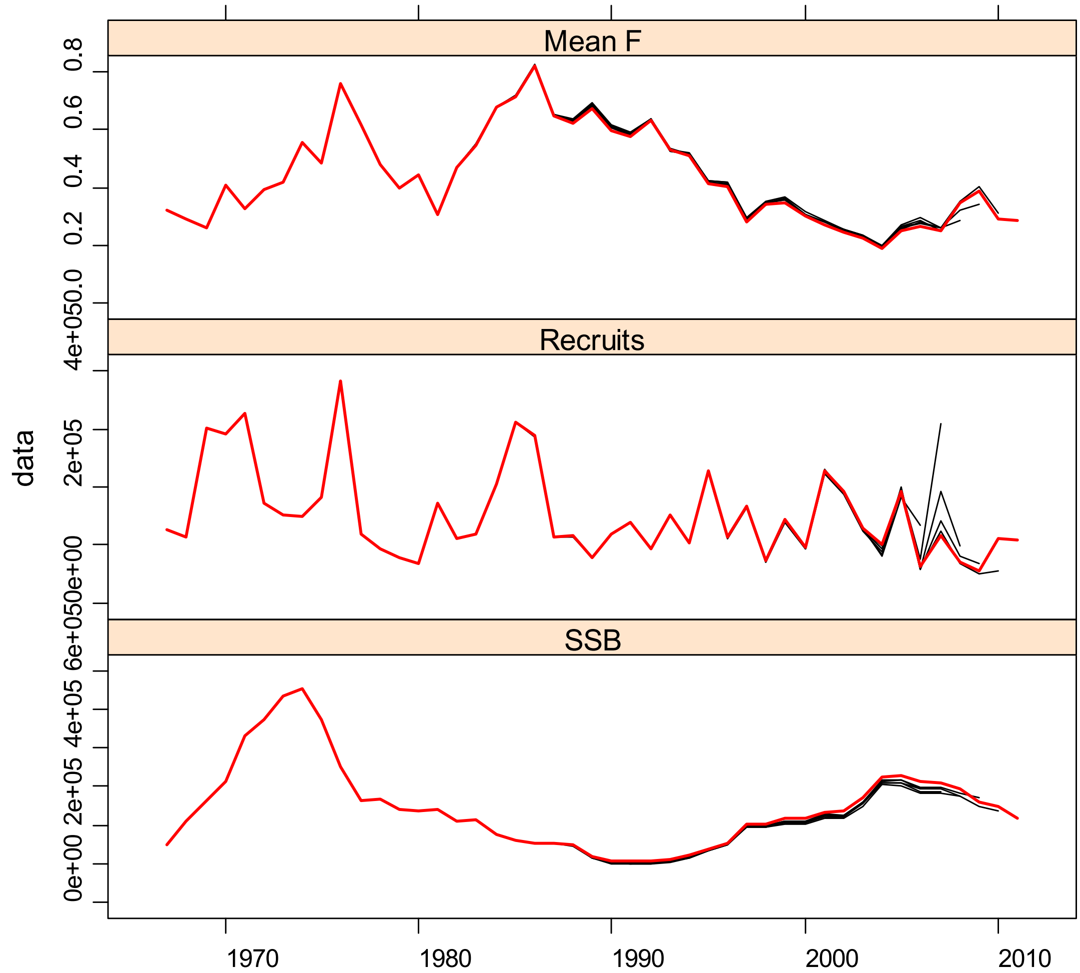


Figure 11.3.18. Retrospective plot for the final assessment, showing the retrospective pattern in F_{3-6}, R3 and SSB.

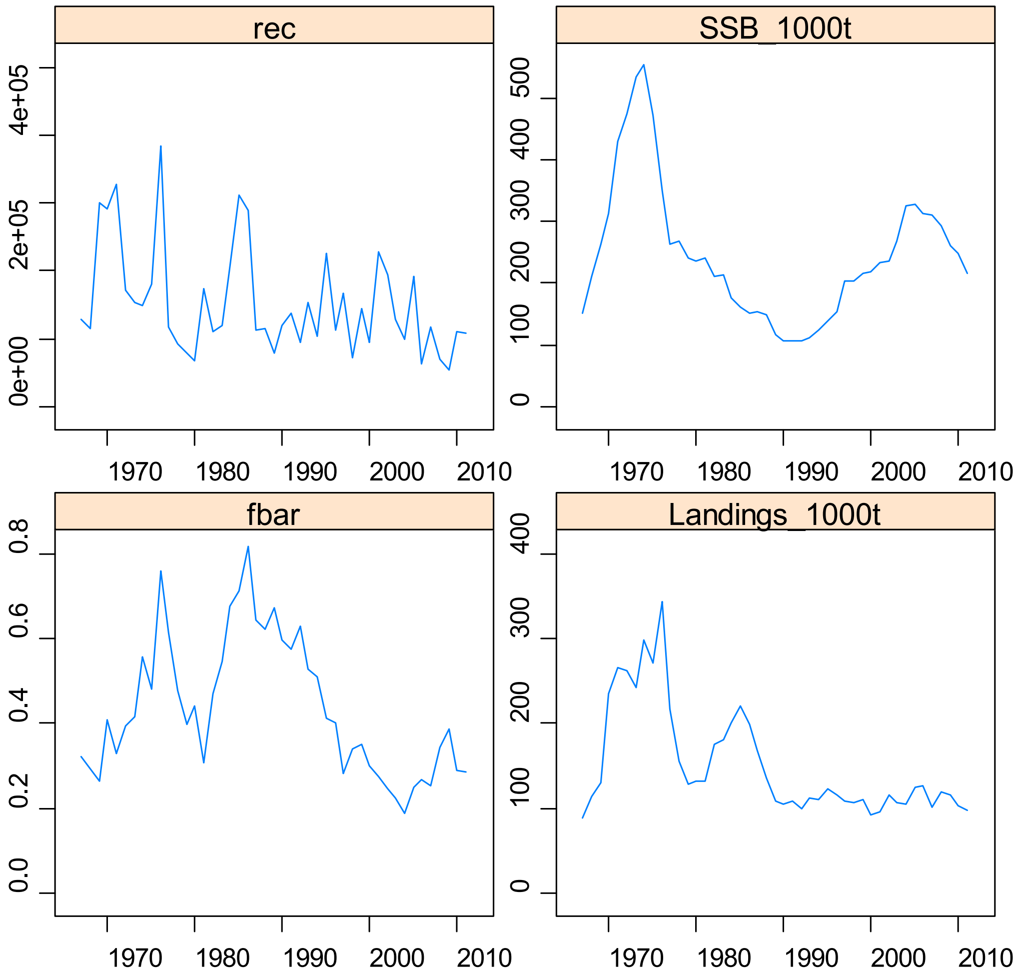


Figure 11.4.1 Stock summary, historical trends in recruitment, SSB, $F_{3\text{-}6}$ and landings (final assessment).

12 Whiting in Subarea IV and Divisions VIId and IIIa

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 2009, while the next benchmark is planned for 2013. The conclusions from the 2009 benchmark were that the assessment was consistent since 1990 and offers a reliable basis for determining stock status, including estimation of current stock size and fishing mortality. Available information on whiting in Division IIIaN (Skagerrak) is presented in Section 12.12.

12.1 General

12.1.1 Stock definition

No new information was presented at the WG. A summary of available information on stock definition can be found in the Stock Annex prepared at ICES-WKROUND (2009)

12.1.2 Ecosystem aspects

No new information was presented at the WG. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.1.3 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared at ICES-WKROUND (2009).

12.1.4 ICES advice

ICES advice for 2011:

In June 2010, ICES concluded the following:

> *To cautiously avoid impaired recruitment, human consumption landings should be less than 12 700 t.*

This advice was unchanged following the application of the update protocol in October 2010, following the autumn groundfish surveys of that year.

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.*

12.1.5 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 14 832 t in 2011, and 18 106 t in 2012. There is no separate TAC for Division VIId; landings from this Division are counted against the TAC for Divisions VIIb-k combined (16 568 t in 2011 and 19 053 t in 2012). There is 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 Table 12.2.2).

The human consumption landings in Subarea IV and Division VIId are calculated as 70% and 30% of the combined area totals. The figures used as the basis for the division of the TAC are the average proportion of the official landings over a number of recent years, and it may be appropriate to revise them.

The minimum landing size for whiting in Subarea IV is 27 cm. The minimum mesh size for whiting in Division VIId is 80 mm, 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, and in 2012, 64 closures had been implemented by 12th 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.

Recent work 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). However, the effect of this change in behaviour on the whiting stock is still under investigation.

In 2012, 23 Scottish demersal whitefish vessels are participating in a trial Fully Documented Fishery (FDF) scheme, following trials in 2010 and 2001, and with similar trials being conducted 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.

12.2 Data available

12.2.1 Catch

For the first time this year, international data on landings and discards were collated through the InterCatch system (see Section 1.2). The process proved to be slow and cumbersome in this first application, largely due to the definition of around 160 fleet components for which whiting discard rates and age compositions had to be inferred. Further work is required to improve this collation procedure for the whiting stock.

Total nominal landings are given in Table 12.2.1 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.

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.

WG estimates of weights and numbers for the defined catch components (total catch, landings, discards and industrial bycatch) are given in Tables 12.2.2 and 12.2.3. Total catch in 2011 was very similar to 2010, with an increase in the North Sea offset by a corresponding decrease in the Eastern Channel. The reported tonnages of the Subarea IV catch components remain among the lowest in the series due to a restrictive TAC, and whiting industrial by-catch also remains low. For Division VIId, the total catch in 2011 represents a decrease from the preceding two years.

Figure 12.2.1 plots the trends in the commercial catch for each component along with the relevant TAC. Recent years have seen these time-series stabilise to a certain extent, although there has still been an increase in discards in 2011 (Figure 12.2.2).

12.2.2 Age compositions

Age compositions in the landings and discards were based on samples provided by France and the UK. There were no age compositions available for industrial bycatch this year.

Limited sampling of the industrial bycatch component has resulted in the 2006 data appearing as an outlier and the 2007 to 2010 data was 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:

$$\hat{n}_{a,y} = \hat{N}_y \hat{p}_{a,y},$$

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

$$\hat{N}_y = \frac{\sum_a \hat{p}_{a,y} \hat{w}_{a,y}}{W_y},$$

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, age compositions were inferred in InterCatch from corresponding age samples taken from small-mesh fisheries of France and the UK.

Total international catch numbers at age (Subarea IV and Division VIId combined) are presented in Table 12.2.3. Numbers for human consumption landings, discards, and industrial bycatch are given in Tables 12.2.4 – 12.2.6.

12.2.3 Weight at age

Mean weights at age (Subarea IV and Division VIId combined) in the catch are presented in Table 12.2.7. These are also used as stock weights. Mean weights at age (both areas combined) in human consumption landings are presented in Table 12.2.8, and for the discards and industrial by-catch in the North Sea in Tables 12.2.9 and 12.2.10 respectively. Weights-at-age are depicted graphically in Figure 12.2.3, 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. The final-year increase in the industrial bycatch weights-at-age for all available ages is likely to be an artefact of the use of InterCatch data collation for that year, and may lead to an upwards bias in estimates of bycatch yield.

Unrepresentative sampling of industrial bycatch in 2006 to 2010 resulted in poor estimates of the mean weights at age and these have been replaced by the mean weight at age for the period 1995 to 2005 (zero weights are taken as missing values).

12.2.4 Maturity and natural mortality

Values for maturity remain unchanged from those used in recent assessments and are:

Age	1	2	3	4	5	6	7	8+
Maturity Ogive	0.11	0.92	1	1	1	1	1	1

Their derivation is given 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 12.2.11. The estimates are substantially different to those used previously (see the comparisons in Figure 12.2.4), due largely to the addition of seal and harbour porpoise predation to the SMS model. As the benchmark approach is to use natural mortality estimates from the latest SMS key run, the new values in Table 12.2.11 are used in the assessment this year.

12.2.5 Catch, effort and research vessel data

Survey tuning indices used in the assessment are presented in Table 12.2.12. These are ages 1 to 5 from the IBTS Q1 and Q3 from 1990 to 2010 and 1991 to 2010, respectively. The report of the 2001 meeting of this WG (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 (2009).

12.3 Data analyses

Last year's Review Group (RGNSSK), which met in June 2011, made a number of technical comments, but only two recommendations for the assessment of whiting in Subarea IV and Division VIId. These are listed below, along with how this year's WG has addressed them (if this has proved possible):

1) Explore alternative assessment models or XSA configurations to solve retrospective patterns.
   - The retrospective problem appears to have been rectified (see Figure 12.3.18) without changes in model settings or configurations. It is not yet clear why this has occurred, and this will be explored in the coming benchmark.

2) Explore if IBTS Q1 has really changed catchability in recent years.
   - Time did not permit an analysis of this issue.

The next benchmark for whiting in Subarea IV and Division VIId is planned for early 2013. It is intended that these points (and many others) will be addressed then.

12.3.1 Exploratory survey-based analyses

Figure 12.3.1 presents time-series of survey log CPUE at age, and suggests that while broad trends are captured in a consistent way by the two surveys, finer-scale details of year-class strength may not be.

Catch-curve analyses for the surveys are shown in Figures 12.3.2. 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 year class at age 1. The 2007 to 2009 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 year class at age 1; however, numbers at age 2 in the 2007 year class may well be an overestimate. There does not appear to be a problem estimating age 1 in the 2008 or subsequent year classes.

The consistency within surveys is assessed using correlation plots in Figure 12.3.3. These indicate that the IBTS Q1 and Q3 surveys both show good internal consistency across all ages, apart from comparisons of year-class strength for the survey plus group (age 6+) which is not used in the assessment. The log CPUE plots by survey (Figure 12.3.4) support the conclusion of good internal consistency.

Figures 12.3.5 to 12.3.8 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, uncertainty bounds are fairly tight, and retrospective error is low.

12.3.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 12.3.9 and shows numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 3 for some cohorts (although generally selection is only lower than expected for age 1). 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 12.3.10. The gradients (since the 2002 year class) appear to be fluctuating around a mean level that is lower that 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 12.3.11. 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 years' final assessment. Summary plots of these runs are presented in Figure 12.3.12. The population trends from each survey are consistent; however, the mean F estimates differ considerably throughout the time-series apart from the last year. Residual patterns (Figure 12.3.13) show that both the 2006 year class has a large negative residual at age 1 for both surveys (and particularly IBTS Q1).

Finally, Figure 12.3.14 compares the SURBAR results with the final XSA assessment (see Section 12.3.4). The mean Z (total mortality) estimates show year-to-year variation, but the trends in all outputs are very similar.

12.3.3 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 12.3.18), which may indicate that consistency has improved.

12.3.4 Final assessment

The final assessment used an XSA model (in the FLR implementation) fitted to the combined landings, discard and industrial by-catch data for the period 1990–2011. This is the same procedure as last year and that agreed at ICES-WKROUND (2009). The settings are provided in the table below. Those from previous years are also presented.

	year range used	**2009 -**
Catch at age data		**1990 - Ages 1 to 8+**
Calibration period		**1990 -**
ENGGFS Q3 GRT (1990-1991	-	-
ENGGFS Q3 (GOV)	-	-
SCOGFS Q3 (Scotia II)	-	-
SCOGFS Q3 (Scotia III)	-	-
IBTS Q1	**1990 -**	**Ages 1 to 5**
IBTS Q3	**1991 -**	**Ages 1 to 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 fleet survivors estimates		**0.3**

Diagnostics for the final XSA run are given in Table 12.3.1. Residual plots are presented in Figure 12.3.15. These show that the IBTS Q3 survey fits more closely to the model and the catch data, than the IBTS Q1 survey which demonstrated considerable year effects towards the end of the time series. This indicates that the model is effectively paying less attention to the Q1 survey than to the Q3 survey, and this is borne out by Figure 12.3.16 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 12.3.2, estimated stock numbers in Table 12.3.3 and the assessment summary in Table 12.3.4 and Figure 12.3.17.

A retrospective analysis is shown in Figures 12.3.18. 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 (Figure 12.3.4). This translates directly to a large revision of TSB in 2008. However, the last two retrospective runs are very consistent. This may indicate that previous data problems have been corrected, although it is too early to say whether the retrospective bias has actually been eliminated.

12.4 Historic Stock Trends

Historic trends for catch, mean F, SSB and recruitment are presented in Figure 12.3.17. These show that mean F is declining towards the minimum of the post-1990 time-series, that SSB has stabilised after recent increases, and that recruitment is fluctuating around a recent 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 12.4.1 shows some evidence of a positive relationship between SSB and subsequent recruitment, although such evidence is not compelling.

Finally, Figure 12.4.2 compares the XSA stock trends when using the old SMS-derived estimates of natural mortality, with those from the new SMS key-run used in this assessment. The new natural mortality estimates are considerably higher for all ages (except the final years for the youngest age; see Figure 12.2.4), and the XSA model accommodates this increased mortality by inflating estimates of abundance (and hence SSB *and* recruitment) while reducing estimates of fishing mortality. The trends remain the same, but the absolute levels are very different and indicate around 50% more whiting (and 25% less fishing mortality on whiting) than had been thought before.

12.5 Recruitment estimates

RCT3 input data are presented in Table 12.5.1, and RCT3 output is presented in Table 12.5.2. The RCT3 estimate of recruitment in at age 1 in 2012 (that is, the 2011 year-class) was 2 659 million. The geometric mean of all recruitments excluding the most recent two years is 4 239 million. Following the approach taken last year, the WG agreed to use the RCT3 estimates for recruitment in 2012, and the long-term geometric mean for recruitment in 2013 and beyond.

12.6 Short-term forecasts

A short-term forecast was carried out based on the final XSA assessment. XSA survivors from 2011 were used as input population numbers for ages 2 and older in 2012. Recruitment assumptions are detailed in Section 12.5.

The exploitation pattern was chosen as the mean exploitation pattern over the years 2009–2011. 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 2011 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 2009 – 2011.

Mean weights at age are generally consistent over the recent period but there are trends at several ages (Figure 12.2.3). To avoid introducing bias, therefore, the 2011 estimates were used for the purposes of forecasting.

The inputs to the short-term forecast (produced using the MFDP program) are given in Table 12.6.1, and results are presented in Table 12.6.2.

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_{2012} to equal mean F_{2011}, results in human consumption landings in 2012 of 20 230 t from a total catch of 29 483 t, giving an SSB in 2013 of 313 kt (a small increase from the 2012 value of 307 kt. Carrying the same fishing mortality forward into 2013 (the *status quo* F option) would result in landings of 20 493 t out of total catches of 30 205 t, and would result in an SSB of 355 kt (an increase of 14%).

Applying the target F (0.3) from the management plan to the stock in 2013 would generate landings of 34 112 t out of total catches of 49 878 t, and result in an SSB of 339 kt (an 8% increase).

12.7 MSY estimation and medium-term forecasts

No medium-term forecasts or MSY estimation were conducted during the WG meeting. However, the radical revision in the assessment this year, resulting from the use of new natural mortality estimates, implies that the target *F* considered in the last year's evaluation of the EU-Norway management plan may no longer be appropriate. Figure 12.4.2 shows that the new mean *F* estimates equal (on average) around 0.75 times the old mean *F* estimates. While a full re-evaluation of the management plan would be prudent, in the meantime it may be sufficient to apply this same multiplier to the existing target *F* in the management plan to obtain a more relevant value. Thus one possibility for a target *F* would be 0.75 x 0.3 = 0.22. The implications of using this value in the forecast are summarised in Table 12.6.2, and indicate landings in 2013 of 25 622 kt and subsequent SSB in 2014 of 349 kt (an 12% increase on the 2013 forecast estimate).

12.8 Biological reference points

The precautionary fishing mortality and biomass reference points agreed by the EU and Norway (and unchanged since 1999) are as follows:

B_{lim} = 225,000 t; B_{pa} = 315,000 t; F_{lim} = 0.90; F_{pa} = 0.65.

Note that the WG considers that these reference points are not applicable to the current assessment (see discussion in Section 12.9)

$F_{0.1}$ 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 the last 6 years. Due to the shape of the yield per recruit curve, a maximum is often not reached, and F_{max} is thus not defined for several years. The WG considers that yield per recruit 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.

12.9 Quality of the assessment

Previous meetings of this WG and the benchmark workshop (ICES-WKROUND, 2009) have concluded that the survey data and commercial catch data contain different signals concerning the stock. Analyses by working group members and by SGSIMUW in 2005 indicate that data since the early- to mid- 1990s are sufficiently consistent to undertake a catch-at-age analysis calibrated against survey data from 1990. 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, the WG 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.

The IBTS Q1 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 (XSA) 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 was not available in a form that could be used by the WG. 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 historic performance of the assessment is summarised in Figure 12.9.1.

12.10 Status of the Stock

The WG considers the status of the stock unknown with respect to biological reference points and MSY reference points for the reasons given in Sections 12.7 and 12.9. Nevertheless all indications are that the stock, at the level of the entire North Sea and Eastern Channel, was at a historical low level during 2005 to 2008 (relative to the period since 1990), and that the recent increase is in large part due to an improved perception of recruitment in 2008. Fishing mortality is currently fluctuating around a low level, while recruitment varies around a recent mean. Estimated whiting abundance for the whole time period (since 1990) has increased considerably in this year's assessment, due to the use of new natural mortality estimates.

12.11 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 above the long term average, and the stock is perceived to have returned to normal recruitment levels.

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 27 000 t in 2007, including discards and industrial bycatch). Distribution maps of survey IBTS indices (see last year's WG report; ICES-WGNSSK 2011) show a change in distribution of the stock which is now located mainly in the central North Sea. Catch rates from localized fleets may not represent trends in the overall North Sea and English Channel population. The localized distribution of the population is known to be resulting in substantial differences in the quota uptake rate. This is likely to result in localized discarding problems that should be monitored carefully.

Whiting are caught in mixed demersal roundfish fisheries, fisheries targeting flatfish, the *Nephrops* fisheries, and the Norway pout fishery. The current minimum mesh-size in the targeted demersal roundfish fishery in the northern North Sea has resulted in reduced discards from that sector compared with the historical discard rates. Mortality may have increased on younger ages due to increased discarding in recent years as a result of recent changes in fleet dynamics of *Nephrops* fleets and small mesh fisheries in the southern North Sea. The bycatch of whiting in the Norway pout and sandeel fisheries is dependent on activity in that fishery, which has recently declined after strong reductions in the fisheries. Industrial bycatches are considered low in the forecast. A larger catch allocation for bycatch may be required if industrial effort increases.

Catches of whiting in the North Sea are also likely to be affected by the effort reduction seen in the targeted demersal roundfish and flatfish fisheries, although this will in part be offset by increases in the number of vessels switching to small mesh fisheries. It is important to consider both the species-specific assessments of these species for effective management, but also the broader mixed-fisheries context. This is not straightforward when stocks are managed via a series of single-species management plans that do not incorporate such mixed-stocks considerations. WGMIXFISH monitors the consistency of the various single-species management plans and TAC advice under current effort schemes, in order to estimate the potential risks of quota over- and under shooting for the different stocks, and it was demonstrated that the current basis for whiting advice was not consistent with other single-stock management objectives. It is recommended that the ongoing discussions about the whiting management plan takes into account such mixed-fisheries considerations before implementation.

Recent measures to improve survival of young cod, such as the Scottish Credit Conservation Scheme, and increased uptake of more selective gear in the North Sea and Skagerrak, should be encouraged for whiting.

ICES has developed a generic approach to evaluate whether new survey information that becomes available in September forms a basis to update the advice. ICES will publish new advice in October 2012 if this is the case for this year.

References

ICES-WGSAM (2012). Report of the Working Group on Multispecies Assessment Methods. ICES CM 2012/ SSGSUE:10.

ICES-WKROUND (2009). Report of the Benchmark Workshop on Roundfish. ICES CM 2009/ACOM:32.

12.12 Whiting in Division IIIa

12.12.1 General

12.12.1.1 Stock Definition

There is a paucity of information on the population structure of whiting in Division IIIa (the Skagerrak-Kattegat area). No genetic surveys have been conducted, nor otolith based surveys. Tagging of whiting has previously been undertaken, yet these data need to be re-examined. Results from modelled survey data (SURBAR) are inconclusive regarding independent population dynamics in Division IIIa in comparison with the North Sea. The drop in landings in the beginning of the 1990s gives however an indication of local stock structure, as this reduction was not paralleled by any similar event in the North Sea.

12.12.1.2 Ecosystem aspect

No new information was presented at the working group. A summary of available information on ecosystem aspects is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.12.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the spatial distribution of the Swedish landings in 2011 using logbooks information. The plot is reported in Figure 12.12.1 and showed that higher landings were taken along the Swedish coastline than in the offshore Skagerrak. A summary of available information on fisheries is presented in the Stock Annex prepared at ICES-WKROUND (2009).

12.12.2 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 2011 used IBTS indices for plotting age distribution 2005-2011 for ages 1 to 4+. Plots of the IBTS Q1 and IBTS Q3 are shown in Figures 12.12.2 and 12.12.3. The plots indicate high interannual 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.

12.12.3 Data analyses

12.12.3.1 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.

12.12.3.2 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 12.2.1 Whiting in Subarea IV and Division VIId. Nominal landings (in tonnes) as officially reported to ICES, and agreed TAC.

Subarea IV

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium	536	454	270	248	144	105	93	45	115	162	147	72
Denmark	105	105	96	89	62	57	251	78.5	42	80	158	134
France	2527	3455	3314	2675	1721	1261	2711	3312	3051	2304	2631	2648
Germany	424	402	354	334	296	149	252	76	76	125	156	111
Netherlands	1884	2478	2425	1442	977	805	702	618	656	718	615	528
Norway	33	44	47	38.5	23	16	17	11	92	73	118	28
Sweden	4	6	7	10	2	0	1	1	1	4	8	6
UK (E.&W)	1782	1301	1322	680	1209	2560	3539	3048	1541	1397		
UK (Scotland)	17158	10589	7756	5734	5057	3441	8093	9063	8850	7456		
UK (Total)											7841	8693
Total	24453	18834	15591	11251	9491	8394	15659	16253	14424	12319	11674	12220
Unallocated landings	-173	426	-721	-800	-541	2286	-562	-587	-945	-545	607	1085
WG est. of HC landings	24280	19260	14870	10450	8950	10680	15097	15666	13479	11774	12281	13305
WG est of discards	21931	16130	17144	26135	18142	10300	14018	5206	8356	5223	7853	8180
WG est of IBC	9160	940	7270	2730	1210	890	2190	1240	0	1020	1350	1750
WG est of total catch	55371	36330	39284	39315	28302	21870	31305	22112	21835	18017	21484	23235

Table 12.2.1 (Cont'd) Whiting in Subarea IV and Division VIId. Nominal landings (in tonnes) as officially reported to ICES, and agreed TAC.

Division VIId

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium	65	75	58	67	46	45	73	75	69	71	88	74
France	5875	6338	5172	6654	5006	4638	3487	3135	2875	6266	5436	4583
Netherlands	14	67	19	175	132	128	117	118	162	112	270	288
UK (E.&W)	118	134	112	109	99	90	53	50	54	86	253	263
Total	6072	6614	5361	7005	5283	4901	3730	3378	3160	6535	6074	5208
Unallocated	-1772	-814	439	-1295	-933	-111	-287	-124	1311	111	-135	-144
W.G Est of HC landings	4300	5800	5800	5710	4350	4790	3443	3254	4471	6646	5939	5064
WG est of discards	4129	3109	1356	604	907	2219	2291	1763	1943	2477	3727	3538
WG est of Catch	8429	8910	7156	6315	5258	7010	5735	5018	6415	9123	9666	8602

Estimated Catch Subarea IV and Division VIId

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
W.G. estimate	63800	45240	46440	45630	33560	28880	37040	27130	29270	27470	31550	30087

Annual TAC for Subarea IV and Division IIa

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
30,000	29,700	41,000	16,000	16,000	28,500	23,800	23,800	17,850	15,173	12,897	14,832	17,056

Annual TAC for Divisions VIIb-k combined

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
22,000	21,000	31,700	31,700	27,000	21,600	19,940	19,940	19,940	16,949	14,407	16,568	19,053

Table 12.2.2 Whiting in Subarea IV and Division VIId. WG estimates of catch components by weight ('000s tonnes).

	Sub Area IV (North Sea)				Division VIId (Eastern Channel)			Total	Prop VIId
Year	H.cons.	Disc.	Ind.BC	Tot.Catch	H.Cons	Disc.	Tot. Catch		
1990	42.18	52.27	51.34	145.79	3.48	3.33	6.81	152.6	7.60%
1991	46.21	30.84	39.76	116.81	5.72	4.22	9.94	126.75	11.00%
1992	45.21	28.47	25.04	98.72	5.74	4.09	9.83	108.55	11.30%
1993	46.61	41.4	20.72	108.73	5.21	2.97	8.18	116.91	10.10%
1994	41.87	31.84	17.47	91.18	6.62	3.85	10.47	101.65	13.70%
1995	40.55	28.94	27.38	96.87	5.39	3.24	8.63	105.5	11.70%
1996	35.55	27.13	5.12	67.8	4.95	3.37	8.32	76.12	12.20%
1997	30.94	16.66	6.21	53.81	4.62	3	7.62	61.43	13.00%
1998	23.69	12.48	3.49	39.66	4.6	3.21	7.81	47.47	16.30%
1999	25.7	22.11	5.04	52.85	4.43	3.57	8	60.85	14.70%
2000	24.28	21.93	9.16	55.37	4.3	4.13	8.43	63.8	15.00%
2001	19.26	16.13	0.94	36.33	5.8	3.11	8.91	45.24	23.10%
2002	14.87	17.14	7.27	39.28	5.8	1.36	7.16	46.44	28.10%
2003	10.45	26.14	2.73	39.32	5.71	0.6	6.31	45.63	35.30%
2004	8.95	18.14	1.21	28.3	4.35	0.91	5.26	33.56	32.70%
2005	10.68	10.3	0.89	21.87	4.79	2.22	7.01	28.88	31.00%
2006	15.1	14.02	2.19	31.31	3.44	2.29	5.73	37.04	18.60%
2007	15.67	5.21	1.24	22.11	3.25	1.76	5.02	27.13	17.20%
2008	13.48	8.36	0.00	22.86	4.47	1.94	6.41	29.27	24.90%
2009	11.77	5.22	1.02	18.35	6.65	2.48	9.12	27.47	36.10%
2010	12.28	7.85	1.35	21.88	5.94	3.73	9.67	31.55	32.60%
2011	13.31	8.18	1.75	23.24	5.06	3.54	8.6	31.84	38.02%
min.	8.95	5.21	0.00	18.35	3.25	0.60	5.02	27.13	7.60%
mean	24.94	20.49	10.52	56.02	5.01	2.86	7.87	63.89	20.65%
max.	46.61	52.27	51.34	145.79	6.65	4.22	10.47	152.60	38.02%

Table 12.2.3 Whiting in Subarea IV and Division VIId. Total catch numbers at age (thousands).

year	1	2	3	4	5	6	7	8+
1990	258102	501373	127967	84147	31102	1933	719	109
1991	135797	194921	184960	36290	25554	5339	526	267
1992	230302	167479	87820	91081	11654	6634	2546	112
1993	223424	172049	125599	46181	45300	3898	1501	753
1994	191544	158369	97559	51041	18683	17905	1258	514
1995	148169	144023	112416	35649	15061	5117	4472	469
1996	86318	118910	99644	48304	14087	4638	1282	1095
1997	60946	80471	84336	41975	18303	3333	1012	456
1998	92556	50362	43424	36295	17628	6343	1417	406
1999	189162	95415	45920	33921	18271	7443	2021	672
2000	82546	129582	63706	23913	16199	8758	4309	1263
2001	52567	83085	52076	20800	9256	4826	2233	1268
2002	51338	62462	84600	34659	8099	2048	1461	754
2003	83680	111144	55866	41841	14217	2359	473	396
2004	47966	23009	32557	30400	21755	8342	1352	308
2005	47805	34626	12204	18146	14931	8979	3041	653
2006	73908	42199	21651	8642	15077	11822	4618	1456
2007	39041	34001	24900	9906	4008	7657	5268	3118
2008	62163	28301	22741	13571	4305	1847	3954	2951
2009	19919	56301	14922	11605	5331	1409	613	2837
2010	26266	60427	24826	8017	5394	2867	518	1510
2011	32894	59451	27509	14826	3331	2179	1033	312

Table 12.2.4 Whiting in Subarea IV and Division VIId. Human consumption landings numbers at age (thousands).

year	1	2	3	4	5	6	7	8+
1990	6910	52533	43850	48537	16845	1341	605	107
1991	11565	42525	88974	25738	21261	4581	396	267
1992	9565	44697	47843	59208	9784	6099	1453	107
1993	5957	28935	63383	32819	33741	2932	1339	753
1994	17124	31351	45492	36289	13920	14407	914	439
1995	8829	28027	58046	27775	13652	4911	4359	463
1996	12517	26611	47125	35828	11861	4396	1103	1095
1997	6511	23436	47717	31503	15615	2931	1010	439
1998	17071	19828	24860	24473	14579	5395	1204	299
1999	16661	26669	25504	23465	14483	6554	1854	587
2000	15384	31808	28283	14241	11775	6618	3758	1156
2001	12260	28476	27293	17491	8633	4503	2091	1249
2002	2610	10346	30890	22353	6712	1710	1330	638
2003	403	11613	13990	18974	9513	1861	443	395
2004	3973	2812	9629	13302	11846	4409	747	275
2005	11009	10414	5669	10926	10283	5933	2343	429
2006	11055	11023	8494	5362	12259	10161	4118	1191
2007	10378	14740	16491	7666	3310	6681	4227	2639
2008	13234	12334	14120	9106	3564	1519	2505	2235
2009	2462	31910	9615	9516	4318	1252	548	2386
2010	3593	27147	15341	4885	4063	1746	363	1165
2011	4679	22858	14952	10821	2333	1484	729	280

Table 12.2.5 Whiting in Subarea IV and Division VIId. Discard numbers at age (thousands).

year	1	2	3	4	5	6	7	8+
1990	83152	241924	33084	23009	11665	246	85	0
1991	81678	82053	75035	5176	1885	91	60	0
1992	105838	63830	27659	23115	1231	355	1064	2
1993	128248	104844	51054	9205	10727	521	131	0
1994	96890	102020	37751	9867	2885	2338	7	0
1995	53830	81783	50019	7136	1336	206	113	6
1996	43126	86878	49817	11506	2205	240	179	0
1997	26188	34948	32473	9398	2412	400	2	17
1998	50703	24200	17053	11076	2987	936	213	107
1999	96413	56365	15228	9016	3104	862	167	85
2000	48162	81086	24082	3075	2311	1560	478	107
2001	39826	52156	23055	2795	471	283	142	19
2002	10597	33371	45125	10136	1182	218	131	116
2003	65829	94497	39301	21654	4314	449	30	1
2004	31169	15698	21879	16951	9909	3922	605	33
2005	25753	23486	6041	7192	4616	2992	688	216
2006	51961	25906	10935	2474	2595	1598	493	264
2007	22508	16283	7153	1784	572	940	1037	478
2008	48929	15967	8621	4465	741	328	1449	716
2009	12411	21950	4277	1715	910	128	62	450
2010	15988	30046	8121	2637	1194	1082	151	344
2011	28024	34431	11770	3314	866	641	274	22

Table 12.2.6 Whiting in Subarea IV and Division VIId. Industrial bycatch numbers at age (thousands).

year	1	2	3	4	5	6	7	8+
1990	168040	206916	51033	12601	2592	346	29	2
1991	42554	70343	20951	5376	2408	667	70	0
1992	114899	58952	12318	8758	639	180	29	3
1993	89219	38270	11162	4157	832	445	31	0
1994	77530	24998	14316	4885	1878	1160	337	75
1995	85510	34213	4351	738	73	0	0	0
1996	30675	5421	2702	970	21	2	0	0
1997	28247	22087	4146	1074	276	2	0	0
1998	24782	6334	1511	746	62	12	0	0
1999	76088	12381	5188	1440	684	27	0	0
2000	19000	16688	11341	6597	2113	580	73	0
2001	481	2453	1728	514	152	40	0	0
2002	38131	18745	8585	2170	205	120	0	0
2003	17448	5034	2575	1213	390	49	0	0
2004	12824	4499	1049	147	0	11	0	0
2005	11043	726	494	28	32	54	10	8
2006	10892	5270	2222	806	223	63	7	1
2007	6155	2978	1256	456	126	36	4	1
2008	0	0	0	0	0	0	0	0
2009	5046	2441	1030	374	103	29	3	1
2010	6685	3234	1364	495	137	39	4	1
2011	191	2162	787	691	132	54	30	10

Table 12.2.7 Whiting in Subarea IV and Division VIId. Total catch mean weights at age (kg).

year	1	2	3	4	5	6	7	8+
1990	0.084	0.137	0.21	0.252	0.279	0.411	0.498	0.594
1991	0.104	0.168	0.217	0.289	0.306	0.339	0.365	0.4
1992	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.51
1993	0.073	0.174	0.25	0.316	0.328	0.346	0.4	0.379
1994	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.431
1995	0.089	0.18	0.257	0.34	0.384	0.429	0.434	0.419
1996	0.094	0.167	0.235	0.302	0.388	0.407	0.431	0.432
1997	0.096	0.178	0.242	0.295	0.334	0.384	0.386	0.421
1998	0.09	0.179	0.236	0.281	0.314	0.34	0.333	0.369
1999	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.292
2000	0.117	0.182	0.238	0.287	0.286	0.276	0.275	0.268
2001	0.101	0.192	0.244	0.282	0.267	0.298	0.284	0.292
2002	0.069	0.155	0.218	0.273	0.303	0.35	0.343	0.336
2003	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.368
2004	0.111	0.15	0.213	0.253	0.286	0.285	0.286	0.351
2005	0.124	0.199	0.239	0.25	0.282	0.305	0.298	0.286
2006	0.131	0.18	0.231	0.274	0.288	0.36	0.345	0.316
2007	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.32
2008	0.104	0.218	0.282	0.315	0.402	0.407	0.317	0.354
2009	0.092	0.22	0.289	0.381	0.401	0.465	0.393	0.328
2010	0.088	0.226	0.305	0.376	0.448	0.422	0.458	0.373
2011	0.106	0.185	0.316	0.379	0.443	0.499	0.46	0.5

Table 12.2.8 Whiting in Subarea IV and Division VIId. Human consumption landings mean weights at age (kg).

year	1	2	3	4	5	6	7	8+
1990	0.206	0.222	0.263	0.296	0.337	0.455	0.533	0.597
1991	0.202	0.249	0.252	0.308	0.317	0.349	0.387	0.4
1992	0.194	0.246	0.289	0.306	0.34	0.356	0.383	0.504
1993	0.194	0.248	0.284	0.345	0.358	0.385	0.418	0.379
1994	0.182	0.248	0.297	0.346	0.392	0.382	0.412	0.41
1995	0.171	0.256	0.299	0.367	0.397	0.437	0.437	0.421
1996	0.169	0.222	0.274	0.329	0.408	0.415	0.452	0.432
1997	0.171	0.206	0.26	0.315	0.349	0.401	0.386	0.424
1998	0.164	0.208	0.259	0.304	0.331	0.361	0.348	0.427
1999	0.184	0.237	0.271	0.281	0.303	0.316	0.32	0.301
2000	0.166	0.227	0.272	0.299	0.292	0.313	0.276	0.269
2001	0.16	0.216	0.268	0.285	0.267	0.301	0.288	0.293
2002	0.183	0.214	0.26	0.293	0.313	0.364	0.35	0.333
2003	0.208	0.228	0.258	0.308	0.311	0.374	0.391	0.368
2004	0.21	0.216	0.242	0.29	0.326	0.33	0.334	0.364
2005	0.205	0.253	0.277	0.27	0.308	0.339	0.313	0.313
2006	0.217	0.254	0.285	0.295	0.298	0.377	0.353	0.331
2007	0.199	0.264	0.28	0.351	0.361	0.319	0.332	0.338
2008	0.223	0.265	0.324	0.356	0.431	0.424	0.359	0.374
2009	0.205	0.246	0.318	0.386	0.404	0.464	0.404	0.329
2010	0.221	0.255	0.331	0.416	0.47	0.479	0.541	0.388
2011	0.182	0.237	0.374	0.416	0.506	0.569	0.504	0.522

Table 12.2.9 Whiting in Subarea IV and Division VIId. Discard mean weights at age (kg), representing North Sea and Eastern Channel discards.

year	1	2	3	4	5	6	7	8+
1990	0.095	0.13	0.183	0.186	0.196	0.249	0.302	0
1991	0.089	0.154	0.177	0.213	0.23	0.253	0.268	0
1992	0.093	0.173	0.21	0.215	0.241	0.245	0.22	1.183
1993	0.087	0.16	0.205	0.237	0.235	0.225	0.213	0
1994	0.09	0.151	0.203	0.23	0.244	0.254	0.332	0
1995	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.29
1996	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0
1997	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.347
1998	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.206
1999	0.1	0.166	0.197	0.201	0.225	0.231	0.212	0.227
2000	0.127	0.167	0.195	0.226	0.209	0.219	0.222	0.264
2001	0.084	0.183	0.217	0.259	0.248	0.24	0.225	0.243
2002	0.13	0.167	0.196	0.224	0.224	0.225	0.272	0.351
2003	0.062	0.105	0.17	0.214	0.262	0.257	0.293	0
2004	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.244
2005	0.124	0.177	0.207	0.221	0.223	0.235	0.245	0.224
2006	0.131	0.161	0.193	0.229	0.233	0.247	0.273	0.246
2007	0.065	0.17	0.214	0.225	0.247	0.237	0.215	0.217
2008	0.072	0.181	0.213	0.23	0.265	0.328	0.244	0.293
2009	0.089	0.193	0.243	0.376	0.393	0.484	0.286	0.32
2010	0.075	0.211	0.272	0.319	0.384	0.33	0.254	0.324
2011	0.093	0.147	0.242	0.271	0.285	0.339	0.344	0.258

Table 12.2.10 Whiting in Subarea IV and Division VIId. Industrial bycatch mean weights at age (kg).

year	1	2	3	4	5	6	7	8+
1990	0.073	0.123	0.181	0.201	0.28	0.355	0.335	0.472
1991	0.105	0.136	0.215	0.272	0.265	0.279	0.322	0
1992	0.068	0.151	0.235	0.244	0.364	0.219	0.256	0.282
1993	0.045	0.156	0.26	0.264	0.307	0.235	0.392	0
1994	0.055	0.131	0.259	0.388	0.521	0.555	0.44	0.555
1995	0.072	0.16	0.312	0.373	0.511	0	0	0
1996	0.064	0.151	0.239	0.233	0.347	0.25	0	0
1997	0.051	0.145	0.252	0.321	0.348	0.588	0	0
1998	0.049	0.115	0.22	0.304	0.286	0	0	0
1999	0.027	0.077	0.144	0.194	0.286	0	0	0
2000	0.051	0.166	0.242	0.289	0.339	0	0.588	0
2001	0.055	0.118	0.225	0.32	0.351	0.386	0	0
2002	0.044	0.101	0.185	0.294	0.415	0.38	0	0
2003	0.035	0.102	0.189	0.302	0.418	0.462	0	0
2004	0.032	0.083	0.143	0.264	0	0.38	0	0
2005	0.043	0.133	0.196	0.205	0.366	0.438	0.541	0.53
2006	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.53
2007	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.53
2008	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0
2009	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.53
2010	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.53
2011	0.188	0.242	0.305	0.321	0.371	0.464	0.436	0.413

Table 12.2.11 Whiting in Subarea IV and Division VIId. Natural mortality at age from ICES-WGSAM (2012). Note only ages 1-8+ are used in the assessment.

Year/Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1990	1.457	1.563	0.790	0.572	0.540	0.522	0.513	0.509	0.447	0.447	0.447	0.447	0.447	0.447	0.447	0.447
1991	1.486	1.571	0.783	0.568	0.537	0.521	0.512	0.508	0.455	0.455	0.455	0.455	0.455	0.455	0.455	0.455
1992	1.521	1.582	0.779	0.564	0.534	0.520	0.512	0.508	0.463	0.463	0.463	0.463	0.463	0.463	0.463	0.463
1993	1.562	1.594	0.776	0.561	0.533	0.519	0.512	0.508	0.472	0.472	0.472	0.472	0.472	0.472	0.472	0.472
1994	1.607	1.610	0.775	0.559	0.532	0.520	0.513	0.509	0.482	0.482	0.482	0.482	0.482	0.482	0.482	0.482
1995	1.657	1.628	0.774	0.559	0.533	0.522	0.515	0.511	0.491	0.491	0.491	0.491	0.491	0.491	0.491	0.491
1996	1.708	1.647	0.773	0.559	0.534	0.524	0.518	0.514	0.499	0.499	0.499	0.499	0.499	0.499	0.499	0.499
1997	1.760	1.666	0.774	0.560	0.536	0.527	0.521	0.517	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508
1998	1.809	1.685	0.775	0.562	0.538	0.531	0.524	0.521	0.515	0.515	0.515	0.515	0.515	0.515	0.515	0.515
1999	1.852	1.703	0.778	0.565	0.541	0.535	0.527	0.524	0.523	0.523	0.523	0.523	0.523	0.523	0.523	0.523
2000	1.889	1.721	0.782	0.568	0.545	0.539	0.531	0.529	0.531	0.531	0.531	0.531	0.531	0.531	0.531	0.531
2001	1.917	1.737	0.790	0.573	0.549	0.544	0.535	0.534	0.539	0.539	0.539	0.539	0.539	0.539	0.539	0.539
2002	1.934	1.749	0.801	0.578	0.555	0.549	0.540	0.540	0.547	0.547	0.547	0.547	0.547	0.547	0.547	0.547
2003	1.940	1.754	0.814	0.584	0.560	0.554	0.546	0.546	0.556	0.556	0.556	0.556	0.556	0.556	0.556	0.556
2004	1.935	1.751	0.828	0.589	0.565	0.559	0.551	0.553	0.564	0.564	0.564	0.564	0.564	0.564	0.564	0.564
2005	1.921	1.737	0.841	0.592	0.568	0.562	0.555	0.558	0.571	0.571	0.571	0.571	0.571	0.571	0.571	0.571
2006	1.903	1.715	0.854	0.593	0.570	0.563	0.557	0.562	0.577	0.577	0.577	0.577	0.577	0.577	0.577	0.577
2007	1.883	1.685	0.864	0.593	0.569	0.562	0.558	0.564	0.581	0.581	0.581	0.581	0.581	0.581	0.581	0.581
2008	1.863	1.650	0.873	0.591	0.566	0.560	0.556	0.565	0.584	0.584	0.584	0.584	0.584	0.584	0.584	0.584
2009	1.844	1.613	0.880	0.588	0.562	0.556	0.554	0.564	0.586	0.586	0.586	0.586	0.586	0.586	0.586	0.586
2010	1.826	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587	0.587	0.587	0.587	0.587	0.587	0.587	0.587
2011	1.826	1.575	0.887	0.585	0.558	0.552	0.551	0.562	0.587	0.587	0.587	0.587	0.587	0.587	0.587	0.587

Table 12.2.12 Whiting in Subarea IV and Division VIId. Tuning series used in the assessment and forecast. Note that only ages 1-5 are used.

International bottom trawl survey (IBTS) quarter 1:

year	effort	1	2	3	4	5	6+
1990	100	518.936	862.354	198.161	91.605	16.937	3.665
1991	100	1007.621	686.445	479.623	70.946	37.635	7.594
1992	100	907.297	665.714	240.156	150.832	12.672	13.928
1993	100	1075.624	522.811	244.586	65.488	59.015	11.444
1994	100	721.709	627.406	181.022	68.082	11.855	9.113
1995	100	678.59	448.484	239.448	58.074	11.867	5.577
1996	100	502.361	485.968	244.699	69.74	23.085	9.847
1997	100	287.733	342.212	162.521	60.426	18.009	9.181
1998	100	543.117	160.695	125.377	54.046	15.496	9.258
1999	100	676.27	305.445	94.675	57.451	25.825	11.079
2000	100	741.49	460.697	157.811	30.714	12.948	9.31
2001	100	648.649	598.388	299.179	98.318	25.724	26.163
2002	100	557.353	343.308	263.173	63.28	20.805	10.004
2003	100	131.035	296.422	236.526	132.594	48.289	12.606
2004	100	184.472	89.604	172.741	100.17	49.223	22.302
2005	100	142.047	50.037	30.146	30.338	25.755	19.762
2006	100	116.839	114.51	42.248	17.865	23.98	25.755
2007	100	52.53	81.33	40.222	9.507	5.643	23.568
2008	100	268.484	205.862	65.651	22.11	7.538	15.209
2009	100	203.803	332.74	106.952	29.286	13.024	14.182
2010	100	322.351	216.607	239.32	93.256	27.918	27.797
2011	100	171.092	329.844	155.169	92.196	19.199	21.733
2012	100	228.186	579.786	122.491	47.052	29.78	10.198

Table 12.2.12 (cont) Whiting in Subarea IV and Division VIId. Tuning series used in the assessment and forecast. Note that only ages 1-5 are used.

International bottom trawl survey (IBTS) quarter 3:

year	effort	0	1	2	3	4	5	6+
1991	100	536.99	703.368	158.594	79.024	14.568	5.183	1.018
1992	100	1379.459	600.867	296.1	72.451	57.498	10.273	6.212
1993	100	919.193	638.722	177.377	66.118	14.711	15.904	3.039
1994	100	610.743	677.645	219.541	74.71	19.506	4.722	3.16
1995	100	729.246	619.786	291.18	107.195	21.512	6.013	3.464
1996	100	316.501	545.708	278.218	129.356	34.003	6.893	4.1
1997	100	2062.67	332.968	180.681	108.985	28.006	10.711	4.245
1998	100	2631.69	330.6	150.205	52.766	31.01	11.179	4.695
1999	100	2498.55	1203.503	190.645	53.932	24.452	9.529	4.179
2000	100	1968.07	941.658	326.943	64.113	13.625	6.532	4.873
2001	100	3031.442	645.003	282.32	94.854	19.281	4.315	7.508
2002	100	264.063	732.137	237.372	125.148	33.96	5.275	2.76
2003	100	363.406	246.155	302.054	134.824	66.058	16.452	4.663
2004	100	1012.818	188.577	49.05	75.85	48.675	32.286	14.398
2005	100	162.592	179.5	70.531	27.609	45.385	29.211	33.929
2006	100	201.578	172.79	84.975	31.91	13.207	22.853	25.343
2007	100	821.741	95.645	64.042	37.929	11.604	8.459	20.846
2008	100	757.814	356.898	66.197	30.935	13.565	4.057	14.82
2009	100	593.897	588.982	382.796	40.766	12.109	7.92	6.641
2010	100	508.142	268.39	157.823	60.263	13.624	6.243	8.407
2011	100	246.678	443.62	143.05	46.568	15.853	6.807	4.629

Table 12.3.1 Whiting in Subarea IV and Division VIId. XSA tuning diagnostics.

```
FLR XSA Diagnostics 2012-05-01 11:37:05

CPUE data from x.idx

Catch data for 22 years. 1990 to 2011. Ages 1 to 8.

    fleet first age last age first year last year alpha beta
1 IBTS_Q1         1        5       1990      2011     0 0.25
2 IBTS_Q3         1        5       1991      2011   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   2002 2003 2004 2005 2006 2007 2008 2009 2010 2011
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
   year
age  2002  2003  2004  2005  2006  2007  2008  2009  2010  2011
  1 0.021 0.114 0.062 0.047 0.077 0.041 0.032 0.013 0.018 0.023
  2 0.083 0.184 0.129 0.185 0.168 0.143 0.117 0.112 0.143 0.151
  3 0.199 0.168 0.127 0.161 0.302 0.252 0.239 0.146 0.115 0.158
  4 0.231 0.213 0.194 0.145 0.249 0.341 0.326 0.281 0.162 0.138
  5 0.263 0.205 0.244 0.204 0.258 0.263 0.372 0.309 0.306 0.136
  6 0.256 0.164 0.264 0.222 0.377 0.304 0.278 0.297 0.413 0.288
  7 0.452 0.123 0.195 0.213 0.253 0.442 0.388 0.206 0.252 0.388
  8 0.452 0.123 0.195 0.213 0.253 0.442 0.388 0.206 0.252 0.388


 XSA population number (Thousand)
      age
year        1       2      3      4      5     6     7     8
  2002 5836148 1173036 626516 221730  46061 11898  5259  2628
  2003 1863636  993774 484704 288121 101029 20447  5370  4416
  2004 1909320  287745 366341 228583 132955 47279 10049  2240
  2005 2489654  311473 110513 179024 106999 59571 20917  4390
  2006 2361740  418240 111592  52061  87786 49723 27395  8425
  2007 2232825  393674 150515  45578  22943 38616 19539 11182
  2008 4438888  397253 143849  64674  18348 10053 16309 11797
  2009 3591441  825246 147640  62737  26495  7227  4367 19753
  2010 3247857  706842 306038  70884  27002 11158  3085  8772
  2011 3187491  660380 252360 151966  34505 11455  4254  1246


 Estimated population abundance at 1st Jan  2012
      age
year       1      2      3      4     5     6    7    8
  2012 140788 644880 233853 120061 75763 17341 4948 1646
```

Table 12.3.1 (cont) Whiting in Subarea IV and Division VIId. XSA tuning diagnostics.

Fleet: IBTS_Q1

Log catchability residuals.

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.045	0.675	0.623	0.630	0.283	0.316	0.366	0.083	0.389	0.091	-0.019
2	-0.091	0.562	0.449	0.314	0.319	0.041	0.221	0.228	-0.244	0.098	0.015
3	0.067	0.160	0.326	0.208	0.035	0.069	0.136	-0.196	-0.114	-0.125	0.150
4	0.065	0.335	0.083	0.164	0.176	0.054	-0.054	-0.188	-0.257	0.070	-0.193
5	-0.461	0.474	-0.358	0.154	-0.383	-0.383	0.113	-0.421	-0.621	-0.101	-0.425

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.086	0.087	-0.208	0.103	-0.427	-0.569	-1.319	-0.380	-0.451	0.105	-0.509
2	0.044	-0.263	-0.230	-0.192	-0.845	-0.313	-0.596	0.321	0.071	-0.199	0.290
3	0.240	-0.186	-0.039	-0.078	-0.621	-0.276	-0.630	-0.097	0.354	0.426	0.191
4	0.753	-0.422	0.054	0.003	-0.952	-0.234	-0.721	-0.229	0.077	1.098	0.321
5	0.620	0.040	0.090	-0.160	-0.595	-0.462	-0.566	-0.040	0.131	0.874	0.233

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	-13.7352	-12.3705	-12.0986	-12.2478	-12.2478
S.E_Logq	0.4709	0.3422	0.2764	0.4324	0.4119

Fleet: IBTS_Q3

Log catchability residuals.

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.112	0.035	-0.070	0.045	0.055	0.282	0.070	-0.254	0.536	0.077	-0.058
2	-0.328	0.174	-0.214	-0.213	0.122	0.166	0.089	0.173	0.146	0.173	-0.246
3	-0.777	0.017	-0.153	0.060	0.149	0.366	0.255	-0.178	0.166	0.123	-0.136
4	-0.297	0.043	-0.330	-0.046	-0.018	0.152	-0.063	0.060	0.135	-0.081	-0.023
5	-0.390	0.343	-0.137	-0.195	-0.055	-0.166	-0.016	-0.043	-0.180	-0.112	-0.229

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.229	0.341	0.016	-0.316	-0.297	-0.872	-0.270	0.408	-0.298	0.227
2	-0.166	0.311	-0.292	0.035	-0.077	-0.308	-0.295	0.730	0.023	-0.003
3	-0.136	0.179	-0.138	0.073	0.296	0.138	-0.029	0.161	-0.198	-0.237
4	-0.220	0.175	0.092	0.238	0.305	0.365	0.160	0.046	-0.034	-0.660
5	-0.495	-0.176	0.251	0.345	0.332	0.682	0.237	0.497	0.236	-0.028

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	-12.7197	-12.3940	-12.5035	-12.6792	-12.6792
S.E_Logq	0.3136	0.2603	0.2499	0.2338	0.3022

Table 12.3.1 (cont). Whiting in Subarea IV and Division VIId. XSA tuning diagnostics.

```
Terminal year survivor and F summaries:

 Age 1 Year class =2010

source
        scaledWts survivors yrcls
IBTS_Q1     0.302    387458  2010
IBTS_Q3     0.680    809045  2010
fshk        0.018    636472  2010

 Age 2 Year class =2009

source
        scaledWts survivors yrcls
IBTS_Q1     0.417    312624  2009
IBTS_Q3     0.568    233258  2009
fshk        0.015    277469  2009

 Age 3 Year class =2008

source
        scaledWts survivors yrcls
IBTS_Q1     0.493    145297  2008
IBTS_Q3     0.493     94769  2008
fshk        0.013    110816  2008

 Age 4 Year class =2007

source
        scaledWts survivors yrcls
IBTS_Q1     0.310    104426  2007
IBTS_Q3     0.673     39149  2007
fshk        0.017     37431  2007

 Age 5 Year class =2006

source
        scaledWts survivors yrcls
IBTS_Q1     0.333     21899  2006
IBTS_Q3     0.649     16861  2006
fshk        0.018      6318  2006

 Age 6 Year class =2005

source
     scaledWts survivors yrcls
fshk         1      4124  2005

 Age 7 Year class =2004

source
     scaledWts survivors yrcls
fshk         1      3868  2004
NULL
```

Table 12.3.2 Whiting in Subarea IV and Division VIId. Final XSA fishing mortality.

Year	1	2	3	4	5	6	7	8+	Fbar(2-6)
1990	0.106	0.344	0.588	0.748	0.929	0.684	0.759	0.759	0.659
1991	0.053	0.319	0.355	0.502	0.854	0.581	0.588	0.588	0.522
1992	0.097	0.246	0.404	0.453	0.439	0.884	0.984	0.984	0.485
1993	0.080	0.284	0.524	0.603	0.658	0.370	0.766	0.766	0.488
1994	0.072	0.214	0.451	0.661	0.836	0.958	0.275	0.275	0.624
1995	0.062	0.205	0.399	0.446	0.631	0.918	1.109	1.109	0.520
1996	0.051	0.186	0.366	0.453	0.473	0.608	0.995	0.995	0.417
1997	0.048	0.179	0.331	0.389	0.460	0.276	0.366	0.366	0.327
1998	0.053	0.147	0.231	0.346	0.416	0.420	0.258	0.258	0.312
1999	0.065	0.212	0.333	0.436	0.439	0.462	0.329	0.329	0.376
2000	0.023	0.174	0.370	0.443	0.593	0.599	0.858	0.858	0.436
2001	0.019	0.086	0.162	0.295	0.465	0.532	0.441	0.441	0.308
2002	0.021	0.083	0.199	0.231	0.263	0.256	0.452	0.452	0.206
2003	0.114	0.184	0.168	0.213	0.205	0.164	0.123	0.123	0.187
2004	0.062	0.129	0.127	0.194	0.244	0.264	0.195	0.195	0.192
2005	0.047	0.185	0.161	0.145	0.204	0.222	0.213	0.213	0.183
2006	0.077	0.168	0.302	0.249	0.258	0.377	0.253	0.253	0.271
2007	0.041	0.143	0.252	0.341	0.263	0.304	0.442	0.442	0.261
2008	0.032	0.117	0.239	0.326	0.372	0.278	0.388	0.388	0.266
2009	0.013	0.112	0.146	0.281	0.309	0.297	0.206	0.206	0.229
2010	0.018	0.143	0.115	0.162	0.306	0.413	0.252	0.252	0.228
2011	0.023	0.151	0.158	0.138	0.136	0.288	0.388	0.388	0.174

Table 12.3.3 Whiting in Subarea IV and Division VIId. Final XSA stock numbers.

Year	1	2	3	4	5	6	7	8+
1990	5600538	2555960	383316	209324	66740	5045	1744	253
1991	5761512	1055212	822244	120205	57747	15642	1525	747
1992	5495931	1135548	350492	326699	42515	14604	5241	219
1993	6470818	1025346	407613	133164	121791	16290	3616	1739
1994	6149817	1213605	355189	137721	42769	37534	6745	2695
1995	5595850	1143635	451619	129320	41782	11022	8617	854
1996	3945428	1032936	429599	173223	48581	13189	2630	2132
1997	3004586	722111	396039	170290	64568	17927	4277	1877
1998	4187074	541376	278365	162481	67527	24056	8079	2263
1999	7046918	736612	215230	125901	67141	26189	9364	3035
2000	8601549	1202770	273677	87709	47413	25340	9743	2721
2001	6788457	1503794	462609	107126	32649	15286	8184	4505
2002	5836148	1173036	626516	221730	46061	11898	5259	2628
2003	1863636	993774	484704	288121	101029	20447	5370	4416
2004	1909320	287745	366341	228583	132955	47279	10049	2240
2005	2489654	311473	110513	179024	106999	59571	20917	4390
2006	2361740	418240	111592	52061	87786	49723	27395	8425
2007	2232825	393674	150515	45578	22943	38616	19539	11182
2008	4438888	397253	143849	64674	18348	10053	16309	11797
2009	3591441	825246	147640	62737	26495	7227	4367	19753
2010	3247857	706842	306038	70884	27002	11158	3085	8772
2011	3187491	660380	252360	151966	34505	11455	4254	1246
2012		645150	233927	120103	75767	17347	4950	2115

Note that stock numbers in 2012 are estimates of survivors from 2011.

Table 12.3.4 Whiting in Subarea IV and Division VIId. Final XSA summary table. Units are in millions of individuals and tonnes where appropriate

	Recruitment (age 1)	TSB	SSB	Catch	Landings	Discards	Bycatch	Yield/SSB	Mean F(2-6)
1990	5600538	972777	527871	152603	45662	55603	51337	0.087	0.658
1991	5761512	1011925	466298	126742	51929	35057	39755	0.111	0.522
1992	5495931	876679	445489	108556	50947	32564	25045	0.114	0.485
1993	6470818	842808	407666	116911	51818	44370	20723	0.127	0.488
1994	6149817	889840	413543	101651	48486	35692	17473	0.117	0.624
1995	5595850	888263	429517	105493	45938	32176	27379	0.107	0.520
1996	3945428	723724	379105	76123	40503	30504	5116	0.107	0.417
1997	3004586	592866	326872	61435	35563	19659	6213	0.109	0.327
1998	4187074	620282	275337	47475	28288	15693	3494	0.103	0.312
1999	7046918	791687	291998	60845	30130	25677	5038	0.103	0.376
2000	8601549	1337009	425577	63806	28583	26063	9160	0.067	0.436
2001	6788457	1138123	501986	45242	25061	19237	944	0.050	0.308
2002	5836148	801466	429467	46450	20674	18501	7275	0.048	0.206
2003	1863636	432660	328637	45640	16161	26745	2734	0.049	0.187
2004	1909320	446198	253985	33558	13296	19048	1214	0.052	0.192
2005	2489654	497618	218031	28883	15470	12525	888	0.071	0.183
2006	2361740	480758	198670	37038	18535	16310	2193	0.093	0.271
2007	2232825	382210	181712	27126	18915	6971	1239	0.104	0.260
2008	4438888	630458	212099	28246	17951	10296	0	0.085	0.266
2009	3591441	602165	292164	27140	18418	7705	1016	0.063	0.229
2010	3247857	585553	319592	31147	18224	11577	1346	0.057	0.228
2011	3187491	621591	310507	31993	18901	12006	1086	0.061	0.174
min	1863636	382210	181712	27126	13296	6971	0	0.048	0.174
mean	4536704	734848	347097	63823	29975	23363	10485	0.086	0.349
max	8601549	1337009	527871	152603	51929	55603	51337	0.127	0.658

Table 12.5.1 Whiting in Subarea IV and Division VIId. RCT3 input table.

Whiting in IV and VIId, RCT3 input values						
5	23	2				
'YEARCLASS'	'VPA'	'IBTSq11'	'IBTSq12'	'IBTSq30'	'IBTSq31'	'IBTSq32'
1989	5600538	518.936	686.445	-1	-1	158.594
1990	5761512	1007.621	665.714	-1	703.368	296.100
1991	5495931	907.297	522.811	536.990	600.867	177.377
1992	6470818	1075.624	627.406	1379.459	638.722	219.541
1993	6149817	721.709	448.484	919.193	677.645	291.180
1994	5595850	678.590	485.968	610.743	619.786	278.218
1995	3945428	502.361	342.212	729.246	545.708	180.681
1996	3004586	287.733	160.695	316.501	332.968	150.205
1997	4187074	543.117	305.445	2062.670	330.600	190.645
1998	7046918	676.270	460.697	2631.690	1203.503	326.943
1999	8601549	741.490	598.388	2498.550	941.658	282.320
2000	6788457	648.649	343.308	1968.070	645.003	237.372
2001	5836148	557.353	296.422	3031.442	732.137	302.054
2002	1863636	131.035	89.604	264.063	246.155	49.050
2003	1909320	184.472	50.037	363.406	188.577	70.531
2004	2489654	142.047	114.510	1012.818	179.500	84.975
2005	2361740	116.839	81.330	162.592	172.790	64.042
2006	2232825	52.530	205.862	201.578	95.645	66.197
2007	4438888	268.484	332.740	821.741	356.898	382.796
2008	3591441	203.803	216.607	757.814	588.982	157.823
2009	-1	322.351	329.844	593.897	268.390	143.050
2010	-1	171.092	579.786	508.142	443.620	-1
2011	-1	228.186	-1	246.678	-1	-1

Table 12.5.2 Whiting in Subarea IV and Division VIId. RCT3 output table.

```
Analysis by RCT3 ver3.1 of data from file :

 whi4rct.in

 Whiting in IV and VIId, RCT3 input values

 Data for    5 surveys over   23 years :  1989 - 2011

 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

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

 IBTSq1     .63  11.49    .26   .781     20   5.43   14.94     .279     .718
 IBTSq1
 IBTSq3     .68  10.67    .39   .622     18   5.51   14.43     .445     .282
 IBTSq3
 IBTSq3

                                       VPA Mean =   15.26     .471     .000


 Year     Weighted       Log     Int      Ext     Var      VPA       Log
 Class     Average       WAP     Std      Std    Ratio               VPA
          Prediction            Error    Error

 2011     2659317     14.79     .24      .23      .92
```

Table 12.6.1 Whiting in Subarea IV and Division VIId. Short term forecast inputs.

MFDP version 1a						
Run: 01						
Time and date: 16:30 01/05/2012						
Fbar age range (Total) : 2-6						
Fbar age range Fleet 1 : 2-6						
Fbar age range Fleet 2 : 2-6						
2012						
Age	N	M	Mat	PF	PM	SWt
1	2745646	1.57	0.11	0	0	0.106
2	645150	0.89	0.92	0	0	0.185
3	233927	0.58	1	0	0	0.316
4	120103	0.56	1	0	0	0.379
5	75767	0.55	1	0	0	0.443
6	17347	0.55	1	0	0	0.499
7	4950	0.56	1	0	0	0.46
8	2115	0.59	1	0	0	0.5
Catch						
Age	Sel	CWt	DSel	DCWt		
1	0.002	0.182	0.011	0.093		
2	0.054	0.237	0.056	0.147		
3	0.072	0.374	0.041	0.242		
4	0.114	0.416	0.037	0.271		
5	0.152	0.506	0.044	0.285		
6	0.201	0.569	0.07	0.339		
7	0.189	0.504	0.054	0.344		
8	0.206	0.522	0.037	0.258		
IBC						
Age	Sel	CWt				
1	0.003	0				
2	0.005	0.188				
3	0.006	0.242				
4	0.007	0.305				
5	0.006	0.321				
6	0.005	0.371				
7	0.003	0.464				
8	0.003	0.413				

Table 12.6.1 (cont). **Whiting in Subarea IV and Division VIId. Short term forecast inputs.**

2013							2014						
Age	N	M	Mat	PF	PM	SWt	Age	N	M	Mat	PF	PM	SWt
1	4238755	1.57	0.11	0	0	0.106	1	4238755	1.57	0.11	0	0	0.106
2	.	0.89	0.92	0	0	0.185	2	.	0.89	0.92	0	0	0.185
3	.	0.58	1	0	0	0.316	3	.	0.58	1	0	0	0.316
4	.	0.56	1	0	0	0.379	4	.	0.56	1	0	0	0.379
5	.	0.55	1	0	0	0.443	5	.	0.55	1	0	0	0.443
6	.	0.55	1	0	0	0.499	6	.	0.55	1	0	0	0.499
7	.	0.56	1	0	0	0.46	7	.	0.56	1	0	0	0.46
8	.	0.59	1	0	0	0.5	8	.	0.59	1	0	0	0.5

Catch					Catch				
Age	Sel	CWt	DSel	DCWt	Age	Sel	CWt	DSel	DCWt
1	0.002	0.182	0.011	0.093	1	0.002	0.182	0.011	0.093
2	0.054	0.237	0.056	0.147	2	0.054	0.237	0.056	0.147
3	0.072	0.374	0.041	0.242	3	0.072	0.374	0.041	0.242
4	0.114	0.416	0.037	0.271	4	0.114	0.416	0.037	0.271
5	0.152	0.506	0.044	0.285	5	0.152	0.506	0.044	0.285
6	0.201	0.569	0.07	0.339	6	0.201	0.569	0.07	0.339
7	0.189	0.504	0.054	0.344	7	0.189	0.504	0.054	0.344
8	0.206	0.522	0.037	0.258	8	0.206	0.522	0.037	0.258

IBC			IBC		
Age	Sel	CWt	Age	Sel	CWt
1	0.003	0	1	0.003	0
2	0.005	0.188	2	0.005	0.188
3	0.006	0.242	3	0.006	0.242
4	0.007	0.305	4	0.007	0.305
5	0.006	0.321	5	0.006	0.321
6	0.005	0.371	6	0.005	0.371
7	0.003	0.464	7	0.003	0.464
8	0.003	0.413	8	0.003	0.413

Input units are thousands and kg - output in tonnes

Table 12.6.2 Whiting in Subarea IV and Division VIIa. Short term forecast output.

MFDP version 1a
Run: 01
Time and date: 16:30 01/05/2012
Fbar age range (Total) : 2-6
Fbar age range Fleet 1 : 2-6
Fbar age range Fleet 2 : 2-6

2012

Biomass	SSB	Catch FMult	FBar	Yield	Landings FBar	Yield	Discards FBar	Yield	IBC FMult	Landings FBar	Yield
575387	306814	1	0.174	29483	0.1186	20230	0.0496	8312	1	0.0058	941

2013

2013												2014		2012 TAC	17056	
Biomass	SSB	Catch FMult	FBar	Yield	Landings FBar	Yield	Discards FBar	Yield	IBC FMult	Landings FBar	Yield	Biomass	SSB	TAC change	SSB change	
720832	312628	0.00	0.006	947	0.000	0	0.000	0	1	0.0058	947	792801	379905	-100%	22%	No HC fishery
.	312628	0.10	0.023	4042	0.012	2180	0.005	921	1	0.0058	941	790148	377268	-87%	21%	
.	312628	0.20	0.039	7096	0.024	4329	0.010	1832	1	0.0058	935	787531	374669	-75%	20%	
.	312628	0.30	0.056	10113	0.036	6449	0.015	2735	1	0.0058	929	784951	372105	-62%	19%	
.	312628	0.40	0.073	13092	0.047	8539	0.020	3629	1	0.0058	924	782406	369577	-50%	18%	
	312628	0.49	0.088	15703	0.058	10369	0.024	4415	1	0.0058	919	780177	367363	-39%	18%	0.5 * F(sq)
.	312628	0.50	0.090	16034	0.059	10601	0.025	4515	1	0.0058	918	779895	367083	-38%	17%	
.	312628	0.60	0.107	18940	0.071	12634	0.030	5393	1	0.0058	913	777419	364624	-26%	17%	
.	312628	0.69	0.122	21605	0.082	14498	0.034	6200	1	0.0058	907	775149	362369	-15%	16%	15% TAC decrease
.	312628	0.70	0.124	21808	0.083	14639	0.035	6262	1	0.0058	907	774977	362198	-14%	16%	
.	312628	0.76	0.133	23401	0.090	15751	0.038	6746	1	0.0058	904	773622	360853	-8%	15%	0.75 * F(sq)
.	312628	0.80	0.140	24642	0.095	16617	0.040	7123	1	0.0058	902	772567	359806	-3%	15%	
.	312628	0.82	0.144	25272	0.098	17056	0.041	7315	1	0.0058	901	772033	359275	0%	15%	
.	312628	0.90	0.157	27442	0.107	18569	0.045	7976	1	0.0058	897	770191	357446	9%	14%	
.	312628	0.95	0.166	28941	0.113	19614	0.047	8433	1	0.0058	893	768916	356181	15%	14%	15% TAC increase
.	312628	1.00	0.174	30205	0.119	20493	0.050	8821	1	0.0058	891	767846	355118	20%	14%	F(sq)
.	312628	1.10	0.191	32937	0.131	22392	0.055	9659	1	0.0058	886	765533	352821	31%	13%	
.	312628	1.20	0.208	35635	0.142	24265	0.060	10489	1	0.0058	881	763251	350556	42%	12%	
.	312628	1.22	0.211	36171	0.145	24637	0.061	10654	1	0.0058	880	762798	350106	44%	12%	1.25 * F(sq)
.	312628	1.27	0.220	37591	0.151	25622	0.063	11092	1	0.0058	877	761599	348916	50%	12%	0.75 * F(mp)
.	312628	1.30	0.225	38301	0.154	26114	0.065	11311	1	0.0058	876	760999	348321	53%	11%	
.	312628	1.40	0.241	40934	0.166	27937	0.069	12126	1	0.0058	871	758778	346116	64%	11%	
.	312628	1.50	0.258	43535	0.178	29736	0.074	12933	1	0.0058	866	756586	343940	74%	10%	
.	312628	1.60	0.275	46105	0.190	31511	0.079	13733	1	0.0058	861	754423	341794	85%	9%	
.	312628	1.70	0.292	48645	0.202	33263	0.084	14526	1	0.0058	856	752288	339676	95%	9%	
.	312628	1.75	0.300	49878	0.207	34112	0.087	14912	1	0.0058	854	751254	338650	100%	8%	F(mp)
.	312628	1.80	0.309	51155	0.214	34992	0.089	15312	1	0.0058	851	750182	337586	105%	8%	
.	312628	1.90	0.325	53635	0.225	36698	0.094	16091	1	0.0058	846	748103	335524	115%	7%	
.	312628	2.00	0.342	56085	0.237	38381	0.099	16863	1	0.0058	841	746052	333489	125%	7%	

Table 12.12.1 Nominal landings (t) of Whiting from Division IIIa as supplied by the Study Group on Division IIIa Demersal Stocks (ICES 1992b) and updated by the Working Group, and WG estimate of Discards.

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate of Discards
1975	19,018			57	611	4	19,690	
1976	17,870			48	1,002	48	18,968	
1977	18,116			46	975	41	19,178	
1978	48,102			58	899	32	49,091	
1979	16,971			63	1,033	16	18,083	
1980	21,070			65	1,516	3	22,654	
	Total consumption	Total industrial	Total					
1981	1,027	23,915	24,942	70	1,054	7	26,073	
1982	1,183	39,758	40,941	40	670	13	41,664	
1983	1,311	23,505	24,816	48	1,061	8	25,933	
1984	1,036	12,102	13,138	51	1,168	60	14,417	
1985	557	11,967	12,524	45	654	2	13,225	
1986	484	11,979	12,463	64	477	1	13,005	
1987	443	15,880	16,323	29	262	43	16,657	
1988	391	10,872	11,263	42	435	24	11,764	
1989	917	11,662	12,579	29	675	-	13,283	
1990	1,016	17,829	18,845	49	456	73	19,423	
1991	871	12,463	13,334	56	527	97	14,041	
1992	555	3,340	3,895	66	959	1	4,921	
1993	261	1,987	2,248	42	756	1	3,047	
1994	174	1,900	2,074	21	440	1	2,536	

1995	85	2,549	2,634	24	431	1	3,090	
1996	55	1,235	1,290	21	182	-	1,493	
1997	38	264	302	18	94	-	414	
1998	35	354	389	16	81	-	486	
1999	37	695	732	15	111	-	858	
2000	59	777	836	17	138	1	992	
2001	61	9701	1,0311	27	126	+	1,1841	
2002	101	9751	1,0761	23	127	1	1,2271	
2003	93	6541	7471	20	71.9	2	840.91	429
2004	93	1,1201	1,2131	17	74	1	1,3051	909
2005	49	9071	9561	13	73	0	1,0421	299
2006	591	2901	3491	n/a	85.92	n/a	434.92	331
2007	532	2782	3312	14	82	1	4282	561
2008	522	2882	3402	14	52	n/a	4062	241
2009	712	1732	2442	10.3	33.82	-	288.12	128
2010	41	165	206	9.7	29.7	-	245.4	291
2011	40	44	84	8.3	20.4	0.2	112.9	794

[1] Values from 1992 updated by WGNSSK (2007).

[2] Values updated by WGNSSK (2011).

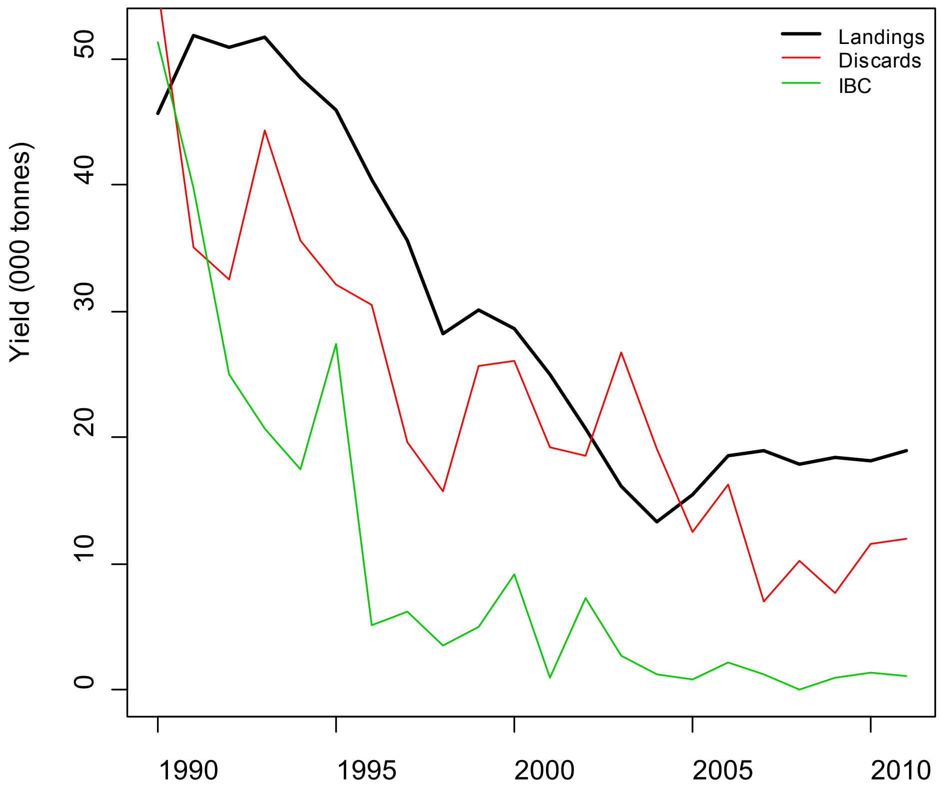


Figure 12.2.1. Whiting in Subarea IV and Division VIId. Yield by catch component.

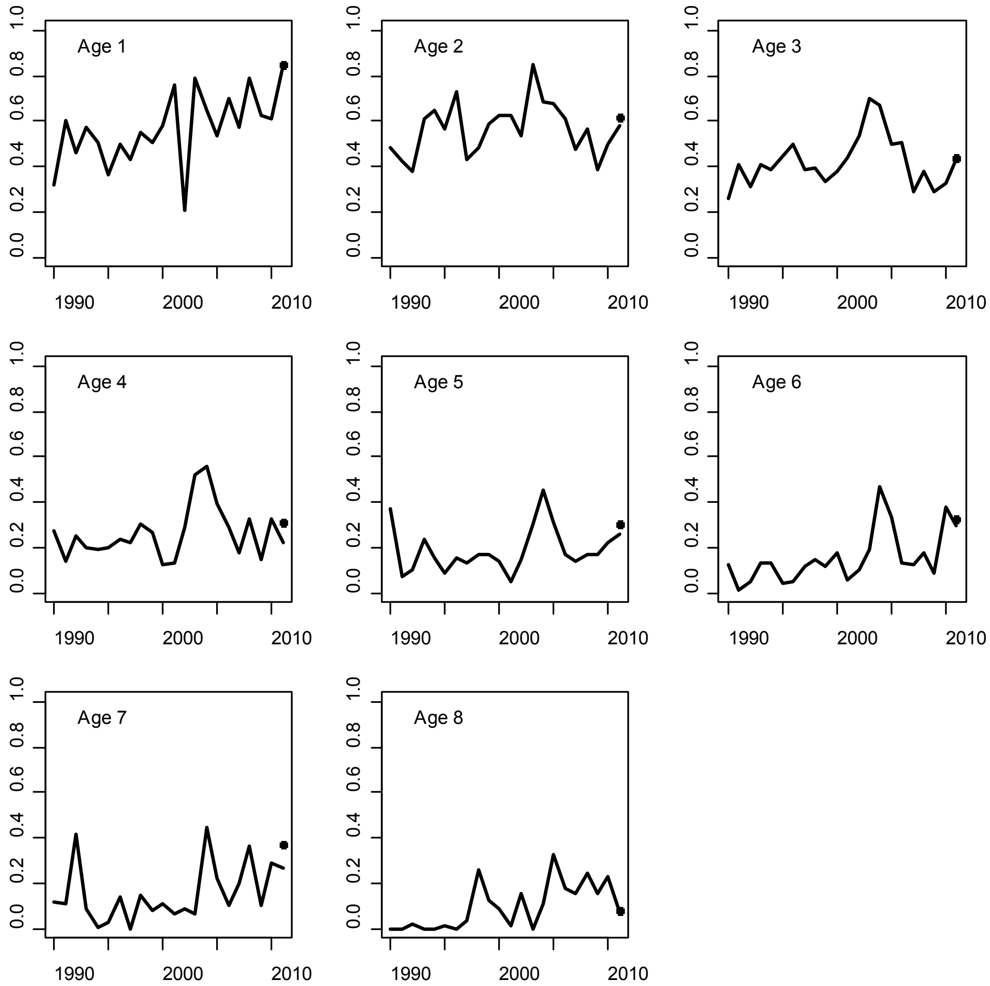


Figure 12.2.2. Whiting in Subarea IV and Division VIId. Proportion of total catch discarded, by age and year. The final year for each line is estimated using the InterCatch collation approach, while the dots on each plot give the final-year discard rates as estimated by the spreadsheet collation approach.

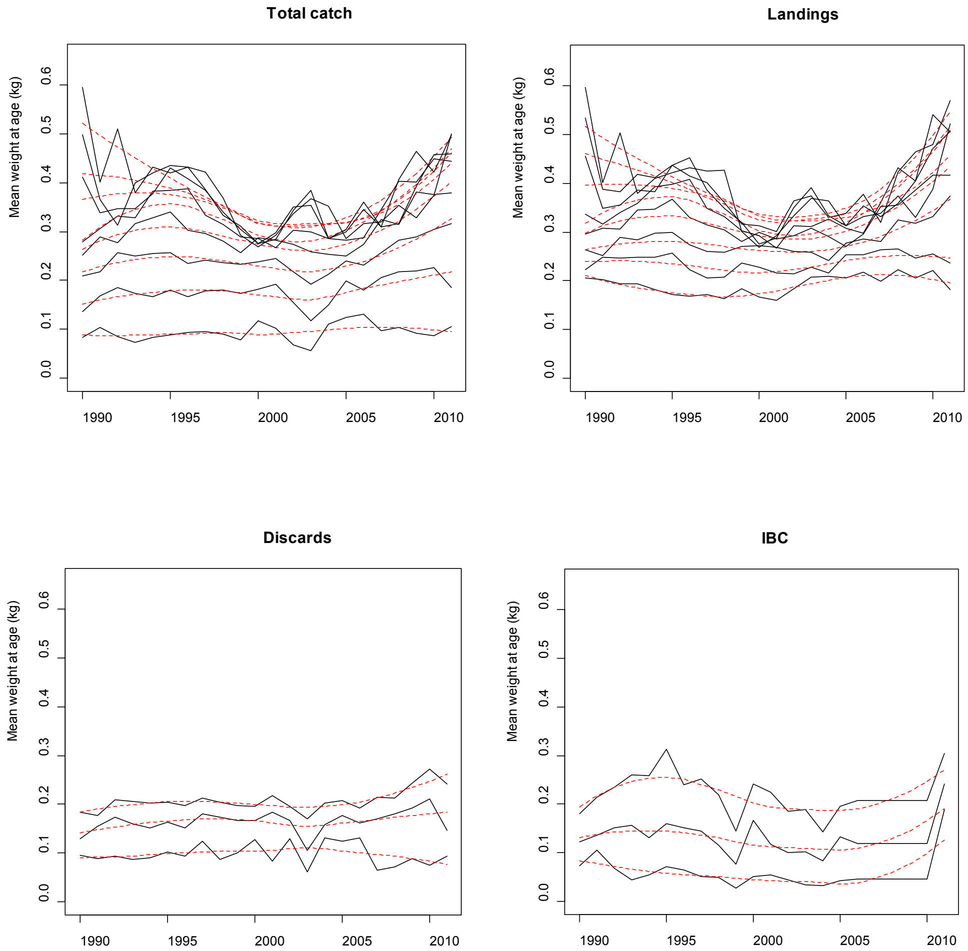


Figure 12.2.3. Whiting in Subarea IV and Division VIId. Mean weights-at-age (kg) by catch component. Catch mean weights are also used as stock mean weights. Red dotted line give loess smoothers through each time-series of mean weights-at-age.

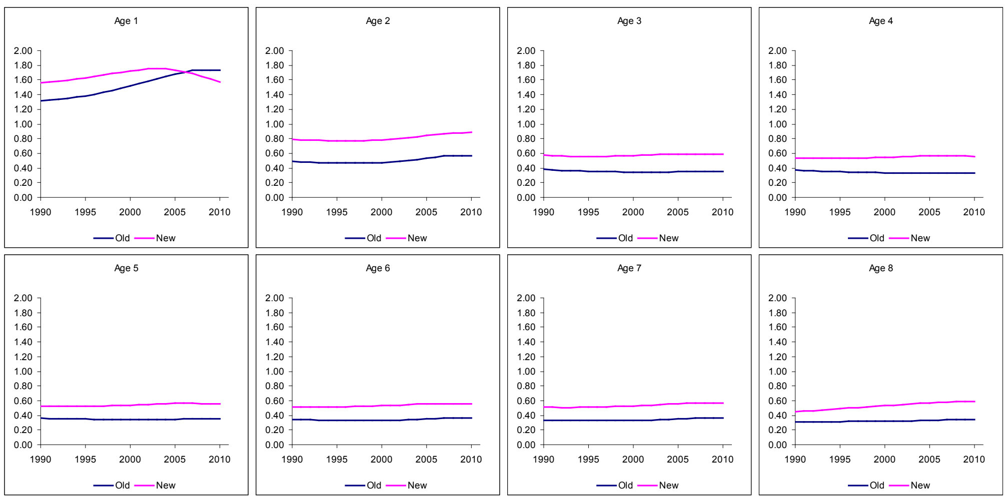


Figure 12.2.4. Whiting in Subarea IV and Division VIId. Comparison of natural mortality (*M*) estimates at age from the 2005 SMS key run, used in last year's assessment (blue), with estimates from the 2012 SMS key run, used in this year's assessment (pink).

Figure 12.3.1. Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) at age.

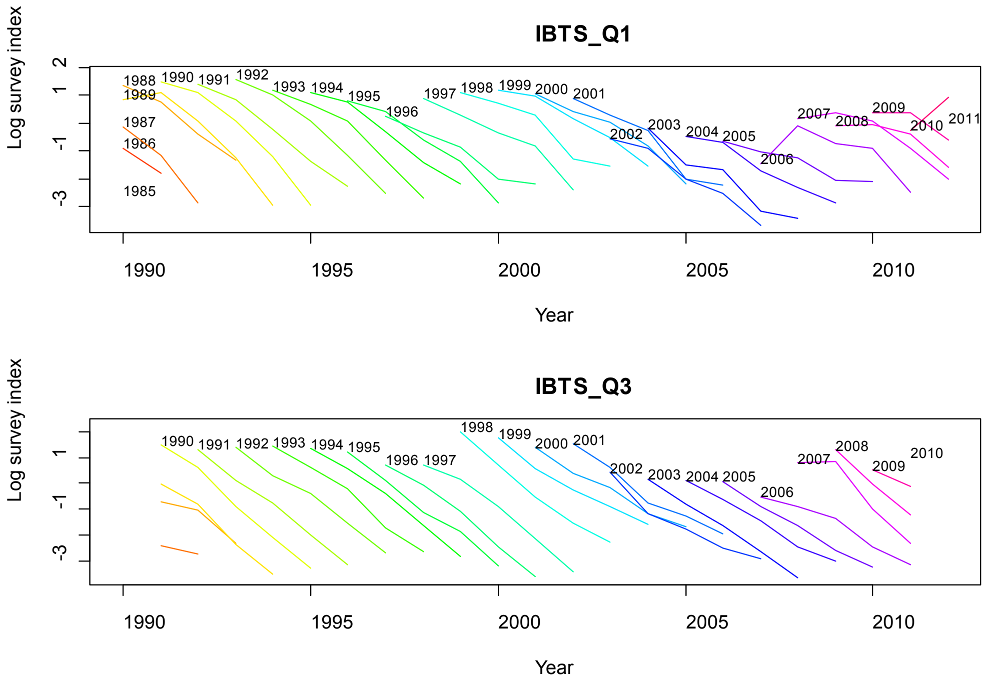


Figure 12.3.2. Whiting in Subarea IV and Division VIId. Log abundance indices by cohort for each of the two survey indices. The spawning year for each cohort is indicated at the start of each line.

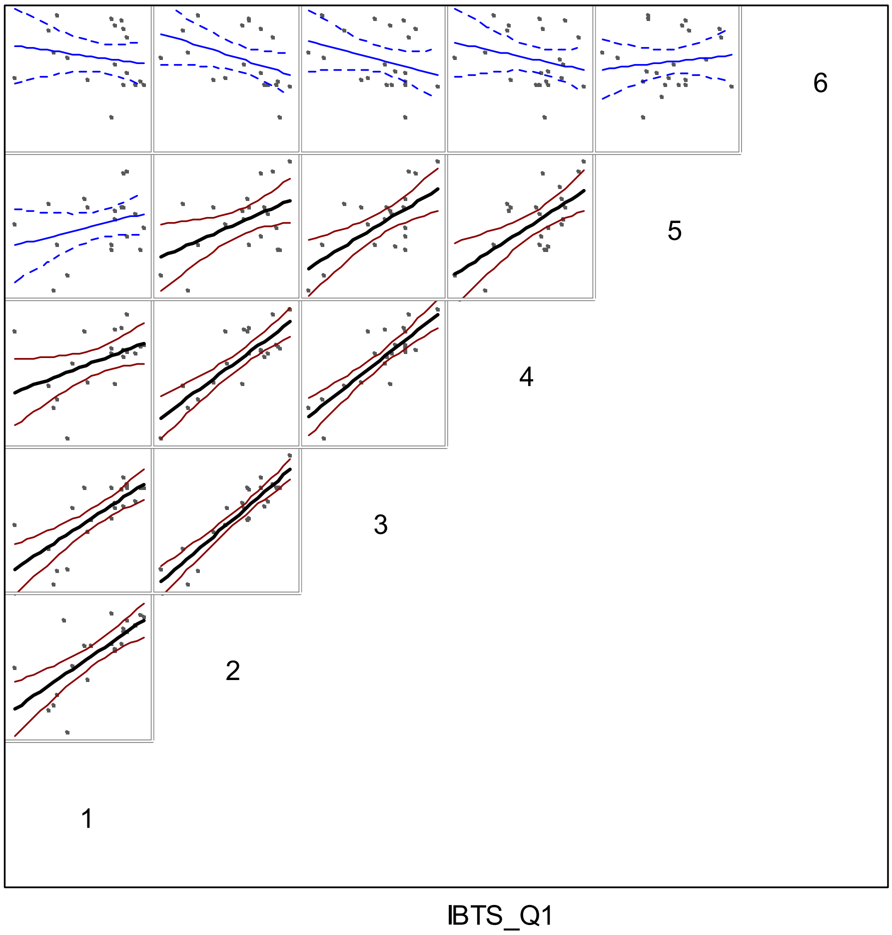


Figure 12.3.3. Whiting in Subarea IV and Division VIId. Within-survey correlations for the IBTS Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents a significant ($p < 0.05$) regression, while a thin line (with blue points) is not significant. Approximate 95% confidence intervals for each fit are also shown. Note that only ages 1-5 are used in the assessment, as age 6 is a plus-group.

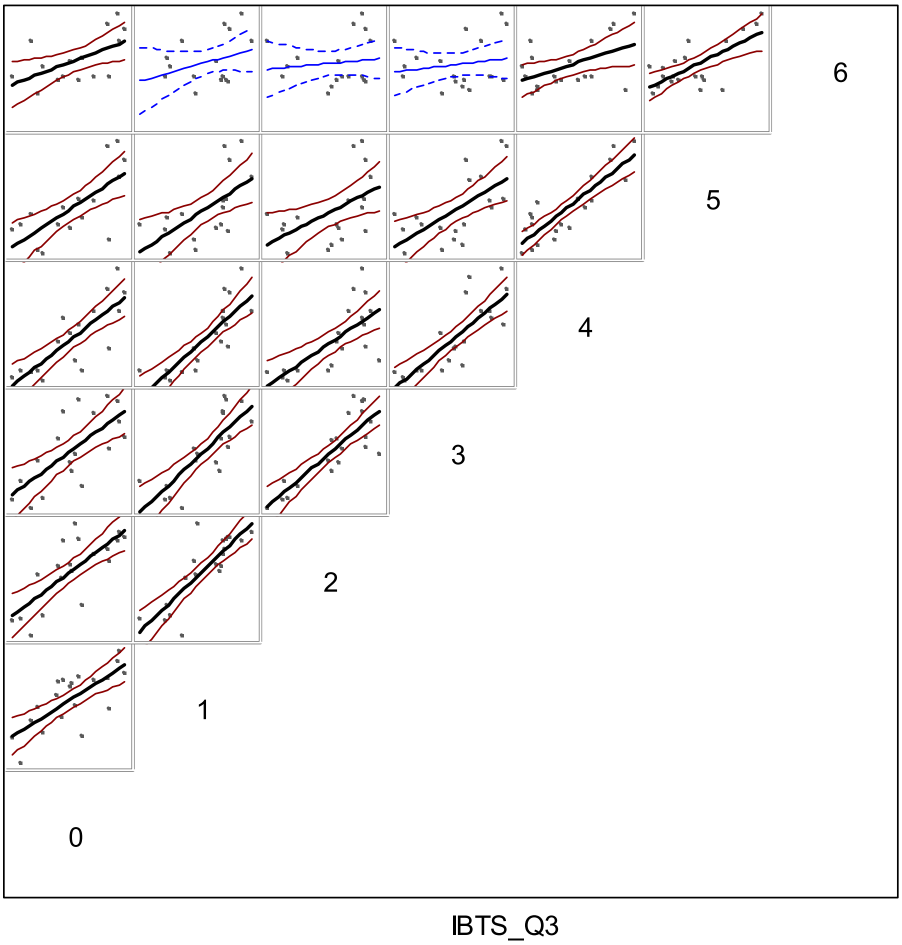


Figure 12.3.3 (cont.). **Whiting in Subarea IV and Division VIId. Within-survey correlations for the IBTS Q3 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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. Note that only ages 1-5 are used in the assessment, as age 6 is a plus-group.**

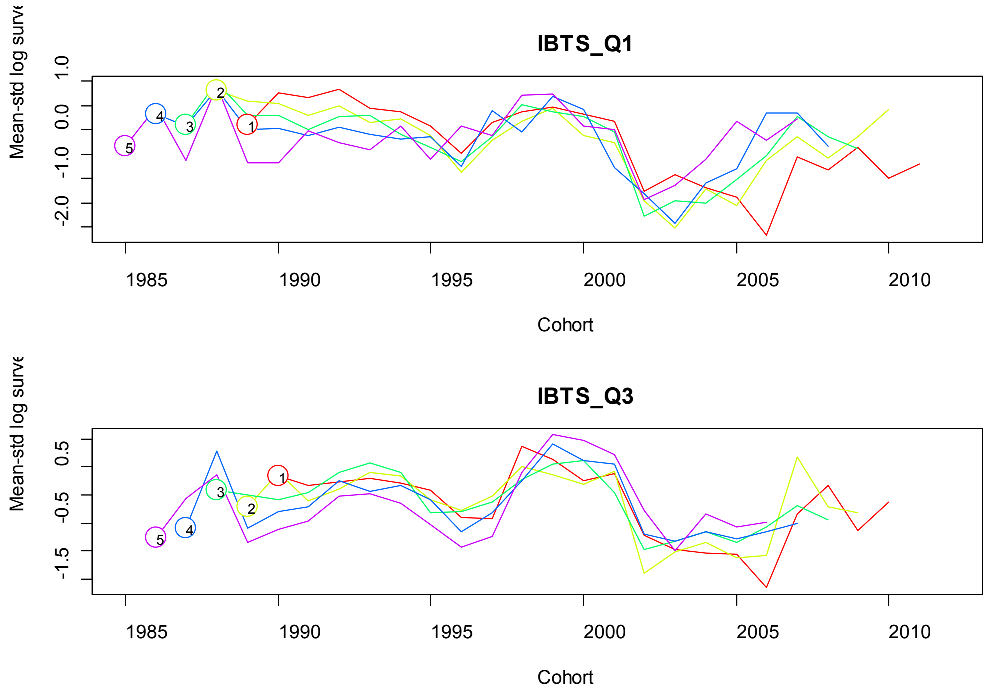


Figure 12.3.4. Whiting in Subarea IV and Division VIId. Survey log CPUE (catch per unit effort) for the IBTS Q1 and Q3 surveys, by cohort. Each line shows the log CPUE for the age indicated at the start of the line.

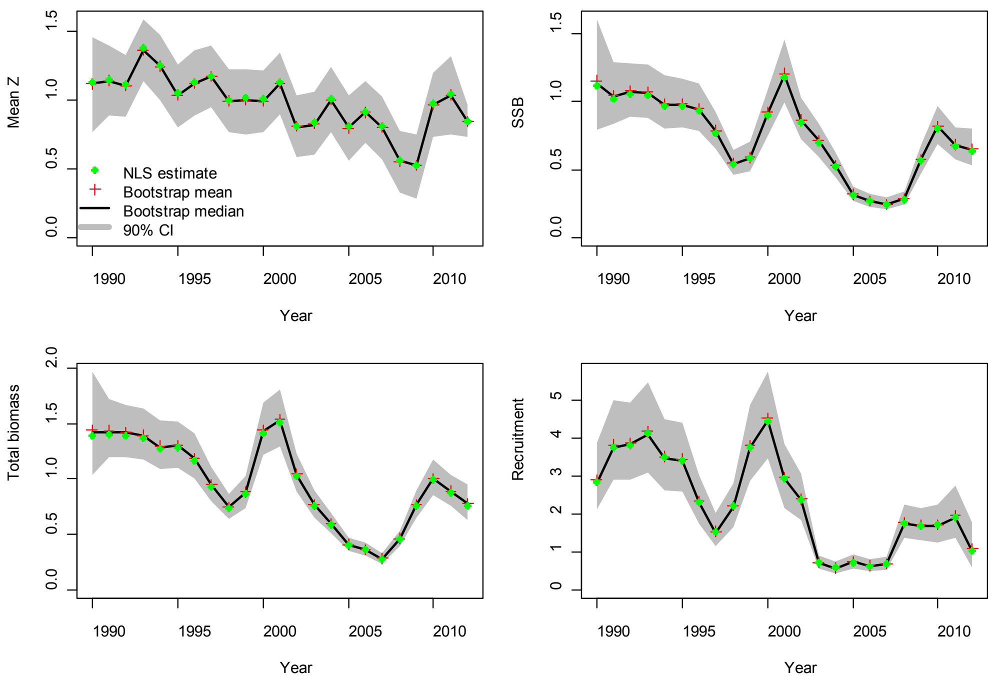


Figure 12.3.5. Whiting in Subarea IV and Division VIId. Summary plots from an exploratory SURBAR assessment, using both available surveys (IBTS Q1 and Q3). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond 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.

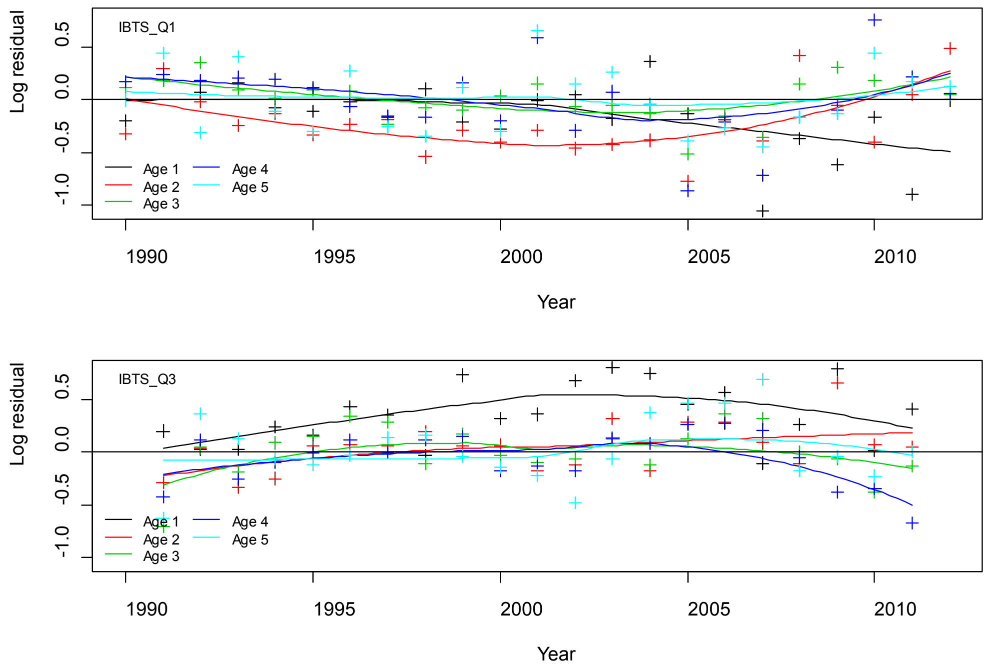


Figure 12.3.6. Whiting in Subarea IV and Division VIId. Log survey residuals from the SURBAR analysis. Ages are colour-coded, and a loess smoother (span = 2) has been fitted through each age time-series.

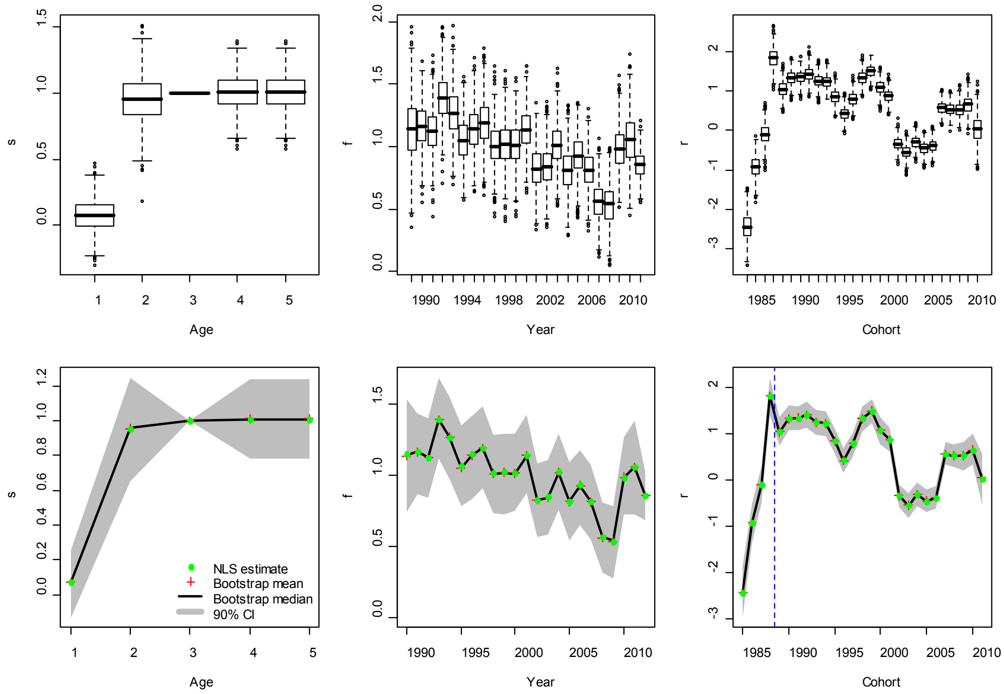


Figure 12.3.7. Whiting in Subarea IV and Division VIId. Parameter estimates from SURBAR analysis. Top row: age, year and cohort effect estimates as box-and-whisker plots. Bottom row: estimates as line plots with 90% confidence intervals.

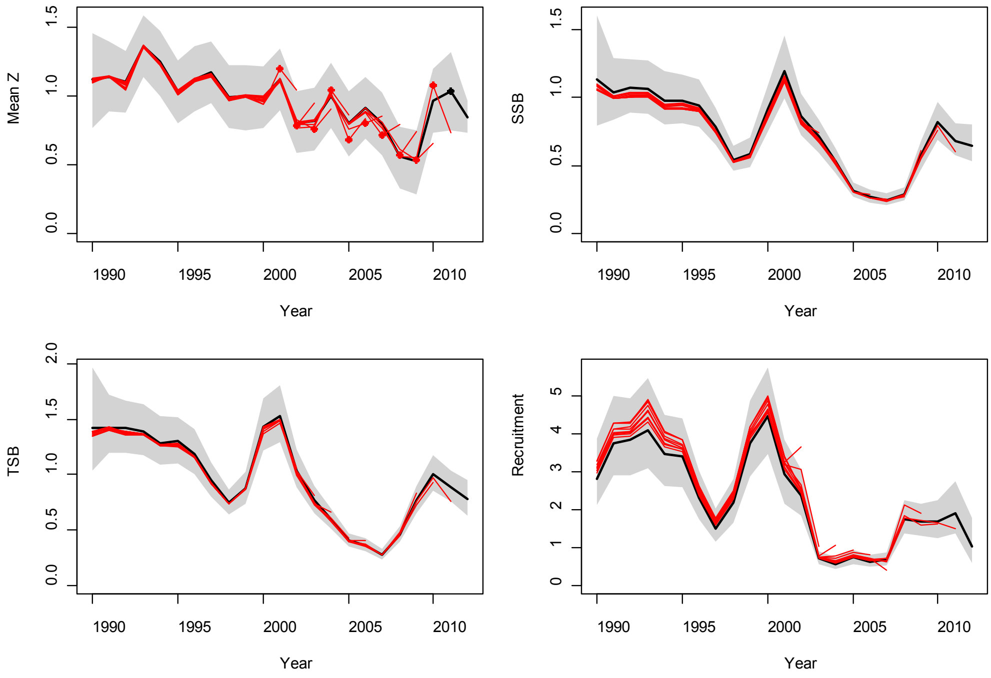


Figure 12.3.8. Whiting in Subarea IV and Division VIId. Results of the retrospective SURBAR analysis. For each plot, the black line gives the full time-series estimate (with 90% confidence intervals shown by a grey band), while the red lines show the retrospective estimates. The points on the mean *Z* plot show the last true data-derived estimate for each time-series (the final point is based on a three-year mean). SSB, TSB and recruitment are relative estimates.

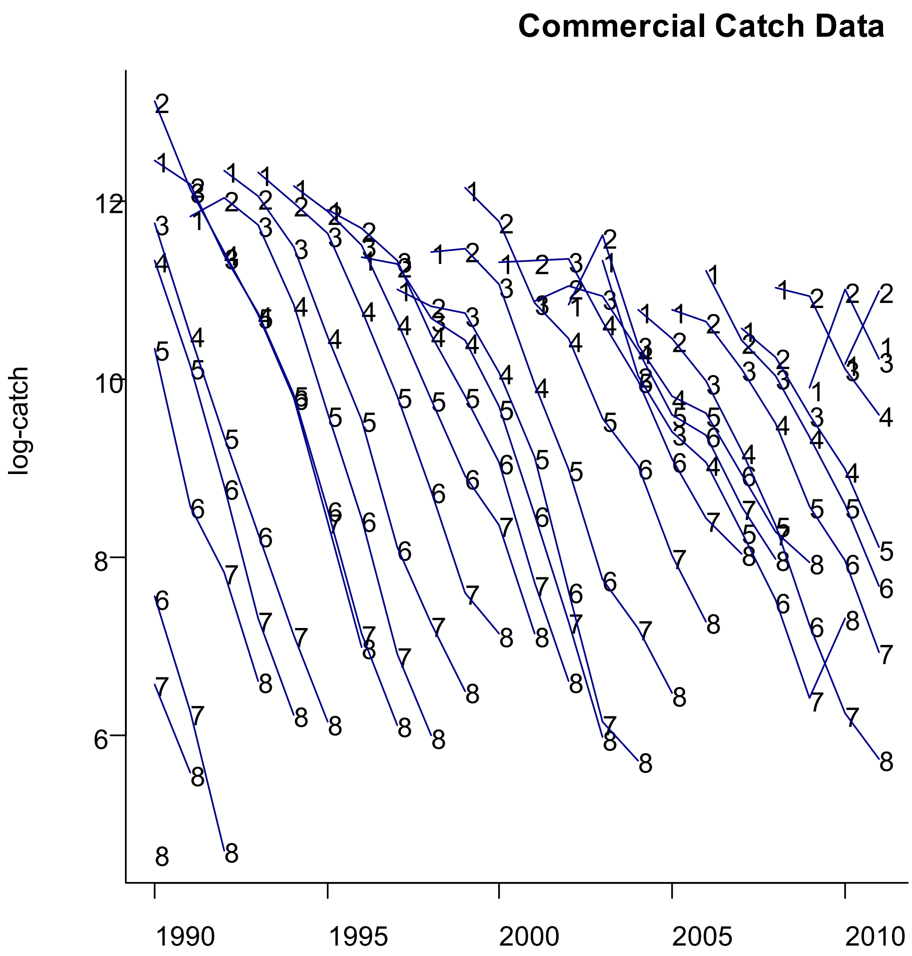


Figure 12.3.9. Whiting in Subarea IV and Division VIId. Log catch curves by cohort for total catches.

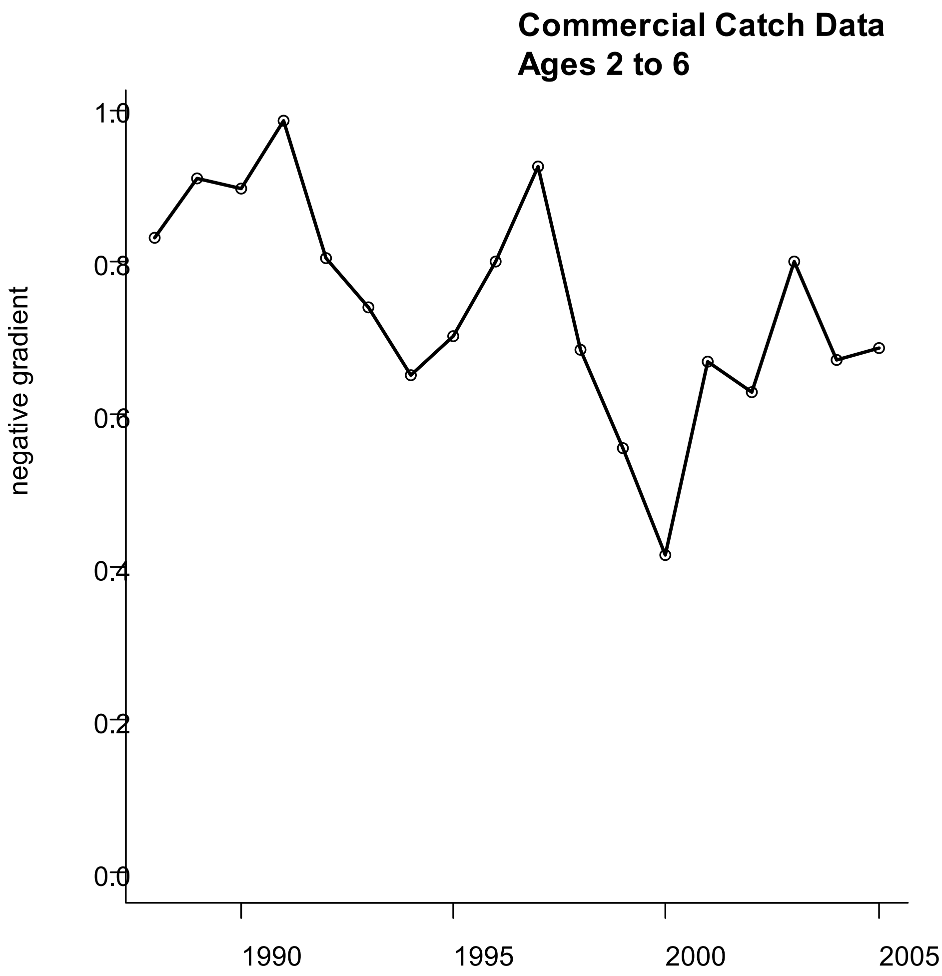


Figure 12.3.10. Whiting in Subarea IV and Division VIId. Negative gradients of log catches per cohort, averaged over ages 2-6. The x-axis represents the spawning year of each cohort.

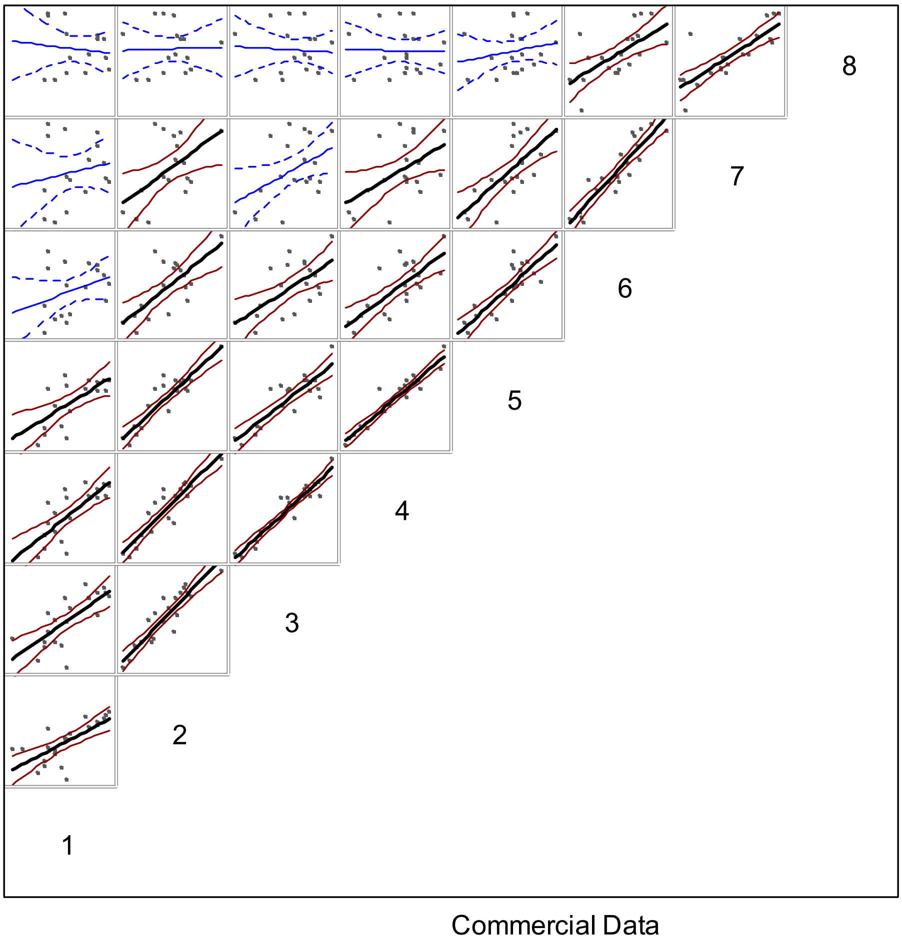


Figure 12.3.11. Whiting in Subarea IV and Division VIId. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and 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.

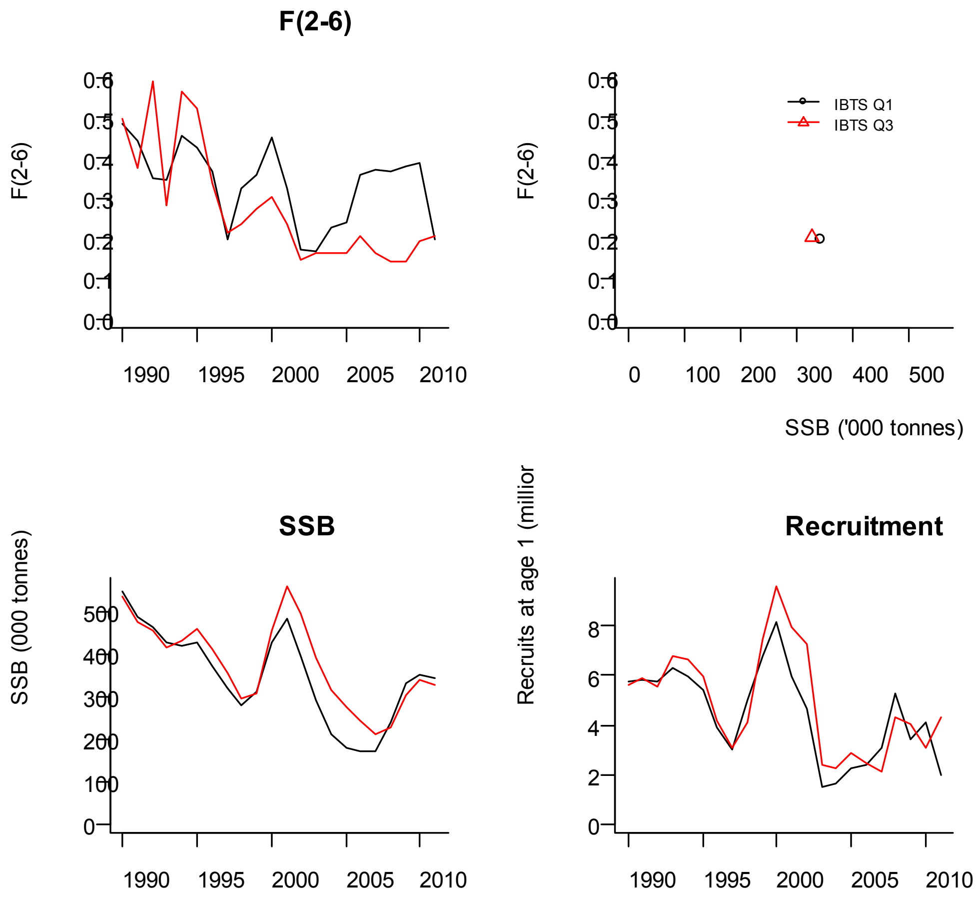


Figure 12.3.12. Whiting in Subarea IV and Division VIId. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2010) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

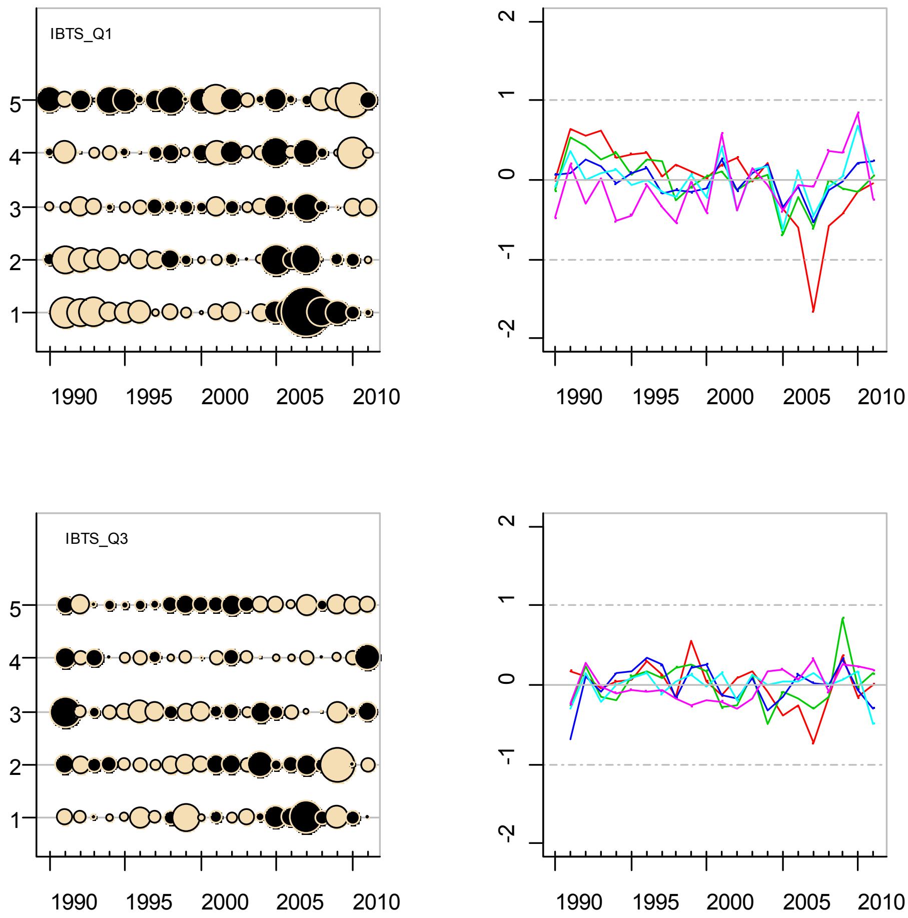


Figure 12.3.13. Whiting in Subarea IV and Division VIId. Log catchability residuals from single-fleet XSA runs.

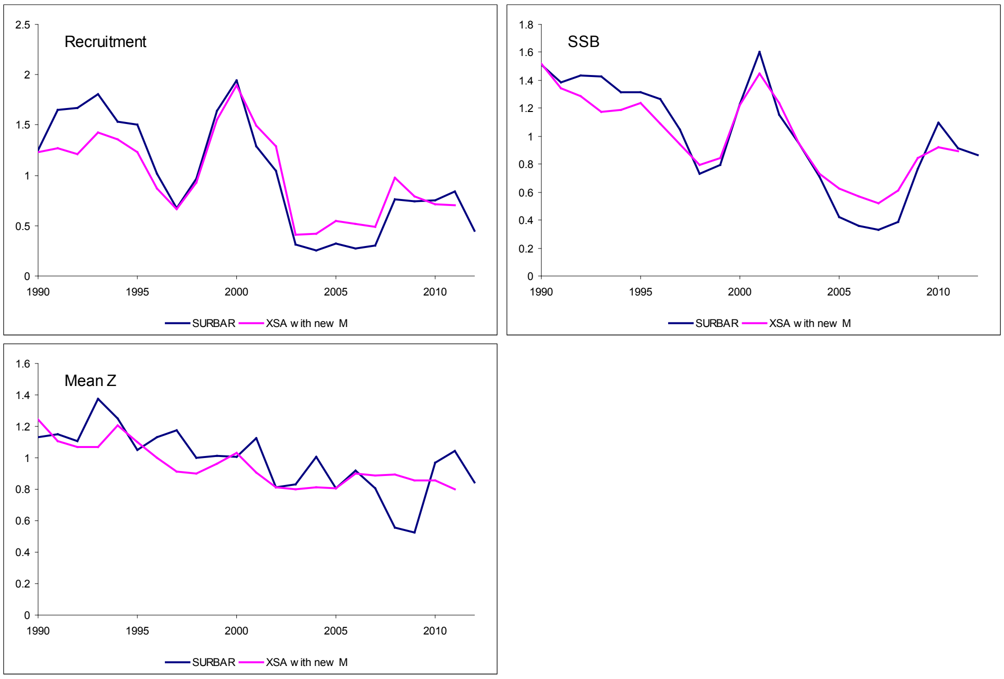


Figure 12.3.14. Whiting in Subarea IV and Division VIId. Comparisons of stock summary estimates from the final XSA (blue) and SURBAR (pink) models. To facilitate comparison, values have been mean-standardised using the year range for which estimates are available from all three models.

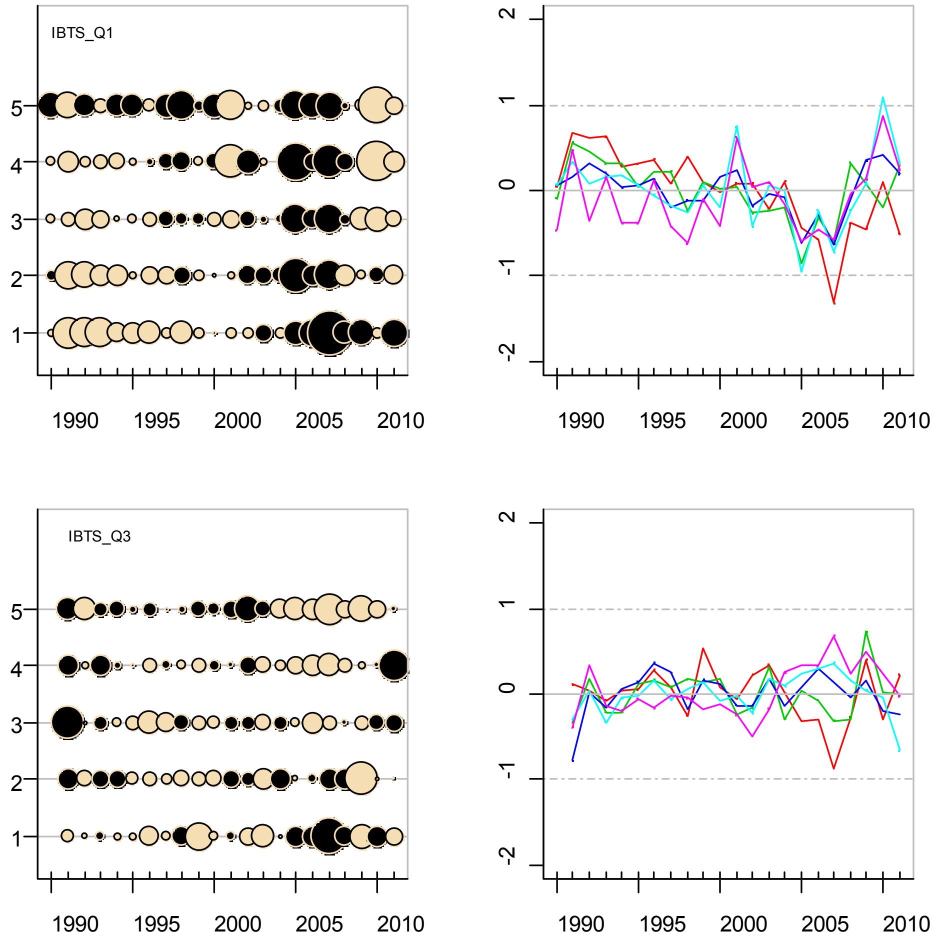


Figure 12.3.15. Whiting in Subarea IV and Division VIId. Log catchability residuals for final XSA assessment.

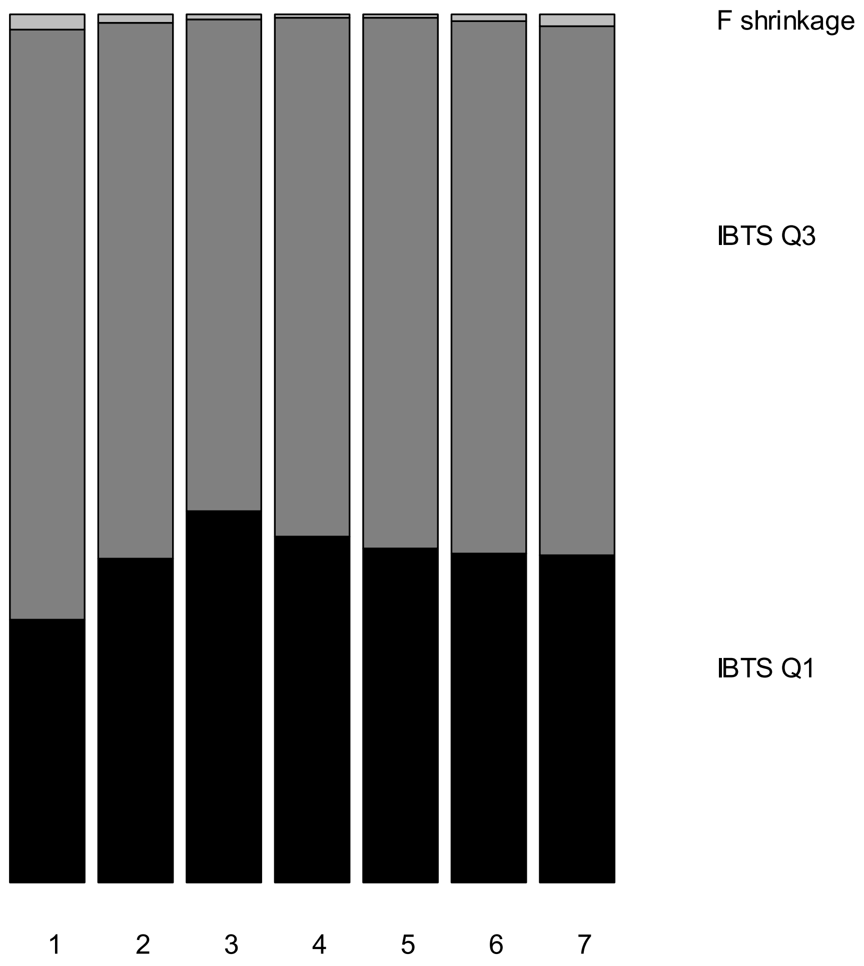


Figure 12.3.16. Whiting in Subarea IV and Division VIId. Contribution to survivors' estimates in final XSA assessment.

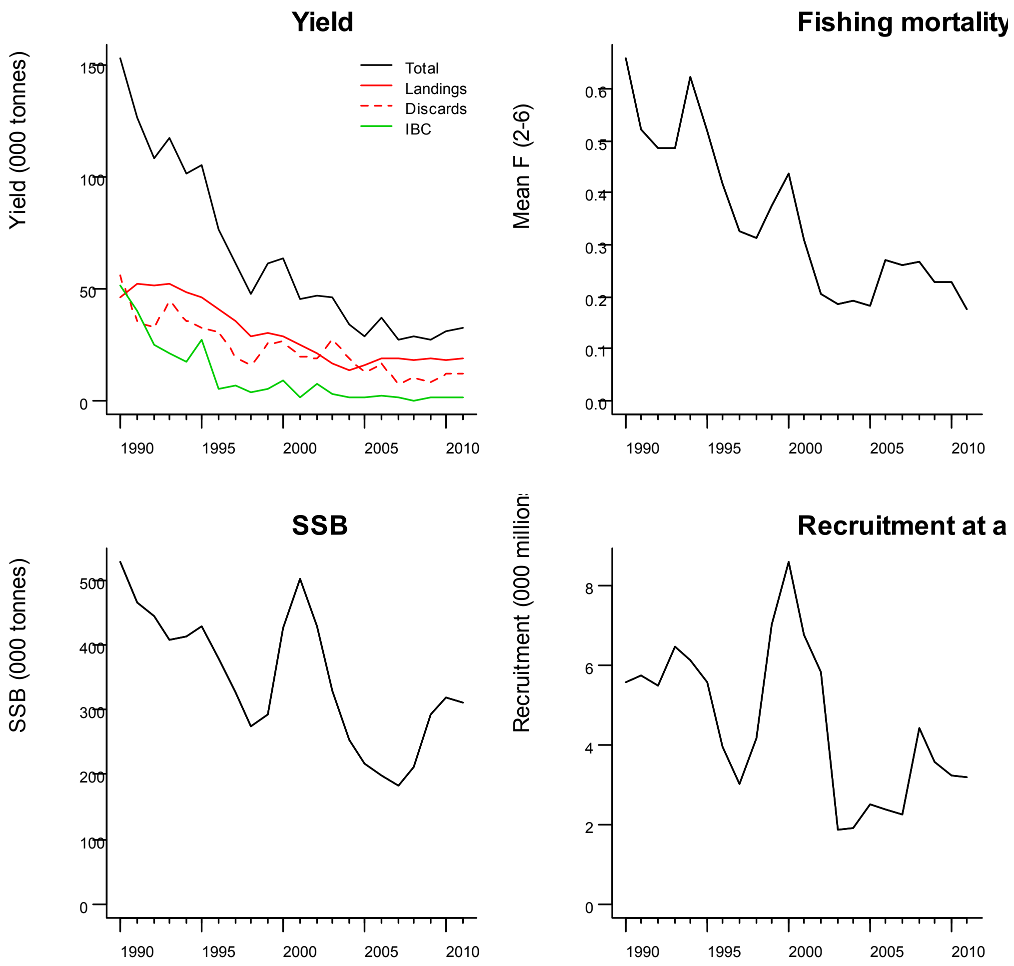


Figure 12.3.17. Whiting in Subarea IV and Division VIId. Summary plots for final XSA assessment.

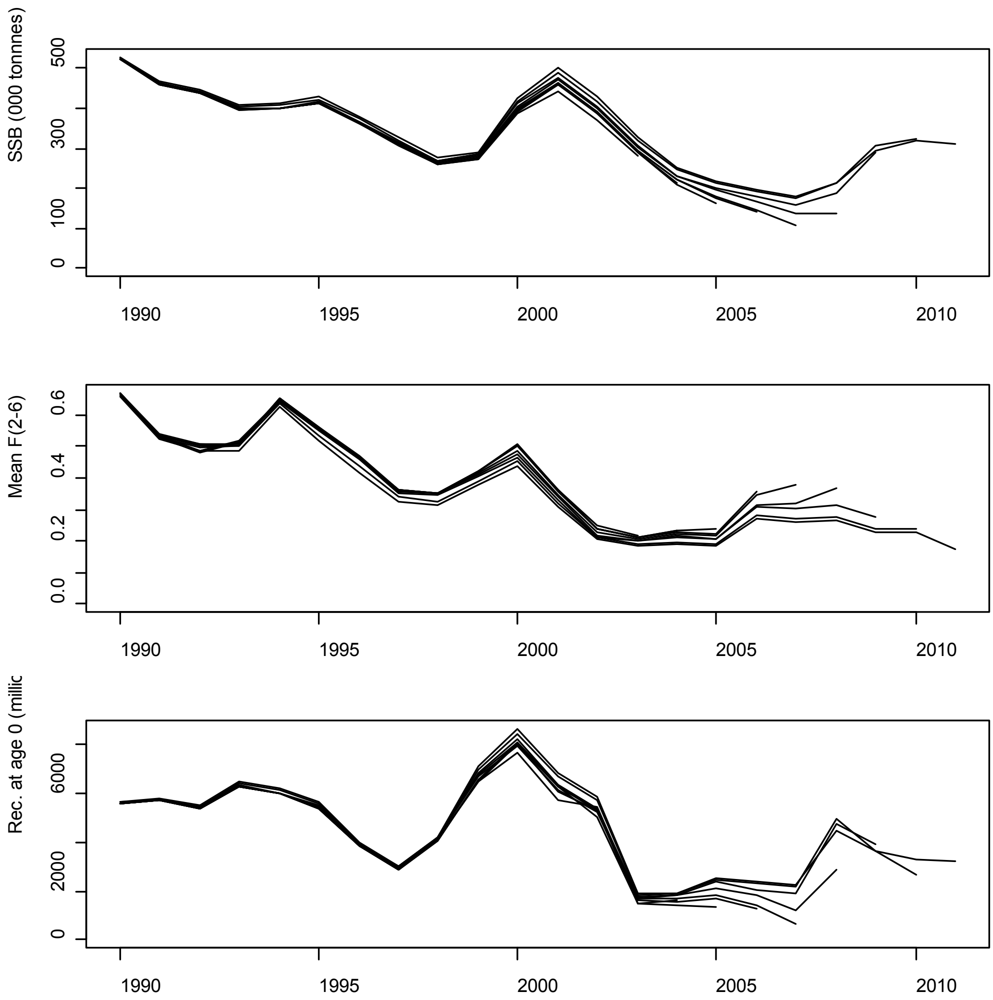


Figure 12.3.18. Whiting in Subarea IV and Division VIId. Retrospective plots for final XSA assessment.

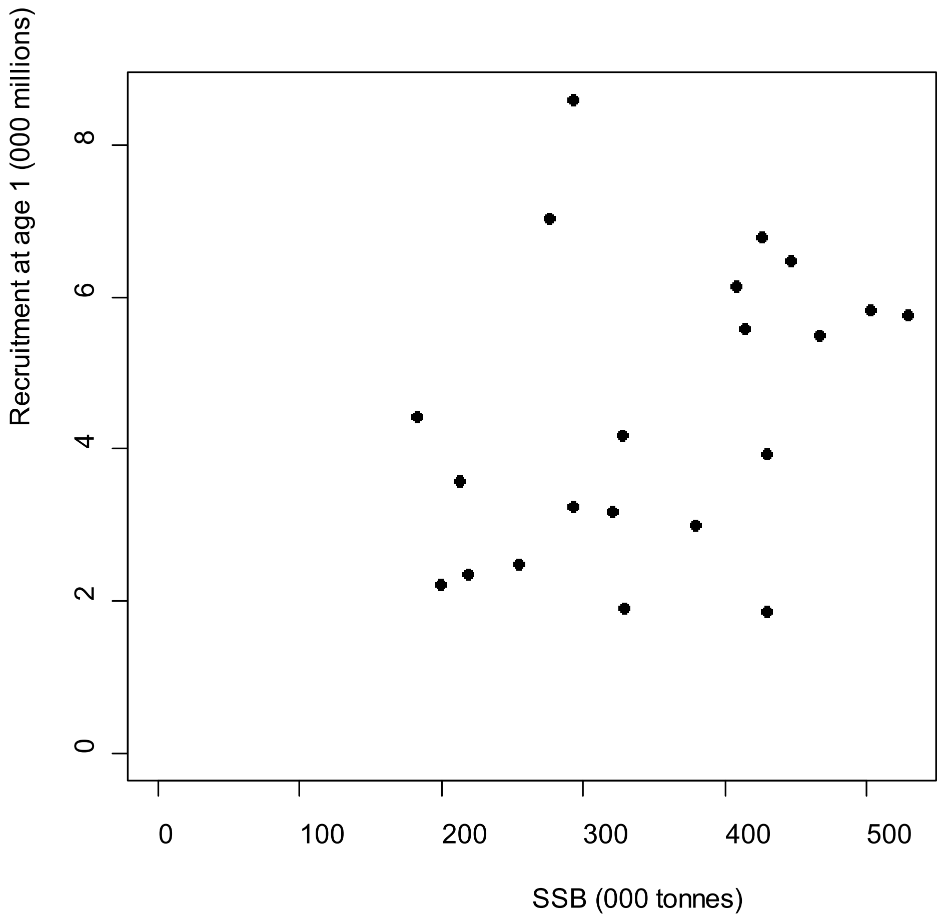


Figure 12.4.1. Whiting in Subarea IV and Division VIId. Stock-recruitment plot from the update FLXSA assessment.

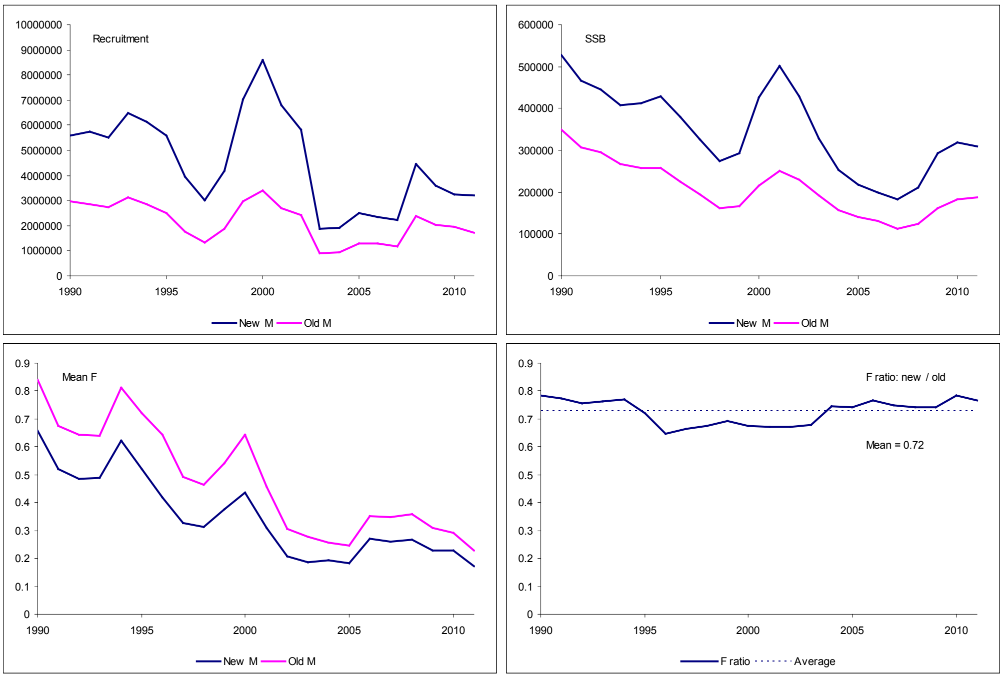
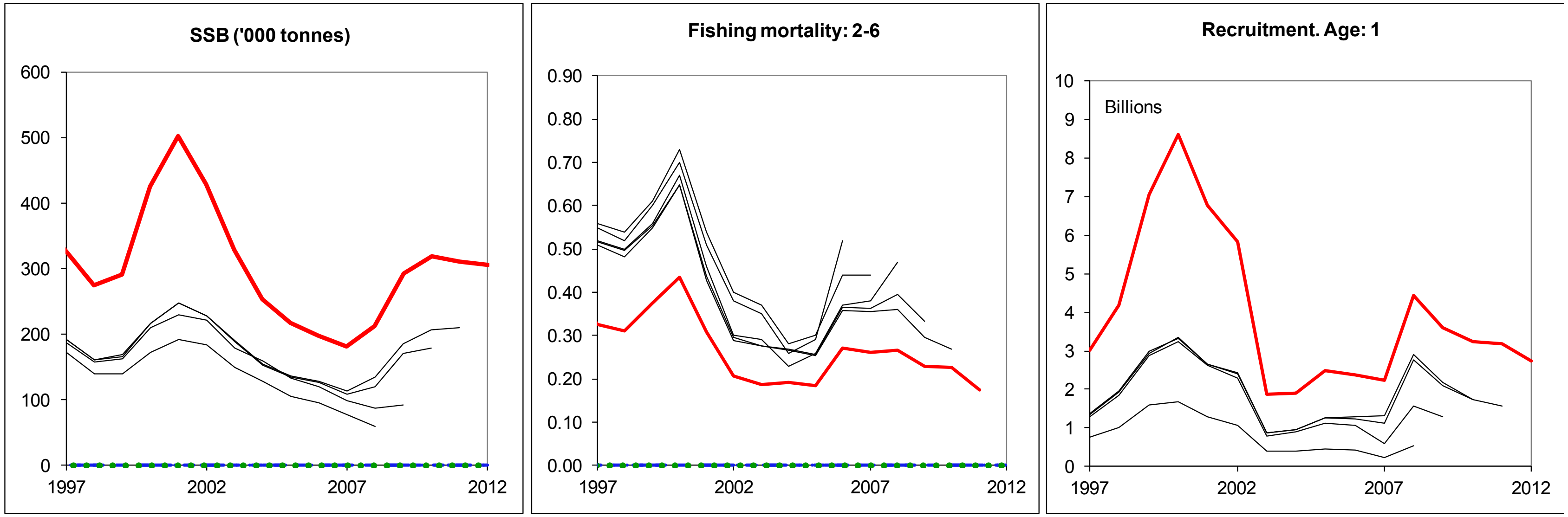


Figure 12.4.2. Whiting in Subarea IV and Division VIId. Comparison of XSA results when using old (blue) and new (pink) natural mortality estimates. The bottom right plot gives the time-series of the ratio of the new to the old mean *F* estimates, which averages at 0.72.

Figure 12.9.1. Whiting in Subarea IV and Division VIId. Historical assessment quality plot.



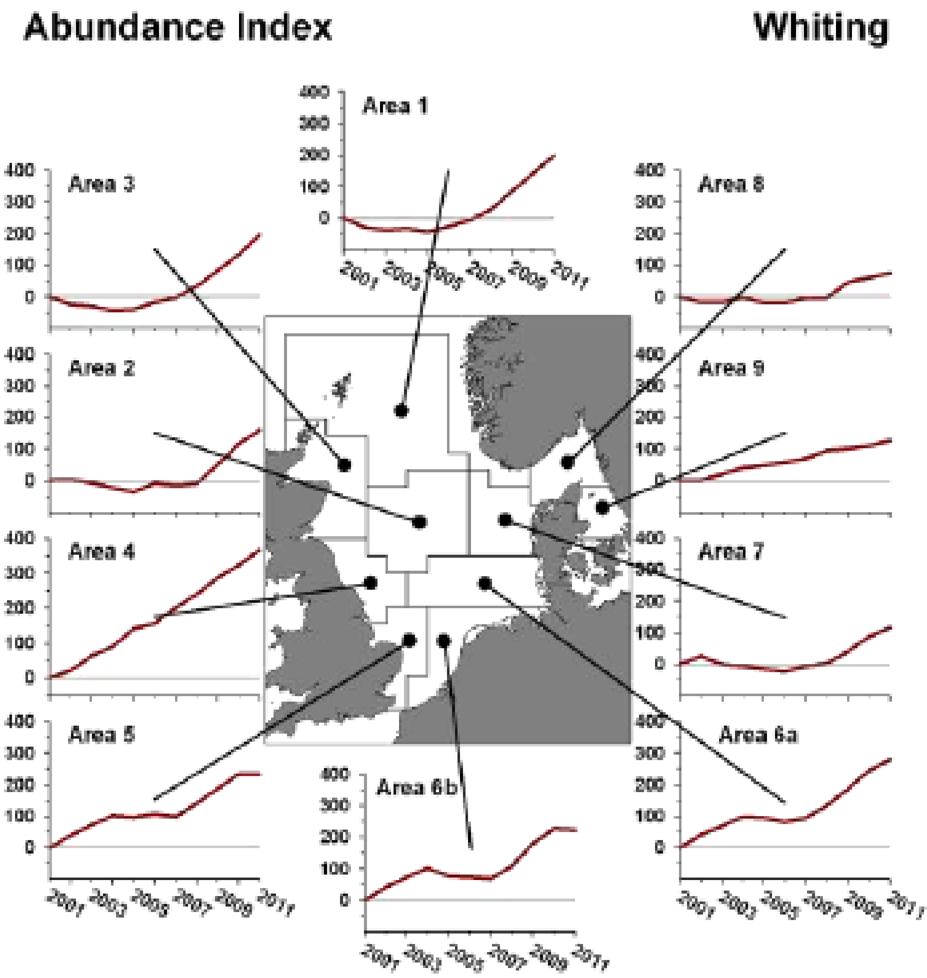


Figure 12.10.1. Whiting in Subarea IV and Division VIId. Results of 2011 North Sea Stock Survey: cumulative time series of index of perceptions of haddock abundance. Source: Napier (2012)

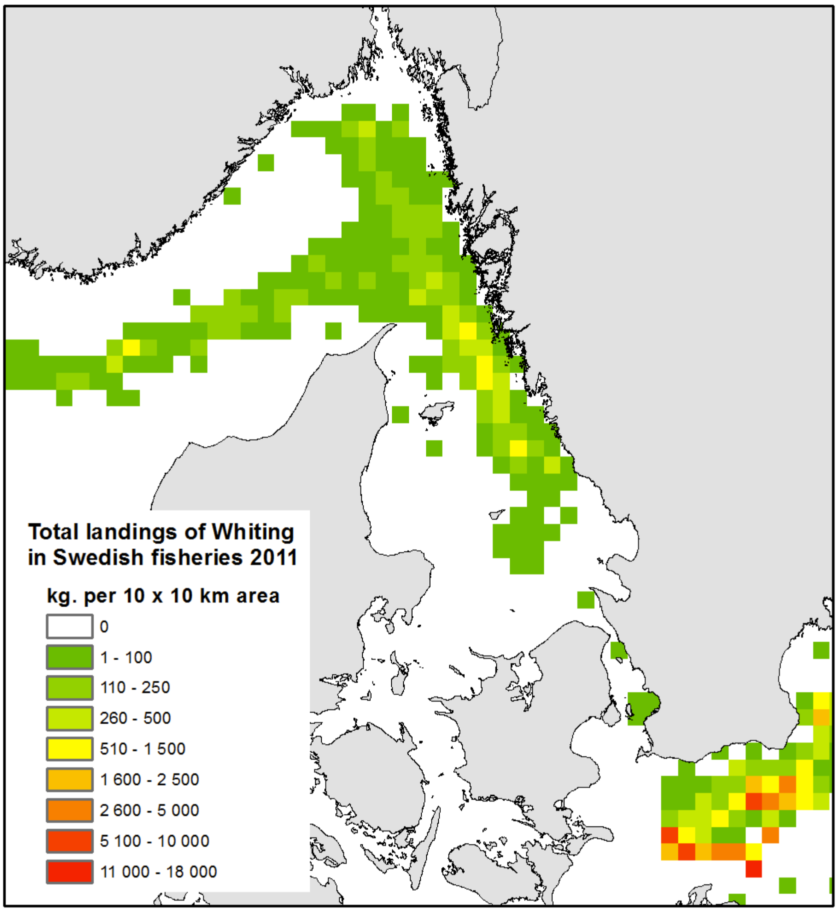


Figure 12.12.1. Whiting in Division IIIa. Spatial distribution of the total landings of Whiting IIIa in Swedish fisheries 2011 from logbooks information.

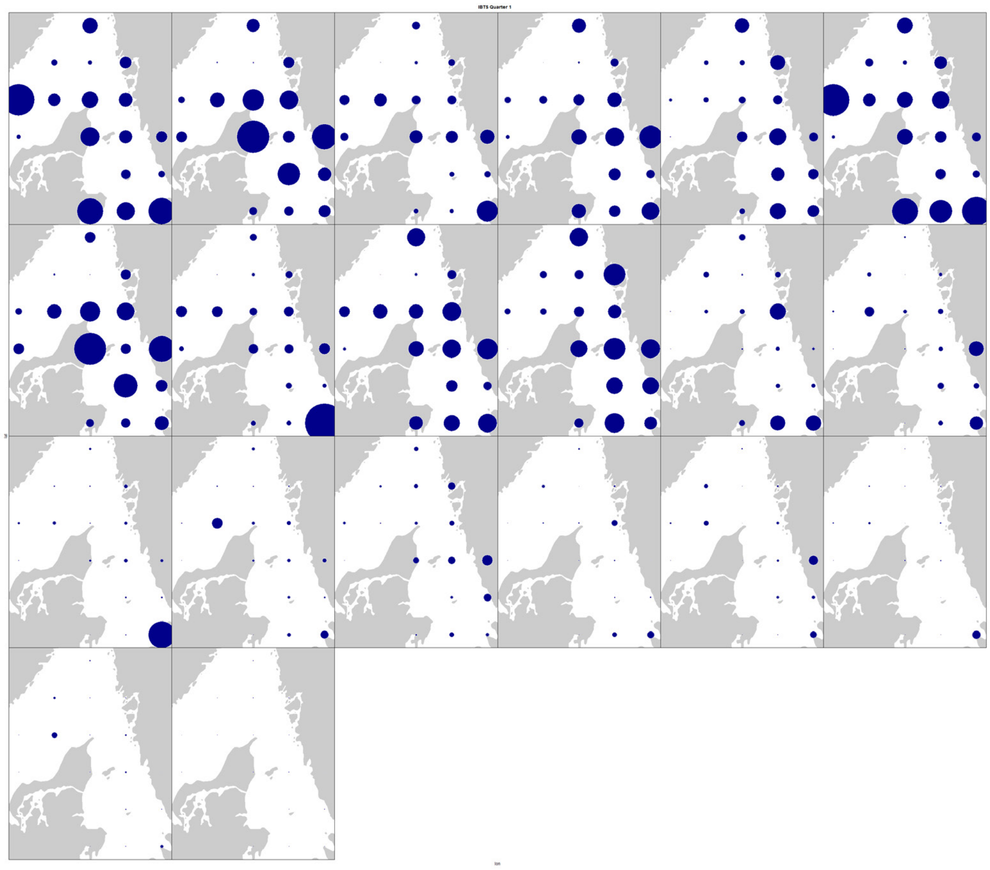


Figure 12.12.2 Whiting in IIIa. Distribution plot of the IBTS quarter 1 Survey age 1 to 4+ for demersal areas 9 and 10. Ages are on rows, years on columns from left to right 2006 to 2011.

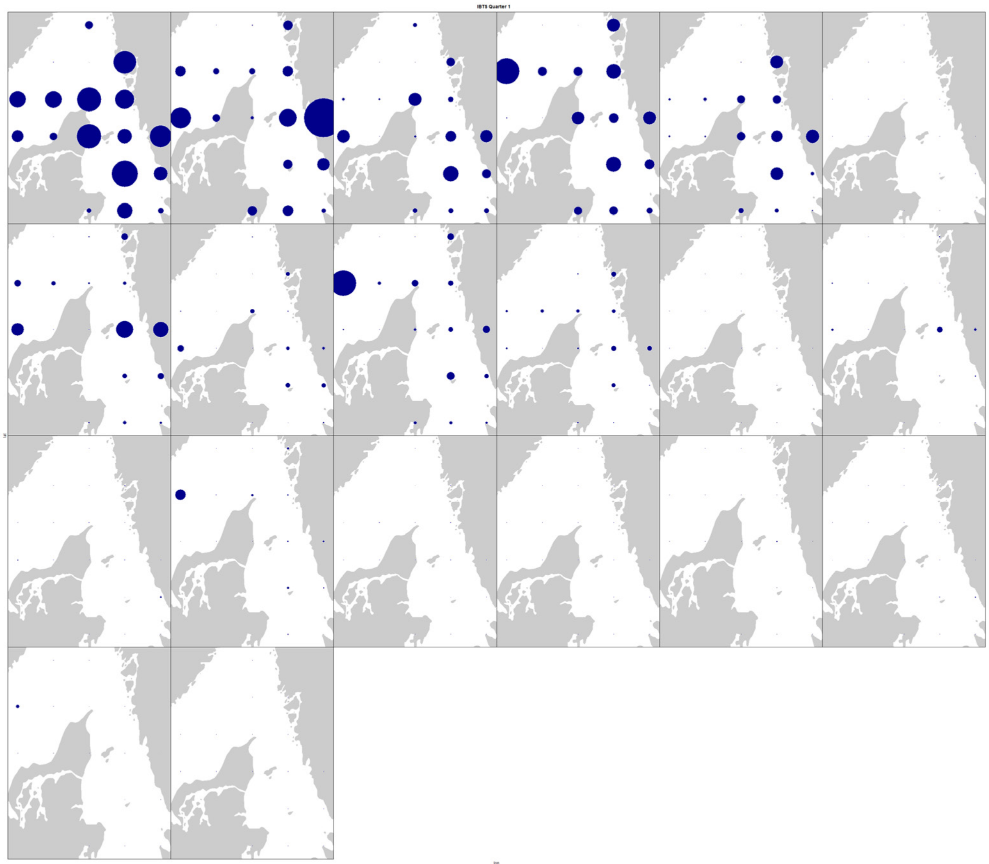
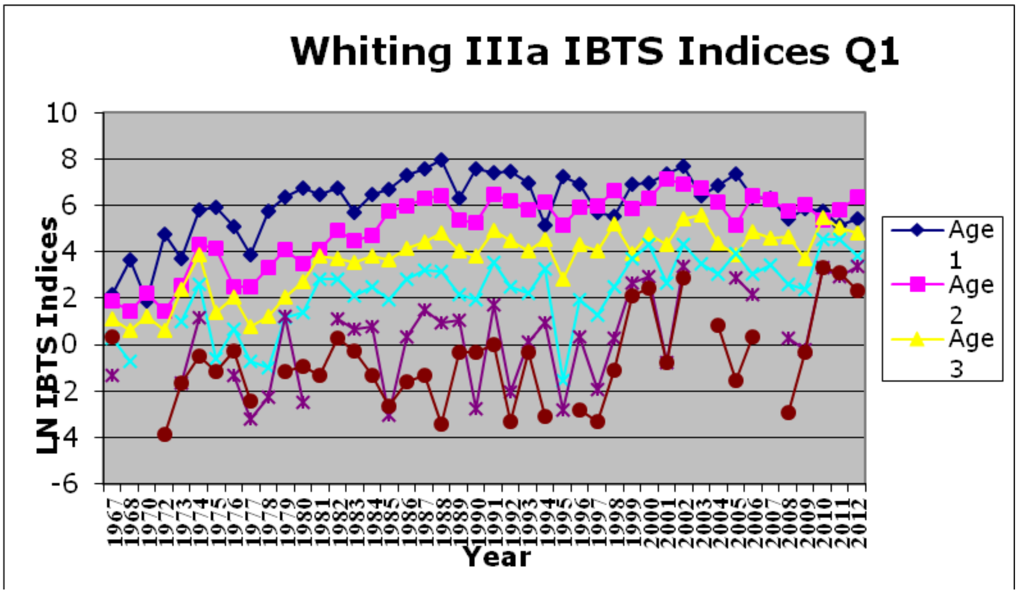


Figure 12.12.3 Whiting in IIIa. Distribution plot of the IBTS quarter 3 Survey age 1 to 4+ for demersal areas 9 and 10. Ages are on rows, years on columns from left to right 2005 to 2010.



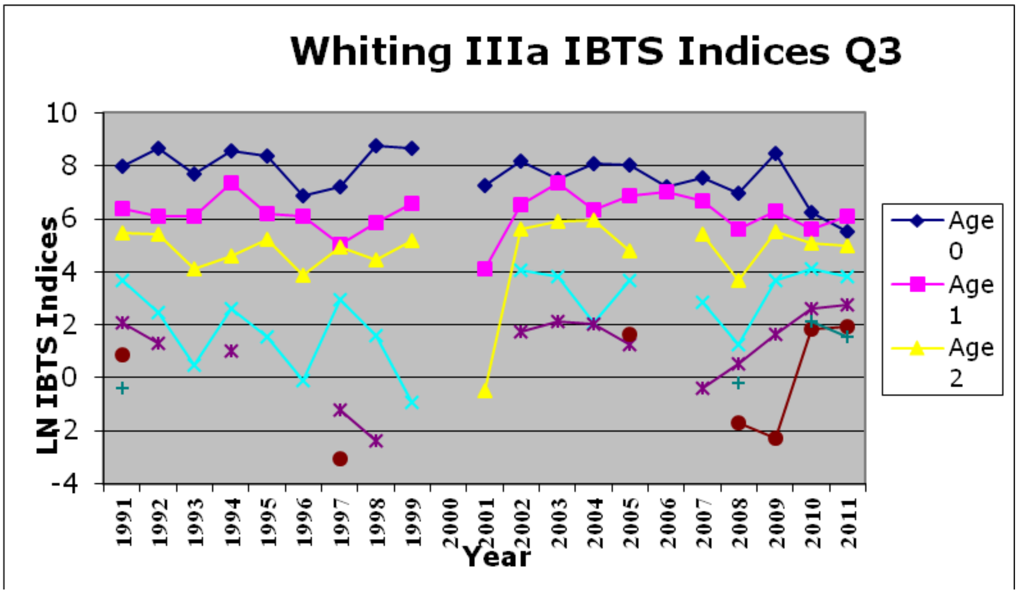


Figure 12.12.4. Whiting in Division IIIa. IBTS indices per age class for Q1 covering the years 1967-2012 and Q3 covering the years 1991-2011.

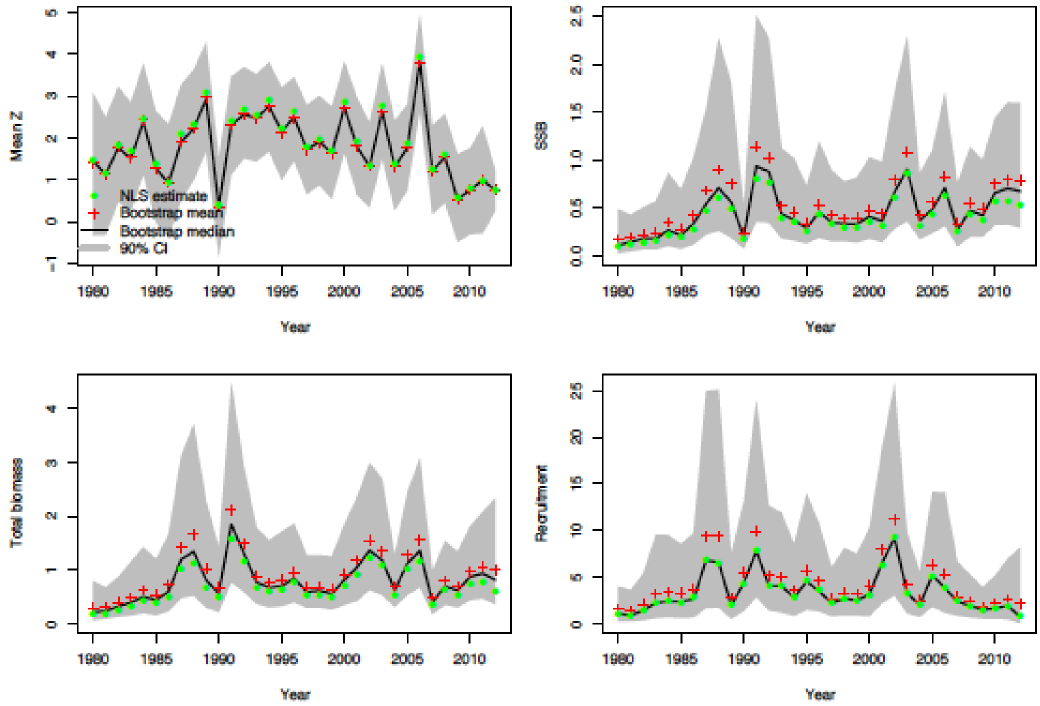


Figure 12.12.5. Whiting in Division IIIa. SURBAR analysis. Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomass (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

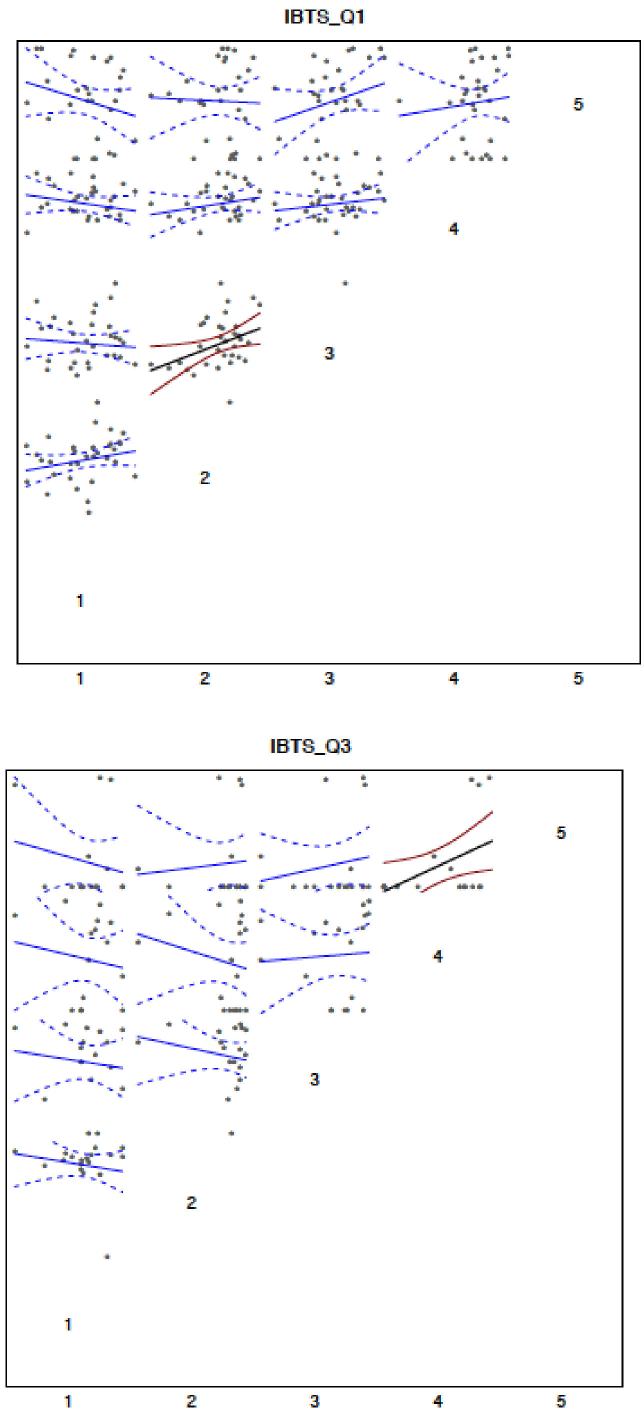


Figure 12.12.6 Whiting in Division IIIa. SURBAR analysis. IBTS indices per age class 1-5 for Q1 covering the years 1980-2012 and Q3 covering the years 1991-2011. The log index values (number at age) plotted against numbers at age+1 of the same cohort in the following year.

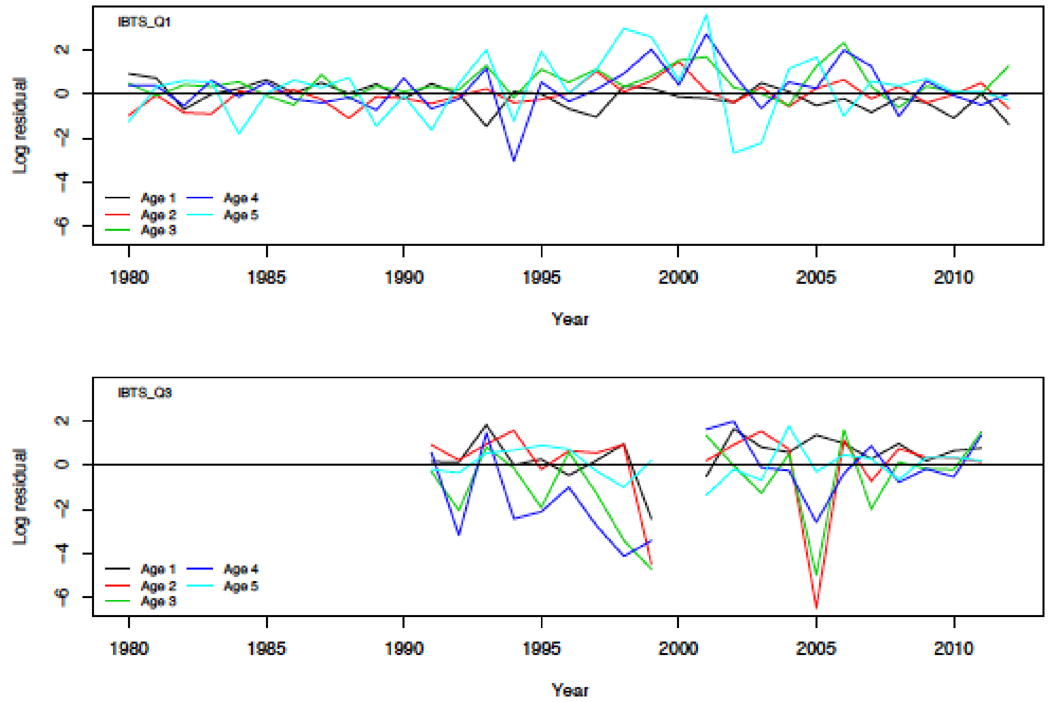


Figure 12.12.7 Whiting in Division IIIa. SURBAR analysis. Log residual estimates per age class for IBTS Q1 (upper line plots) and IBTS Q3 (lower line plots).

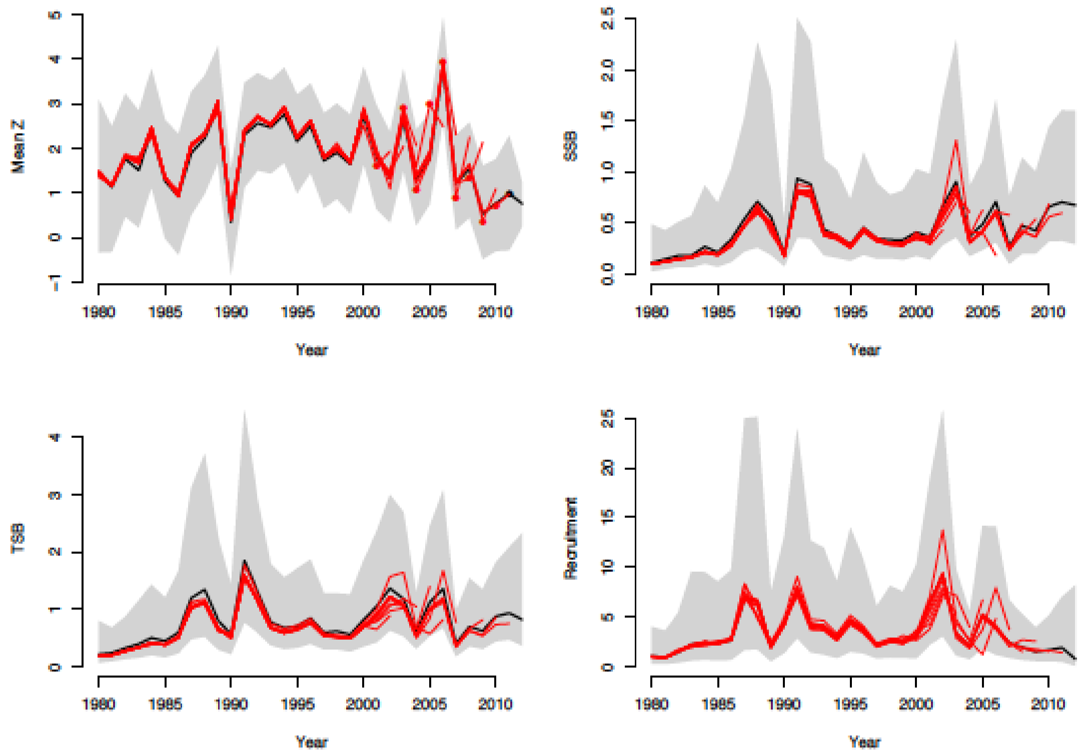


Figure 12.12.8. Whiting in Division IIIa. SURBAR analysis. Retrospective analysis plots for mean total mortality Z over ages 2 to 4, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment. The full time-series run is indicated by a black line, the retrospective runs by 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" is a three-year mean).

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 2012, 23 Scottish demersal whitefish vessels are participating in a trial Fully Documented Fishery (FDF) scheme, following trials in 2010 and 2001, and with similar trials being conducted by Denmark, England, Germany, Sweden and the Netherlands. In the Scottish North Sea FDF trials, vessels are exempt from some effort restrictions and are allocated additional cod quota: in return, they must carry monitoring cameras and land *all* cod caught. It is not clear what the impact would be on haddock fisheries of an enforceable discard ban for cod, and in data collation for the haddock assessment it was assumed that FDF vessels would have similar haddock discard patterns as other vessels, but this remains to be verified.

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 2011 was almost 100%, which is the highest since last year and 2003 (76%) The projected UK quota uptake for 2012 is thought to be in line with last year.

13.1.3 ICES advice

ICES advice for 2011

In June 2010, ICES concluded the following:

> *Fishing mortality has been below Fpa and SSB is 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 36 000 t in 2011. This is expected to lead to an SSB of 218 000 t in 2012. Following the management plan implies a TAC of 36 152t in 2011 which is expected to lead to a TAC reduction of 5% and an F increase of 29%.*

Following the 2010 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 2010, but the difference was not significant enough to warrant reconsideration of the 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.

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 Division IIIa (EC waters), which are considered jointly. The 2011 and 2012 TACs for haddock in this area were 34 057 t and 39 166 t respectively. The second area is Divisions IIIa-d, for which the TACs for 2011 and 2012 were 2 095 t and 2 409 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, 64 closures have been implanted by 16th May. The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it will undoubtedly have an effect on the mortality of associated species such as haddock.

Recent work tracking Scottish vessels in 2009 has concluded that vessels did indeed move from areas of higher to lower cod concentration following real-time closures during the first and third quarters (there was no significant effect during the second and fourth quarters; see Needle and Catarino 2011). However, the effect of this change 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

The international catch data for haddock have been aggregated using Intercatch (see Section 1.2). The raising of the data was also made through Intercatch.

For the data collation of the international landings and discards, the approach to the estimating of discards for unsampled catches was made using Intercatch. The process for allocating discards i.e. the discard ratio (of sampled discards to the entire fleet's discards) was used to estimate discards allocated to any unsampled catches. The estimated numbers at age and mean weights at age from sampled catches were applied to unsampled catches, weighted by the estimated numbers at age from the sampled catches.

Intercatch

A comparison between the Intercatch system and the previous spreadsheet approach was made. This relied on the respective national institutes uploading their data into Intercatch – particularly where age compositions were available. The Intercatch and spreadsheet approaches were very similar in terms of values obtained.

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 decreased slightly between 2009 and 2010, however in 2011 increased slightly. 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 fishery 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 1990s. In 2011, the haddock discards decreased slightly (as a proportion of total catch).

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 in-

shore 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. Discards for age 3 went down slightly for the year of 2011.

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 13.2.2–4. The fishery in 2010 (landings for human consumption) was strongly reliant on the 2005, 2008 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 (2012). 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: in particular, all three surveys indicate the increase in recruitment for the 2009 year-class.

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**	**1998-2011**	0-8	**0-6**
England	Groundfish survey	Q3	**EngGFS Q3 GRT**	**1977-1991**	0-15+	**0-6**
	Groundfish survey	Q3	**EngGFS Q3 GOV**	**1992-2011**	0-15+	**0-6**
International	Groundfish survey	Q1	**IBTS Q1 (backshifted)**	**1982-2011**	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 SAM and SURBAR analyses are also shown, to corroborate (or otherwise) the update assessment.

13.3.1 Reviews of last year's assessment

At its meeting in May 2011, the North Sea Review Group (RGNSSK) raised a number of relatively minor issues (as part of a generally positive review). Due to problems arising from late collation of data, the WG could not address these issues this year, but will endeavour to do so in the near future.

13.3.2 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 from ages 2 to 4 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.

The results of the SAM run on the North Sea haddock data are given in Figures 13.3.2.7 (SSB), 13.3.2.8 (mean F), 13.3.2.9 (recruitment) and 13.3.2.10 (log residuals). These are discussed further in Section 13.3.4 below.

13.3.3 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 13.3.4 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).

13.3.4 Conclusions drawn from exploratory analyses

Stock summary results (SSB, mean F and recruitment) are compared for the update FLXSA and exploratory SAM runs in Figure 13.3.4.1. Overall, the SAM assessment tends to estimate higher fishing mortality and lower SSB than the FLXSA assessment. The difference in SSB estimates is particularly pronounced towards the end of the time series. SAM also provides a much smaller estimate of the size of the 1967 year-class than FLXSA: this estimate is based wholly on catch data (including discard and IBC data that could be dubious), and SAM considers the large 1967 cohort indicated by FLXSA to be unlikely.

Mean-standardising results (using a common year-range for the mean) enables the comparison between FLXSA, SAM and SURBAR shown in Figure 13.3.4.2. 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 estimate follows the pattern of the SAM estimate, rather than FLXSA.

The concordance of the SAM and SURBAR runs presented here lends some confidence to the argument that FLXSA is overestimating SSB due to slow convergence, but we have not yet been able to demonstrate this conclusively using well-structured simulation testing. Concerns remain, but until such testing can be carried out intersessionally the parsimonious conclusion is to remain with FLXSA as the update assessment method for the time being, with SAM and SURBAR exploratory runs included in the report. As last year: **WGNSSK recommends that a definitive answer to the question of FLXSA convergence be sought at the earliest possible opportunity.**

13.3.5 Final assessment

The final FLXSA assessment uses the following settings. 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. In all other respects, the FLXSA settings are the same as those used last year (except for the addition of another year of data). XSA and FLXSA settings from a number of recent years are compared in the Stock Annex.

ASSESSMENT YEAR		2012
q plateau		6
Tuning fleet year ranges	EngGFS Q3	77-91; 92-11
	ScoGFS Q3	82-97; 98-11
	IBTS Q1*	82-11
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. **It would appear that FLXSA is no longer being maintained, which should be a source of concern to ICES as it is increasingly used in preference to XSA.**

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. A retrospective analysis, shown in Figure 13.4.2., indicates very little retrospective bias in the assessment.

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 subsequent growth of the 1999, 2005 and 2009 year-classes, while industrial bycatch (IBC) is now at a very low level for haddock (see also Figure 13.2.1.1).

Estimated fishing mortality for 2008 to 2010 appeared to have stabilised at or just above 0.2, and is still just below the management plan target of 0.3 in 2011. 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 2011 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 a continued slow reduction in SSB as the 2005 year-class is fished, but the 2009 year-class can be expected to impact beneficially on SSB in future if fishing mortality remains low (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 2012 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 2012 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 1994–2009 (3604 millions) has been assumed for recruitment in 2012-2014. Recruitment estimates for 2010 and 2011 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 2012	FLXSA estimate (millions)	Geometric mean of 5 lowest recruitments 1994–2009
2010	2	45	
2011	1	86	
2012	0		3604
2013	Age 0 in 2013		3604
2014	Age 0 in 2014		3604

13.6 Short-term forecasts

Weights-at-age

The following text is taken from the new (May 2011) Stock Annex – 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 (2009-2011) means by age are used for all forecast years.

Finally, the weights-at-age for 2012-14 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 2011 was higher than that in 2010, at just under 0.3. The WG decided that it would be reasonable to assume that this level would continue into the forecast period. Rather than just use the 2011 fishing mortalities at age for the forecast, a three-year average exploitation pattern scaled to the level of the mean 2011 fishing mortality was used. To be precise: the exploitation pattern for each year (2009, 2010 and 2011) 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 2009, 2010 and 2011. The vector of mean exploitation is then scaled by multiplying by the average F over ages 2-4 in the last historical assessment year (2011). 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 2009-2011) 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. Given that recent years have seen a high quota uptake, the WG decided to use a TAC constraint in 2012. The *status quo* forecast indicated landings in the intermediate year of 41 575 t (equal to the TAC).

Assuming *status quo* F in both 2012 and 2013, SSB is expected to decrease to 255 kt in 2013, before falling again in 2014 to 202 kt. In this case, human consumption yield will be around 49 kt in 2013, with associated discards of 6 kt. This substantial decrease in discards is largely due to the growth above minimum landing size of the 2009 year-class.

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 2013 landings yield of 48 kt (the maximum permitted 15% increase on the 2011 quota) and discards of 6 kt lead to SSB in 2014 of 203 kt. All of these SSB forecasts for 2014 are above B_{pa} (140 kt). 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, 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 2011:-

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, and the interim joint assessment carried out at WGNSSK (Section 13.3.2) suggested that a "northern shelf" haddock as-

sessment would be dominated by data from the North Sea, but this needs further consideration.

2) The issue of XSA convergence has not been solved, and must be addressed at the earliest opportunity.

3) A longer time-series of discard data from UK(E&W) was made available this year (see Section 13.2). Its inclusion in the overall discard estimation procedure is a question that should be resolved.

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 (around 0.3) in 2011 and now fluctuating around the historical minimum. This is well below F_{pa} (0.7), and is also at or around the mortality rate recommended in the management plan (0.3) and most estimates of F_{msy}. Discards have increased slightly in 2011. Spawning stock biomass is predicted to decrease in the near future, but will still remain well above B_{pa} (140 kt). The 2006-2008 and 2010 year-classes were estimated to be weak, but the 2009 year-class is stronger.

Figure 13.10.1 gives the results of the North Sea stock survey from 2011 (Napier 2012). This shows that the industry perception is of increasing haddock abundance in all areas of the North Sea in 2011 (although the conclusions for the southern North Sea should be viewed with caution as research-vessel survey data indicate that haddock are not normally resident there).

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. Discards are predicted to increase in 2011 as the 2009 year class enters the fishery, although they are likely to fall again as this year class grows. 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 (ICES-WKMIXFISH 2010). 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.

References

Bailey, N., and Rätz, H. (Ed.), 2011. Report of the STECF SGMOS-10-05 Working Group on Fishing Effort Regimes Regarding Annexes IIA, IIB and IIC of TAC & Quota Regulations, Celtic Sea and Bay of Biscay. 27 September – 1 October 2010, Edinburgh, Scotland.

Coull, K. A., Jermyn, A. S., Newton, A. W., Henderson, G. I. and Hall, W. B. 1989. Length/weight relationships for 88 species of fish encountered in the North east Atlantic. *Scottish Fisheries Research Report* 43, ISSN 0308 8022.

Fernandes, P. G., Coull, K., Davis, C., Clark, P., Catarino, R., Bailey, N., Fryer, R. and Pout, A. (in press) Observations of discards in the Scottish mixed demersal trawl fishery. *ICES Journal of Marine Science*.

Hislop, J. R. G. 1988. The influence of maternal length and age on the size and weight of the eggs and relative fecundity of the haddock, *Melanogrammus aeglefinus*, in British waters. *Journal of Fish Biology* 32:923-930

Hislop, J. R. G. and Shanks, A. M. 1981. Recent investigations on the reproductive biology of the haddock, *Melanogrammus aeglefinus*, of the northern North Sea and the effects on fecundity of infection with the copepod parasite *Lernaeocera branchialis*. *Journal du Conseil International pour l'Exploration de la Mer* 39:244-251.

ICES-ACOM, 2010. Report of the ICES Advisory Committee, 2010. ICES Advice, 2010. Books 1 - 11.

ICES-WGMG, 2009. Report of the ICES Working Group on Methods of Fish Stock Assessment. ICES CM 2009/RMC:12.

ICES-WGSAM, 2008. Report of the Working Group on Multispecies Assessment Methods, Copenhagen, 6–10 October 2008. ICES C.M. 2008/RMC:06, 108 pp.

ICES-WKADSAM, 2010. Report of the Workshop on Reviews of Recent Advances in Stock Assessment Models World-wide: "Around the World in AD Models". ICES CM 2010/SSGSUE:10.

ICES-WKBENCH, 2011. Report of the Benchmark Workshop on Roundfishand Pelagic Stocks. ICES CM 2011/ACOM:38

Jaworski, A. 2011. Evaluation of methods for predicting mean weight-at-age: an application in forecasting yield of four haddock (*Melanogrammus aeglefinus*) stocks in the Northeast Atlantic. *Fisheries Research*, doi:10.1016/j.fishres.2011.01.017.

Millar, C. P. and Fryer, R. J. 2005. Revised estimates of annual discards-at-age for cod, haddock, whiting and saithe in ICES Sub-Area IV and Division VIa. *Fisheries Research Services Internal Report* No. 15/05. Marine Laboratory, Aberdeen, Scotland. 22 pp.

Needle, C. L., 2008a. Evaluation of interannual quota flexibility for North Sea haddock: Final report. Working paper for the ICES Advisory Committee (ACOM), September 2008.

Needle, C. L., 2008b. Management strategy evaluation for North Sea haddock. *Fisheries Research*, 94(2): 141–150.

Needle, C. L., 2010. Revised management strategy evaluation for North Sea haddock: July 2010. Working paper to ACOM.

Raitt, D. S. 1932. The fecundity of the haddock. *Fishery Board for Scotland Scientific Investigations* 1:1-43

Trippel, E. A. 1999. Estimation of stock reproductive potential: history and challenges for Canadian Atlantic gadoid stock assessments. *J. Northw. Atl. Fish. Sci.*, Vol. 25: 61–81.

Wright, P. J. and Gibb, F. M. 2005. Selection for birth date in North Sea haddock and its relation to maternal age. *Journal of Animal Ecology* 74:303-312

Wright, P. J., Gibb, F. M., Gibb, I. M. and Millar, C. P. (in press). Temporal and spatial variation in reproductive investment of haddock in the North Sea. *Marine Ecology Progress Series*.

Table 13.2.1.1. Haddock in Subarea IV and Division IIIa. Nominal landings (000 t) during 2002–2011, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2011 are preliminary. Quota up-take estimates are also given, calculated as the WG estimates of landings divided by available quota.

Country	Division	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Belgium	III a	0	0	0	0	0	0	0	0			
Denmark	III a	3791	1741	1116	615	1001	1054	1052	1263	1139	1648	
Germany	III a	239	113	69	69	186	206	87	105	65		
Netherlands	III a	0	6	1	0	0	0	0	0	1		
Norway	III a	149	211	154	93	113	152	170	121	125		
Portugal	III a	0	0	0	0	30	37	0	0			
Sweden	III a	393	165	158	180	246	278	276	166	126	193	
UK -E+W+NI	III a	0	0	0	0	0	0	0	0	0		
UK - Scot	III a	0	0	0	0	0	0	0	0	0		
Official landings	III a	4572	2236	1498	957	1576	1727	1585	1655	1456	1841	
WG landings	III a	4137	1808	1443	764	1537	1515	1374	1515	1287	9850	
WG discards	III a		195	112	217	970	816	646	556	608	1744	
WG total catch	III a	4137	2003	1555	981	2507	2332	2020	2072	1896	11595	
TAC	III a	6300	3150	4940	4018	3189	3360	2856	2590	2201	2095	
Belgium	IV	559	374	373	190	105	179	113	108	78	105	
Denmark	IV	5123	3035	2075	1274	759	645	501	553	725	698	
Faeroe Islands	IV	25	12	22	22	4	0	3	32	5		
France	IV	914	1108	552	439	444	498	448	125	277	237	
Germany	IV	852	1562	1241	733	725	727	393	657	634	575	
Netherlands	IV	359	187	104	64	33	55	29	24	41	72	
Norway	IV	2404	2196	2258	2089	1798	1706	1482	1278	1119	1188	
Poland	IV	17	16	0	0	8	8	16	0	0		
Portugal	IV	0	0	0	0	76	0	0	0			
Sweden	IV	572	477	188	135	100	130	83	141	90	128	
UK - E+W+NI	IV	3647	1561	1159	651	485	1799	1378	2155	2362		
UK – Scot	IV	39624	31527	39339	25319	31905	24919	25987	26238	22622		
UK – all	IV									24984	22648	
Official landings	IV	54096	42055	47311	30916	36442	30666	30433	31311	27953	25651	
WG landings	IV	54171	40140	47253	47616	36074	29418	28893	31264	27770	26275	
WG discards	IV	45892	23499	15439	8416	16943	27805	12532	9986	9515	10249	
WG IBC	IV	3717	1150	554	168	535	48	199	52	431	23	
WG total catch	IV	103780	64788	63246	56200	53551	57271	41624	41302	37717	36547	
TAC	IV	104000	51735	77000	66000	51850	54640	46444	42110	35794	34057	
WG landings	IV & IIIa	58308	41948	48697	48380	37611	30934	30267	32779	29058	36125	
WG discards	IV & IIIa	45892	23694	15550	8633	17913	28621	13178	10543	10124	11993	
WG IBC	IV & IIIa	3717	1150	554	168	535	48	199	52	431	23	
WG total catch	IV & IIIa	107917	66792	64800	57181	56058	59603	43644	43374	39612	48141	
TAC	IV & IIIa	110300	54885	81940	70018	55039	58000	49300	44700	37995	36152	41575
WG quota uptake		53%	76%	59%	69%	68%	53%	61%	73%	76%	100%	

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(N)				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
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

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. 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

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

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

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

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

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

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

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 – 2011	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

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 - 2011	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

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 - 2011	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

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 2012-05-01 09:35:23

CPUE data from x.idx

Catch data for 49 years. 1963 to 2011. Ages 0 to 6.

               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      2011   0.5 0.75
3 ScoGFS Aberdeen Q3         0        6       1982      1997   0.5 0.75
4      ScoGFS Q3 GOV         0        6       1998      2011   0.5 0.75
5            IBTS Q1         0        4       1982      2011  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
  all    1    1    1    1    1    1    1    1    1    1

Fishing mortalities
   year
age  2002  2003  2004  2005  2006  2007  2008  2009  2010  2011
  0 0.040 0.007 0.001 0.000 0.001 0.001 0.001 0.001 0.002 0.012
  1 0.127 0.106 0.051 0.053 0.046 0.038 0.040 0.024 0.037 0.042
  2 0.146 0.345 0.340 0.296 0.475 0.213 0.187 0.146 0.189 0.093
  3 0.189 0.159 0.305 0.434 0.573 0.592 0.162 0.218 0.293 0.372
  4 0.389 0.128 0.190 0.264 0.613 0.481 0.373 0.261 0.180 0.428
  5 0.184 0.197 0.154 0.208 0.412 0.405 0.189 0.202 0.191 0.297
  6 0.100 0.076 0.103 0.141 0.168 0.355 0.184 0.094 0.129 0.180
  7 0.048 0.033 0.024 0.059 0.100 0.102 0.121 0.126 0.063 0.181
  8 0.048 0.033 0.024 0.059 0.100 0.102 0.121 0.126 0.063 0.181
```

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
2002	3594830	352695	595011	1596507	23031	13400	12435	12895	17597
2003	3755801	444570	59671	344530	1029624	12159	9126	9217	8212
2004	3608561	480248	76813	28323	228831	705624	8173	6927	6487
2005	41942928	464178	87613	36652	16257	147375	495266	6038	2781
2006	8911436	5397792	84542	43669	18498	9723	97970	352328	2056
2007	5646237	1146347	989971	35249	19173	7803	5274	67828	77752
2008	4544929	726226	211922	536081	15186	9228	4260	3027	35981
2009	34698981	584395	133952	117875	354914	8148	6252	2902	8729
2010	1900441	4463934	109584	77617	73857	213016	5451	4657	6013
2011	680950	244094	826285	60814	45082	48058	144090	3925	2673

Estimated population abundance at 1st Jan 2012

year \ age	0	1	2	3	4	5	6	7	8
2012	31380	86609	44968	504624	32635	22890	29236	98526	2681

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	0.721	1.402	0.157	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	-0.106	0.313	0.545	0.383	0.104	-0.037	0.059	0.074	-0.446
3	-0.246	-0.818	0.126	0.571	0.820	0.364	0.307	0.168	0.226	-0.411	-0.516
4	0.364	0.169	-0.147	0.386	0.507	0.036	0.002	0.038	0.086	-0.223	-0.476
5	0.198	0.196	-0.093	0.266	0.049	0.182	-0.069	-0.169	0.485	0.052	-0.497
6	0.224	-0.695	-0.403	0.203	-1.043	1.539	-0.721	0.280	-0.205	-0.052	-0.171

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	0.170	0.033	-0.114	-0.682
4	-0.165	0.001	-0.039	-0.537
5	0.125	-0.401	-0.198	-0.125
6	0.954	0.156	0.927	-0.993

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	-16.9657	-15.5105	-15.0289	-15.2010	-15.3322	-15.4965	-15.9091
S.E_Logq	0.5677	0.3304	0.3666	0.4624	0.2919	0.2595	0.7391

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
0,	.86,	.852,	16.96,	.73,	15,	.49,	-16.97,
1,	1.02,	-.197,	15.53,	.84,	15,	.35,	-15.51,
2,	.84,	1.623,	14.70,	.89,	15,	.29,	-15.03,
3,	.86,	1.387,	14.73,	.88,	15,	.38,	-15.21,
4,	.94,	.780,	15.07,	.93,	15,	.28,	-15.35,
5,	1.02,	-.263,	15.65,	.92,	15,	.27,	-15.52,
6,	.98,	.075,	15.83,	.61,	15,	.75,	-15.96,

1

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

Fleet: EngGFS Q3 GOV

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	1.214	0.576	1.047	0.793	0.499	0.601	-0.102	0.971	0.708	-1.489
1	0.300	0.122	0.173	0.226	0.171	0.293	0.267	0.062	0.095	-0.409
2	0.491	0.041	-0.063	0.349	-0.026	0.109	0.122	0.060	-0.304	-0.253
3	0.387	0.080	-0.498	0.232	0.237	0.205	-0.081	-0.175	-0.278	0.538
4	-0.284	-0.398	-0.148	-0.141	-0.109	-0.121	-0.149	-0.186	-0.444	0.176
5	0.084	0.264	-0.116	0.095	-0.085	0.135	-0.049	0.002	-0.496	-0.111
6	1.272	-1.935	-0.590	0.119	0.409	0.099	-0.364	-0.510	0.037	-0.488

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	-0.827	-0.729	-0.633	0.498	-0.207	-0.168	-1.126	-0.753	-0.094	-0.781
1	-0.113	0.062	0.044	0.468	-0.270	-0.358	-0.393	-0.346	-0.248	-0.146
2	-0.122	-0.594	0.281	0.561	0.089	0.065	-0.423	0.167	-0.435	-0.115
3	-0.035	0.012	-0.838	0.737	-0.173	0.262	-0.145	0.018	-0.307	-0.178
4	-0.123	0.335	-0.008	0.982	-0.005	0.259	0.577	-0.359	-0.029	0.176
5	-1.056	1.053	0.152	0.785	-0.171	-0.430	0.330	-0.440	-0.172	0.226
6	-0.026	-1.503	0.746	-0.511	-0.319	0.318	0.988	0.224	1.436	0.599

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	-16.5775	-14.7880	-14.3228	-14.4755	-14.7410	-15.1460	-15.6983
S.E_Logq	0.8013	0.2663	0.3024	0.3592	0.3438	0.4497	0.8354

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
0,	.67,	4.542,	16.46,	.92,	19,	.37,	-16.54,
1,	.98,	.402,	14.78,	.95,	19,	.26,	-14.79,
2,	1.00,	-.014,	14.33,	.93,	19,	.32,	-14.33,
3,	1.00,	-.052,	14.51,	.90,	19,	.37,	-14.50,
4,	1.03,	-.485,	14.94,	.93,	19,	.35,	-14.81,
5,	.96,	.582,	15.02,	.91,	19,	.46,	-15.25,
6,	1.14,	-.973,	16.62,	.76,	18,	.82,	-15.75,

Fleet: ScoGFS Aberdeen Q3

age \ year	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	-0.104	-0.437	0.169	-0.045	-0.761	0.095	0.016	0.155	-0.521
2	0.288	0.173	-0.107	-0.034	0.007	-0.272	-0.063	0.132	-0.204	-0.662
3	0.233	0.604	0.001	0.066	-0.096	-0.081	0.008	0.147	-0.260	-1.032
4	0.026	0.615	0.187	0.350	-0.086	0.023	0.233	0.079	-0.005	-0.622
5	-1.084	0.577	0.092	0.101	0.438	-0.033	-0.115	-0.194	0.133	-0.486
6	-0.282	0.145	-0.087	0.104	-0.233	0.013	0.004	0.062	-0.260	0.161

age \ year	1992	1993	1994	1995	1996	1997
0	0.993	-0.101	1.208	0.435	0.238	0.040
1	0.317	0.340	-0.023	0.337	0.434	0.248
2	-0.226	0.196	0.066	0.150	0.453	0.103
3	-0.432	-0.059	-0.206	0.527	0.263	0.318
4	-0.420	-1.008	-0.205	0.214	0.361	0.260
5	0.178	0.385	-0.877	0.416	0.280	0.190
6	0.107	0.346	-0.101	0.049	0.005	-0.033

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	-12.8416	-10.6270	-10.1073	-10.3409	-10.6018	-10.8444	-11.0717
S.E_Logq	0.6020	0.3411	0.2625	0.3893	0.4057	0.4664	0.1666

Table 13.3.5.1 (cont). Haddock in Subarea IV and Division IIIa. XSA final assessment: Tuning diagnostics.

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
0,	.86,	.755,	13.38,	.69,	16,	.53,	-12.85,
1,	1.17,	-1.297,	9.91,	.80,	16,	.39,	-10.63,
2,	.92,	1.042,	10.35,	.92,	16,	.24,	-10.11,
3,	.79,	2.881,	10.69,	.93,	16,	.25,	-10.35,
4,	.76,	3.963,	10.64,	.95,	16,	.22,	-10.62,
5,	.95,	.411,	10.81,	.83,	16,	.45,	-10.88,
6,	.99,	.283,	11.11,	.98,	16,	.15,	-11.14,

Fleet: ScoGFS Q3 GOV

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	0.146	0.538	0.478	-2.303	0.754	0.694	0.509	0.489	-0.119	-0.374
1	0.879	-0.057	0.037	-0.389	0.160	0.467	0.379	-0.040	-0.240	-0.087
2	0.050	0.158	-0.496	-0.299	-0.176	0.099	0.420	0.445	-0.290	0.099
3	-0.041	0.312	-0.120	-0.135	-0.044	0.273	-0.169	0.069	0.012	-0.062
4	-0.075	0.125	-0.018	-0.203	-0.004	0.162	0.036	0.737	-0.397	0.031
5	-0.139	0.164	0.130	-0.127	0.134	-0.281	-0.202	-0.011	-0.376	-0.401
6	-0.050	-0.035	-0.154	-0.131	0.206	0.444	-0.065	-0.163	-0.415	-0.058

age \ year	2008	2009	2010	2011
0	0.365	-0.104	-1.560	0.487
1	-0.533	-0.146	0.079	-0.510
2	-0.084	-0.256	0.189	0.142
3	-0.020	-0.114	-0.105	0.143
4	-0.514	0.010	0.166	-0.056
5	0.077	0.642	0.459	-0.069
6	0.232	0.080	-0.455	0.565

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	-11.4865	-9.9217	-9.5093	-9.7268	-9.9991	-10.3911	-11.1624
S.E_Logq	0.8927	0.3878	0.2775	0.1493	0.2891	0.2978	0.2878

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
0,	.77,	1.549,	12.56,	.80,	13,	.66,	-11.52,
1,	1.05,	-.581,	9.66,	.91,	13,	.39,	-9.89,
2,	1.10,	-1.325,	9.26,	.94,	13,	.30,	-9.54,
3,	.96,	1.227,	9.86,	.99,	13,	.14,	-9.78,
4,	.95,	.788,	10.12,	.96,	13,	.30,	-10.07,
5,	.95,	.789,	10.49,	.96,	13,	.31,	-10.49,
6,	1.05,	-.885,	11.43,	.97,	13,	.25,	-11.35,

Fleet: IBTS Q1

Log catchability residuals.

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	-0.333	-0.262	-0.449	0.130	-0.135	0.144	0.212	0.170	0.122	0.678	0.349
1	-0.118	-0.293	-0.189	0.103	-0.099	-0.125	0.443	0.062	0.071	-0.246	0.228
2	-0.049	-0.200	0.068	-0.172	-0.232	0.005	0.172	0.424	-0.130	-0.801	0.118
3	0.006	-0.017	-0.055	-0.215	-0.039	0.120	0.097	0.001	0.078	-0.661	0.223
4	0.079	-0.148	-0.250	-0.097	0.228	0.141	0.070	0.183	-0.166	-0.388	-0.095

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	-0.171	0.137	-0.071	0.645	0.287	0.006	0.196	0.491	-0.023	0.197	-0.105
1	-0.217	0.050	-0.073	0.473	0.263	0.140	-0.423	0.009	0.117	-0.074	0.381
2	-0.239	-0.282	-0.161	0.222	0.069	0.068	-0.309	0.033	0.161	0.004	0.584
3	-0.208	-0.055	-0.225	0.285	-0.056	0.369	-0.177	-0.262	-0.270	-0.007	0.377
4	-0.089	-0.232	0.219	-0.014	0.410	0.104	0.053	-0.090	0.252	0.098	0.160

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
0	-0.102	-0.157	-1.056	-0.698	-0.262	-0.078	0.134	0.005
1	-0.017	-0.435	-0.835	-0.343	0.387	-0.079	0.278	0.564
2	0.258	-0.325	-0.244	-0.447	0.220	0.223	0.846	0.119
3	0.205	-0.320	-0.395	0.624	-0.311	0.284	0.405	0.197
4	0.006	-0.200	-0.431	-0.864	-0.260	0.061	0.896	0.368

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 -13.3175 -11.8665 -11.8752 -12.1685 -12.4344
S.E_Logq    0.3582   0.3083   0.3194   0.2798   0.3095

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

  0,     .93,    1.271,     13.49,     .93,     29,     .29,  -13.28,
  1,    1.04,    -.771,     11.74,     .94,     29,     .25,  -11.84,
  2,    1.13,   -1.929,     11.74,     .90,     29,     .35,  -11.85,
  3,    1.06,   -1.162,     12.18,     .93,     29,     .29,  -12.16,
  4,     .93,    1.482,     12.35,     .94,     29,     .29,  -12.46,

Terminal year survivor and F summaries:

 Age 0 Year class =2011

source
              scaledWts survivors yrcls
EngGFS Q3 GOV     0.142     39668  2011
ScoGFS Q3 GOV     0.112    140912  2011
IBTS Q1           0.722     87026  2011
fshk              0.024    767321  2011

 Age 1 Year class =2010

source
              scaledWts survivors yrcls
EngGFS Q3 GOV     0.400     38865  2010
ScoGFS Q3 GOV     0.224     27015  2010
IBTS Q1           0.367     79010  2010
fshk              0.009     45084  2010

 Age 2 Year class =2009

source
              scaledWts survivors yrcls
EngGFS Q3 GOV     0.333    449603  2009
ScoGFS Q3 GOV     0.355    581566  2009
IBTS Q1           0.303    568107  2009
fshk              0.009    177408  2009

 Age 3 Year class =2008

source
              scaledWts survivors yrcls
EngGFS Q3 GOV     0.246     27318  2008
ScoGFS Q3 GOV     0.371     37652  2008
IBTS Q1           0.371     39720  2008
fshk              0.012     32806  2008
```

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

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

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

Table 13.6.1. Haddock in Subarea IV and Division IIIa. Short-term forecast input.

MFDP version 1a
Run: rerun1pa
Time and date: 15:34 02/05/2012
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4
Fbar age range Fleet 2 : 2-4

2012						
Age	N	M	Mat	PF	PM	SWt
0	3604229	2.05	0	0	0	0.032
1	86616	1.65	0.01	0	0	0.155
2	44950	0.4	0.32	0	0	0.289
3	504688	0.25	0.71	0	0	0.399
4	32649	0.25	0.87	0	0	0.544
5	22885	0.2	0.95	0	0	0.574
6	29236	0.2	1	0	0	0.59
7	98538	0.2	1	0	0	0.732
8	6789	0.2	1	0	0	1.181

Catch				
Age	Sel	CWt	DSel	DCWt
0	0.001	0	0.005	0.032
1	0.002	0.329	0.039	0.146
2	0.055	0.424	0.129	0.231
3	0.247	0.426	0.112	0.286
4	0.308	0.544	0.04	0.393
5	0.27	0.52	0.01	0.412
6	0.162	0.709	0.001	0.397
7	0.149	0.749	0.001	0.531
8	0.148	1.041	0.001	0.734

IBC		
Age	Sel	CWt
0	0	0.0317
1	0.001	0.192
2	0.002	0.2732
3	0.001	0.3022
4	0	0.3228
5	0	0.4266
6	0	0.4385
7	0	0.4528
8	0	0.4945

Table 13.6.1 (cont). Haddock in Subarea IV and Division IIIa. Short-term forecast input.

2013

Age	N	M	Mat	PF	PM	SWt
0	3604229	2.05	0	0	0	0.032
1	.	1.65	0.01	0	0	0.155
2	.	0.4	0.32	0	0	0.289
3	.	0.25	0.71	0	0	0.378
4	.	0.25	0.87	0	0	0.526
5	.	0.2	0.95	0	0	0.666
6	.	0.2	1	0	0	0.675
7	.	0.2	1	0	0	0.677
8	.	0.2	1	0	0	0.841

2014

Age	N	M	Mat	PF	PM	SWt
0	3604229	2.05	0	0	0	0.032
1	.	1.65	0.01	0	0	0.155
2	.	0.4	0.32	0	0	0.289
3	.	0.25	0.71	0	0	0.378
4	.	0.25	0.87	0	0	0.425
5	.	0.2	0.95	0	0	0.653
6	.	0.2	1	0	0	0.787
7	.	0.2	1	0	0	0.775
8	.	0.2	1	0	0	0.878

Catch

Age	Sel	CWt	DSel	DCWt
0	0.001	0	0.005	0.032
1	0.002	0.329	0.039	0.146
2	0.055	0.424	0.129	0.231
3	0.247	0.426	0.112	0.283
4	0.308	0.441	0.04	0.371
5	0.27	0.666	0.01	0.476
6	0.162	0.555	0.001	0.478
7	0.149	0.785	0.001	0.45
8	0.148	0.829	0.001	0.605

Catch

Age	Sel	CWt	DSel	DCWt
0	0.001	0	0.005	0.032
1	0.002	0.329	0.039	0.146
2	0.055	0.424	0.129	0.231
3	0.247	0.426	0.112	0.283
4	0.308	0.441	0.04	0.298
5	0.27	0.559	0.01	0.456
6	0.162	0.787	0.001	0.559
7	0.149	0.59	0.001	0.544
8	0.148	0.887	0.001	0.614

IBC

Age	Sel	CWt
0	0	0.0317
1	0.001	0.192
2	0.002	0.2732
3	0.001	0.3022
4	0	0.3228
5	0	0.4266
6	0	0.4385
7	0	0.4528
8	0	0.4945

IBC

Age	Sel	CWt
0	0	0.0317
1	0.001	0.192
2	0.002	0.2732
3	0.001	0.3022
4	0	0.3228
5	0	0.4266
6	0	0.4385
7	0	0.4528
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.

MFDP version 1a
Run: rerun1
Time and date: 14:50 02/05/2012
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4
Fbar age range Fleet 2 : 2-4

2012

		Catch			Landings		Discards		IBC	Landings	
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield
471416	272592	0.6579	0.196	51505	0.134	41575	0.062	9782	1	0.001	148

2013												2014		2012 TAC	41575
		Catch			Landings		Discards		IBC	Landings					
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	TAC change	Basis
469065	254836	0.00	0.001	58	0.000	0	0.000	0	1	0.001	58	478007	263831	-100%	Zero catch
.	254836	0.10	0.031	6233	0.020	5494	0.009	681	1	0.001	58	470500	256770	-87%	
.	254836	0.20	0.060	12235	0.041	10834	0.019	1344	1	0.001	57	463219	249923	-74%	
.	254836	0.30	0.090	18071	0.061	16022	0.028	1992	1	0.001	57	456155	243283	-61%	
.	254836	0.40	0.120	23746	0.081	21066	0.038	2623	1	0.001	57	449304	236844	-49%	
.	254836	0.50	0.149	29171	0.101	25885	0.047	3229	1	0.001	57	442768	230704	-38%	0.5 * F(sq)
.	254836	0.50	0.150	29264	0.102	25968	0.047	3239	1	0.001	57	442656	230599	-38%	
.	254836	0.60	0.179	34629	0.122	30733	0.056	3840	1	0.001	56	436206	224541	-26%	
.	254836	0.70	0.209	39848	0.142	35365	0.066	4427	1	0.001	56	429948	218666	-15%	15% TAC decrease
	254836	0.75	0.224	42429	0.153	37655	0.070	4718	1	0.001	56	426860	215768	-9%	0.75 * F(sq)
.	254836	0.80	0.239	44924	0.163	39869	0.075	4999	1	0.001	56	423875	212966	-4%	
.	254836	0.84	0.250	46848	0.171	41575	0.079	5217	1	0.001	56	421579	210812	0%	Rollover TAC
.	254836	0.90	0.268	49862	0.183	44248	0.084	5558	1	0.001	56	417981	207437	6%	0.9 * F(sq)
.	254836	0.98	0.293	53882	0.200	47811	0.092	6015	1	0.001	56	413195	202949	15%	15% TAC increase
.	254836	1.00	0.298	54667	0.203	48507	0.094	6104	1	0.001	56	412261	202073	17%	Status quo
.	254836	1.01	0.300	54982	0.205	48786	0.094	6140	1	0.001	56	411887	201723	17%	F(msy)
.	254836	1.10	0.328	59341	0.224	52648	0.103	6638	1	0.001	55	406709	196869	27%	
.	254836	1.20	0.357	63890	0.244	56676	0.112	7159	1	0.001	55	401319	191819	36%	
	254836	1.25	0.373	66215	0.255	58734	0.117	7426	1	0.001	55	398571	189245	41%	1.25 * F(sq)
.	254836	1.30	0.387	68317	0.264	60594	0.122	7668	1	0.001	55	396088	186918	46%	
.	254836	1.40	0.417	72626	0.285	64405	0.131	8166	1	0.001	55	391008	182163	55%	
.	254836	1.50	0.447	76818	0.305	68112	0.141	8652	1	0.001	54	386077	177547	64%	
.	254836	1.60	0.476	80902	0.325	71720	0.150	9128	1	0.001	54	381288	173068	73%	
.	254836	1.70	0.506	84877	0.346	75230	0.159	9593	1	0.001	54	376637	168720	81%	
.	254836	1.80	0.536	88747	0.366	78645	0.169	10048	1	0.001	54	372121	164500	89%	
.	254836	1.90	0.565	92516	0.386	81969	0.178	10493	1	0.001	54	367735	160402	97%	
.	254836	2.00	0.595	96187	0.407	85205	0.187	10929	1	0.001	53	363474	156424	105%	
.	254836	2.35	0.700	108194	0.479	95766	0.220	12376	1	0.001	53	349648	143538	130%	F(pa)
.	254836	2.50	0.744	113169	0.508	100141	0.234	12975	1	0.001	53	343920	138199	141%	
.	254836	3.00	0.892	128100	0.610	113224	0.281	14824	1	0.001	52	326965	122443	172%	
.	254836	3.50	1.041	141269	0.712	124713	0.328	16505	1	0.001	51	312227	108795	200%	
.	254836	4.00	1.189	152917	0.813	134826	0.375	18041	1	0.001	50	299385	96948	224%	
.	254836	4.50	1.338	163253	0.915	143752	0.422	19452	1	0.001	49	288163	86643	246%	
.	254836	5.00	1.486	172457	1.017	151651	0.468	20757	1	0.001	49	278331	77658	265%	

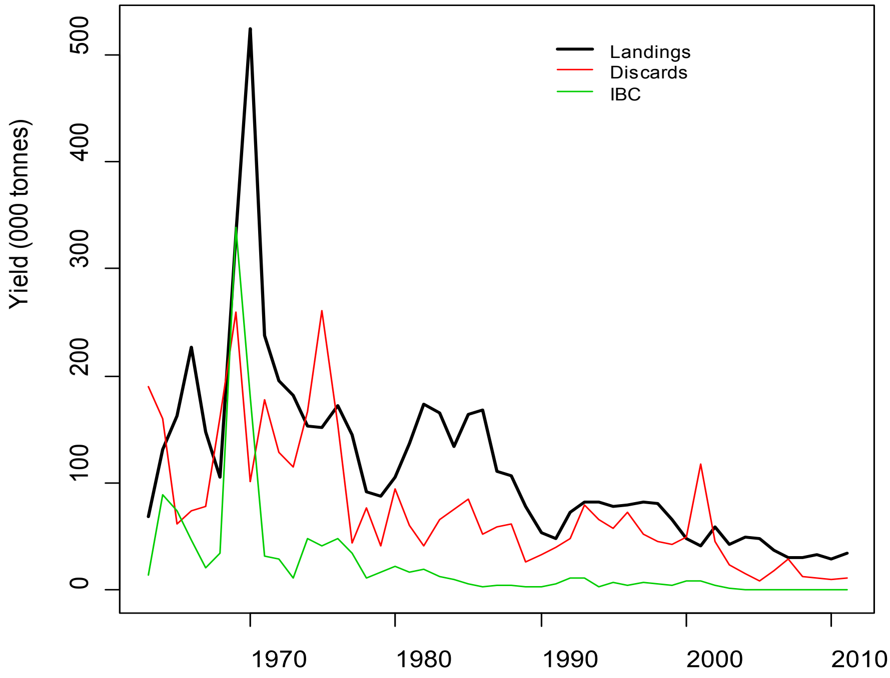


Figure 13.2.1.1. Haddock in Subarea IV and Division IIIa. Yield by catch component.

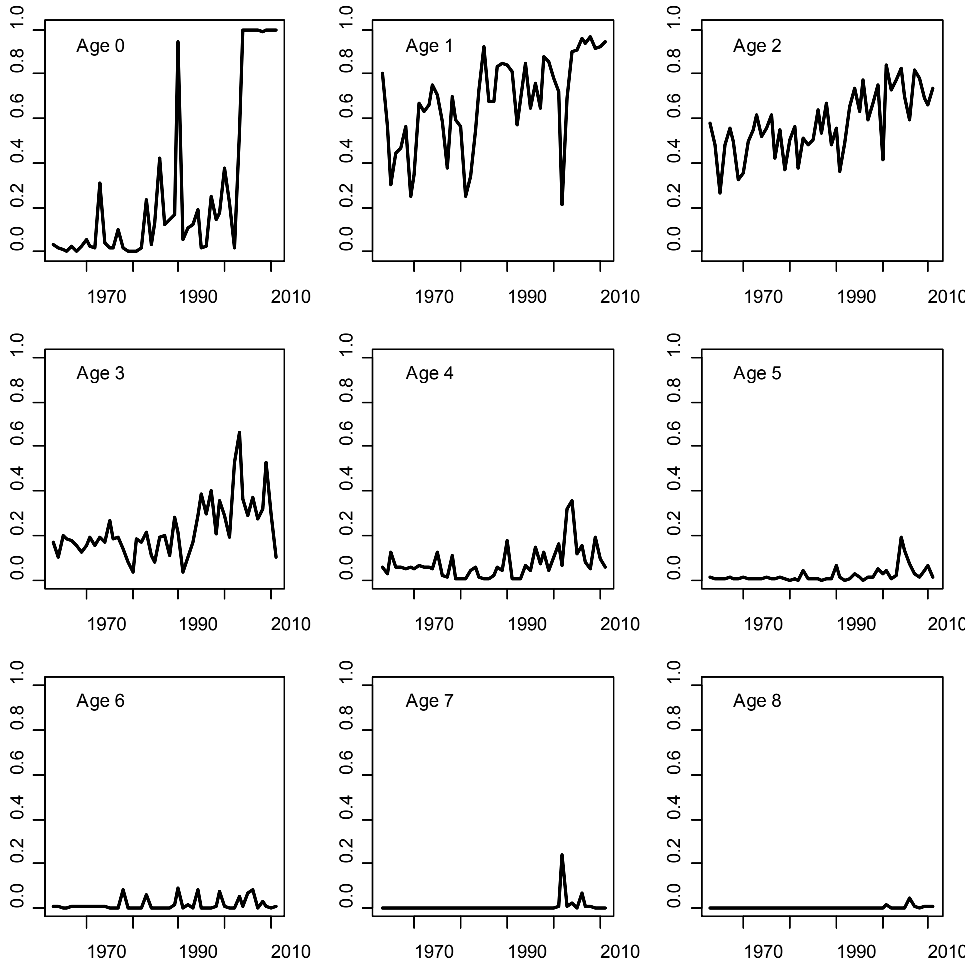


Figure 13.2.1.2. Haddock in Subarea IV and Divisions IIIa. Proportion of total catch discarded, by age and year.

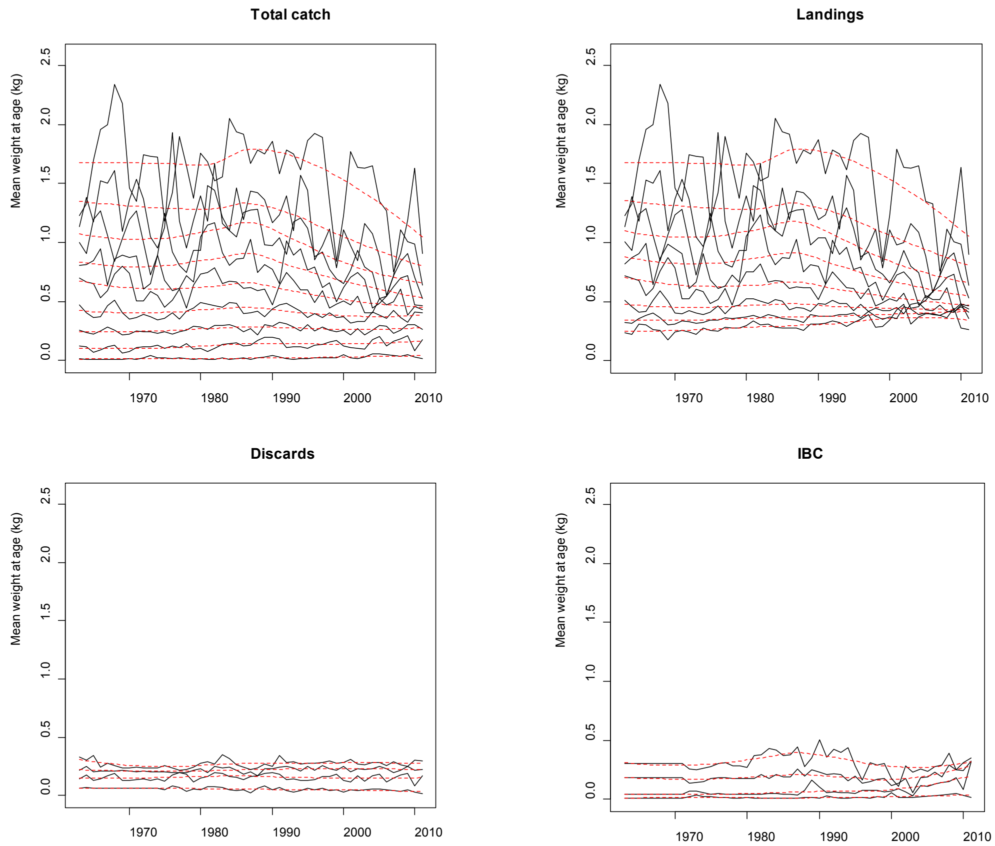


Figure 13.2.3.1. Haddock in Subarea IV and Division IIIa. Mean weights-at-age (kg) by catch component. Catch mean weights are also used as stock mean weights. Red dotted lines give loess smoothers through each time-series of mean weights-at-age.

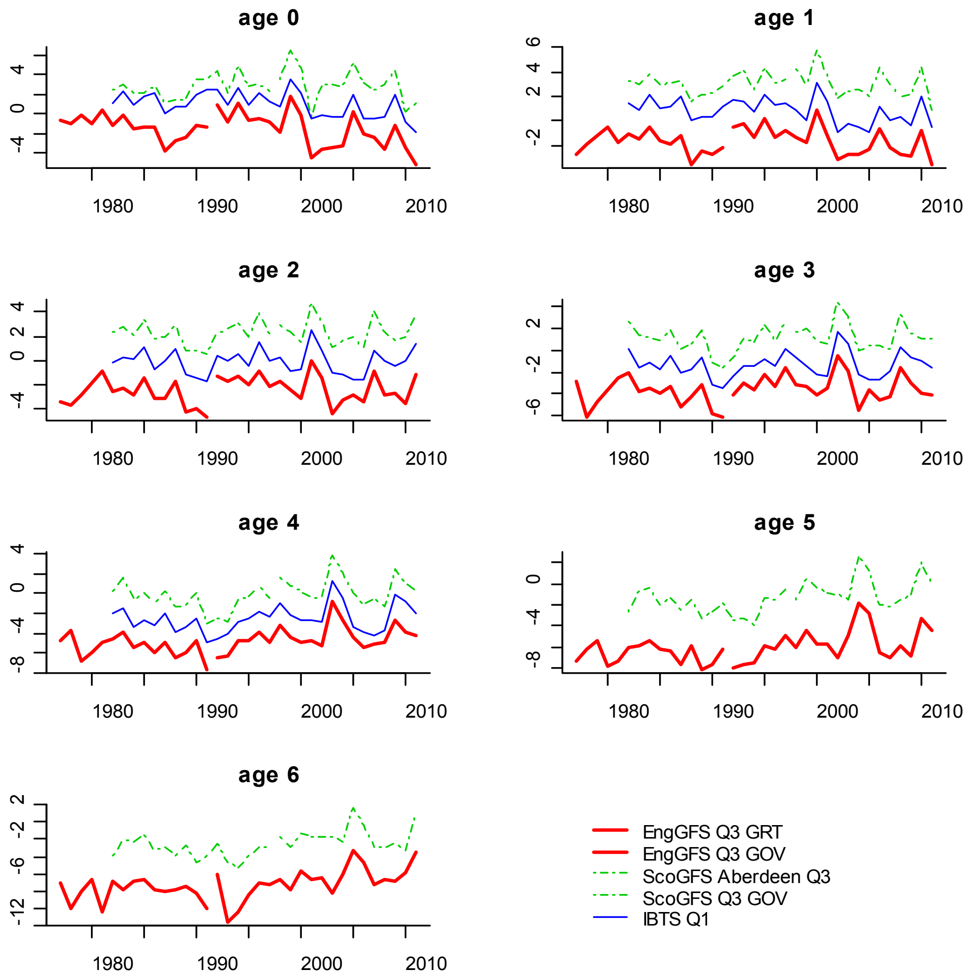


Figure 13.2.6.2. Haddock in Subarea IV and Division IIIa. Survey log CPUE (catch per unit effort) at age.

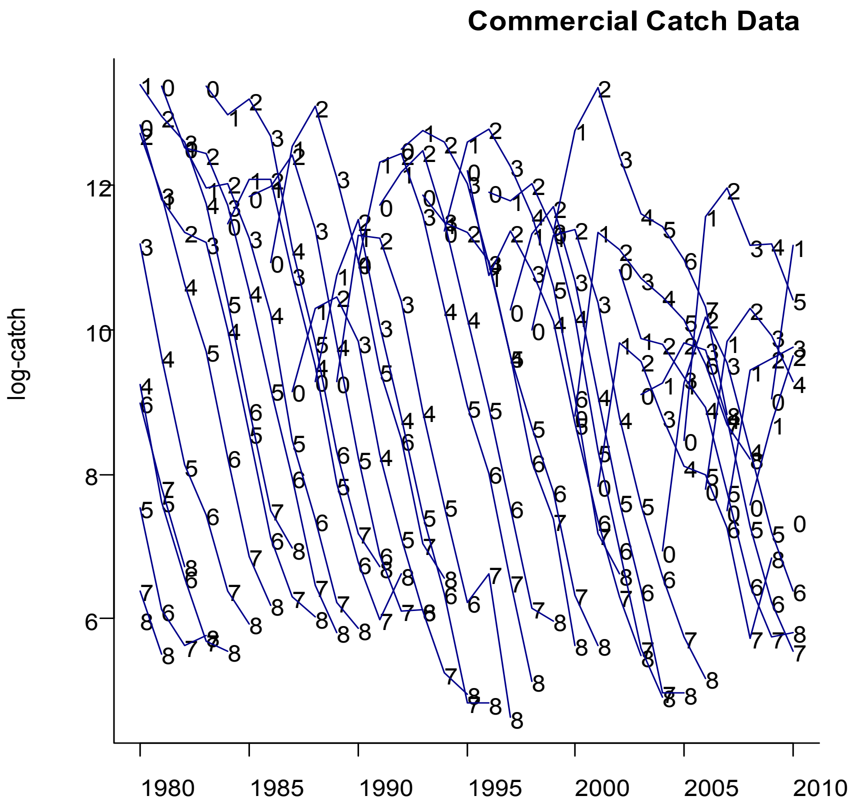


Figure 13.3.2.1. Haddock in Subarea IV and Division IIIa. Log catch curves by cohort for total catches.

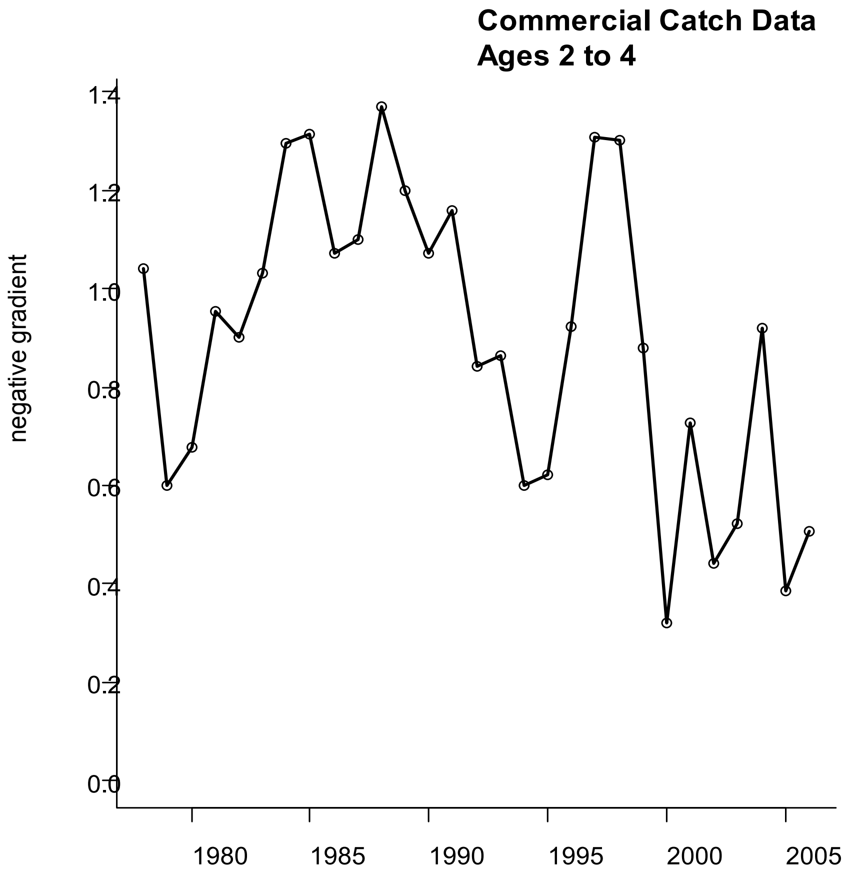


Figure 13.3.2.2. Haddock in Subarea IV and Division IIIa. Negative gradients of log catches per cohort, averaged over ages 2-4. The x-axis represents the spawning year of each cohort.

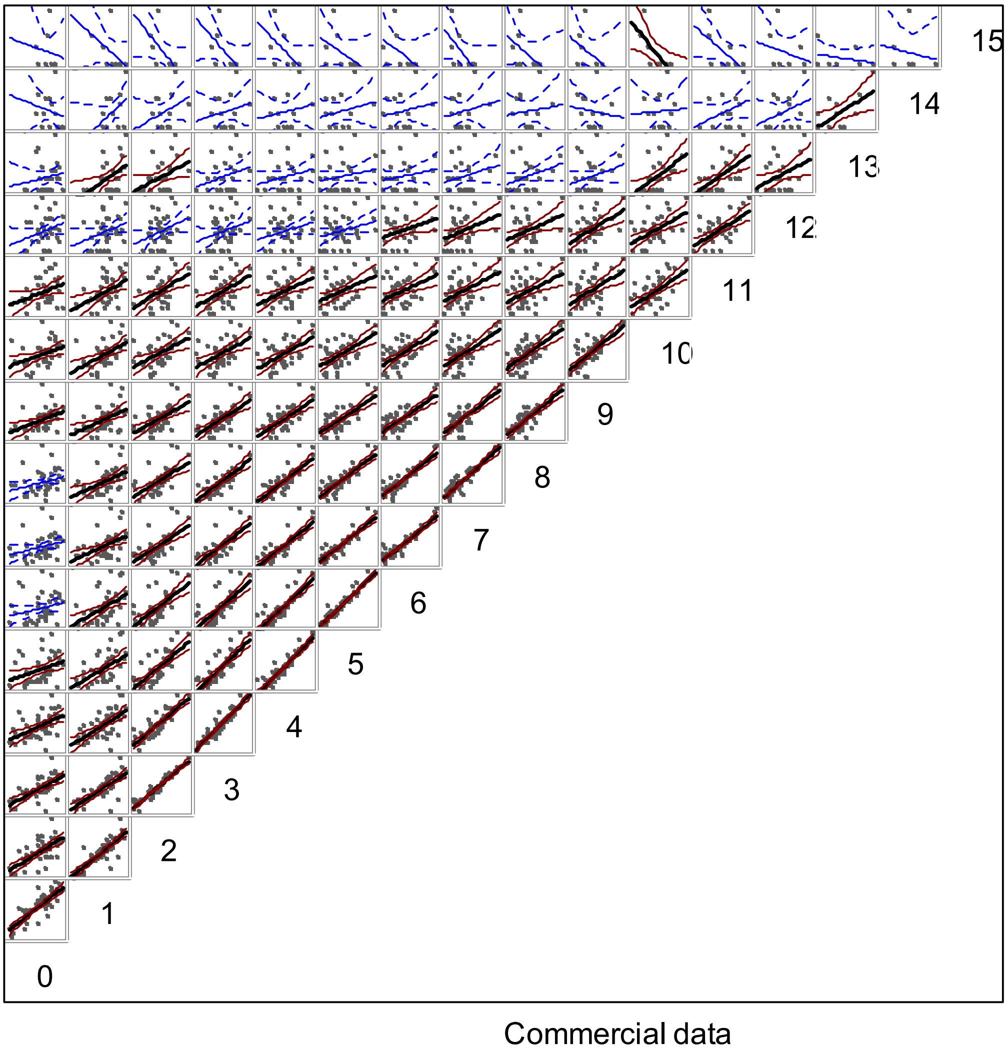


Figure 13.3.2.3. Haddock in Subarea IV and Division IIIa. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and 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.

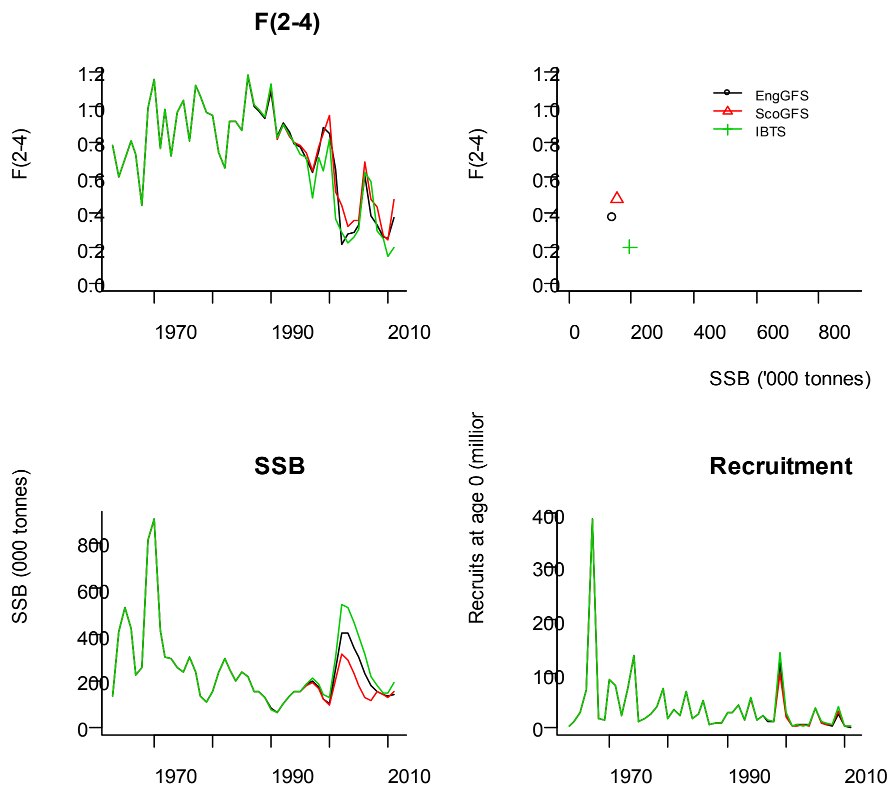


Figure 13.3.2.5. Haddock in Subarea IV and Division IIIa. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2011) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

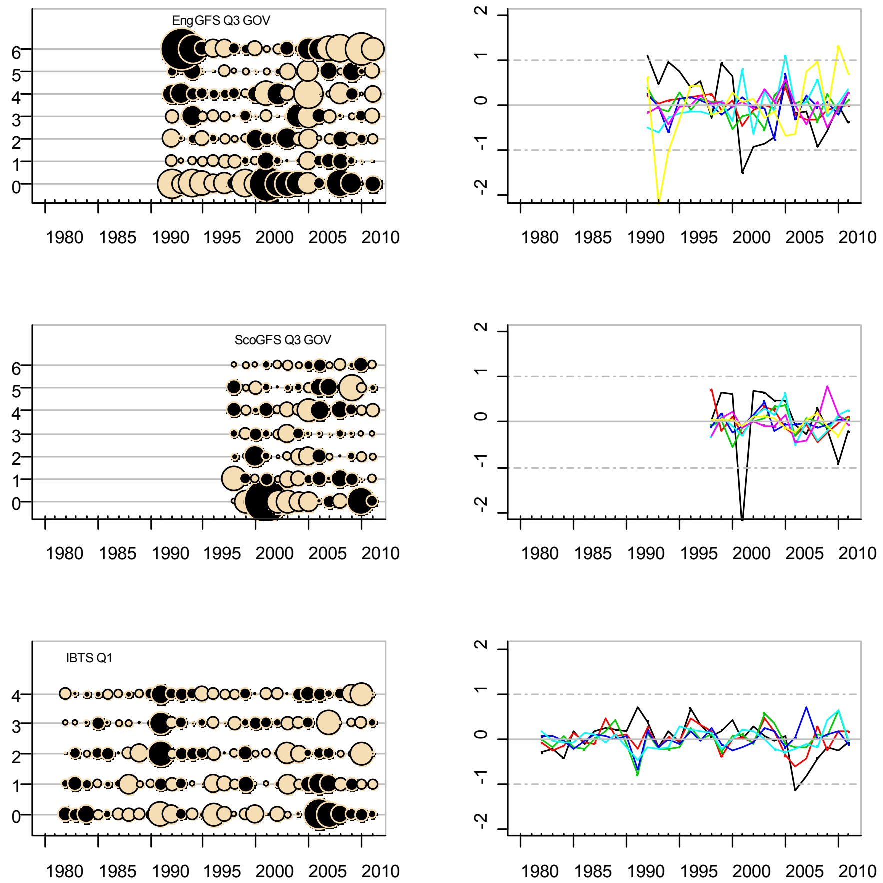


Figure 13.3.2.6. Haddock in Subarea IV and Division IIIa. Log catchability residuals from single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here.

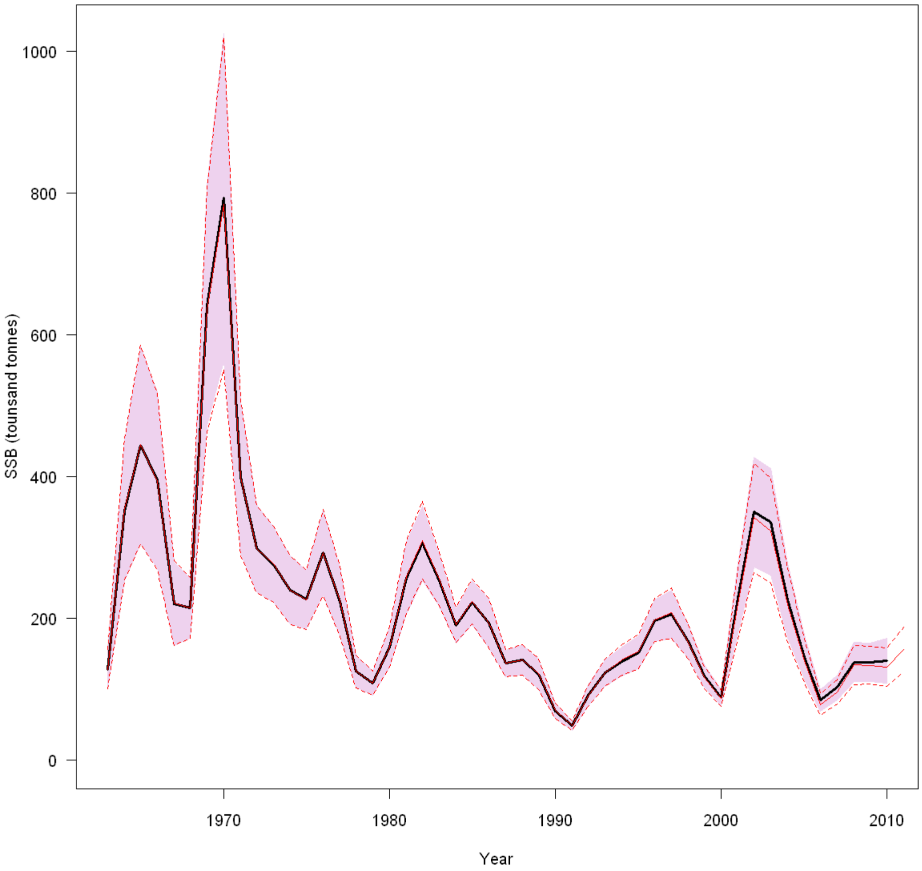


Figure 13.3.2.7. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated SSB (black line) along with 95% confidence interval.

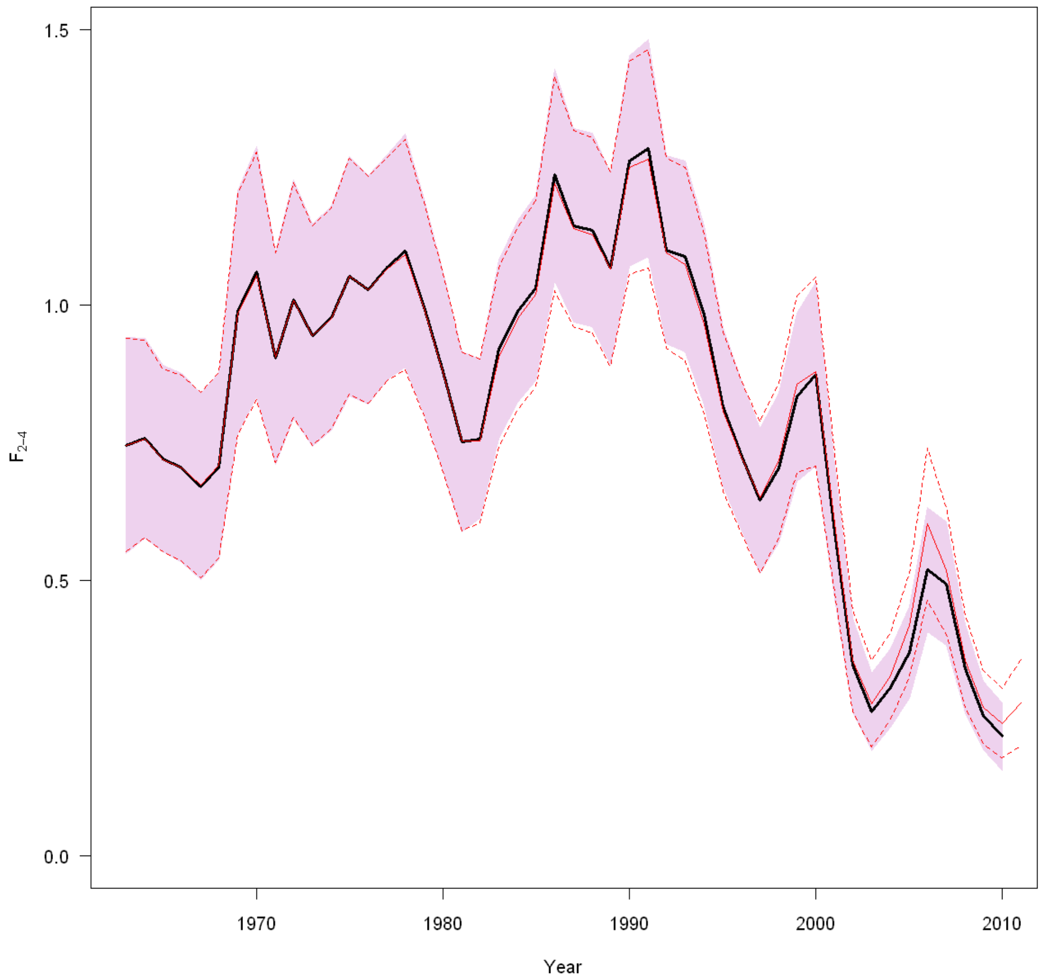


Figure 13.3.2.8. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated mean F(2-4) (black line) along with 95% confidence interval.

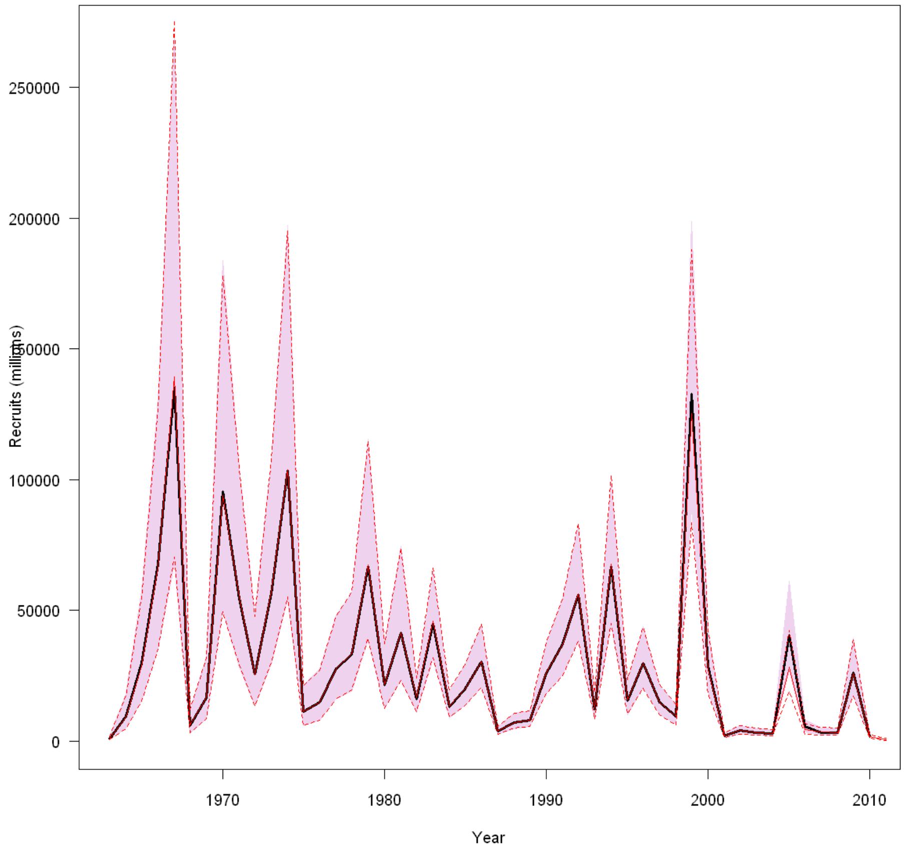


Figure 13.3.2.9. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated recruitment at age 0 (black line) along with 95% confidence interval.

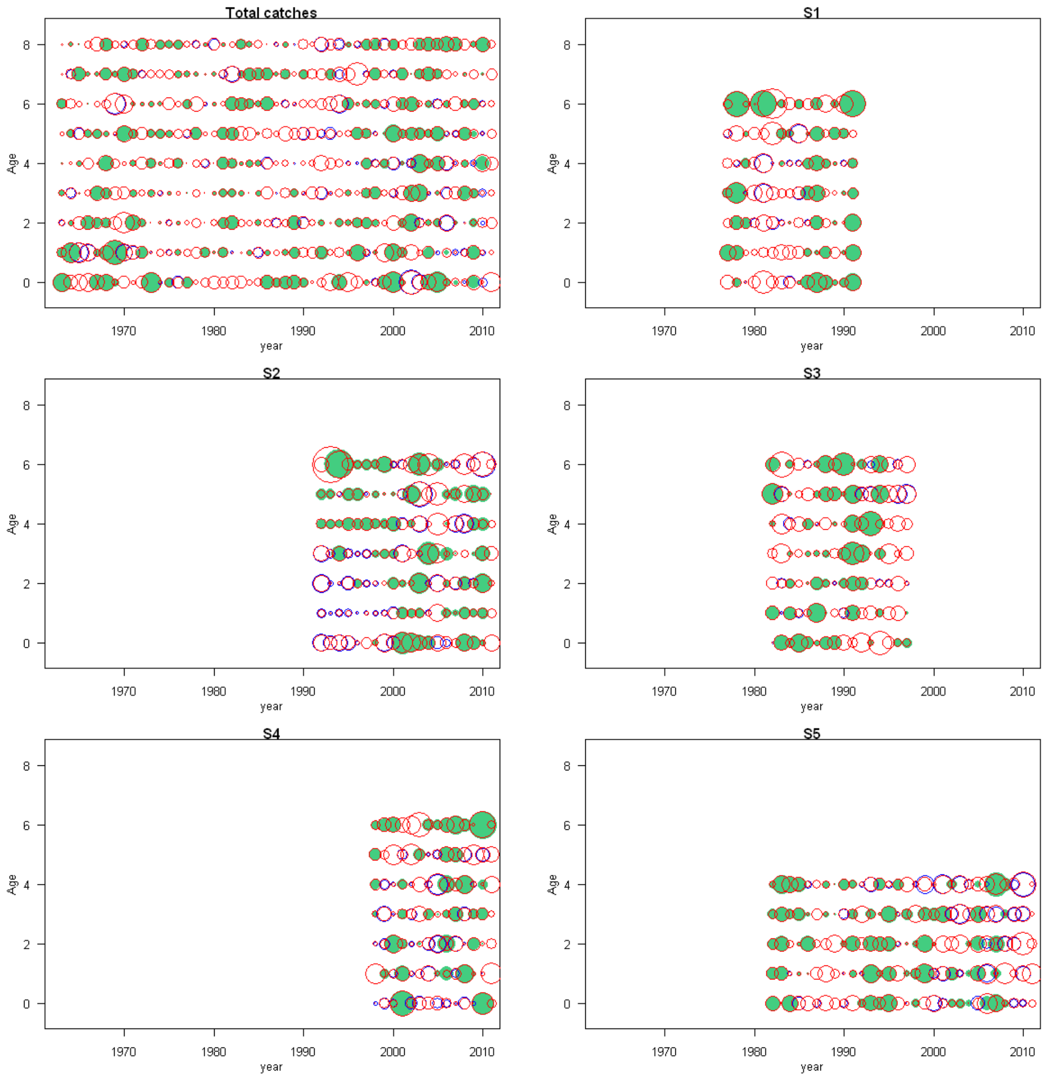


Figure 13.3.2.10. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: log residuals (open points = positive values, closed points = negative values).

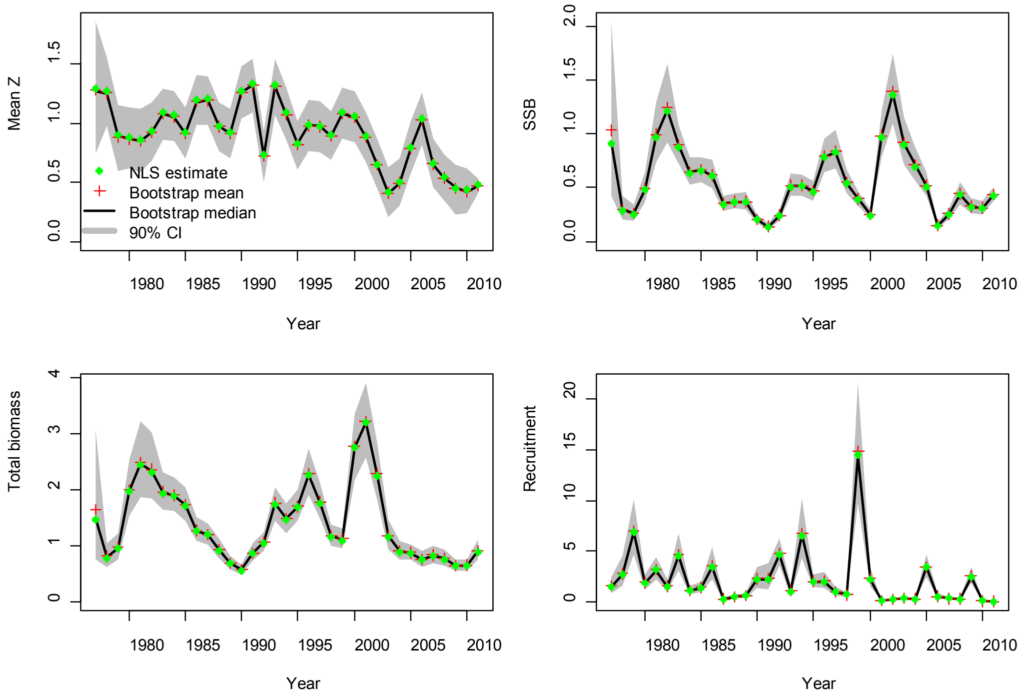


Figure 13.3.3.1. Haddock in Subarea IV and Division IIIa. Summary plots from an exploratory SURBAR assessment, using all available surveys (EngGFS Q3, ScoGFS Q3, IBTS Q1). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded 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.

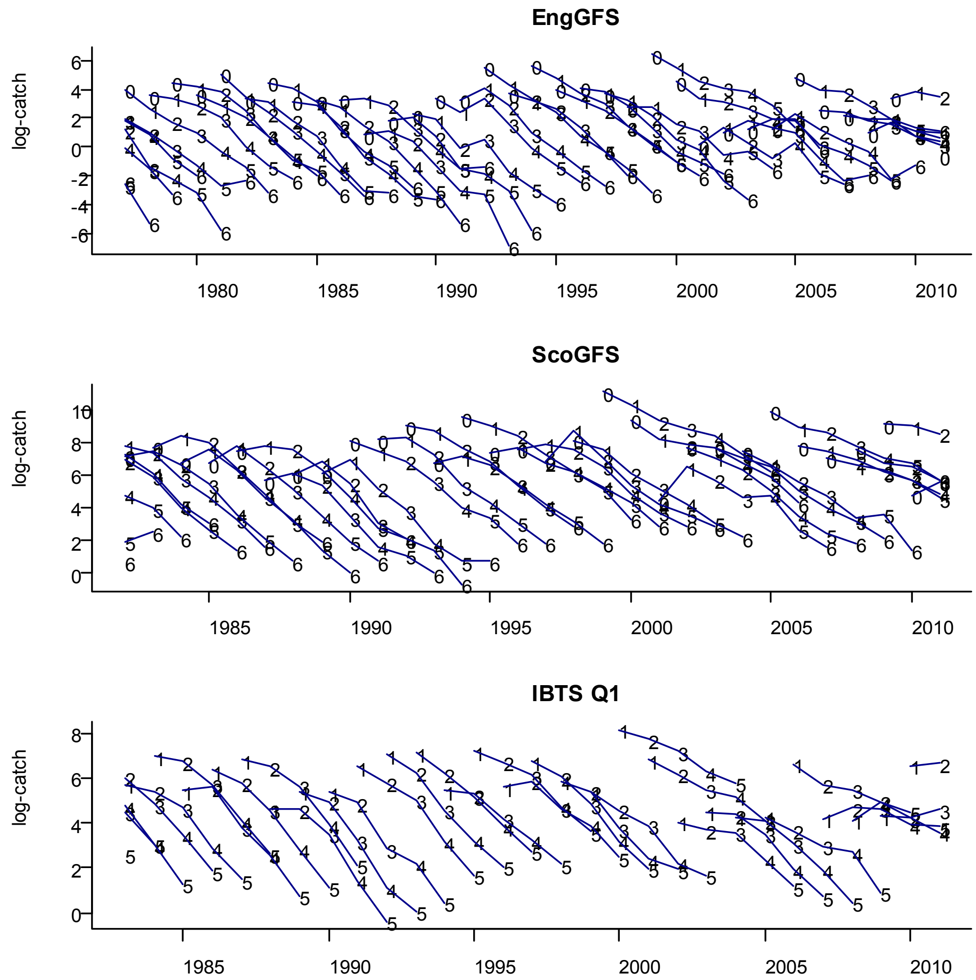


Figure 13.3.3.2. Haddock in Subarea IV and Division IIIa. Log abundance indices by cohort for each of the five survey indices. The separate sections of the ScoGFS and EngGFS Q3 surveys have been combined for the purposes of this plot.

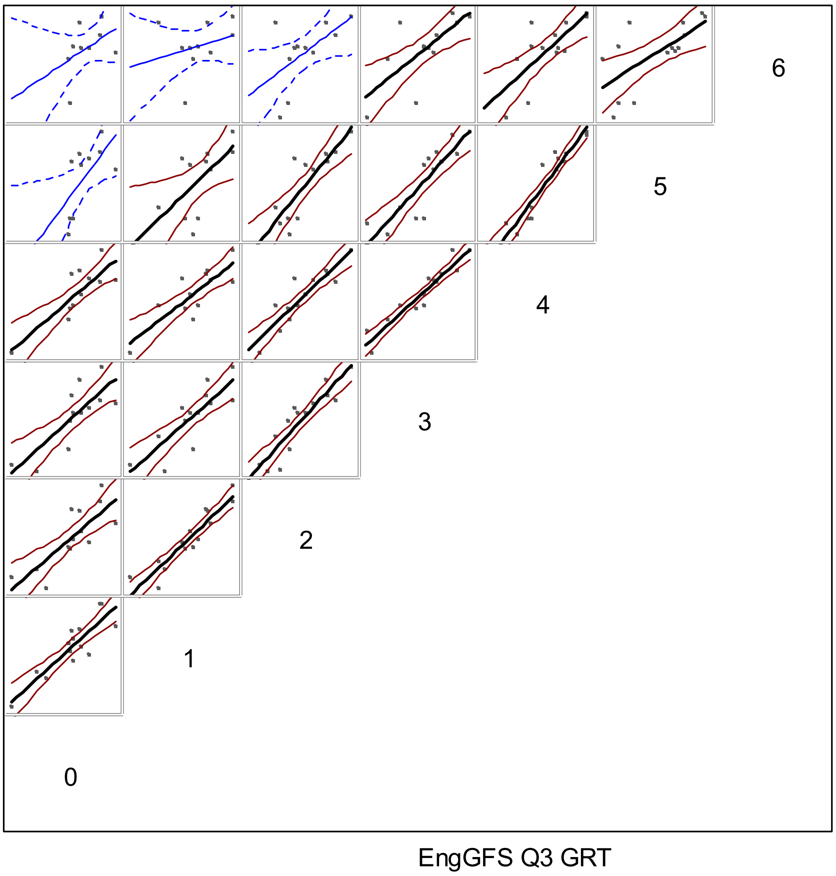


Figure 13.3.3.3. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GRT) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

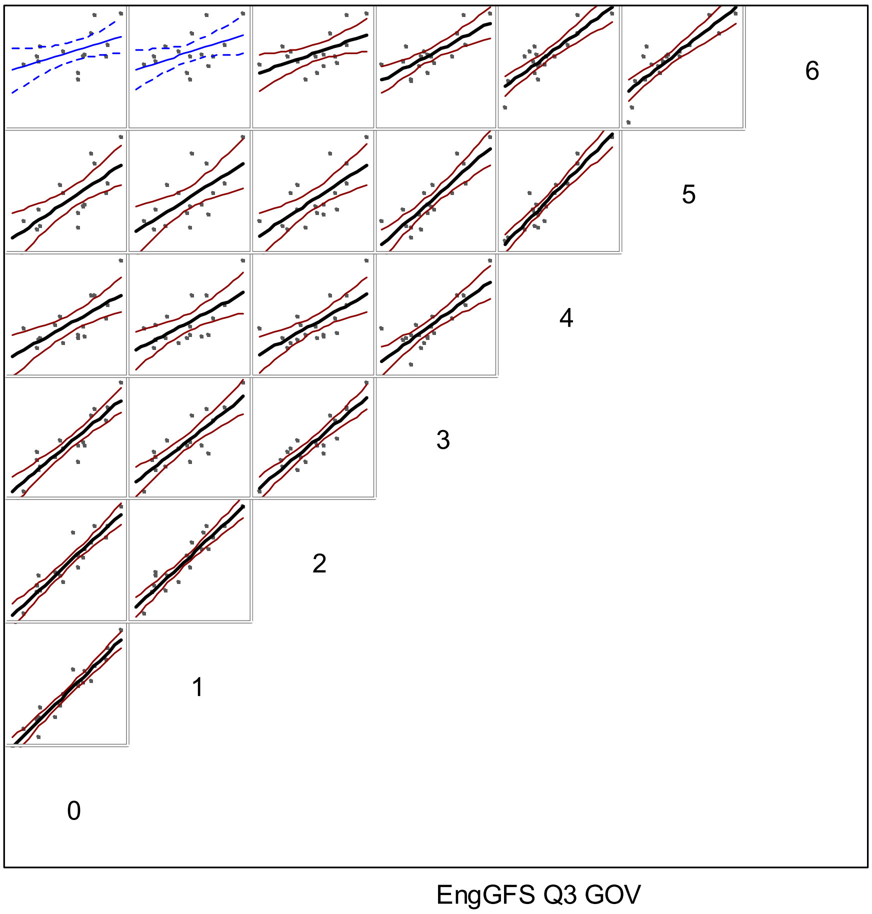


Figure 13.3.3.3. cont. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.**

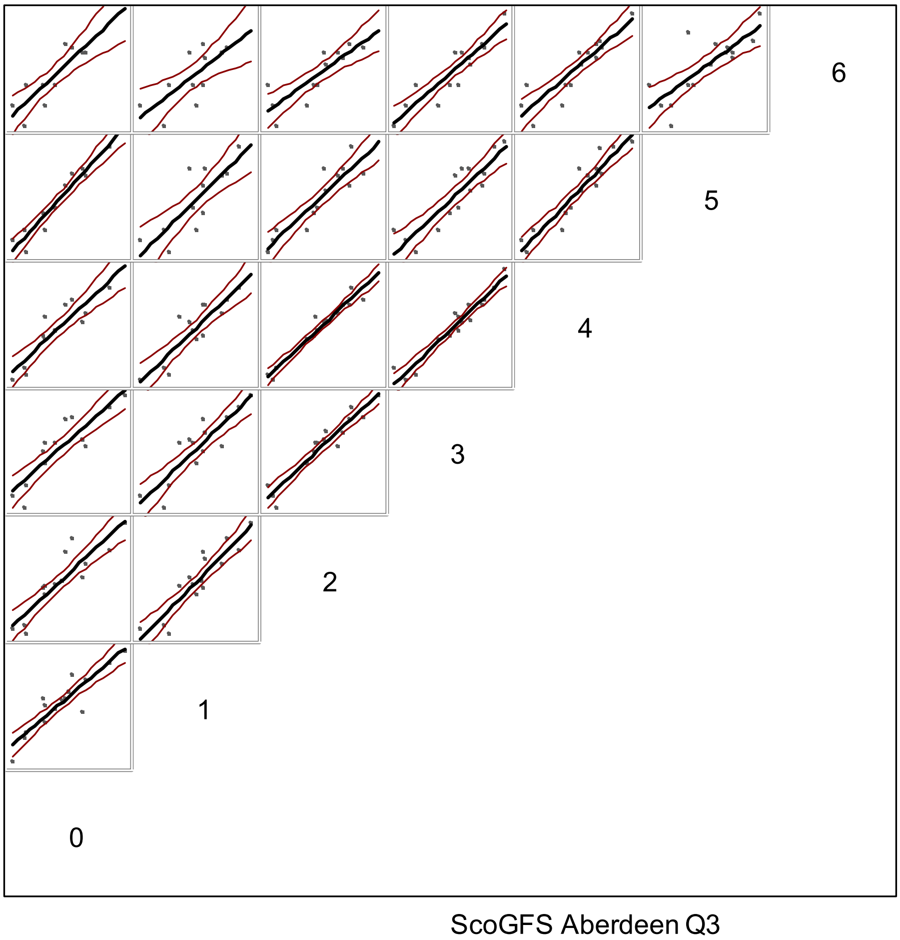


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (Aberdeen) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.

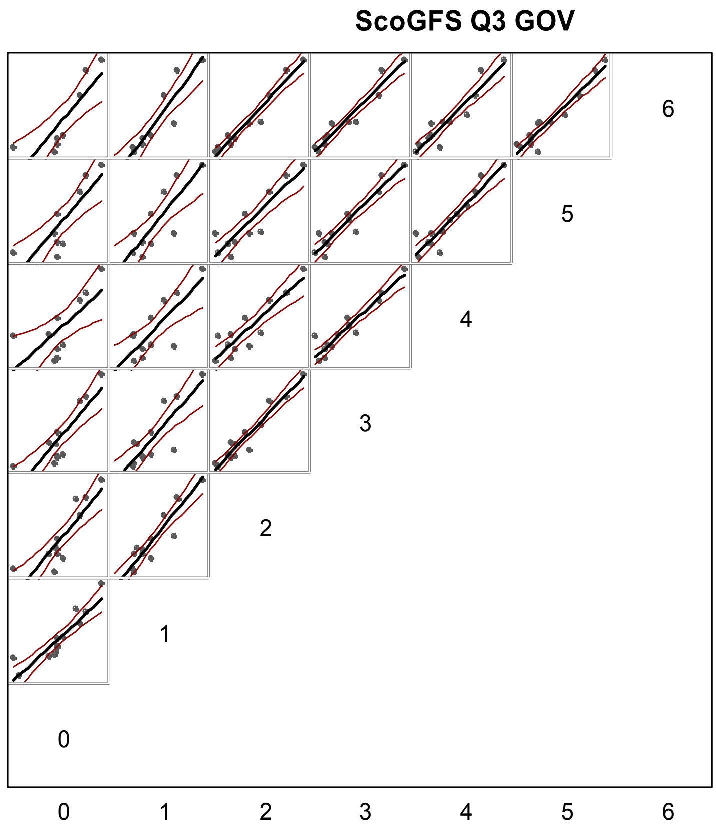


Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

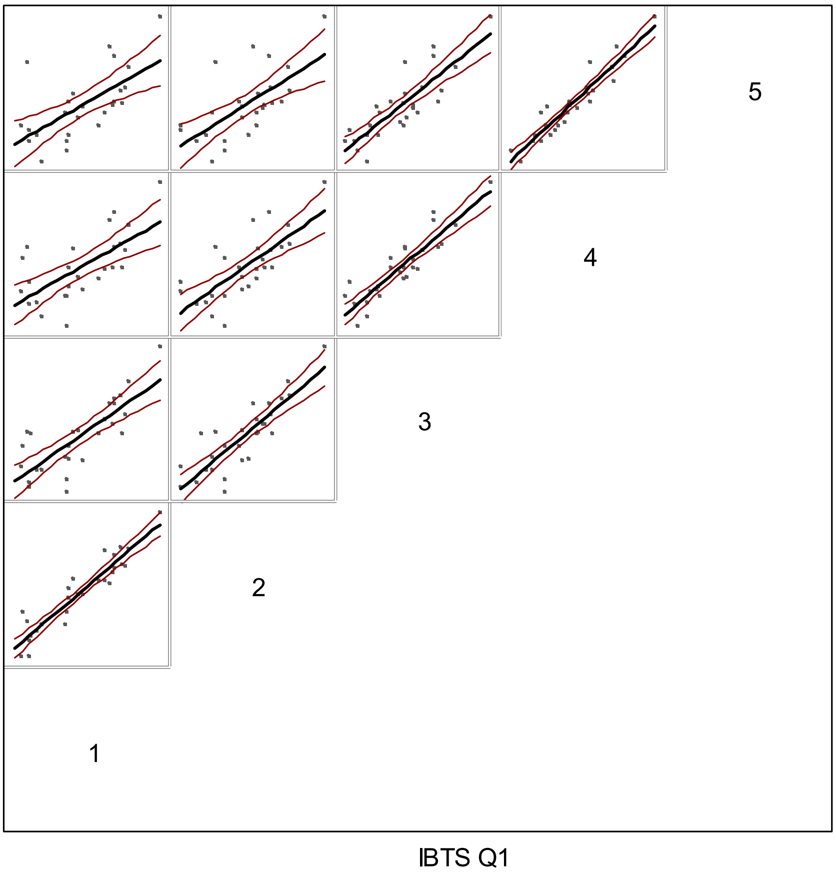


Figure 13.3.3.3. cont. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the IBTS Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.**

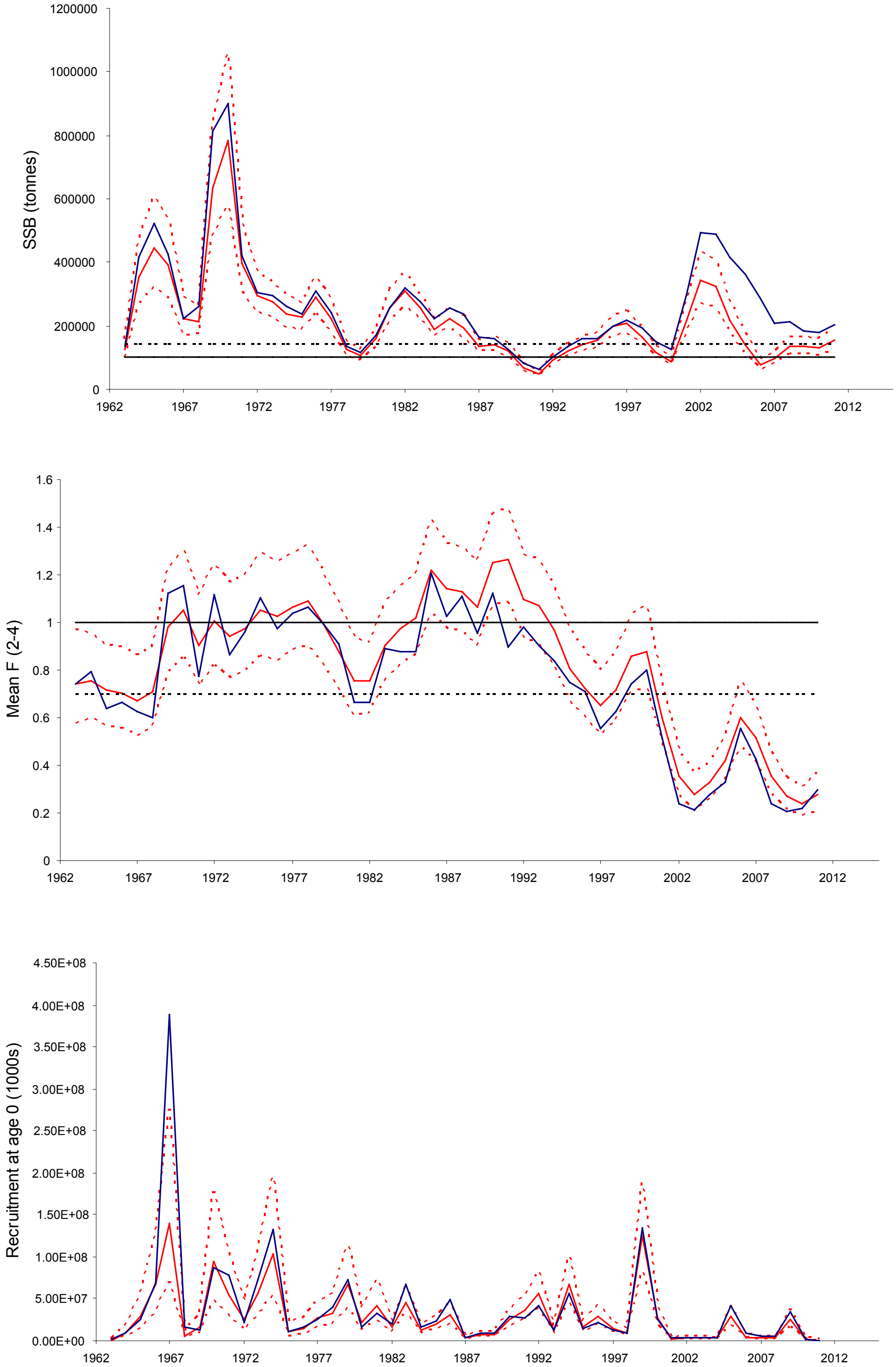


Figure 13.3.4.1. Haddock in Subarea IV and Division IIIa. Comparisons of stock summary estimates from XSA (blue) and SAM (red) models. The SAM estimates are presented along with 95% confidence intervals. Top: SSB. Middle: mean F(2-4). Bottom: recruitment.

Figure 13.3.4.2. Haddock in Subarea IV and Division IIIa. Comparisons of stock summary estimates from XSA (blue), SAM (pink) 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.

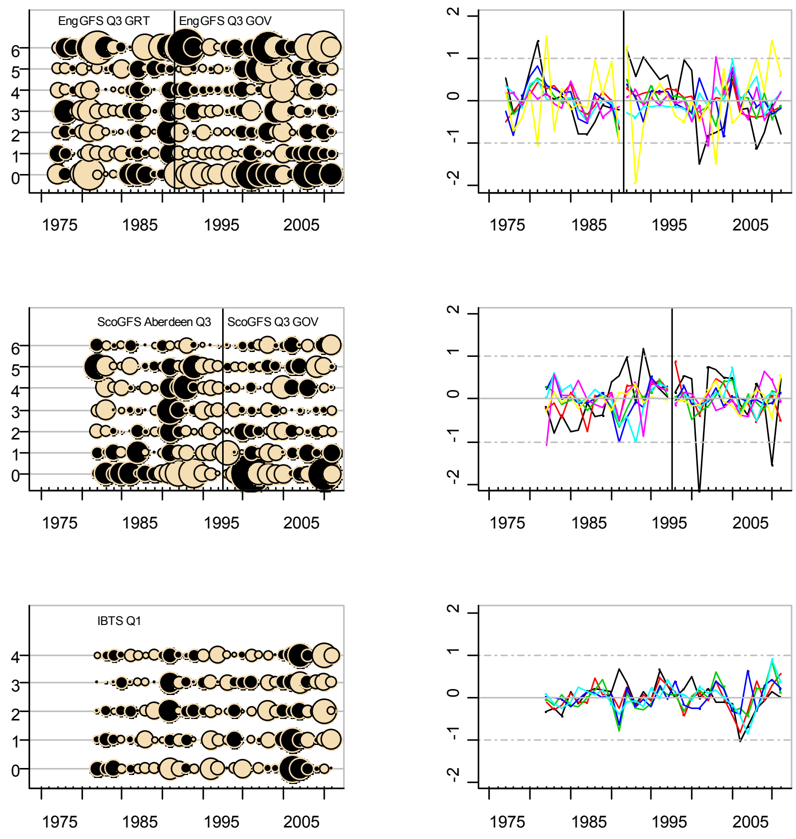


Figure 13.3.5.1 Haddock in Subarea IV and Division IIIa. Log catchability residuals for final XSA assessment. Both EngGFS and ScoGFS are split when used as tuning indices, and this split is shown by vertical lines on the relevant plots.

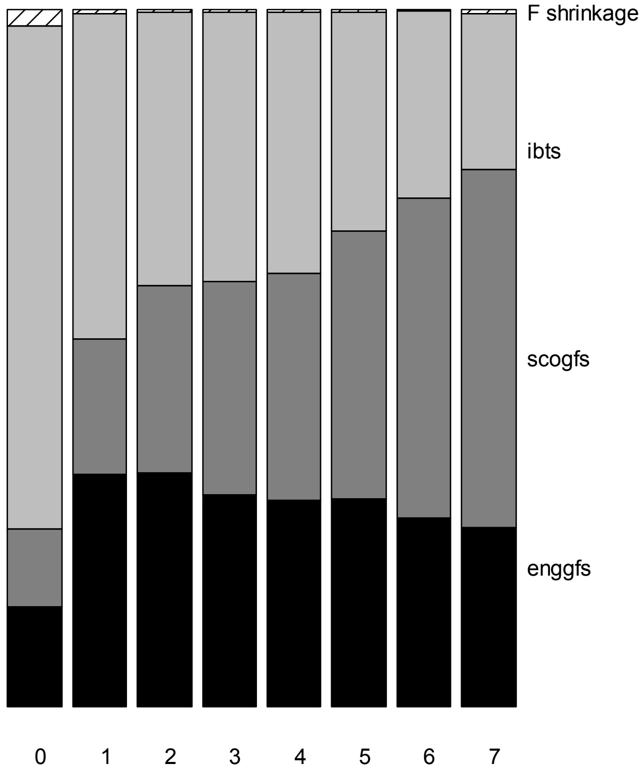


Figure 13.3.5.2. Haddock in Subarea IV and Division IIIa. Contribution to survivors' estimates in final XSA assessment.

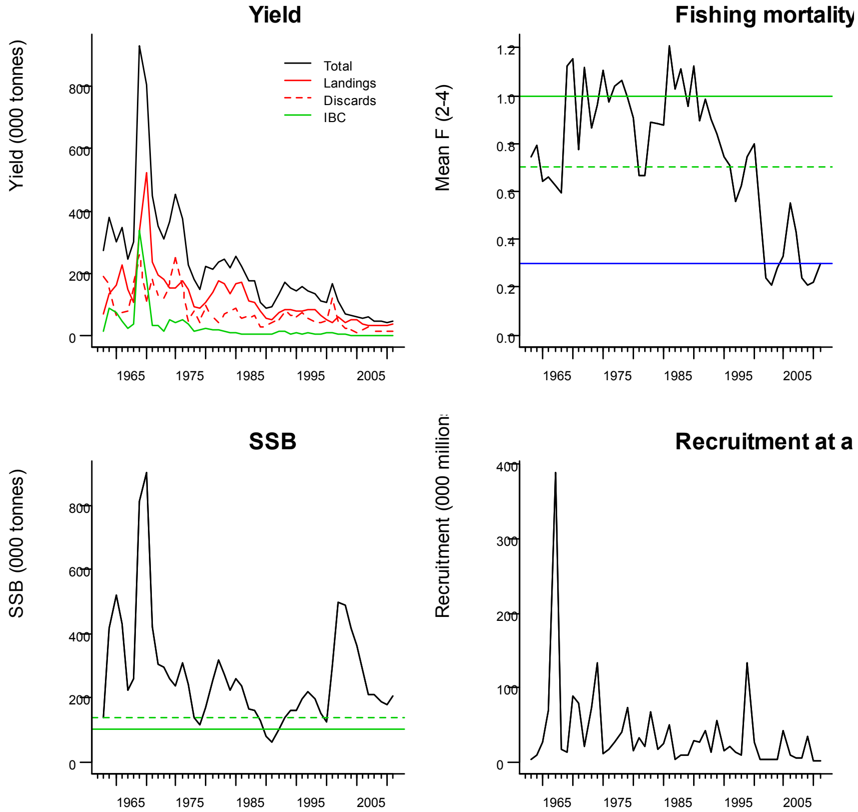


Figure 13.4.1. **Haddock in Subarea IV and Division IIIa. Summary plots for final XSA assessment. Dotted horizontal green lines indicate F_{pa} (top right plot) and B_{pa} (bottom left plot), while solid horizontal green lines indicate F_{lim} and B_{lim} in the same plots. The solid blue line in the 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}.**

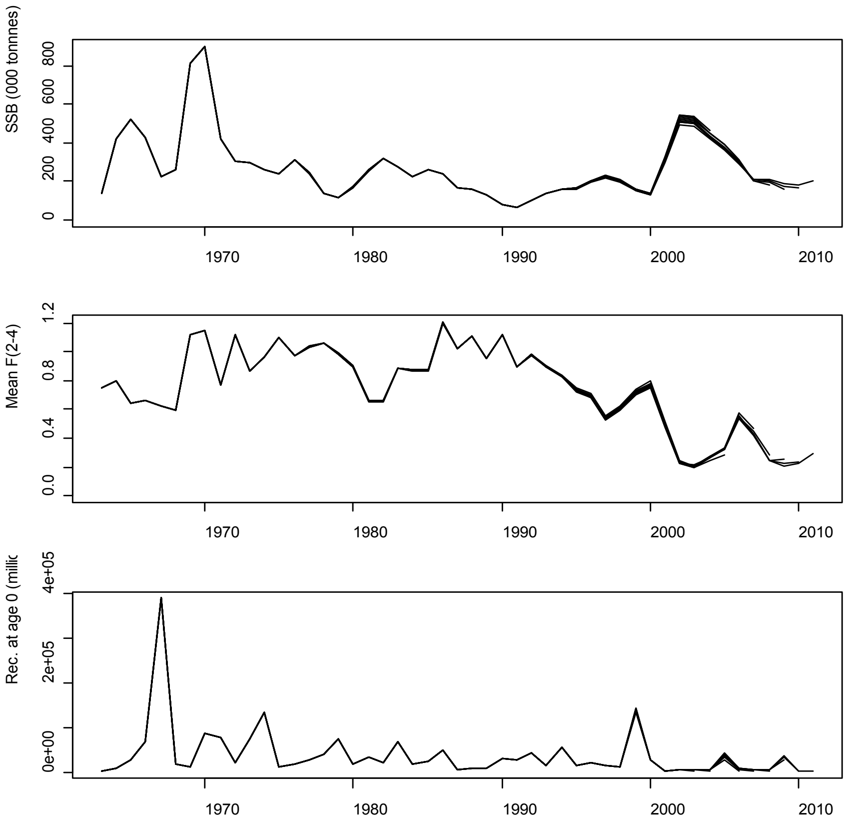


Figure 13.4.2. Haddock in Subarea IV and Division IIIa. Eight-year retrospective plots for final XSA assessment.

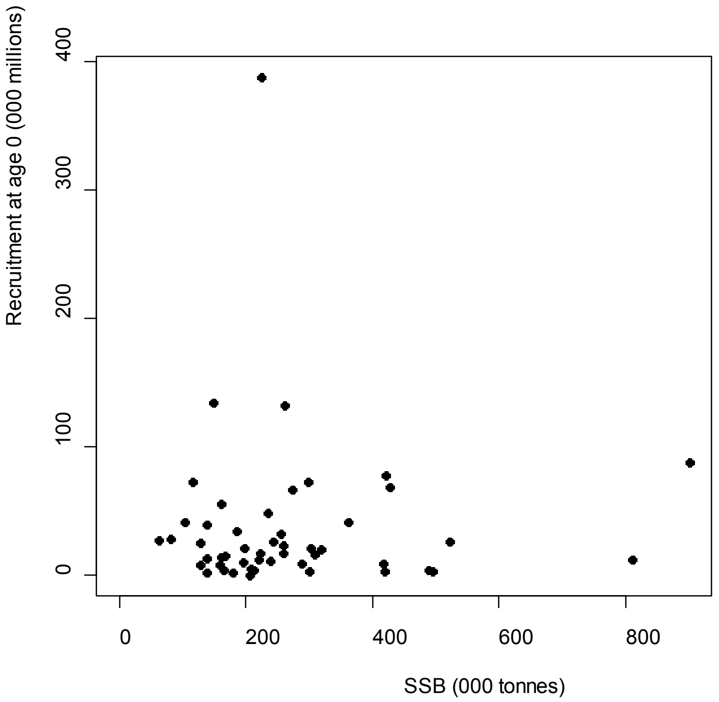


Figure 13.4.3. Haddock in Subarea IV and Division IIIa. Stock-recruitment plot from the update FLXSA assessment.

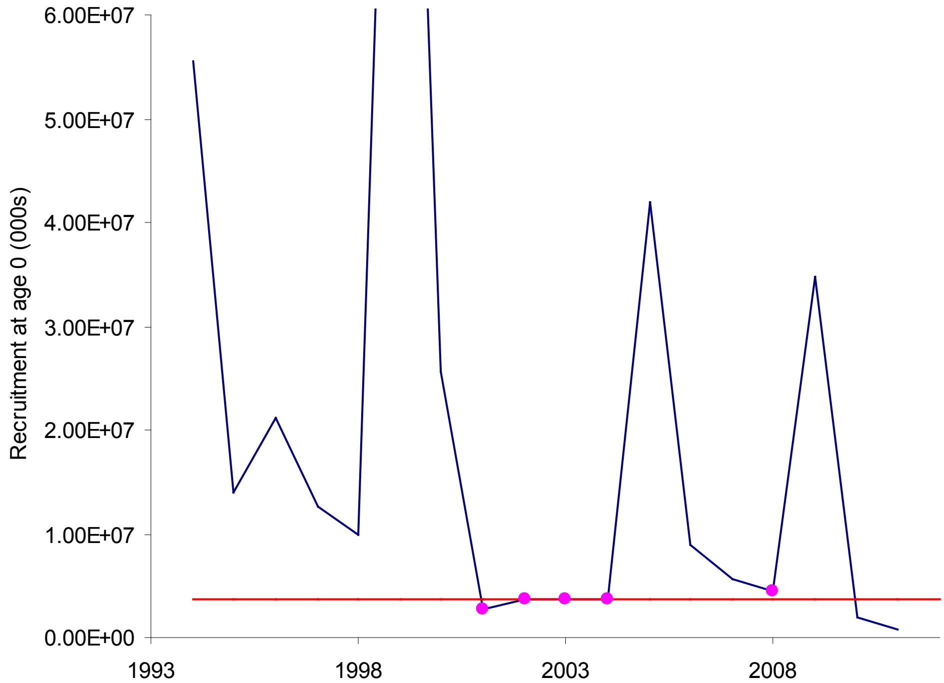


Figure 13.5.1.1. Haddock in Subarea IV and Division IIIa. Estimated recruitment from the final XSA assessment for 1994-2009 (black line), with 5 lowest values (pink dots) and the geometric mean of these (red line).

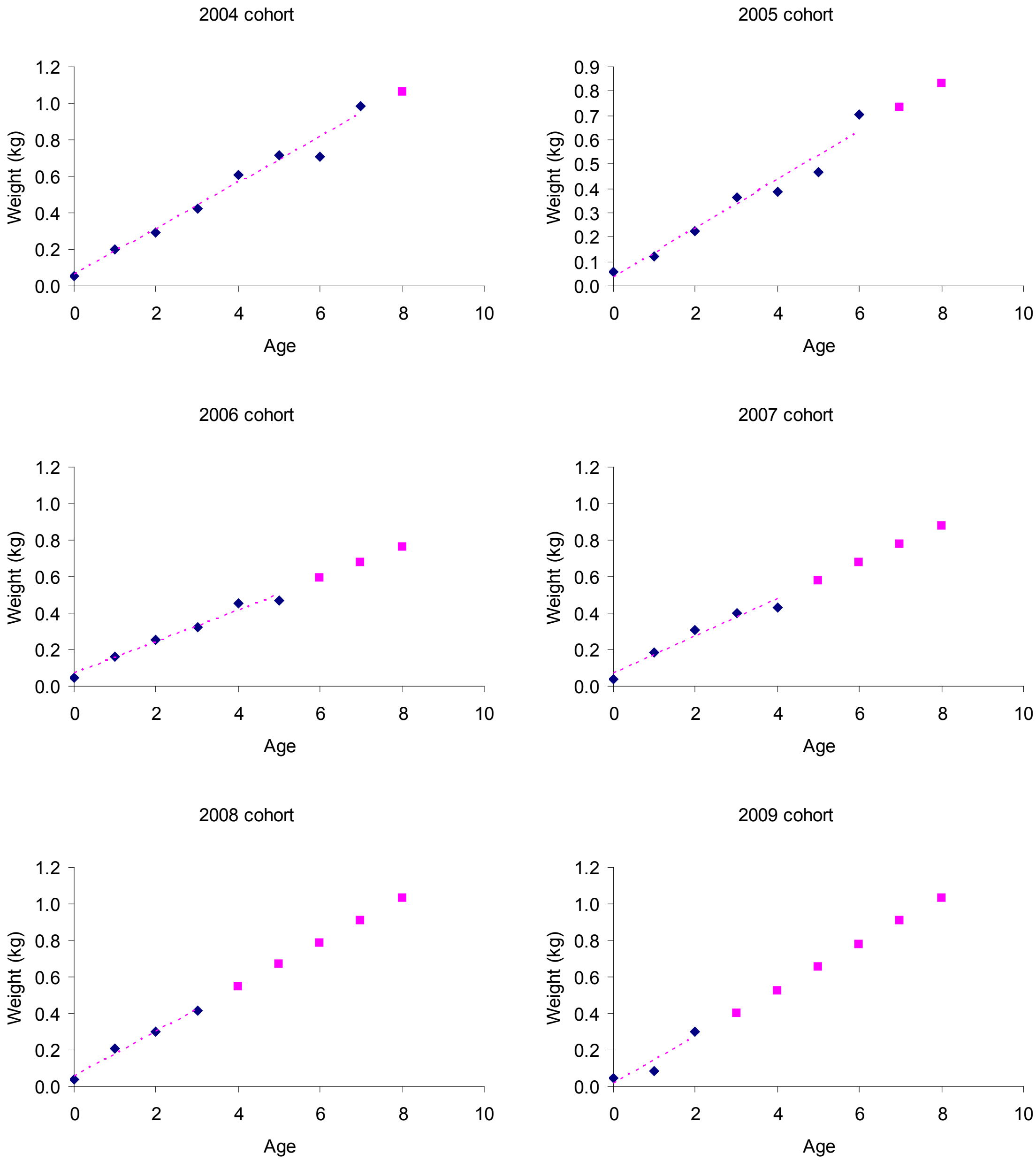


Figure 13.6.1. Haddock in Subarea IV and Division IIIa. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski 2011). Cohorts 2004-2009 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

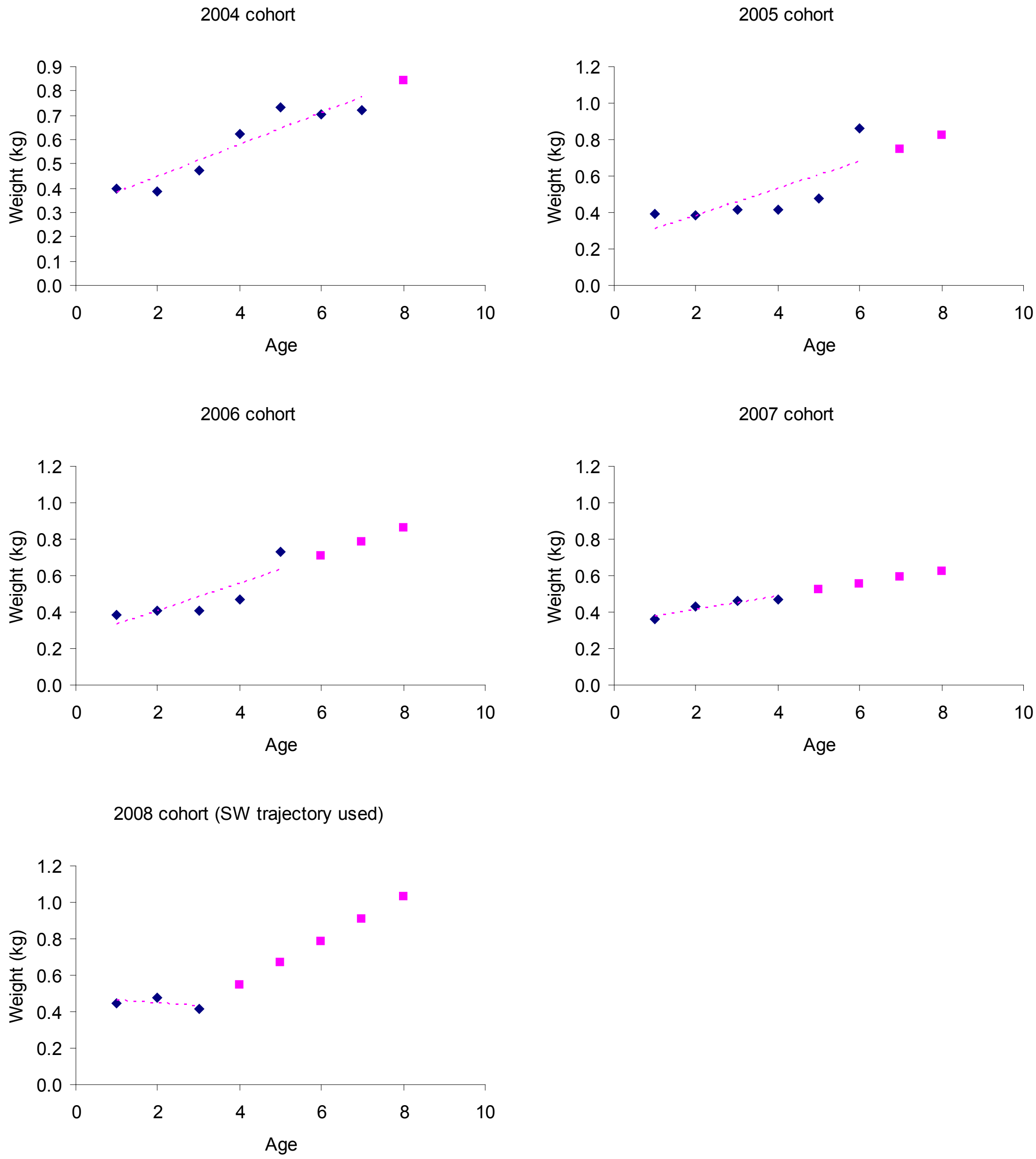


Figure 13.6.2. Haddock in Subarea IV and Division IIIa. Results of growth modelling for landings weights using cohort-based linear models (Jaworski 2011). Cohorts 2004-2008 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

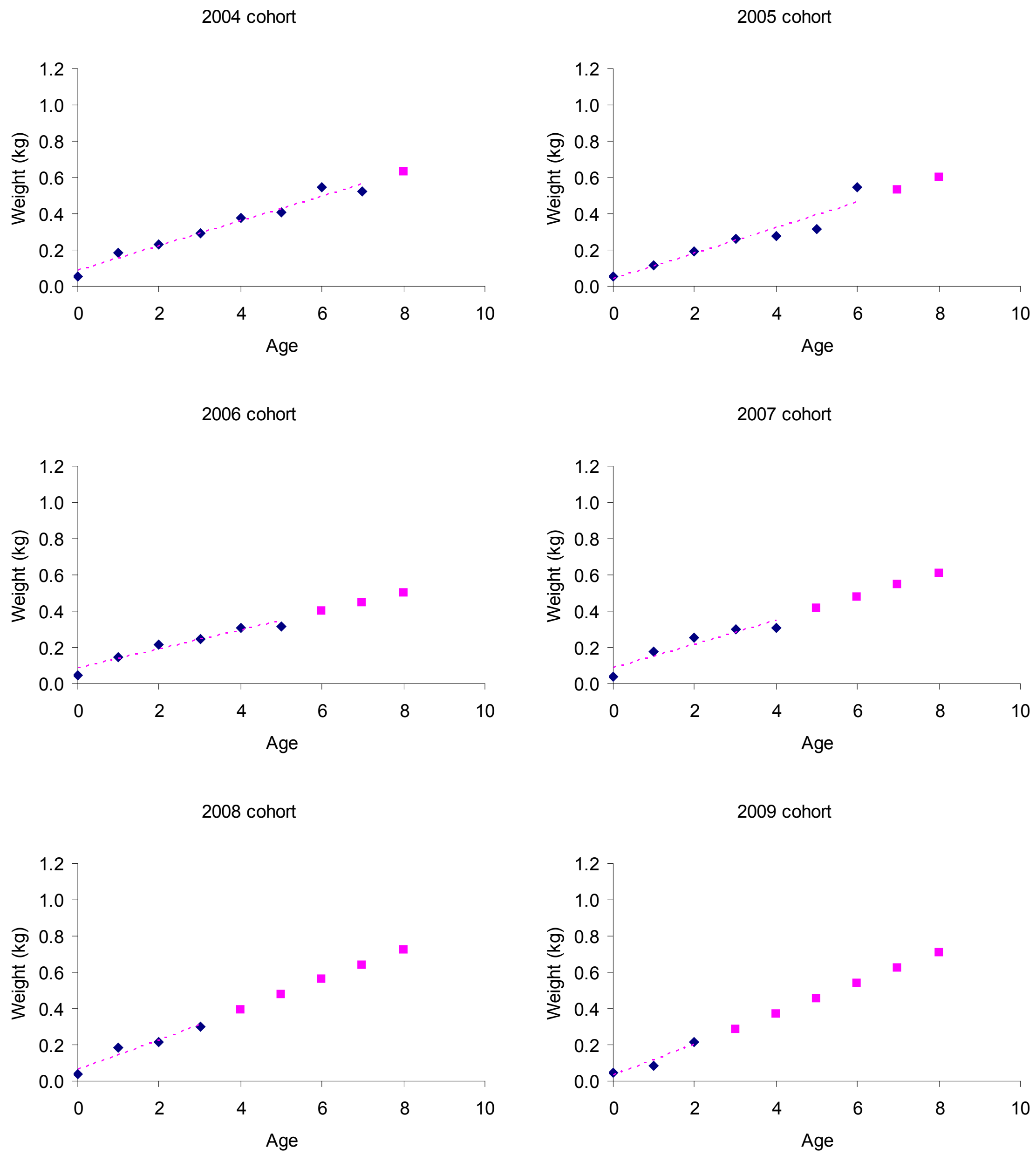


Figure 13.6.3. Haddock in Subarea IV and Division IIIa. Results of growth modelling for discard weights using cohort-based linear models (Jaworski 2011). Cohorts 2004-2009 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages

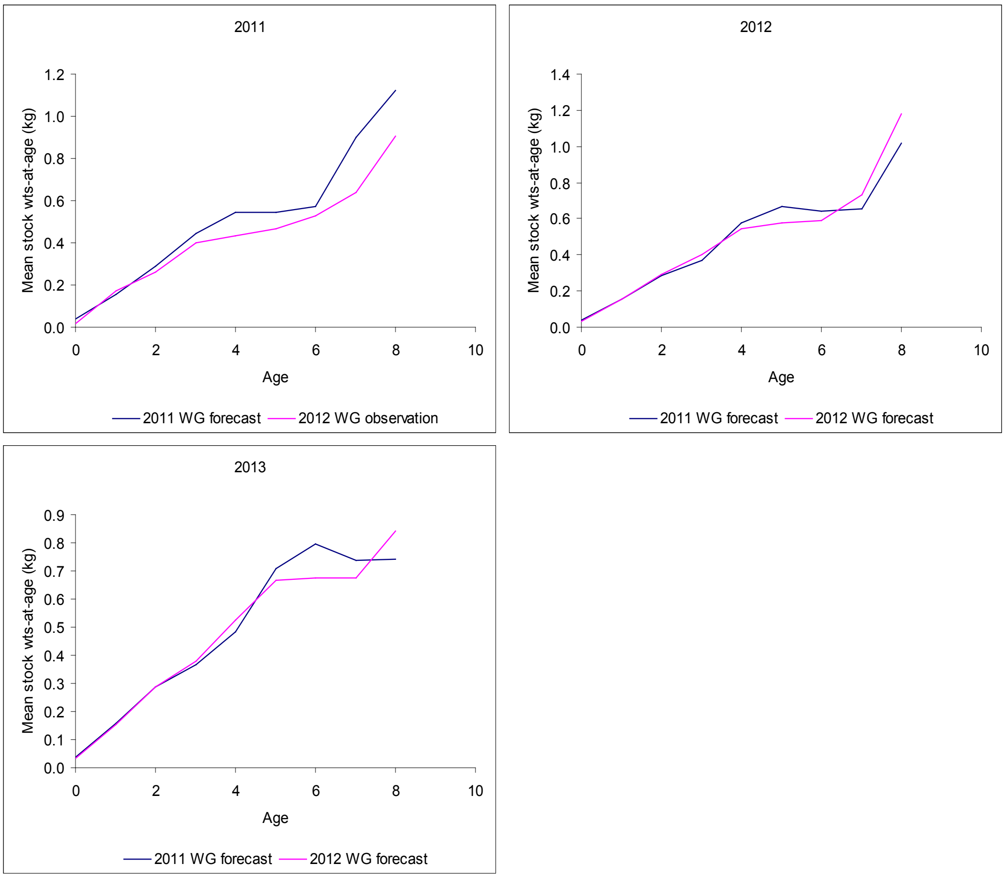


Figure 13.6.4. Haddock in Subarea IV and Division IIIa. Comparison of weights-at-age for 2011-13 from the 2011 WG, with the weights-at-age for 2011-13 from the 2012 WG.

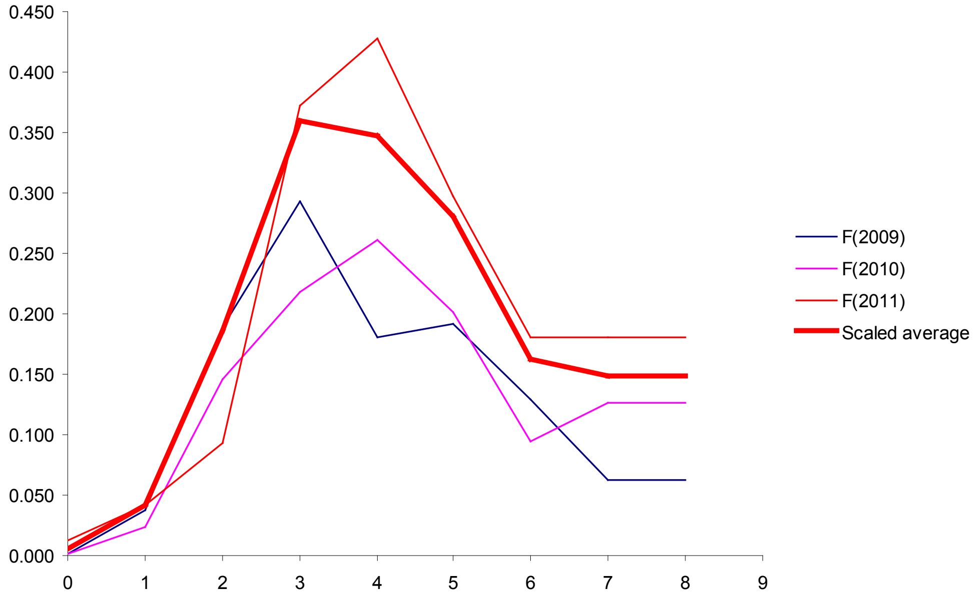
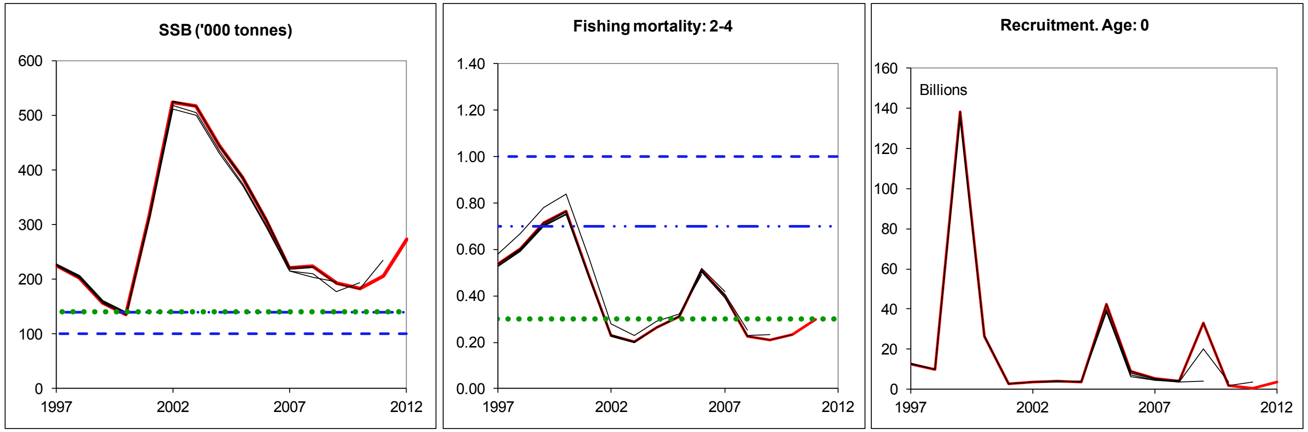


Figure 13.6.5. Haddock in Subarea IV and Division IIIa. Comparison of fishing mortality estimates for 2009-2011 with a three-year (2009-2011) mean exploitation pattern scaled to the mean level of the 2011 estimates.

Figure 13.9.1. Haddock in Subarea IV and Division IIIa. Historical assessment quality plot.



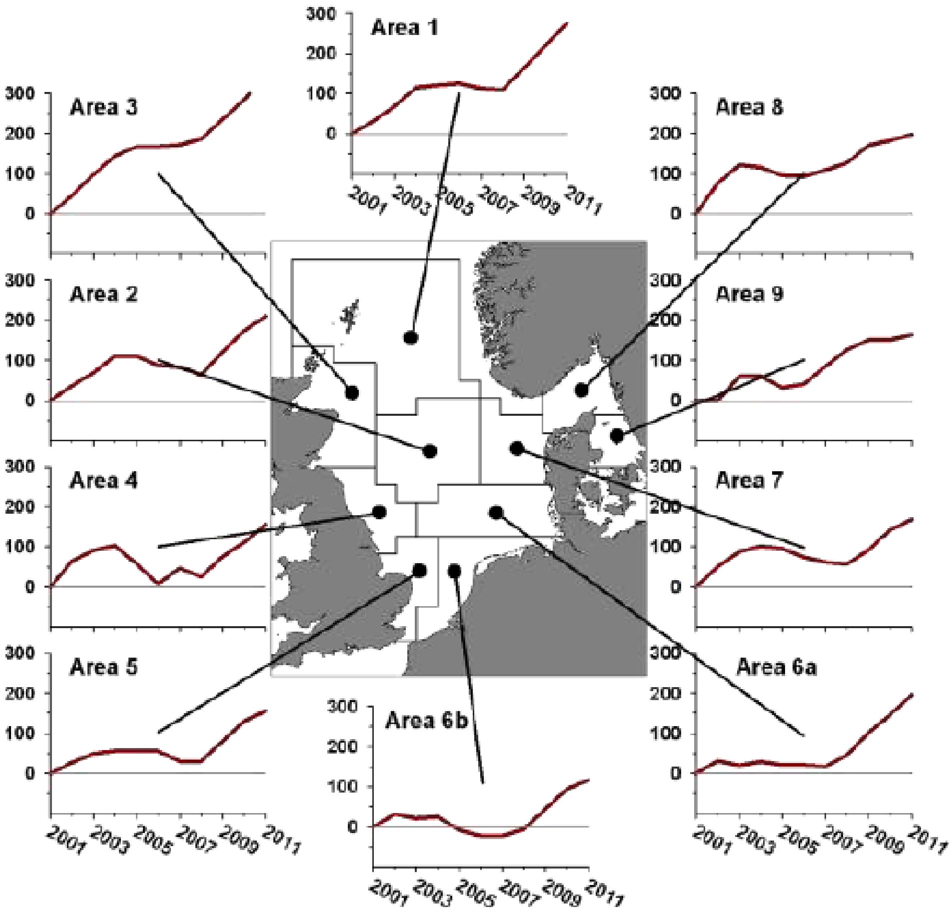


Figure 13.10.1. **Haddock in Subarea IV and Division IIIa. Results of 2011 North Sea Stock Survey: cumulative time series of index of perceptions of haddock abundance Source: Napier (2012)**

14 Cod

This assessment relates to the cod stock in the North Sea (Subarea IV), the Skagerrak (the northern section of Division IIIa) and the eastern Channel (Division VIId). This assessment is an update from last year, but it should be noted that the M-values used have been updated following a new key run conducted by WGSAM (ICES-WGSAM, 2011).

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

No new information was presented at the EG. A summary of 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), followed by 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), has been 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 four times from July 2010. The use of more species and size selective gears (some trialled by the Marine Laboratory in Aberdeen) formed a further series of options within the scheme. These included the 'Orkney trawl, the use of nets with 130mm codends and larger meshes in the square meshed panels of *Nephrops* trawls.

The scheme has delivered a total of 165 and 185 closures in 2010 and 2011, respectively. ICES notes that from the initial year of operation (2008) cod discarding rates in Scotland have decreased from 62% to 24% in 2011.

Changes in national fleet dynamics

The ICES WGFTFB 2012 report was not yet available. The latest report available is ICES-WGFTFB (2011).

The expansion of the Closed Circuit TV (CCTV)/Fully Documented Fisheries (FDF) programmes in 2010-2012 in Scotland, Denmark, and England is expected to have contributed to the reduction of cod mortality. Under this scheme, UK vessels are not permitted to discard any cod, while Danish vessels are still permitted to discard undersize cod.

The introduction of the one-net rule as part of the Scottish Conservation Credit Scheme is likely to have improved the accuracy of reporting of metier-based landings from 2008 onwards. Scottish legislation implemented in January 2008, banning the use of multi-rigs (>2 rigs per trawl), could limit the potential of uncontrolled increase in effort.

There has been growing interest in the Netherlands and Belgium in the use of more fuel-efficient gears such as electric pulse trawling and Sumwing as a replacement for standard beam trawl gears, driven by increasing fuel prices. There has also been a reduction in the number of vessels in the French fleet of around 3% between 2008 and 2009, with a shift in effort from trawls to Scottish seines, again driven by high fuel prices. There is now wide-spread use of rigid sorting grids in Swedish TR2 gears in the Skagerrak, the most important gear category in this area (comprising 80-90% of total effort). There has been an increase in effort in VIId by Dutch and Belgium beam trawlers for flat fish, and seine net vessels for mixed demersal species.

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.

UK - North East Coast Cod Survey

The NE Coast cod survey (De Oliveira et al., 2012) 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; in contrast, the assessment indicates a relatively stronger 2009 year class (almost the same size as the 2005 year class). 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.

North Sea Whitefish Survey

The North Sea whitefish (NSW) 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*., 2011). 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, 2010 and 2011. These results are starting to provide a valuable evaluation of the dynamics of the three target species on hard and soft ground in the North Sea.

In 2009 and 2011 catch rates of the target gadoid species were higher on hard ground than on soft; in 2010 catch rates between the substrata were reversed in many areas for cod and whiting. Differences in catch rates result from differences in local abundance, substratum preferences and/or differences in gear catchability. The reversal in catch rates between substratum type between years was unexpected and will require more detailed analysis as the time-series develop. Overall, the age structure recorded on soft ground was similar to that on hard in all years, with differences in the age distribution related to the area of fishing rather than the substratum fished.

When compared at an overall North Sea scale, the relative indices at age of cod, haddock and whiting abundance from the NSW and IBTSQ3 surveys show good correlation in all years, better for cod than haddock and whiting. Catches of older fish were more frequent and showed less noise in the NSW survey data than in the IBTSQ3, particularly for cod.

The results demonstrate the value in developing a time-series for gadoids based on a commercial vessel, derived across the areas surveyed. The NSW time-series are showing consistent agreement with the IBTSQ3 survey indicating that it could with time form the basis for an assessment tuning series for the three main target species. The results will allow industry questions about potential differences in stock dynamics on hard and soft ground to be evaluated, to determine whether substratum type can affect survey estimates of stock abundance, especially as the stock of cod rebuilds under the current management regime, providing a valuable input to the debate on the dynamics of the stocks and survey practices.

Denmark - REX

Many fishermen do not consider the North Sea IBTS surveys as representative of stock status, because the commercial fishery continues to maintain viable catch rates in areas where the IBTS surveys report no or low densities of cod above minimum landing size. Fishermen complained that the IBTS does not cover rough bottom where the highest commercial CPUE of cod is usually obtained and thus has a much less pessimistic perception of the status of the stock than the most recent assessments suggested. Against this background, a collaborative biologist-fishermen project on spatially-explicit management methods for North Sea cod (REX) was established by DTU Aqua (National Institute of Aquatic Resources at the Technical University of Denmark) and the Danish Fishermen Association in summer 2006 (Wieland et al. 2009). Initially, three commercial vessels representing different fishing methods participated in the study. These were a trawler, a flyshooter and a gillnetter. The field work for the REX project finished in 2009 (Wieland et al. 2010). Survey activities with the trawler continued in summer 2010 within a new project (RESOURCE). The main objective of the surveys has been to provide information on distribution, density and size composition of North Sea cod in particular in respect to bottom type and for comparison with the IBTS.

In general, mean CPUE at age for the surveys with the commercial trawler were considerably higher on rough bottom than smooth bottom for almost all age groups in the years 2007 to 2009 and 2011 whereas higher mean CPUE on smooth bottom than on rough bottom were recorded for age 3 to 6+ in 2010, a pattern also noted in the North Sea Whitefish survey (see above). Differences in the distribution between bottom categories may depend on density or changes in the distribution of food (e.g. sandeel) but this needs further investigation.

Length distributions from the commercial trawler showed peaks at about 30 cm (age 1) and 45 cm (age 2) but also a broad range of medium sizes (> 55 cm, age 3 and 4) and even frequently larger (> 85 cm, age 5 and 6+) cod. In contrast, the length distributions from the 3rd quarter IBTS were dominated by small (< 45 cm) individuals and larger cod were generally rare. The low numbers of medium and large sizes of cod in the IBTS catches may, however, be due to the relative low sampling intensity in the study area and does not necessarily mean that the IBTS is not able catch representatively older ages (3+) of cod in general.

Some consistency concerning the trends in mean CPUE from the surveys with the commercial trawler and the 3rd quarter IBTS indices for the North Sea cod standard area were found for age 1 to 3 but not for the older ages. The mean CPUE from the commercial trawler indicate a slight decrease in abundance for age 1, a minor increase for age 2, a decrease for age 4, and relative small changes for age 5 and 6+ during the years 2008 to 2011.

The North Sea Stock Survey

The North Sea Stock Survey (Napier 2011) 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 2010 to 2011. A total of 275 completed questionnaires were returned in 2011, of which 252 were included in the analysis. The number of questionnaires returned was slightly higher than in 2010, and the highest for several years. 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). Of the fishing gears, the otter trawl and beam trawl accounted for about one-third and one-quarter of responses respectively, with most of the remainder from gill nets.

The spatial distribution of the change in the perceived abundance since 2001 is recorded by survey area in Figure 14.16. Just under half of respondents reported that cod were more abundant in 2011 than 2010, while about one third reported no change in abundance. Compared to 2010, there were substantial increases in the proportions reporting lower abundances of cod, or no change, and a reduction in the proportion reporting higher abundance. There was a clear south to north trend in perceptions of changes in the abundance of cod in 2011, with the proportion of respondents reporting higher abundances greatest in the north and north-west (areas 1 & 3), and lowest in the most southerly areas (areas 5 & 6b). A similar trend, in reverse, was apparent in the proportions of respondents reporting lower levels of cod abundance, with these being highest (although still only one quarter to one third) in the southernmost areas. The cumulative index of perceptions of the abundance of cod continued to increase in all areas, except the most southerly where it declined slightly (1% in area 5; 5% in area 6b). In other areas the rate of increase was greatest (>25%) in the west (areas 3 & 4) and lowest (~5%) in the east (areas 7 & 8).

Overall, well over half of respondents reported no change in the level of discarding of cod in 2011, substantially more than in 2010. Of the balance, a slightly higher proportion reported lower levels of discards, but the proportions reporting both lower and higher levels of discards were markedly less than in 2010. Higher levels of discarding of cod were most commonly reported in the north and west (areas 1, 3 & 4), and least commonly in the south and east (areas 6b, 7 & 8). The proportions reporting lower levels of cod discards varied somewhat between areas, but without any clear pattern.

Overall, the vast majority of respondents reported either moderate or high levels of recruitment of cod in 2011. The proportion reporting 'moderate' levels of recruitment was substantially higher in 2011 than in 2010, but there was a decline in the proportion reporting high levels. The proportions varied between areas, with moderate levels of recruitment most commonly reported in the south and south-west (areas 4, 5, 6a & 6b) while high levels were most commonly reported in the north-west (areas 1, 3 & 4) and east (areas 7 & 8).

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
IIIa (Skagerrak)	3.3	2.9	3.2	4.1	4.8	3.8	3.8
IIa + IV	23.2	20.0	22.2	28.8	33.6	26.8	26.5
VIId				1.7	2.0	1.6	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 1.2.1 for complete list). The areas are Kattegat, part of IIIa not covered by Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned 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 and 2012, Council Regulations (EC) N°53/2010, N°57/2011 and N°44/2012 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 is 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 implementing the new system of effort management and a target fishing mortality of 0.4. ICES has evaluated the management plan in 2009 and considers it to be in accordance with the precautionary approach if it is implemented and enforced adequately. Discarding in excess of the assumptions under the management plan will affect the effectiveness of the plan. The evaluation is most sensitive to assumptions about implementation error (i.e. TAC and effort overshoot and the consequent increase in discards). Details of it 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; Simmonds and Kraak, 2011), 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. These management plans will be re-considered during 2012.

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

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).

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.

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.

Subsequently, if the size of the stock on 1 January of the year prior to the year of application of the TACs is:

above the precautionary spawning biomass level, the TACs shall correspond to a fishing mortality rate of 0,4 on appropriate age groups;

*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))*

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.

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.

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 2011.

The landings estimate for 2011 is 32.9 thousand tonnes, split as follows for the separate areas (thousand tonnes):

	TAC	Landings	Discards
IIIa-Skagerrak	3.8	3.9	2.1
IV	26.8	27.7	7.4
VIId	1.6	1.2	
Total	32.2	32.9	9.5

WG estimates of discards are also shown in the above table.

Discard numbers-at-age have in the past been estimated for areas IV and VIId by applying the Scottish discard ogives to the international landings-at-age. For 2006, Denmark was excluded from this calculation as they provided their own discard estimates. For 2007-2010, Scottish, Danish, German and England & Wales discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in sub-area IV to account for missing discards. Discard numbers-at-age for IIIa-Skagerrak were based on observer sampling estimates. For 2006-2009, Danish and Swedish discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in Division IIIa-Skagerrak to account for missing discards. Raising for IIIa-Skagerrak was similar in 2010, but with the inclusion of German discard estimates. Discard raising for 2011 was performed in Intercatch, with the different nations providing information by quarter and métier. The provision of discard information has improved in 2011, with Belgium now providing discard information (tonnage and age composition) for IV and VIId, and France 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, operates 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.

The by-catch of cod from the Danish and Norwegian industrial fisheries that was sent for reduction to fishmeal and oil in 2011 was 1 tonne (Table 2.1.3##).

Age compositions

Age compositions were provided by all nations (see Section 1.2.4##).

Landings in numbers at age for age groups 1-11+ and 1963-2011 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 and Norwegian small-meshed fishery in Sub-area IV (Tables 2.1.3 to 2.1.5##) and separately for the Skagerrak (Table 14.1). During the last five years, an average of 77% of the international landings in number were accounted for by juvenile cod aged 1-3; this averages rises to 91% when considering landings and discards combined. In 2011, age 1 cod comprised 19% of the total catch by number, age 2, 54% and age 3, 17%.

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. 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. Since 2006, it was estimated to be above 90%, but has declined from 91% in 2010 to 82% in 2011. At ages 2 to 4 discard proportions increased to a maximum around 2007-9, but have subsequently declined and are now 66% of age 2, 19% of age 3 and

6% of 4 year old cod in 2011. 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 2011. Data co-ordinators from each nation were tasked to input data for 2011 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. A comparison is provided below for the Intercatch raising method, and for the method used in previous years (named the "spreadsheet" method) for 2011. Although landed totals are similar for the two methods, there is a difference of 13% for discard totals, and differences for age 1 landed numbers and weights, and across all ages for discard numbers and weights. The Intercatch estimates for 2011 were used in the assessment.

	Landings numbers							Landings weights							Land tons
	1	2	3	4	5	6	7+	1	2	3	4	5	6	7+	
Intercatch	994	5218	3830	1492	602	579	109	0.722	1.301	2.520	4.365	6.256	7.721	10.065	32871
Spreadsheet	1142	5052	3668	1476	594	573	106	0.840	1.320	2.527	4.401	6.255	7.673	9.982	32916
%dif	15%	-3%	-4%	-1%	-1%	-1%	-2%	16%	2%	0%	1%	0%	-1%	-1%	0%
	Discards numbers							Discard weights							Disc tons
	1	2	3	4	5	6	7+	1	2	3	4	5	6	7+	
Intercatch	4391	10166	882	98	11	7	3	0.248	0.595	2.005	4.119	5.709	6.781	7.746	9485
Spreadsheet	3341	7211	822	91	7	4	2	0.257	0.701	2.111	4.361	5.453	5.861	7.155	8228
%dif	-24%	-29%	-7%	-8%	-40%	-38%	-19%	4%	18%	5%	6%	-4%	-14%	-8%	-13%

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 recent 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 1976–2012. 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.

Quarter 3 international bottom-trawl survey (IBTS Q3): ages 0–6+, covering the period 1991–2011. 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 used 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 occurred 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 14.3a).

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 last year, and continues to be used in the assessment presented this year.

Maps showing the IBTS distribution of cod are presented in Figures 14.3b-c (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 14.3b and c).

Both surveys have been used in assessments up to 2010, but there have been conflicting residual trends for the most recent survey data points, and when applied independently, the two surveys have resulted in divergent trends in population estimates, with the IBTS Q1 survey indicating declining or stable mortality rates in recent years, but the IBTS Q3 survey rapidly increasing mortality rates for the same period (ICES-WGNSSK, 2010). This led to studies, presented to ICES-WKCOD (2011) that looked into the distribution of cod in the surveys and the possibility of catchability changes.

Darby and Parker-Humphreys (2010) reviewed maps of the spatial distribution of the IBTS Q1 and Q3 surveys in recent years to establish whether there have been any significant changes that could account for the differences in the fishing mortality trends derived from the separate indices. They found a relatively stable pattern of catches over time for all ages in the IBTS Q1 survey, and although the distribution of cod in the IBTS Q3 survey remained relatively unchanged until around 2003/4, 2+ cod became increasingly concentrated in the northern region of the survey area. Catch rates in the southern region of the IBTS Q3 survey area were found to be very low or zero – although this has been true for ages 4 and 5 throughout the time series, it has also become so for ages 2 and 3 since 2003/4. In a subsequent study, Darby and Parker-Humphreys (WD3 in ICES-WKCOD, 2011) demonstrated that recent catch rates in the south are making less of a contribution to the IBTS survey index in Q3 than Q1. Reasons for the change in distribution recorded by the IBTS Q3 survey are unknown. Either cod have changed their migration behaviour and are moving from the south in greater proportions, or they have changed their local behaviour in the summer months and are becoming less catchable to the survey.

Rindorf and Vinther (WD1 in ICES-WKCOD, 2011) and Darby and Parker-Humphreys (WD3 in ICES-WKCOD, 2011) both examined the relative catchability changes in the catches of the IBTS Q1 and Q3 surveys, the former through an examination of catch curves, and the latter through a comparison of catch rates; both studies demonstrated that the catchability of the IBTS Q3 survey seems to have increased in recent years. The conflict between the IBTS Q1 and Q3 surveys was not fully resolved at the WKCOD meeting. It was concluded that until the reasons for the discrepancy have been resolved, the Q1 survey is considered more likely to reflect the actual stock trends in recent years, because of suspected changes in catchability/availability of cod in the Q3 survey in relation to recent changes in the fish distribution in the latter part of the year. WKCOD recommended that further investigation would most appropriately be addressed within a dedicated study group on improving the use of survey data for assessment and advice. The lack of Norwegian participation in the 2009 IBTS Q3 survey also raised concerns (ICES-WGNSSK, 2010), with an analysis highlighting the sensitivity of the survey index to the inclusion/exclusion of the Norwegian data. The proposed group, WGISDAA, met in early 2012 but has not yet been able to look into 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 2011 (ICES-WGNSSK, 2011), and were satisfied that the assessment had been done as outlined in the Stock Annex. Responses to some of their comments, relevant to this year's report, are given below:

1. *Subsections 14.5 and 14.6 seem out of place. When you start reading section 14.5 you think it is about historical recruitment estimates but it really refers to recruitments used in the forecast. This section should be part of section 14.7. 'Short-term forecasts'. Biological reference points and MSY reference points are both used for management as part of HCRs, thus it would be more appropriate to have it together to ease their comparison. And finally, it would be advisable to describe the HCR of the management plan in a more clear way or mathematically.*
   Section 14.4 specifically discusses historic recruitment trends, while Section 14.5 discusses recruitment in the context of stock projections. Furthermore, it makes sense to discuss MSY estimation (Section 14.6) before going into short-term forecasts (Section 14.7) because outputs from the former are used in the latter. Biological reference points (Section 14.9) have always been handled in a separate section. The HCR part of the management plan is described in detail under Section 14.1.4 "Management" and can be found in EC 1342/2008, as indicated in that section.

2. *In page 784, Total mortality paragraph, it is not clear if high level of uncertainty is a general characteristic of SURBA or a particular characteristics in the fits of SURBA to cod data. This is a bit discerning in that SURBA is based on survey data.*
   The comment pertains only to the SURBA fit to North Sea cod data; the text has been modified this year to reflect indications of a downward trend in total mortality in recent years.

3. *The assessment shows a general tendency (Retrospective pattern) overestimate F, this could be problematic in a stock that is managed based on F (effort). This fact is not discussed in the report. Maybe it would be interesting to consider this uncertainty at the time of conducting short term forecasts. Stochastic forecast are run due to uncertainty in F estimates but I'm not sure if this is the appropriate way to deal with the bias in F-estimates.*
   A general tendency to over-estimate F because we are in a period of decreasing F has previously been noted as a feature of the SAM fit to North Sea cod data, although it has also been shown that the retrospective medians lie within the 95% confidence bounds of the F estimates that immediately follow.
   One of the short-term forecast options presented this year (Basis B) was to use the trend from Fs over the period 2006-2010 in order to extrapolate the intermediate year F in 2012, which gets around the over-estimation problem.

4. *Assessment model has changed and IBTS Q3 survey is no longer used in the assessment but reference points, MSY and biological, have not been recalculated. It would be recommendable to assess the suitability of the reference points according to the new assessment procedure.*
   The WG recognises that the re-estimation of reference points is needed, but WKCOD (ICES-WKCOD, 2011) had recommended that these should not considered until further model development (distinguishing between landings and discards, instead of treating them as a combined total) had taken place. These further developments were presented to the WG this year, but were not taken further as they did not lead to an improvement in model fit. Revised M estimates from WGSAM (ICES-WGSAM, 2011) also necessitate re-estimation of reference points, and these will be considered in the near future.
5. *In section 14.7 Btrigger is used in the formulas for advice but is not defined along the text or the table of Section 14.9.*
   Btrigger is now defined in Sections 14.7 and 14.9.
6. *Table 14.7b, the row names of the correlation matrix are not meaningful for people not familiar with the model. More meaningful names would help to interpret the values.*
   An attempts is made to provide more meaningful names, in line with the description of the model given in the Stock Annex.
7. *Table 14.12: Basis A. Management plan assumption is given as F2011 = 0.85*F2010 but as far as I understand according to management plan F should be reduced by a 10%.*
   The reviewer has misunderstood that the intermediate year assumption (cut in F2011 relative to F2010) is different to the assumption of F in the TAC year, which in the recovery phase of the management plan is set relative to F2008. Details are given in Section 14.1.4.
8. *According to stock annex fishing mortality is given by:*
   $$\log C_{a,y}^{(\circ)} = -\log S_{a,y} + \log\left(\frac{F_{a,y}}{Z_{a,y}}(1-e^{-Z_{a,y}})N_{a,y}\right) + \varepsilon_{a,y}^{(\circ)}$$
   Where Say is a scaled factor to account for uncertainty in catches. Thus according to the formula the estimated F corresponds with observed catches and not with model predicted/corrected catches. Say (Table 14.11c) is significantly bigger or lower than 1, thus the mortality derived from corrected catches would be significantly different to Fay. It would be more appropriate to work with fishing mortalities derived from corrected catches instead of observed ones. A solution could be to apply the scaled factor multiplicatively to Fay.
   The assertion that estimated F corresponds with observed catches and not with model predicted/corrected catches is not correct. The formula is correct as it stands: a simple re-arrangement of the formula, taking the term –log$S_{a,y}$ to the left-hand side shows that F indeed corresponds to the model predicted/corrected catch.

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 and 2009 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 2010-2012 data from the IBTS Q1 indicate that the 2009 year class may be the same level as the 2005 year class, but that the 2010 year class is be 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. SAM assumes that there is random variability around the exponential equation, which would account for demographic variability and features such as migration or departures from the assumed natural mortality values. This has the consequence that estimated F-at-age paths display less interannual variability with SAM than with the other assessment models, because part of the interannual changes estimated along cohorts are deemed to arise from "other sources of variability" 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 from 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 is considered the most appropriate modelling approach for the North Sea cod stock assessment at this time.

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. However, information from national authorities refers only to landings rather than to the whole catch. Because discarding is known to be very substantial and there are some concerns about the quality of the discards estimates (e.g. suggestions that crews may discard less when an observer is on board), the decision was taken not to fix the catch multiplicative factor to 1 in recent years until issues related to the quality of landings and discards estimates separately have been investigated.

Four assessment runs were conducted, three involving SAM, and one B-Adapt for comparison. These were as follows:

1. A SPALY run using the same M-estimates as used last year (i.e. based on the 2007 M key run, assuming M-values from 2008-2011 equal to those in 2007).
2. A version of the SAM model that distinguishes between landings and discards (the base model treats them as combined), but using the same M-estimates as 1 above. Details of the split SAM model can be found in the 2011 WGMG report (ICES-WGMG, 2011), where it is referred to as "Discard scaling, the first crude approximation".
3. A SPALY run using revised M-estimates from the 2011 M key run (ICES-WGSAM, 2011), where the M-values for 2011 are set equal to those in 2010. This SAM run is considered **the base run**.
4. A B-Adapt run, using the same data as the SAM base run in 3 above.

Figures 14.9a-c compare these four assessment runs. Figure 14.9a compares runs 1 and 2 (i.e. the SPALY and split SAM models using the 2007 key run M values). The split model, which places the catch multiplier only on discards from 1993 onwards, estimates more variable F values, and much higher catch multipliers. An alternative run (not shown), which placed the catch multiplier on combined landings and discards from 1993 to 2005, and on discards only from 2006 onwards (the period of improved reliability of reported landings) showed similar behaviour. Because the split model did not lead to improved model fits, it was discarded from further consideration. Figure 14.9b compares runs 1 and 3 (i.e. the SPALY run for the 2007 and 2011 key run M values). The major difference in this case was the re-scaling of recruitment levels upwards for the 2011 key run M values. This adjustment is expected because of the higher M values, particularly at ages 1-2, although the effect on SSB and F is much smaller because 3 year-old cod are only 23% mature, and F is the average over ages 2 to 4. Figure 14.9c compares the SAM base run to B-adapt (runs 3 and 4) and shows similar differences to previous years.

Normalised residual plots are show in Figure 14.10 for the SAM base run, indicating no serious model misspecification. Ten-year retrospective runs for SSB, Fbar (2-4), recruitment and the catch multiplier are shown in Figure 14.11, indicating no serious retrospective problem in the assessment, apart from a general tendency to overestimate F because we are in a period of decreasing F, a previously noted feature of the SAM fit to North Sea cod data. A summary of the SAM base run 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 ages is shown in Figure 14.13.

14.3.4 Final assessment

The SAM base run 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 14.10 and 14.11 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. 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 below F_{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 appear to have decreased slightly in 2011 because of the weak 2010 year class.

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 in the southernmost areas; these perceptions are consistent with the stronger 2005 and 2009 year classes entering the fishery.

14.5 Recruitment estimates

Estimates of recruitment were sampled from the 1997-2009 year classes, reflecting recent low levels of recruitment, but including the stronger 1999, 2005 and 2009 year classes. These re-sampled recruitments are only used for SAM forecasts in order to evaluate future stock dynamics.

14.6 MSY estimation

MSY estimation was conducted in 2010, but was not repeated this year. 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.

Four sets of forecasts are presented, each differing by the assumption made about fishing mortality in 2012, the intermediate year. These differing assumptions are reflected in Figure 14.15. The first set (Basis A) assumes that F in 2012 follows the management plan, so it assumes there has been a 18% cut in effort (derived by comparing effort allocations in Council Regulations (EC) N°57/2011 and N°44/2012) so that Fbar (2012) = 0.82×Fbar (2011). The second set (Basis B) assumes that there is a continuation of the F trend observed over 2006-2010, resulting in a 12% decrease in F between 2011 and 2012, i.e. Fbar (2012) = 0.88×Fbar (2011). The third set (Basis C) assumes that the management plan is not followed in the intermediate year so that there is no cut in effort and Fbar (2012) = Fbar (2011). The fourth set (Basis D) assumes that the TAC is adhered to in terms of landings in 2012, and an Fbar (2012) = 0.35 will result in this criterion being met. Nine scenarios are considered for the first three sets, with an additional scenario added for the fourth set, as follows [note, $B_{trigger} = B_{pa}$]:

1. Management plan: Fbar (2013) = 0.35×Fbar (2008); ensure TAC (2013) is within 20% of TAC (2012)
2. MSY framework: Fbar (2013) = F_{MSY}×SSB_{2013}/$B_{trigger}$
3. MSY transition rule: Fbar (2013) = min{0.4×Fbar (2010) + 0.6×(F_{MSY}×SSB_{2013}/$B_{trigger}$); F_{pa}}
4. Zero catch: Fbar (2013) = 0
5. MSY: Fbar (2013) = F_{MSY}
6. Lower TAC constraint: Fbar (2013) such that TAC (2013) = 0.8×TAC (2012)
7. Upper TAC constraint: Fbar (2013) such that TAC (2013) = 1.2×TAC (2012)
8. Status quo – constant F: Fbar (2013) = Fbar (2012)
9. Status quo – constant landings: Landings 2013 = Landings 2012
10. B_{pa} in one year: Fbar (2013) such that SSB_{2014} = B_{pa} (Basis D only)

Forecasts for these four sets (Basis A-D) and associated scenarios are given in Table 14.12. Basis B is the preferred WG option.

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	= 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), and making the same assumptions about input values underlying the MSY analysis presented in Section 14.6.

WKCOD recommended that the reference points are not revised in the short term until the SAM assessment model has been finalised (ICES-WKCOD, 2011; see Section 14.10). Further developments in the SAM model (modelling landings and discards separately) were presented to the WG this year, but were not taken further as they did not lead to an improvement in model fit. Revised M estimates from WGSAM (ICES-WGSAM, 2011) also necessitate re-estimation of reference points, and these will be considered in the near future.

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 in 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 Bpa. Fishing mortality is declining more rapidly, but is still above the management plan target of 0.4, and well above F_{msy}.

Recruitment variability has been reduced historically as a result of catch and survey data being estimated to be less reliable at the youngest ages.

The estimated CVs for observed catch-at-age 1, survey index-at-age 1 and the stock–recruitment relationship are all very large: 76%, 60% 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 (0.74) 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 this year, and did not show improved model fits, so the SAM assessment as adopted by WKCOD continues to form the basis for assessments. WKCOD recommended that the reference points are not revised in the short term until the assessment model has been finalised. However, since there is currently no alternative to the SAM assessment model configuration adopted by WKCOD that provides an improved fit, revised reference points for the current assessment model should be considered in the near future.

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, B-Adapt, 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 “unallocated 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 unallocated 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 this year, 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 close to 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.

Fishing mortality has declined from 2000, and is now below F_{pa}, but still estimated to be well 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. 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 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 been much higher than intended. Fishing mortality has been reduced but has remained well above the implied targets. Discarding currently contributes about 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 are 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 2005–2011 fluctuated between 40% and 62% of the estimated total removals, 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. Progress is being made in terms of reducing the incidence of discarding, and in 2011, the proportion of fish discarded by number is 82% of 1 year old (compared to 91% in 2010), 66% of 2 year old, 19% of 3 year old and 6% of 4 year old cod .

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.

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 2011 were 32.9 thousand tonnes and the estimated discards in 2011 were 9.5 thousand tonnes, giving a total of 42.4 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.

It is considered that conclusions drawn from the trends in the historic stock dynamics are robust to the uncertainty in the level of recent recorded catches.

References for this section

Darby, C., Normandale, D., Parker-Humphreys, M., Randall, P. and S. Elliot. 2011. North Sea Whitefish Survey: 2011. Fisheries Science Partnership 2011/11: 41pp. [Accessed online, 15/05/2012: http://www.cefas.defra.gov.uk/media/554008/nsw%202011%20report.pdf]

Darby, C. and M. Parker-Humphreys. 2010. A review of the IBTS cod survey data with particular reference to its use in the North Sea cod stock assessment. Document presented to WGNSSK by correspondence meeting in September 2010.

De Oliveira, J.A.A., Armstrong, F.W. and J. Hingley. 2012. NE cod survey: 2003-2011, Final Report. Fisheries Science Partnership 2011/12: 47pp [Accessed online, 15/05/2012: http://www.cefas.defra.gov.uk/media/556605/fsp201112%20ne%20cod_final.pdf]

ICES-WGFTFB. 2006. Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 3–7 April 2006, Izmir, Turkey. ICES CM 2006/FTC:06, Ref. ACFM. 180 pp.

ICES-WGFTFB. 2007. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 23–27 April 2007, Dublin, Ireland. ICES CM 2007/FTC:06. 197 pp.

ICES-WGFTFB. 2011. Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 9-13 May 2011, Reykjavik, Iceland. ICES CM 2011/SSGESST:11. 151 pp.

ICES-WGMG. 2011. Report of the Working Group on Methods of Fish Stock Assessment (WGMG), 10–19 October 2011, Vigo, Spain. ICES CM 2011/SSGSUE:08. 250 pp.

ICES-WGNSSK 2001. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 19-28 June 2001, Hamburg, Germany. ICES CM 2002/ACFM:01.

ICES-WGNSSK 2007. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak – Combined Spring and Autumn (WGNSSK), 1-8 May 2007, ICES Headquarters and September 2007 by correspondence. ICES CM 2007/ACFM:18&30: 960.

ICES-WGNSSK. 2009. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Spring and Autumn (WGNSSK), 6-12 May, ICES Copenhagen, and September 2009, by correspondence. ICES CM 2009\ACOM:10: 1028pp.

ICES-WGNSSK. 2010. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5 -11 May 2010, ICES Headquarters, Copenhagen. ICES CM 2010/ACOM:13. 1058 pp.

ICES-WGNSSK. 2011. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 4 - 10 May 2011, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:13. 1174 pp.

ICES-WGSAM. 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM), 10–14 October 2011, Woods Hole, USA. ICES CM 2011/SSGSUE:10. 229 pp.

ICES-WKCOD 2011. Report of the Workshop on the Analysis of the Benchmark of Cod in Subarea IV (North Sea), Division VIId (Eastern Channel) and Division IIIa (Skagerrak) (WKCOD 2011), 7–9 February 2011, Copenhagen, Denmark. ICES CM 2011/ACOM:51: 94pp.

ICES-WKROUND. 2009. Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND), January 16–23 2009, Copenhagen, Denmark. ICES CM 2009/ACOM:32: 259pp.

ICES-WKROUNDMP. 2011. Report of the Joint ICES-STECF Workshop on management plan evaluations for roundfish stocks (WKROUNDMP/EWG 11-01), 28 February - 4 March 2011, ICES Headquarters, Copenhagen. . 67 pp.

Napier, I. R. 2011. Fishers' North Sea stock survey 2011. NAFC Marine Centre, University of the Highlands and Islands: 100pp. [Accessed online, 15/05/2012: www.nsss.eu]

Simmonds, J. and S. Kraak 2011. Evaluation of multi-annual plans for cod in Irish Sea, Kattegat, North Sea and West of Scotland (STECF-11-07). EUR XXXX EN – 2011.

STECF. 2011. Report of the STECF SGMOS-10-05 Working Group on Fishing Effort Regimes Regarding Annexes IIA, IIB and IIC of TAC & Quota Regulations, Celtic Sea and Bay of Biscay. Edited by Nick Bailey and Hans-Joachim Rätz. 27 September – 1 October 2010, Edinburgh, Scotland. [Accessed online, 18/05/2011: https://stecf.jrc.ec.europa.eu/c/document_library/get_file?p_l_id=53310&folderId=44891&name=DLFE-9402.pdf]

Wieland, K., Pedersen, E.M.F., Olesen, H.J. and J.E. Beyer. 2009. Effect of bottom type on catch rates of North Sea cod (Gadus morhua) in surveys with commercial fishing vessels. Fish. Res. 96: 244-251.

Wieland, K., Pedersen, E.M., Olesen, H.J., Karlsen, J., Andersen, N.G. and J.E. Beyer. 2010. Spatially-explicit management methods for North Sea cod – a Danish fishermen science collaboration (REX): Fisker/forsker samarbejdet REX om Nordsø torsk - REX III report FERV, June 2010. 137 pp.

Table 14.1 Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1991-2011 as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Belgium	3,356	3,374	2,648	4,827	3,458	4,642	5,799	3,882	3,304	2,470
Denmark	18,479	19,547	19,243	24,067	23,573	21,870	23,002	19,697	14,000	8,358
Faroe Islands	109	46	80	219	44	40	102	96	-	9
France	2,146	1,868	1,868	3,040	1,934	3,451	2,934	.	1,222	717
Germany	8,446	6,800	5,974	9,457	8,344	5,179	8,045	3,386	1,740	1,810
Greenland	.	.	.	.	.	.	.	.	.	.
Netherlands	11,133	10,220	6,512	11,199	9,271	11,807	14,676	9,068	5,995	3,574
Norway	10,476	8,742	7,707	7,111	5,869	5,814	5,823	7,432	6,410	4,369
Poland	-	-	-	-	18	31	25	19	18	18
Sweden	823	646	630	709	617	832	540	625	640	661
UK (E/W/NI)	14,462	14,940	13,941	14,991	15,930	13,413	17,745	10,344	6,543	4,087
UK (Scotland)	28,677	28,197	28,854	35,848	35,349	32,344	35,633	23,017	21,009	15,640
Total Nominal Catch	98,107	94,380	87,457	111,468	104,407	99,423	114,324	77,566	60,881	41,713
Unallocated landings	-758	10,200	7,066	8,555	2,161	2,746	7,779	826	-1,114	-740
WG estimate of total landings	**97,349**	**104,580**	**94,523**	**120,023**	**106,568**	**102,169**	**122,103**	**78,392**	**59,767**	**40,973**
Agreed TAC	**100,000**	**101,000**	**102,000**	**120,000**	**130,000**	**115,000**	**140,000**	**132,400**	**81,000**	**48,600**

Division VIId

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Belgium	187	157	228	377	321	310	239	172	110	93
Denmark	1	-	9	-	-	-	-	-	-	-
France	2,079	1,771	2,338	3,261	2,808	6,387	7,788	.	3,084	1,677
Netherlands	2	-	-	-	-	-	19	3	4	17
UK (E/W/NI)	443	530	312	336	414	478	618	454	385	249
UK (Scotland)	22	2	<0.5	<0.5	4	3	1	-	-	-
Total Nominal Catch	2,734	2,460	2,887	3,974	3,547	7,178	8,665	629	3,583	2,036
Unallocated landings	-65	-28	-37	-10	-44	-135	-85	6,229	-1,258	-463
WG estimate of total landings	**2,669**	**2,432**	**2,850**	**3,964**	**3,503**	**7,043**	**8,580**	**6,858**	**2,325**	**1,573**

Division IIIa (Skagerrak)**

Country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Denmark	11,187	11,994	11,921	15,888	14,573	12,159	12,339	8,682	7,656	5,870
Germany	-	530	399	285	259	81	54	54	54	32
Norway	1,208	1,043	850	1,039	1,046	1,323	1,293	1,146	926	762
Sweden	2,523	2,575	1,834	2,483	1,986	2,173	1,900	1,909	1,293	1,035
Others	102	88	71	134	-	-	-	-	-	-
Norwegian coast *	923	909	760	846	748	911	976	788	624	846
Danish industrial by-catch *	1,360	511	666	749	676	205	97	62	99	687
Total Nominal Catch	15,020	16,230	15,075	19,829	17,864	15,736	15,586	11,791	9,929	7,699
Unallocated landings	-1,018	-1,493	-1,814	-7,720	-1,615	-790	-255	-817	-652	-613
WG estimate of total landings	**14,002**	**14,737**	**13,261**	**12,109**	**16,249**	**14,946**	**15,331**	**10,974**	**9,277**	**7,086**
Agreed TAC	**15,000**	**15,000**	**15,500**	**20,000**	**23,000**	**16,100**	**20,000**	**19,000**	**11,600**	**7,000**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total Nominal Catch	115,861	113,070	105,419	135,271	125,818	122,337	138,575	89,986	74,393	51,448
Unallocated landings	-1,841	8,679	5,215	825	502	1,821	7,439	6,239	-3,024	-1,816
WG estimate of total landings	**114,020**	**121,749**	**110,634**	**136,096**	**126,320**	**124,158**	**146,014**	**96,225**	**71,369**	**49,632**

** 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	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Norwegian coast *	923	909	760	846	748	911	976	788	624	846
Danish industrial by-catch *	1,360	511	666	749	676	205	97	62	99	687
Total	**2,283**	**1,420**	**1,426**	**1,595**	**1,424**	**1,116**	**1,073**	**850**	**723**	**1,533**

Table 14.1 cont. Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1991-2011 as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium	2,616	1,482	1,627	1,722	1,309	1,009	894	946	666	648
Denmark	9,022	4,676	5,889	6,291	5,105	3,430	3,831	4,402	5,686	4,863
Faroe Islands	34	36	37	34	3	-	16	45	32	0
France	1,777	620	294	664	354	659	573	950	781	510
Germany	2,018	2,048	2,213	2,648	2,537	1,899	1,736	2,374	2,844	2,211
Greenland	.	.	.	35	23	17	17	11	.	.
Netherlands	4,707	2,305	1,726	1,660	1,585	1,523	1,896	2,649	2,657	1,961
Norway	5,217	4,417	3,223	2,900	2,749	3,057	4,128	4,234	4,498	4,870
Poland	39	35	-	-	-	1	2	3	.	.
Sweden	463	252	240	319	309	387	439	378	363	315
UK (E/W/NI)	3,112	2,213	1,890	1,270	1,491	1,587	1,546	2,384	2,553	
UK (Scotland)	15,416	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	n/a	12,026
Others	.	.	.	.	786	.	.	.	.	.
Norwegian indust by-catch *	.	.	.	.	48	101	22	4	201	1
Danish industrial by-catch *	.	.	.	.	34	18	46	76	11	0
Total Nominal Catch	44,421	25,936	23,789	22,479	23,108	20,080	22,263	27,428	31,647	19,172
Unallocated landings	-121	-89	-240	1,391	-1,012	-336	-68	-1,800	-347	8,557
WG estimate of total landings	**44,300**	**25,847**	**23,549**	**23,870**	**22,096**	**19,744**	**22,195**	**25,628**	**31,300**	**27,728**
Agreed TAC	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**	**26,842**

Division VIId

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium	51	54	47	51	80	84	154	73	57	55
Denmark	-	-	-	-	-	.	.	.	.	.
France	1,361	1,730	810	986	1,124	1,743	1,326	1,779	1,606	1,111
Netherlands	6	36	14	9	9	59	30	35	45	52
UK (E/W/NI)	145	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	n/a	119
Total Nominal Catch	1,563	1,941	974	1,230	1,481	2,073	1,661	2,024	1,836	1,336
Unallocated landings	1,534	-707	-167	-197	-353	-331	-307	-777	-44	-119
WG estimate of total landings	**3,097**	**1,234**	**807**	**1,033**	**1,128**	**1,742**	**1,354**	**1,247**	**1,792**	**1,218**
Agreed TAC								**1,678**	**1,955**	**1,564**

Division IIIa (Skagerrak)**

Country	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Denmark	5,511	3,054	3,009	2,984	2,478	2,228	2,552	3,023	3,289	3,042
Germany	83	49	99	86	84	67	52	55	56	60
Norway	645	825	856	759	628	681	779	440	433	421
Sweden	897	510	495	488	372	370	365	459	458	.
Others	-	27	24	21	373	385	13	2	26	0
Norwegian coast *	.	.	720	759	524	494	498	342	369	342
Danish industrial by-catch *	.	.	10	18	9	.	-	1	0	0
Total Nominal Catch	7,136	4,465	4,483	4,338	3,935	3,731	3,761	3,979	4,262	3,523
Unallocated landings	332	-674	-696	-533	-569	-784	-463	-101	-174	402
WG estimate of total landings	**7,468**	**3,791**	**3,787**	**3,805**	**3,366**	**2,947**	**3,298**	**3,878**	**4,089**	**3,925**
Agreed TAC	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**	**3,835**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total Nominal Catch	53,120	32,342	29,246	28,047	28,524	25,884	27,685	33,431	37,745	24,031
Unallocated landings	1,745	-1,470	-1,103	661	-1,934	-1,451	-838	-2,678	-565	8,840
WG estimate of total landings	**54,865**	**30,872**	**28,143**	**28,708**	**26,590**	**24,433**	**26,847**	**30,753**	**37,180**	**32,871**

** 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	2002	2002	2004	2003	2006	2007	2008	2009	2010	2011
Norwegian coast *	.	.	720	759	524	494	498	342	369	342
Norwegian indust by-catch *	.	.	.	.	48	101	22	4	201	1
Danish industrial by-catch *	.	.	10	18	43	18	46	77	11	0
Total	**.**	**.**	**730**	**777**	**615**	**613**	**566**	**423**	**582**	**343**

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
1	1241	556	620	904	994
2	6852	3400	4403	5175	5218
3	2443	4293	2763	4450	3830
4	1532	1064	2693	1567	1492
5	307	697	547	1281	602
6	114	170	245	238	579
7	39	70	52	87	68
8	36	30	29	19	25
9	6	21	20	9	5
10	1	4	7	5	10
+gp	0	3	2	3	2
TOTALNUM	12573	10307	11381	13737	12824
TONSLAND	24433	26847	30753	37180	32871
SOPCOF %	100	99	100	101	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
1	14622	8384	8600	9443	4391
2	20183	9165	7020	6829	10166
3	1506	7474	1435	1192	882
4	371	149	586	52	98
5	49	21	34	22	11
6	25	13	16	0	7
7	0	0	8	0	1
8	2	3	0	0	1
9	0	0	0	0	0
10	0	0	2	0	0
+gp	0	0	0	0	0
TOTALNUM	36757	25210	17701	17538	15558
TONSDISC	23636	21814	14022	9982	9485
SOPCOF %	100	100	101	100	100

Table 14.2c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch numbers at age (Thousands).

Catch numbers at age (thousands)

AGE/YEAR	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	19445	13118	114228	127146	61270	37101	5462	107718	305050	42274	112315
2	62594	28685	58520	84752	95756	106909	33005	42617	192757	247327	49230
3	7063	20220	17735	29916	32854	42784	31691	18640	17266	48304	55178
4	3536	4306	9182	6184	11261	12392	13710	13339	6754	5682	14072
5	2788	1917	2387	3379	3271	6076	4565	6297	7101	2726	2206
6	1213	1818	950	1278	1974	1414	2895	1763	2700	3201	1109
7	81	599	658	477	888	870	588	961	893	1680	1060
8	492	118	298	370	355	309	422	209	458	612	489
9	14	94	51	126	138	151	147	186	228	390	80
10	6	12	75	56	40	111	46	98	77	113	58
+gp	0	4	8	83	17	24	78	40	94	18	162
TOTALNUM	97232	70890	204093	253767	207823	208142	92610	191868	533377	352326	235958
TONSLAND	128704	130771	210287	259445	276416	305943	205576	244053	412490	387824	269241
SOPCOF %	100	100	100	100	100	100	100	100	100	100	100

AGE/YEAR	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	140339	170719	233649	549790	58774	619440	1252297	177157	250252	81211	605546
2	74878	63439	183912	99307	254204	96999	122460	223566	73747	140869	79022
3	11476	18944	18766	26087	17258	44653	35056	34901	60510	21687	31281
4	15824	4663	6741	4615	9440	4035	12316	9019	9567	11900	4264
5	4624	7563	1741	2294	3003	3395	1965	4118	3476	2830	3436
6	961	2067	3071	836	1108	712	1273	785	2065	1258	1019
7	438	449	924	1144	410	398	495	604	428	595	437
8	395	196	131	371	405	140	197	134	236	181	244
9	332	229	67	263	153	158	74	65	78	90	60
10	81	95	63	26	36	42	55	37	27	28	45
+gp	189	63	43	96	44	17	25	21	16	23	20
TOTALNUM	249535	268428	449108	684830	344834	769989	1426214	450405	400402	260672	725372
TONSLAND	254086	242304	307009	348974	329605	433252	589093	393394	357752	281388	380209
SOPCOF %	100	100	100	100	100	101	100	100	100	100	100

AGE/YEAR	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	72504	665992	49647	36942	200504	45932	61576	131989	38896	340260	61143
2	154827	38221	190476	72509	45109	102988	31950	42124	84390	42291	107670
3	19111	34413	9800	44172	18685	11985	17230	8684	11372	21306	12974
4	7823	5814	8723	3134	9866	4339	3310	5007	3190	3083	5301
5	1377	2993	1534	2557	1002	2468	1390	1060	1577	870	802
6	1265	604	1075	655	1036	310	1053	491	435	519	286
7	373	556	235	295	251	310	225	329	204	142	151
8	173	171	215	66	140	54	139	52	108	58	42
9	79	69	55	63	27	60	28	40	18	32	15
10	16	44	48	23	31	12	4	17	10	7	13
+gp	31	23	12	18	10	9	10	9	13	16	5
TOTALNUM	257577	748900	261822	160435	276661	168468	116916	189803	140212	408583	188400
TONSLAND	246131	343134	244052	194954	202055	152336	121030	150940	143609	210212	168283
SOPCOF %	100	101	100	100	100	100	100	99	100	100	99

AGE/YEAR	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	19389	111077	16864	37491	46275	7820	20565	8911	13454	12792	28596
2	60181	43085	172877	15468	28683	54778	10492	19591	8744	13883	10495
3	24138	18687	18472	40662	6472	6972	15223	4629	6107	2973	5251
4	3169	6499	5967	4034	6697	1142	2519	2728	1965	1646	1068
5	1860	1238	2402	1446	1021	1080	366	460	988	478	483
6	399	700	509	626	385	144	349	68	150	394	153
7	162	153	236	223	139	84	51	50	43	44	117
8	88	47	41	91	40	27	31	13	23	11	22
9	43	14	16	14	18	14	13	7	8	8	4
10	4	15	4	10	5	6	5	3	3	2	2
+gp	8	10	12	2	1	1	0	1	0	0	0
TOTALNUM	109438	181526	217400	100066	89736	72069	49615	36462	31485	32232	46191
TONSLAND	140575	157774	186494	110405	85084	63565	60571	37244	34037	34980	34640
SOPCOF %	100	100	100	101	100	100	100	102	100	100	103

AGE/YEAR	2007	2008	2009	2010	2011
1	15862	8940	9220	10347	5385
2	27035	12565	11423	12004	15383
3	3949	11767	4198	5642	4713
4	1903	1212	3280	1618	1590
5	356	718	581	1303	613
6	139	183	261	238	586
7	39	71	60	87	69
8	38	33	29	19	26
9	6	21	20	9	5
10	1	4	9	5	10
+gp	0	3	2	3	2
TOTALNUM	49330	35517	29083	31275	28382
TONSLAND	48069	48661	44775	47163	42357
SOPCOF %	100	100	100	101	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
1	0.805	0.801	0.717	0.803	0.722
2	1.161	1.503	1.33	1.287	1.301
3	2.376	2.511	2.671	2.712	2.520
4	4.046	4.026	4.109	4.233	4.365
5	5.523	5.777	5.996	6.06	6.256
6	8.197	7.164	7.511	7.694	7.721
7	8.986	9.358	8.152	9.235	9.236
8	9.777	10.909	10.291	10.312	9.637
9	12.358	11.596	9.999	10.801	11.497
10	13.725	15.278	11.886	11.462	15.756
+gp	9.482	13.653	13.597	10.522	12.421

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
1	0.231	0.299	0.366	0.244	0.248
2	0.762	0.683	0.84	0.831	0.595
3	1.881	1.660	1.689	1.484	2.005
4	4.136	2.459	3.339	3.169	4.119
5	6.141	2.848	6.769	5.414	5.709
6	9.724	8.051	7.951	5.291	6.781
7	1.735	1.239	13.127	6.378	8.254
8	12.032	0.576	1.967	3.119	6.623
9	0.000	0.000	0.000	0.000	11.6
10	0.000	0.000	12.014	0.000	15.17
+gp	0.500	0.500	0.000	0.000	12.3576

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
1	0.276	0.330	0.390	0.293	0.335
2	0.863	0.904	1.029	1.028	0.835
3	2.187	1.971	2.335	2.453	2.424
4	4.064	3.834	3.972	4.199	4.349
5	5.607	5.692	6.041	6.049	6.245
6	8.467	7.228	7.538	7.692	7.710
7	8.917	9.321	8.795	9.234	9.216
8	9.902	9.879	10.212	10.311	9.495
9	12.358	11.596	9.999	10.801	11.499
10	13.725	15.278	11.915	11.462	15.754
+gp	8.154	13.295	13.597	10.522	12.421

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

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

*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.

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 25 April 12

101

IBTS_Q1_ext, 6 is a plusgroup

1983	2011						
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	**8.131**	**1.644**	**1.316**	**0.261**	**0.156**	0.282	2006
1	**3.397**	**6.658**	**1.247**	**0.375**	**0.331**	0.352	2007
1	**3.620**	**2.279**	**3.090**	**0.721**	**0.464**	0.189	2008
1	**2.178**	**3.570**	**1.179**	**0.986**	**0.327**	0.272	2009
1	**5.814**	**4.635**	**1.862**	**0.648**	**0.533**	0.231	2010
1	**1.103**	**7.038**	**1.940**	**0.750**	**0.417**	0.408	2011
1	**5.144**	**3.529**	**4.942**	**1.214**	**0.326**	0.230	2012

Table 14.7a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base 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

# The following matrix describes the coupling
# of fishing mortality PARAMETERS
# Rows represent fleets.
# Columns represent ages.
 0  0  0  0  0  0  0
 1  2  3  4  5  0  0

# Survey q-scaling coefficient (better name wanted)
#
# Rows represent fleets.
# Columns represent ages.
 0  0  0  0  0  0  0
 0  0  0  0  0  0  0

# The following matrix describes the coupling
# of fishing mortality variance parameters
# Rows represent fleets.
# Columns represent ages.
 1  1  1  1  1  1  1
 0  0  0  0  0  0  0

# The following vector describes the coupling
# of the log N variance parameters at different
# ages
 1  2  2  2  2  2  2

# The following matrix describes the coupling
# of observation variance parameters
# Rows represent fleets.
# Columns represent ages.
 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
19
  # Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
2011
  # 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
 14   14   14   14   14   14   14
 15   15   15   15   15   15   15
 16   16   16   16   16   16   16
 17   17   17   17   17   17   17
 18   18   18   18   18   18   18
 19   19   19   19   19   19   19
# Define Fbar range
2 4
```

Table 14.7b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base run model fitting diagnostics, parameter estimates and correlation matrix (.par and .cor files)

```
# Number of parameters = 35  Objective function value = 105.370  Maximum gradient component = 0.00000
```

The logarithm of the determinant of the hessian = 158.851

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	30	31	32	33	34	35
1	log survey q 1	-10.90	0.12	1																																		
2	log survey q 2	-9.49	0.06	0.24	1																																	
3	log survey q 3	-9.00	0.06	0.20	0.37	1																																
4	log survey q 4	-8.76	0.06	0.19	0.36	0.39	1																															
5	log survey q 5	-8.39	0.06	0.19	0.35	0.37	0.39	1																														
6	log sigF	-2.65	0.14	-0.02	-0.03	-0.04	-0.04	-0.04	1																													
7	log sigR	-0.69	0.11	0.00	0.00	-0.02	-0.03	-0.02	-0.01	1																												
8	log sigN	-2.30	0.17	0.00	0.01	-0.01	-0.02	-0.01	-0.09	0.22	1																											
9	log sigC1	-0.28	0.11	0.00	0.01	0.02	0.02	0.02	-0.05	-0.09	-0.08	1																										
10	log sigC2	-1.52	0.16	0.01	0.02	0.03	0.04	0.03	-0.03	-0.16	-0.25	0.14	1																									
11	log sigC3+	-2.48	0.15	-0.01	-0.01	0.00	0.00	0.00	-0.07	-0.14	-0.64	0.06	0.11	1																								
12	log sigS1	-0.51	0.14	0.02	0.04	0.06	0.06	0.06	0.01	-0.06	-0.08	0.00	0.03	0.05	1																							
13	log sigS2+	-1.37	0.07	0.00	-0.01	0.00	0.00	-0.01	-0.03	-0.09	-0.23	0.04	0.13	0.12	0.02	1																						
14	rec_loga	1.87	0.15	-0.10	-0.07	-0.02	-0.01	0.00	-0.01	0.00	0.01	0.02	0.03	-0.01	-0.01	0.00	1																					
15	rec_logb	-13.80	1.15	-0.06	-0.04	-0.01	0.00	0.00	-0.02	0.00	0.02	0.03	0.03	-0.02	-0.01	0.00	0.86	1																				
16	log Cmult 93	-0.03	0.08	-0.11	-0.21	-0.23	-0.23	-0.23	0.03	0.00	0.03	-0.01	-0.03	0.00	-0.04	-0.02	0.00	-0.01	1																			
17	log Cmult 94	0.09	0.10	-0.15	-0.28	-0.29	-0.29	-0.29	0.04	0.00	0.00	0.01	0.00	0.01	-0.06	0.00	0.00	0.00	0.49	1																		
18	log Cmult 95	0.23	0.10	-0.16	-0.31	-0.32	-0.32	-0.32	0.07	0.02	0.00	0.00	0.03	-0.02	-0.06	0.00	0.01	0.00	0.31	0.56	1																	
19	log Cmult 96	0.06	0.10	-0.17	-0.32	-0.34	-0.34	-0.34	0.09	0.04	0.06	-0.03	-0.03	-0.05	-0.07	-0.03	0.01	0.00	0.21	0.36	0.58	1																
20	log Cmult 97	-0.04	0.10	-0.17	-0.32	-0.34	-0.34	-0.34	0.05	0.04	-0.03	-0.02	-0.03	0.02	-0.06	0.01	0.02	0.01	0.15	0.24	0.37	0.57	1															
21	log Cmult 98	-0.23	0.10	-0.17	-0.32	-0.34	-0.34	-0.34	0.08	0.03	-0.02	-0.02	-0.01	0.01	-0.06	0.00	0.02	0.01	0.13	0.18	0.25	0.37	0.58	1														
22	log Cmult 99	-0.15	0.10	-0.17	-0.31	-0.33	-0.34	-0.33	0.12	0.03	0.05	-0.03	-0.10	-0.02	-0.06	-0.05	0.01	0.00	0.13	0.16	0.20	0.26	0.37	0.57	1													
23	log Cmult 00	0.04	0.10	-0.16	-0.31	-0.33	-0.33	-0.33	0.09	0.01	-0.02	-0.02	-0.04	0.03	-0.04	-0.02	0.01	0.00	0.13	0.16	0.18	0.20	0.26	0.37	0.57	1												
24	log Cmult 01	0.42	0.10	-0.16	-0.31	-0.32	-0.32	-0.32	0.01	0.01	-0.04	-0.02	0.01	0.02	-0.03	0.03	0.01	0.00	0.13	0.16	0.17	0.18	0.20	0.24	0.35	0.56	1											
25	log Cmult 02	0.24	0.10	-0.16	-0.31	-0.32	-0.33	-0.32	0.02	0.05	-0.01	-0.03	-0.12	0.05	-0.04	-0.01	0.01	0.00	0.13	0.17	0.17	0.18	0.19	0.20	0.25	0.36	0.57	1										
26	log Cmult 03	0.63	0.10	-0.16	-0.31	-0.32	-0.32	-0.32	0.05	0.02	0.00	0.00	0.02	-0.01	-0.06	-0.02	0.02	0.01	0.13	0.17	0.19	0.19	0.18	0.18	0.19	0.25	0.36	0.56	1									
27	log Cmult 04	0.28	0.10	-0.17	-0.31	-0.32	-0.32	-0.32	0.03	0.01	0.01	-0.01	-0.04	0.01	-0.06	0.02	0.01	0.00	0.14	0.17	0.19	0.20	0.19	0.18	0.18	0.20	0.25	0.37	0.57	1								
28	log Cmult 05	0.29	0.10	-0.16	-0.31	-0.32	-0.32	-0.32	-0.02	-0.03	-0.04	0.00	-0.02	0.04	-0.06	0.06	0.01	0.00	0.13	0.17	0.19	0.19	0.19	0.18	0.17	0.18	0.20	0.25	0.37	0.58	1							
29	log Cmult 06	0.22	0.10	-0.16	-0.30	-0.31	-0.31	-0.31	-0.12	-0.03	-0.08	0.00	0.02	0.07	-0.07	0.14	0.01	0.00	0.12	0.17	0.18	0.18	0.19	0.18	0.16	0.16	0.18	0.19	0.24	0.37	0.58	1						
30	log Cmult 07	0.26	0.10	-0.16	-0.30	-0.31	-0.31	-0.31	-0.15	-0.01	-0.03	0.00	0.02	0.04	-0.07	0.11	0.02	0.01	0.12	0.17	0.18	0.18	0.19	0.18	0.16	0.16	0.17	0.17	0.19	0.26	0.39	0.61	1					
31	log Cmult 08	0.09	0.10	-0.16	-0.31	-0.31	-0.31	-0.31	-0.10	0.04	0.08	-0.02	-0.03	-0.06	-0.08	0.03	0.02	0.01	0.13	0.17	0.18	0.19	0.19	0.19	0.18	0.17	0.17	0.17	0.17	0.21	0.27	0.40	0.60	1				
32	log Cmult 09	0.15	0.11	-0.17	-0.31	-0.31	-0.31	-0.31	-0.07	0.03	0.03	-0.03	-0.05	-0.01	-0.06	0.04	0.03	0.02	0.13	0.17	0.18	0.19	0.20	0.19	0.19	0.18	0.18	0.18	0.17	0.18	0.22	0.30	0.42	0.61	1			
33	log Cmult 10	0.19	0.11	-0.17	-0.31	-0.31	-0.31	-0.31	-0.05	0.03	0.01	-0.03	-0.05	0.00	-0.05	0.03	0.03	0.02	0.13	0.17	0.18	0.19	0.20	0.19	0.19	0.18	0.18	0.18	0.17	0.17	0.19	0.23	0.30	0.42	0.62	1		
34	log Cmult 11	0.36	0.11	-0.17	-0.30	-0.31	-0.31	-0.31	-0.01	0.03	0.05	-0.03	-0.07	-0.02	-0.04	-0.01	0.04	0.03	0.13	0.17	0.18	0.20	0.20	0.19	0.20	0.19	0.18	0.19	0.17	0.17	0.17	0.18	0.22	0.30	0.42	0.61	1	
35	rho	0.74	0.11	0.00	0.01	0.01	0.00	-0.02	0.29	-0.01	0.11	0.11	0.13	0.03	-0.02	-0.05	0.02	0.04	0.03	0.03	0.05	0.05	0.01	0.02	0.03	0.02	-0.03	-0.03	0.02	-0.01	-0.05	-0.12	-0.12	-0.09	-0.09	-0.08	-0.04	1

Table 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base run estimated fishing mortality at age.

Fishing mortality (F) at age

Year\Age	1	2	3	4	5	6	7+	Fbar 2-4
1963	0.119	0.456	0.520	0.479	0.456	0.492	0.492	0.485
1964	0.125	0.475	0.559	0.505	0.482	0.511	0.511	0.513
1965	0.132	0.498	0.598	0.531	0.505	0.523	0.523	0.542
1966	0.136	0.517	0.621	0.542	0.520	0.536	0.536	0.560
1967	0.147	0.561	0.672	0.581	0.567	0.579	0.579	0.605
1968	0.154	0.593	0.701	0.611	0.594	0.596	0.596	0.635
1969	0.152	0.589	0.684	0.596	0.584	0.580	0.580	0.623
1970	0.156	0.613	0.700	0.603	0.591	0.572	0.572	0.639
1971	0.173	0.688	0.766	0.659	0.642	0.621	0.621	0.704
1972	0.189	0.764	0.829	0.712	0.688	0.684	0.684	0.768
1973	0.187	0.760	0.803	0.694	0.666	0.659	0.659	0.752
1974	0.186	0.759	0.778	0.672	0.650	0.649	0.649	0.736
1975	0.195	0.802	0.815	0.698	0.677	0.673	0.673	0.772
1976	0.203	0.843	0.852	0.715	0.696	0.690	0.690	0.803
1977	0.204	0.842	0.854	0.700	0.699	0.687	0.687	0.799
1978	0.218	0.888	0.931	0.753	0.761	0.721	0.721	0.857
1979	0.206	0.816	0.890	0.708	0.705	0.663	0.663	0.805
1980	0.219	0.857	0.957	0.765	0.735	0.712	0.712	0.860
1981	0.225	0.874	0.996	0.799	0.744	0.737	0.737	0.890
1982	0.247	0.952	1.105	0.893	0.816	0.821	0.821	0.983
1983	0.244	0.938	1.086	0.893	0.807	0.812	0.812	0.972
1984	0.231	0.886	1.010	0.850	0.765	0.774	0.774	0.915
1985	0.224	0.860	0.968	0.833	0.742	0.755	0.755	0.887
1986	0.235	0.899	1.016	0.894	0.787	0.807	0.807	0.936
1987	0.234	0.899	1.009	0.905	0.785	0.817	0.817	0.938
1988	0.234	0.899	1.027	0.918	0.797	0.815	0.815	0.948
1989	0.238	0.914	1.040	0.944	0.823	0.836	0.836	0.966
1990	0.223	0.861	0.968	0.890	0.779	0.784	0.784	0.906
1991	0.224	0.857	0.969	0.904	0.798	0.816	0.816	0.910
1992	0.216	0.817	0.932	0.881	0.779	0.792	0.792	0.877
1993	0.217	0.818	0.957	0.899	0.798	0.809	0.809	0.891
1994	0.219	0.815	0.987	0.917	0.817	0.824	0.824	0.906
1995	0.223	0.827	1.030	0.946	0.852	0.848	0.848	0.934
1996	0.228	0.830	1.061	0.974	0.902	0.902	0.902	0.955
1997	0.229	0.814	1.067	1.003	0.933	0.921	0.921	0.961
1998	0.232	0.811	1.087	1.042	0.984	0.939	0.939	0.980
1999	0.237	0.805	1.109	1.083	1.030	0.990	0.990	0.999
2000	0.237	0.793	1.085	1.107	1.068	0.997	0.997	0.995
2001	0.229	0.760	1.028	1.080	1.045	0.980	0.980	0.956
2002	0.222	0.727	0.992	1.058	1.022	0.971	0.971	0.926
2003	0.216	0.710	0.960	1.034	0.999	0.947	0.947	0.901
2004	0.206	0.671	0.909	0.992	0.939	0.925	0.925	0.857
2005	0.194	0.627	0.846	0.925	0.890	0.885	0.885	0.799
2006	0.176	0.568	0.773	0.827	0.811	0.812	0.812	0.723
2007	0.163	0.524	0.725	0.758	0.747	0.753	0.753	0.669
2008	0.155	0.496	0.692	0.703	0.715	0.741	0.741	0.630
2009	0.149	0.472	0.659	0.674	0.687	0.730	0.730	0.602
2010	0.144	0.453	0.640	0.654	0.662	0.713	0.713	0.582
2011	0.142	0.444	0.626	0.647	0.656	0.706	0.706	0.572

Table 14.9 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base 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	465562	192914	21354	10320	8585	3313	1642	703690
1964	852561	137861	53051	11614	5327	4649	2321	1067384
1965	1069819	245487	40782	23086	6380	2631	3153	1391338
1966	1379180	286932	69703	16722	9885	3347	2932	1768701
1967	1271872	358613	73865	29202	7963	4822	3309	1749646
1968	656711	320937	91309	28170	14351	3526	3613	1118617
1969	606221	156530	76420	33962	11357	6704	3157	894351
1970	1839492	146825	39815	32112	15271	4750	4072	2082337
1971	2369051	444631	35313	14948	15508	6791	4181	2890423
1972	584201	559053	94466	12326	6126	6736	5485	1268393
1973	875018	129314	111748	29703	5001	2532	4572	1157888
1974	807744	195830	25719	37049	11062	2159	3168	1082731
1975	1377802	180052	39656	9643	16259	4606	2279	1630297
1976	849158	311763	35990	13738	3961	6810	2776	1224196
1977	2096962	184425	55770	11232	5295	1735	4034	2359453
1978	1271872	472125	32991	18792	5219	2265	2281	1805545
1979	1435466	285215	85306	9370	7203	1796	1785	1826141
1980	2273884	313013	61759	25135	4029	2810	1687	2682317
1981	885582	494845	62069	17964	9190	1637	1829	1473116
1982	1407042	187400	96086	17149	6741	3797	1450	1719665
1983	819132	298343	34648	21735	5552	2469	1842	1183721
1984	1426879	177549	55548	8283	6960	2049	1602	1678870
1985	378511	313953	36026	15780	2954	2665	1391	751280
1986	1692979	85819	61883	10585	5776	1177	1648	1859867
1987	671319	393171	17980	15950	3296	2052	1055	1104823
1988	462314	157472	74682	5427	5144	1271	998	707308
1989	767582	109098	32533	17903	1867	1936	854	931773
1990	333701	183506	21670	8171	5238	658	966	553910
1991	370275	81716	34030	6216	2729	1987	706	497659
1992	792541	94183	16934	9246	2092	983	920	916899
1993	446860	206902	20729	5510	3081	812	687	684581
1994	944112	115382	42193	6039	1902	1109	541	1111278
1995	557936	251702	26716	11523	1957	709	575	851118
1996	403528	147709	47572	6452	3594	733	527	610115
1997	1059174	109974	31382	10868	2130	1176	413	1215117
1998	170587	290977	24909	7824	3191	734	481	498703
1999	303458	45071	60114	5847	2207	929	449	418075
2000	548532	84036	11281	11797	1638	677	387	658348
2001	208981	158261	19928	2736	2782	409	336	393433
2002	255761	59101	37198	5083	772	757	224	358896
2003	119134	71396	16004	8896	1429	231	273	217363
2004	200186	34030	16496	4136	2530	379	172	257929
2005	137448	56557	8879	4004	1175	898	169	209130
2006	344897	39340	15132	2559	1158	376	350	403812
2007	147119	103881	11587	4595	985	403	246	268816
2008	178796	43217	30424	3325	1683	407	281	258133
2009	191186	53960	12999	8833	1428	637	281	269324
2010	326440	58689	17077	4447	3619	597	332	411201
2011	165711	101620	18511	5296	1933	1689	356	295116
2012	341465	51328	33996	6358	2106	821	826	436900

Table 14.10 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base run estimated total removals at age (including catches due to unallocated mortality)

Total removals at age (thousands)

Year\Age	1	2	3	4	5	6	7+
1963	31952	50352	7803	3586	2873	1176	583
1964	60367	36960	20422	4202	1862	1701	849
1965	78253	67962	16472	8691	2313	980	1174
1966	102724	81455	28848	6392	3665	1270	1113
1967	101013	108250	32293	11767	3153	1939	1331
1968	54176	100932	41056	11787	5882	1449	1484
1969	49168	48986	33678	13946	4600	2698	1271
1970	152268	47387	17806	13291	6240	1893	1623
1971	214894	157000	16796	6608	6730	2878	1772
1972	57694	213395	47363	5753	2792	3060	2491
1973	85451	49281	54803	13622	2228	1119	2022
1974	78300	74757	12347	16623	4845	944	1385
1975	139777	71725	19641	4443	7330	2068	1023
1976	89438	128849	18353	6437	1822	3111	1268
1977	220665	76367	28447	5182	2441	790	1837
1978	142401	203353	17776	9124	2551	1068	1075
1979	151919	116262	44614	4359	3341	798	793
1980	254613	132349	33786	12342	1925	1312	787
1981	101773	213011	34745	9077	4426	783	875
1982	175958	85571	57119	9314	3455	1953	746
1983	101570	135280	20376	11799	2824	1261	940
1984	169431	77746	31282	4358	3416	1014	793
1985	43936	135090	19754	8193	1420	1297	677
1986	207233	38174	34961	5753	2888	599	838
1987	82430	175168	10122	8727	1646	1052	541
1988	57377	70228	42514	2996	2594	651	511
1989	97470	49227	18670	10061	962	1008	444
1990	40239	79531	11911	4426	2602	328	482
1991	45180	35277	18716	3399	1378	1018	362
1992	93714	39360	9085	4976	1039	494	462
1993	53434	86535	11281	3002	1556	414	350
1994	114211	48132	23346	3330	976	572	279
1995	68920	106351	15107	6474	1032	373	302
1996	51108	62668	27242	3688	1964	400	288
1997	135293	46143	17929	6316	1189	651	229
1998	22210	122125	14291	4647	1840	411	270
1999	40465	18882	34655	3548	1308	538	260
2000	73357	34906	6375	7240	991	394	225
2001	27157	63780	10834	1654	1663	235	194
2002	32468	23098	19651	3033	455	433	128
2003	14756	27397	8237	5233	832	130	154
2004	23687	12507	8161	2372	1418	211	96
2005	15353	19730	4175	2198	637	485	91
2006	35235	12707	6672	1306	591	192	179
2007	13961	31448	4874	2211	476	196	120
2008	16188	12526	12370	1518	788	196	135
2009	16642	15003	5097	3917	651	303	134
2010	27537	15808	6547	1929	1606	279	155
2011	13784	26882	6979	2279	852	784	165

Table 14.11a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base 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	465562	346383	625746	514011	458510	576230	151903	137479	167841	124991	111393	140250	0.485	0.432	0.545
1964	852561	639934	1135837	686938	598517	788423	164226	149789	180055	152818	138062	169150	0.513	0.462	0.570
1965	1069819	807469	1417407	862853	760402	979109	203822	186820	222370	203211	182158	226697	0.543	0.491	0.600
1966	1379180	1040737	1827684	1050734	922752	1196467	227294	209349	246777	249197	224021	277203	0.560	0.508	0.618
1967	1271872	957633	1689224	1135973	1004934	1284099	251450	232062	272459	298045	267223	332422	0.605	0.550	0.666
1968	656711	491089	878192	944112	855552	1041839	262236	242285	283830	299539	271759	330159	0.635	0.577	0.699
1969	606221	454794	808067	804519	723014	895212	258590	238710	280126	239666	219948	261151	0.623	0.567	0.685
1970	1839492	1383075	2446527	1333077	1115146	1593597	273758	252288	297055	268069	236281	304133	0.639	0.582	0.701
1971	2369051	1779851	3153300	1460077	1246602	1710110	276233	255304	298877	351864	307065	403199	0.705	0.644	0.771
1972	584201	438599	778139	976764	875190	1090126	241349	222982	261229	361855	318951	410531	0.768	0.701	0.842
1973	875018	657895	1163799	800507	713004	898748	213203	197688	229936	259627	236994	284421	0.752	0.688	0.823
1974	807744	606852	1075138	755398	675155	845178	232350	214317	251901	240867	217270	267027	0.736	0.673	0.806
1975	1377802	1024751	1852488	859409	739184	999188	212990	196802	230509	238470	213151	266797	0.772	0.706	0.843
1976	849158	629915	1144708	659344	586124	741710	182956	169538	197436	237518	209065	269844	0.803	0.734	0.879
1977	2096962	1560630	2817611	1007518	836246	1213867	161135	149748	173388	244019	211359	281725	0.798	0.730	0.873
1978	1271872	950592	1701737	1122423	957172	1316203	160332	149432	172026	323515	275897	379351	0.858	0.785	0.937
1979	1435466	1075956	1915099	1006511	878527	1153139	166708	155438	178796	314268	277926	355361	0.804	0.737	0.878
1980	2273884	1696673	3047463	1172912	1000826	1374587	181498	169274	194604	339422	296329	388783	0.860	0.791	0.935
1981	885582	663736	1181576	989544	874170	1120146	194658	181971	208230	362943	317563	414807	0.890	0.819	0.966
1982	1407042	1064675	1859503	1018661	880198	1178907	188339	176317	201182	334703	297358	376739	0.983	0.905	1.069
1983	819132	623722	1075762	817495	716778	932363	154972	145018	165610	282377	248504	320868	0.972	0.896	1.054
1984	1426879	1085140	1876239	828192	711878	963510	132455	124089	141385	246225	217735	278442	0.916	0.844	0.993
1985	378511	285758	501370	569777	510510	635924	126627	118499	135312	225709	198651	256451	0.887	0.816	0.963
1986	1692979	1284988	2230508	776848	649623	928989	115728	108388	123565	206489	180214	236594	0.936	0.864	1.015
1987	671319	512102	880038	739700	643468	850323	108989	101957	116506	248202	213131	289045	0.938	0.866	1.016
1988	462314	352561	606233	550730	487913	621635	100609	94190	107467	199586	179255	222223	0.948	0.875	1.027
1989	767582	580636	1014717	538208	462094	626858	94278	88020	100981	169058	149833	190751	0.966	0.890	1.048
1990	333701	254542	437477	378890	336702	426363	80178	74919	85805	136216	120586	153872	0.906	0.834	0.985
1991	370275	282383	485522	350459	309215	397205	73644	69101	78486	120211	108172	133589	0.910	0.839	0.987
1992	792541	604188	1039614	517622	437058	613035	71111	66579	75952	134861	117489	154801	0.877	0.808	0.951
1993	446860	341008	585569	431059	380163	488768	68597	64415	73050	149343	130422	171008	0.891	0.822	0.966
1994	944112	711976	1251934	527023	449225	618294	72114	67745	76765	153430	135498	173736	0.906	0.836	0.982
1995	557936	426053	730643	562980	489906	646955	81064	75916	86562	185907	161754	213666	0.934	0.862	1.013
1996	403528	307737	529136	459089	406639	518305	79221	74414	84339	165545	148161	184970	0.955	0.882	1.033
1997	1059174	802173	1398513	632225	526439	759268	75207	70632	80079	166375	143617	192739	0.961	0.890	1.038
1998	170587	128831	225876	342833	302889	388046	61267	57470	65316	140787	121969	162507	0.980	0.908	1.058
1999	303458	230794	399001	256530	228576	287902	55938	52441	59668	100912	91510	111279	0.999	0.924	1.081
2000	548532	418244	719405	344897	293524	405261	49662	46314	53252	101926	88540	117335	0.995	0.921	1.075
2001	208981	157475	277335	247954	220119	279310	41731	39159	44472	90853	80334	102750	0.956	0.885	1.032
2002	255761	193501	338054	266465	233606	303947	42574	39884	45445	88521	79067	99107	0.926	0.856	1.001
2003	119134	90746	156401	150995	136822	166635	36901	34378	39610	60718	54729	67363	0.901	0.833	0.975
2004	200186	152808	262252	149642	131281	170571	31984	29936	34173	47620	42977	52764	0.857	0.791	0.929
2005	137448	105169	179635	144929	129072	162734	29762	27851	31805	47052	41989	52724	0.800	0.736	0.869
2006	344897	263899	450755	156530	136450	179565	26239	24534	28062	41606	37182	46556	0.723	0.663	0.788
2007	147119	112688	192071	185535	165218	208351	32827	30557	35265	56106	49278	63880	0.669	0.611	0.732
2008	178796	136806	233673	186093	167105	207237	38254	35465	41262	54122	49147	59601	0.630	0.573	0.693
2009	191186	145402	251385	211716	187697	238808	47193	43289	51449	56897	51354	63039	0.602	0.541	0.669
2010	326440	236201	451152	246225	212427	285400	51792	46924	57166	61821	55563	68784	0.583	0.513	0.662
2011	165711	105755	259658	236807	200556	279610	56331	49366	64278	66903	59064	75782	0.572	0.485	0.676
2012				295079	208797	417016	65317	52987	80515						

Table 14.11b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base 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 unallocated mortality), while total removals are the SAM estimate of catch, including a catch multiplier incorporated from 1993 onwards.

Year	Landings	Discards	Catch	Catch multiplier	Total Removals
1963	111525	13544	124991		124991
1964	139525	13249	152818		152818
1965	181861	21199	203211		203211
1966	217075	32080	249197		249197
1967	264342	33490	298045		298045
1968	278730	20919	299539		299539
1969	227521	12139	239666		239666
1970	244019	24029	268069		268069
1971	290977	61084	351864		351864
1972	327420	34303	361855		361855
1973	235155	24588	259627		259627
1974	215993	24934	240867		240867
1975	206282	32145	238470		238470
1976	200186	37309	237518		237518
1977	180954	62881	244019		244019
1978	284077	39577	323515		323515
1979	272393	41856	314268		314268
1980	272938	66436	339422		339422
1981	324487	38216	362943		362943
1982	294490	40215	334703		334703
1983	256786	25566	282377		282377
1984	199786	46677	246225		246225
1985	203008	22788	225709		225709
1986	161619	44846	206489		206489
1987	218163	29912	248202		248202
1988	186652	12942	199586		199586
1989	136489	32598	169058		169058
1990	114348	21781	136216		136216
1991	105556	14747	120211		120211
1992	107796	27092	134861		134861
1993	126988	26340	153254	0.97	149343
1994	104849	34971	139842	1.10	153430
1995	121407	26981	148435	1.25	185907
1996	134948	21454	156318	1.06	165545
1997	131834	41785	173564	0.96	166375
1998	136488	40255	176661	0.80	140787
1999	100559	16868	117301	0.86	100912
2000	78174	20082	98193	1.04	101926
2001	47205	12703	59890	1.52	90853
2002	62263	7480	69712	1.27	88521
2003	27136	5152	32325	1.88	60718
2004	28829	7041	35887	1.33	47620
2005	29210	5933	35146	1.34	47052
2006	25730	7798	33538	1.24	41606
2007	22471	20702	43174	1.30	56106
2008	27117	22357	49459	1.09	54122
2009	32327	16506	48907	1.16	56897
2010	37888	13224	51092	1.21	61821
2011	34983	11679	46659	1.43	66903

Table 14.11c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base 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	0.97	0.82	1.15
1994	1.10	0.91	1.33
1995	1.25	1.02	1.53
1996	1.06	0.86	1.30
1997	0.96	0.78	1.18
1998	0.80	0.65	0.98
1999	0.86	0.70	1.06
2000	1.04	0.85	1.27
2001	1.52	1.24	1.86
2002	1.27	1.03	1.56
2003	1.88	1.53	2.30
2004	1.33	1.08	1.63
2005	1.34	1.09	1.64
2006	1.24	1.01	1.53
2007	1.30	1.05	1.60
2008	1.09	0.89	1.35
2009	1.16	0.94	1.43
2010	1.21	0.98	1.49
2011	1.43	1.16	1.77

Table 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch options based on the SAM base run. Units are '000t (SSB, landings, discards, unallocated) or millions (recruitment).

Basis A

Management Plan assumption: F(2012) = 0.82*F(2011) =	**0.47**
Recruitment resampled from 1998-2011 =	**200**
SSB(2013) =	**78.3**
HC landings (2012) =	**40.3**
Discards (2012) =	**10.3**
Unallocated (2012) =	**13.6**

Rationale	Landings (2013)	Basis	Ftotal (2013)	F land (2013)	F disc (2013)	F unal (2013)	Discards (2013)	Unalloc. (2013)	SSB (2014)	%SSB change	%TAC change
Management Plan	25.4	F08*0.35 with TAC constr	0.26	0.15	0.06	0.05	6.5	8.6	107.3	37	-20
MSY framework	10.6	FMSY *SSB2013/Btrigger	0.10	0.06	0.02	0.02	2.7	3.6	126.4	61	-67
MSY transition	28.6	Transition rule	0.29	0.17	0.06	0.06	7.4	9.7	103.3	32	-10
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	140.2	79	-100
MSY	19.5	FMSY	0.19	0.11	0.04	0.04	4.9	6.6	114.9	47	-39
TAC constraint	25.4	TAC2012-20%	0.26	0.15	0.06	0.05	6.5	8.6	107.3	37	-20
TAC constraint	38.2	TAC2012+20%	0.41	0.24	0.09	0.09	10.1	13.0	91.1	16	20
Status quo	42.1	Fsq	0.47	0.28	0.09	0.10	11.2	14.4	86.1	10	33
Status quo	40.3	Constant landings	0.44	0.26	0.09	0.09	10.7	13.7	88.4	13	27

Basis B

Assume F(2012) follows trend: F(2006) to F(2010)	**0.50**
Recruitment resampled from 1998-2011 =	**200**
SSB(2013) =	**75.7**
HC landings (2012) =	**42.6**
Discards (2012) =	**10.9**
Unallocated (2012) =	**14.4**

Rationale	Landings (2013)	Basis	Ftotal (2013)	F land (2013)	F disc (2013)	F unal (2013)	Discards (2013)	Unalloc. (2013)	SSB (2014)	%SSB change	%TAC change
Management Plan	25.4	F08*0.35 with TAC constr	0.27	0.16	0.06	0.06	6.6	8.6	103.3	36	-20
MSY framework	10.0	FMSY *SSB2013/Btrigger	0.10	0.06	0.02	0.02	2.5	3.4	123.0	63	-69
MSY transition	27.6	Transition rule	0.29	0.17	0.06	0.06	7.2	9.4	100.6	33	-13
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	136.1	80	-100
MSY	18.9	FMSY	0.19	0.11	0.04	0.04	4.9	6.4	111.6	47	-41
TAC constraint	25.4	TAC2012-20%	0.27	0.16	0.06	0.06	6.6	8.6	103.3	36	-20
TAC constraint	38.2	TAC2012+20%	0.43	0.25	0.09	0.09	10.2	13.0	87.2	15	20
Status quo	43.2	Fsq	0.50	0.29	0.10	0.11	11.7	14.8	80.8	7	36
Status quo	42.6	Constant landings	0.49	0.28	0.10	0.10	11.5	14.6	81.6	8	34

Basis C

Assume no reduction in F: F(2012) = F(2011) =	**0.57**
Recruitment resampled from 1998-2011 =	**200**
SSB(2013) =	**70.5**
HC landings (2012) =	**47.0**
Discards (2012) =	**12.1**
Unallocated (2012) =	**15.9**

Rationale	Landings (2013)	Basis	Ftotal (2013)	F land (2013)	F disc (2013)	F unal (2013)	Discards (2013)	Unalloc. (2013)	SSB (2014)	%SSB change	%TAC change
Management Plan	25.4	F08*0.35 with TAC constr	0.28	0.17	0.06	0.06	6.9	8.7	95.4	35	-20
MSY framework	8.7	FMSY *SSB2013/Btrigger	0.09	0.06	0.02	0.02	2.3	3.0	116.6	65	-73
MSY transition	25.6	Transition rule	0.29	0.17	0.06	0.06	7.0	8.8	95.1	35	-19
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	128.1	82	-100
MSY	17.8	FMSY	0.19	0.11	0.04	0.04	4.8	6.1	105.2	49	-44
TAC constraint	25.4	TAC2012-20%	0.28	0.17	0.06	0.06	6.9	8.7	95.4	35	-20
TAC constraint	38.2	TAC2012+20%	0.46	0.27	0.09	0.10	10.6	13.1	79.4	13	20
Status quo	45.0	Fsq	0.57	0.33	0.12	0.12	12.7	15.5	71.1	1	41
Status quo	47.0	Constant landings	0.61	0.36	0.13	0.13	13.3	16.2	68.6	-3	48

Basis D

Assume F(2012) so that HC landings (2012) = TAC(2012) =	**0.35**
Recruitment resampled from 1998-2011 =	**200**
SSB(2013) =	**88.5**
HC landings (2012) =	**31.8**
Discards (2012) =	**8.0**
Unallocated (2012) =	**10.7**

Rationale	Landings (2013)	Basis	Ftotal (2013)	F land (2013)	F disc (2013)	F unal (2013)	Discards (2013)	Unalloc. (2013)	SSB (2014)	%SSB change	%TAC change
Management Plan	25.4	F08*0.35 with TAC constr	0.23	0.13	0.05	0.05	6.1	8.5	122.6	38	-20
MSY framework	13.2	FMSY *SSB2013/Btrigger	0.11	0.06	0.02	0.02	3.1	4.4	138.5	56	-58
MSY transition	32.4	Transition rule	0.30	0.17	0.06	0.06	7.9	10.8	113.7	28	2
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	156.0	76	-100
MSY	21.6	FMSY	0.19	0.11	0.04	0.04	5.2	7.2	127.5	44	-32
TAC constraint	25.4	TAC2012-20%	0.23	0.13	0.05	0.05	6.1	8.5	122.6	38	-20
TAC constraint	38.2	TAC2012+20%	0.36	0.21	0.07	0.08	9.3	12.8	106.3	20	20
Status quo	36.9	Fsq	0.35	0.21	0.07	0.07	9.0	12.4	107.9	22	16
Status quo	31.8	Constant landings	0.29	0.17	0.06	0.06	7.7	10.6	114.4	29	0
Bpa in one year	4.5	SSB2013=Bpa	0.04	0.02	0.01	0.01	1.1	1.5	150.0	69	-86

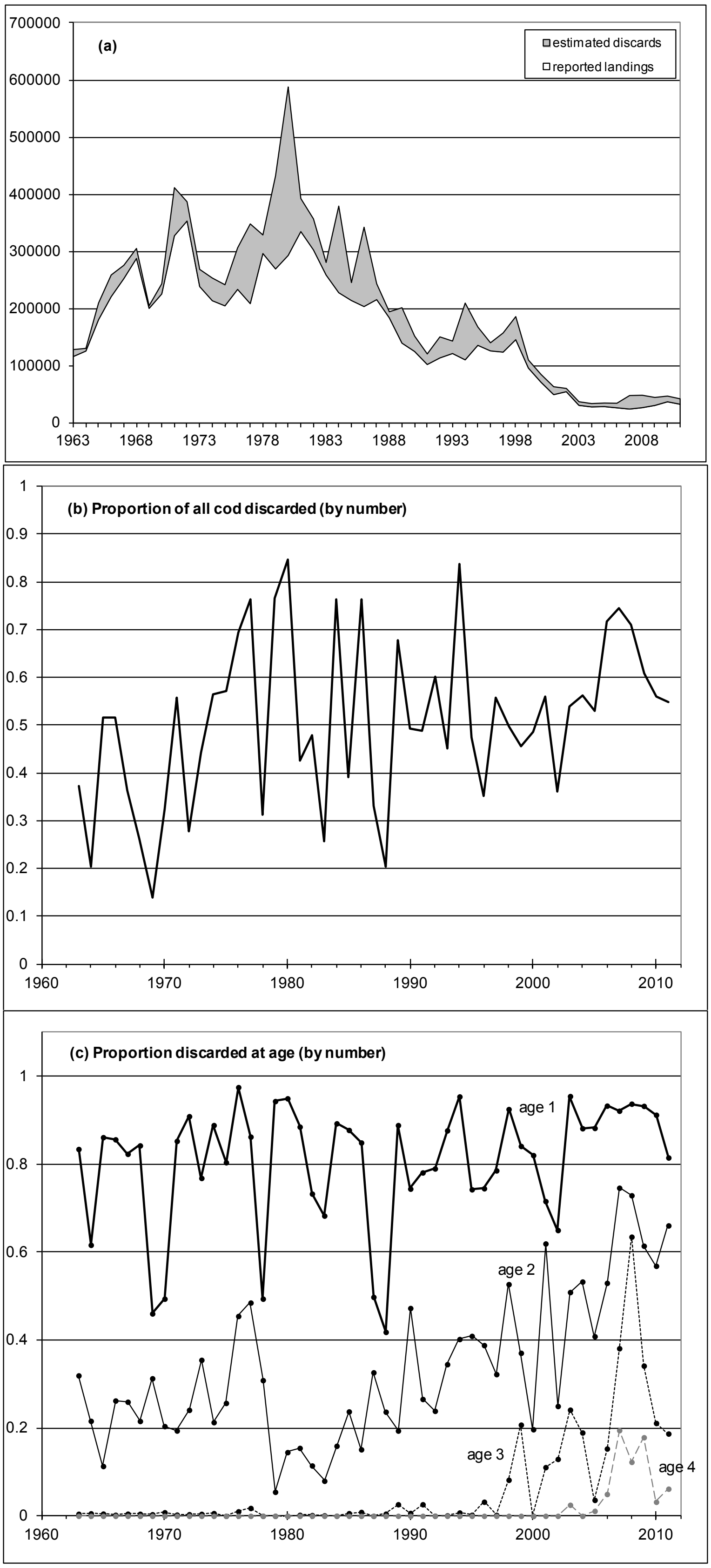


Figure 14.1 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: (a) stacked area plot of reported landings and estimated discards (in tons); (b) proportion of total numbers caught that are discarded; and (c) proportion of total numbers caught at age that are discarded

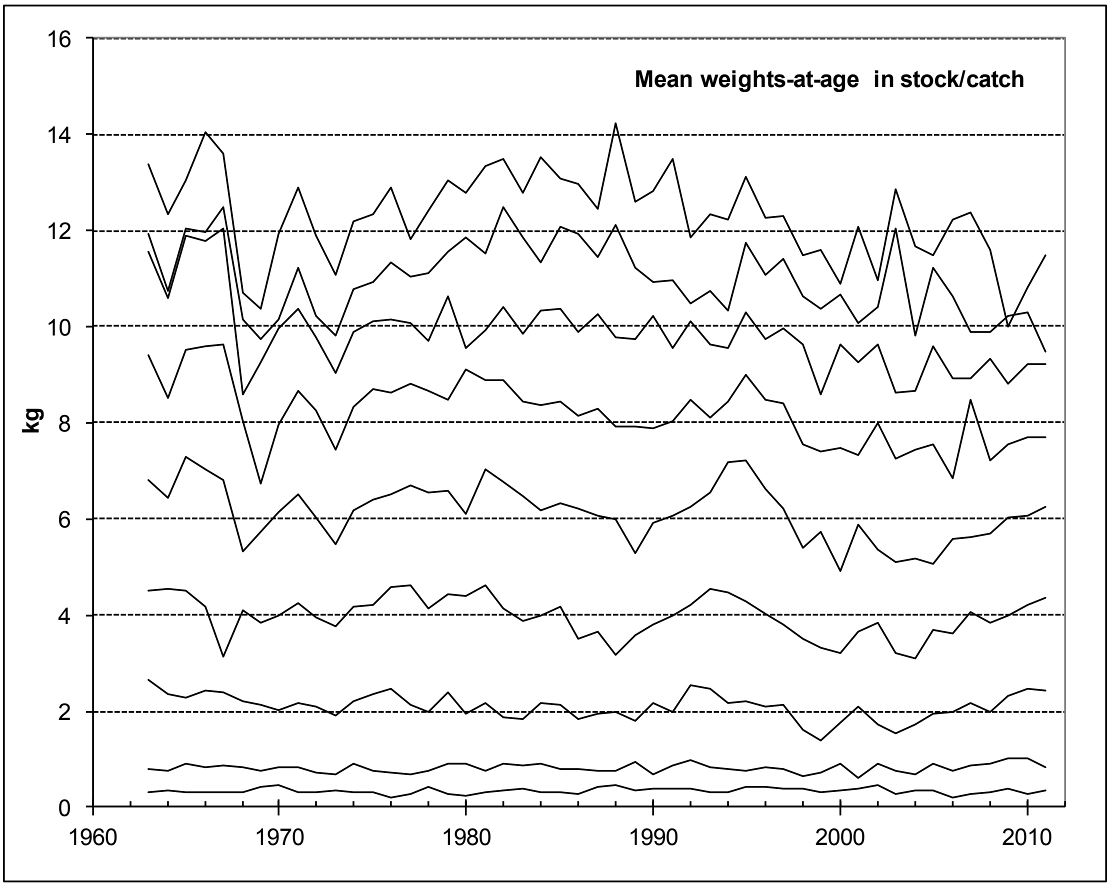


Figure 14.2 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: Mean weight at age in the catch for ages 1-9.

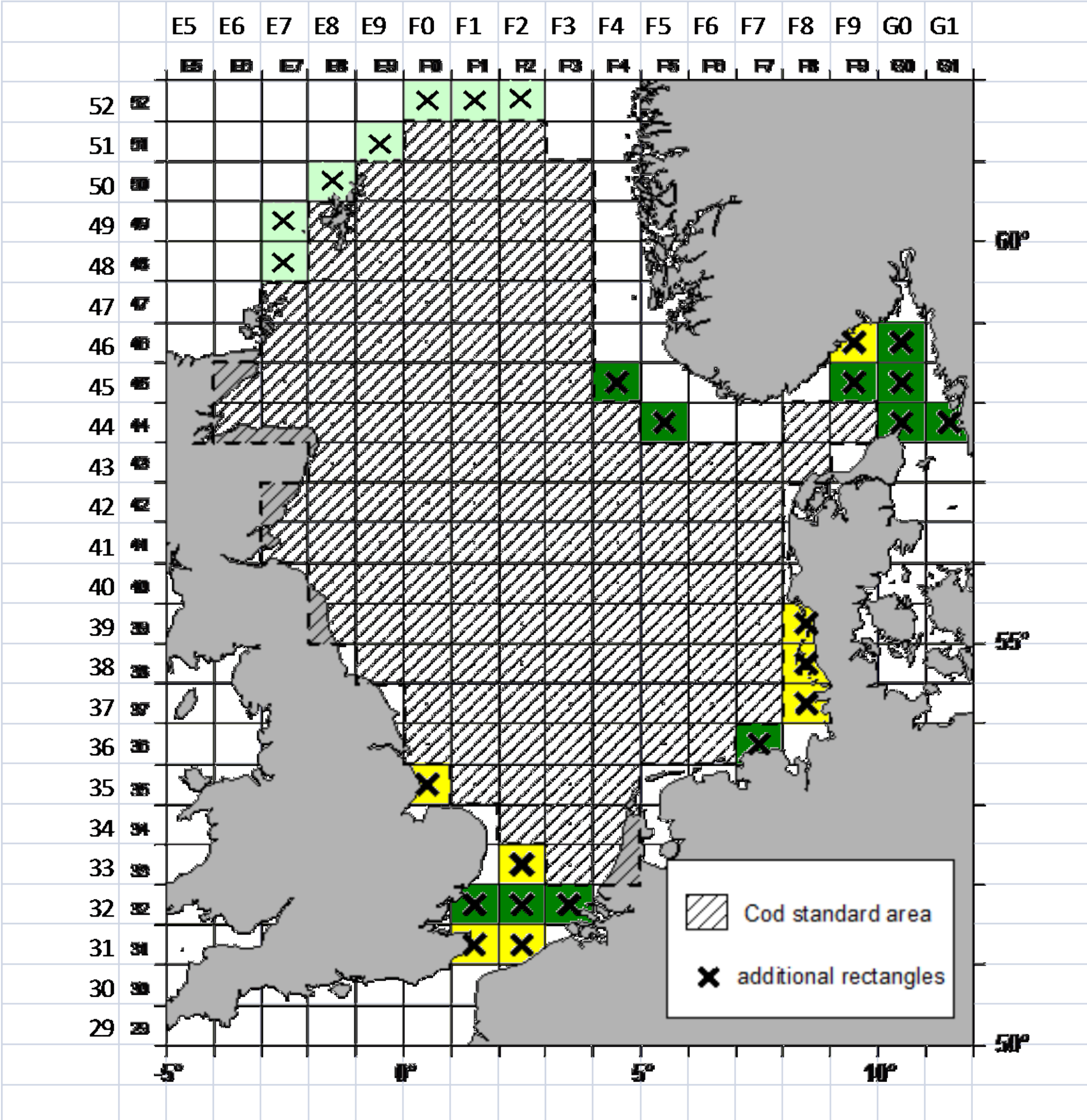


Figure 14.3a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Extension of cod standard area used for the revision of IBTS indices. Crosses indicate suggested extensions to the survey (ICES-WKROUND, 2009; ICES-WKCOD, 2011); green squares (light and dark) indicate where the IBTS group indicate 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).

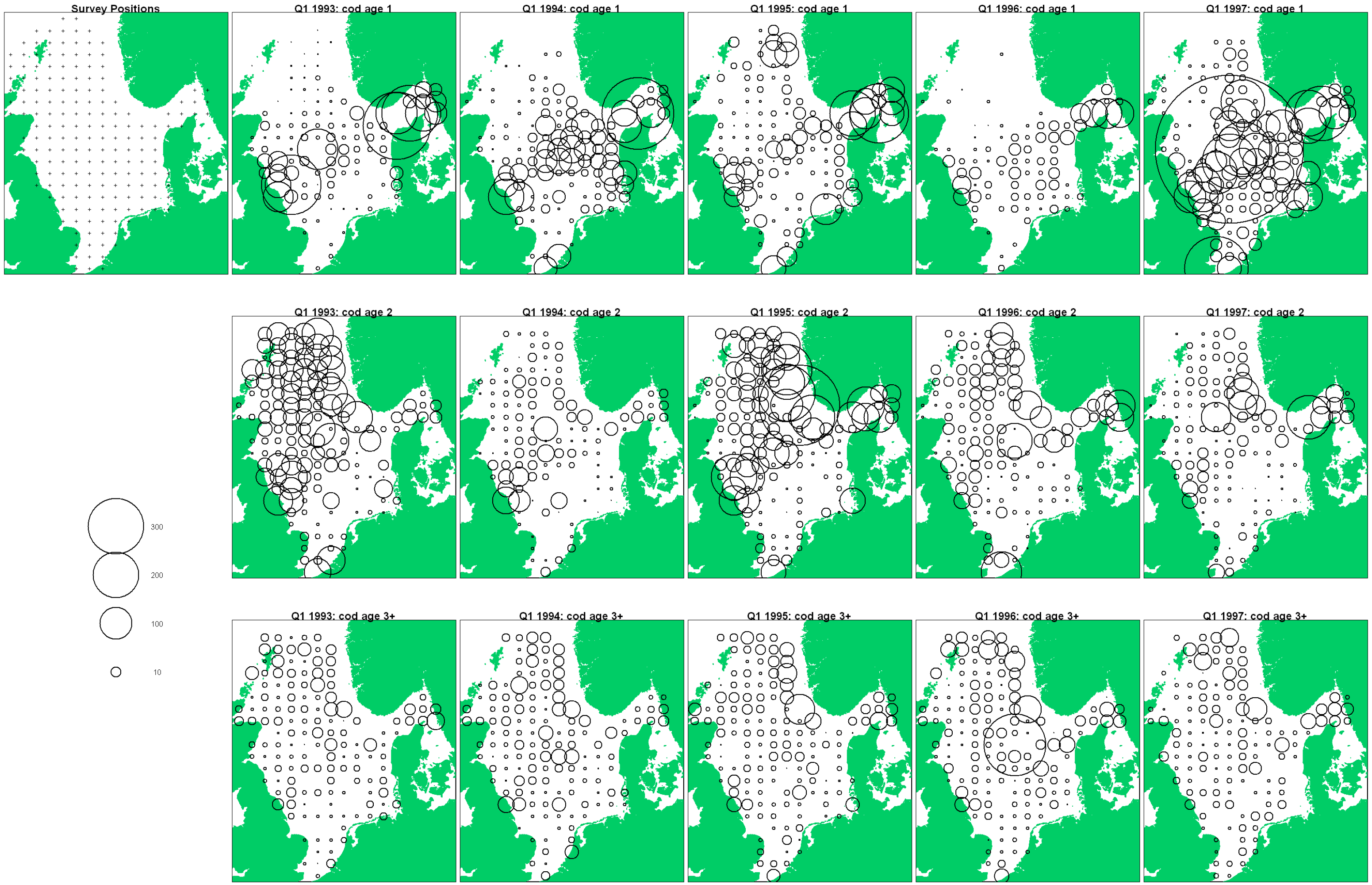


Figure 14.3b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1993-2012 in the North Sea.

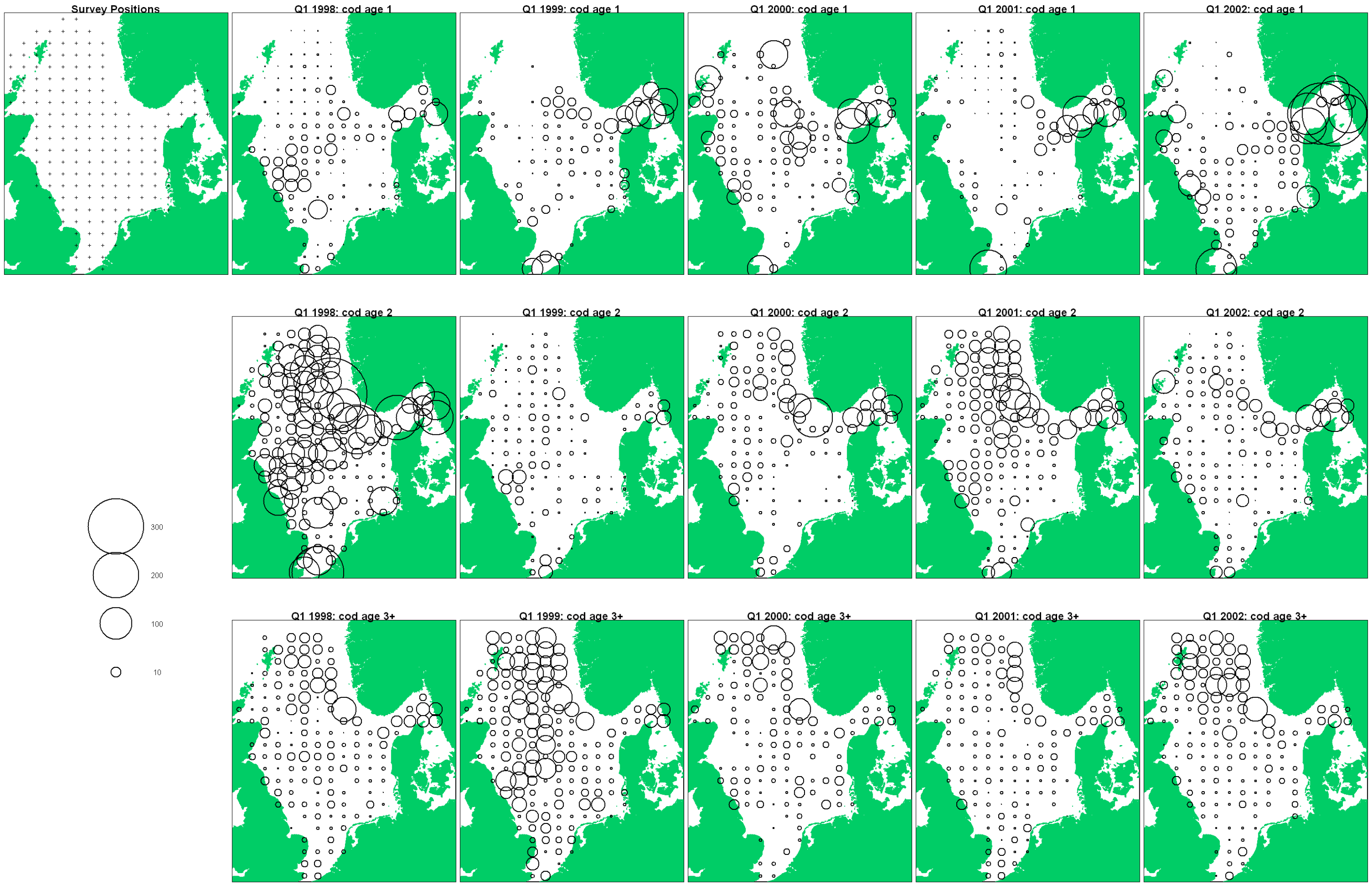


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1993-2012 in the North Sea.

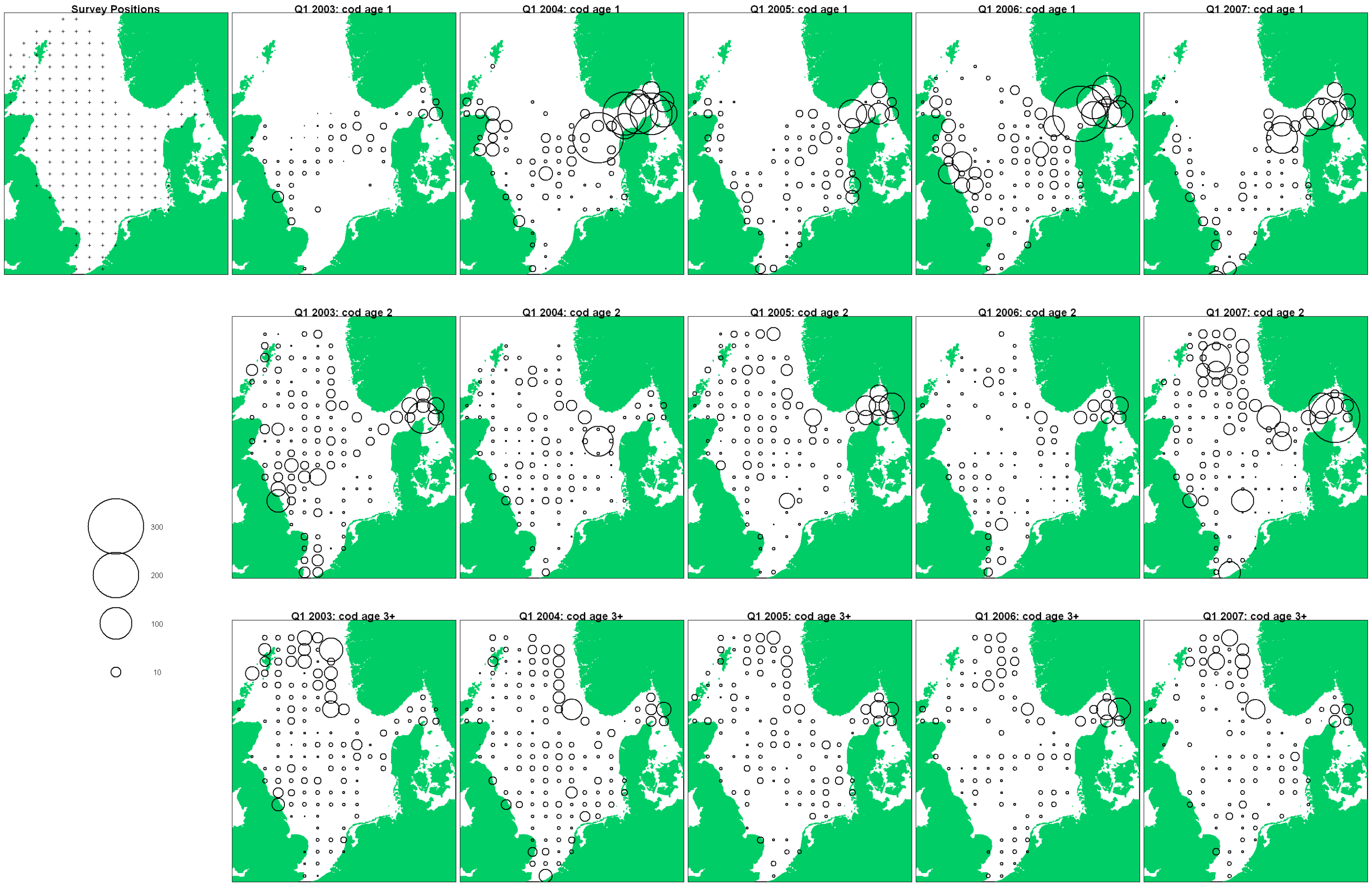


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1993-2012 in the North Sea.

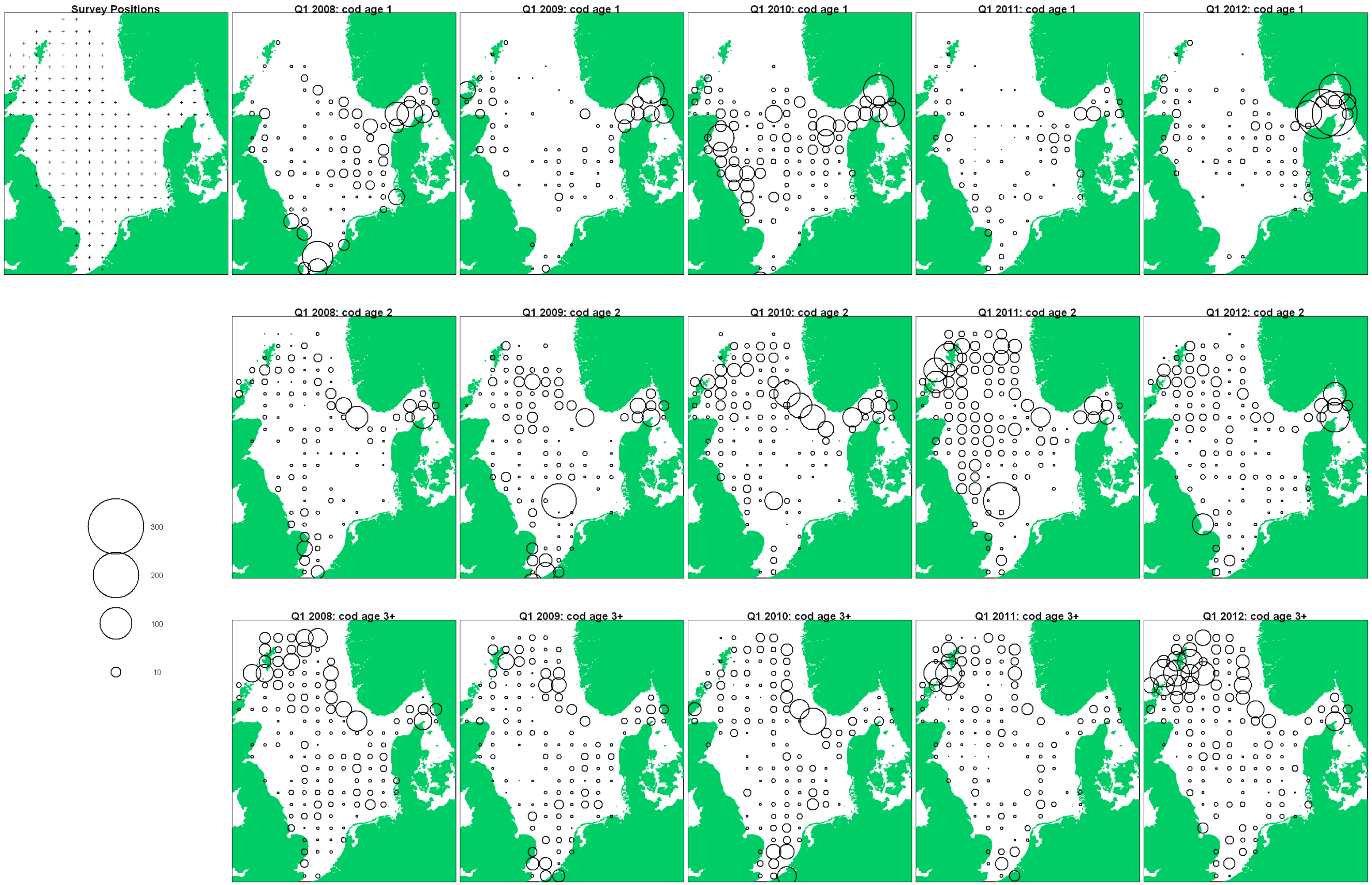


Figure 14.3b contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1993-2012 in the North Sea.

Figure 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1993-2011 in the North Sea.

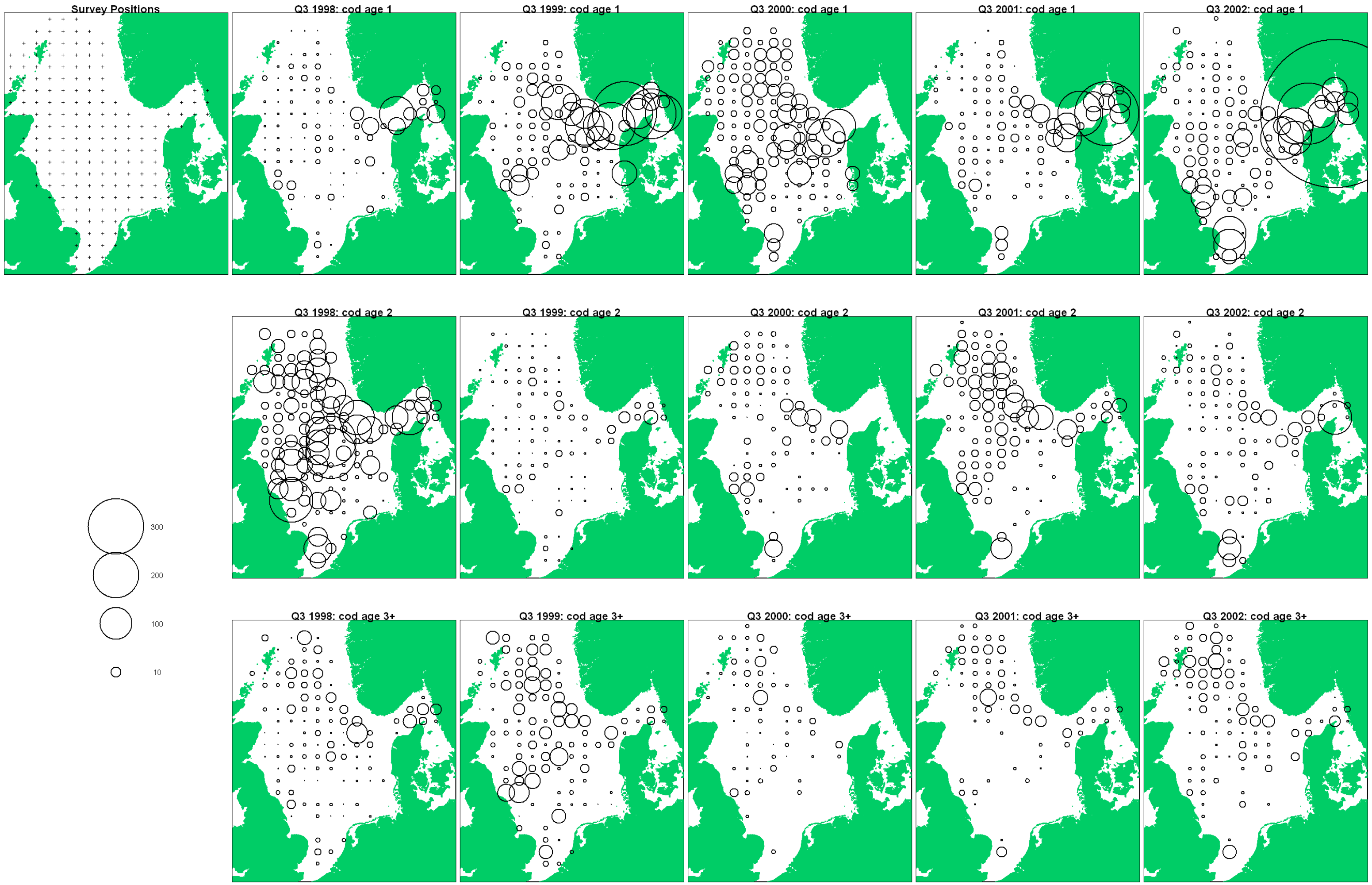


Figure 14.3c contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1993-2011 in the North Sea.

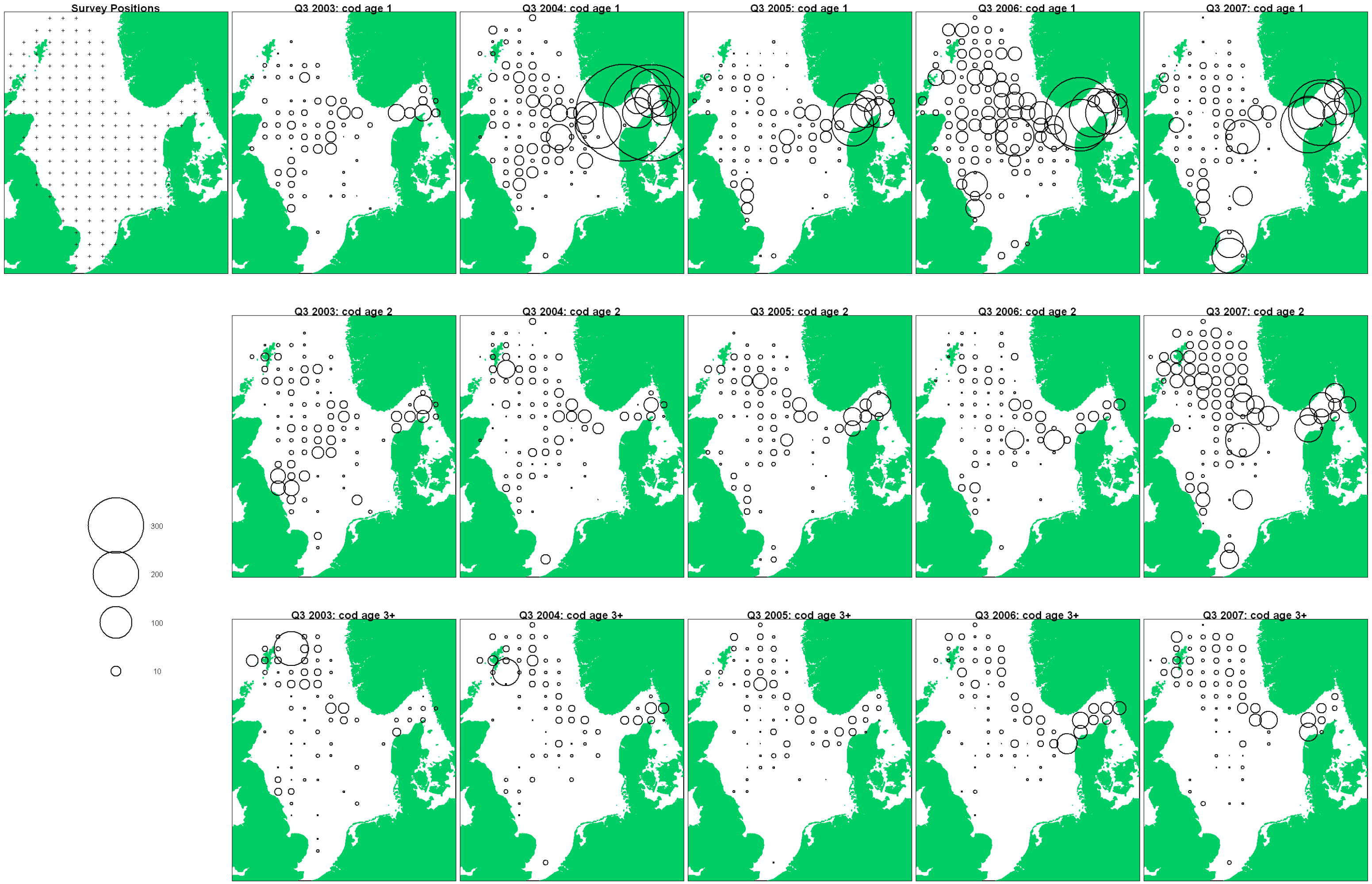


Figure 14.3c contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1993-2011 in the North Sea.

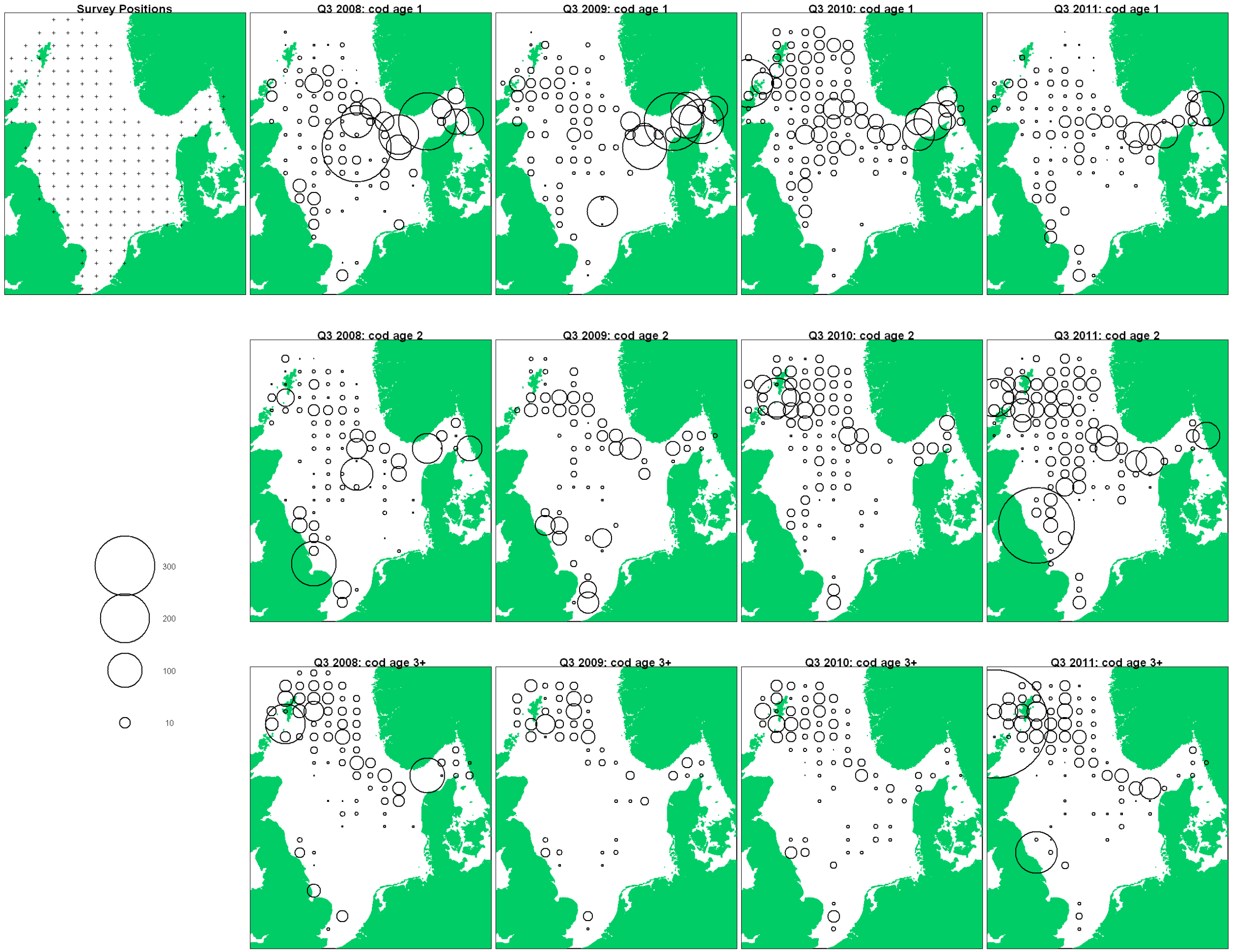


Figure 14.3c contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1993-2011 in the North Sea.

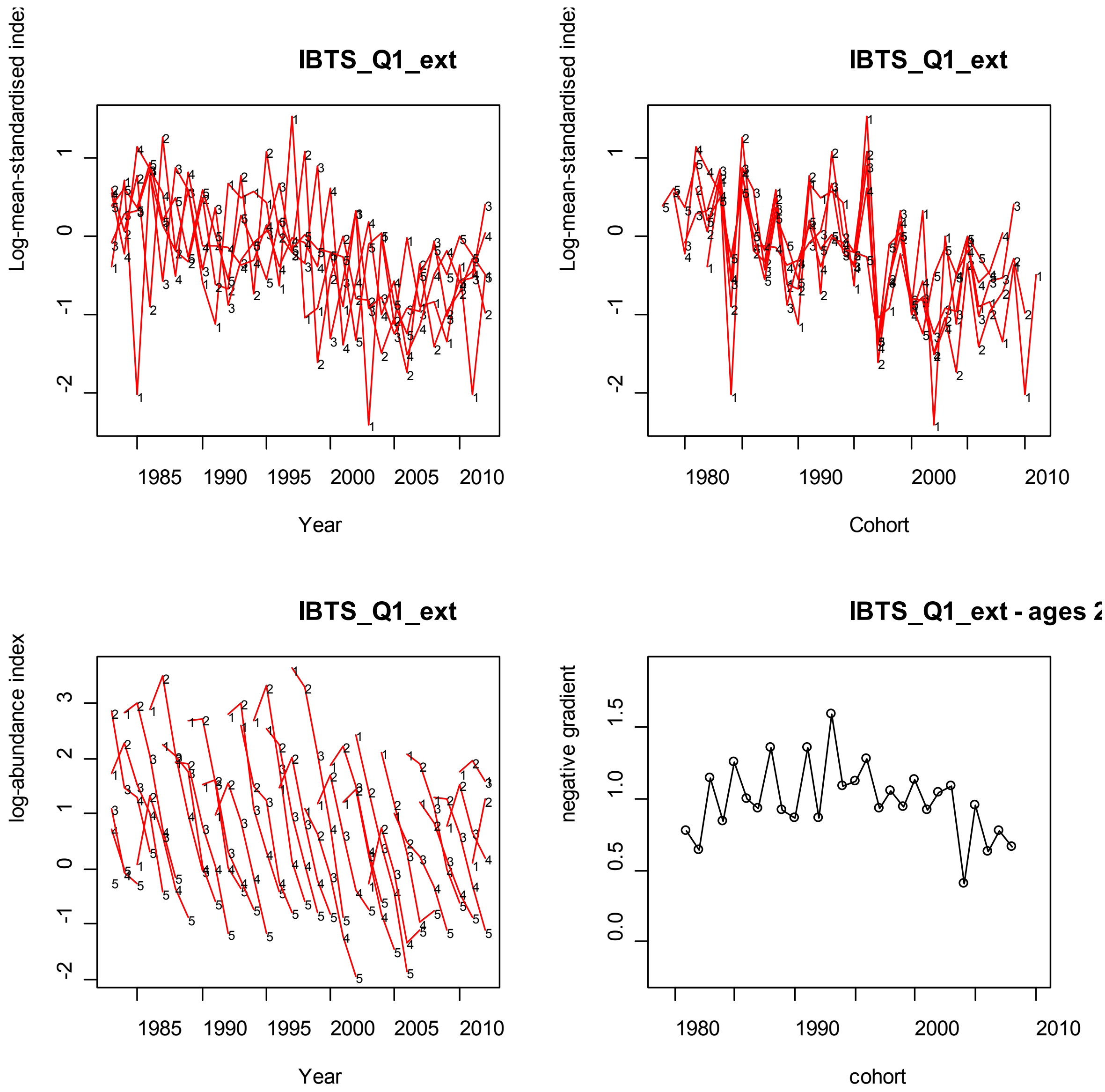


Figure 14.4a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ1 extended area groundfish survey.

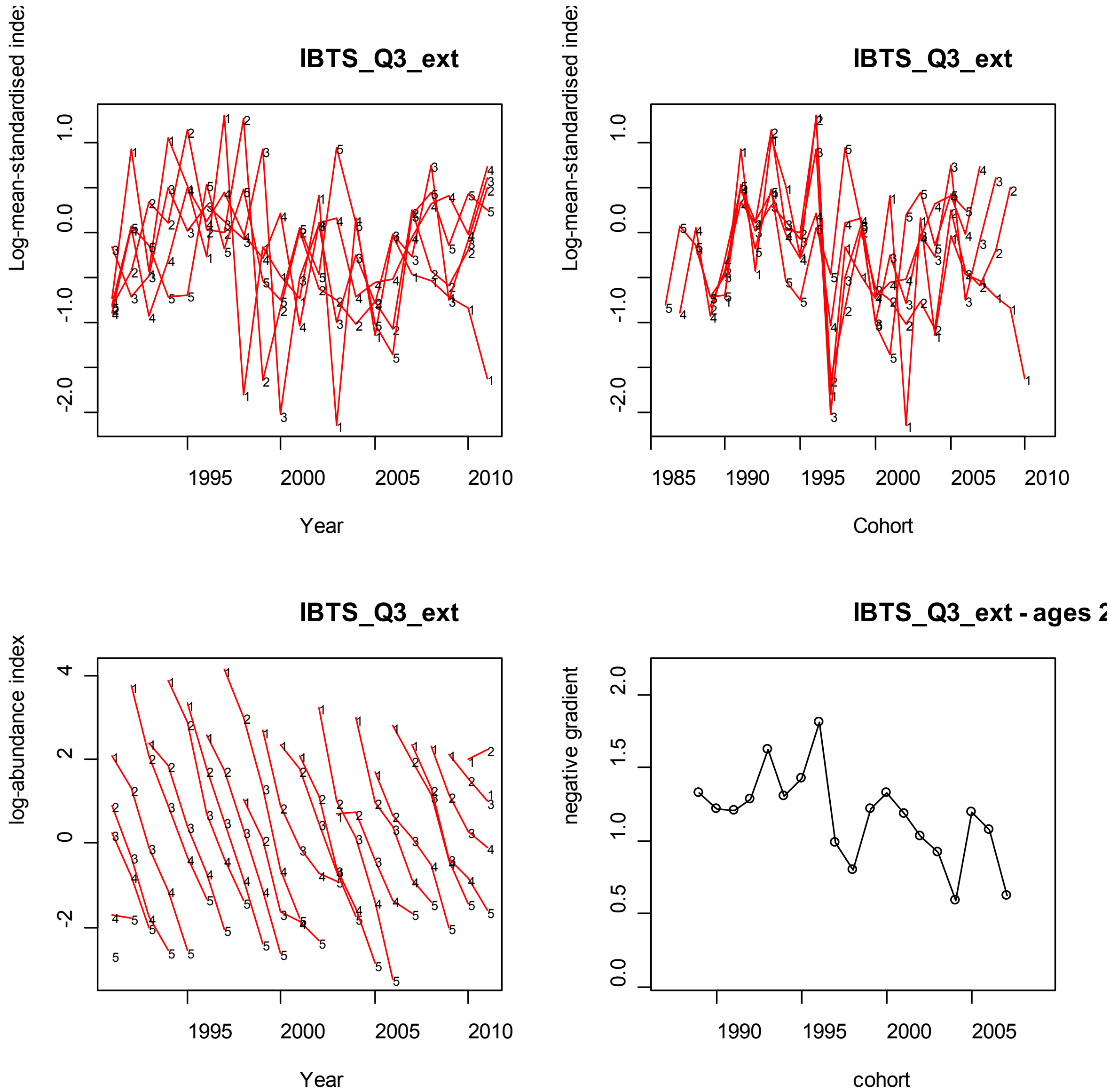


Figure 14.4b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ3 extended area groundfish survey.

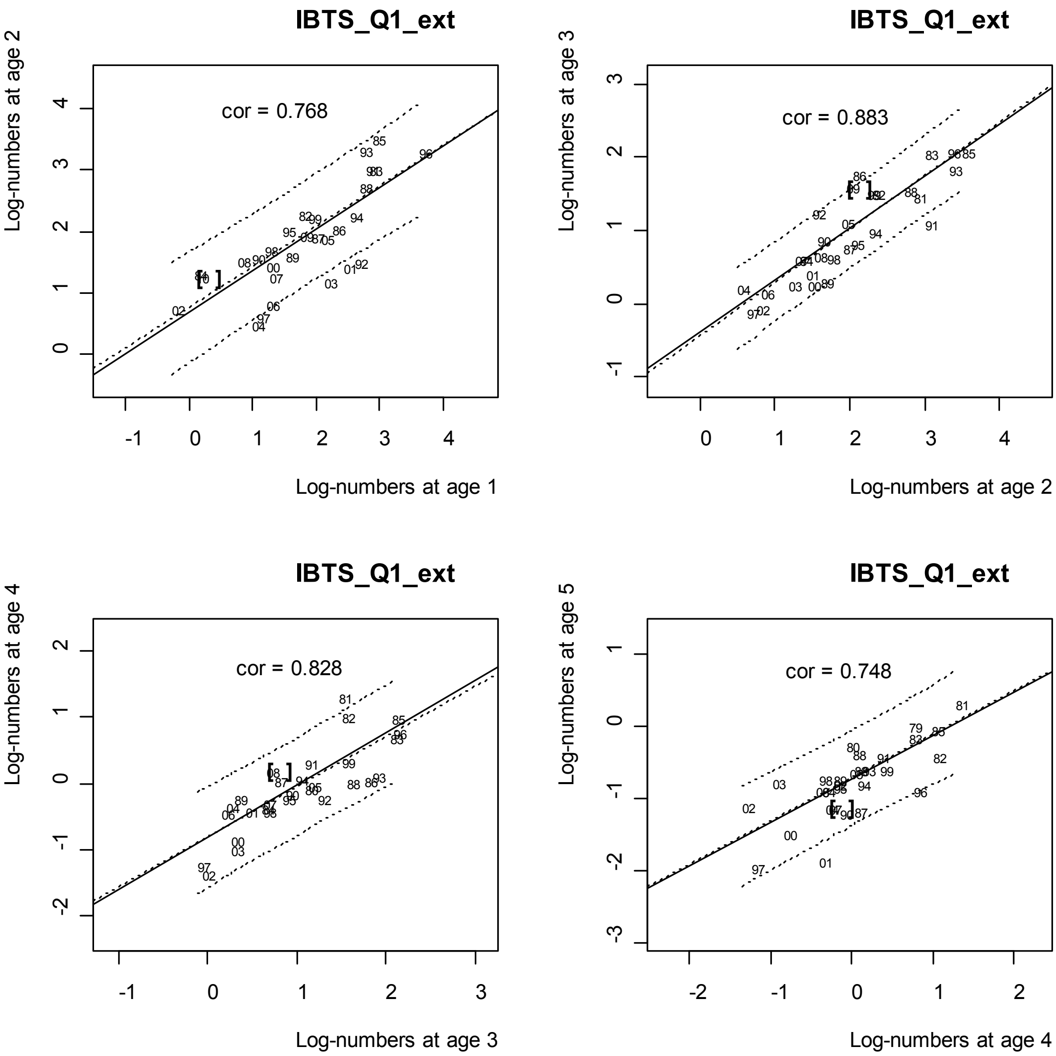


Figure 14.5a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ1 for the period 1983-2012. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

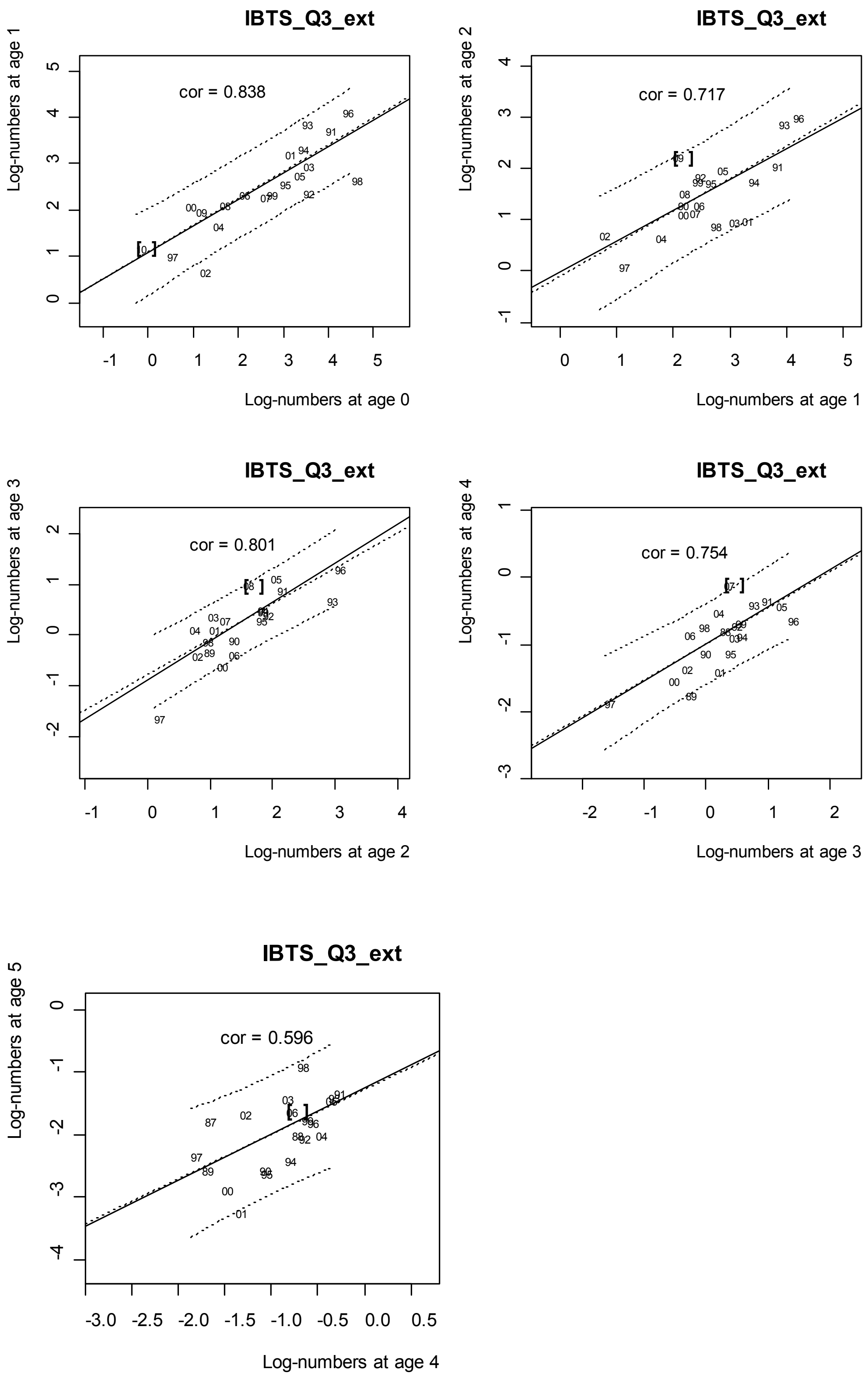


Figure 14.5b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ3 for the period 1991-2011. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

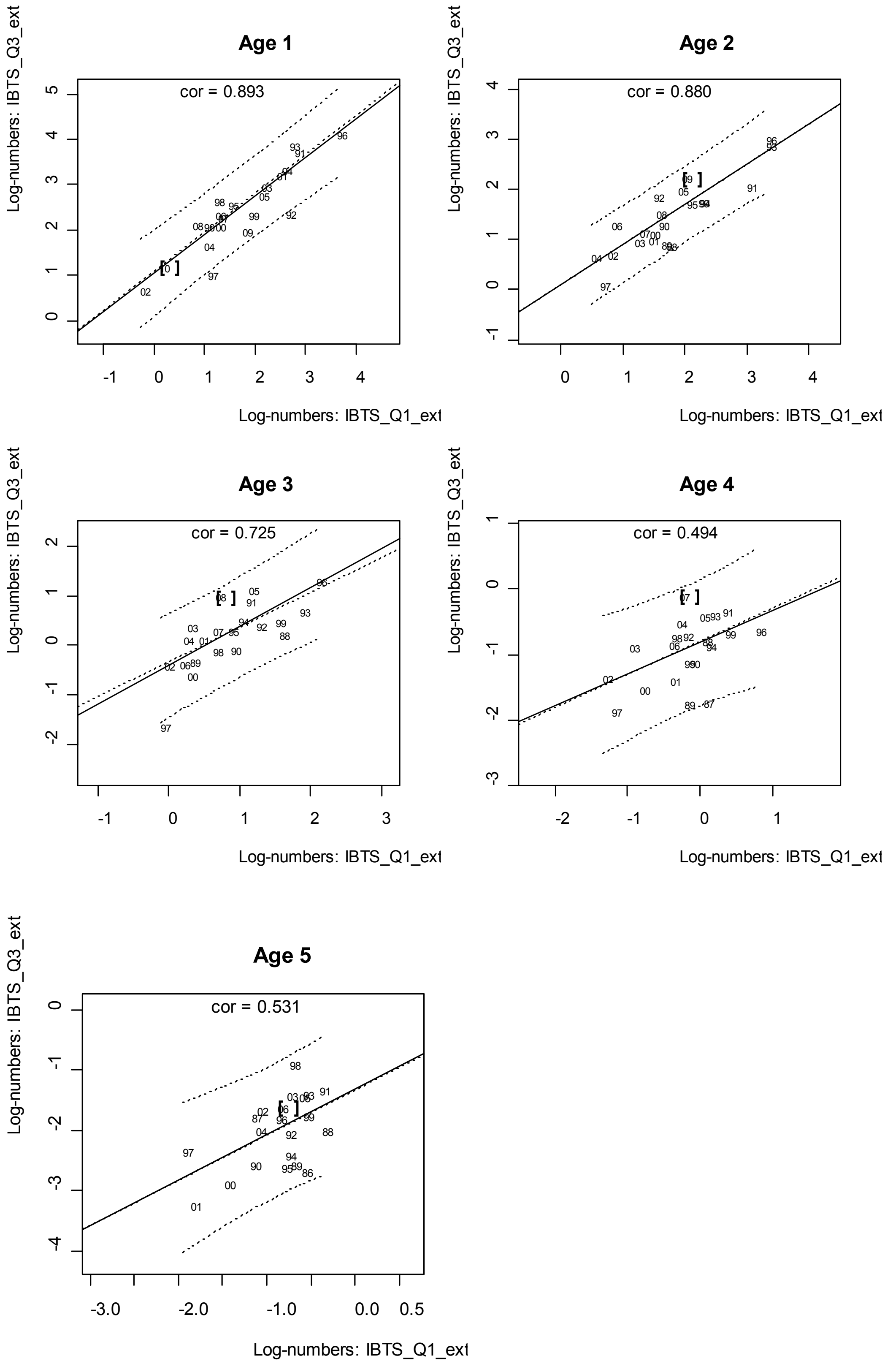


Figure 14.5c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Between-survey correlations for IBTSQ1 and Q3 surveys for the period 1991-2011. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear 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.

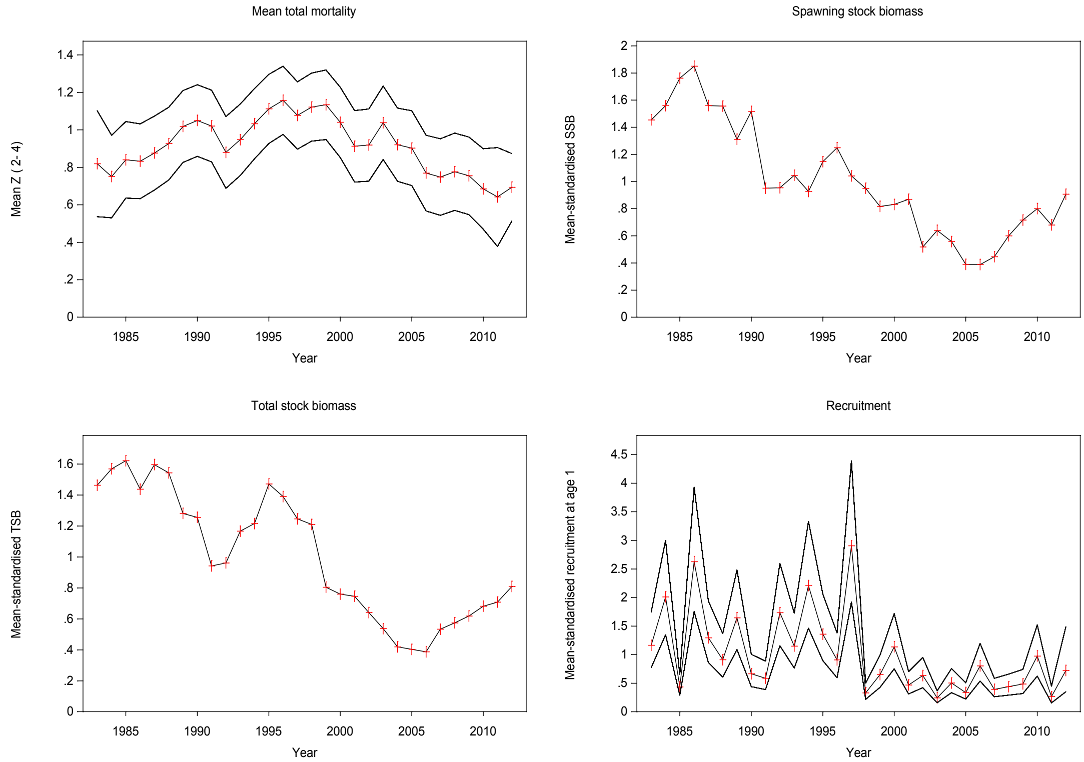


Figure 14.6 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Surba summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for the IBTSQ1 survey. The smoothing parameter λ is set to 2, and reference age at 3. Broken lines are 95% confidence bounds.

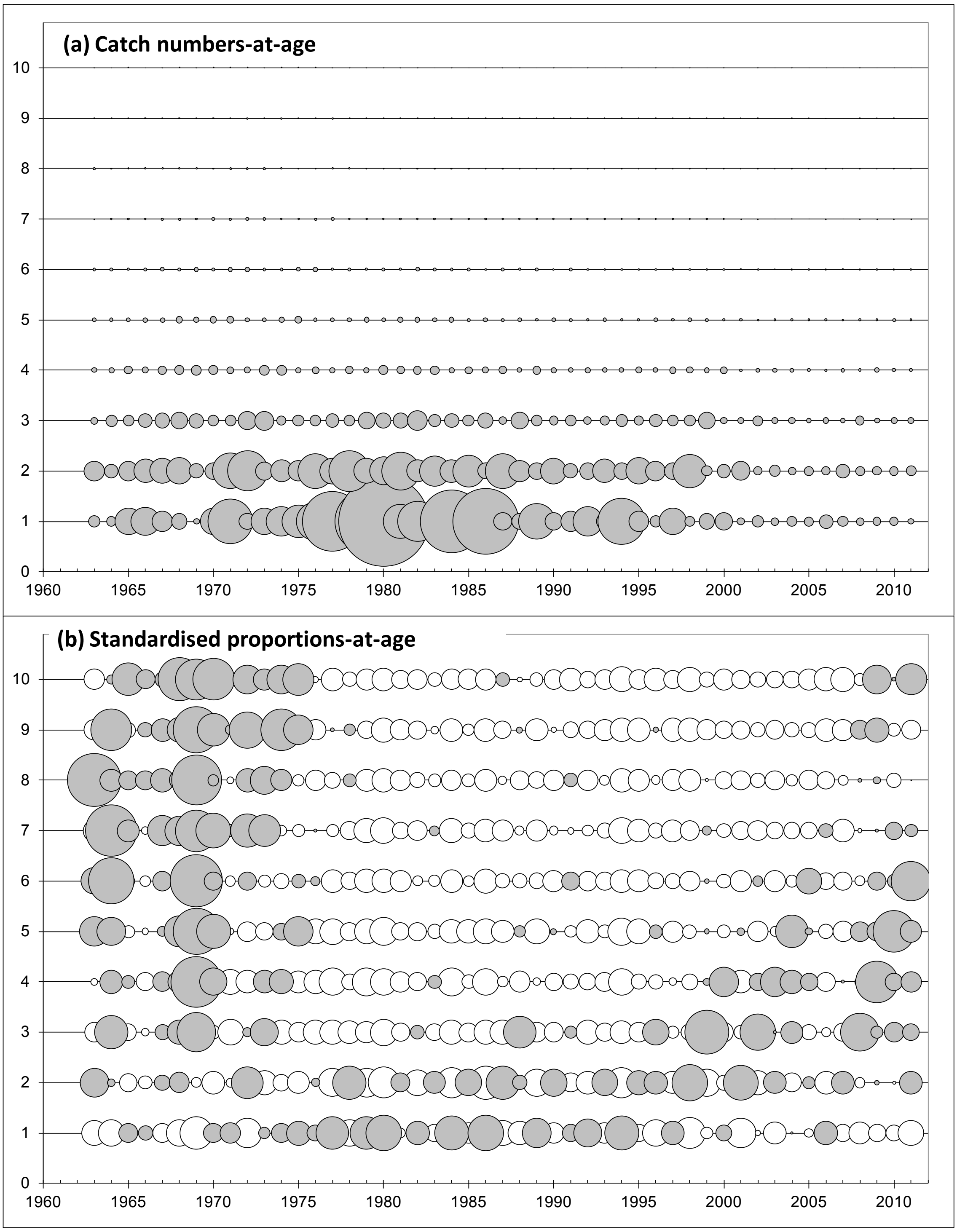


Figure 14.7 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

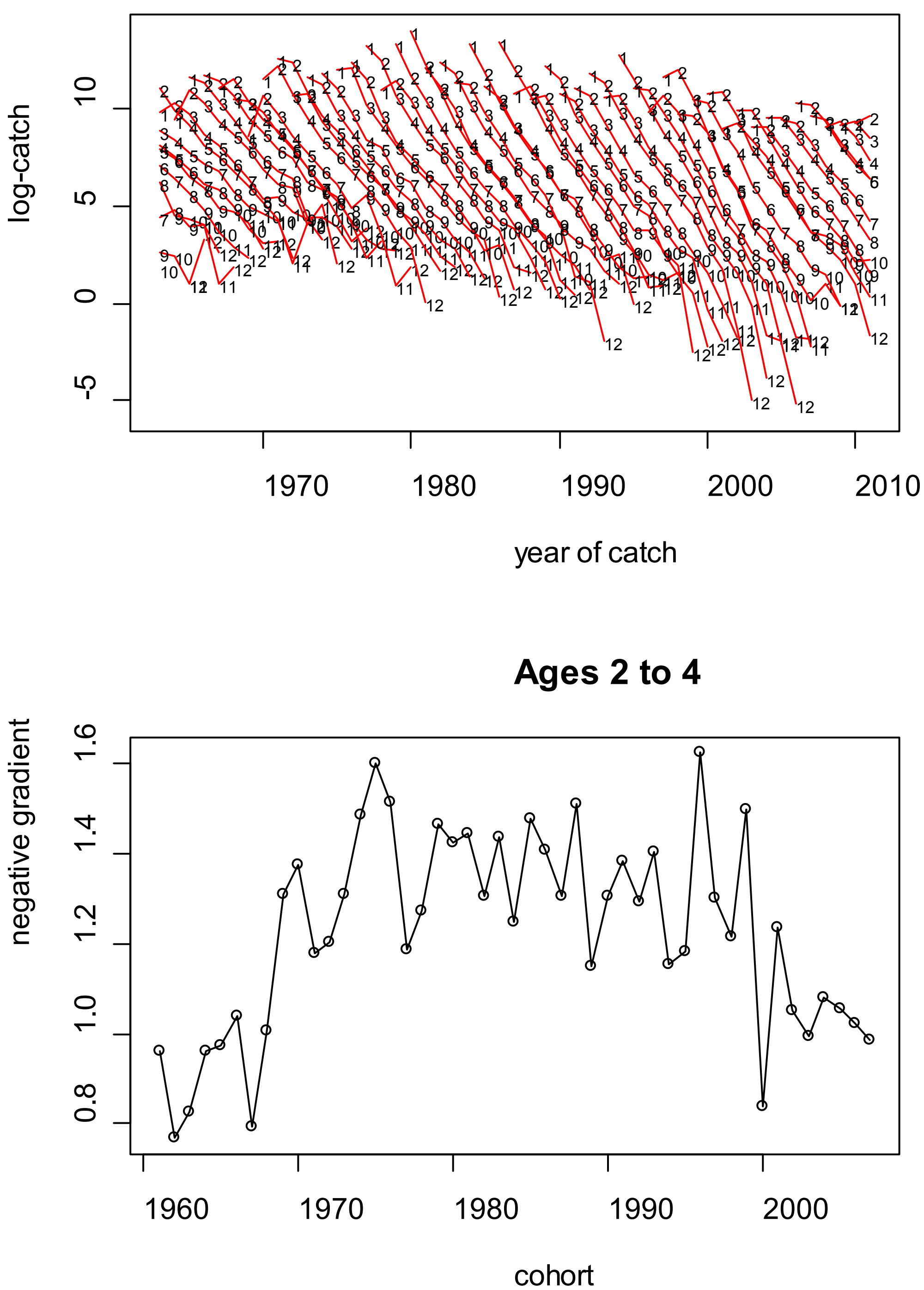


Figure 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2-4.

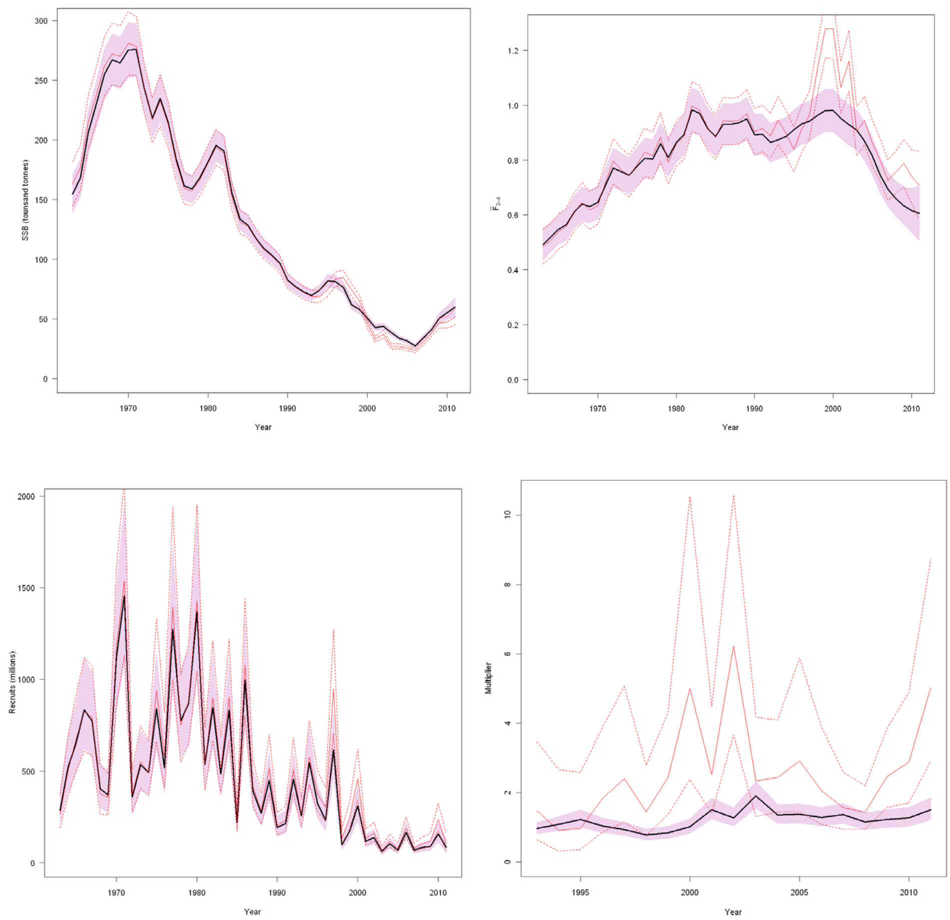


Figure 14.9a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM SPALY run (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals) and SAM split model run (solid red lines=estimate and dotted red lines=corresponding point-wise 95% confidence intervals). The M-values used in both cases are based on the 2007 key run (as used last year; M-values from 2008 onwards set equal to those in 2007).

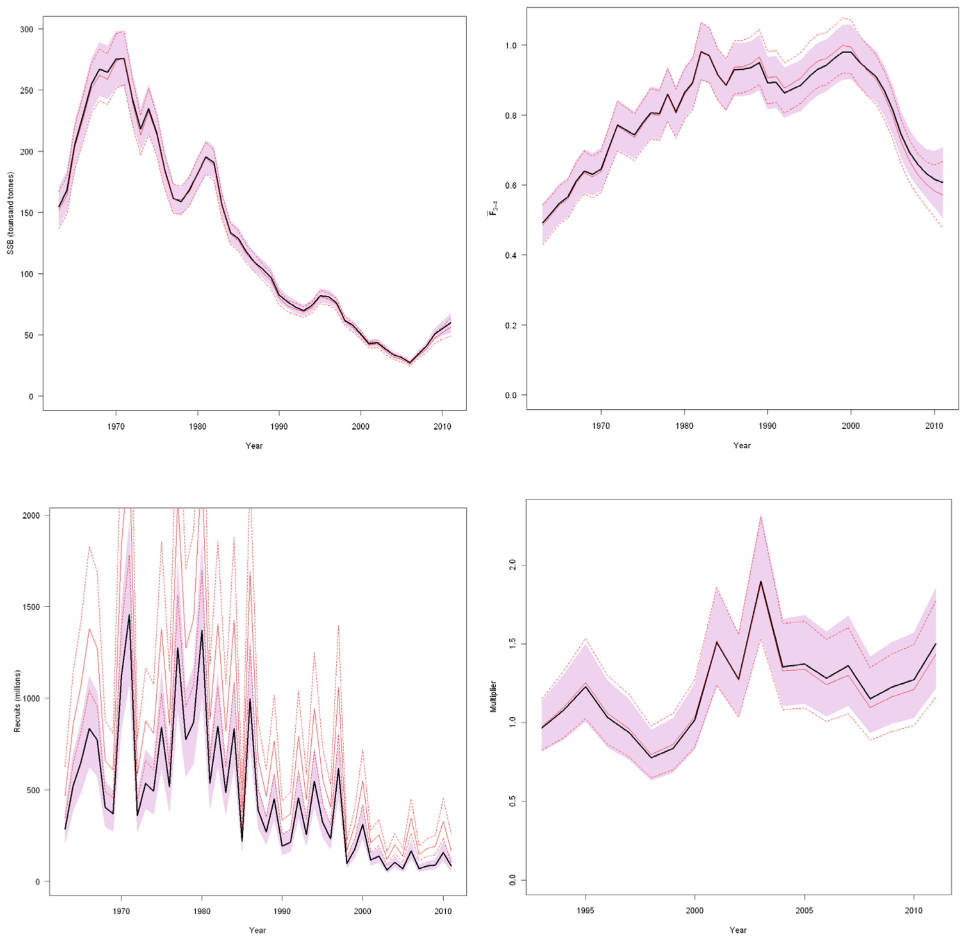


Figure 14.9b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM SPALY run with 2007 key run M-values (solid black lines=estimate and shaded area=corresponding point-wise 95% confidence intervals) and with 2011 key run M-values (solid red lines=estimate and dotted red lines=corresponding point-wise 95% confidence intervals). The SAM run using the 2011 key run M (red lines) is used as the base run.

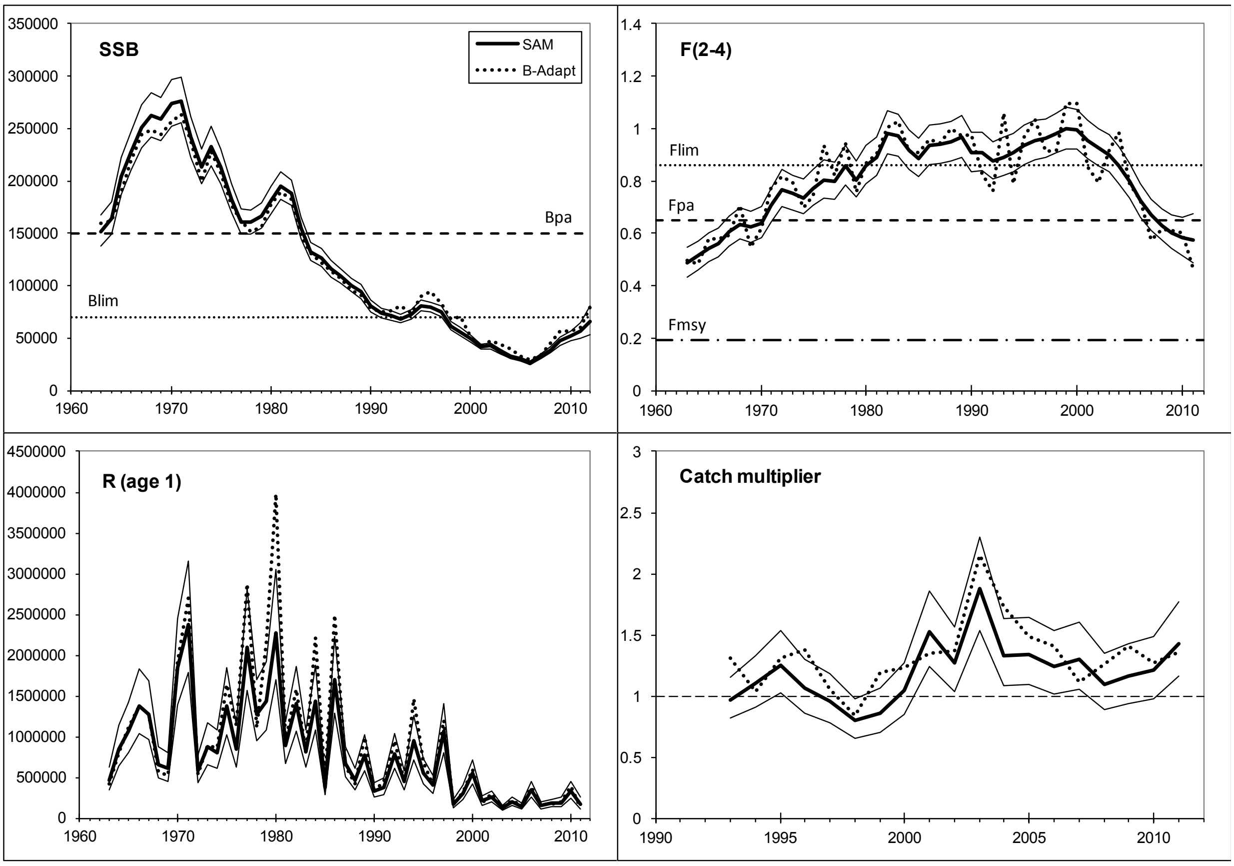


Figure 14.9c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM base run. Solid black lines (heavy lines=estimate, light lines=point-wise 95% confidence intervals) are from the SAM base run model (red lines in Figure 14.9b), and dotted lines medians from the B-ADAPT model using the same data as the SAM base run.

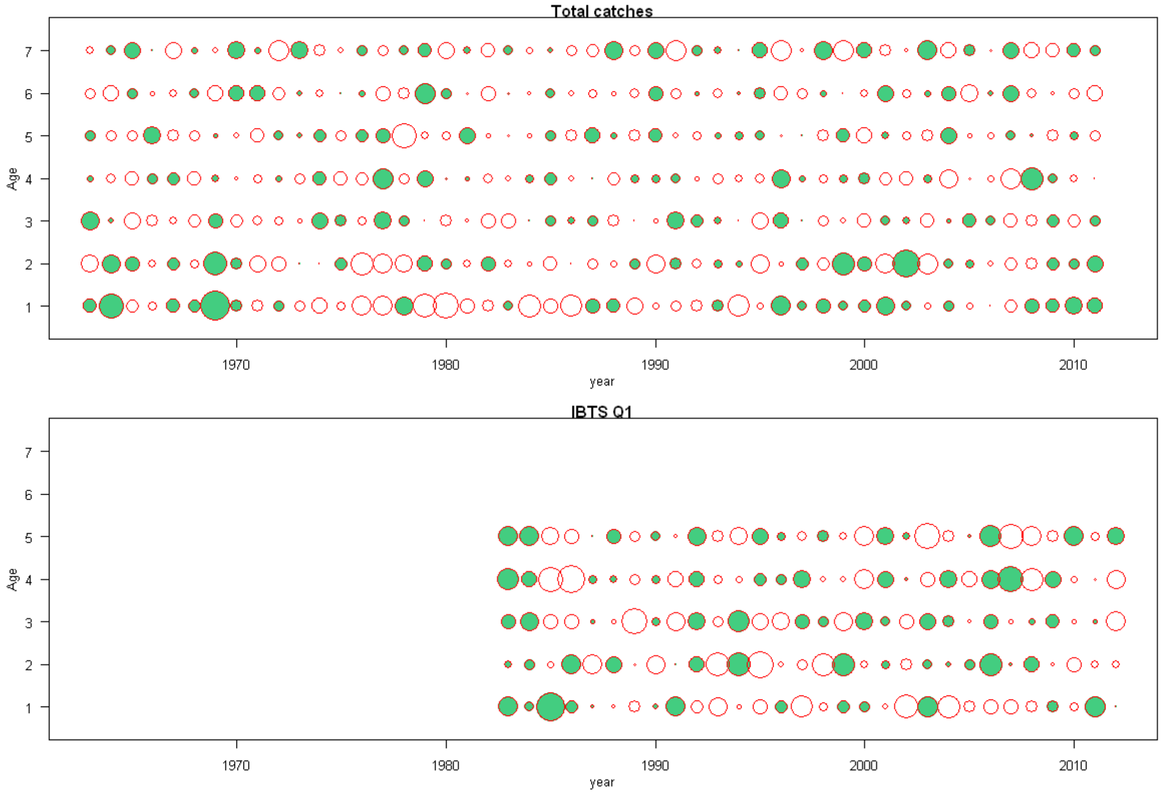


Figure 14.10 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the SAM base run, for total catch and IBTSQ1. Empty circles indicate a positive residual and filled circles negative residual.

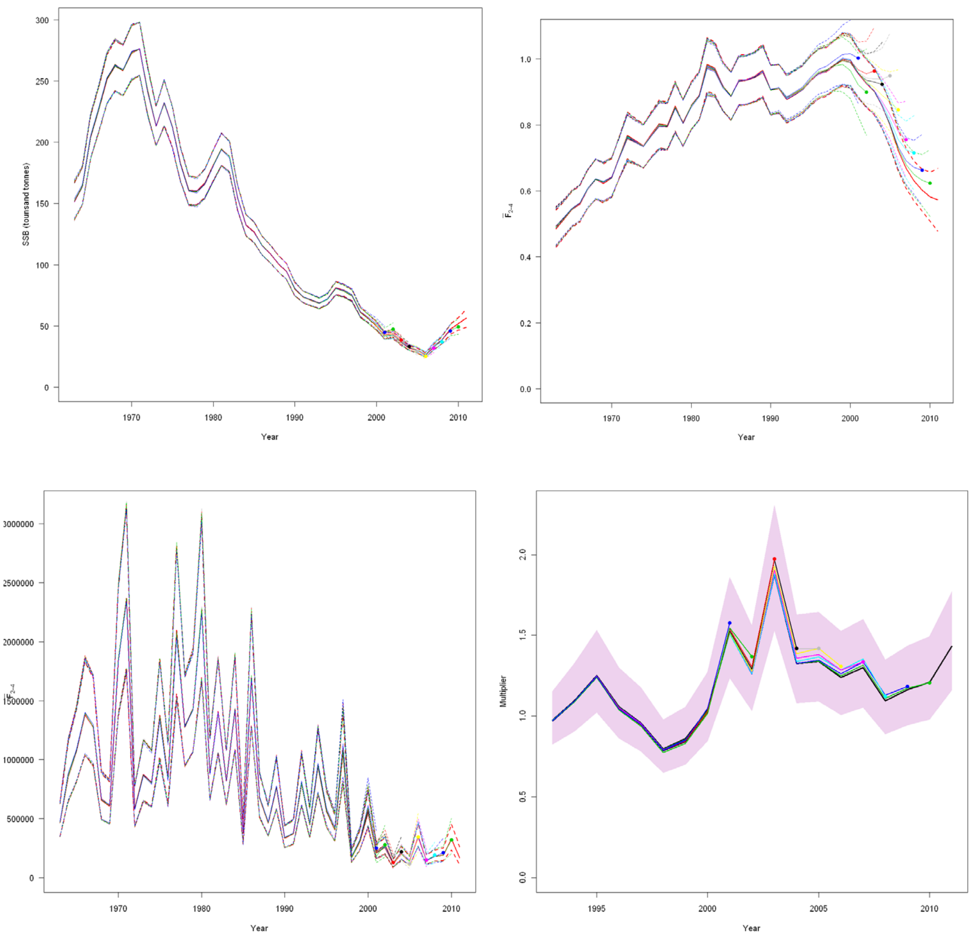


Figure 14.11 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Retrospective estimates (10 years) from the SAM base run. Estimated yearly SSB (top-left), average fishing motality (top-right), recruitment age 1 (bottom-left) and catch multiplier (bottom-right), together with corresponding point-wise 95% confidence intervals.

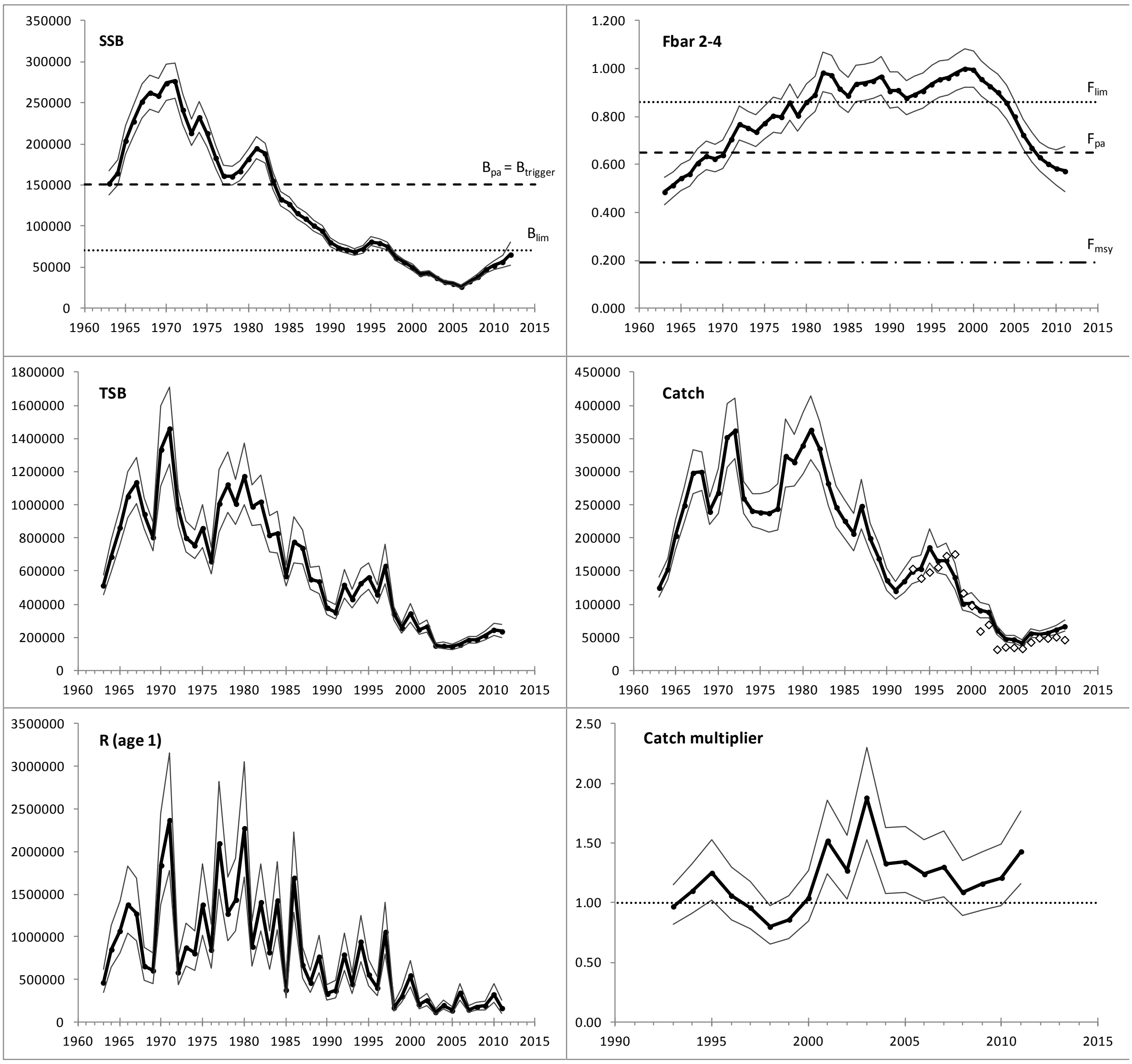
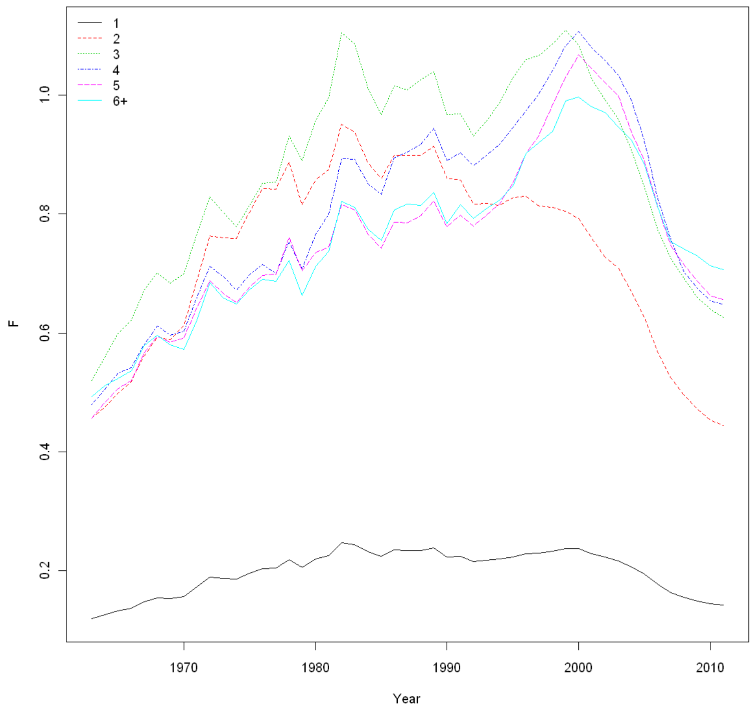


Figure 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Clockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2-4 (F(2-4)), from the SAM base run. 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 unallocated mortality, while the solid lines represent the total catch including unallocated mortality from 1993 onwards. 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.



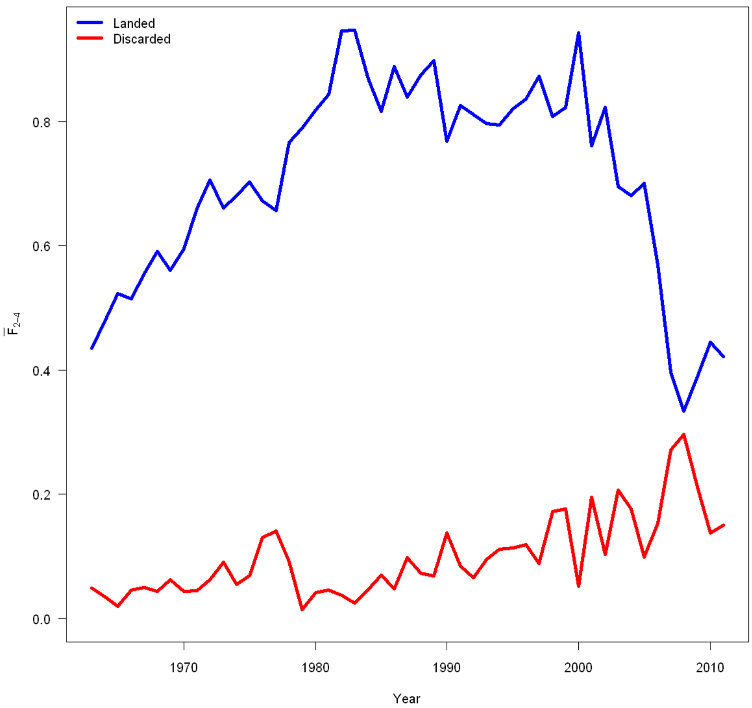


Figure 14.13 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM model base run estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2-4 (shown in Figure 14.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

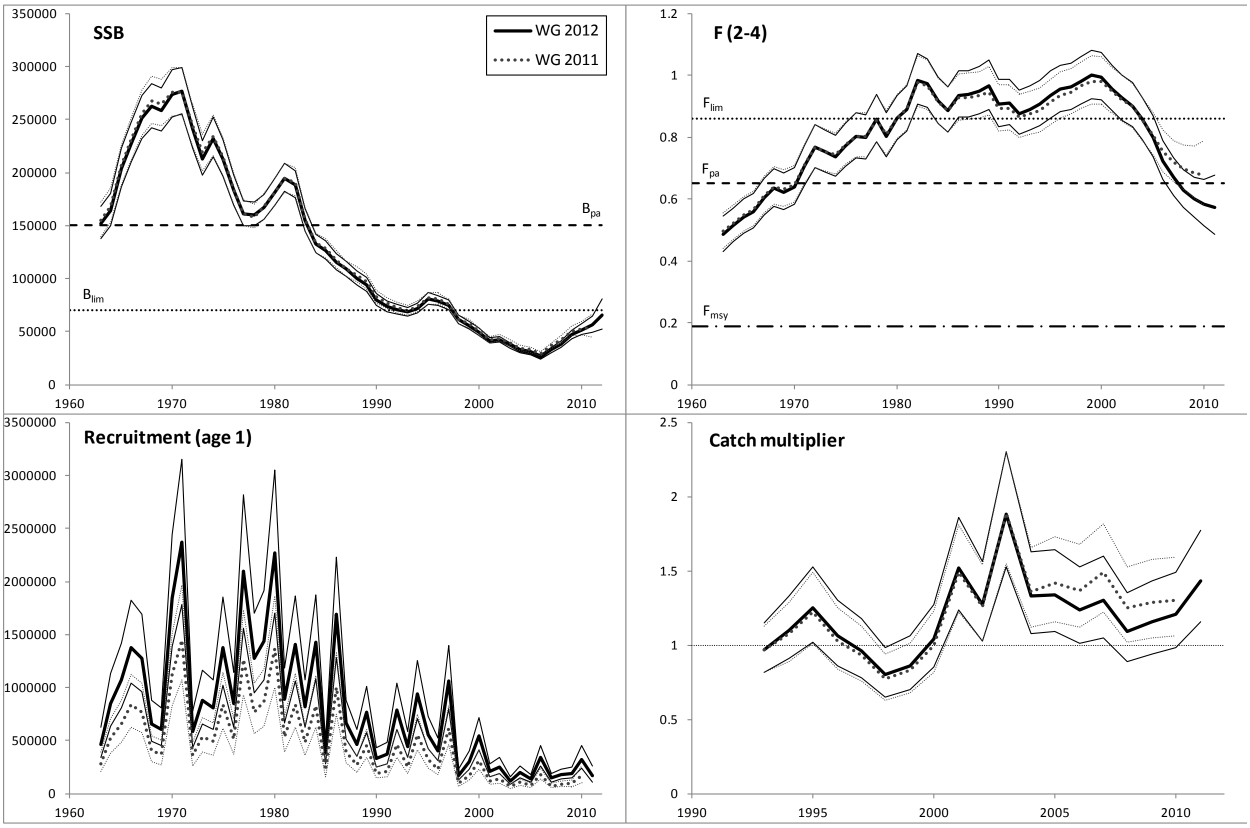


Figure 14.14 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Comparison of final SAM assessment for 2012 (using 2011 key run M-values) with the final SAM assessment for 2011 (using 2007 key run M-values). Plots are as described in Figure 14.12.

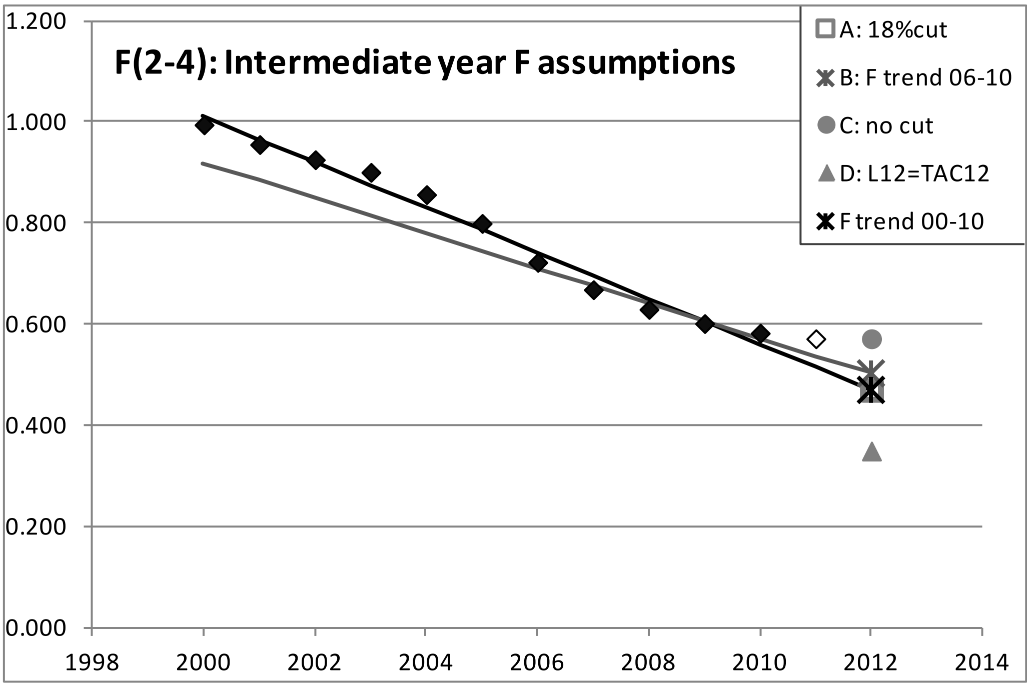


Figure 14.15 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Intermediate year F(2-4) options (relative to F in 2011) for the stochastic projections, corresponding to the Catch Options table (Table 14.12). A: 18% cut in F; B: extrapolate from the trend in F over 2006-2010; C: No cut in F; D: Landings in 2012 correspond to the TAC set for 2012. The final option (extrapolate the trend in F over 2000-2010) led to an identical F in 2012 as given in option A, and was therefore not pursued.

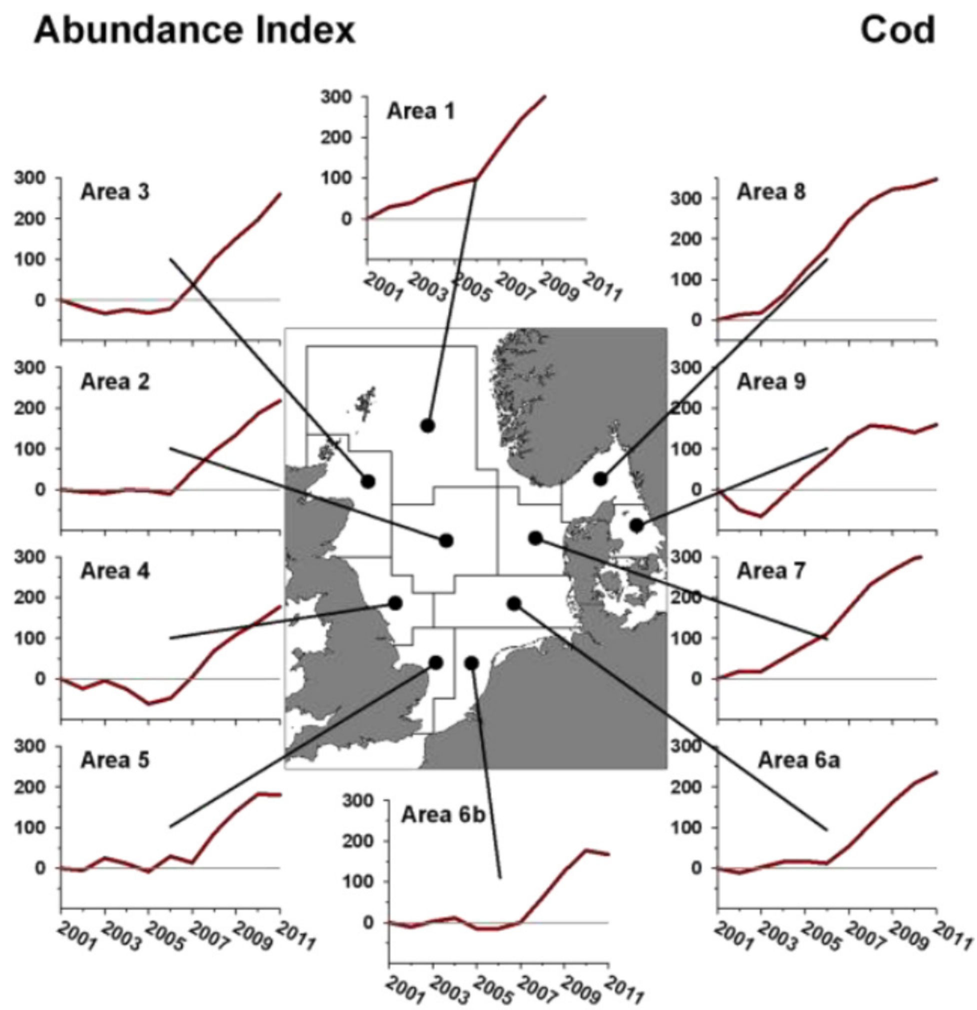


Figure 14.16 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. The North Sea Stock Survey fishers perception of the change abundance of North Sea cod since 2003 (Napier 2011).

15 Pollack in the North Sea and Skagerrak (Subarea IV and Division IIIa)

15.1 General Biology

The existing knowledge of pollack biology is summarised in the Stock Annex. According to this information it is benthopelagic, and is found down to 200 m. In Skagerrak, 0-group pollack are regularly found in shallow areas close to the shore. Pollack are therefore protected from the fisheries in the early life stages. Pollack move gradually away from the coast into deeper waters as they grow.

Spawning takes place from January to May, depending on the area, and mostly at 100 m depth. FAO reports maximum length at 130 cm and maximum weight at 18.1 kg. Female length-at-maturity is estimated at 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.

15.2 Stock identity and possible assessment areas

WGNEW (ICES, 2012) proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including VIId and IIIa). In the ICES advice, it was, however, decided to include VIId Pollack in the Celtic Seas Ecoregion.

15.3 Management

For IV and IIIa there are no formal TACs for pollack, but catches of pollack should be counted against the quota for some other species when caught in Norwegian waters south of 62°N. There is a Minimum Landing Size of 30 cm in European Member States (Council Regulation (EU) 850/1998). No explicit objective has been defined, no precautionary reference points have been proposed, and there is no management plan. Analytical assessments leading to fisheries advice have never been carried out for pollack.

15.4 Fisheries data

Landings statistics for pollack are available from ICES, but are clearly incomplete in earlier years. From 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

Landings by country for the years 1977–2011 in Division IIIa (Skagerrak/Kattegat) and Subarea IV (North Sea) are shown in Tables 15.1 and 15.2. In Division IIIa landings have declined during this period, but the landings from Subarea IV show no clear trend. Figure 15.1 shows total landings in Subarea IV and Division IIIa 1977–2011. Two periods with high landings can be seen, but they have been at a rather stable low level during the last 10 years. Swedish fishers targeted pollack from the 1940s until mid-1980s when landings sometimes amounted to over 1000 tonnes. From the 1980s pollack started to decline severely and is today seldom caught in the Kattegat or along the Swedish Skagerrak coast.

Nowadays, no fishing 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 and otter trawl, responsible for 70 and 14 % of the catches, respectively. In 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 Norwegian otter trawl catches resembles those of the saithe fisheries, but the catches of pollack are much lower.

Pollack is also often caught in recreational fisheries, but no data about these catches are known to the working group.

15.5 Survey data / recruit series

For the time being, pollack is caught in the IBTS survey only in small numbers; however, in the Skagerrak-Kattegat the cpue was much higher in the 1970s. They are distributed mainly over the northwestern North Sea (along the Norwegian Deep) and into the Skagerrak (Figure 15.1). 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) (Figure 15.2). The catches are small, and rather irregular, and no clear patterns emerge in IV, whereas in IIIa a decline in pollack abundance is clearly detectable (Figure 15.3).

15.5.1 Biological sampling

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.

15.5.2 Analysis of stock trends

For Division IIIa (Skagerrak and Kattegat), the trends in landings indicate a decline in the stock, which is supported by the study by Cardinale et al. (2012) who analysed the spatial distribution and stock trends for the period 1906–2007, based on surveys and commercial catches (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 contrast, landings from the North Sea do not reveal any clear trend after 1977, but some periodic variation.

In routine surveys, Pollack is caught in small, but 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 trend is seen in the North Sea, landings are currently close to the lowest observed since 1977.

15.5.3 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 recommends that also the Norwegian biological data from commercial catches should be processed.

15.6 References

Cardinale, M., H. Svedäng, V. Bartolino, L. Maiorano, M. Casini and H. Linderholm, 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. J. Appl. Ichthyol. 28(2): 200-208

Council Regulation (EU) No 850/1998. Conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

ICES 2012. Report of the Working Group on the assessment of new MoU species (WGNEW). ICES CM 2012/ACOM:20. 258 pp.

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

Table 15.2. Pollack. Landings by country in Subarea IV as officially reported to ICES.

	ICES Subarea IV										
	Belgium	Denmark	Faeroes	France	Germany	Netherl.	Norway	Poland	Sweden	UK	Total
1977	121	275		75	142	38	419	9	0	442	1521
1978	102	249		98	154	21	492	2	0	471	1589
1979	62	333		72	64	8	563	11	31	429	1573
1980	82	407		66	58	2	1095		38	355	2103
1981	59	500		173	21	2	1261		12	362	2390
1982	46	431		59	40	1	1169	33	23	270	2072
1983	58	481		79	44	1	1081		57	300	2101
1984	52	402		108	37	0	880	2	106	315	1902
1985	14	308		69	23	0	686		51	363	1514
1986	44	550		45	21	0	602		67	362	1691
1987	21	427		988	21	0	471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273		0	21	4	568		37	269	1203
1990	44	924		0	34	3	651		126	366	2148
1991	31	1464		0	48	4	887		153	684	3271
1992	49	794		18	59	7	1051		141	1310	3429
1993	46	1161		8	161	19	1429		217	1561	4602
1994	42	635		12	55	14	845		113	872	2588
1995	56	532	1	7	84	18	1203		175	1525	3601
1996	13	366		4	99	13	909		82	945	2431
1997	20	272	1	1	115	11	733		82	1185	2420
1998	21	265		7	44	5	567		75	780	1764
1999	21	288		0	62	5	768		72	636	1852
2000	45	291		24	38	5	880		91	877	2251
2001	36	156		6	40	1	860		63	809	1971
2002	27	234		6	112	0	879		68	711	2037
2003	13	191		9	82	1	971		36	837	2140
2004	28	162		5	57	0	517		16	612	1397
2005	26	173		3	128	3	511		46	477	1367
2006	18	152		4	80	1	545		12	587	1399
2007	18	192		130	137	2	754		43	905	2181
2008	15	150		129	114	1	840		46	999	2294
2009	13	121	2	6	50	1	668		32	658	1551
2010	12	163		10	129	0	599		32	540	1485
2011	12	299		NA	73	0	743		63	481	1671

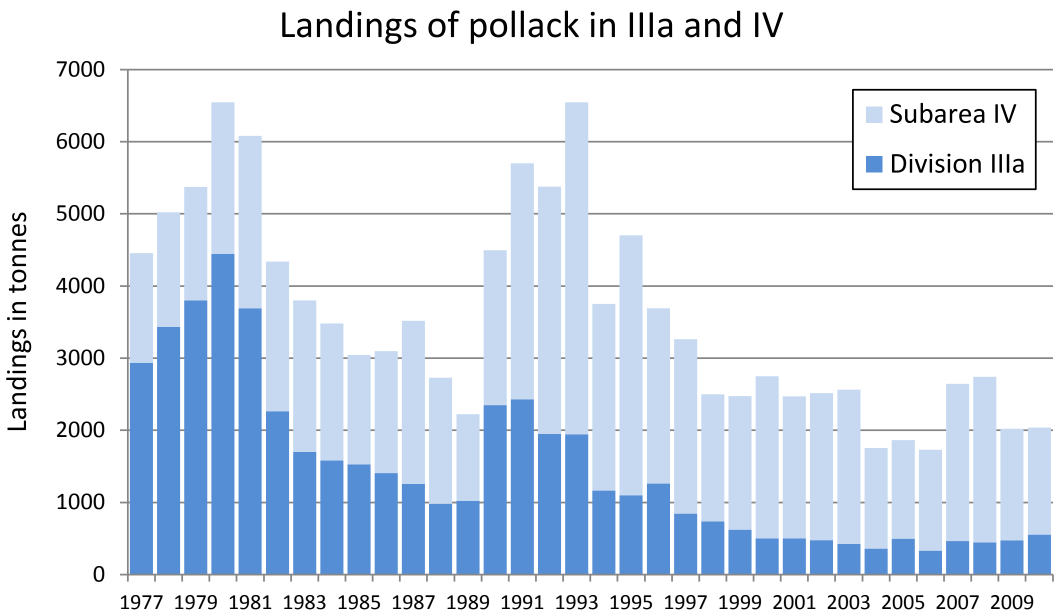


Figure 15.1. Pollack. Total landings of pollack in Division IIIa and Subarea IV as officially reported to ICES.

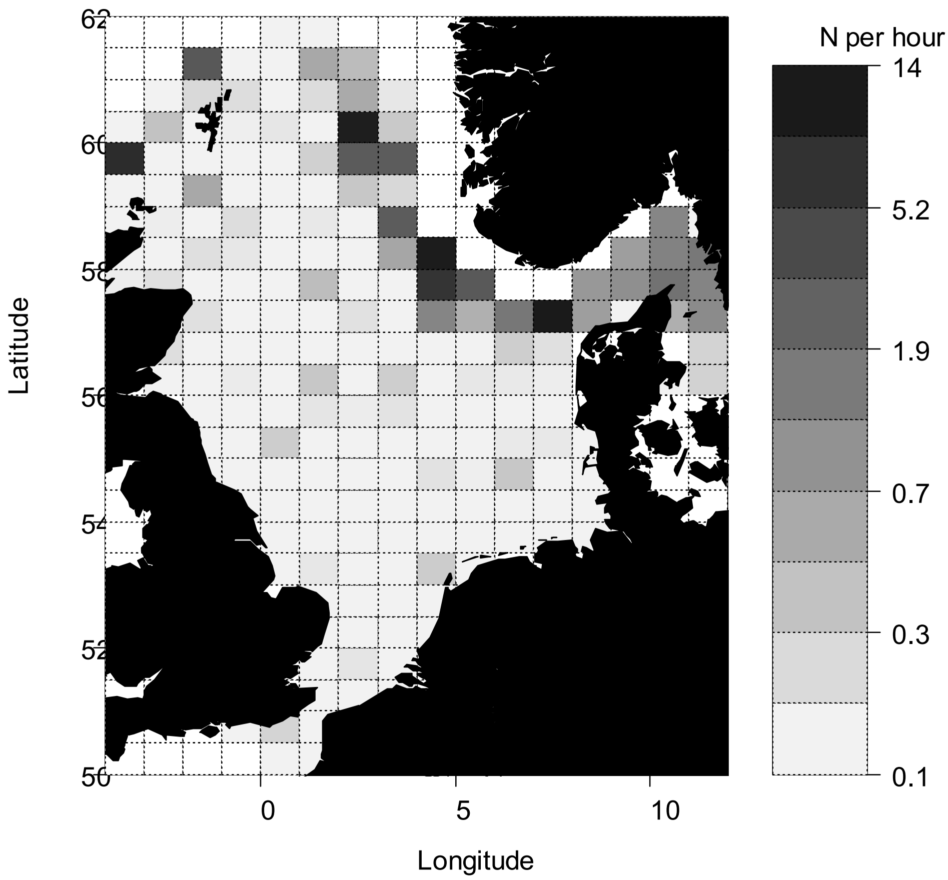


Figure 15.2. Pollack. Distribution of pollack in the North Sea. Abundance shown as N per hour caught in the GOV-trawl, based on all data available in Datras for quarter 1.

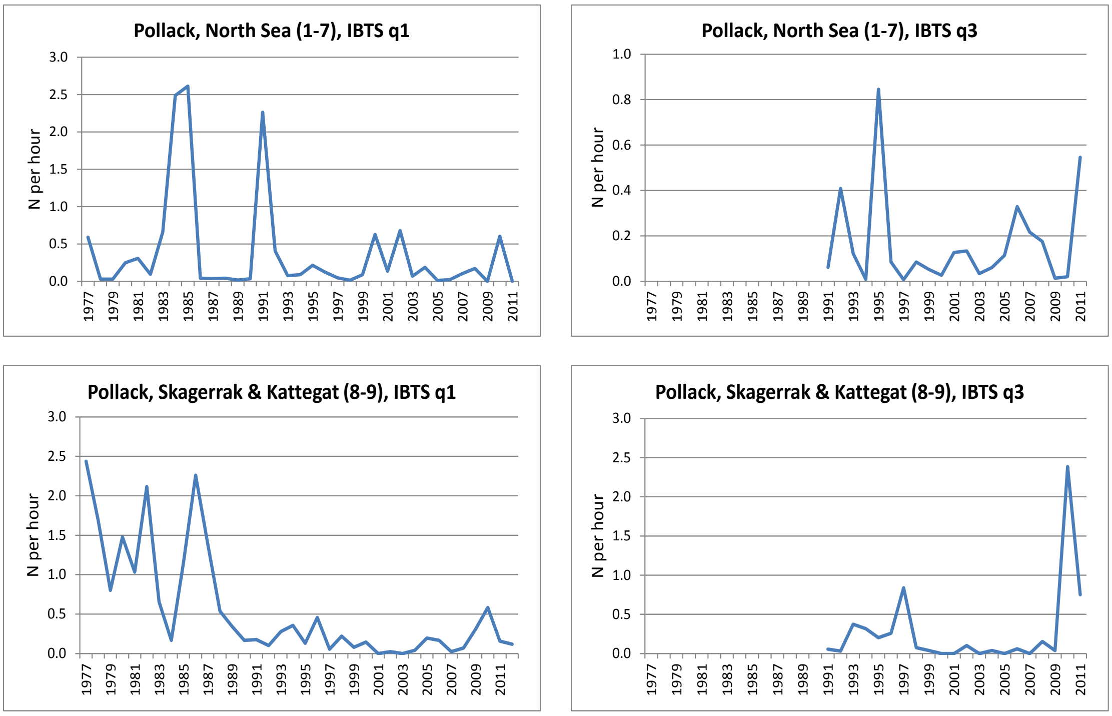


Figure 15.3. Pollack. Time series of abundance of pollack in the IBTS survey in the North Sea (roundfish areas 1-7) and in Skagerrak/Kattegat (roundfish areas 8 and 9), shown as Nos caught per hour with the GOV-trawl. Data from Datras.

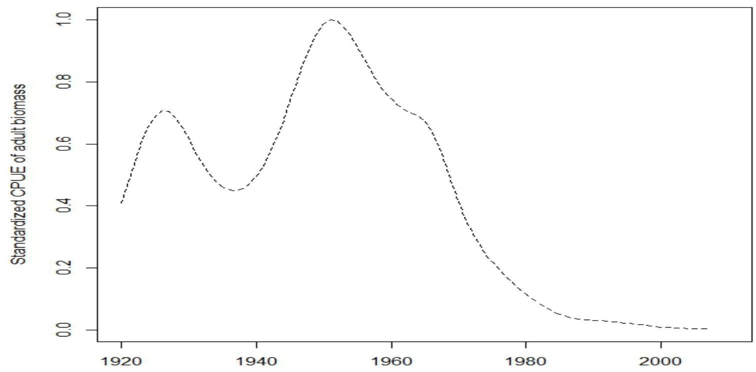


Figure 15.4. Pollack in Subarea IV and Division IIIa. Biomass trend of pollack in Division IIIa since 1920 (modified from Cardinale *et al.* 2012).

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

In the past, gurnards were often not sorted by species when landed and reported into one generic category of "gurnards". In recent years the official statistics seem to improve gradually, however, also obvious that the catch statistics are incomplete for several years: some countries reporting no landings at all, other countries reporting exceptionally high landings (Table 16.1-16.3; Figures 16.1, 16.2).

Official landings reported by Ecoregion are shown in Figure 16.3.

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 postwar 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) because of Danish landings for reduction purposes. In the same period, however, there was some misreporting as well. After a few years the Danish landings dropped again to a low level. The Netherlands did not report gurnards during the years 1984–1999. Recent international-al landings have been very low at around 300 to 500 t per year only. The average 2000-2010 is at 361 t.

In Celtic Seas, influenced by high landings reported by Russia in VIb in the period 2000-2006, the production of grey gurnard peaked above 20 000 t. In average the total catches in VIa were around 3 t since 2000. In area VII (without VIId), in average 65 t of grey gurnard have been reported since 2000.

In South European Atlantic (VIII+IX), official landings have fluctuated at low level and were in average 63 t since 2000.

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 (see also stock Annex). Owing to the low commercial value of this species, landings data will usually not reflect the actual catches very well.

16.4.2 Discards

Some samples collected in France under DCF regulation by observations at sea in 2010 have been exploited with the COST tools.

Samples were aggregated for an area composed of IVc+VIId+VIIe to obtain measured fish enough in the retained and in the discarded part of the catch and in the same way data from all trawlers were used. Only the quarter 1 and 3 of 2010 data sets have allowed estimates of catch and discards. Results are shown in figure 7-4. Almost all the catches have been discarded.

In Table 16.4 the numbers per hour of discarded non-target fish species 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 16.1 and 16.6). 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.

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).

Spawning occurs in spring and summer and, perhaps, in autumn (Russel, 1976), and may also explain the observed seasonal movements (Van der Land, 1990).

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. The drawn line excludes the exceptional abundance observe occasionally as proposed in Heessen and Daan (1996) (figure 16.7).

IBTS-Q3 series shows the same strong increase of the index during the 90's and stabilized at high level since then (figure 16.8).

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.

The CGFS survey series in VIId from 1988 have shown low level of abundance index except in 1999 where a shoal effect might occur (figure 16-8). In recent years, abundance index at length have indicated some higher abundance of smaller fish in 2005 (Figure 16-9).

The time series of abundance index of EVHOE-WIBTS-Q4 survey in Celtic Sea and Bay of Biscay has clearly shown a higher abundance in Celtic Sea than in Bay of Biscay but in some years the signal is noisy (Figure 16.11). The trends in both areas are relatively similar. The time series of abundance at length by area have shown that the last higher but uncertain abundance of smaller fish was observed in 2007 in Celtic sea and in 2004 in Bay of Biscay (Figures 16.12 & 16.13). Spatial distribution of grey gurnard from this survey series is available in the stock annex. It shows that the higher abundances are observed in the northern part of Celtic Sea.

The index of the short time series from the autumn PGFS survey has fluctuated at low value and was at 0 in 2010 and 2011 (Figure 16.14).

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 grey gurnard displays a significant number of individuals over a large span of ages (up to group 14). The ALK is shown in figure 16-14.

A maturity length key of Grey gurnard sampled shows that above 19-20 cm almost all the individuals can be considered mature. The sampling was not carried out during the spawning which takes place in spring and summer.

Both these two datasets suggest that grey gurnard is early maturing in North Sea and a proportion of fish at age 1 are mature.

16.7 Population biological parameters and other research

The information delivered at the WGNEW 2010 are 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

In Celtic Seas Ecoregion, the CGFS survey indicates that since 2006 the abundance has remained at lower level. In Celtic Sea, the index from the EVHOE-WIBTS-Q4 survey tend to slightly increase in 2010 and 2011 but remain at lower level.

In Bay of Biscay and Southern European shelf, both the EVHOE-WIBTS-Q4 and the PGFS surveys indicate very low levels of abundance.

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

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. I La croissance de: *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(2): 127–144.

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. II La reproduction de : *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(3): 255–281.

Daan, N., Bromley, P. J., Hislop, J. R. G., and Nielsen, N. A., 1990. Ecology of North Sea Fish. Netherlands Journal of Sea Research 26(2–4): 343–386.

Heessen and Daan (1996) Long-term trends in ten non-target North Sea fish species. ICES Journal of Marine Science, 53: 1063–1078.

Hertling, H. 1924. Über den grauen und den roten Knurrhahn (*Trigla gurnardus* L. und *Trigla hirundo* Bloch). Wissenschaftliche Meeresuntersuchungen Helgoland 15(2), Abhandlung 13: 1–53.

ICES-FishMap 2005. http://www.ices.dk/marineworld/fishmap/ices/pdf/greygurnard.pdf

ICES. 2011. Report of the Working Group on Multispecies Assessment Methods (WGSAM)

ICES. 2012. Report of the Working Group on Assessment of New MoU Species (WGNEW), 5-9 March 2012, ICES Headquarters, Denmark. ICES CM 2012/ACOMYY.

Knijn, R.J., Boon, T.W., Heessen, H.J.L. and Hislop, J.R.G., 1993. Atlas of North Sea Fishes. ICES Cooperative Research Report. No. 194. (http://www.ices.dk/pubs/crr/crr194/ /CRR194 .PDF)

Land, M. A. van der. 1990. Distribution and mortality of pelagic eggs of by-catch species in the 1989 egg surveys in the southern North Sea. ICES CM 1990/H:19. 11 pp.

Russell, F. S. 1976. The eggs and planktonic stages of British marine fishes. Academic Press, London. 524 pp.

Sahrhage, D. 1964. Über die Verbreitung der Fischarten in der Nordsee. I. Juni-Juli 1959 und Juli 1960. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung 17(3): 165-278.

Wheeler, A. 1978. Key to the fishes of northern Europe. Frederick Warne, London. 380 pp.

Table 16.1. Grey gurnard. Official landings (tonnes) of grey gurnard in area VI and VII as reported to ICES.

VI &VII	Official landings in tonnes						
	Belgium	Denmark	France	Ireland	Netherlands	Russian Fed.	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	0	0
1958	0	0	0	0	0	0	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	0	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	0	0
1976	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0
1978	0	0	206	0	0	0	0
1979	0	0	165	0	0	0	0
1980	0	0	155	0	0	0	0
1981	0	0	0	0	0	0	0
1982	0	0	407	0	0	0	0
1983	0	0	271	0	0	0	0
1984	0	0	157	0	0	0	2
1985	35	0	130	0	0	0	2
1986	0	0	280	0	0	0	0
1987	37	0	216	0	0	0	0
1988	30	0	211	0	0	0	21
1989	34	0	646	0	0	0	0
1990	18	0	538	16	0	0	0
1991	17	0	298	15	0	0	4
1992	13	0	123	17	0	0	0
1993	11	0	113	10	0	0	1
1994	11	0	107	0	0	0	2
1995	7	0	101	0	0	0	0
1996	6	0	117	0	0	0	2
1997	8	0	61	0	0	0	2
1998	13	0	59	38	0	0	0
1999	11	0	0	0	0	0	0
2000	13	0	109	0	7	26081	0
2001	3	0	116	0	0	3155	13
2002	7	0	81	0	0	60	11
2003	3	0	66	0	1	263	0
2004	5	0	61	0	7	1401	0
2005	9	0	59	0	8	2456	0
2006	4	0	28	0	10	138	6
2007	4	0	24	0	1	0	4
2008	7	0	1	0	3	0	1
2009	11	0	33	0	1	0	8
2010	14	0	45	0	5	0	12

Table 16.2. Grey gurnard. Official landings (tonnes) of grey gurnard in area IIIa, IV, and VIId as reported to ICES.

IIIa,IV,VIId	Official landings in tonnes						
	Belgium	Denmark	France	Netherlands	Norway	Sweden	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	308	0
1958	0	0	0	0	0	387	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	51	0
1973	0	0	0	0	0	58	0
1974	0	0	0	0	0	64	0
1975	0	0	0	0	0	14	0
1976	0	0	0	0	0	131	0
1977	0	0	0	0	0	74	0
1978	0	0	15	0	0	108	0
1979	0	0	944	0	0	98	0
1980	0	0	993	0	0	74	0
1981	0	0	0	0	0	92	0
1982	0	446	480	0	0	86	0
1983	0	1096	553	0	0	15	0
1984	0	4103	197	0	0	13	0
1985	102	2361	187	0	0	18	0
1986	0	320	283	0	0	20	0
1987	77	46611	122	0	0	12	0
1988	86	38296	389	0	0	5	22
1989	82	26758	135	0	0	9	0
1990	91	22110	134	0	0	6	0
1991	75	14564	122	0	0	10	0
1992	104	8158	106	0	0	20	10
1993	113	858	74	0	0	18	24
1994	67	111	54	0	0	24	22
1995	50	83	62	0	0	11	21
1996	112	88	62	0	0	7	54
1997	52	49	103	0	0	10	57
1998	34	83	47	0	0	16	0
1999	36	109	0	0	0	137	0
2000	37	128	72	452	0	10	0
2001	28	319	60	277	0	7	33
2002	55	82	64	286	0	3	29
2003	34	124	47	319	0	8	26
2004	35	107	9	299	0	7	23
2005	29	94	7	242	0	10	22
2006	18	87	4	155	2	4	21
2007	14	59	5	166	5	6	50
2008	9	72	5	120	5	13	78
2009	16	36	3	157	1	7	83
2010	20	28	12	259	1	4	77

Table 16.3. Grey gurnard. Official landings (tonnes) of grey gurnard in area IIIa, IV, and VIId as reported to ICES.

VIII, IXa	Official landings in tonnes		
	Belgium	France	Netherlands
1950	0	0	0
1951	0	0	0
1952	0	0	0
1953	0	0	0
1954	0	0	0
1955	0	0	0
1956	0	0	0
1957	0	0	0
1958	0	0	0
1959	0	0	0
1960	0	0	0
1961	0	0	0
1962	0	0	0
1963	0	0	0
1964	0	0	0
1965	0	0	0
1966	0	0	0
1967	0	0	0
1968	0	0	0
1969	0	0	0
1970	0	0	0
1971	0	0	0
1972	0	0	0
1973	0	0	0
1974	0	0	0
1975	0	0	0
1976	0	0	0
1977	0	0	0
1978	0	1	0
1979	0	9	0
1980	0	24	0
1981	0	0	0
1982	0	8	0
1983	0	28	0
1984	0	46	0
1985	0	54	0
1986	0	73	0
1987	2	94	0
1988	0	54	0
1989	3	60	0
1990	1	31	0
1991	1	22	0
1992	1	30	0
1993	2	53	0
1994	1	33	0
1995	1	41	0
1996	4	41	0
1997	4	53	0
1998	3	53	0
1999	1	0	0
2000	1	43	0
2001	1	40	4
2002	2	34	0
2003	1	46	0
2004	1	62	0
2005	1	58	0
2006	3	71	0
2007	2	68	0
2008	3	5	0
2009	3	96	0
2010	8	147	0

Table 16.4. 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

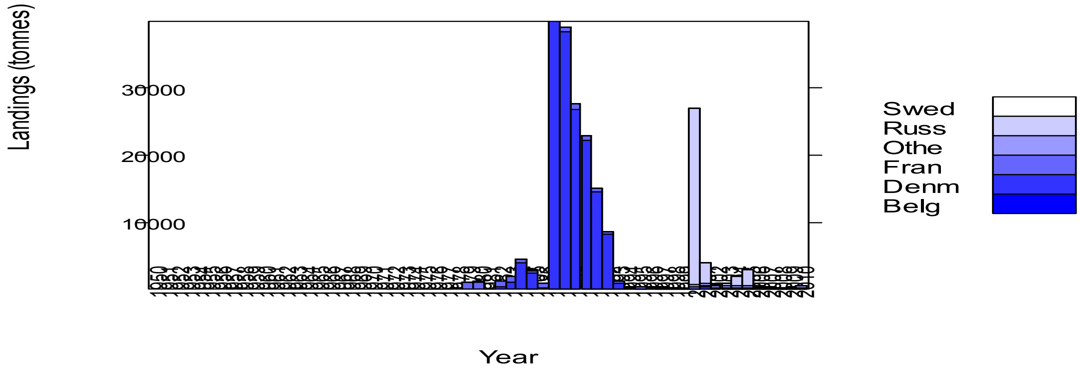


Figure 16.1. Grey gurnard. Official catches of grey gurnard reported at ICES from 1950 to 2010.

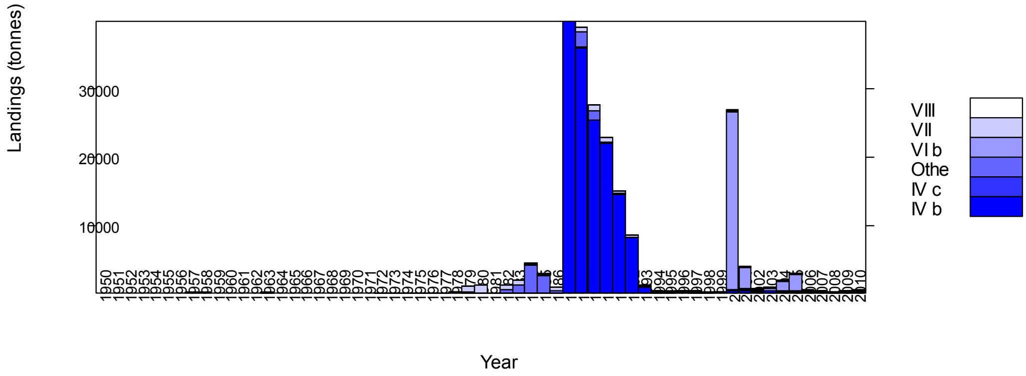


Figure 16.2. Grey gurnard. Official catches of grey gurnard reported at ICES from 1950 to 2010 in the main areas.

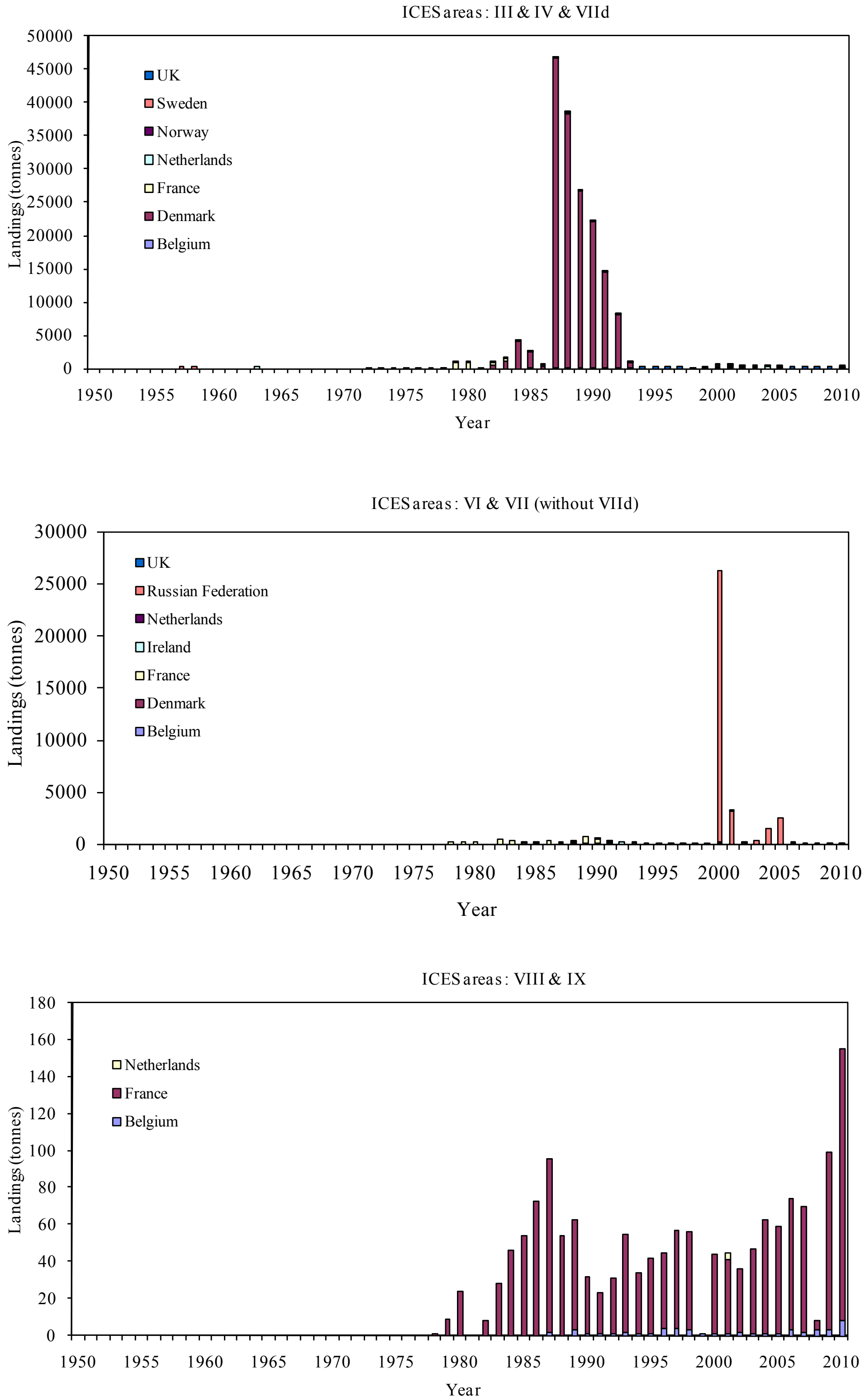


Figure 16.3. Grey gurnard. Official landings of grey gurnard reported at ICES from 1950 to 2010 by area covering the Ecoregions.

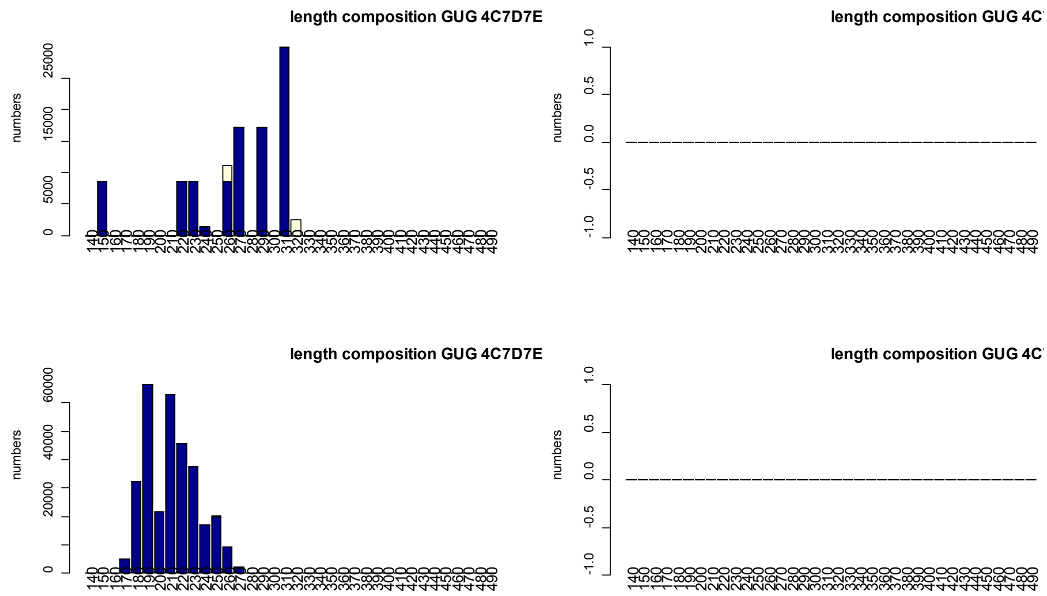


Figure 16.4. Grey gurnard. 2010 Length compositions of catch and discard of grey gurnard by French trawlers in Divisions IVc+VIId+VIIe. Datasets available from DCF only support the estimation in quarter 1 and quarter 3. Almost all the catches have been discarded.

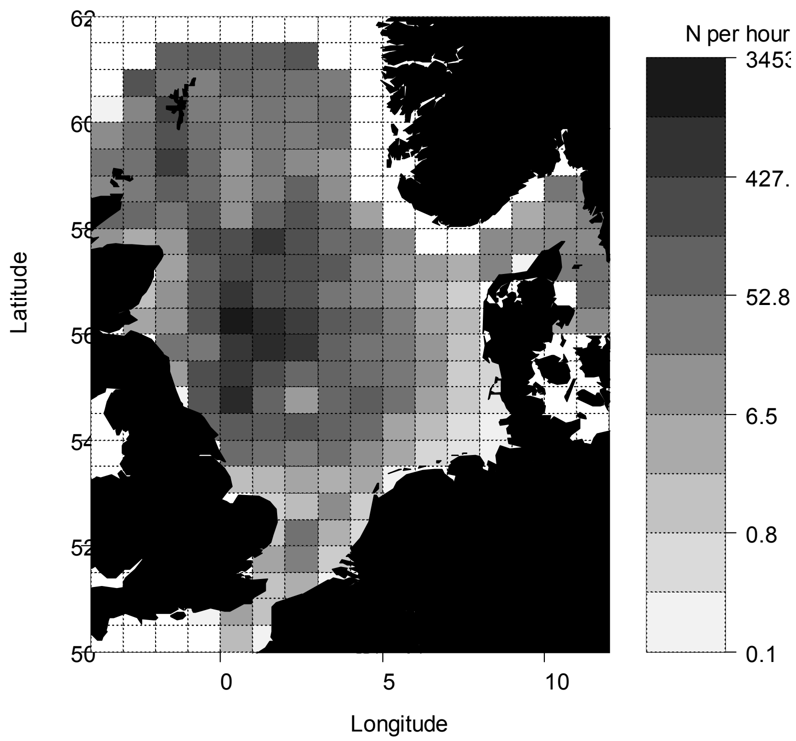


Figure 16.5. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q1 survey .

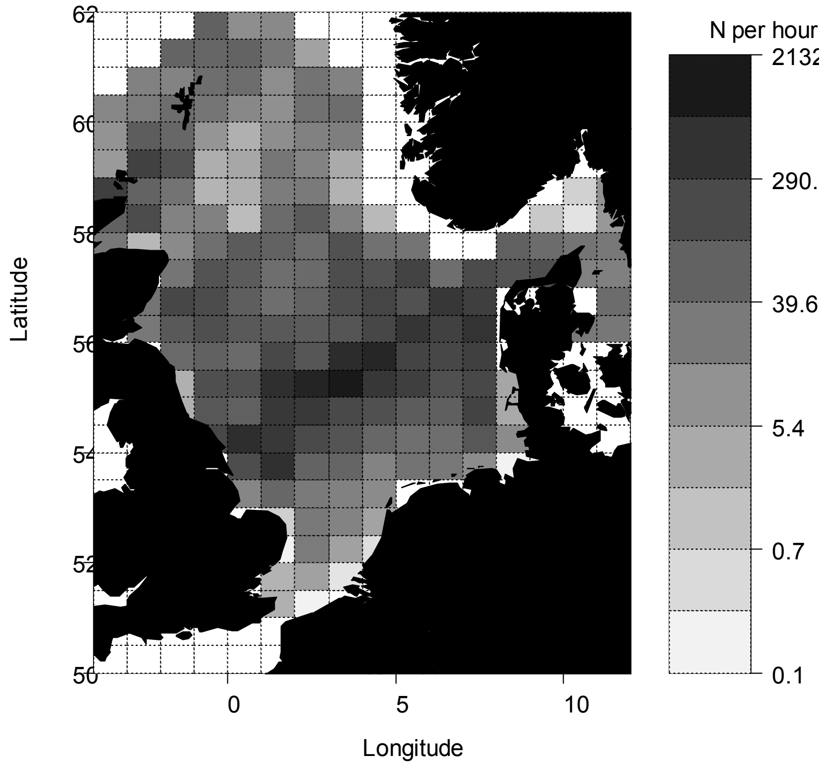


Figure 16.7. Grey gurnard. Spatial distribution of grey gurnard from IBTS-Q3 survey .

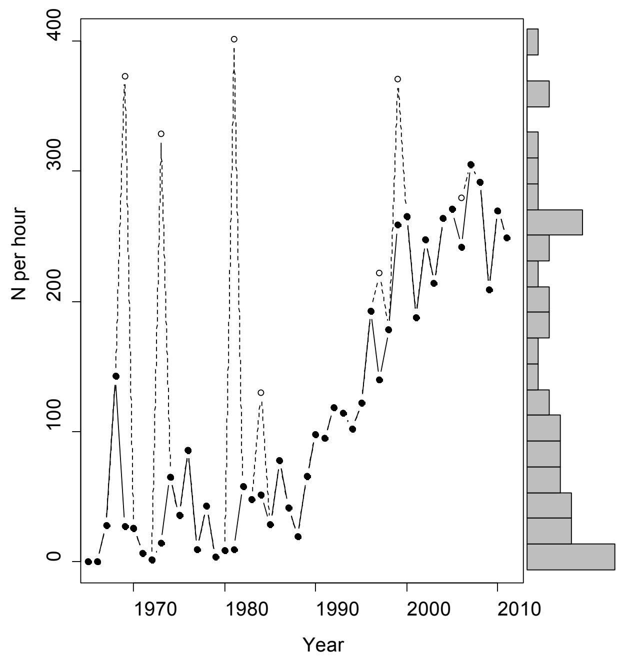


Figure 16.7. Grey gurnard. Abundance index of grey gurnard from IBTS-Q1 survey time series . The plain line excludes the exceptional abundance observed occasionally in a single rectangle by shoal behaviour.

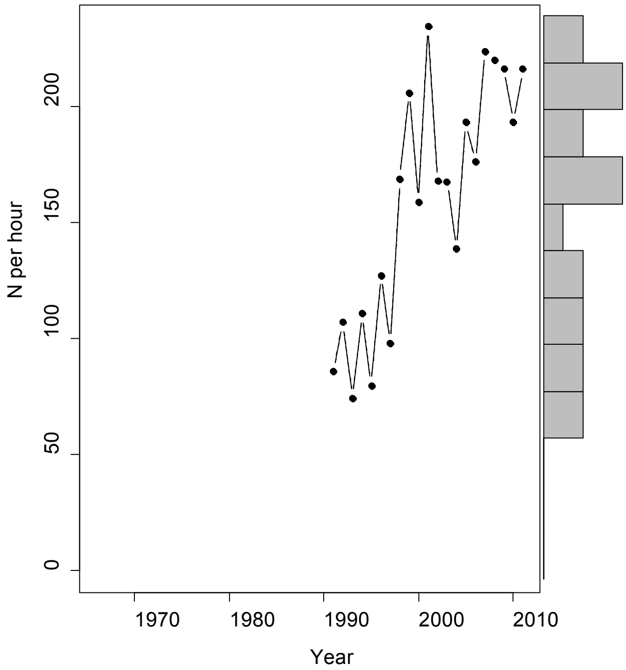


Figure 16.8. Grey gurnard. Abundance index of grey gurnard from IBTS-Q3 survey time series .

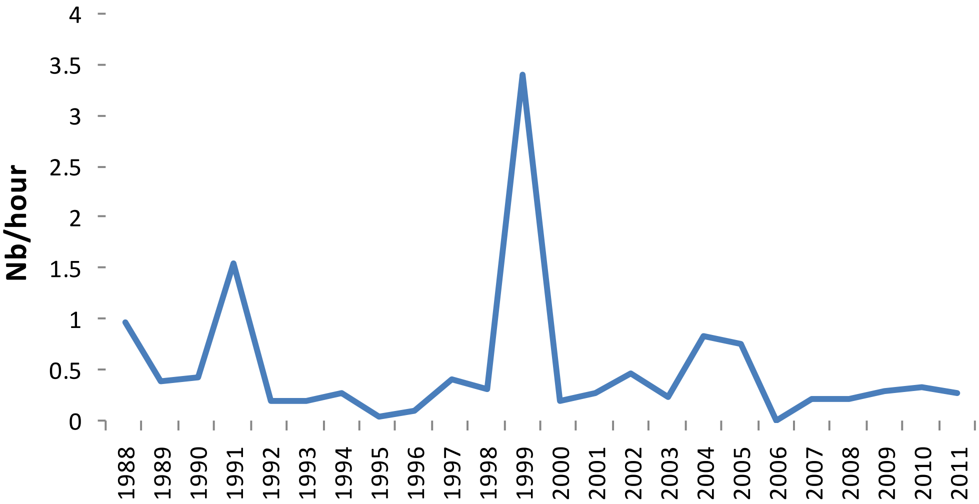


Figure 16.9. Grey gurnard. Abundance index of grey gurnard from CGFS-Q4 survey time series in Eastern Channel .

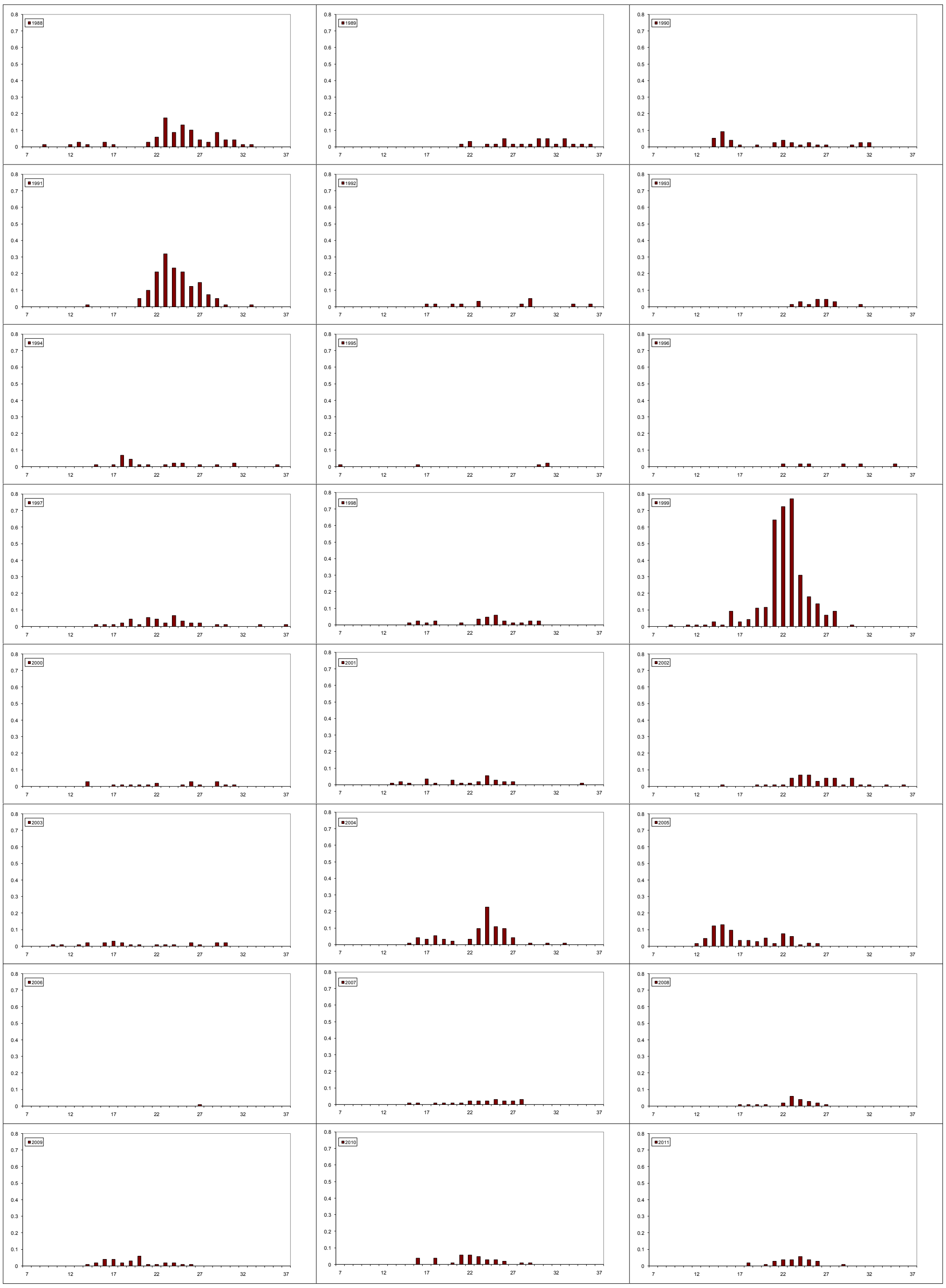


Figure 16.10. Grey gurnard. Abundance index at length of grey gurnard from CGFS-Q4 survey time series in Eastern Channel. 1999 indicates sporadic higher abundances.

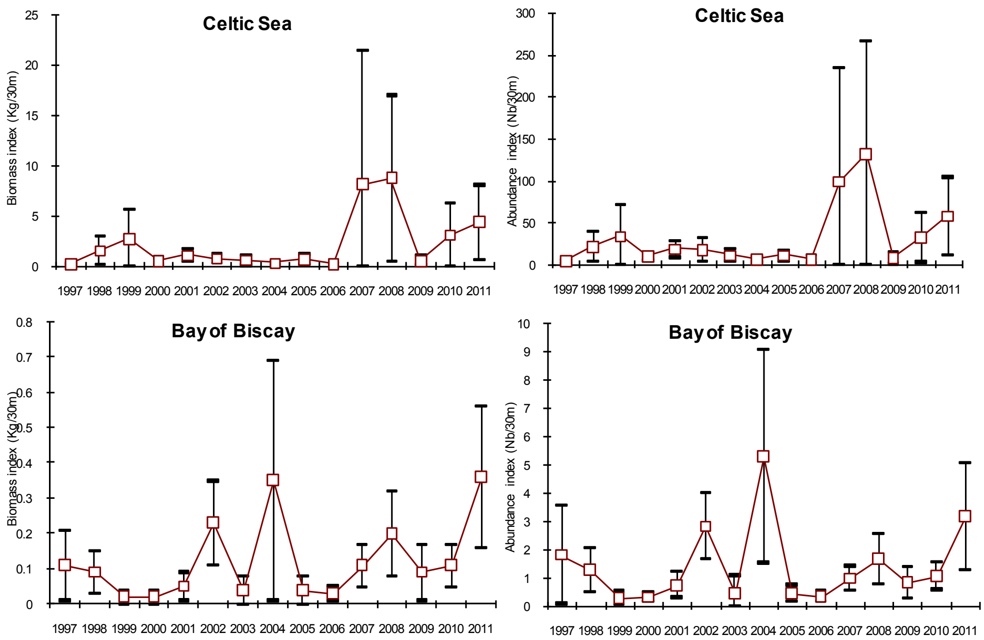


Figure 16.11. Grey gurnard. Abundance index (Nb/30mn and Weight/30 mn) of grey gurnard and their confidence interval from EVHOE-WIBTS-Q4 survey time series in Celtic sea and Bay of Biscay.

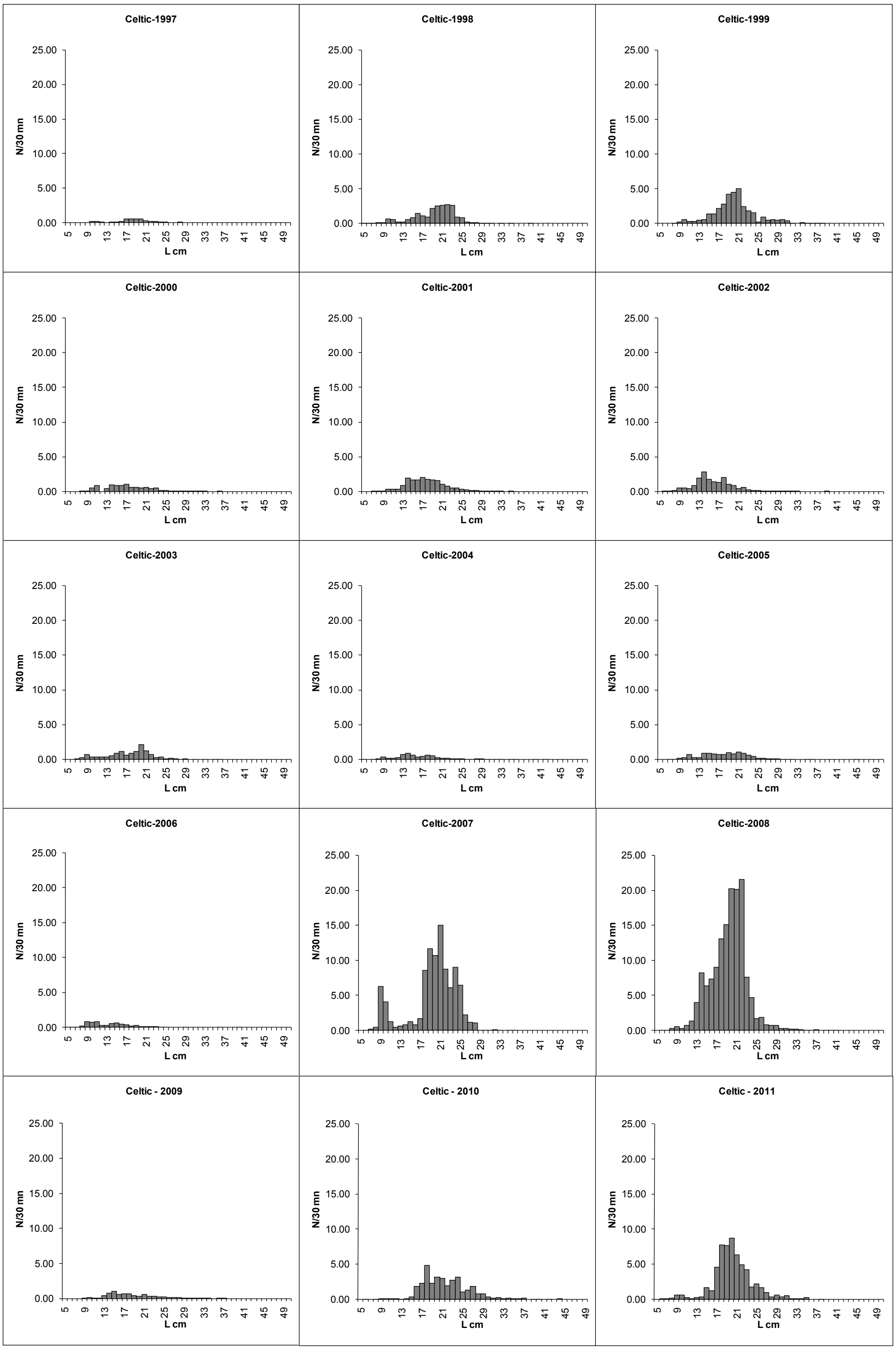


Figure 16.12. Grey gurnard. Abundance index at length of grey gurnard from EVHOE-WIBTS-Q4 survey time series in Celtic sea.

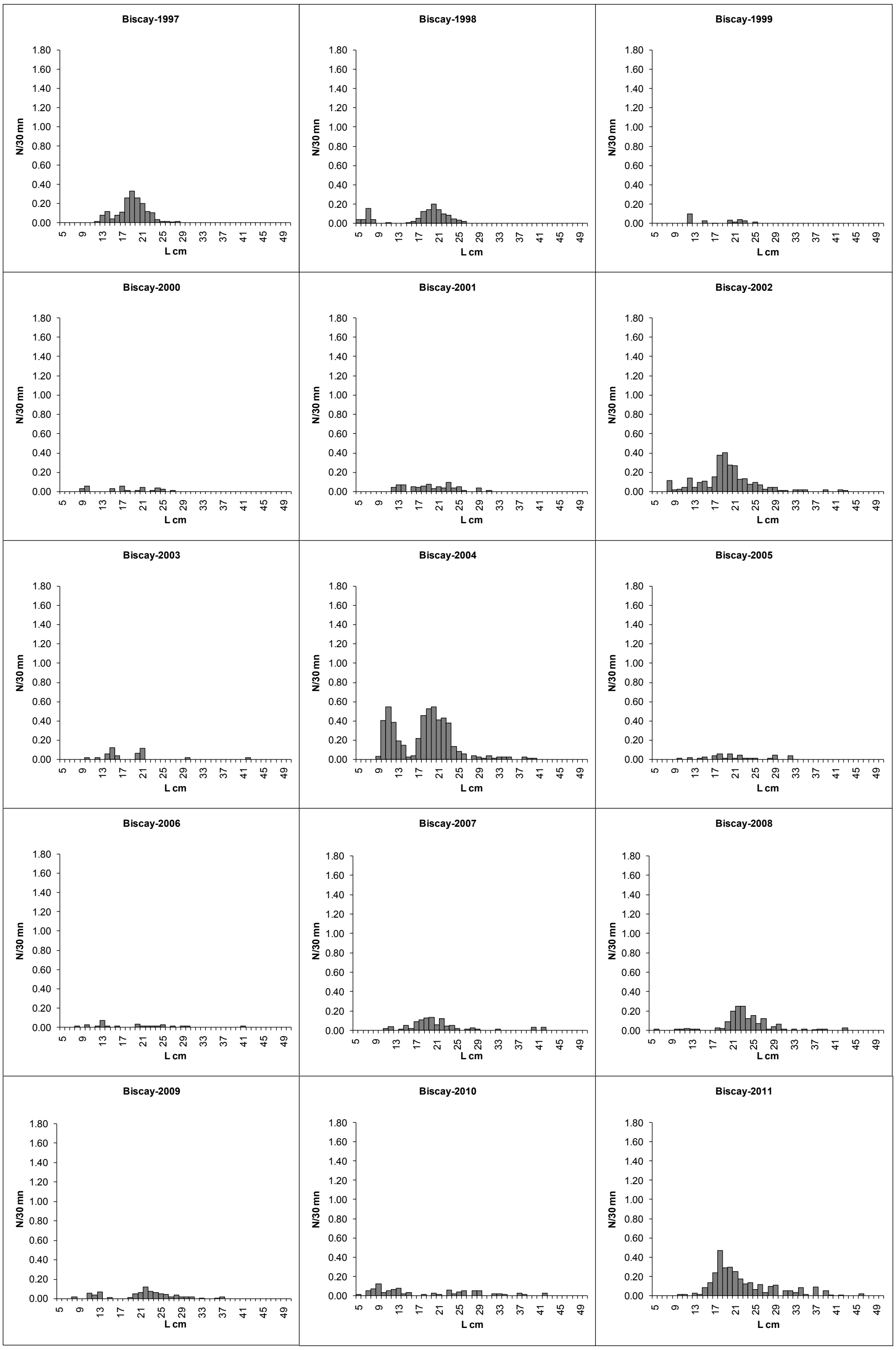


Figure 16.13. Grey gurnard. Abundance index at length of grey gurnard from EVHOE-WIBTS-Q4 survey time series in the Bay of Biscay.

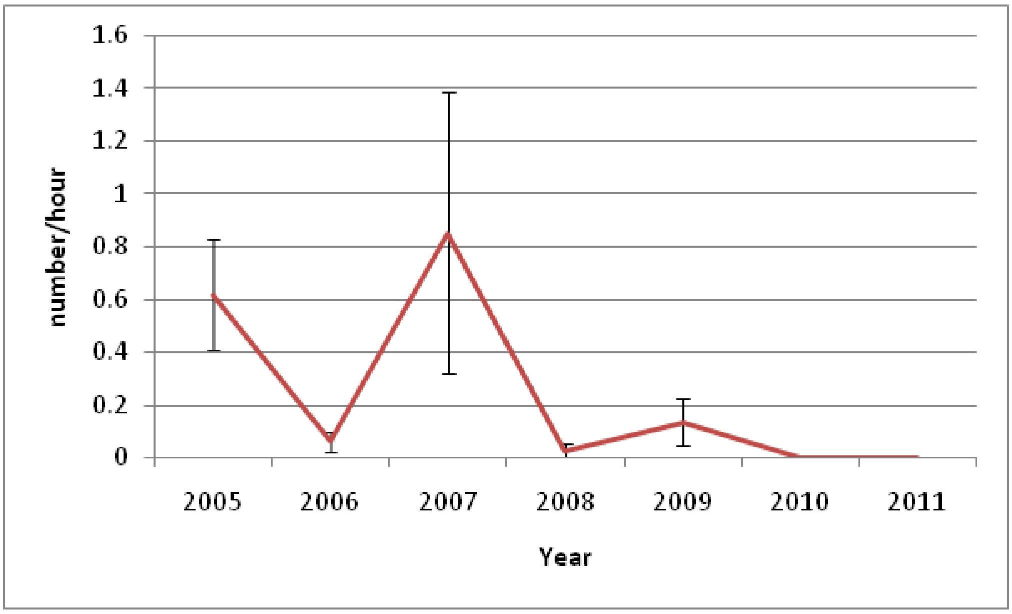


Figure 16.14. Grey gurnard. Abundance index of grey gurnard from PGFS-Q4 survey time series on the Western shelf of Portugal (the survey does not catch any grey gurnard in 2010 and 2011).

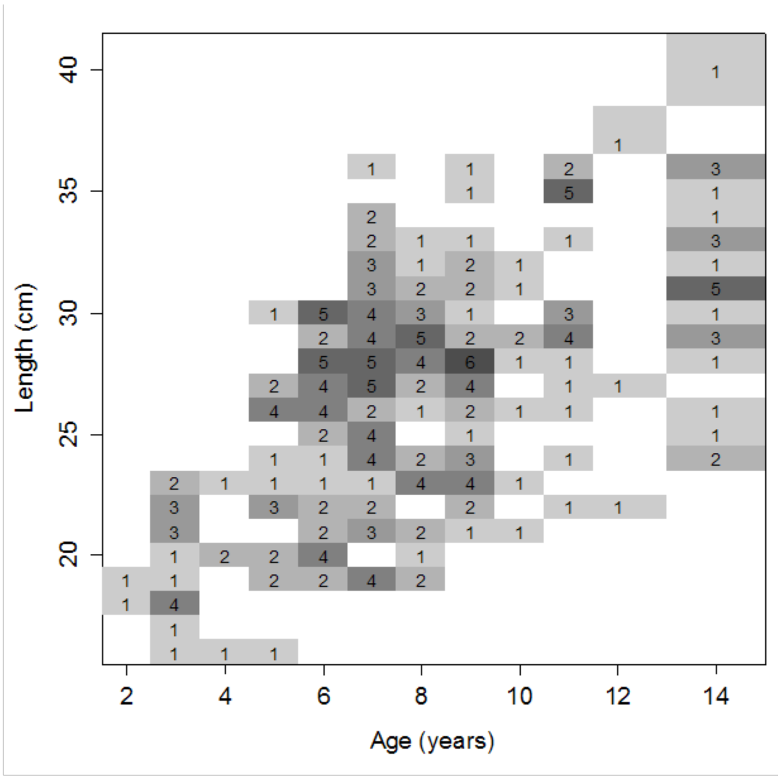


Figure 16.15. Grey gurnard. ALK from otoliths of Grey gurnard collected during 2010 IBTS-Q1 survey showing that grey gurnard displays a significant number of individuals over a large span of ages (up to 14).

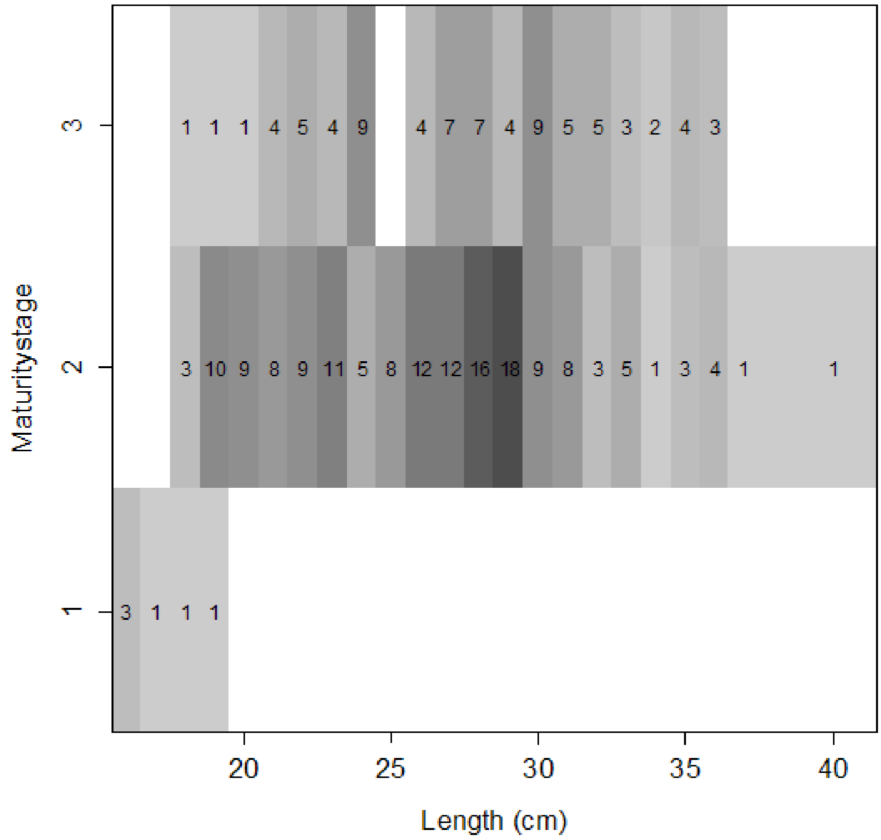


Figure 16.16. Maturity length key of Grey gurnard sampled during IBTS-Q1 surveys . which shows that above 19-20 cm almost all the individuals can be considered mature.

17 Striped red mullet in Divisions VIId, IIIa and Subarea IV

17.1 No analytical assessment is available for this stock

17.2 .General

17.2.1 Ecosystem aspects

The available information is summarized in the Stock Annex. According to this information, striped red mullet 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.

Adult striped red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search in the mud. In the English Channel, spawning occurs from May to July. The pelagic eggs incubate 3 to 8 days, depending on temperature. After hatching, the pelagic larvae migrate to the coast in the autumn. Juveniles of length greater than 5 cm return to the sandy and shelly substrates deeper than 10 meters. Growth during the first year of life is particularly fast (Carpentier *et al*, 2009)

The Nespman project identified striped red mullet from the Eastern Channel and North Sea as a distinct population based on the shape of the otoliths.

17.2.2 Fisheries

In the Eastern Channel, the main country fishing on striped red mullet was historically France. From 2000, landings are shared by French, Dutch and English fisheries (Table 17.1.2.1).

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. In the Eastern English Channel and south of the North Sea, the complementary gears are essentially represented by various trawlers. Striped red mullet catches, achieved by these complementary metiers, remain accessory. French trawlers concerned by striped red mullet fishery have an average length of 20 meters and 400 kilowatts. This has remained stable since 1991. Among this fleet, 71% of the ships which fish in the south of the North Sea also fish 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 and spring.

17.2.3 ICES advice

Advice for 2012 is:

This is the first time that ICES has provided advice for striped red mullet. Currently there is no TAC for this species and preliminary data on stock identity suggests there is more than one stock in the ICES area. There is insufficient information to evaluate the status of the striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat). Therefore, based on precautionary considerations, ICES advises that catches should not be allowed to increase in 2012.

17.2.4 Management

There are no explicit management objectives for this stock.

There are no quotas for striped red mullet in these areas.

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.

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. The areas are Kattegat, part of IIIa not covered by Skaggerak and Kattegat, ICES zone IV, EC waters of ICES zone IIa, ICES zone VIId, ICES zone VIIa, ICES zone VIa and EC waters of ICES zone Vb. The grouping of fishing gear concerned 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 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. (see section 1.2.1 for complete list).

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 for striped red mullet are available from ICES but are clearly incomplete for 2011. Considering that striped red mullet is neither subject to TAC nor minimum landing size and that small individual are landed, discard practices should not be problematic for this stock.

Landings by countries and areas from 1975 to 2011 are shown in tables Table 17.1.2.1 and Table 17.2.1.1. Before 2000, most of the landings were made by French fisheries with more than 90% of the total landings. In the recent years, French fisheries are still dominating followed by Dutch fisheries and English fisheries (48, 31 and 17% respectively of the landings in 2011).

Most of these landings are made in the area VIId (80% in 2011) or in the southern part of the North Sea (IVc).

17.3.2 Age compositions

Since 2004, data (age, length, sexual maturity) are usually collected by France for the Eastern English Channel and the southern North Sea. The Netherlands also sampled fishes in 2009 and 2010 for age estimation in the North Sea.

17.3.3 Weight at age

No weight at age is available to the group, however the sampling level in France should allow it from 2004 (table 17.2.3.1)

17.3.4 Maturity and natural mortality

Striped red mullet are mature between 1-2 years and 16-19 cm. 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).

17.3.5 Catch, effort and research vessel data

Since 1988, striped red mullet abundance indices are currently available for the eastern English Channel (CGFS survey), and for the North Sea (IBTS survey Q1 and Q3) (Figure 17.2.5.1).

17.4 Data analyses

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 17.3.1). 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.

17.5 Status of the stock

This is the first time that ICES has provided advice for striped red mullet. Currently there is no TAC for this species and preliminary data on stock identity suggests there is more than one stock in the ICES area. There is insufficient information to evaluate the status of the striped red mullet in Subarea IV (North Sea) and Divisions VIId (Eastern Channel) and IIIa (Skagerrak - Kattegat).

17.6 Management considerations

Considering that striped red mullet is neither subject to TAC nor minimum landing size and that small individual are landed, discard practices should not be problematic for this stock.

To reduce fishing on immature, a minimum landing size of 16 cm should be re-introduced.

EU Council Regulation (EC) N°43/2012 allocates different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size.

Sources

Mahé K., Destombes A., Coppin F., Koubbi P., Vaz S., Leroy D. & Carpentier A., 2005. Le rouget barbet de roche Mullus surmuletus (L. 1758) en Manche orientale et mer du Nord, 186pp.

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management, final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom

Table 17.1.2.1 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Official landings by country (tonnes).Include both official landings and ICES landings (where these differ), make clear what data are presented and which of these are used for the assessment

Year	Belgium	Denmark	Denmark	France	Netherlands	Norway	UK
1975	0	0	0	140	0	0	0
1976	0	0	0	156	3	0	1
1977	0	0	0	279	12	0	1
1978	0	0	0	207	25	0	3
1979	0	0	0	212	32	0	11
1980	0	0	0	86	25	0	4
1981	0	0	0	44	19	0	1
1982	0	2	0	32	18	0	2
1983	0	0	0	232	15	0	1
1984	0	0	0	204	0	0	3
1985	0	1	0	135	0	0	4
1986	0	1	0	84	0	0	3
1987	0	2	1	40	0	0	3
1988	0	1	1	35	0	0	4
1989	0	0	0	37	0	0	5
1990	0	0	0	524	0	0	13
1991	0	0	0	208	0	0	11
1992	0	0	0	431	0	0	14
1993	0	0	0	516	0	0	18
1994	0	0	0	308	0	0	14
1995	0	0	0	2016	0	0	63
1996	0	1	1	1785	1	0	36
1997	0	1	1	731	0	0	48
1998	0	1	1	2598	0	0	97
1999	0	2	2	0	0	0	70
2000	0	2	2	2590	235	0	93
2001	0	5	5	1417	533	0	142
2002	0	12	12	1346	326	0	82
2003	17	0	0	2750	396	0	115
2004	22	0	0	3618	804	0	91
2005	19	0	0	1595	600	0	81
2006	12	0	0	1029	293	0	69
2007	13	0	0	3475	906	0	161
2008	15	0	0	3249	873	0	313
2009	13	0	0	736	562	0	260
2010	62	0	0	879	567	0	311
2011[1)]	0	0	0	1027	0	0	0

[1)] Provisional

Table 17.2.1.1 Striped red mullet in Subarea IV and Divisions VIId and IIIa. Official landings by area (tonnes).

Year	IV	IIIa	VIId
1975	0	0	140
1976	4	0	156
1977	19	0	273
1978	30	0	205
1979	49	0	206
1980	29	0	86
1981	20	0	44
1982	21	0	33
1983	41	0	207
1984	22	0	185
1985	10	0	130
1986	6	0	82
1987	7	0	38
1988	7	0	33
1989	5	0	37
1990	33	0	504
1991	26	0	193
1992	30	0	415
1993	63	0	471
1994	58	0	264
1995	527	0	1552
1996	264	0	1559
1997	139	0	641
1998	389	0	2307
1999	35	0	37
2000	882	0	2038
2001	800	0	1297
2002	617	0	1149
2003	809	0	2469
2004	910	0	3625
2005	702	0	1593
2006	320	0	1083
2007	773	0	3782
2008	914	0	3536
2009	454	0	1117
2010	350	0	1469
2011[2)]	10	0	1026

[1)] No data reported by France in 1999.

[2)] Provisional

Table 17.2.4.1 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

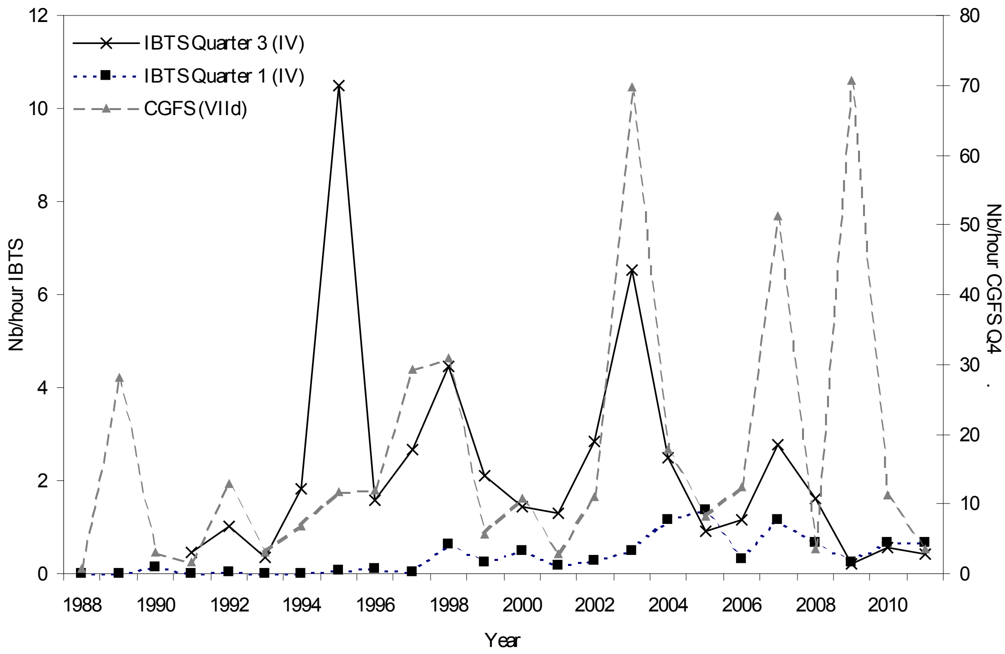


Figure 17.2.5.1. Striped red mullet. Time series of abundance (Nb/hour) of striped red mullet base on Surveys (International Bottom Trawl Survey (IBTS, IV), Channel Ground Fish Survey (FR-CGFS, VIId), UK-WCBTS (VIIe), EVHOE-WIBTS survey (VIIg, h, j ; VIIIa,b) from 1988 to 2011.

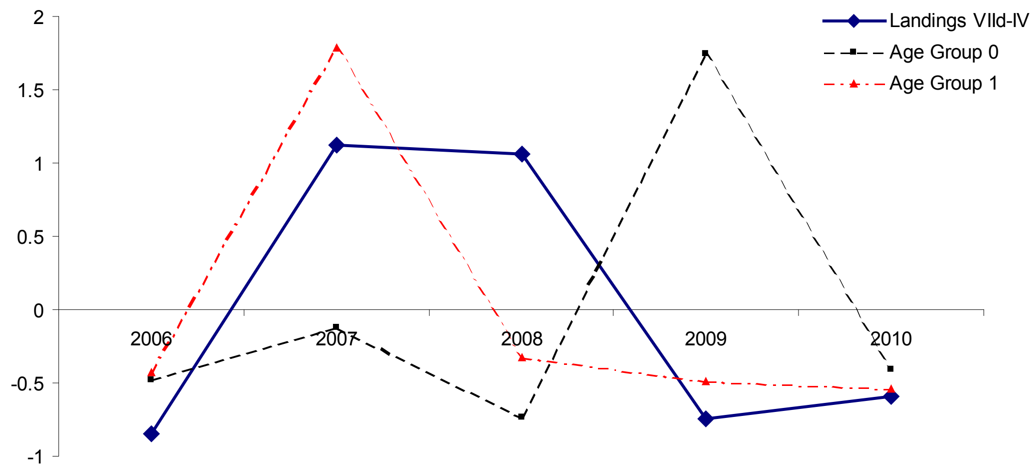


Figure 17.3.1. Striped red mullet. Mean standardised of Abundance indices base on CGFS survey (ICES Subarea VIId) from 2006 to 2010 per age class and total landings (ICES Subareas VIId-IV) of striped red mullet.

18 Plaice in IIIa: alternative assessment and management request

This stock is a result of the recommendation made by WKPESTO 2012, which suggested revising the stock structure for the plaice stocks in the North Sea, Skagerrak, Kattegat and the Baltic Sea. Plaice in Skagerrak is recommended to be included in the North Sea stock, Kattegat and Subdivision 22 and 23 are merged into one stock and Subdivision 24- 32 is regarded as one stock. The stock should therefore be regarded as provisional until the possible new stock structure is approved. The assessment made during the WGNSSK is the first attempt (except the exploratory one done during the WKPESTO) to carry out an assessment on the SD 21-23 stock. Therefore, it is to be considered as a premature assessment with room for improvements until the data foundation is more complete. Kattegat is named different depending on the point of view. For Baltic people Kattegat is denoted "Subdivision 21" originally based on the area classification of the Baltic Fishery Commission while other people denote Kattegat as "Subdivision IIIaS" based on the NEAF system. Below Kattegat will be denoted SD 21.

Compared to the work done during WKPESTO where both the XSA and the FLSAM models were used, the present assessment was made using the SAM model only. This model allows different age ranges in the catch matrix and the tuning data. Therefore age 1 was included in the catch matrix. Furthermore, data from 2011 was now available.

Due to time constraints, only biological information from Denmark was made available for SD 22 and 23 and it was therefore applied to both Swedish and German landings. No discard information was readily available this year, but will be available in the future. It was not possible during the WG to be able to achieve convergence in the retrospective analysis due to the relative short time series available (1999-2011).

No final assessment was produced for this stock and hence no forecast was made either.

18.1 Ecosystem aspects

No description of the ecosystem is available at present.

18.1.1 Fisheries

Technical Conservation Measures

Minimum Landing Size in SD 21 is 27 cm.

Minimum Landing Size in SD 22 and SD 23 is 22 cm.

Closed areas were implemented by Denmark and Sweden in the Southeast Kattegat and North of Oresund from the fourth quarter of 2008, with the aim of protecting spawning cod. Two areas are closed on a permanent basis while one large area is closed during the first quarter only.

In the Oresund (SD 23) trawling is only allowed in the most northern part.

In SD 22 the BACOMA exit window is implemented. This is a square mesh window inserted in the top panel of the codend. The mesh size in the exit panel was increased to from 110 to 120 mm in 2010.

Description of the fishery

The landings decreased dramatically in the end-seventies in SD 21 from 11000 t to 2000 t and in SD 22 (from 3500 t to almost nothing). Implementation of a number of changes in the regulatory systems in the Kattegat between 2007 and 2008 as well as continuous reductions in the allowed days at sea to protect Kattegat cod have significantly changed the fishing patterns of the Danish and Swedish fleets. After the mid-nineties the landings in SD 22 again increase to present level around 1000 t while the landings in SD 21 again have decreased in the latest years. In SD 23 the catches have been low and stable in the whole period (Figure 18.1.1a-c and table 18.1.1).

The peak season for the fishery is 1st quarter for SD 21 and 22, during 2nd and 3rd quarter the landings are small while it again increase in 4th quarter. In SD 23 the landings are stable and low throughout the year (Figure. 18.1.2).

87 % of the landings are caught by active gears. 11 % is caught by passive gears. About 2 % have the métier "No logbook" which by Denmark denotes the situation where no logbook could be associated to the given landing. This most often is landings made by small vessels < 10 m, fishing in the local area and having an area declaration and therefore in Denmark have no obligation to fill in logbooks. A preliminary investigation in Denmark has indicated that these vessels predominantly are gillnetters. Figure 18.1.2a-c gives the landings for the top 5 métiers in SD 21, 22 and 23 respectively. The "No logbook" métiers is within the top 5 métiers in all three areas. In SD 22 the top métiers are the same as the top 5 métiers for cod in the same area and reflect the fact that the important métiers most often are targeting a combination of cod, and plaice. In SD 21 plaice is almost exclusively a by-catch in the combined *Nephrops*-sole fishery. The complete table showing the landings of all métiers is given in table 18.1.2a-c.

Discard estimated was only available for 2011. The discard by métier is shown in each SD in table 18.1.3. All countries have derogations from the Data Collection Framework (DCF (EU Commission)) for sampling métiers which is known to have insignificant discards. Denmark only provides estimates from métiers which have been sampled and summing up the discards across métiers will therefore probably be an underestimate of the total discard.

Fisheries Science Partnerships

No Fisheries Science Partnerships are applicable for this stock

18.1.2 ICES Advice

No advice is made for this stock at present.

18.1.3 Management

The preliminary stock is not at present accepted as a stock and there are therefore no management objectives for the stock.

TAC in 2011 was for Kattegat 1988 t and 3041 t for SD 22-32. For 2012 the TAC in Kattegat was rolled over, and the TAC for SD 22-32 was decreased by 5% to 2889 t.

From 2009, a new European scheme for effort management was implemented (Council Regulations (EC) N°43/2009, N°43/2009, N° 53/2010 and N° 57/2011) allocating different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. There is a specific amount of KWdays allocated to the Kattegat fisheries. 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.

In addition to these common European rules, additional national management actions have been implemented (cf. 7.1.1), with the specific aim of protecting spawning cod in the Kattegat.

Finally, in 2007, a rights-based regulation system was introduced in Denmark for the allocation of national quotas. Before that year the quotas were split into 14-days rations which were continuously adjusted to the amount of quota left. In 2007 this system was changed to a complex system were individual rights are attached to the vessels and not to the owners (FKA - Vessel Quota Share), with specific provisions for coastal and recreational fisheries. It is acknowledged that this complex system may have dramatically affected the structure of Danish fisheries, as can be seen from effort trends (Bailey and Rätz, 2011).

18.2 Data available

18.2.1 Catch

The annual landings used by the Working Group, available since 1970 and 1972, are given by Sub-Division and country separately in Table 18.1.1. In 2011, 63 % of the landings were taken by Denmark. The landings by SD and country are plotted in Figure. 18.1.1a-c.

No significant misreporting is believed to take place.

Catch at age information is available from Denmark only, and this was used to raise to international landings. Landings at age are presented on Figure 18.2.1a-b.

No discards information except for 2011 was available for the WG. Discard data is not included in the assessment.

Since 2004, Denmark and Sweden have put a significant amount of effort into increasing the quality of age reading for plaice in IIIa through a series of workshops and otolith exchanges between age readers. Significant improvement in the consistency have been reached, although some uncertainties remain, particularly for Kattegat plaice and for fish older than 6.

It is therefore acknowledged that the variability of growth is a more important source of uncertainty in the catch matrix than the age reading process in itself. It is not expected that with the current sampling levels, which are consistent with the Data Collection Framework requirements, significant precision improvements can be gained.

Landings at age were raised using ICES InterCatch database.

18.2.2 Weight at age

Weight at age in landings is presented in Table 18.2.1 and Figure 18.2.2a-b.

18.2.3 Maturity and natural mortality

Natural mortality is assumed constant for all years and is set at 0.1 for all ages.

The maturity ogive was revised during the 2006 WG, and uses a fixed value per age based on 1994-2005 average of IBTS 1st quarter data.

18.2.4 Catch, effort and research vessel data

Only scientific tuning fleets are used. 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 ground rope may lift the ground panel of the trawl and enable flatfish escape.

IBTS in area Kattegat has normally been conducted by the Swedish research vessel 'RV Argos', twice a year, in the first and the third quarters and survey indices are available since 1991. In 2011 "RV Argos" was laid-up and the survey was instead carried out using the Danish research vessel "RV DANA" which also conducts the Danish part of the IBTS.

IBTS samplings take place in the Kattegat. All individuals from the survey 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 survey is designed to provide an annual abundance index for cod, plaice and sole. The trawl used is a standard TV3-520 with rubber discs of 10cm diameter on the ground rope and with a trawl speed at 3knots. This trawl targets flatfish better than the GOV trawl used during IBTS. The 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.

Individual weight information are available for age 1-6, the survey area are distributed further to the Danish cost compared to the IBTS.

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.

18.3 Data analyses

18.3.1 Catch-at-age matrix

The Landings-at-age matrix is shown on the figure 18.2.1a and 18.2.1b for Kattegat and the Baltic by Sub-Division. The internal consistency in Kattegat is significant while the Baltic clearly shows a limited ability to track down the cohorts over time.

18.3.2 Catch curve cohort trends

No catch curve diagrams were available.

18.3.3 Tuning series

The internal consistency for the 1st quarter IBTS is quite good and considerable better than 3rd quarter IBTS (figure 18.3.1a-b). Similarly, the KASU show good internal consistency, particularly for the younger age classes. Again, here the 1st quarter is better than the 4th quarter (figure 18.3.1c-d). The consistency between KASU 1st and 4th quarter is rather good (figure 18.3.2). The four surveys are not entirely consistent with each other, and convey different signals about the dynamics of the stock. All surveys show unchanged abundance of age class 1 compared to last year except KASU 1st quarter which shows a decrease compared to last year very high index. Age class 2 is on average level again except KASU 1st quarter which shows record high abundance index. In general KASU 1st quarter has increased indices for all age classes except age class 1. The indices by age classis for all 4 surveys are shown in figure 18.4.2a-d).

18.4 Exploratory analysis

As the stock is not accepted as such, only an exploratory assessment was done. The settings followed the recommendations made by WKPESTO (ICES. 2012) with F(3-5) and including the updated data from 2011 and including age class 1.

18.4.1 Exploratory SAM

An exploratory SAM was run. As could be expected from the limited input data material (short time series, only biological information from Denmark and no discard information), the confidence intervals are rather wide. Globally, the perception from this assessment is though broadly in line with the information from the surveys, indicating that the spawning stock biomass is increasing from 2007 due to decreasing fishing pressure. The recruitment has been stable around 10 -15 mill individuals since 2001. Due to the short time serials the model failed to converge when performing retrospective analysis.

18.4.2 Final assessment

No final assessment was made.

18.5 Historic Stock Trends

No historical stock trends are available from the final assessment.

18.6 Recruitment estimates

Not available

18.7 Short-term forecasts

Not performed

18.8 Medium-term forecasts

None

18.9 Biological reference points

	ICES considers that:	ICES proposed that:
Precautionary Approach reference points	N/A.	N/A..
	N/A.	N/A.
Target reference points		N/A.

Technical basis

18.10 Quality of the assessment

The assessment builds on the assessment done by the WKPESTO and uses the same settings for the SAM run. The data has been improved by including age group 1 in the catch matrix and by updating the time series with 2011 data. German and Swedish biological information will probably improve the assessment. However, the catch share of Sweden and Germany is small compared to the catches of Denmark.

18.11 Status of the Stock

It is difficult to provide a reliable status of the stock based on analytical assessment due to the short time series available. Landings have been stable over a long time period, and the effort of commercial fleets has decreased. The recruitment seems to be stable. There had never been sign of impaired recruitment.

18.12 Management Considerations

Plaice is to some degree in Kattegat (SD 21) taken in a directed fishery, but is also taken as a by-catch in a mixed cod-*Nephrops*- plaice fishery. In the Belt area (SD 22) an exit window (BACOMA) is mandatory in all trawls. The mesh size in the exit panel was increased to from 110 to 120 mm in 2010. Plaice are caught together with cod using the same trawl. In Oresund (SD 23) trawling is prohibit except in the most northern part and therefore most plaice here are caught in gillnet. The landings in all three Subdivisions are at the same level as last year and are much below the TAC. This probably do not reflect the catch opportunities but instead a consequence of the general bad situation of the cod stock.

18.13 References

Bailey, N., and Rätz, H. (Ed.), 2011. Report of the STECF SGMOS-10-05 Working Group on Fishing Effort Regimes Regarding Annexes IIA, IIB and IIC of TAC & Quota Regulations, Celtic Sea and Bay of Biscay. 27 September – 1 October 2010, Edinburgh, Scotland.

ICES. 2012. Report of the Working Group on XXXXX (XXXX). diane

18.14 Joint EU-Norway request on management measures for plaice in the Skagerrak

With the objective of establishing a long-term management plan for plaice in Skagerrak to provide for sustainable fisheries with high and stable yield in conformity with the MSY approach, ICES is requested by 30 June 2012:

1) To consider the stock identities of plaice in the Skagerrak and adjacent waters.
2) To evaluate possible approaches to develop a long-term management plan for plaice in Skagerrak, including a possible link with trends in the status of the plaice stock in the North Sea.

This request was first considered and partially answered by ICES WKPESTO (Workshop for the Evaluation of Plaice Stocks), which met in early March 2012. WGNSSK addressed this further during its meeting.

18.15 Proposal for new assessment/management units for plaice in area IIIa (ToR 1).

ICES WKPESTO (2012) reviewed in depth all the information available on stock structure and connectivity of plaice populations between the Eastern North Sea and the Baltic Sea. This included both old and more recent information on spawning areas, egg and larvae drift, nursery grounds, migrations, hydrographical models, genetic structure, and fisheries distribution. In general, the sources of information are mostly old and sporadic, and the stock structure has remained fairly uncertain. WKPESTO draw nevertheless some hypotheses and conclusions on this basis, underlining though that the knowledge could only be qualitative but not quantitative, and that new tagging and genetic data are absolutely needed in to verify these hypotheses and quantify the exchanges between populations. This was also supported as a clear need by ICES WG on Stock Identity (ICES SIMWG, 2012).

WKPESTO concluded that the collected information on biology and fishery of plaice in IIIa and adjacent waters suggest for changes in assessment units as well as in management areas. WKPESTO suggested also using an updated version of Cardinale et al. (2010) indices of local adult aggregation during spawning as a monitoring of local abundance in the area IIIa (see below).

Plaice in Skagerrak (Division 20) is considered to be closely associated with plaice in the North Sea and is proposed to be included in the North Sea plaice stock assessment, although it is recognised that local populations are present in the area. Therefore, separate management of the Skagerrak plaice is suggested to take place to assure the preservation of the local populations. The fishery is continuously distributed from the North Sea into the western part of Skagerrak and towards Skagen. Hydrographical features in the area combined with egg and larvae survey in the North Sea, suggest a drift of egg and larvae into the Skagerrak region. Further particle modelling in combination with the hydrography suggest potential nursery grounds along the coastline in the Skagerrak. Therefore it is assumed that a substantial part of the juveniles in the Skagerrak have their origin at spawning grounds in the North Sea. Spawning grounds in the Skagerrak are assumed to be located around Skagen and west towards the North Sea and on the Swedish Skagerrak coasts. The extensive intermingling of tagged plaice between the North Sea, Skagerrak and the most Northern part of the Kattegat (where little fishing occurs) suggest a mix of plaice within these areas, partly reflecting feeding and spawning migrations. However, the contribution of the Skagerrak population in relation to the contribution of plaice from the North Sea in the Skagerrak is unknown and cannot at the present be quantified.

Plaice in Kattegat (SD 21), the Belts (SD 22) and the Sound (SD 23) is considered a stock unit and is proposed to be assessed as such. However, separate management for the Kattegat, the Belts and the Sound is suggested to take place to assure the preservation of the local populations (see section on Monitoring of subpopulations).

Several observed spawning grounds are located in the Kattegat, in the Belts and in the Sound and hydrographic conditions support recruitment to nursery grounds along the Danish and Swedish coasts in Kattegat. Tagging of plaice has shown intermingling between Kattegat and the Belts and the Sound. The tagging has also shown that little migration extends out from this suggested stock unit. Further, the distribution of the fishery is continuous from the Kattegat into the Belts.

Plaice in the Baltic (SD 24-32) is considered a stock unit and is proposed to be assessed and managed as such. There are indications that the spawning areas are likely to be located in the southern part of SD 25 and 26, but the exact spawning locations are not known. The fishery is mainly concentrated around Bornholm (SD 24 and 25) and has increased in recent years.

18.16 Management considerations (ToR 2)

18.16.1 Introduction

As a contribution to the second aspect of the EU-Norway Request on management measures, WKPESTO considered possible approaches to develop a LTMP for plaice in Skagerrak.

As summarised above, WKPESTO considered that plaice populations, and their corresponding catches, are most likely a mixture of an extension of the North Sea plaice into the Skagerrak, and local population(s). This mixing cannot be quantified, however for adults it is considered to be more important on the Western entrance (Northern Danish Coast), whereas it is considered to be much lower, or potentially absent, along the Swedish Skagerrak coast. On the opposite, it is likely that this Swedish coast serves as a nursery ground to some North Sea juveniles.

As a consequence, it is considered that the management of the fisheries in the Skagerrak could be linked to some extend to the management of the North Sea plaice, since the largest part of the fisheries takes place in the Western area closest to the North Sea. However, a precautionary approach would call for particular considerations of the dynamics of the local populations, which are estimated to be currently very low and unproductive. A pragmatic management approach would therefore integrate an indexing of the Skagerrak TAC to the North Sea TAC, but with provisions explicitly linked to a monitoring of the local dynamics within Skagerrak.

18.16.2 NSRAC proposal

The North Sea Regional Advisory Council (NSRAC) has closely followed the developments of the scientific endeavours around the plaice IIIa stock over the recent years, and formulated accordingly during the Autumn 2011 a suggestion for an interim management plan following a specific Harvest Control Rule (HCR) (Annex 1). This initiative was well received by managers (European Commission in particular); however, during its 2011 winter plenary meeting (STECF PLEN-11-03), STECF didn't have enough material to evaluate the potential risks linked to this approach and could not conclude further.

This NSRAC proposal can be summarized as follows:

Given that there is an accepted NS assessment, it is possible to use NS SSB as a global index for stock development in the North Sea. On the opposite, it is unlikely that there will be a consistent stand-alone assessment in the Skagerrak area, and there is no adequate survey coverage. Therefore, commercial CPUE indices could be used as an interim proxy for stock development in the Western Skagerrak, until an extension of survey coverage in the Western area is available. For the Eastern Skagerrak, the IBTS provide sufficient spatial coverage for the estimation of an appropriate survey index for this stock component.

On this basis, it was suggested by NSRAC to use the relative stock trends in the different areas to link the Skagerrak TAC to the North Sea TAC as such:

NS SSB		SKA LPUE	
		RISING	FALLING
Above B trigger	RISING	SKA TAC increases with same rate as NS SSB (a)	SKA TAC remains at same level as previous year (b)
	FALLING	SKA TAC remains at same level as previous year (c)	SKA TAC decreases with same rate as NS SSB (d)
Below B trigger	RISING	SKA TAC remains at same level as previous year (e)	SKA TAC remains at same level as previous year (f)
	FALLING	SKA TAC decreases with same rate as NS SSB (g)	SKA TAC decreases with the rate of the NS SSB (h)

18.16.3 Qualitative evaluation of NSRAC proposal and elements to be considered in the design of a long-term management plan for plaice in the Skagerrak.

As a general point, the WKPESTO welcomed this proposal, and acknowledged the proactive and pragmatic NSRAC initiative attempting to propose a simple solution, based on best biological knowledge at the time, to a complex biological and political issue. The WK reviewed the suggested rules and made the following observations:

- The overall approach seems relevant and globally sensible; However, the situations of NS SSB rising and SKA LPUE falling (situations *(b)* and *(f)* in the table) are certainly the main source of concern, and it is unlikely that maintaining constant TAC on a decreasing stock abundance is sustainable and precautionary over the medium to long-term. In addition, a prolonged period in these situations would indicate that the basic assumptions of interlinkages between both areas with a dominance of the North Sea would be erroneous, and that the abundance and dynamics of the local populations would override those of the North Sea. Should this happen, there would be a need for a full revision of the design of the proposed management action.
- Suggested action is missing when either or biomass stock indices are neither increasing nor decreasing;
- The WK acknowledged that a pragmatic approach along similar lines might form the basis of an ***interim*** management plan, especially in the current period of high NS plaice abundance. However, the WK underlines strongly that more research is needed in the medium-term to updating the knowledge base behind the underlying assumptions and developing quantitative analysis of the amount of mixing between both components.
- Given the unavoidable inter-annual variability in indices due to both natural fluctuations and observation error, it is capital to define quantitative rules on how to measure rising or falling trends. As an example the WK referred to the EC rules suggested in the EC Policy Paper 2010 (COM(2010) 241) stating that an increase of the stock can be inferred If the average estimated abundance in the last two years exceeds the average estimated

abundance in the three preceding years by 20% or more (and similarly for a decrease).

- As noted also by the NSRAC, there are great concerns about the use of commercial LPUE as abundance indices, and survey-based alternatives should be preferred. The WK considered that the spatially-explicit abundance indices of adults aggregation during spawning developed by Cardinale *et al*. (2010) would be the best alternative to commercial LPUEs. There indices have a number of properties that make them well fitted for that purpose, including i) They are based on data from standard survey (currently IBTS) that is conducted every year, and are therefore easy to update on a routine basis, ii) they distinguish between the various local components in area IIIa, based on spawning behaviour, iv) they are fully standardized allowing direct quantitative comparison across areas and time periods, v) they extend over a long time and are therefore indicative of changes in productivity and vi) they are fully documented as peer-reviewed publication. A LTMP could therefore account explicitly for such ongoing monitoring of the productivity of the various components in area IIIa.
- The analyses from Cardinale *et al*. (2010), as well as the general knowledge about fisheries trends have shown that the most easterly component in the Skagerrak is likely very depleted and unproductive, while the increases in both commercial and surveys CPUE are mostly observed in the West of the Skagerrak. It would be therefore most sensible to make explicit provision to the protection of these Eastern components, through specific area-based management preventing the fishing pressure to increase.

18.16.4 Management strategies evaluation and quantitative risk assessment

The WKPESTO considered the possibilities for performing quantitative evaluations of the NSRAC HCR proposal (or any alternative HCR), following established Management Evaluation Strategies (MSE) standards (e.g. ICES WKOMSE 2009). A preliminary and simple 2-areas extension of a FLR MSE previously developed for the evaluation of management strategies for Western Baltic Herring (Ulrich *et al*., 2010) and North Sea whiting (STECF 2011, EWG 11-07) was presented, as a first attempt to model and quantify the likely impact of the NSRAC HCR, provided crude scenarios on the relative productivity of the stock within Skagerrak compared to the North Sea. Results were though considered far too preliminary to be included in the WKPESTO report.

The WKPESTO considers that due to human power limitations a further development of this simple and rough approach is the only option that could reasonably be envisaged if any quantitative evaluation was to be performed in 2012. In addition, given the general workload associated to the Spring season quality-checked results could be produced before the 30th June (it should be kept in mind that a previous attempt to develop advanced and realistic MSE models considering mixing stocks, as performed by ICES SGHERWAY for the herring stocks West of British Isles, extended over four years of work).

In addition, it must be kept in mind that even with more advanced model development, the basic quantitative model assumption regarding the relative productivity of the local vs. mixing components in the Skagerrak cannot be conditioned on any data at present; therefore, any simulation might only be able to compare risks associated with the different HCR under a range of theoretical situations, but it will not be possible to define which situations is most likely to reflect the current situations. If the simulations would conclude to clear-cut outcomes that one HCR is definitively better than another one under all possible situations, it might be possible to identify a robust management plans. If this would not be the case and if the relative risk associated with the various HCR would be situation-dependent, then it might not be possible to conclude on which HCR is most appropriate for the current real situation.

18.16.5 Application of NSRAC rule to propose a catch option for plaice in Skagerrak in 2013

The above conclusions from WKPESTO were reviewed during WGNSSK meeting in May 2012, and the conclusions were acknowledged. In addition, WGNSSK made a first attempt to implement the above NSRAC proposal in practice to derive catch advice for the Skagerrak in 2013.

18.16.5.1 Combined North Sea Skagerrak assessment

The combined North Sea – Skagerrak plaice assessment implemented by WKPESTO was updated with the latest data (Skagerrak discards not included). The increase of catch numbers lead to an increased perception of the stock biomass, but the trends are exactly similar (Figure 18.16.5.1.)

18.16.5.2 Indices of local abundance in area IIIa

Recent analyses (Cardinale *et al*. 2010) showed that at the beginning of the last century, areas of high concentration of adult plaice biomass were identified both in the West (Danish Skagerrak northern coast and south-western Kattegat) and in the East (south-eastern Kattegat and Swedish Skagerrak coast, Figure 18.16.5.2) part of the IIIa. These stock components showed a distinct temporal development during the century (Cardinale *et al*., 2010). The western components (i.e. DSNC and SWK in Figure 18.16.5.3) have largely increased in the last decade while the eastern components (SEK and SSC) remain at low level.

As noted above, ICES WKPESTO (2012) suggested using an updated version of Cardinale et al. (2010) indices as a proxy for the trend of the different subpopulations abundance in the Skagerrak and Kattegat. Therefore, new indices were made available to WGNSSK. These indices follows the same data processing and area definition as in Cardinale *et al*. (2010); however the time series starts in 1974 in order to make only use of IBTS data and not of previous Swedish survey, thus getting rid of potential issues of technical creep and intercalibration between surveys. Secondly, the indices have not been smoothed over years, and are therefore the raw annual IBTS estimate. These new indices are presented Figure 18.16.5.4.

18.16.5.3 Interpretation and application of the NSRAC rule

WGNSSK applied the NSRAC rule, but a number of interpretations had to be made:

- As there is no provision for what to do when the trends are stable, then WGNSSK interpreted NSRAC rule as “index falling or being stable”
- WGNSSK also used the Bloss (lowest observed value of the index for each sub-area in IIIa) as a trigger reference point, and suggested to replace “Increase” with “same” and “same” with “decrease” in last column of the rule

In addition, and as noted by WKPESTO, an issue remains how to define a trend in a time series when the interannual variability is noisy. As a preliminary trial, WGNSSK explored a number of possible options, and considered the trend to be increasing if for example:

- Index in 2011 is more than 20% higher than in 2010 (“vs previous year” option)
- Slope of the last three years (2009-2011) is larger than 0.2 (“3yr slope” option)
- 2011 value is 20% higher than the average of the three preceding years 2008-2010 (“last vs prev 3yr” option)
- 2010-2011 average is 20% higher than the average of the three preceding years 2007-2009 (“avg2 vs prev 3yr” option)
- Slope of the last 5 years (2007-2011) is larger than 0.2 (“5yr slope” option)
- 2011 value is 20% higher than the average of the five preceding years 2006-2010 (“last vs prev 5yr” option)
- Slope of the last 10 years (2002-2011) is larger than 0.2 (“10yr slope” option)
- 2011 value is more than 20% higher than the average over the whole time series (“vs long term mean” option).

These options were computed for the North Sea component (using the SSB from the latest (2012) assessment, for the index in the West of Skagerrak and for the index in the East of Skagerrak.

The results obtained were as follows (Table 1)

Table 1.

	NS SSB		WEST SKAGERRAK		EAST SKAGERRAK	
Basis	Value	Inc/Dec/Stable?	Value	Inc/Dec/Stable?	Value	Inc/Dec/Stable?
vs previous year	1.18	Stable	2.65	Inc.	0.87	Stable
3yr slope	0.25	Inc.	1.20	Inc.	-0.45	Dec.
last vs prev 3yr	1.34	Inc.	1.70	Inc.	0.28	Dec.
avg2 vs prev3	1.24	Inc.	1.17	Stable	0.30	Dec.
5yr slope	0.40	Inc.	-0.17	Stable	-0.28	Dec.
last vs prev 5yr	1.59	Inc.	1.98	Inc.	0.24	Dec.
10yr slope	0.35	Inc.	0.15	Stable	-0.04	Stable
vs long term mean	1.97	Inc.	2.34	Inc.	0.24	Dec.
Above Btrigger/Bloss?		Yes		Yes	0	No

On this basis, the trend in the North Sea stock is considered to be increasing in almost all options, except the first one since 2011 SSB is estimated around the same high level as in 2010. Similarly, the trend in the East of Skagerrak is considered decreasing in almost all options, and the 2011 value is the lowest observed. This indicates that, as noted by Cardinale *et al*. (2010) and ICES WKPESTO, the productivity and abundance along the Swedish Coast remains very poor.

The picture is less clear when dealing with the West of Skagerrak, where by far most of the fisheries occurs. The index is globally increasing but with great variability over time, and some computations would consider that the trends is increasing while some others consider it to be stable. However, the index is largely above the lowest observed.

On this basis, and applying the NSRAC rule as interpreted by WGNSSK, the advice for 2013 would imply that:

- North Sea SSB is rising and above Btrigger
- West of Skagerrak abundance index can be considered either as stable or rising, suggesting that TAC in the Skagerrak could either increases with same rate as North Sea TAC or be rolled-over from 2012 to 2013
- Productivity in the East of Skagerrak has decreased and is at its lowest level observed. In this area, which does likely not beneficiate from the increase of the North Sea stock, catches should decrease compared to previous year.

18.17 Conclusions

In conclusion, the approach developed by ICES WKPESTO and ICES WGNSSK, and largely based on inputs from and collaboration with the NSRAC, represents a pragmatic step specifically tailored to the particular issues of the Plaice IIIa assessment and management. It has been shown to be fairly operational and can be implemented with data readily available. While a number of refinements and additional evaluation could be brought forward, it represents nevertheless an interesting alternative and an improvement to the current situation. There aren't many other options that could be investigated within the time and resources available. WGNSSK and WKPESTO are of the opinion that this approach could be implemented during an interim period with periodic evaluation, while waiting for new tagging and genetic data to be collected and analysed.

Table 18.1 1. Plaice in SD 21-23. Official landings by sub-Division and country. 1970-2011.

	Denmark	Germany	Sweden	Denmark	Germany	Sweden	Sweden	Denmark
Year/SD	21	21	21	22	22	22	23	23
1970				3,757	202			
1971				3,435	160			
1972	15,504	77	348	2,726	154			
1973	10,021	48	231	2,399	165			
1974	11,401	52	255	3,440	202			
1975	10,158	39	296	2,814	313			
1976	9,487	32	177	3,328	313			
1977	11,611	32	300	3,452	353			
1978	12,685	100	312	3,848	379			
1979	9,721	38	333	3,554	205			
1980	5,582	40	313	2,216	89			
1981	3,803	42	256	1,193	80			
1982	2,717	19	238	716	45			
1983	3,280	36	334	901	42			
1984	3,252	31	388	803	30			
1985	2,979	4	403	648	94			
1986	2,470	2	202	570	59			
1987	2,846	3	307	414	18			
1988	1,820	0	210	234	10			
1989	1,609	0	135	167	7			
1990	1,830	2	202	236	9			
1991	1,737	19	265	328	15			
1992	2,068	101	208	316	11			
1993	1,294	0	175	171	16		2	
1994	1,547	0	227	355	1		6	
1995	1,254	0	133	601	75		12	64
1996	2,337	0	205	859	43	1	13	81
1997	2,198	25	255	902	51		13	
1998	1,786	10	185	642	213		13	
1999	1,510	20	161	1,456	244	1	13	
2000	1,644	10	184	1,932	140		26	
2001	2,069		260	1,627	58		39	
2002	1,806	26	198	1,759	46		42	
2003	2,037	6	253	1024	35	0	26	
2004	1,395	77	137	911	60		35	
2005	1,104	47	100	908	51		35	145
2006	1,355	20	175	600	46		39	166
2007	1,198	10	172	894	63		69	193
2008	866	6	136	750	92	0	45	116
2009	570	5	84	633	194	0	42	139
2010	428	3	66	748	221	0	17	57
2011[1]	328	0	40	851	310		11	46

Table 18.1.2a. Landings and discard by métiers in Subdivision 21 in 2011.

Metier	SD 21		
	Landings (kg)	Discard (kg)	Discard rate
OTB_MCD_90-119_0_0	224977	1212767	0.84
SDN_DEF_90-119_0_0	55770	19810	0.26
No_logbook6	35464		N/A
GTR_DEF_120-219_0_0	19832		N/A
GNS_DEF_120-219_0_0	7440		N/A
OTT_MCD_90-119_0_0	6121		N/A
GNS_DEF_100-119_0_0	5705	6778	0.54
OTB_CRU_70-89_2_35	3359	1877	0.36
No_Matrix6	3251		N/A
OTB_MCD_>=120_0_0	1568	1631	0.51
OTB_MCD_90-119_1_120	1015		N/A
OTT_MCD_90-119_1_120	920		N/A
OTM_SPF_16-31_0_0	564		N/A
OTT_CRU_90-119_1_300	405		N/A
GNS_DEF_50-70_0_0	394		N/A
OTB_SPF_16-31_0_0	268		N/A
GNS_DEF_90-99_0_0	193		N/A
PTB_SPF_16-31_0_0	191		N/A
GNS_CRU_>0_0_0	130		N/A
GNS_DEF_>=220_0_0	90		N/A
OTT_CRU_32-69_0_0	87		N/A
PTM_SPF_16-31_0_0	67		N/A
OTB_DEF_70-89_2_35	47	401	0.89
OTB_CRU_32-69_0_0	13		N/A

Table 18.1.2b. Landings and discard by métiers in Sub-Division 22 in 2011.

Metier	SD 22		
	Landings (kg)	Discard (kg)	Discard rate
OTB_DEF_>=105_1_120	591626	1105931	0.65
GNS_DEF_110-156_0_0	222823	17098	0.07
OTB_DEF_90-104_0_0	121436	17745	0.13
GNS_DEF_>=157_0_0	101051		N/A
No_logbook6	49852		N/A
GTR_DEF_110-156_0_0	32631	207	0.01
PTB_DEF_>=105_1_120	18450	17226	0.48
PTB_DEF_90-104_0_0	14612	10279	0.41
No_Matrix6	2826		N/A
SDN_DEF_>=105_1_120	1998		N/A
SSC_DEF_>=105_1_120	1197		N/A
OTB_CRU_>0_0_0	456		N/A
PTM_DEF_16-31_0_0	413		N/A
GNS_CAT_>0_0_0	305		N/A
GNS_SPF_110-156_0_0	205		N/A
PTB_SPF_16-31_0_0	175		N/A
GNS_DEF_90-109_0_0	164		N/A
FPN_DEF_>0_0_0	157		N/A
GNS_FWS_>0_0_0	101		N/A
FPN_SPF_>0_0_0	100		N/A
PTB_SPF_32-89_0_0	99	1	0.01
OTM_DEF_90-104_0_0	40	270	0.87
GNS_SPF_32-109_0_0	30		N/A
GNS_CRU_>0_0_0	18		N/A
LLS_DEF_0_0_0	6	17	0.74
FPN_CAT_>0_0_0	3		N/A
PTM_SPF_16-31_0_0	2		N/A
FPO_DEF_>0_0_0	1	19	0.95

Table 18.1.2c. Landings and discard by métiers in Sub-Division 23 in 2011.

Metier	SD 23		
	Landings (kg)	Discard (kg)	Discard rate
GNS_DEF_110-156_0_0	31855	447	0.01
No_logbook6	14014		N/A
GTR_DEF_110-156_0_0	6011	327	0.05
GTR_DEF_>=157_0_0	2212	47	0.02
GNS_DEF_>=157_0_0	1181	440	0.27
OTB_DEF_>=105_1_120	548	5259	0.91
No_Matrix6	253		N/A
OTB_DEF_90-104_0_0	148		N/A
OTB_CRU_>0_0_0	126		N/A
FPN_CAT_>0_0_0	106		N/A
PTB_DEF_>=105_1_120	73	435	0.86
GNS_DEF_90-109_0_0	71	3	0.04
GNS_CAT_>0_0_0	69		N/A
FPN_DEF_>0_0_0	54		N/A
FYK_CAT_>0_0_0	21		N/A
GNS_SPF_110-156_0_0	16		N/A
FPN_SPF_>0_0_0	5		N/A

Table 18.1.3. Discard (kg) by Sub-Division, country and métier (lvl. 6) in 2011.

Metiers	SD 22		SD 23		SD 21
	DEU	DNK	DNK	SWE	DNK
	Weight(kg)	Weight(kg)	Weight(kg)	Weight(kg)	Weight(kg)
FPO_DEF_>0_0_0	19				
GNS_DEF_>=157_0_0				440	
GNS_DEF_100-119_0_0					6778
GNS_DEF_110-156_0_0	8506			447	
GNS_DEF_90-109_0_0				3	
GTR_ANA_>=157_0_0	3				
GTR_DEF_>=157_0_0				47	
GTR_DEF_110-156_0_0	207			327	
LLS_DEF_0_0_0	17				
No_Matrix6		3270			
OTB_CRU_70-89_2_35					1877
OTB_DEF_>=105_1_120	55397	583768	5216	43	
OTB_DEF_>=120_0_0				214	
OTB_DEF_70-89_2_35					401
OTB_DEF_90-104_0_0	15233				
OTB_MCD_>=120_0_0					1631
OTB_MCD_90-119_0_0					1212767
OTM_DEF_90-104_0_0	270				
PTB_DEF_>=105_1_120	16860	366	435		
PTB_DEF_90-104_0_0	10279				
PTB_SPF_32-89_0_0	1				
PTM_DEF_>=105_1_120	50				
PTM_SPF_32-89_0_0	0				
SDN_DEF_90-119_0_0					19810

Table 18.2.1 Mean weight in catch (landing) (kg) by year (1999-2011).

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10
1999	0.220	0.283	0.291	0.329	0.374	0.371	0.412	0.862	0.569	1.274
2000	0.220	0.276	0.289	0.309	0.334	0.447	0.569	0.648	1.016	1.221
2001	0.227	0.264	0.271	0.304	0.323	0.397	0.457	0.596	0.851	1.190
2002	0.235	0.266	0.295	0.289	0.287	0.259	0.391	0.484	0.696	1.221
2003	0.273	0.277	0.278	0.299	0.292	0.352	0.413	0.538	0.532	0.855
2004	0.257	0.240	0.269	0.303	0.318	0.370	0.550	0.819	0.649	0.495
2005	0.201	0.260	0.273	0.309	0.329	0.329	0.349	0.460	0.820	1.580
2006	0.238	0.244	0.296	0.319	0.331	0.320	0.358	0.462	0.596	0.953
2007	0.238	0.240	0.275	0.308	0.436	0.486	0.596	0.689	0.507	0.856
2008	0.239	0.246	0.257	0.302	0.362	0.464	0.536	0.592	0.538	0.585
2009	0.216	0.245	0.290	0.327	0.428	0.549	0.687	0.889	0.860	1.180
2010	0.227	0.273	0.264	0.272	0.276	0.299	0.765	0.319	0.332	0.365
2011	0.277	0.307	0.328	0.347	0.361	0.546	0.545	0.486	0.502	0.449

Table 18.4.1. Estimated recruitment, total stock biomass (TBS), spawning stock biomass (SSB), and average fishing mortality for ages 3 to 5 (F35).

Year	Recruits	Low	High	TSB	Low	High	SSB	Low	High	F35	Low	High
1999	26903	17917	40396	2990	2199	4065	2063	1487	2862	0.774	0.515	1.165
2000	22516	15312	33110	3899	2914	5219	2593	1949	3448	0.744	0.536	1.033
2001	11986	7983	17997	6272	4595	8562	4468	3271	6102	0.761	0.559	1.035
2002	15670	10624	23113	5334	3968	7170	4088	3025	5523	0.734	0.547	0.984
2003	12328	8319	18268	5696	4304	7538	4378	3295	5818	0.644	0.469	0.884
2004	15183	10093	22838	5326	4046	7010	4238	3207	5599	0.562	0.388	0.814
2005	12944	8619	19439	5681	4245	7602	4446	3313	5966	0.723	0.507	1.033
2006	10515	7175	15410	5293	3987	7026	4185	3151	5559	0.683	0.486	0.96
2007	8505	5836	12395	4732	3479	6437	3809	2785	5211	0.91	0.665	1.247
2008	7672	5081	11584	3595	2718	4757	2911	2188	3873	0.853	0.611	1.19
2009	8101	5021	13070	2994	2295	3905	2402	1835	3144	0.475	0.307	0.736
2010	11126	6144	20145	3551	2655	4750	2824	2112	3776	0.334	0.202	0.553
2011	11830	5537	25278	4288	3042	6044	3423	2435	4811	0.275	0.148	0.509
2012	10762	4188	27659	5276	3450	8068	4277	2817	6493	0.268	0.113	0.639

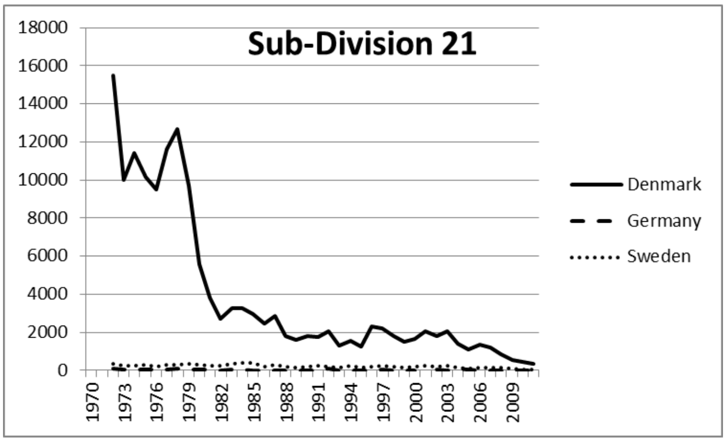


Figure 18.1.1a. Landings by country.

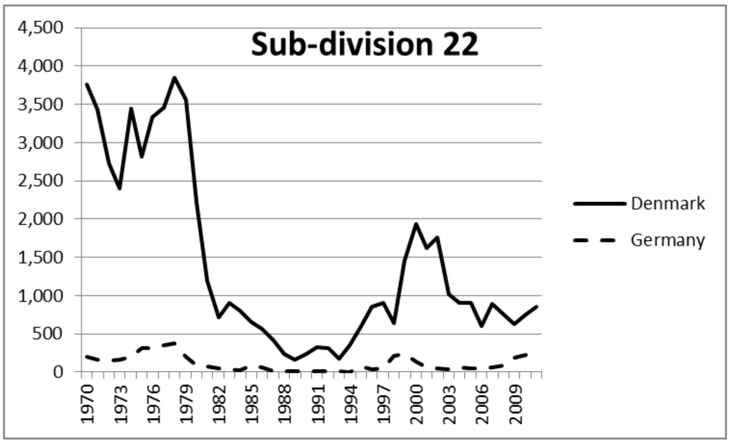


Figure 18.1.1b. Landings by country.

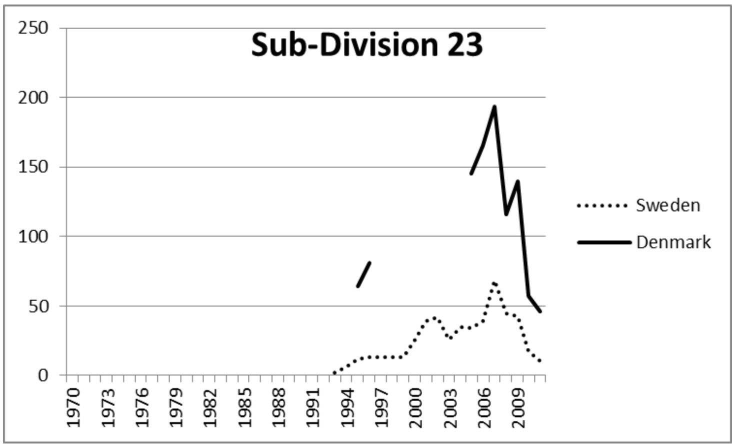


Figure 18.1.1c. Landings by country.

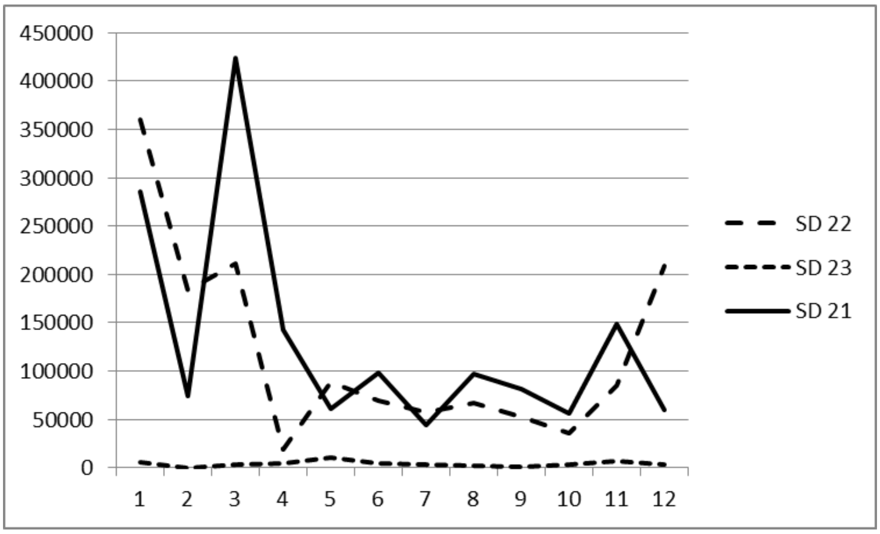


Figure 18.1.2. Landings in 2011 by sub-Division and month.

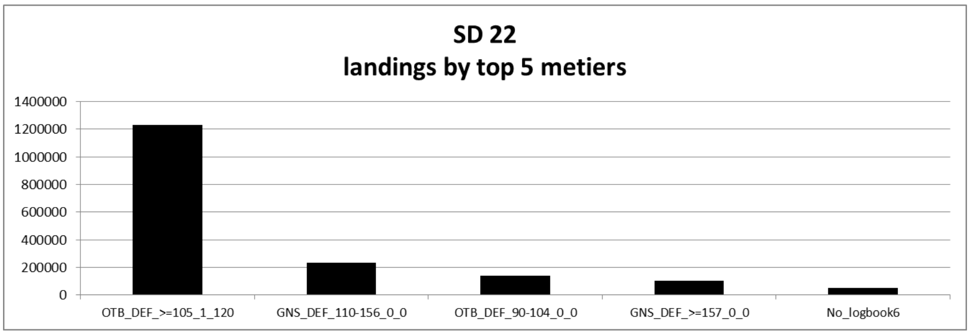


Figure 18.1.3a. Landing in top 5 métiers in Sub-Division 22 in 2011.

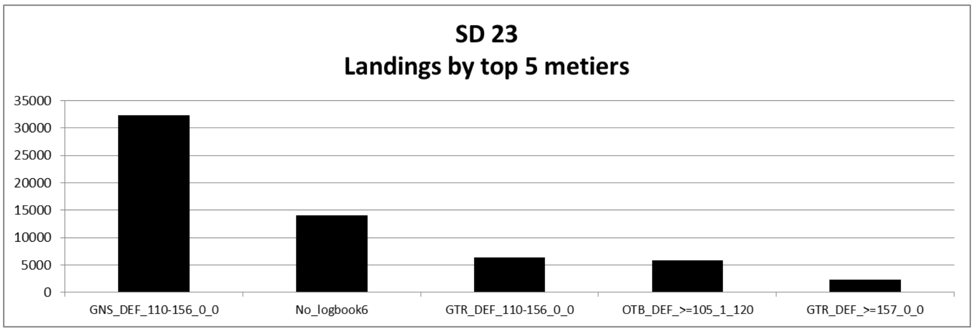


Figure 18.1.3b. Landing in top 5 métiers in Sub-Division 22 in 2011.

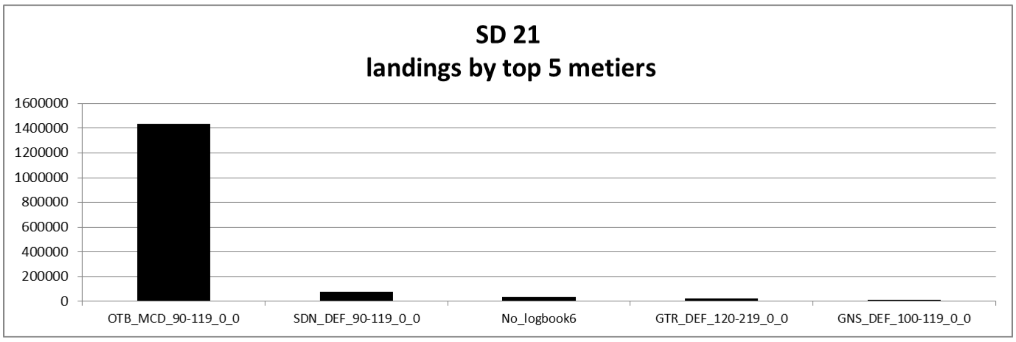


Figure 18.1.3c. Landing in top 5 métiers in Sub-Division 22 in 2011.

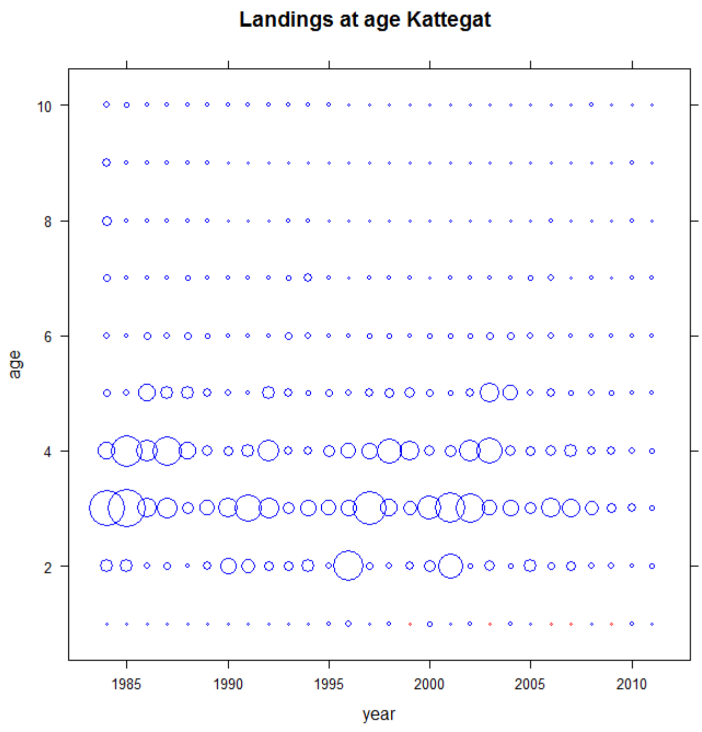


Figure 18.2.1a. Catch (Landing) at age (1984-2011) for Kattegat.

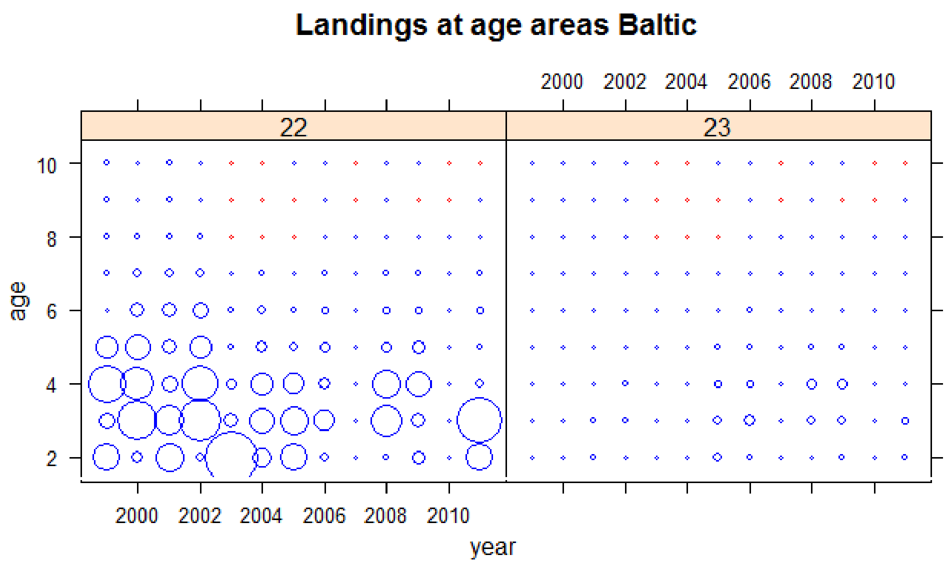


Figure 18.2.1b. Catch (Landing) at age (1999-2011) by Sub-Division.

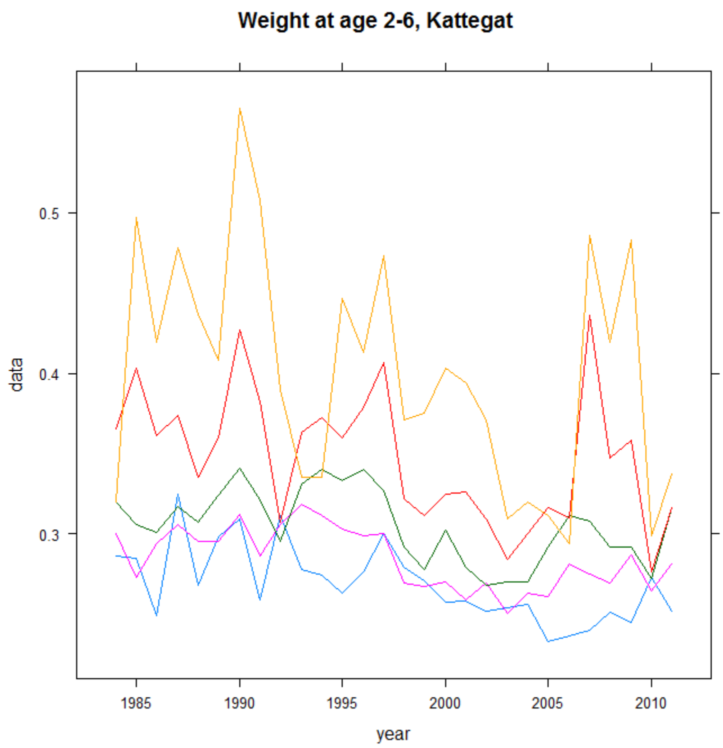


Figure 18.2.2a. Mean weight at age (age 2-6) in landings in Kattegat.

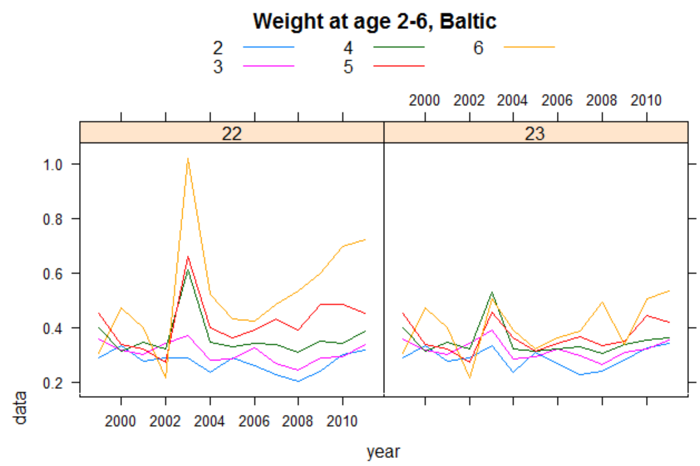


Figure 18.2.2b. Mean weight at age (age 2-6) in landings in the Baltic.

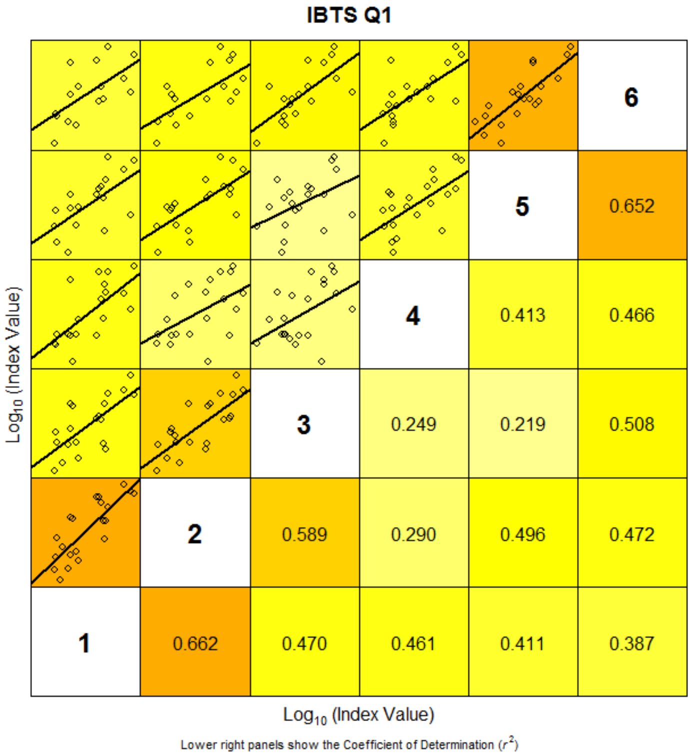


Figure 18.3.1a Internal consistency for IBTS I.

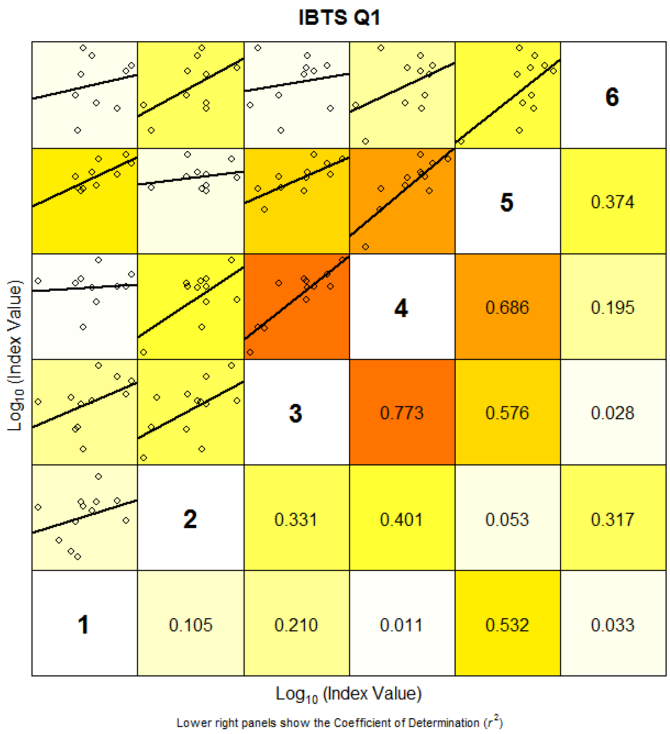


Figure 18.3.1b. Internal consistency for IBTS III. **Figure title is wrongly labeled with "IBTS Q1".**

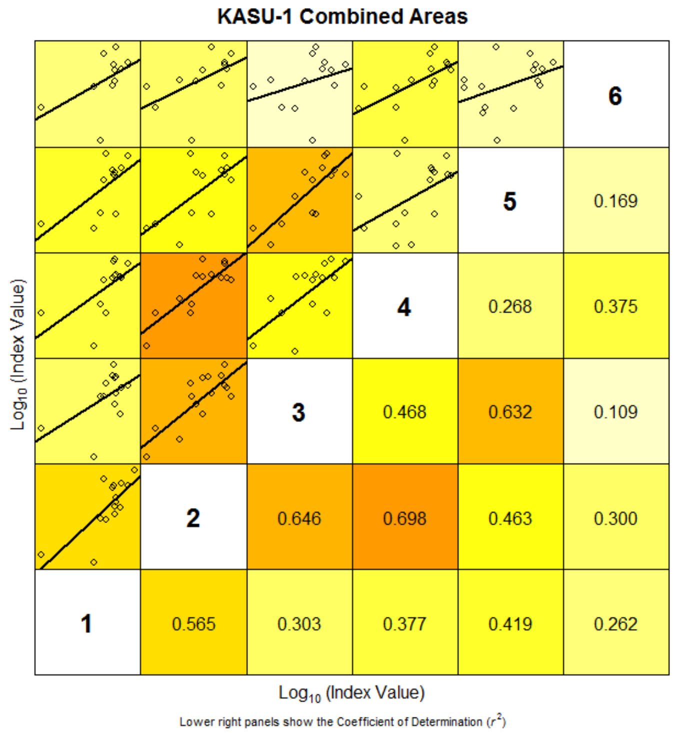


Figure 18.3.1c. Internal consistency for KASU I.

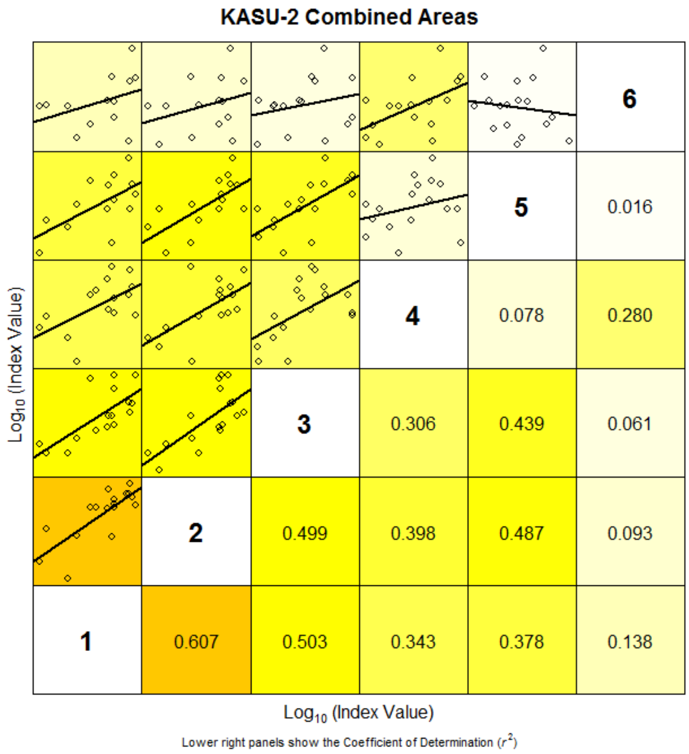


Figure 18.3.1d. Internal consistency for KASU IV.

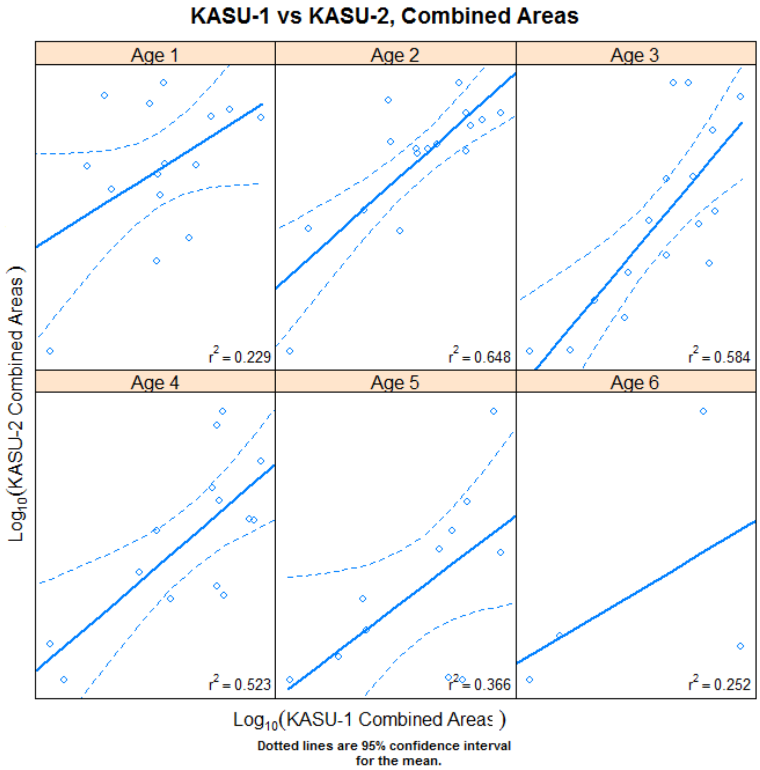


Figure 18.3.2. Consistency between KASU I and IV.

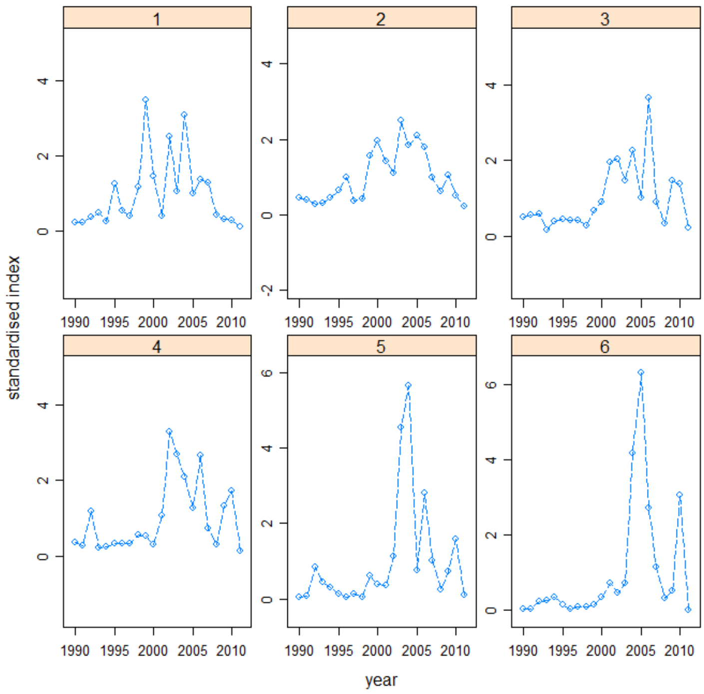


Figure 18.4.2a. Index time series by age class for IBTS I.

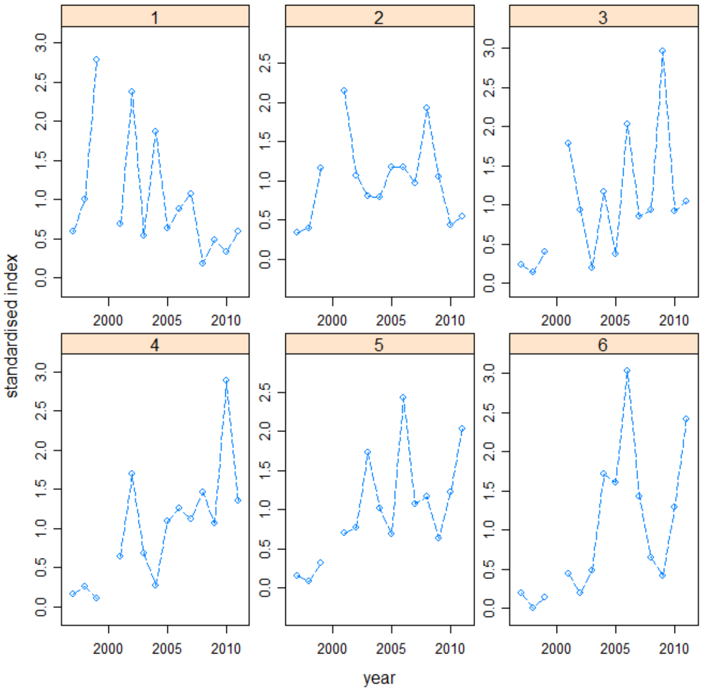


Figure 18.4.2b. Index time series by age class for IBTS III.

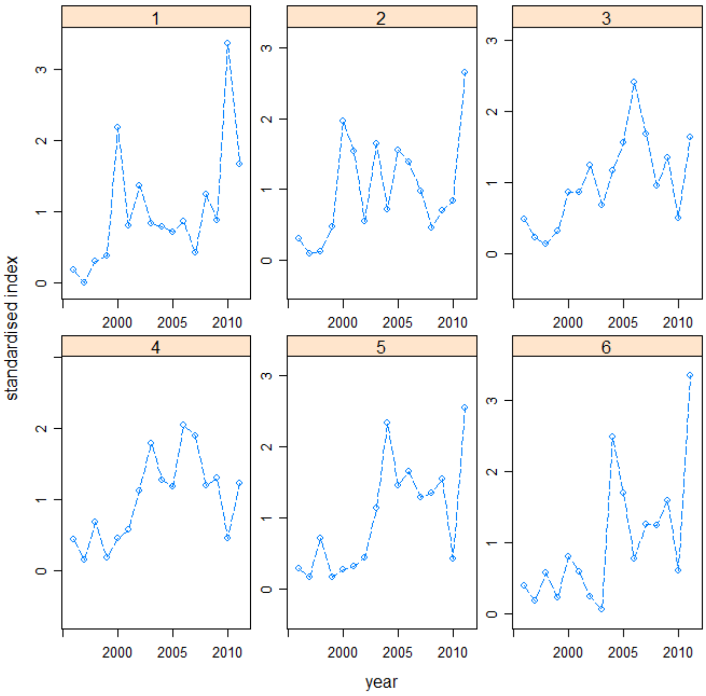


Figure 18.4.2c. Index time series by age class for KASU I.

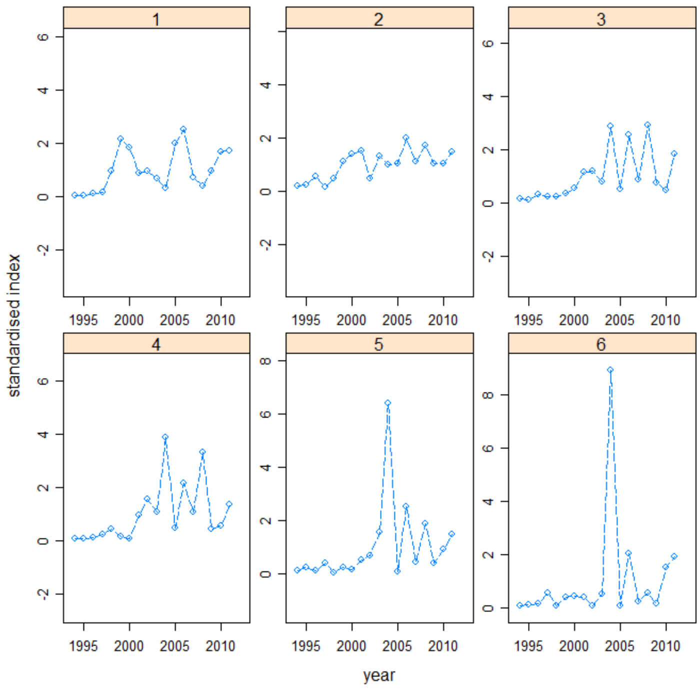


Figure 18.4.2d. Index time series by age class for KASU IV.

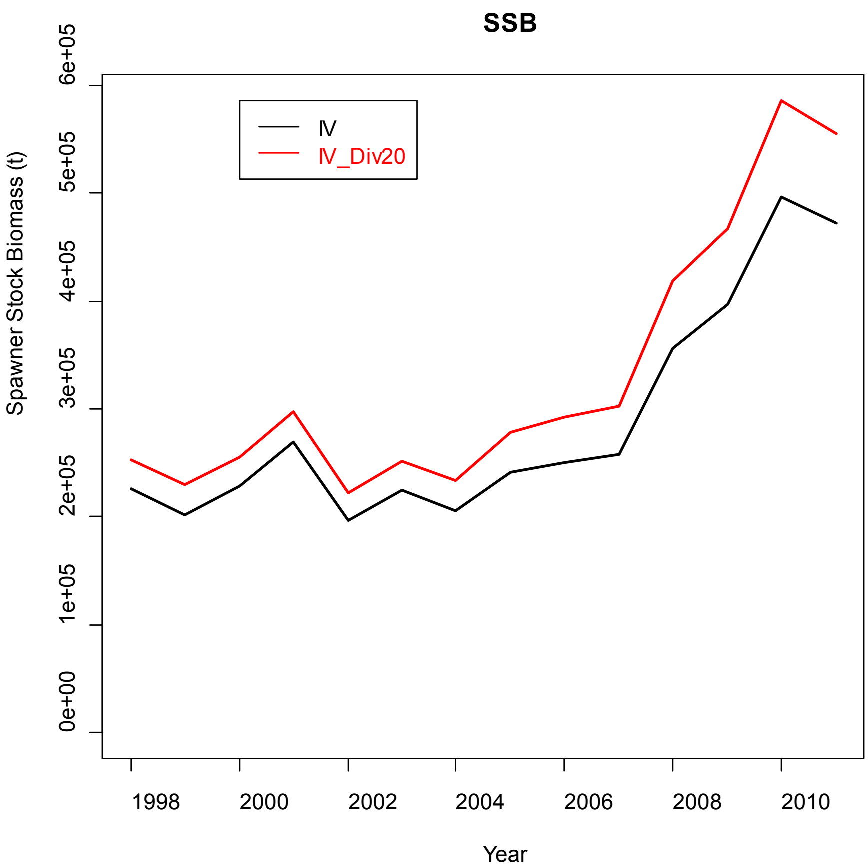


Figure 18.16.5.1. Plaice SSB for the North Sea assessment alone (black) and the combined North Sea – Skagerrak assessment (red).

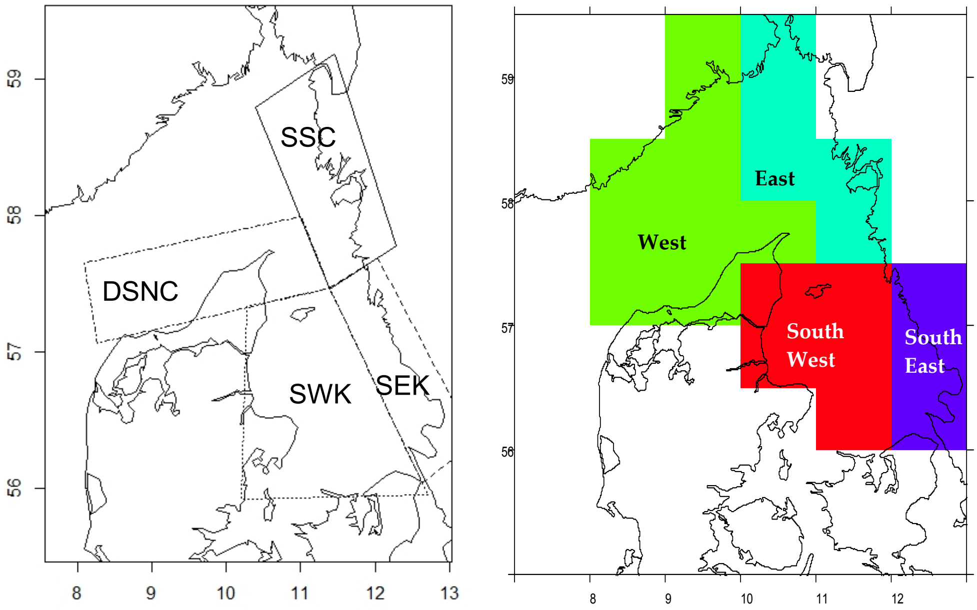


Figure 18.16.5.2. Left panel: the coordinates of the polygons (i.e. putative spawning sub-areas) in which the different components were estimated (From Cardinale et al. (2010). Right panel: corresponding areas in terms of ICES statistical rectangles as used by WGNSSK and WKPESTO

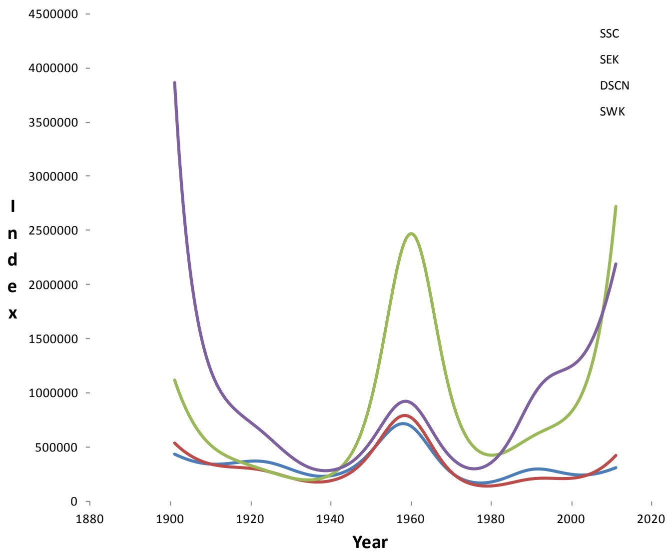


Figure 18.16.5.3. Trend (on a relative scale) of the different subcomponents as estimated by Cardinale *et al.*, 2010 and updated to 2011 by WKPESTO. The different subcomponents are estimated as the sum of fish larger than 25 cm in the different sub-areas (see figure below) during spawning time (January to March). See Cardinale *et al.*, 2010 for details.

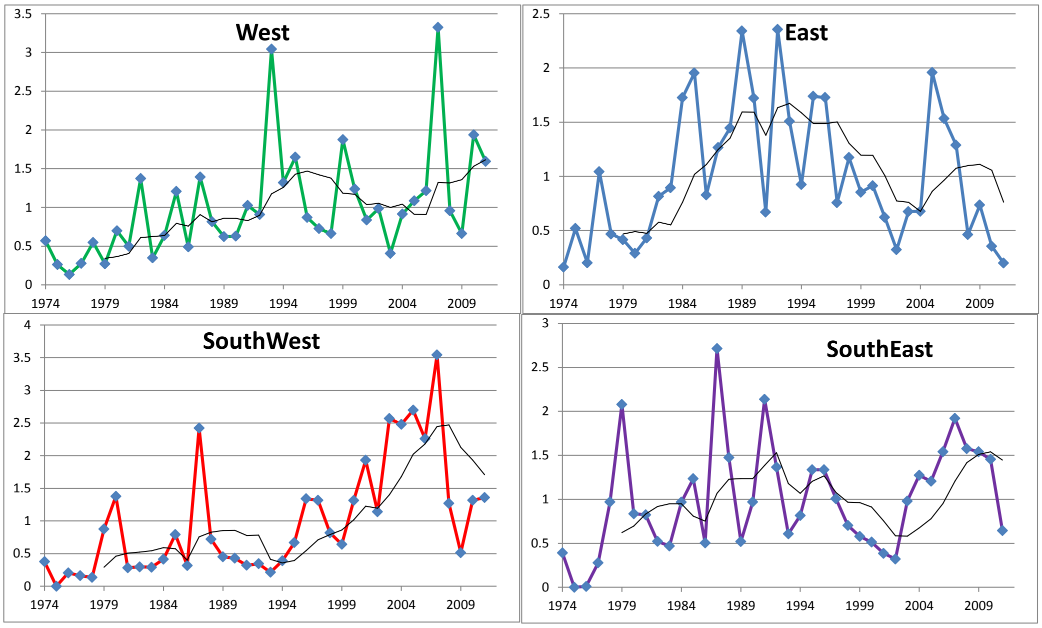


Figure 18.16.5.4. Relative index of local adult aggregation during spawning in the Skagerrak and Kattegat (adapted from Cardinale et al., 2010). Thin black line is a 6-years moving average.

19 Multiannual Management plan for North Sea plaice and sole

The results of WGNSSK 2012 assessment and forecast for North Sea plaice and sole are described in sections 8 and 10 respectively.

19.1 The multiannual plan

19.1.1 Objectives of the 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). See Section 19 (Management Plan Evaluations) of this report for further details. Objectives are defined for the two stages: to rebuild the stocks to within safe biological limits and to exploit the stocks at MSY respectively. Stage 1 is deemed to be completed when both stocks have been within safe biological limits for two consecutive years.

Safe biological limits are defined as follows (based on the precautionary reference points): the spawning biomass of the stock of plaice exceeds 230 000 tonnes; the average fishing mortality rate on ages two to six years experienced by the stock of plaice is less than 0,6 per year; the spawning biomass of the stock of sole exceeds 35 000 tonnes; the average fishing mortality rate on ages two to six years experienced by the stock of sole is less than 0,4 per year.

19.1.2 TAC setting procedure

TAC setting procedures are provided independent of the applicable stage of the plan (article 7) through a HCR which describes both a recovery process (reductions of F by 10% annually) and a stable plateau stage (continuous application of an F of 0.3 when this level is reached (which at the time of developing the plan was the suggested value by ICES to approximate F_{msy}). This TAC setting procedure is also applicable in the 'transitional' period once the objectives of stage one have been met but before both stocks are being exploited at the target F levels and until an Impact Assessment and evaluation have taken place to reconsider long term objectives for stage two (in accordance with article 5 of the EC regulation).

19.1.3 Transitional measures

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 (B_{pa}=35 000 tonnes) since 2008. WGNSSK concluded in 2011 that the objectives of stage one were met since the SSB of sole had been above B_{pa} for two successive years (i.e. in 2010 and 2011). Consequently, ICES advised managers to commence the evaluation process as stipulated in the plan. Similarly, this year's assessments of the two stocks confirms that the objectives of stage one are still met, despite the fact that the SSB of sole in 2010 was perceived as slightly lower, bringing it just under B_{pa} (SSB in 2011 and 2012 are perceived at and above 35 kt respectively). At the time of WGNSSK 2012, ICES had not been informed whether or not an Impact Assessment had taken place (or indeed started) and although a special request to evaluate specified changes to the plan was received by ICES from the Netherlands, the evaluation of the proposed amendments to the plan could not be conducted by the WGNSSK due to time constraints. See section 1.7.5 of this report for further details on the special request received by the Dutch ministry.

Based on agreement between ICES secretariat and the European Commission the WGNSSK interpreted that the stipulated TAC setting procedure in the current plan was to 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. Since ICES has established a generic approach to evaluate whether new survey information that becomes available in September should initiate an update of the advice, the results of this evaluation could be taken into account when the assessments of North Sea sole and plaice are revisited at that time in November 2012.

19.1.4 Special request by the Netherlands

A special request was received by ICES from the Netherlands for amendments to the management plan in terms of its objectives and TAC setting procedure shortly before the meeting. Ideally, this request should be responded to by November, when the stock advice would be revisited.

Proposal for phase 2 of the flatfish management plan by the Netherlands (23rd of April 2012):

Introduction

ICES concluded in June 2011 that both North Sea plaice and sole stocks were within safe biological limits, for two consecutive years, and that the first phase of the plan was achieved. WGNSSK 2012 may come back on that conclusion, in light of the reassessment of the 2010 sole stock, but at least the objective is met for 2011 and 2012.

Following article 5 of the multi annual plan on the management of North Sea plaice and sole (EC 676 / 2007), the Commission should propose amendments to article 4(2) and 4(3) on the target fishing mortality for plaice and sole, article 7 and 8 for setting the TACs for plaice and sole and article 9 on fishing effort limitation, with a view to permit the exploitation at MSY.

ICES has already stated that in the absence of a proposal for review, their advice on North Sea plaice and sole, which is due for June 2012 will not be based on the plan. It is put in their so-called “table 3: Management plans that ICES does not consider appropriate as a basis for advice”

The Netherlands consider this situation as highly unfortunate. We propose amendments to the named articles (below) and invite ICES to review and assess whether they are in accordance with the precautionary principle and MSY approach. If positive, we invite ACOM to include this proposal in its 2012 advice.

Proposed amendments:

Article 4: Objectives of the multiannual plan in the second stage

2) No amendments

3) The objective specified in paragraph 1 shall be attained by maintaining the fishing mortality on sole at a rate equal to or no lower than 0.25 on ages two to six years.

Clarification to the proposed amendments in article 4.

Ad 2. Little is known on the stock recruitment relationships of both stocks. Taking into account a number of stock–recruitment relationships for plaice, ACOM of ICES generated a range of values between 0.2 and 0.3 for plaice (ICES, June 2011). This is in line with the evaluation of the plan done by STECF (November 2010). F targets examined over the range from 0.2 to 0.3 all lead to similar long term TAC values (because these values lie on the flat top of the Fmsy distribution), yet F targets above 0.3 were not found to be precautionary over any time period. The risk of stocks falling below B_{lim} or B_{pa} with targets lower than 0.3 are considered very small (see table below, taken from the STECF 10-06b Vigo meeting report, 2010). This coincides with the evaluation of the plan done by ICES in November 2010 (special request). It should be noted that these levels are lower than the possible range (see figure C5 below, taken from STECF 2010), but this is due to the fact that STECF has also taken into account the mixed nature of the fisheries, the effects on sole catches and discards.

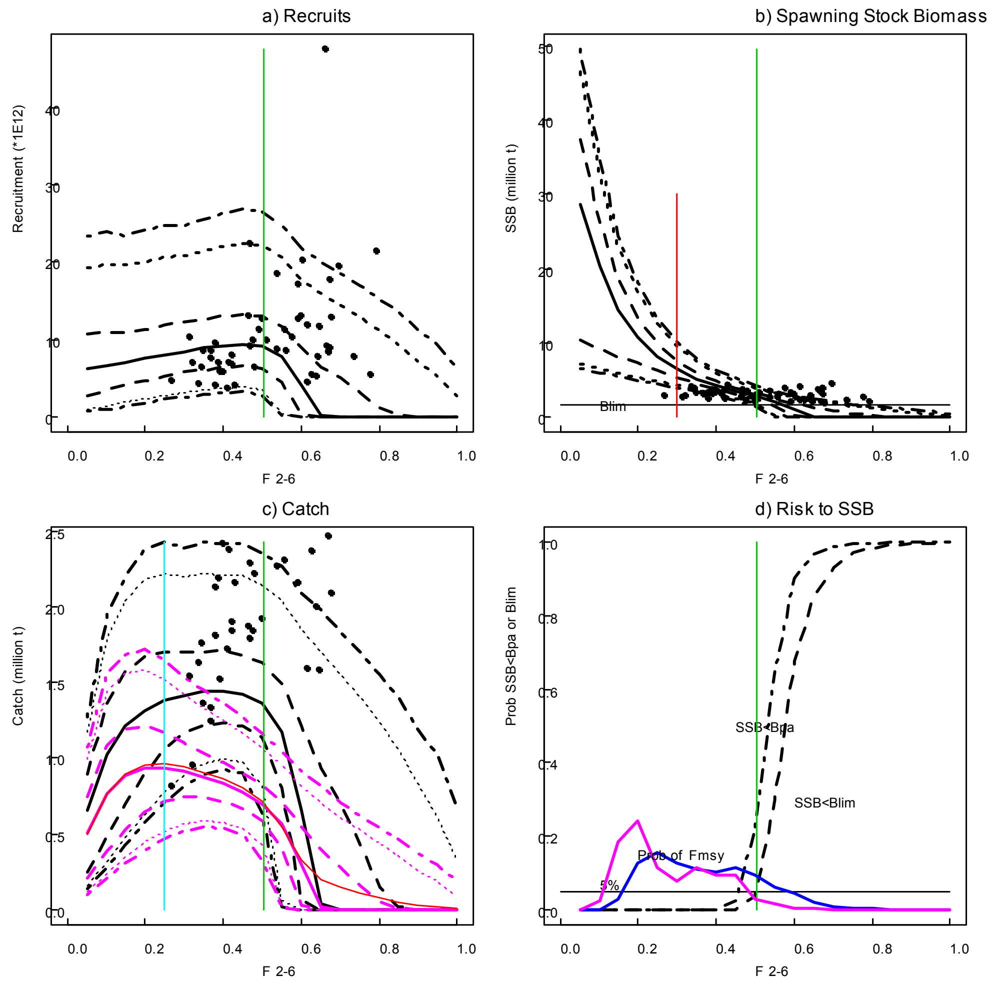


Figure C5 Equilibrium exploitation of NS plaice against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch (axes values incorrect – should be divided by 10): black lines and Landings pink lines. Historic Recruits, SSB and Catch: black dots. c) mean landings: red line. d) probability of SSB below Blim and Bpa: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch, blue line, and maximum landings, pink line. F for maximum Landings: cyan line, based on 50% point on the distribution of F panel (d) and maximum mean Landings panel (c). The red line in panel b shows the current management plan target F.MSE analyses (first few columns) and equilibrium analyses from the 'combined' SR results (above):

Table 8.3. Plaice yields and likelihoods of meeting WKOMSE precautionary criteria (risk to stock) under different targets Fs in the multi-annual plan and from the equilibrium analysis (Annex c). (For scenarios that were run with less than 100 iterations, it is not possible to adequately estimate the risk to the stock, so NA values are given.)

	Yield		Risk			Bayesian equilibrium values		
F	ST (2011-2015)	MT (2016-2025)	ST (2011-2020)	MT (2016-2025)	LT (2021-2030)	Yield	Risk <Blim	Risk <Bpa
0.15§	**69357**	**97825**	**NA**	**NA**	**NA**	80345	0.00	0.00
0.2§	**73307**	**112434**	**NA**	**NA**	**NA**	85997	0.00	0.00
0.22	*	*	*	*	*	86691	0.00	0.00
0.23	79190	124038	0	0	0	87038	0.00	0.00
0.25	82168	124938	0	0	0	87732	0.00	0.00
0.3	93044	130710	0	0	0	86734	0.00	0.00
0.35	*	*	*	*	*	83743	0.00	0.00

§ based on only 21 replicates (too few to estimate risk) * Not run for this stock.

Ad 3. Similarly, targets for F_{MSY} for sole within a range a range of 0.2-0.25 are considered by ICES to produce high yields while maintaining a low risk to the stock and therefore sustainable. However, for F values above 0.25 there was an increasing risk of driving the stock out of safe biological limits and exploitation levels greater than this were not considered to be precautionary. These values lie well within the range given by STECF in their evaluation of the plan in November 2010 (see figure C4 below, taken from STECF). The risk of the stock falling below B_{pa} with a Fmsy of 0.25 is still very low (see table below).

In addition is should be noted that the ratio of the proposed Fmsy for plaice (0.3) and sole (0.25) are consistent with the average long term ratio of 1.18 (Fmsy plaice/ Fmsy sole), see figure 11.1 from evaluation STECF (November 2010)

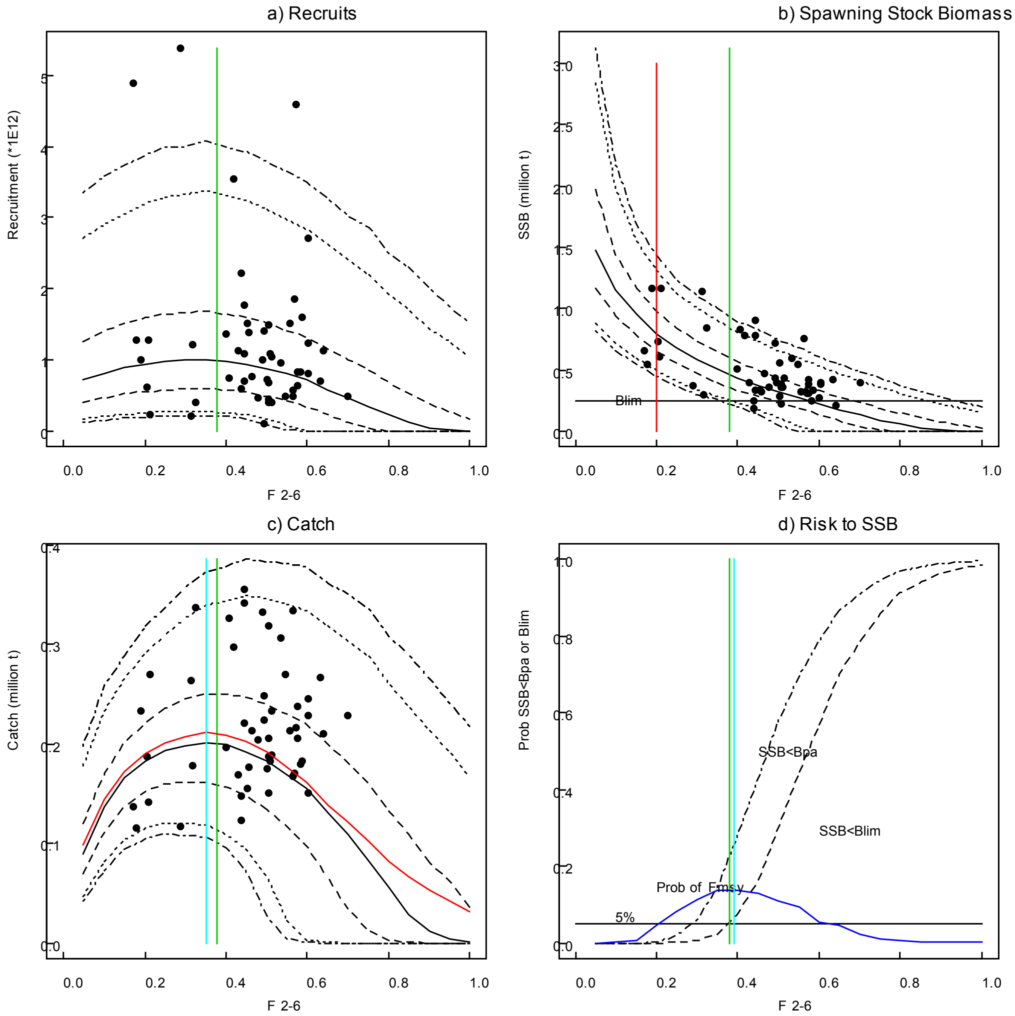


Figure C4 Equilibrium exploitation of NS sole against target F from F=0.05 to 1.0.

Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch/Landings (axes values incorrect – should be divided by 10): black lines. Historic Recruits, SSB and Catch/Landings black dots. c) mean catch/landings: red line. d) probability of SSB below B_{lim} and B_{pa}: black lines and 5% probability of SSB below Blim green line in all panels. d) distribution of F for maximum catch/landings blue line. F for maximum catch/landings: cyan line, based on 50% point on distribution of F panel (d) and maximum mean catch/landings panel (c) The red line in panel b shows the current management plan target F.

MSE analyses (first few columns) and equilibrium analyses from the 'combined' SR results:

Table 8.4. Sole yields and likelihoods of meeting WKOMSE precautionary criteria (risk to stock) under different targets Fs in the multi-annual plan(Annex B and from the equilibrium analysis (Annex c). (For scenarios that were run with less than 100 iterations, it is not possible to adequately estimate the risk to the stock, so NA values are given.)

	Yield		Risk			Bayesian equilibrium values		
F	ST (2011-2015)	MT (2016-2025)	ST (2011-2020)	MT (2016-2025)	LT (2021-2030)	Yield	Risk <Blim	Risk <Bpa
$0.15^{\S}$	**14365**	**15904**	**NA**	**NA**	**NA**	16644	0.00	0.00
0.2	14512	17687	0.1	0.05	0.02	18202	0.00	0.00
0.22	14531	18215	0.1	0.05	0.02	18595	0.00	0.01
0.23	*	*	*	*	*	18792	0.00	0.01
0.25	14615	19151	0.1	0.06	0.06	19185	0.00	0.02
0.3	14645	20236	0.14	0.14	0.19	19694	0.01	0.08
$0.35^{\S}$	**15886**	**20568**	**NA**	**NA**	**NA**	19608	0.04	0.19

Based on only 21 replicates (too few to estimate risk) * Not run for this stock.

Article 7: Procedure for setting the TAC for plaice

No amendments

Article 8: Procedure for setting the TAC for sole

No amendments

CHAPTER III

FISHING EFFORT LIMITATION

Article 9: Fishing effort limitation

1. When a stock is outside biological limits, the TACs referred to in Chapter II shall be complemented by a system of fishing effort limitation established in Community legislation,

6. Notwithstanding paragraph 4, fishing effort shall not increase above the level allocated in 2006 and not be lower than the level allocated in 2011.

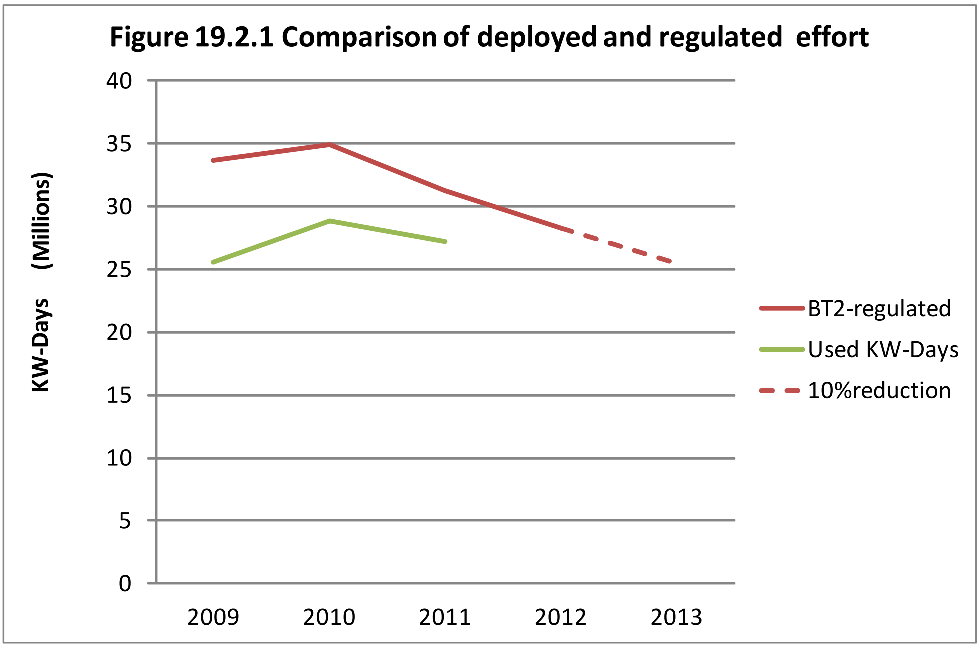
Clarification on the proposed amendments:

The current management plan provides little guidance on how STECF should provide advice on the appropriate effort level. As a consequence both TAC and effort restrictions are used equally to reduce the fishing mortality of the smallest denominator (in this case sole). Since the entry of enforcement of the plaice and sole management plan, the number of days at sea (or kWdays) have been reduced with some 10% every year. Effort restriction has helped as a supplementary measure to restore both stocks to safe biological levels. We are now in a situation where not only both stocks are within safe biological limits, but where the fishing mortality for plaice and sole stocks should go in opposite directions to reach the objectives. The Netherlands therefore consider the effort cap as a backup to TAC management failure. Also for socio-economic reasons this would be acceptable by allowing stability in employment. We propose to apply an effort reduction only when one or two of the stocks are outside biological limits.

19.2 Effort restrictions

The multiannual plan furthermore prescribes effort limitations (kW-days per metier) to be adjusted in line with changes in fishing mortality. The current advice implies a reduction of 10% in effort in 2013 (following a 10% reduction in F to 0.27 for sole). Figure 19.1.1 shows the development of deployed effort as well as the regulated effort restrictions from 2009 onwards for the Dutch beam trawl fleet with a mesh size of between 80 and 120 mm (BT2). It is clear that in these recent years, catching capacity has not been restricted by effort limitations but likely by the TAC or other (per year differing) factors. It also suggests that effort limitations may become restrictive to the fleet's fishing capacity in 2013 however. This is likely one of the motivations for the Netherlands to amend the plan as proposed and described above.

[Figure 19.2.1]



Annex 1 – List of Participants

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

27 April - 3 May 2012

Name	Address	Phone/Fax	Email
Clara Ulrich (Chair)	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 2920 Charlottenlund Denmark	Phone +45 21157486 Fax +45 3588 3333	clu@aqua.dtu.dk
Bo Solgaard Andersen	DTU Aqua - National Institute of Aquatic Resources The North Sea Science Park Section for Management Systems P.O. Box 101 9850 Hirtshals Denmark	Phone +45 35883251 Fax +45	bsa@aqua.dtu.dk
Henrik Svedang	Swedish University of Agricultural Sciences, Lysekil P.O. Box 4 SE-453 21 Lysekil Sweden	Phone +46 523 18722 Fax + 46 523 13977	Henrik.svedang @slu.se
Ewen Bell	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1 502 524 238 Fax +44	ewen.bell@cefas.co.uk
Aukje Coers	Pelagic RAC Secretariat PO Box 72 2280 AB Rijswijk Netherlands	Phone +31 70 336 9624 Fax +31 70 399 3004	a.coers@pelagic-rac.org
Gjert Endre Dingsør	Institute of Marine Research P.O. Box 1870 Nordnes 5817 Bergen Norway	Phone +47 Fax +47	Gjert.endre.dingsoer@imr.no
Nick Bailey	Marine Scotland – Science Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen Torry United Kingdom	Phone +44 1224 295411 Fax +44 1224 295511	n.bailey@marlab.ac.uk
Tessa van der Hammen	Wageningen IMARES P.O. Box 68 1970 AB IJmuiden Netherlandsl	Phone +31 Fax +31	tessa.vanderhammen@wur.nl
Irene Huse	Institute of Marine Research P.O. Box 1870 N-5817 Bergen Norway	Phone +47 55 23 68 22 Fax +47 55 23 53 93	irene.huse@imr.no
Alexander Kempf	Johann Heinrich von Thunen Institute Institute for Sea Fisheries, Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 194	alexander.kempf@vti.bund.de

Name	Address	Phone/Fax	Email
Elisa Barreto	Marine Scotland – Science Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen Torry United Kingdom	Phone +44 1224 295363 Fax +44 1224 295511	e.barreto@marlab.ac.uk
David Miller	Wageningen IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 3174 85369 Fax +31 3174 87326	david.miller@wur.nl
Savas Kilic	Ministry of Food Agriculture and Livestock Konyaaltı District Directorate Öğretmenevleri Mah. 18. Cad. No:19/2, 07000 Konyaaltı- Antalya TURKEY	Phone +90 242 2299470 Fax +90 2422299471	savasyay@gmail.com savas.kilic@vti.bund.de
Coby Needle	Marine Scotland Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen Torry United Kingdom	Phone +44 1224 295456 Fax +44 1224 295511	c.needle@marlab.ac.uk coby.needle@scotland.gsi.gov.uk
Rasmus Nielsen	DTU Aqua - National Institute of Aquatic Resources Section for Management Systems Jægersborg Allé 1 2920 Charlottenlund Denmark	Phone +45 33 963381 Fax +45 33 96 3333	rn@aqua.dtu.dk
Anders Nielsen	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 2920 Charlottenlund Denmark	Phone +45 Fax +45	an@aqua.dtu.dk
José De Oliveira	Centre for Environment, Fisheries and Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1502 527 727 Fax +44 1502 524 511	jose.deoliveira@cefas.co.uk
Anna Rindorf	DTU Aqua - National Institute of Aquatic Resources Jægersborg Allé 1 2920 Charlottenlund Denmark	Phone +45 33 96 33 78 Fax +45 33 96 33 33	ar@aqua.dtu.dk
Guldborg Søvik	Norwegian Institute of Marine Research P.O. Box 1870 Nordnes, N-5817 Bergen, Norway	Phone +47 55 23 53 48 Fax +47 55 23 85 55	Guldborg.soevik@imr.no
Mats Ulmestrand	Swedish Board of Fisheries Institute of Marine Research Box 4 SE-453 21 Lysekil, Sweden	Phone +46 523 187 00 Fax +46 523 139 77	Mats.ulmestrand@slu.se

Name	Address	Phone/Fax	Email
Mikael van Deurs	DTU Aqua - National Institute of Aquatic Resources Section for Fisheries Advice Charlottenlund Slot Jægersborg Alle 1 2920 Charlottenlund Denmark	Phone +45 33 96 34 38 Fax +45 33 96 33 80	mvd@aqua.dtu.dk
Sofie Vandemaele	Institute for Agricultural and Fisheries Research (ILVO) Ankerstraat 1 8400 Oostende Belgium	Phone +32 59 569883 Fax +32 59 330629	sofie.vandemaele@ilvo.vlaanderen.be
Willy Vanhee	Institute for Agricultural and Fisheries Research Ankerstraat 1 B-8400 Oostende Belgium	Phone +32 5 956 9829 Fax +32 5 933 0629	Willy.vanhee@ilvo.vlaanderen.be
Youen Vermard	IFREMER Boulogne-sur-Mer Centre P.O. Box 699 F-62 321 Boulogne Cedex France	Phone +33 321 995 686 Fax +33	youen.vermard@ifremer.fr

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 2012 to evaluate new information from the fisheries independent surveys carried out during 2012 subsequent to the meeting of the group in May.

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 2012 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, some problems occurred due to the sometimes late and incomplete submission of the data, and therefore the indices used in the current update must be considered as provisional and will likely be revised for the assessment in May next year.

The comparisons indicated that there was no potential for re-opening of advice.

2.2 Cod in Subarea IV, VIID and IIIa

No update was presented for cod this year, 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. The following analysis compares the effect of the new survey data with the forecast provided by the relevant assessment Working Group (ICES-WGNSSK 2012), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008.

The Workshop on the Reopening Framework and the Frequency of the Assessment (ICES-WKFREQ 2012) was to have considered potential revisions to the protocol, and after several postponements finally convened in March 2012. However, by the time of the meeting the remit of WKFREQ had changed, and it did not consider the reopening framework.

2.3.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2012) year class at age 0. The RCT3 input and output files are given in Tables 2.3.2 and 2.3.3.

2.3.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2012 year-class at age 0	
Log WAP from RCT3 (R)	8.04
Log of recruitment assumed in spring (A)	8.18
Int SE of log WAP (S)	0.40
Distance D $\left(D = \dfrac{R-A}{S} \right)$	**-0.35**

2.3.4 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 similar to what had been assumed in the forecast produced by WGNSSK in May 2012.

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 2012 are highlighted.

EngGFS							
1992	2012						
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

ScoGFS							
1998	2012						
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

Table 2.3.2. Haddock in Sub-Area IV and Division IIIa. RCT3 input file. Data from surveys in autumn 2012 are highlighted.

HADDOCK IN IV, RCT3 INPUT VALUES									
8	31	2							
'YEARCLASS'	'VPA'	'IBTS1'	'IBTS2'	'EGFS0'	'EGFS1'	'EGFS2'	'SGFS0'	'SGFS1'	'SGFS2'
1981	32576.04	-1	403.079	-1	-1	-1	-1	-1	-1
1982	20481.69	302.278	221.275	-1	-1	-1	-1	-1	-1
1983	66909.876	1072.285	833.257	-1	-1	-1	-1	-1	-1
1984	17177.777	230.968	266.912	-1	-1	-1	-1	-1	-1
1985	23909.776	573.023	328.062	-1	-1	-1	-1	-1	-1
1986	48942.986	912.559	677.641	-1	-1	-1	-1	-1	-1
1987	4142.632	101.691	98.091	-1	-1	-1	-1	-1	-1
1988	8336.069	219.705	139.114	-1	-1	-1	-1	-1	-1
1989	8599.813	217.448	134.076	-1	-1	-1	-1	-1	-1
1990	28288.258	680.231	331.044	-1	-1	29.133	-1	-1	-1
1991	27409.583	1141.396	519.521	-1	58.746	17.435	-1	-1	-1
1992	41680.271	1242.121	491.051	246.059	73.145	26.992	-1	-1	-1
1993	13027.872	227.919	201.069	40.336	23.99	13.223	-1	-1	-1
1994	55451.946	1355.485	813.268	279.344	113.775	43.044	-1	-1	-1
1995	13975.862	267.411	353.882	53.435	26.747	12.608	-1	-1	-1
1996	21238.655	849.943	420.926	61.301	45.346	16.778	-1	-1	1924
1997	12614.987	357.597	222.907	40.653	26.497	8.404	-1	6349	1141
1998	9871.026	211.139	96.075	15.747	16.551	4.528	3280	1907	460
1999	134022.05	3482.017	2255.213	626.61	249.813	96.498	66067	30611	11352
2000	25599.443	894.651	473.628	92.139	28.622	22.559	11902	3790	2632
2001	2746.756	57.312	39.267	1.097	3.954	1.247	79	675	307
2002	3594.83	89.991	79.617	2.721	6.015	3.864	2149	1172	547
2003	3755.801	71.877	60.982	3.199	6.599	5.992	2159	1198	657
2004	3608.561	69.697	38.742	3.398	9.74	3.226	1729	761	272
2005	41942.928	766.995	304.067	122.383	54.403	43.401	19708	7275	5527
2006	8911.436	66.313	106.461	12.838	10.628	5.801	2280	1810	1002
2007	5646.237	60.047	139.651	8.463	6.494	6.781	1119	733	547
2008	4544.929	74.725	71.685	2.613	5.532	2.959	1885	877	680
2009	34698.981	686.401	772.907	28.978	46.229	32.592	9015	8328	5192
2010	1900.441	46.375	55.952	3.065	2.792	2.630	115	252	270
2011	680.95	14.468	-1	0.549	1.3551	-1	317	69	-1
2012	-1	-1	-1	4.004	-1	-1	580	-1	-1

Table 2.3.3. Haddock in Sub-Area IV and Division IIIa. RCT3 output file.

```
Analysis by RCT3 ver3.1 of data from file :

 hadivrct.in

 HADDOCK IN IV, RCT3 INPUT VALUES


 Data for    8 surveys over   32 years :  1981 - 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

          I-----------Regression----------I  I-----------Prediction---------I

 Survey/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series          cept   Error           Pts  Value   Value    Error   Weights

 IBTS1
 IBTS2
 EGFS0      .77   6.86    .41   .914     20   1.61    8.11     .454     .779
 EGFS1
 EGFS2
 SGFS0      .85   2.42    .75   .793     14   6.36    7.81     .853     .221
 SGFS1
 SGFS2

                                        VPA Mean =    9.48    1.188     .000

Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class    Average      WAP     Std     Std    Ratio              VPA
          Prediction          Error   Error

 2012        3112      8.04     .40     .12      .09
```

2.4 Saithe in Subarea IV, VI and Division IIIa

At the time of the update, the most recent NORASS index could not be entirely worked out, and was therefore not considered reliable enough at that stage. Therefore, no new recruitment was estimated, and the advice will not be reopened.

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 2012), according to the protocol specified by the ICES Ad hoc Group on Criteria for Reopening Fisheries Advice (ICES-AGCREFA 2008). The Workshop on the Reopening Framework and the Frequency of the Assessment (ICES-WKFREQ 2012) was to have considered potential revisions to the protocol, and after several postponements finally convened in March 2012. However, by the time of the meeting the remit of WKFREQ had changed, and it did not consider the reopening framework.

2.5.2 RCT3 analysis

Following the protocol stipulated by AGCREFA (ICES-AGCREFA 2008), an RCT3 analysis was run to provide an estimate of the abundance of the incoming (2011) year-class at age 1. The RCT3 input and output files are given in Tables 2.5.2 and 2.5.3.

2.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2011 year-class at age 1	
Log WAP from RCT3 (R)	14.81
Log of recruitment assumed in spring (A)	14.79
Int SE of log WAP (S)	0.17
Distance D $\left(D = \frac{R-A}{S}\right)$	**0.10**

2.5.4 Conclusions from protocol

As the distance -1.0 < D < 1.0, the protocol concludes that **the advisory process for North Sea whiting should not be reopened.** The autumn indices suggest that the size of the incoming year-class is similar to what had been assumed in the forecast produced by WGNSSK in May 2012.

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 2012 are highlighted.

IBTS_Q3						
1991	2012					
1	1	0.5	0.75			
0	5					
100	536.99	703.368	158.594	79.024	14.568	5.183
100	1379.459	600.867	296.1	72.451	57.498	10.273
100	919.193	638.722	177.377	66.118	14.711	15.904
100	610.743	677.645	219.541	74.71	19.506	4.722
100	729.246	619.786	291.18	107.195	21.512	6.013
100	316.501	545.708	278.218	129.356	34.003	6.893
100	2062.67	332.968	180.681	108.985	28.006	10.711
100	2631.69	330.6	150.205	52.766	31.01	11.179
100	2498.55	1203.503	190.645	53.932	24.452	9.529
100	1968.07	941.658	326.943	64.113	13.625	6.532
100	3031.442	645.003	282.32	94.854	19.281	4.315
100	264.063	732.137	237.372	125.148	33.96	5.275
100	363.406	246.155	302.054	134.824	66.058	16.452
100	1012.818	188.577	49.05	75.85	48.675	32.286
100	162.592	179.5	70.531	27.609	45.385	29.211
100	201.578	172.79	84.975	31.91	13.207	22.853
100	821.741	95.645	64.042	37.929	11.604	8.459
100	757.814	356.898	66.197	30.935	13.565	4.057
100	593.897	588.982	382.796	40.766	12.109	7.92
100	508.142	268.39	157.823	60.263	13.624	6.243
100	246.678	443.62	143.05	46.568	15.853	6.807
100	307.848	258.384	194.586	57.411	20.034	10.598

Table 2.5.2. Whiting in Sub-Area IV and Division VIId. RCT3 input file. Data from surveys in autumn 2012 are highlighted.

Whiting in IV and VIId, RCT3 input values						
5	24	2				
'YEARCLASS'	'VPA'	'IBTSq11'	'IBTSq12'	'IBTSq30'	'IBTSq31'	'IBTSq32'
1989	5600538	518.936	686.445	-1	-1	158.594
1990	5761512	1007.621	665.714	-1	703.368	296.1
1991	5495931	907.297	522.811	536.99	600.867	177.377
1992	6470818	1075.624	627.406	1379.459	638.722	219.541
1993	6149817	721.709	448.484	919.193	677.645	291.18
1994	5595850	678.59	485.968	610.743	619.786	278.218
1995	3945428	502.361	342.212	729.246	545.708	180.681
1996	3004586	287.733	160.695	316.501	332.968	150.205
1997	4187074	543.117	305.445	2062.67	330.6	190.645
1998	7046918	676.27	460.697	2631.69	1203.503	326.943
1999	8601549	741.49	598.388	2498.55	941.658	282.32
2000	6788457	648.649	343.308	1968.07	645.003	237.372
2001	5836148	557.353	296.422	3031.442	732.137	302.054
2002	1863636	131.035	89.604	264.063	246.155	49.05
2003	1909320	184.472	50.037	363.406	188.577	70.531
2004	2489654	142.047	114.51	1012.818	179.5	84.975
2005	2361740	116.839	81.33	162.592	172.79	64.042
2006	2232825	52.53	205.862	201.578	95.645	66.197
2007	4438888	268.484	332.74	821.741	356.898	382.796
2008	3591441	203.803	216.607	757.814	588.982	157.823
2009	3247857	322.351	329.844	593.897	268.39	143.05
2010	3187491	171.092	579.786	508.142	443.62	194.586
2011	-1	228.186	-1	246.678	258.384	-1
2012	-1	-1	-1	307.848	-1	-1

Table 2.5.3. Whiting in Sub-Area IV and Division VIId. RCT3 output file.

```
Analysis by RCT3 ver3.1 of data from file :

 whi4rct.in

 Whiting in IV and VIId, RCT3 input values


 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 =   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

 IBTSq1     .63  11.51    .25   .778     22   5.43   14.94     .270     .408
 IBTSq1
 IBTSq3     .68  10.68    .37   .628     20   5.51   14.43     .415     .172
 IBTSq3     .81  10.35    .24   .791     21   5.56   14.83     .265     .420
 IBTSq3

                                       VPA Mean =   15.23     .455     .000


 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

 IBTSq1
 IBTSq1
 IBTSq3     .68  10.68    .37   .628     20   5.73   14.58     .409    1.000
 IBTSq3
 IBTSq3

                                       VPA Mean =   15.23     .455     .000


 Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class     Average      WAP     Std     Std    Ratio             VPA
          Prediction           Error   Error

 2011     2692443     14.81     .17     .13      .53
 2012     2156653     14.58     .41     .00      .00
```

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 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 2.6.1. In 2011, the new data comprises age 1 of year class 2011 and age 2 of year class 2010. The last 4 years from the assessment estimates were removed from the time series.

2.6.3 Update protocol calculations

The outcomes from the RCT3 analyses for the two ages are presented in table 2.6.2. For age 1, the D value for this age indicates -0.095, negative signal, but not different from spring assumptions. For age 2 the D value=0.42 indicating a, positive signal, but no 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

```
North  Sea    Plaice Age    1
1      28     2
1984   1853892       136.8
1985   4775439       667.4
1986   1970104       225.8
1987   1776234       680.2
1988   1189264       467.9
1989   1039262       185.3
1990   918015        291.4
1991   781976        360.9
1992   532656        189
1993   445836        193.3
1994   1167369       265.6
1995   1296449       310.3
1996   2160323       1046.8
1997   777736        347.6
1998   845152        293.3
1999   987140        267.5
2000   544499        206.5
2001   1729930       519.2
2002   528876        132.8
2003   1270058       233.7
2004   770698        163
2005   937388        128.6
2006   1168187       312
2007   1014800       221.6
2008   -11           409
2009   -11           261.1
2010   -11           486.2
2011   -11           241.8
BTS1

North  Sea    Plaice Age    2
1      28     2
1983   847805        173.893
1984   1291741       131.704
1985   3256552       764.186
1986   1438737       146.993
1987   1275608       319.272
1988   872002        146.071
1989   800662        159.424
1990   655070        174.526
1991   572330        283.4
1992   387004        77.139
1993   342990        40.618
1994   935840        206.883
1995   1066201       59.241
1996   1831514       402.657
1997   604098        121.551
1998   643092        69.252
1999   792274        72.236
2000   459528        44.475
2001   1269420       159.12
2002   413472        39.623
2003   927104        66.176
2004   605542        36.385
2005   638099        67.169
2006   982324        120.728
2007   789129        105.222
2008   -11           84.254
2009   -11           148.217
2010   -11           191.502
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 ver3.1 of data from file : ple_iv1.txt  North Sea  Plaice  Age
1 Data for    1 surveys over   28 years :  1984 - 2011

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    .03, Minimum of
3 points used for regression

Forecast/Hindcast variance correction used.

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

BTS        1.67   4.49    .74   .355     24   5.49   13.66     .788    1.000
                                       VPA Mean =   13.90     .536     .000


 Year     Weighted      Log     Int     Ext     Var
 Class     Average      WAP     Std     Std    Ratio
          Prediction            Error   Error
 2011      852694     13.66     .79     .00      .00

Plaice age 1 D = (13.66 - log(922293))/ 0.788  =  -0.095, negative signal, but
not different from spring assumptions.
```

D calculation North Sea plaice age 2

```
Analysis by RCT3 ver3.1 of data from file : ple_iv2.txt North Sea Plaice Age 2,
Data for 1 surveys over   28 years :  1983 - 2010

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    .03
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

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

BTS         .90   9.32    .47   .549     25   5.26   14.06     .505    1.000
                                        VPA Mean =   13.63     .509     .000


Year     Weighted      Log     Int     Ext     Var
Class     Average      WAP     Std     Std    Ratio
         Prediction            Error   Error

2010     1281756     14.06     .50     .00      .00

Plaice age 2 D= (14.06- log(1033366))/0.505 =  0.42, positive signal, but no
different from spring assumptions.


The new estimates have no effect on advice.
```

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 2011, the new data comprises age 1 of year class 2011 and age 2 of year class 2010. 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 -1.40, which represents a negative signal and is different from spring assumptions. As this value is below -1. For age 2 the D value is 1.32 indicating a positive signal. Hence, the forecast should be recalculated. The full RCT3 analysis table is given in Table 2.7.3 and the revised recruitment estimates in Table 2.7.4.

The input to the North Sea sole forecast is provided in Tables 2.7.5, the detailed output in Table 2.7.6 and the short term management summary table in Table 2.7.7. A possible option table for the advice sheet is given in Table 2.7.8

2.7.4 Conclusions from protocol

Following the AGCREFA protocol, the revised recruitment index for sole at age 1 in 2010 has a D << -1. For age 2, D >>1. Subsequent recruitment estimates based on RCT for age 1 and 2 from DFS, SNS, and BTS indicate a lower than average recruitment for age 1, and a higher than average recruitment for age 2. The June landings prediction for landings associated with fishing at F=0.27 was 13850 tonnes. The updated short term forecast resulting from the new recruitment estimates indicates 14187 tonnes for this fishing mortality. Given the rounding of the TAC advice, the TAC would not change. Please note that the DFS index used in this report differs from earlier index values. This is because ICES WGBEAM 2012 revised the data. See the ICES WGBEAM report for an elaborate description and for a comparison of the series before and after revision.

Table 2.7.1 North Sea sole RCT3 input data

```
Sole   North  Sea    Age    1
1      28     2
1984   81951         7.03
1985   159426        7.17
1986   72756         6.97
1987   458067        83.11
1988   108190        9.01
1989   177141        37.84
1990   70374         4.03
1991   352793        81.63
1992   69118         6.35
1993   56960         7.66
1994   95940         28.13
1995   49345         3.98
1996   270749        169.34
1997   113725        17.11
1998   82207         11.96
1999   123139        14.59
2000   62897         8
2001   184631        20.99
2002   81869         10.51
2003   44666         4.19
2004   48057         5.53
2005   205913        17.09
2006   56682         7.5
2007   72568         15.25
2008   -11           15.95
2009   -11           54.81
2010   -11           26.17
2011   -11           5.149
BTS1

Sole   North  Sea-Age       2
1      28            2
1983   63982         7.12
1984   73996         5.18
1985   143899        12.55
1986   65743         12.51
1987   414467        68.08
1988   97783         24.49
1989   159463        28.84
1990   63563         22.28
1991   318288        42.35
1992   62489         7.12
1993   50857         8.46
1994   82243         7.64
1995   44486         4.92
1996   243472        27.42
1997   102670        18.36
1998   74111         6.14
1999   109184        9.96
2000   56071         4.18
2001   166057        9.94
2002   73081         4.35
2003   39925         3.4
2004   42384         2.33
2005   179836        19.5
2006   50987         9.06
2007   63836         5
2008   -11           10.71
2009   -11           17.39
2010   -11           18.212
BTS2
```

Table 2.7.2 North Sea sole RCT3 analysis and D value with the new survey

D calculation North Sea sole age 1

```
Analysis by RCT3 ver3.1 of data from file: altin_1.txt, Sole North Sea Age 1,
Data for 1 surveys over 28 years: 1984 - 2011

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 .03, Minimum of 3
points used for regression

Forecast/Hindcast variance correction used.

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

BTS1       .79   9.42    .39   .739     24   1.82   10.86     .424    1.000
                                       VPA Mean =   11.54     .643     .000

Year     Weighted      Log     Int     Ext     Var
Class     Average      WAP     Std     Std    Ratio
         Prediction           Error   Error
2011       52046     10.86     .42     .00      .00
Sole age 1 D= (10.86 - log(93669 ))/0.42= -1.40 negative signal, and different
from spring assumptions.
```

D calculation North Sea sole age 2

```
Analysis by RCT3 ver3.1 of data from file : altin_2.txt Sole North  Sea-Age2
Data for    1 surveys over   28 years :  1983 - 2010

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    .03
Minimum of   3 points used for regression

Forecast/Hindcast variance correction used.

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

BTS2       .99   8.98    .43   .699     25   2.96   11.92     .457    1.000
                                       VPA Mean =   11.42     .635     .000

Year     Weighted      Log     Int     Ext     Var
Class     Average      WAP     Std     Std    Ratio
          Prediction           Error   Error

 2010      149538     11.92     .46     .00      .00

(11.92 - log(81891))/0.46

Sole age 2 D= (11.92 - log(81891))/0.46= 1.32 positive signal, and different
from spring assumptions.
```

Full RCT3 input North Sea sole age 1 all survey data

```
Sole    North   Sea     1
2       40      2
1972    105157  -11     -11
1973    110007  -11     -11
1974    40846   -11     -11
1975    113320  -11     -11
1976    140406  -11     -11
1977    47213   -11     -11
1978    11679   -11     -11
1979    151694  -11     -11
1980    149004  -11     -11
1981    152575  -11     -11
1982    141599  -11     -11
1983    70911   -11     -11
1984    81951   -11     7.03
1985    159426  -11     7.17
1986    72756   -11     6.97
1987    458067  -11     83.11
1988    108190  -11     9.01
1989    177141  -11     37.84
1990    70374   6.38    4.03
1991    352793  167.56  81.63
1992    69118   9.27    6.35
1993    56960   15.32   7.66
1994    95940   22.06   28.13
1995    49345   7.06    3.98
1996    270749  40.27   169.34
1997    113725  26.94   17.11
1998    82207   -11     11.96
1999    123139  -11     14.59
2000    62897   9.50    8
2001    184631  51.42   20.99
2002    81869   58.58   10.51
2003    44666   10.61   4.19
2004    48057   31.25   5.53
2005    205913  40.99   17.09
2006    56682   12.57   7.5
2007    72568   13.73   15.25
2008    -11     11.77   15.95
2009    -11     27.33   54.811
2010    -11     42.86   26.166
2011    -11     12.13   5.149
DFS0
BTS1
```

Full RCT3 input North Sea sole age 2 all survey data

```
Sole    North   Sea     Age     2
5       40      2
1971    68799   -11     1454.7  935.3   -11     -11
1972    94481   -11     5587.2  361.4   -11     -11
1973    99442   -11     2347.9  864.5   -11     -11
1974    36707   -11     525.4   73.6    -11     -11
1975    101546  -11     1399.4  776.1   -11     -11
1976    125383  -11     3742.9  1354.7  -11     -11
1977    42694   -11     1547.7  408.3   -11     -11
1978    10559   -11     93.8    88.9    -11     -11
1979    136652  -11     4312.9  1413.1  -11     -11
1980    134422  -11     3737.2  1146.2  -11     -11
1981    135525  -11     5856.5  1123.3  -11     -11
1982    127754  -11     2621.1  1099.9  -11     -11
1983    63982   -11     2493.1  715.6   -11     7.121
1984    73996   -11     3619.4  457.6   7.031   5.183
1985    143899  -11     3705.1  943.7   7.168   12.548
1986    65743   -11     1947.9  593.8   6.973   12.512
1987    414467  -11     11226.7 5005.0  83.111  68.084
1988    97783   -11     2830.7  1119.5  9.015   24.487
1989    159463  -11     2856.2  2529.1  37.839  28.841
1990    63563   6.38    1253.6  144.4   4.035   22.284
1991    318288  167.56  11114.0 3419.6  81.625  42.345
1992    62489   9.27    1290.8  498.3   6.350   7.121
1993    50857   15.32   651.8   223.7   7.660   8.458
1994    82243   22.06   1362.1  349.1   28.125  7.634
1995    44486   7.06    218.4   153.6   3.975   4.919
1996    243472  40.27   10279.3 3126.4  169.343 27.422
1997    102670  26.94   4094.6  971.8   17.108  18.363
1998    74111   -11     1648.9  125.9   11.960  6.144
1999    109184  -11     1639.2  655.4   14.594  9.963
2000    56071   9.50    970.3   379.0   7.998   4.182
2001    166057  51.42   7547.5  -11     20.989  9.947
2002    73081   58.58   -11     624.4   10.507  4.354
2003    39925   10.61   1369.5  162.9   4.192   3.395
2004    42384   31.25   568.1   117.1   5.534   2.332
2005    179836  40.99   2726.4  911.0   17.089  19.504
2006    50987   12.57   848.6   258.5   7.498   9.062
2007    63836   13.73   1259.1  344.4   15.247  4.999
2008    -11     11.77   1931.6  237.1   15.950  10.707
2009    -11     27.33   2636.9  883.9   54.811  17.387
2010    -11     42.86   1248.0  -11     26.166  18.212
DFS0
SNS1
SNS2
BTS1
BTS2
```

Full RCT3 calculation North Sea sole age 1 all survey data

Analysis by RCT3 ver3.1 of data from file: altin_1.txt, Sole North Sea 1, Data for 2 surveys over 40 years : 1972 – 2011, 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.

2011 I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
DFS0	.96	8.43	.53	.617	16	2.57	10.90	.591	.271
BTS1	.79	9.42	.39	.739	24	1.82	10.86	.424	.527
					VPA Mean =		11.48	.684	.202

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio
2011	59714	11.00	.31	.17	.31

Full RCT3 input North Sea sole age 2 all survey data

Analysis by RCT3 ver3.1 of data from file : altin_2.txt Sole North Sea Age 2
Data for 5 surveys over 40 years : 1971 - 2010

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.

2010 I-----------Regression----------I I-----------Prediction---------I

Survey/ Series	Slope	Inter- cept	Std Error	Rsquare	No. Pts	Index Value	Predicted Value	Std Error	WAP Weights
DFS0	.96	8.31	.53	.613	16	3.78	11.95	.600	.122
SNS1	.74	5.72	.35	.800	36	7.13	11.02	.363	.333
BTS1	.80	9.29	.40	.733	24	3.30	11.93	.428	.239
BTS2	.99	8.98	.43	.699	25	2.96	11.92	.457	.210
					VPA Mean =		11.36	.675	.096

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2010	106009	11.57	.21	.21	1.03		

Table 2.7.4 Updated North Sea sole recruitment table

Recruitment table. Choices are bold and underlined

YEAR CLASS	AGE IN 2012	XSA THOUSANDS	RCT3 THOUSANDS	GM(1957 – 2007) THOUSANDS
2010	2	**81891**	106009	82 525
2011	1		**59714**	94 000
2012	Recruit			**94 000**

Updated North Sea sole STF results

STF Input table

age	year	F	stock.n	stock.wt	landings.wt	mat	M
1	2012	0.006	59714	0.05	0.15	0	0.1
2	2012	0.127	106009	0.14	0.18	0	0.1
3	2012	0.299	107348	0.19	0.21	1	0.1
4	2012	0.349	44868	0.23	0.24	1	0.1
5	2012	0.373	19779	0.26	0.26	1	0.1
6	2012	0.335	9325	0.29	0.29	1	0.1
7	2012	0.391	19440	0.31	0.29	1	0.1
8	2012	0.314	1556	0.34	0.31	1	0.1
9	2012	0.468	1521	0.37	0.33	1	0.1
10	2012	0.468	2955	0.40	0.38	1	0.1
1	2013	0.006	93669	0.05	0.15	0	0.1
2	2013	0.127		0.14	0.18	0	0.1
3	2013	0.299		0.19	0.21	1	0.1
4	2013	0.349		0.23	0.24	1	0.1
5	2013	0.373		0.26	0.26	1	0.1
6	2013	0.335		0.29	0.29	1	0.1
7	2013	0.391		0.31	0.29	1	0.1
8	2013	0.314		0.34	0.31	1	0.1
9	2013	0.468		0.37	0.33	1	0.1
10	2013	0.468		0.40	0.38	1	0.1
1	2014	0.006	93669	0.05	0.15	0	0.1
2	2014	0.127		0.14	0.18	0	0.1
3	2014	0.299		0.19	0.21	1	0.1
4	2014	0.349		0.23	0.24	1	0.1
5	2014	0.373		0.26	0.26	1	0.1
6	2014	0.335		0.29	0.29	1	0.1
7	2014	0.391		0.31	0.29	1	0.1
8	2014	0.314		0.34	0.31	1	0.1
9	2014	0.468		0.37	0.33	1	0.1
10	2014	0.468		0.40	0.38	1	0.1

Detailed STF table

age	year	F	stck	stck.wt	lnd.wt	mat	M	landings.n	landings	SSB	TSB
1	2012	0.006	59714	0.05	0.15	0	0.1	333	50	0	2986
2	2012	0.127	106009	0.14	0.18	0	0.1	12008	2119	0	15265
3	2012	0.299	107348	0.19	0.21	1	0.1	26459	5447	20181	20181
4	2012	0.349	44868	0.23	0.24	1	0.1	12606	3055	10245	10245
5	2012	0.373	19779	0.26	0.26	1	0.1	5884	1554	5195	5195
6	2012	0.335	9325	0.29	0.29	1	0.1	2530	727	2679	2679
7	2012	0.391	19440	0.31	0.29	1	0.1	6003	1766	6085	6085
8	2012	0.314	1556	0.34	0.31	1	0.1	400	125	534	534
9	2012	0.468	1521	0.37	0.33	1	0.1	543	181	561	561
10	2012	0.468	2955	0.40	0.38	1	0.1	1055	397	1173	1173
1	2013	0.006	93669	0.05	0.15	0	0.1	522	79	0	4683
2	2013	0.127	53715	0.14	0.18	0	0.1	6084	1074	0	7735
3	2013	0.299	84516	0.19	0.21	1	0.1	20831	4288	15889	15889
4	2013	0.349	72037	0.23	0.24	1	0.1	20239	4905	16448	16448
5	2013	0.373	28647	0.26	0.26	1	0.1	8523	2251	7525	7525
6	2013	0.335	12319	0.29	0.29	1	0.1	3343	961	3540	3540
7	2013	0.391	6038	0.31	0.29	1	0.1	1864	548	1890	1890
8	2013	0.314	11901	0.34	0.31	1	0.1	3059	959	4082	4082
9	2013	0.468	1029	0.37	0.33	1	0.1	367	123	380	380
10	2013	0.468	2536	0.40	0.38	1	0.1	906	341	1007	1007
1	2014	0.006	93669	0.05	0.15	0	0.1	522	79	0	4683
2	2014	0.127	84259	0.14	0.18	0	0.1	9544	1684	0	12133
3	2014	0.299	42824	0.19	0.21	1	0.1	10555	2173	8051	8051
4	2014	0.349	56715	0.23	0.24	1	0.1	15934	3862	12950	12950
5	2014	0.373	45993	0.26	0.26	1	0.1	13683	3613	12081	12081
6	2014	0.335	17842	0.29	0.29	1	0.1	4842	1391	5127	5127
7	2014	0.391	7977	0.31	0.29	1	0.1	2463	725	2497	2497
8	2014	0.314	3697	0.34	0.31	1	0.1	950	298	1268	1268
9	2014	0.468	7868	0.37	0.33	1	0.1	2810	938	2903	2903
10	2014	0.468	2020	0.40	0.38	1	0.1	721	271	802	802

Option table

Fmult	year	ssb	f2-6	recruit	landings
1	2012	46654	0.296	59714	15422

year	fmult	f2-6	landings	ssb2013	ssb2014
2013	0.0	0.000	0	50760	61785
2013	0.1	0.030	1784	50760	59928
2013	0.2	0.059	3513	50760	58131
2013	0.3	0.089	5187	50760	56391
2013	0.4	0.119	6808	50760	54708
2013	0.5	0.148	8379	50760	53078
2013	0.6	0.178	9901	50760	51501
2013	0.7	0.208	11375	50760	49974
2013	0.8	0.237	12803	50760	48495
2013	0.9	0.267	14187	50760	47064
2013	1.0	0.296	15528	50760	45678
2013	1.1	0.326	16828	50760	44337
2013	1.2	0.356	18087	50760	43038
2013	1.3	0.385	19307	50760	41780
2013	1.4	0.415	20490	50760	40562
2013	1.5	0.445	21636	50760	39382
2013	1.6	0.474	22748	50760	38240
2013	1.7	0.504	23825	50760	37134
2013	1.8	0.534	24869	50760	36062
2013	1.9	0.563	25882	50760	35024
2013	2.0	0.593	26863	50760	34019

2.8 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

Contents

Contents

Annex 03 – Stock Annexes

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 °N.

A.3. Ecosystem aspects

Nephrops lives in burrows in suitable muddy sediments and is characterised by being omnivorous and emerge out of the burrows to feed. It can, however, also sustain itself as a suspension feeder (in the burrows) (Loo *et al*., 1993).

Sediment maps for the Norwegian Deep (Figure A3-1) indicate that the area of suitable sediment for *Nephrops* is larger than the current extent of the fishery, and there may be possibilities of expansion into new grounds on which *Nephrops* is not currently exploited or only slightly exploited. These grounds are mainly found along the Norwegian coast as the Danish fishery takes place along the western slope of the Norwegian Deep (Figure A2-2).

Nephrops directed trawl fisheries are characterised by large amounts of non-commercial bycatch and *Nephrops* below MLS. However, in FU 32 *Nephrops* is fished together with demersal fish in a mixed fishery, and directed trawl fishery for *Nephrops* seems to be less common. The amount of *Nephrops* below MLS is small in the Danish and Norwegian fisheries in FU 32 due to the legislated mesh size of 120 mm. The *Nephrops* discard mortality from trawl fishing is considered to be high (75 %, Wileman *et al*. 1999), while it is basically zero in creel fisheries.

B. Data

B.1. Commercial catch

Onboard sampling of Danish catches (split into discard and landings components) are carried out by Danish observers, providing information on length distribution and sex ratio (Figure A2-1). For 2008-2009 sex specific data do not exist as the observers pooled data on males and females. Due to changes in the Danish at-sea-sampling programme implemented in the second quarter of 2011, where observer trips are randomly drawn from all fishing trips, the number of Danish fishing trips in FU 32 with onboard sampling was a single one in the first quarter of 2011. This is due to the very few Danish fishing trips in FU 32.

Onboard sampling of catches as part of inspections (not split into discard and landings components) have been carried out by the Norwegian coast guard, mainly on Danish trawlers, since 2005. There were, however, no data in 2010 and very limited data in 2005 and 2009. The coast guard tend to measure catches by total length. This results in fewer *Nephrops* below MLS compared with measuring by CL as a MLS of 130 mm total length actually corresponds to a CL of 38 mm, not 40 mm (the official MLS for CL). Upon request by the Norwegian Institute of Marine Research the coast guard measure CL, but seemingly include some of the animals of 39 mm length in the 40 mm length group, probably in order to make the outcome of the inspection independent of measuring method.

Since 2003 the Danish at-sea-sampling programme has provided data for discard estimates (Figure A2-1). However, the samples have not covered all quarters. There were no discards data for 2008 and 2011.

B.2. Biological

No biological data exist for this stock.

B.3. Surveys

No survey abundance index is available for this stock. The annual Norwegian shrimp survey covers most of the area, however, the catches of *Nephrops* in the survey trawl (Campelen 1800/35 bottom trawl with rockhopper gear, cod end mesh size is 22 mm with 6 mm lining net) are too small and variable to provide a reliable abundance index. This is partly due to the survey being designed to cover shrimp grounds. The survey data only give an impression of the distribution of *Nephrops* in FU 32 (Figure A1-1).

B.4. Commercial LPUE

A landings-per-unit-effort time-series is available from the Danish trawl fleet (Figure A2-1). LPUE is estimated using officially recorded effort (days fished). There is no account taken of any technological creep in the fleet.

Norwegian log books from FU 32 are incomplete regarding *Nephrops* recordings, with log book catches constituting 12-40% of the landings in 2001-2011. Therefore, the landings-per-unit-effort time-series from the Norwegian fleet in FU 32 are not utilized. Furthermore, the recordings of the various gears seems to be inconsistent, both between years as well as between the landings statistics and the logbooks. For instance, there are no records on the use of *Nephrops* trawls in the 2006-2011 logbooks, while a substantial part of the landings in the same time period are recorded as caught by *Nephrops* trawl in the official landings statistics. Electronic logbooks were introduced in Norway in 2011 and made compulsory for all vessels ≥ 15 m. This will provide the working group with consistent data for part of the fleet. However, as a large portion of the Norwegian fleet landing *Nephrops* in FU 32 consists of vessels < 15 m, especially north of 60 °N (Figure A2-4), the Norwegian logbook data available for analysis will continue to be limited.

The state of the stock is assessed based on the Danish LPUE.

C. Historical Stock Development

None

D. Short-Term Projection

None

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. Biological Reference Points

None specified.

H. Other Issues

I. References

Loo, L-O., S. Baden & M. Ulmestrand, 1993. Suspension feeding in adult *Nephrops* norvegicus (L.) and Homarus gammarus (L.) (Decapoda). Netherland Journal of Sea Research. 31:3, 1-6.

Wileman, D.A., G. I. Sangster, M. Breen, M. Ulmestrand, A. V. Soldal and R.R. Harris, 1999. Roundfish and *Nephrops* survival after escape from commercial fishing gear. EC Contract No: FAIR-CT95-0753. Final Report 1999. 125 p + appendix.

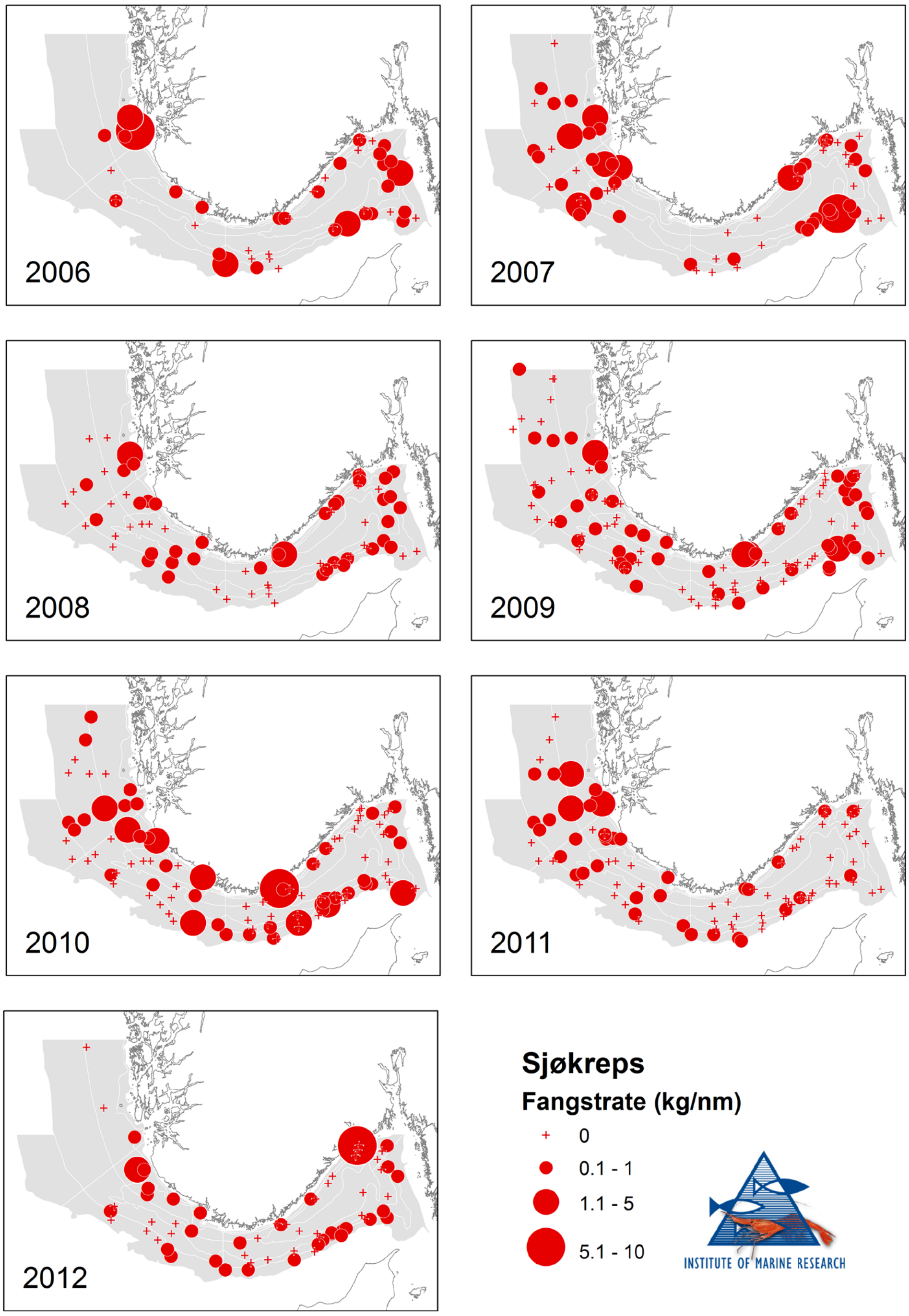


Figure A1-1. *Nephrops* Norwegian Deep (FU 32). Catches (kg/nm trawled) from the Norwegian shrimp survey, January-February 2006-2012.

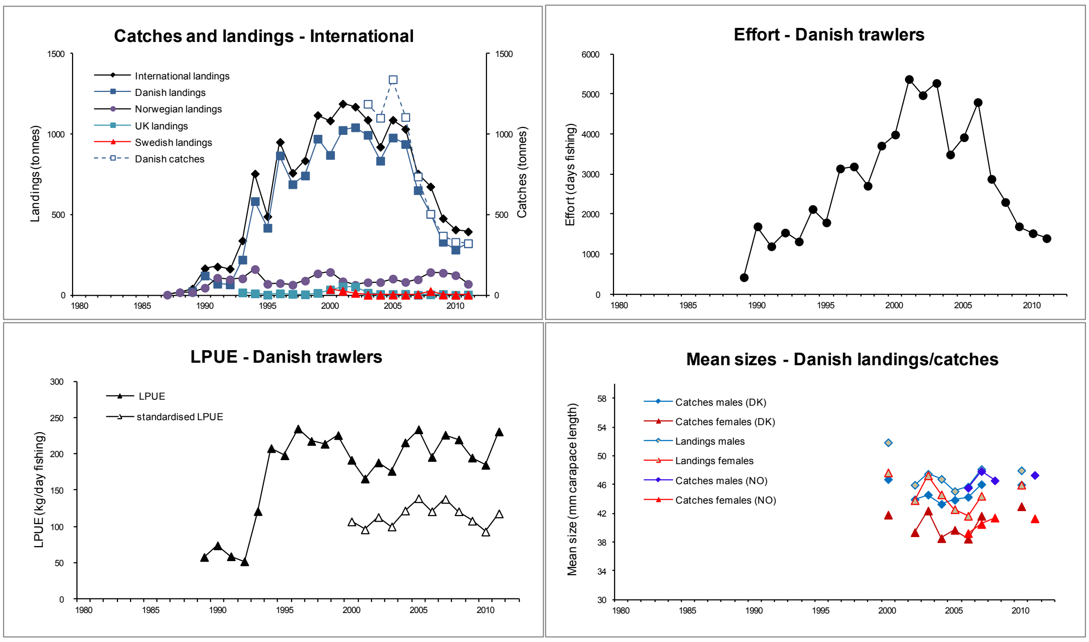


Figure. A2-1. ***Nephrops*** **Norwegian Deep (FU 32). Long term landings, Danish effort, Danish LPUE and Danish mean sizes of catches and landings.**

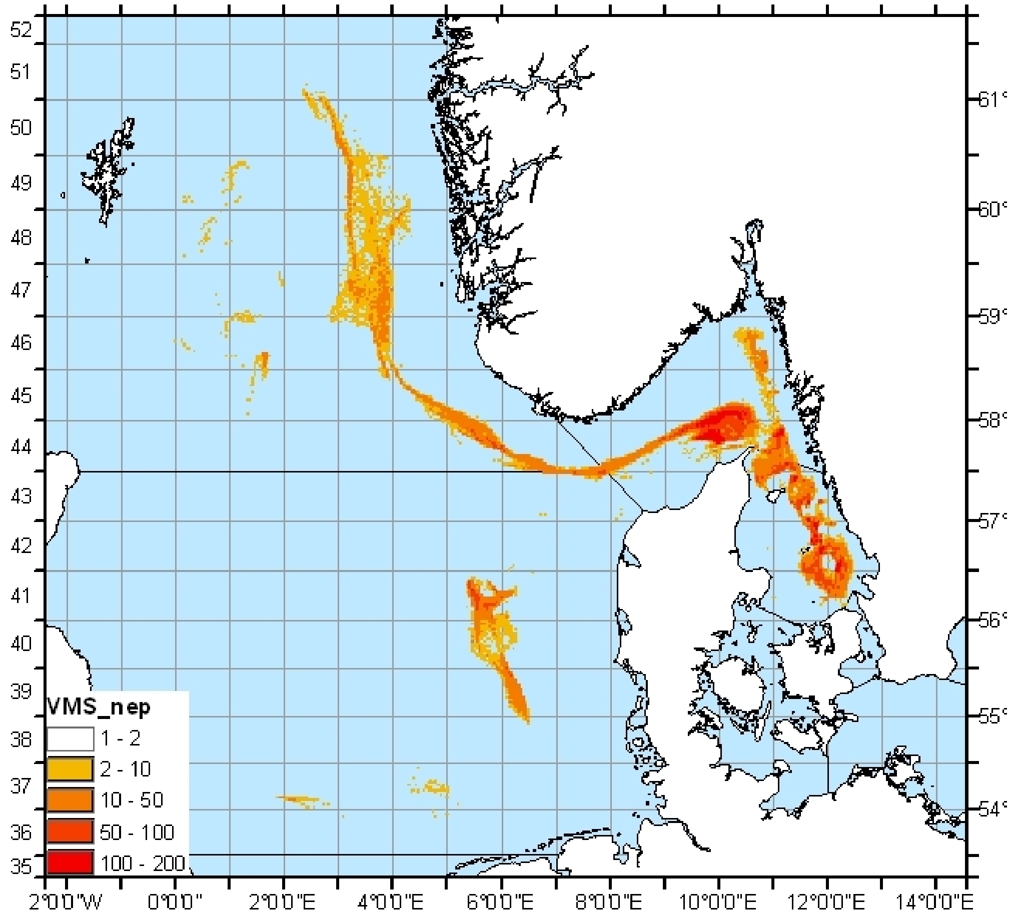


Figure A2-2. ***Nephrops*** **Norwegian Deep (FU 32). VMS data showing the spatial distribution of the Danish and Swedish fleet fishing for** ***Nephrops*** **in Skagerrak, Kattegat, and the North Sea. The Swedish vessels are mainly fishing in Kattegat and the northeastern part of Skagerrak.**

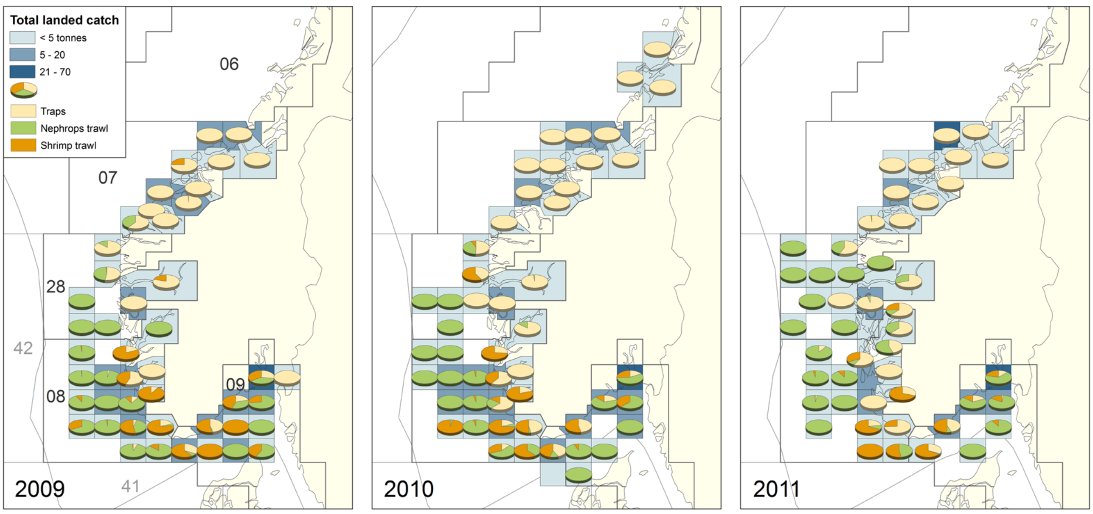


Figure A2-3. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings per gear type and ICES statistical rectangle in 2009-2011. The numbers are area codes from the Norwegian Directorate of Fisheries, where 08 refers to FU 32 south of 60 °N, and 28 refers to FU 32 north of 60 °N. Data from the Norwegian Directorate of Fisheries.**

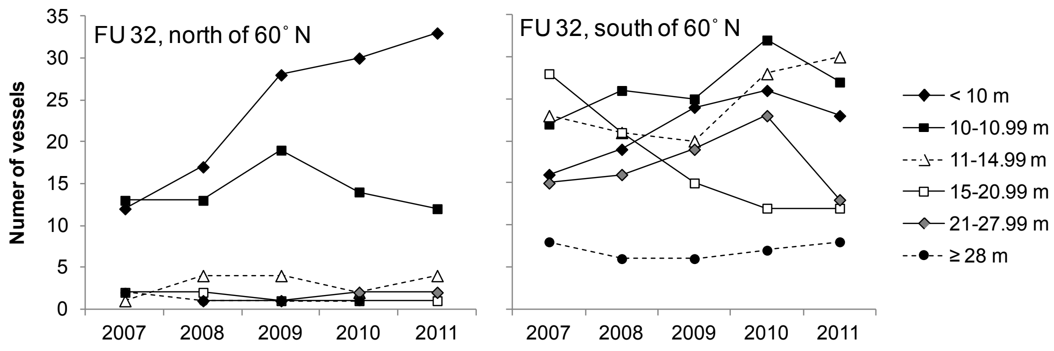


Figure A2-4. *Nephrops* Norwegian Deep (FU 32). The Norwegian fleet landing *Nephrops*, per length group in 2007-2011, north and south of 60 °N. Data from the Norwegian Directorate of Fisheries.

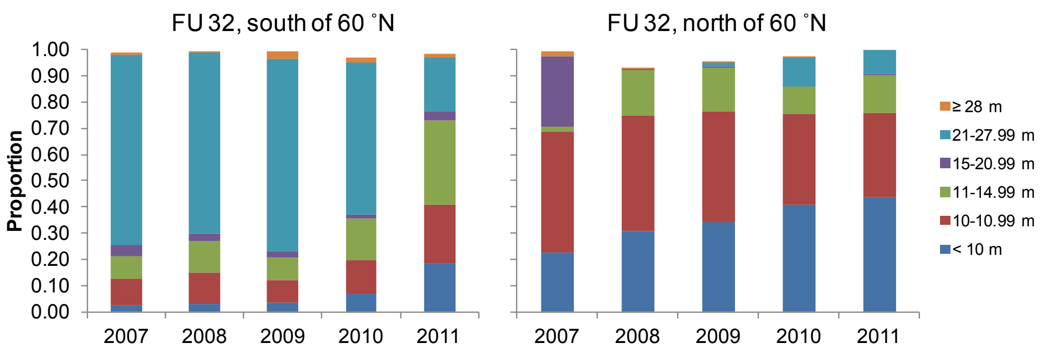


Figure A2-5. *Nephrops* Norwegian Deep (FU 32). Norwegian landings (proportion) in 2007-2011 per vessel length group, north and south of 60 °N. Not all columns add up to one due to lack of lengths for some vessels. Data from the Norwegian Directorate of Fisheries.

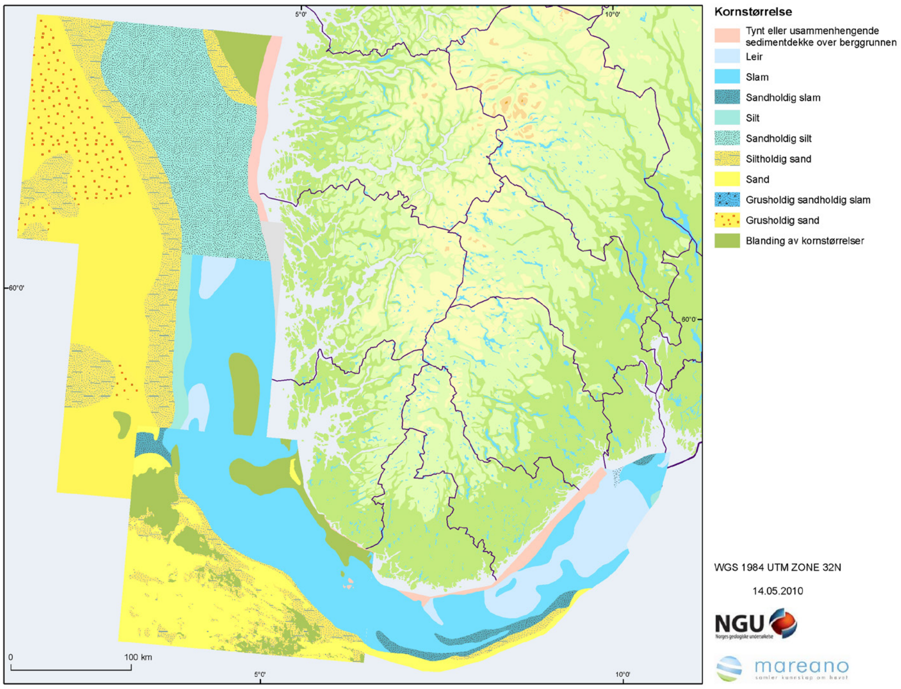


Figure A3-1. Sediment map of the Norwegian Deep and Skagerrak. Map from www.mareano.no.

Table A2-1. *Nephrops* Norwegian Deep (FU 32). International landings, and Danish effort (days) and LPUE (kg/day), 1993-2011.

Year	Landings	Effort	LPUE
1993	339	1317	121
1994	755	2126	208
1995	489	1792	198
1996	952	3139	235
1997	760	3189	218
1998	836	2707	214
1999	1119	3710	226
2000	1085	3986	192
2001	1190	5372	166
2002	1171	4968	188
2003	1090	5273	177
2004	922	3488	216
2005	1089	3919	234
2006	1033	4796	196
2007	755	2878	226
2008	675	2301	220
2009	477	1694	195
2010	407	1522	185
2011	395	1398	231

Stock Annex: FU6, Farn Deeps

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Farn Deeps *Nephrops* (FU06)
Date:	18/05/2010
Revised by	Ewen Bell/Jon Elson

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, 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

A.2 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.

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

Three types of sampling occur on this stock, landings sampling, catch sampling and discard sampling providing information on size distribution and sex ratio. Landing and catch sampling occurs at North Shields, Blyth, Amble and Hartlepool.

Historically, estimates of discarding were made using the difference between the catch samples and the landings samples. For the period prior to 2002, catch length samples and landings length samples are considered to be representative of the fishery. An estimate of retained numbers at length was obtained for this period from the catch sample using a discard ogive estimated from data from the 1990s, a raising factor was then determined such that the retained numbers at length matched the landings numbers at length. This raising factor was then applied to the estimate of discard numbers at length.

More recently, there has been concern that the landings sampling may be missing portions of the landings landed as tails (as opposed to whole individuals) thus leading to an artificial inflation of the estimated discards. On-board discard sampling has been of sufficient frequency since 2002 to enable the estimation of discards from these data. There are two modes of operation for “tailing” in the FU6 *Nephrops* fishery, some vessels tail at sea, others tail at the quayside. Discard estimates from the latter category only sample those animals discarded at sea, the undersize individuals discarded at the quayside are not sampled, consequently the proportion of discards at sizes below MLS for this tailing practice are very low (Figure B.1.1). Discard trips, which saw discarding of less than 50% of individuals below MLS, were ignored. Annual discard ogives showed no systematic change, therefore a single ogive was constructed from the pooled data from 2002–2007 (Figure B.1.2). This was then applied to the catch data to produce estimates of landings at length.

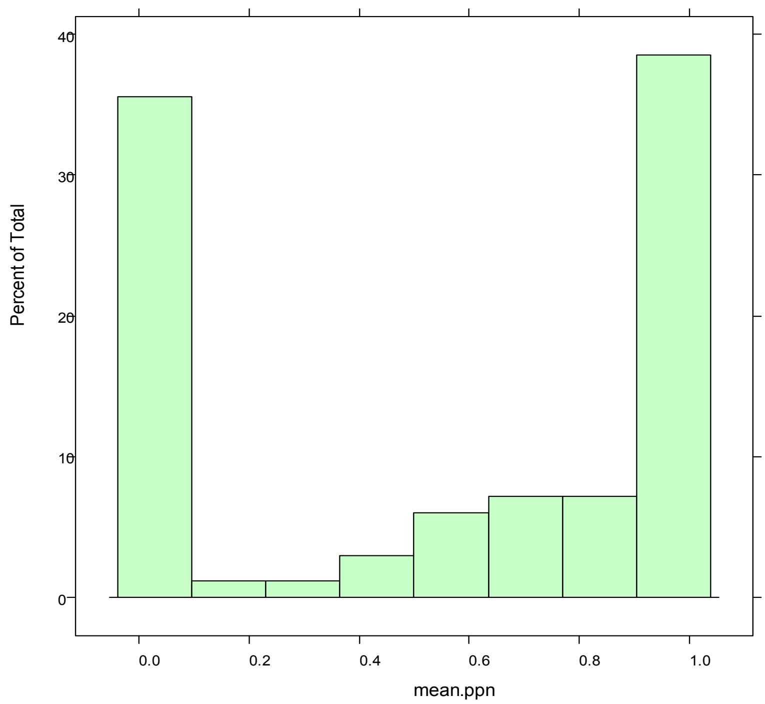


Figure B.1.1. Farn Deeps (FU 6): Histogram of proportion individuals <26mm discarded.

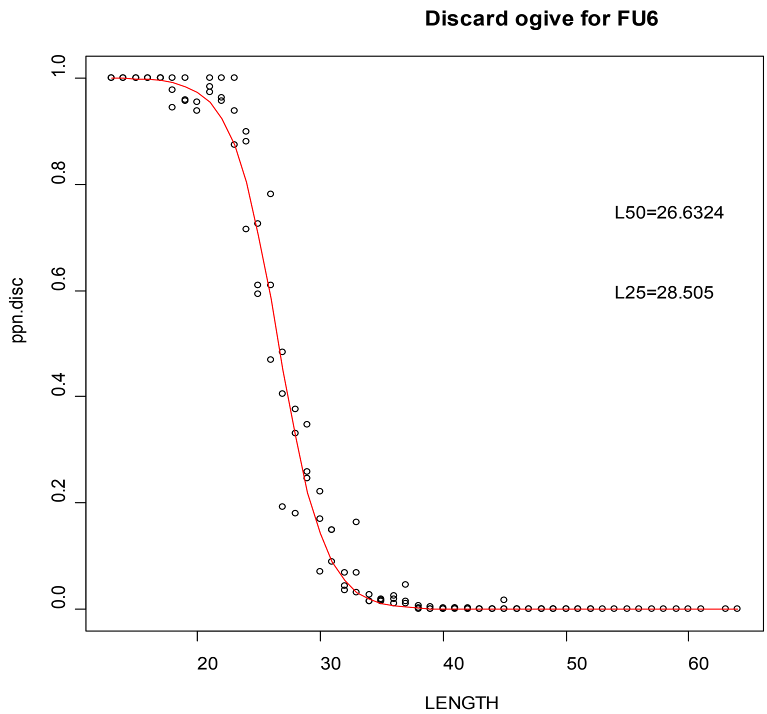


Figure B.1.2. Farn Deeps (FU 6): Discard ogive selected for FU6 *Nephrops*, trip level data pooled to year 2002-2007

B.2 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%

B.3 Surveys

Abundance indices are available from the following research-vessel surveys:

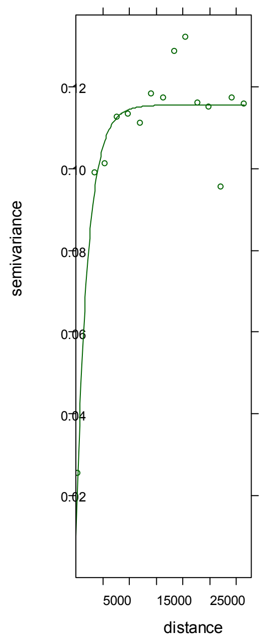
Underwater TV survey: years 1996 – present. Surveys have been conducted in Spring and/or Autumn each year but only consistently in Autumn from 2001. In 2008 there was an historical revision of burrow density estimates from the TV survey. Previous estimates of burrow density had assumed that station density 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

B.4 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.

B.5 Other relevant data

C. 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).

D. 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

E. Medium-Term Projections

None

F. Long-Term Projections

None

G. 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.

H. Other Issues

I. References

Stock Annex: FU7, Fladen Ground

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Fladen Ground *Nephrops* (FU 7)
Date:	09 March 2009 (WKNEPH2009)
Updated:	16 May 2011

Revised by Sarah Clarke/Carlos Mesquita/Helen Dobby

A General

A.1 Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Fladen Ground is located towards the centre of the northern part of Division IV and is defined by statistical rectangles 44-49E9-F1 and 45-46E8. Its eastern boundary is adjacent to the Norwegian Deeps area, while its western boundary borders the Moray Firth functional unit (FU9). There is some evidence for overlap of habitat at the boundary of these areas. The ground represents one of the largest areas of soft muddy sediments in the North Sea and there are wide variations in sediment composition across the ground. *Nephrops* is distributed throughout the area and is associated with various benthic communities reflecting the variations in physical environment.

A.2 Fishery

The Fladen fishery (FU7), the largest Scottish *Nephrops* fishery, takes a mixed catch with haddock, whiting, cod, monkfish and flatfish such as megrim, also making an important contribution to vessel earnings. The Fladen *Nephrops* fleet comprises vessels from 12m up to 35m fishing mainly with 80mm twin-rig. The fleet has a diverse range of boats, and includes some of the largest most modern purpose built boats in the Scottish fleet and vessels which have recently converted to *Nephrops* fishing.

The area supports well over 100 vessels and the majority of the fleet (80%) fish out of Fraserburgh, with the other important ports being Peterhead, Buckie, Macduff, and Aberdeen. Boats fish varying lengths of trip between 3 days (small boats) and 8-9 day trips (larger vessels). During 2006 and 2007 around 20 vessels joined the fleet and 5 ongoing new boat builds have the capability to fish at Fladen. Some whitefish vessels have converted to *Nephrops* twin-rigging.

The Fladen fishery generally follows a similar pattern every year, with different areas of the Fladen grounds producing good fishing at different times of the year (boats fish the north of the ground in winter, then move east towards the sector line in the summer). During 2004-5 this seasonal pattern was less apparent with fishing being good throughout the year on a range of grounds. There was also no lull in catch rates which traditionally happens in April-May. In 2006 however, there was a return to a more usual pattern of fishing with catches poor for most of the spring and slowly getting better throughout the summer. Some participating vessels explored slightly different areas to fish in 2006, particularly on the eastern edge of the ground. Bad weather at the start of 2006 and part of 2007 also contributed to the slower start to the fishery in these years. In some years, high squid abundance in the Moray Firth attracts Fladen vessels but in the last two years this was not so evident compared to 2005.

Other developments include the capability of freezing at sea and in one case, processing at sea. A recent tendency towards shorter trip lengths and improved handling practice is associated with market demand for high quality *Nephrops* which appears to have increased dramatically. The implementation of buyers and sellers legislation in 2006 has reduced the problem of underreporting and prices have risen, while weighing at sea has improved the accuracy of reported landings.

A.3 Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B Data

B.1 Commercial catch

Length compositions of Scottish landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling have increased since 2000 and are considered adequate for providing representative length structure of removals at the Fladen Ground. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE and CPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests a rapid increase since 2003. It is likely, however, that improved reporting of landings data) in recent years particularly arising from 'buyers and sellers legislation has contributed to the increase. The high levels have been maintained since 2003. In addition, effort recording in terms of hours fished is non-mandatory and therefore it is unclear whether these trends and those that are discussed below are actually indicative of trends in LPUE.

Males consistently make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary. In earlier years effort was generally highest in the latter part of the year in this fishery, but the pattern varies between years, and the seasonal pattern does not appear as strong in recent years. LPUE of both sexes remained relatively constant up to 2002, and in common with the overall figure has shown a marked increase since then. This suggests that exploitation (or other external factors) are not disproportionately affecting one sex or the other. LPUE is fairly similar through the year for males but for females there is no consistent pattern in these data.

LPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the size above which the effects of discarding practices were not expected to occur and the size below which recruitment events might be observed in the length composition. The data show a rise in LPUE in all categories since 2001. There is, however, no apparent lag between the increased LPUEs of <35mm animals and >35mm animals which one might expect if the reason was increasing abundance.

B.2 Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Parameters applied in a preliminary length-based assessment and age (with length) based simulation to inform the catch forecast process were as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

SUMMARY

Von Bertalanffy growth parameters are as follows:

Males; L_∞ = 66mm, k = 0.16

Immature Females; L_∞ = 66mm, k = 0.16

Mature Females; L_∞ = 56mm, k = 0.10,

Size at maturity = 25mm

Weight length parameters:

Males a = 0.0003, b = 3.25

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%.

Discard proportion: 3 year average (13.8% at benchmark WG)

B.3 Surveys

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

On average, about 60 stations have been considered valid each year with over 70 stations in the last three years. Data are raised to a stock area of 28153 km^2 based on the stratification. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground has a range of mud types from soft silty clays to coarser sandy muds, the latter predominate (Figure B3–1). Most of the variance in the survey is associated with this variable sediment which surrounds the main centres of abundance. Abundance is generally higher in the soft and intermediate sediments located to the centre and south east of the ground but in 2007, higher densities were also recorded in the more northerly parts of the ground. In general the confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Fladen are:

	Time period	Edge effect	detection rate	species identification	occupancy	Cumulative bias
FU 7: Fladen<=2009		1.45	0.9	1	1	1.35

B.4 Commercial CPUE

Scottish *Nephrops* trawl gears: Landings, discards and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in 1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

B.5 Other relevant data

C Historical Stock Development

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).

D Short-Term Projection

4. 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).
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. 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.
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

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	F	HR (%)	SPR (%) M	F	T
$F_{0.1}$	M	0.14	0.10	9.4	41.7	48.9	44.7
	F	0.19	0.14	11.7	34.5	41.9	37.6
	T	0.16	0.11	10.2	39.1	46.3	42.1
F_{max}	M	0.27	0.19	15.4	25.8	33.1	28.9
	F	0.40	0.29	20.9	17.6	24.2	20.3
	T	0.30	0.22	17.0	23.1	30.2	26.0
$F_{35\%SpR}$	M	0.19	0.14	11.7	34.5	41.9	37.6
	F	0.25	0.18	14.8	27.1	34.5	30.1
	T	0.21	0.15	12.7	31.7	39.1	34.8

At the 2011 WG, the analysis was updated using data from 2008-10 to account for the apparent changes in the discard pattern in this fishery. The complete range of the current per-recruit F_{msy} proxies is given in the table below:

WGNSSK 2011		Fbar(20-40 mm) M	F	HR (%)	SPR (%) M	F	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

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

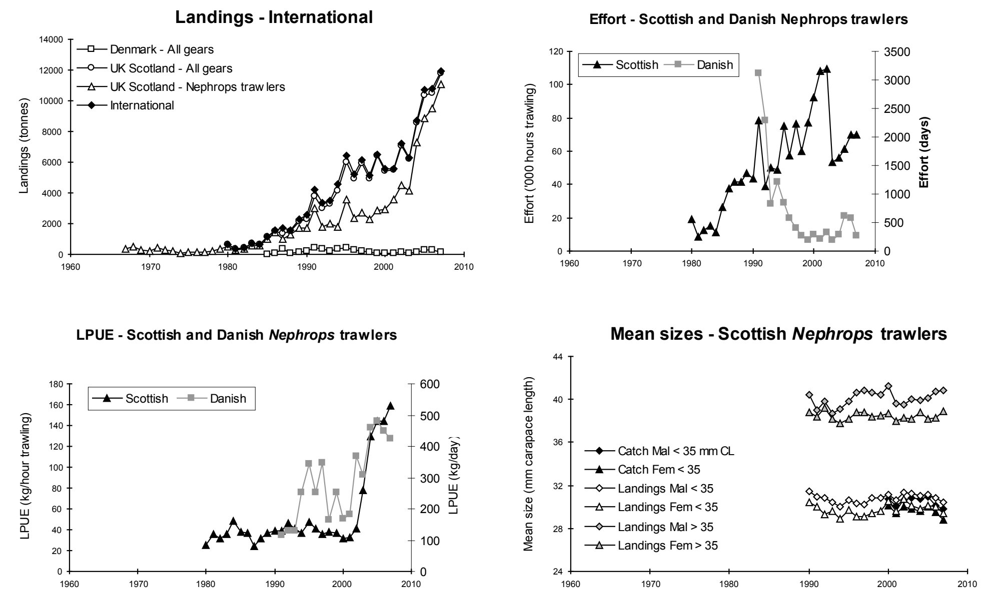


Figure B1-1. ***Nephrops*, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.**

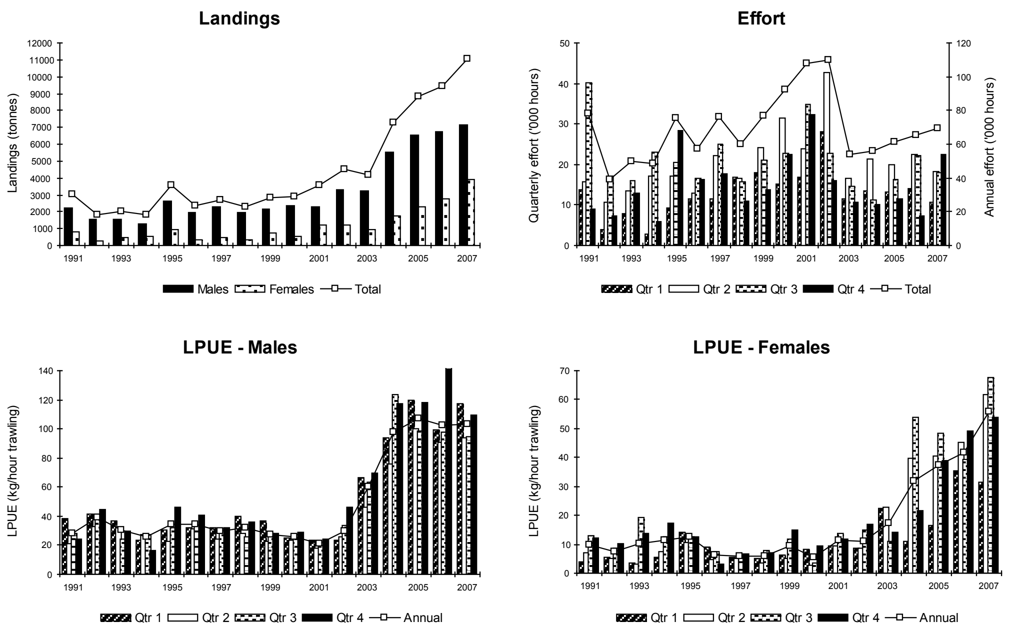


Figure B1-2. ***Nephrops*, Fladen (FU 7), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**

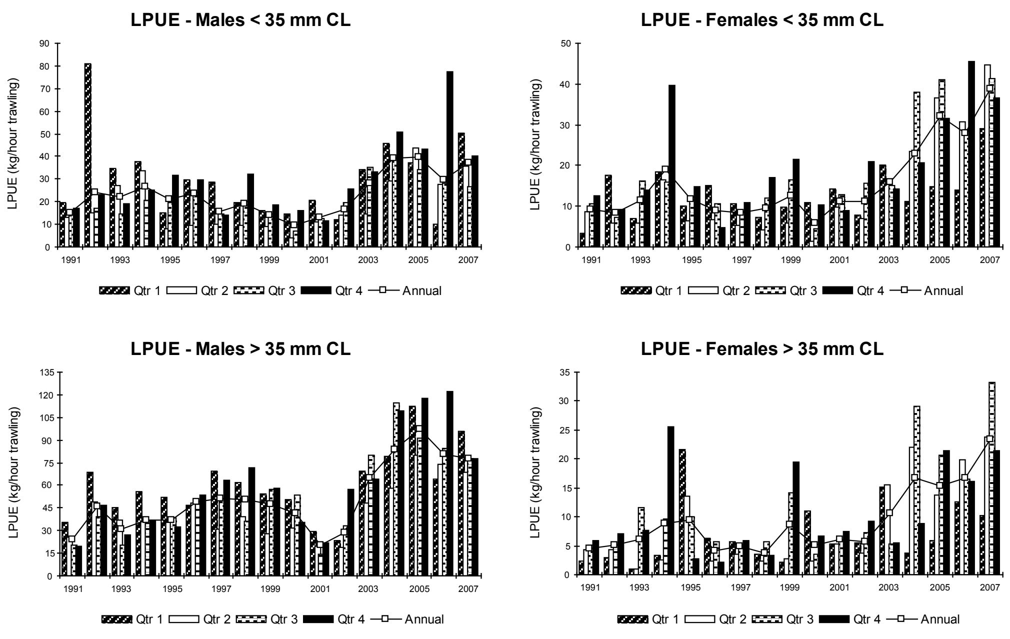


Figure B1-3. ***Nephrops*, Fladen (FU 7), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.**

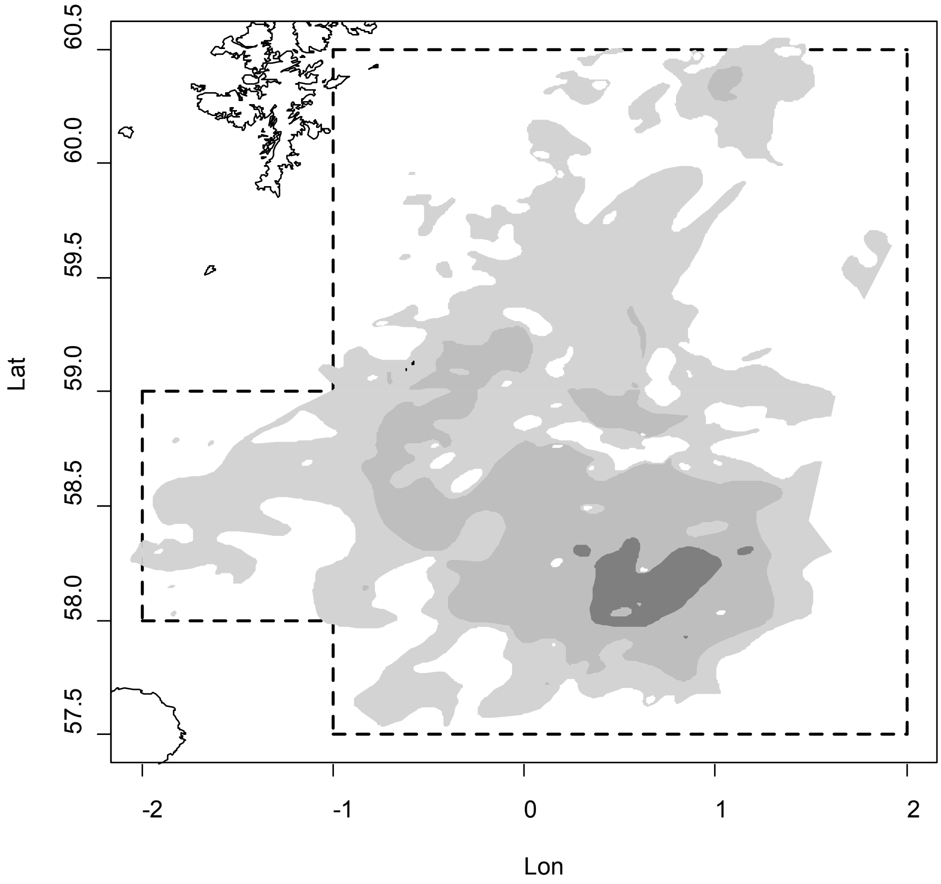


Figure B3–4. Distribution of *Nephrops* sediments in the Fladen Ground (FU 7). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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

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).

D Short-Term Projection

4. 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).
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. 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.
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

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	F	HR (%)	SPR (%) M	F	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	F	HR (%)	SPR (%) M	F	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

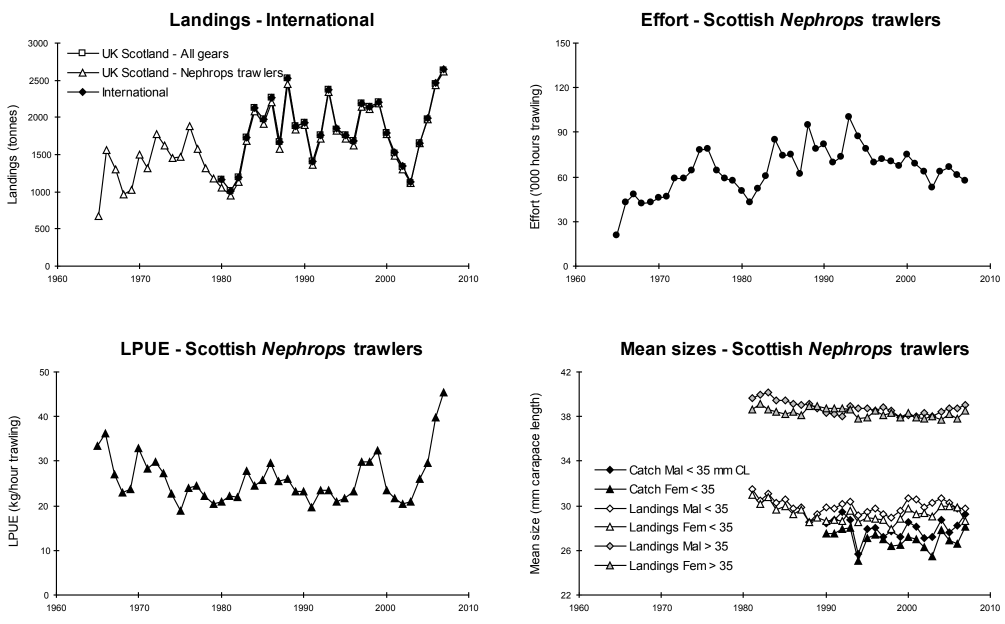


Figure B1-1. ***Nephrops*****, Firth of Forth (FU 8), Long term landings, effort, LPUE and mean sizes.**

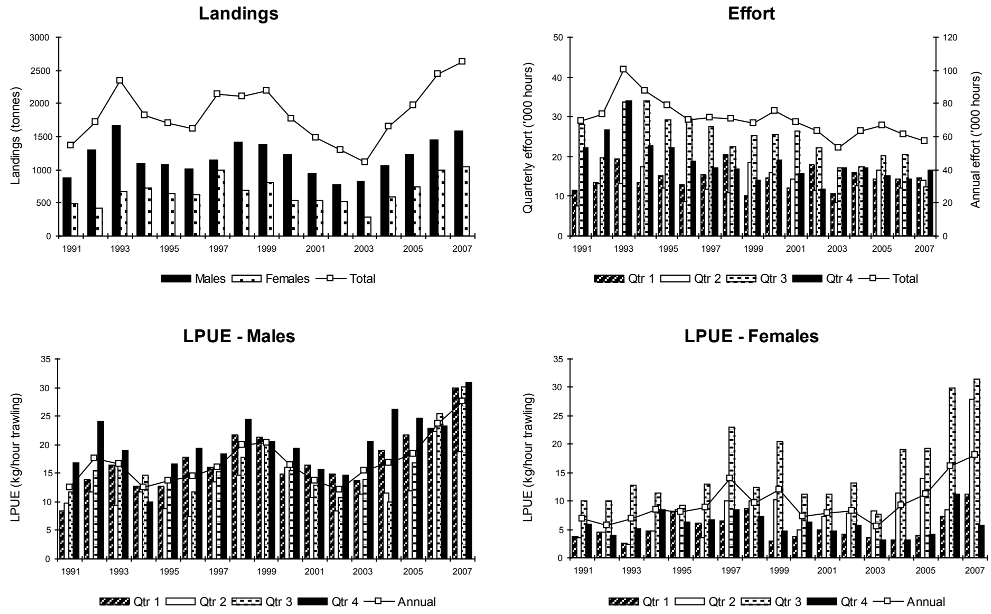


Figure B1-2. ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**

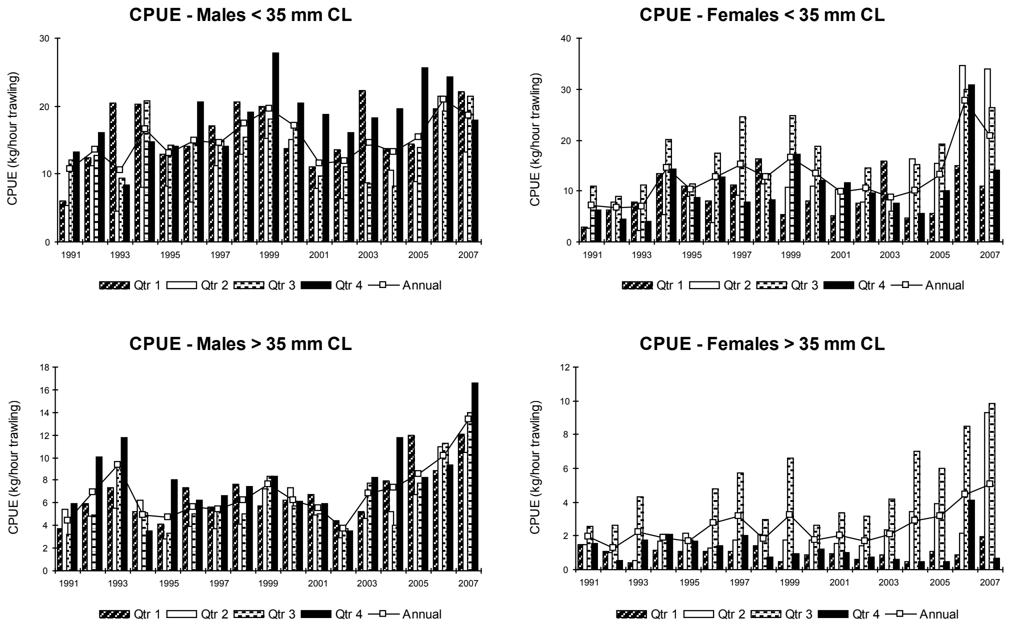


Figure B1-3. ***Nephrops*****, Firth of Forth (FU 8), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.**

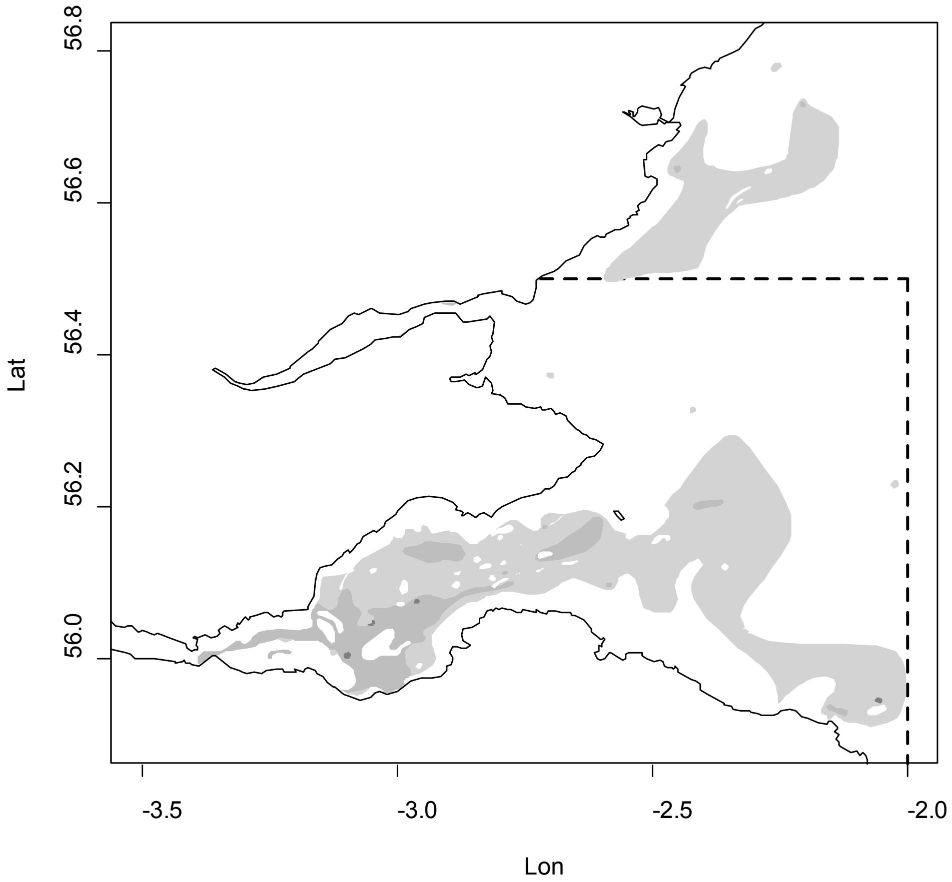


Figure B3–1. Distribution of *Nephrops* sediments in the Firth of Forth (FU 8). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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

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).

D Short-Term Projection

4. 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).
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. 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.
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

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

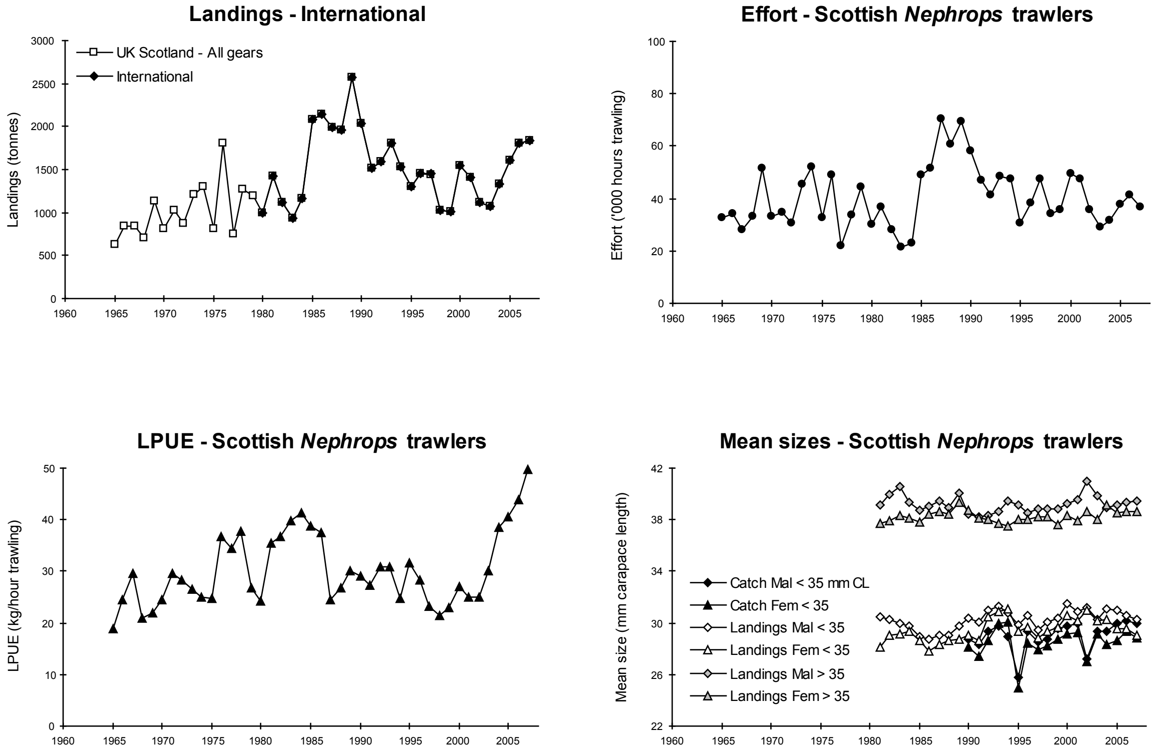


Figure B1-1. ***Nephrops*, Moray Firth (FU 9), Long term landings, effort, LPUE and mean sizes.**

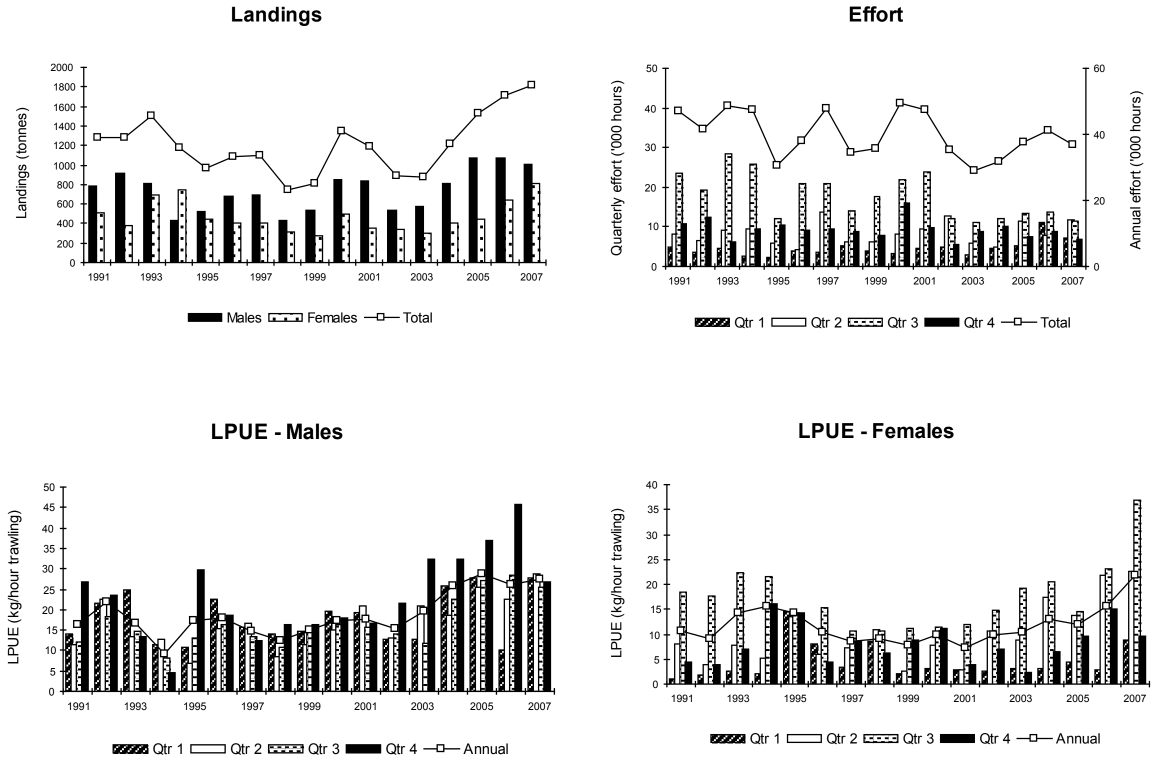


Figure B1-2. *Nephrops*, Moray Firth (FU 9), Landings, effort and unstandardised LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

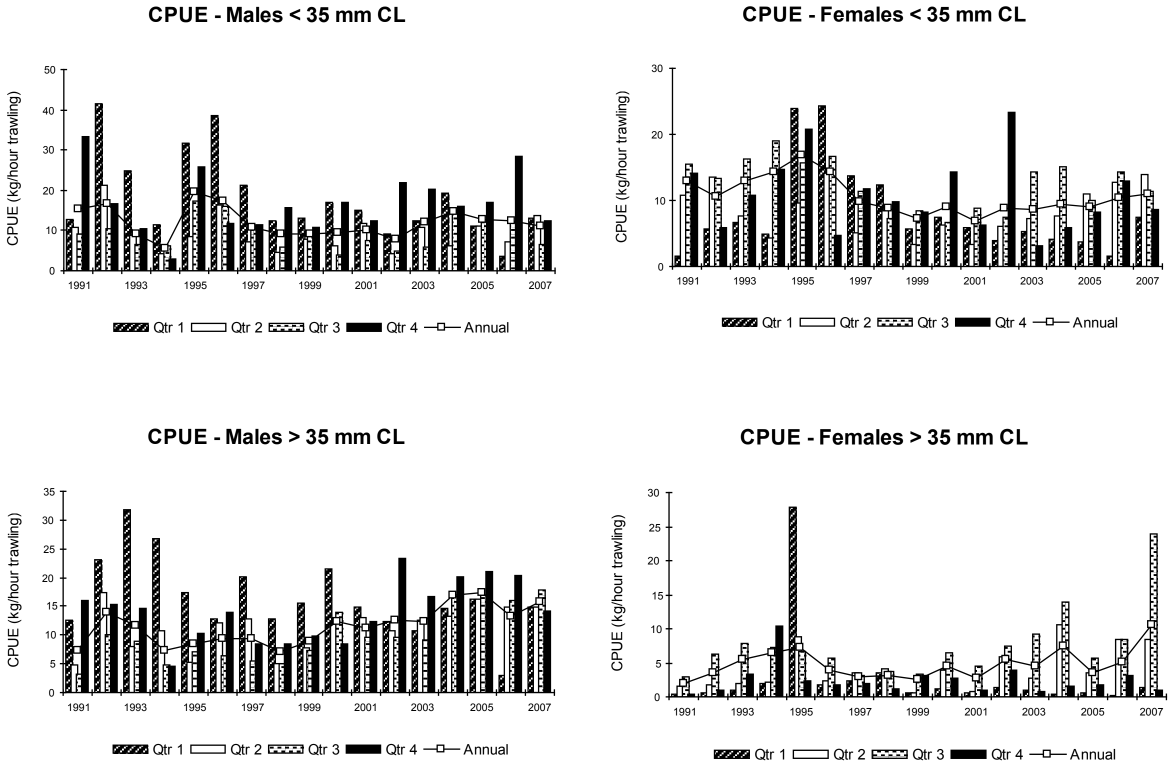


Figure B1-3. *Nephrops*, Moray Firth (FU 9), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.

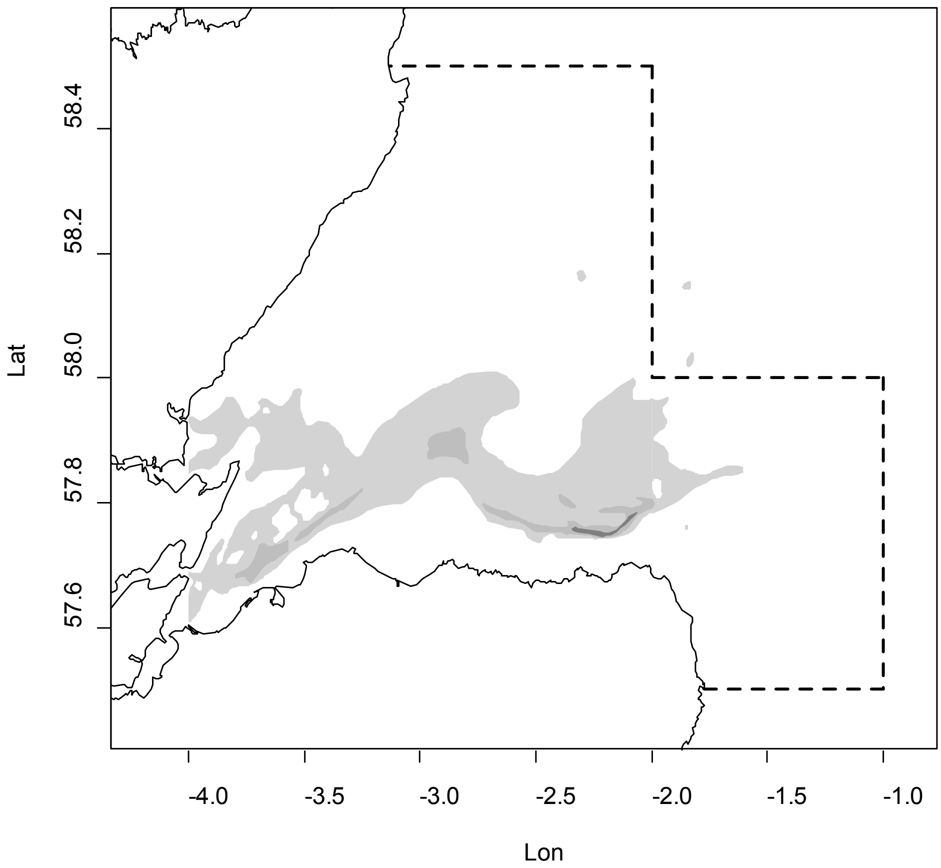


Figure B3–1. Distribution of *Nephrops* sediments in the Moray Firth (FU 9). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex Noup *Nephrops* (FU 10)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Noup *Nephrops* (FU 10)
Date:	09 March 2009
Revised by Sarah Clarke/Carlos Mesquita	

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.

A.2. Fishery

The Noup grounds are regularly fished by 3-4 boats (16-24m) from Scrabster. They mainly target a mixed fish (mainly flat fish and monkfish) and *Nephrops* fishery using 100mm (twin-rig) to stay within the catch composition regulations. Boats land an average of around 1.5 tonnes of *Nephrops* from a 6-7 day trip. Occasionally some of the Fraserburgh *Nephrops* fleets fish the Noup grounds although this did not happen in 2005 - 2007, as many of the boats who used to make the journey have been decommissioned. The Noup ground has previously produced a period of good fishing every year but the area has not been important in the last couple, of years.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B. Data

B.1. Commercial catch

Given that the levels of market sampling are low and discard sampling is not available, the length structure of removals in the fishery is not considered to be well represented by the available data.

Table B1-1 shows the landings, effort and LPUE data for single trawls, multiple trawls and combined while Figure B1-1 illustrates the long term commercial LPUE data. The low levels of sampling for this fishery mean it is not realistic to draw conclusions from changes in size composition or sex ratio. 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 km² (Figure B3–1). These 2 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.

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

D. Short-Term Projection

E. Medium-Term Projections

F. Long-Term Projections

G. Biological Reference Points

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	-

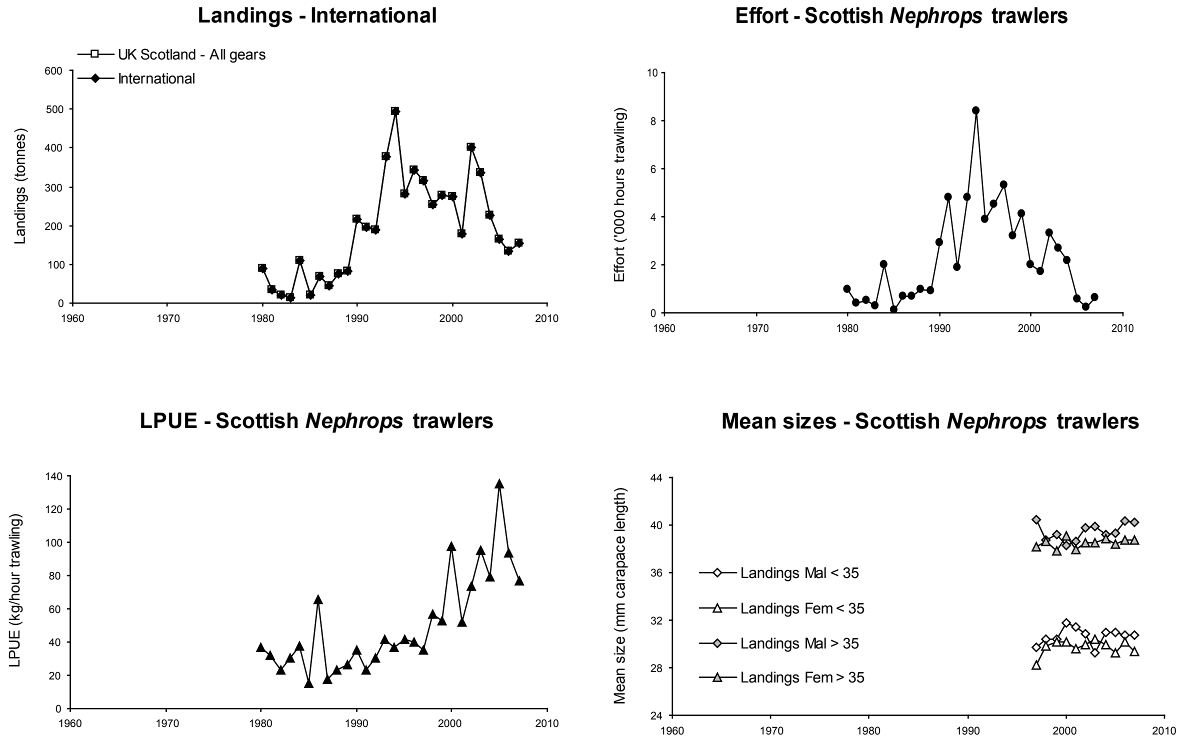


Figure 3.4.1.11 ***Nephrops*, Noup (FU 10), Long term landings, effort, LPUE and mean sizes.**

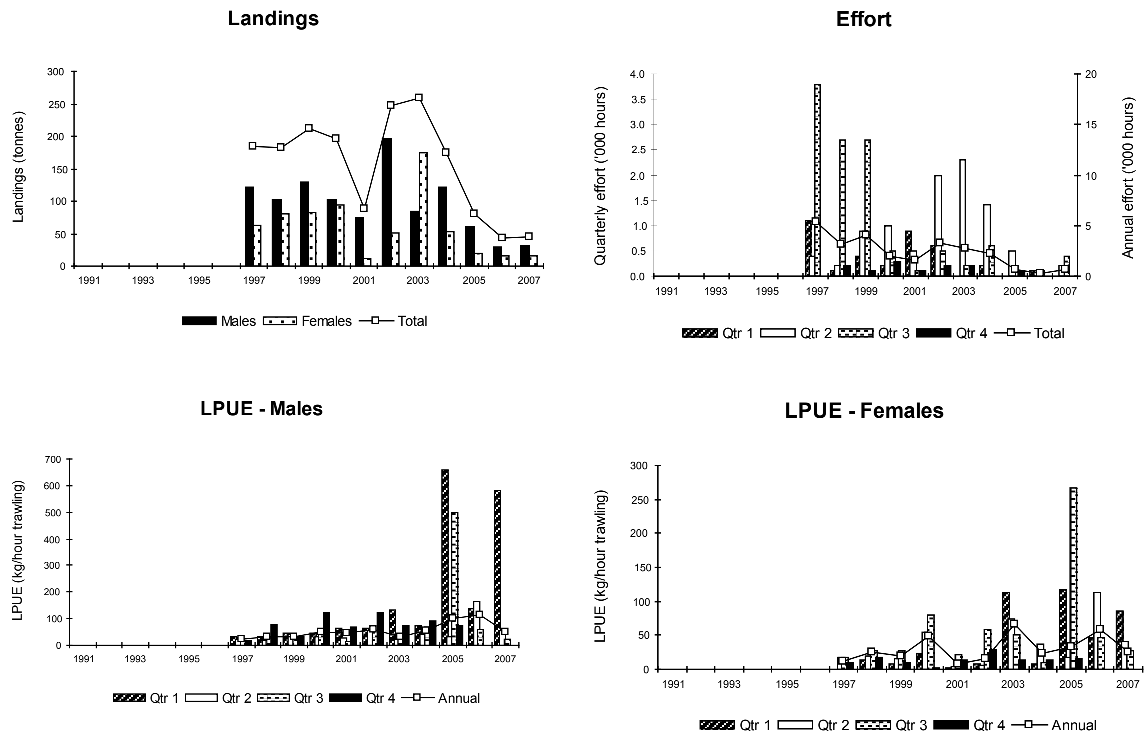


Figure 3.4.1.12 ***Nephrops*, Noup (FU 10), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**

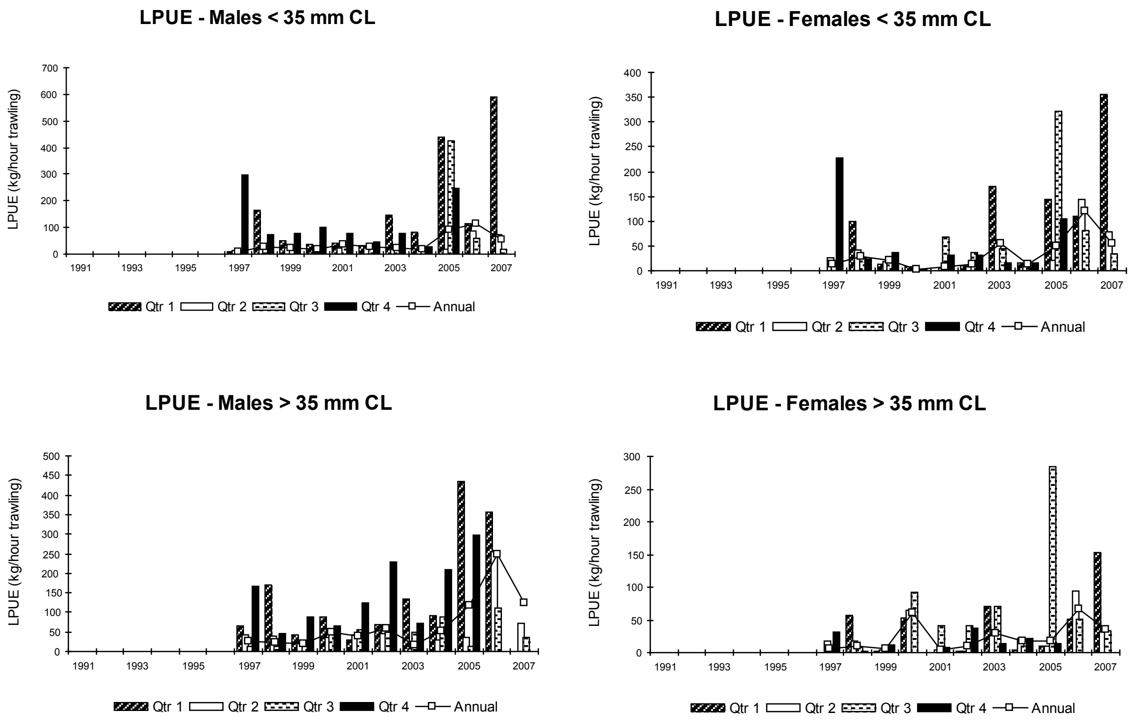


Figure 3.4.1.13 *Nephrops*, Noup (FU 10), LPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.

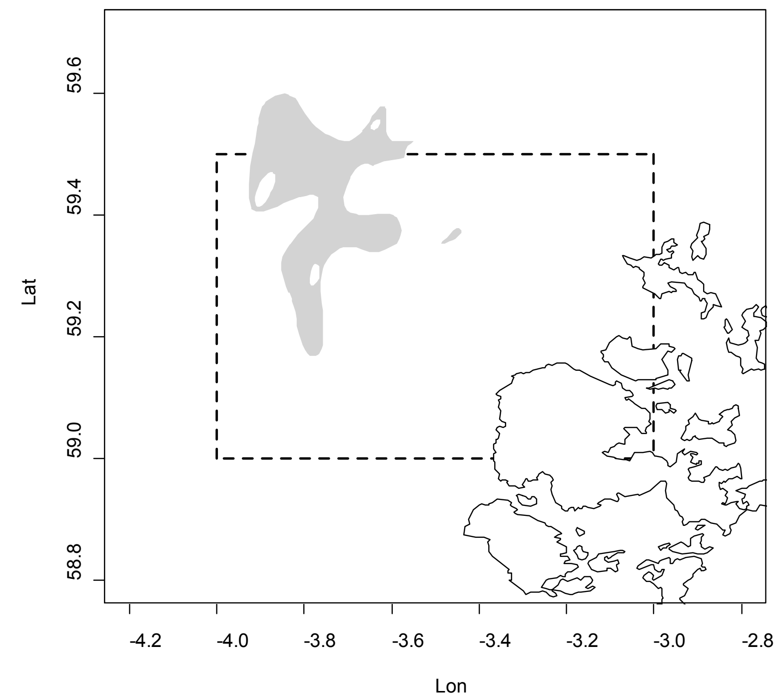


Figure B3–1. Distribution of *Nephrops* sediments in Noup (FU 10). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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 2012 [IBP NOP 2012 updated sections A, B, C, D, E, F, G]

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.

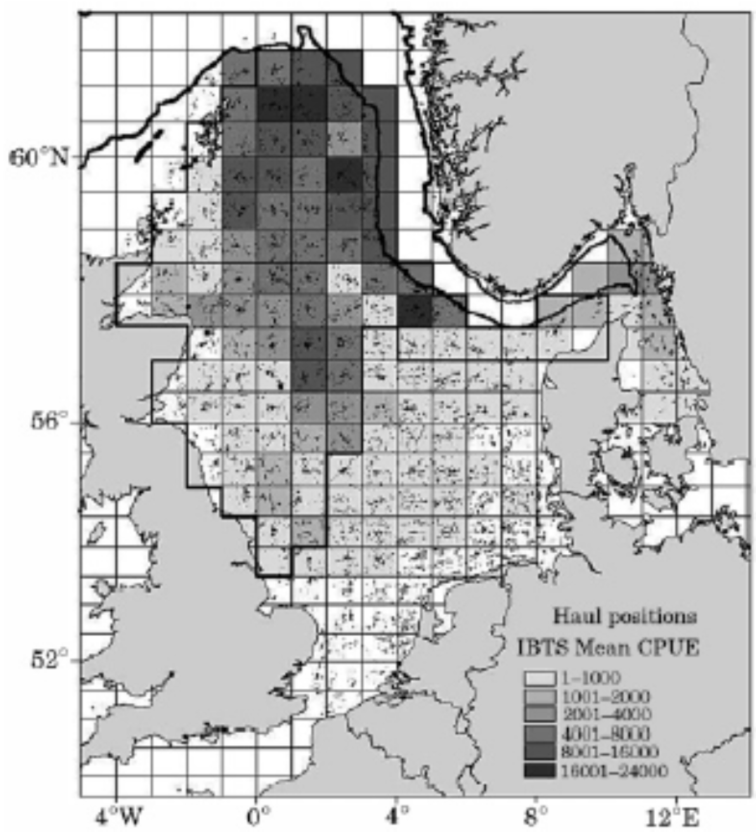


Figure 1 Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al.*, 2002b].

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. The TAC was not taken in 2008, 2009 and 2010. 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). The 2010 landings was 126 kt based on the strong 2009 year class, but based on the very low 2010 and 2011 year classes being at the same level as the low 2003-04 year classes the fishery has been been closed in the first half years of 2011 and 2012. The fishery was re-opened in second half year 2011 where a small TAC of 6 kt was taken.

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, 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**.

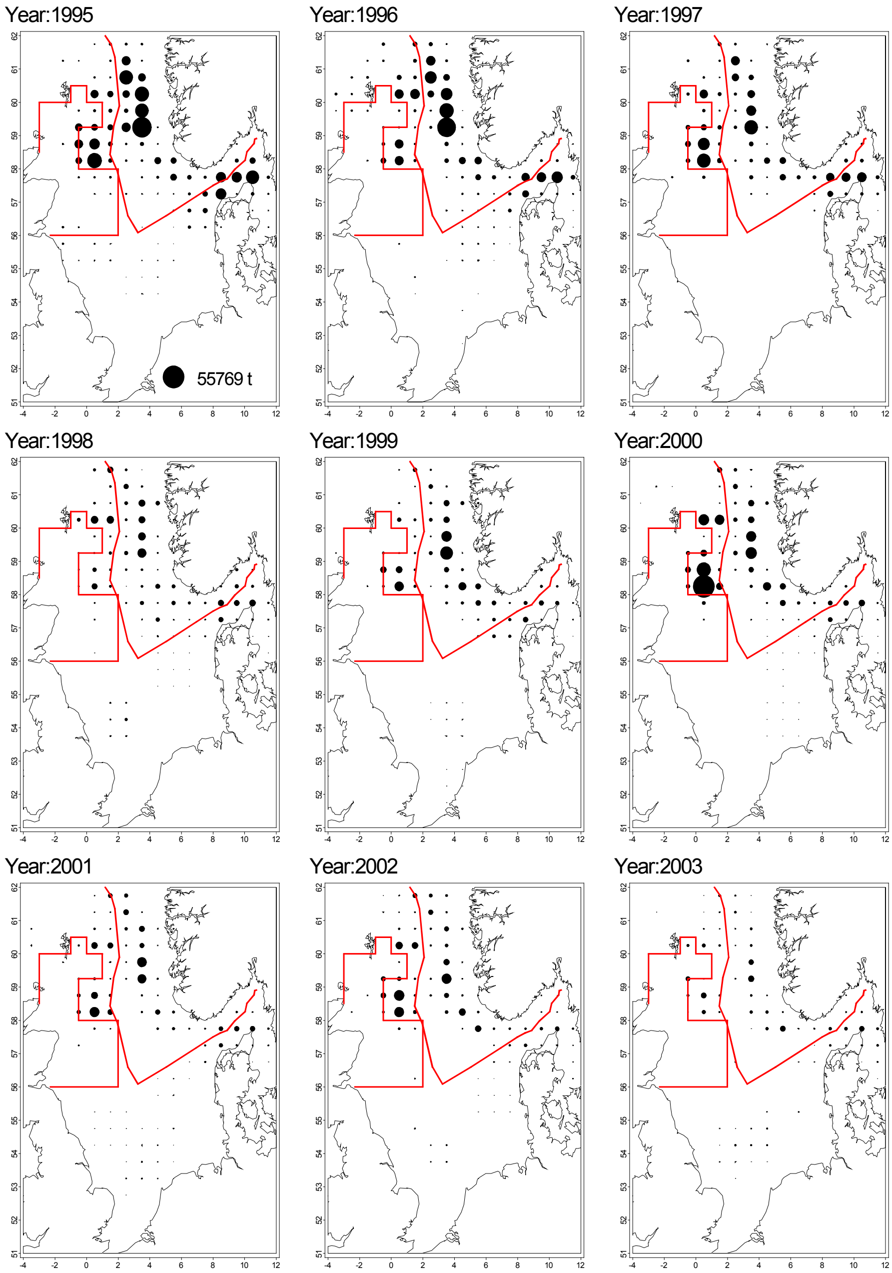


Figure 2. Landings of Norway pout by year and ICES rectangles for the period 1995-2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map.

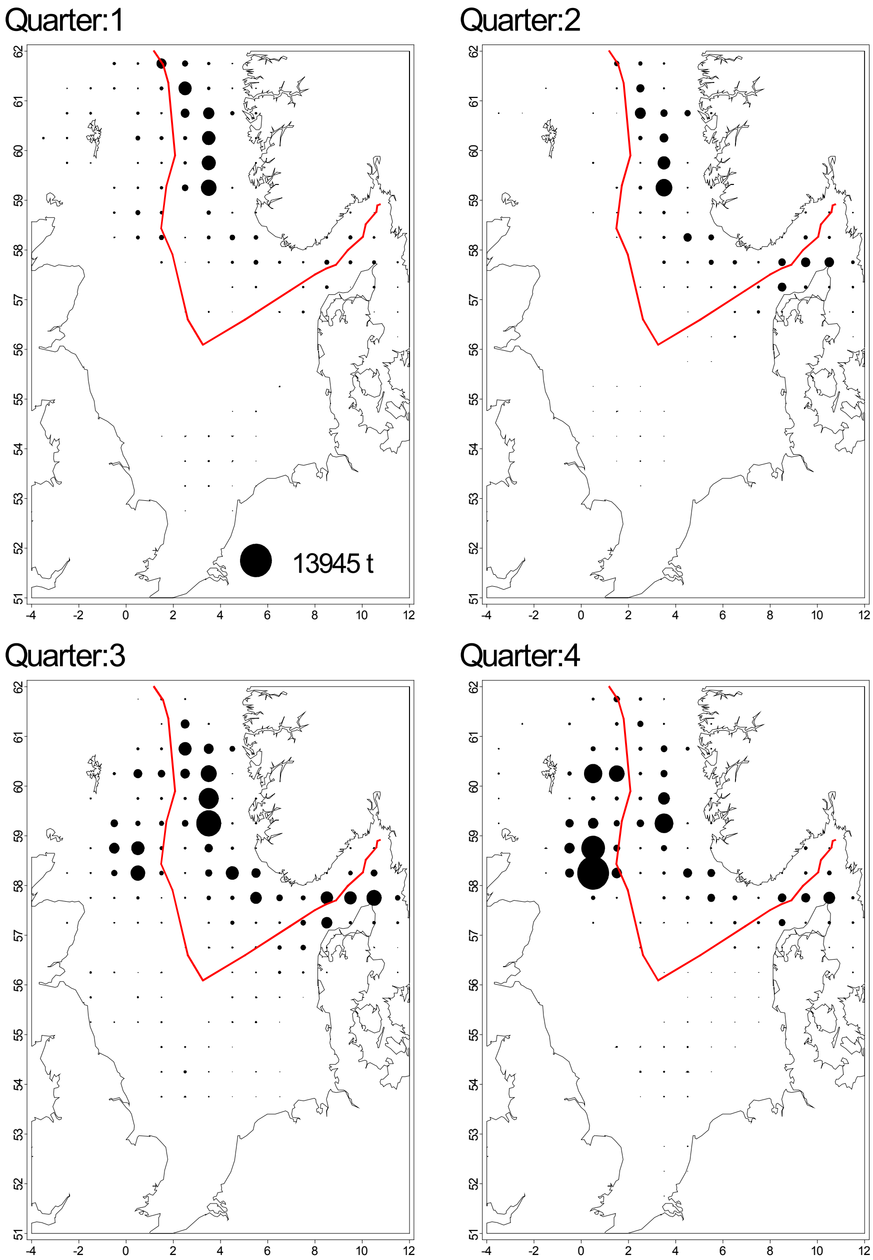


Figure 3. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994-2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map

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

In relation to an ecosystem based approach to fisheries management (CFP), spatial planning and EU Directives such as the Marine Strategy Framework Directive there will for this quality handbook be produced plots using coupled VMS and Logbook data for the Norway pout fishery by metier with recent distributions in effort, landings, and fishery capacity in the Norway pout fishery together with GIS Plots of recent stock distributions based on research survey data. This is also relevant for the fishery section with inclusion of description of recent developments in the Danish and Norwegian Norway pout fishery.

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.

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: $CPUE=b*GRT^a \Rightarrow \ln(CPUE)=\ln(b)+a*\ln((GRT-50))$

Parameter estimates from regressions of ln(CPUE) versus ln(average GRT) by period together with estimates of standardized CPUE to the group of Danish 175 GRT industrial fishery trawlers is used to standardize effort in the commercial fishery tuning fleet used in the Norway pout assessment. Parameter estimates for the period 1994-2006 is the following:

Year	Slope	Intercept	R-Square	CPUE(175 tonnes)
1994-2006	0.18	14.05	0.77	32.76

Norwegian effort data

In 1997, Norwegian effort data were revised as described in sections 13.1.3.1 and 1.3.2 of the 1997 working group report (ICES CM 1998/Assess:7). Furthermore, in the 2000 assessment Norwegian average GRT and Effort data for 1998-99 were corrected because data from ICES area IIa were included for these years in the 1998-99 assessments. Observed average GRT and effort for the Norwegian commercial fleets are given in the input data to the yearly performed assessment. This information has been put together in the report of the ICES WGNSSK meeting in 2004 (ICES WGNSSK (2005), ICES CM 2005/ACFM:07). No Norwegian effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Norwegian effort data for the directed Norway pout fishery in 2008 has not been prepared because the fishery has been on low level, and data for 2010 and 2011 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.

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 2011-2012 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 and second half year 2010 and 2011. 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 IBPNorwayPout 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 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. The revised values are shown in **Table** 5.2.6.

Summary of Inter-benchmark with revised weight, maturity and natural mortality parameters at age included in the assessment

Evaluations performed

The ICES IBPNorwayPout inter-benchmark exercise evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight at age in the stock) for the Norway pout stock in the North Sea and Skagerrak. The natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originate from results published in Nielsen *et al*. (2012), Lambert *et al*. (2009), Sparholt *et al.* (2002a,b), as well as from the multi-species assessment working group ICES WGSAM 2011. In particular, natural mortality estimates for Norway pout originating from the new key run of the multi-species SMS model were applied here. Five scenarios were considered, a Baseline Scenario following the current assessment approach and four additional scenarios which explored alternative biological inputs as presented in **Table** 5.2.5.1.

Baseline:

The May 2011 assessment is selected as the Baseline assessment. The settings of the Baseline are constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The following alternative scenarios were tested in the benchmark exercise:

Scenario1:

Natural mortality (M) change: Average Z at age used as a proxy for M, computed for ages 1-3 in the years 2004, 2005, 2007 and 2008 (years with low fishing mortality) based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1-Q1 cohorts as averages for these 4 years based on the approach in Nielsen *et al.* (2012, Fig. 1). Yearly Ms are divided by 4 to obtain quarterly Ms, and M at age 0 is set equal to that for age 1. In Scenario 1 the same maturity ogive and mean weight at age is used as in the Baseline assessment.

Scenario 2:

Natural mortality (M) change*:* Same M inputs as Scenario 1. Maturity ogive change: Maturity at age 1 is set to 0.2 from Lambert *et al.* 2009, Fig. 4. Maturity at age 2 is set to 100 %. Mean weight at age in stock (MWA) change: The settings are based on results from commercial fishery during the period 1983 to 2006 as presented in Lambert *et al.* (2009, Fig. 8.). The long term trends in MWA have been calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery and compared to Lambert *et al.* (2009) Fig. 8 values and were found to be consistent. The revised Mean Weight at Age (MWA) in the stock used in the benchmark assessment are for the 1-, 2- and 3- groups taken as the long term averages from the commercial data. Data for MWA by quarter for age 0 are kept constant as used in the Baseline. MWA is recorded from commercial fishery catch data, but not during the IBTS, from which only length data are available.

Scenario 3:

Natural mortality (M) change*:* Average Z at age (being a proxy for M) for ages 1-3 for the full year range 1983-2005 from Q1-Q1 IBTS revised indices from Nielsen *et al.* (2012) Figure 1 (as presented in Table 2 below). Yearly Ms divided by 4 to obtain average quarterly M's. M at age 0 set equal to that for age 1. Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

Scenario 4:

Natural mortality (M) change*:* M1+M2 from the multi-species SMS model from the new key run presented in the ICES WGSAM 2011 Report. Averages of the SMS estimates of quarterly M1+M2 have been used for the full year range used in the SMS key run. Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

The change in natural mortality in Scenario 1, where survey based average Zs in the 4 years with very low or no fishing mortality has been used as a proxy for M, results in applying M-values of similar magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the age and quarter invariant values used in the Baseline assessment (0.4 by age and quarter). The total mortality on the cohort (and the age specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality is very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) results in a slightly lower total stock biomass (TSB) and R and nearly the same SSB and Fbar(1-2) as the, Baseline. This is expected given these modest age specific changes in M. between Baseline and Scenario 1. The maturity ogive in Scenario 1 is the same as the Baseline with only 10% of age 1 mature, resulting in SSB similar to the Baseline. Because the catch at age data used in the Baseline and in all tested scenarios is the same, and because natural mortality on the main fished part of the population, i.e. age 1-3, is slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in Scenario 1 (and 2)), this results in the recruitment being a little bit lower while fishing mortality is similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time is observed for Scenario 1 and the Baseline.

Scenario 2 has the same natural mortality change used as in Scenario 1 but the maturity ogive and MWA vector are different. The maturity ogive has been changed to 20% mature of the 1-group, and the revised MWA in the stock is applied, obtained from long term averages measured from the commercial fishery catch. The changes in MWA are minor compared to the Baseline and do not have much impact. The change in the maturity ogive, where 20% are mature compared to value of 10% in the Baseline results in a higher SSB in Scenario 2 compared to the Baseline (and Scenario 1) as would be expected. The same trends in R and TSB as well as F are observed in Scenario 2 as in Scenario 1 and the reason for this is the same as described above under Scenario 1. Also recruitment is somewhat lower under Scenario 2. In combination, higher SSB and lower R under Scenario 2 implies a lower overall recruitment rate (R/SSB). Overall, the same perception of the stock dynamics (fluctuations) over time is observed for Scenario 2 and the Baseline.

Scenario 3 operates with bigger changes in mortality by age compared to the baseline. In this scenario the M-value for the 0- and 1-groups is around 0.25 and the M for the older age groups are significantly higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA vector is in Scenario 3 as was used in Scenario 2. Much higher mortality on the old, large fish together with fishing mortality results in a high total mortality on the older fish, and consequently, there needs to be more recruits to sustain this mortality (as the same number of fish is caught in all scenarios). This results in higher R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment for Scenario 3 are different over time compared to the Baseline.

Scenario 4 uses the multi-species model estimates of M where the quarterly mortality is higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This results in similar TSB and SSB as the Baseline but a perception of slightly higher recruitment and fishing mortality.

Conclusions

The independent reviewers considered that the new values for biological inputs constituted an improvement to the assessment of Norway pout and they support the use of Scenario 2 as the new Baseline for the stock assessment. They expressed some concern regarding the estimation of mortality rates from survey data without accounting for the survey catchability at age. Ideally natural mortality should be estimated within the stock assessment model simultaneously with estimates of survey catchability, but in most cases the data are inadequate to do this. Evidence of density dependence in Norway Pout mortality, growth and maturation rates suggests that using fixed estimates in stock assessments could lead to biases and this is worthy of further investigation. The reviewers note that the stock-recruit scatter was relatively uninformative but considered that the values being used for biological reference point should still apply. Consideration could also be given to a higher target escapement level given the importance of Norway Pout as a forage species in the ecosystem.

The Benchmark group concluded that revisions to natural mortality, maturity and mean weight at age should be included in the final benchmark assessment based on the approach in Lambert *et al*. (2009) and Nielsen *et al.* (2012). It is not recommended that Z values be used as proxies for M values for the full year range since 1983 (Scenario 3) as this average includes fishing mortality which, especially in the early part of the period, has been relatively high, i.e. this gives a biased over-estimation of M. Both Scenarios 2 and 4 were found worthy of further consideration in the Benchmark. The results of Scenarios 2 and 4 are not significantly different from the baseline scenario, and both scenarios give the same perception of the stock dynamics (fluctuations) over time as is observed for the baseline.

The population dynamic parameters and approach used in Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on A1 are higher than those based on Z estimates from the IBTS index. This difference in perception could occur if the catchability on A1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout is not lower than for the older age groups (although this is somewhat contrary to the catchability estimates at age for IBTS coming out of both the Baseline and the Scenario 2 SXSA assessment model estimates), and that there is no age specific migration out of the assessment area (being the whole North Sea and Skagerrak-Kattegat).

Scenario 4 uses results of M from the SMS model assessment which has a number of characteristics and assumptions as well. The SMS assumes constant residual mortality at age (M1), i.e. natural mortality due to other reasons than predation. This is in contradiction to potential spawning mortality as discussed in Nielsen *et al.* (2012) which would result in M increasing with age. Also, the SMS smoothes mortality out between ages 1-3, i.e. does not fully consider potential differences in natural mortality between these ages, because the model uses rather wide size intervals in its prey-predator preference model (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2012). This means that the mortalities between age 1, age 2 and age 3 tend to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 is saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS uses the saithe (predator) biomass estimates from the ICES WGNSSK single stock assessment (ICES WGNSSK 2011), and this assessment is very uncertain. Consequently, the SMS natural mortality estimates on Norway pout are dependent on uncertain assessment estimates of saithe in the North Sea which also influences age specific mortalities on Norway pout.

In comparison with the analysis of IBTS survey data , SMS estimates of total yearly M (and also Z) are higher for age 0 and 1 and lower for age 2 and 3 Norway pout (Nielsen *et al.* 2012). Even if the catchability in the surveys was lower for age group 1 then it is difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared to the observed age 2 and age 3 survey based mortality estimates. In Nielsen *et al.* (2012) it is argued that migration in or out of the area is very unlikely, so the lower estimates of Z from SMS at age 2 and especially age 3 compared to estimates from the the IBTS data (Nielsen *et al.* 2012) is difficult to explain.

In conclusion the benchmark group agreed that Scenario 2 is preferred based on the available information, and recommends Scenario 2 be used as the new baseline assessment for the Norway Pout stock.

Possible revision of the natural mortality parameter in the assessment has also been evaluated in the September 2006 benchmark assessment in response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea. In summary no conclusions could be reached from the exploratory runs then using different natural mortalities from previous primary literature (Sparholt *et al*., 2002a,b; ICES 2006) as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources used showing different trends with no obvious biological explanation. On that basis it was in the 2006 benchmark assessment decided that the final assessment continues using the constant values for natural mortality at age. The background for these conclusions and the benchmarking in 2006 was that exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 assessments (Norway pout benchmark assessments) with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt et al., 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model (ICES SGMSNS 2006) in the 2006 assessment (ICES CM 2006/ACFM:35). These revised natural mortalities are given in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005); ICES CM2005/ACFM:07) and the ICES WGNSSK 2006 report including the described inter-benchmark assessments. Furthermore, estimates of total mortality based on the SURBA assessment model estimates (2005 SURBA run for Norway pout, ICES C.M. 2006/ACFM:35) using all survey time series included in the baseline assessment (ICES CM 2007/ACFM:18 and 30) covering the period 1983-2005 indicated that for the period up to 1990-1995 Z estimated from SURBA and Sparholt *et al.,* 2002a,b is at the same level for both the 1-2 group and 2-3 group, and there also seems to be age specific differences in Z. In the period from 1995 and onwards the Z-estimates from SURBA are lower compared to the constant M values obtained from Sparholt *et al.*, 2002a,b. In later years from 2002-03 SURBA estimates of Z increased again compared to the period 1995-2001. In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. Previous evaluation of total mortality Z in recent years, where fishing mortality has been very low and where total mortality accordingly approximately equals natural mortality, has been performed and is shown in the September 2007 report (ICES CM 2007/ACFM:18 and 30, **Table** 5.2.12). This evaluation has been based on catch curve analysis on recent (IBTS Q1 and Q3) survey estimates for Norway pout. The results indicate somewhat different levels of Z between different survey time series mirroring the results from the 2006 benchmark assessment.

B.3. Assessment tuning fleet data and indices (general)

Revision of assessment tuning fleets (survey CPUE data and commercial fishery CPUE data) in the 2004 benchmark assessment (see also section B.1 and B.5 concerning the commercial fishery tuning fleet):

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described here in the stock quality handbook as well as in the benchmark assessment in the working group report from 2004.

Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohorte analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under section 12.3 of the 2004 benchmark assessment (ICES WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES WGNSSK (2005)) Figures 12.2.3-12.2.8 and Tables 12.2.9-12.2.12.

An overview over the resulting tuning data and fleets used in the assessment during different time periods are shown in the table over tuning data in section C below.

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 cor-

relation 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 subarea averages.

For an overview of the time series included and used by year and age in the assessment see Table 5.3.1 in section 5 of the assessment report. The table is also given in up-dated form here under section C.

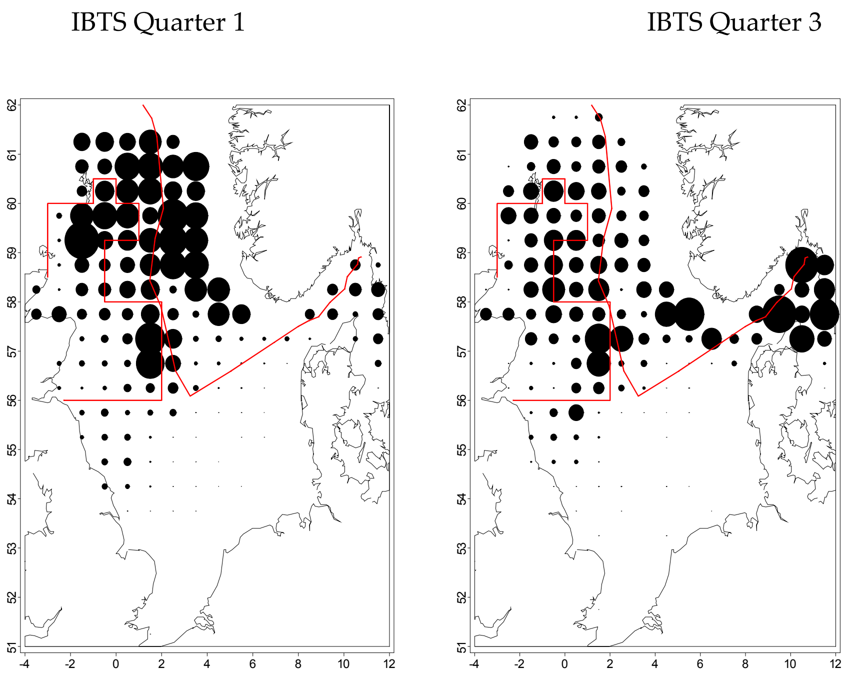


Figure 4 IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually.

B.5. Commercial CPUE data

Combined CPUE indices by age and quarter for the Danish and Norwegian commercial fishery tuning fleet (including data up to 2006) is calculated from effort data obtained from the method of effort standardization of the commercial fishery tuning fleet described under section B.1 (and B.3) and vessel category specific catches by area. CPUE is estimated on a quarterly basis for the Danish and Norwegian commercial fleets.

The resulting combined, commercial fishery CPUE data by age and quarter is presented in the input data to the yearly performed assessment. The commercial fleet data (up to 2006) are used in tuning of the assessment based on the combined and standardized Danish and Norwegian effort data and on the catch data for the commercial fishery

See also section B.1 and B3 concerning the commercial fishery tuning fleet.

Commercial fishery tuning fleets:

In addition to the analyses of the commercial fishery assessment tuning fleet (including data up to 2006) as described above (effort standardization) the quarterly CPUE indices of the commercial fishery tuning fleet were analyzed during the 2004 benchmark assessment:

1. The indices for the 0-group in 3rd quarter of the year have been excluded from the commercial fishery tuning fleet. The main argumentation for doing that is that this age group indicate clear patterns in trends in catchability over the assessment period as shown in the single fleet/quarter assessment runs in section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Secondly, there is no correlation between the commercial fishery 3rd quarter 0-group index and the commercial fishery 4th quarter 0-group index, and no correlation between the 3rd quarter commercial fishery 0-group index in a given year with the 1-group index of the 3rd quarter commercial fishery the following year.
2. The 2nd quarter indices for all age groups have been excluded from the commercial fishery tuning fleet. This is mainly because of indications of strong trends in catchability over time in the assessment period for this part of the tuning fleet for all age groups as indicated by single fleet tuning runs in the section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Also, the within quarter and between quarter correlation indices are in general relatively poor. The cohorte analyses of the 2nd quarter commercial fishery indices indicate as well relative changes over time.

C. Assessment: data and method

Model and Software used (current assessment):

The SXSA (Seasonal Extended Survivors Analysis: Skagen (1993)) has been used to estimate quarterly stock numbers and fishing mortalities for Norway pout in the North Sea and Skagerrak as the standard assessment method. The catch at age analysis was carried out according to the specifications given in the present stock quality handbook. The SXSA program is available from ICES. This model is used for the final assessment as standard software.

The assessment is analytical using catch-at-age analysis based on quarterly catch and CPUE data. The assessment is considered appropriate to indicate trends in the stock and immediate changes in the stock because of the seasonal assessment taking into account the seasonality in fishery, use seasonal based fishery independent information, and using most recent information about recruitment. The seasonal variation in effort data is one reason for performing a seasonal VPA. The assessment provides stock status and year class strengths of all year classes in the stock up to the first quarter of the assessment year (spring assessment) and second quarter of the assessment year (autumn assessment). The real time assessment method with up-date every half year also gives a good indication of the stock status the 1st January the following year based on projection of existing recruitment information in 3rd quarter of the assessment year.

The SMS program available from Morten Vinther, DIFRES, Copenhagen (Exploratory run, 2004 and 2005, April 2006 and September 2006). Used in exploratory runs.

The XSA program from ICES. Used in exploratory runs.

The SURBA program available from Coby Needle, MARLAB, Aberdeen; Used in an exploratory run, 2005.

The XSA and SURBA models and software cannot perform quarterly based assessment.

Model Options chosen (current assessment):

In the options chosen in the SXSA for the Norway pout assessment the catchability, r, per age and quarter and fleet is assumed to be constant within the assessment period where the estimated catchability is a geometric mean over years by age, quarter and tuning fleet. In the 2004 benchmark assessment exploration of trends in tuning fleet catchabilities was investigated by single fleet runs with the SXSA. The accepted assessment with revised tuning fleets in the 2004 benchmark assessment assume constant catchability.

Tuning is performed over the period 1983 to present producing log residual (log(Nhat/N)) stock numbers and survivor estimates by year, quarter, age and tuning fleet. The contributions from the various age groups to the survivor estimates by year and quarter and fleet are in the SXSA combined to an overall survivors estimate, shat, estimated as the geometric mean over years of log(shat) weighted by the exponential of the inverse cumulated fishing mortality as described in Skagen (1993).

The parameter settings and options of the SXSA and SMS have been the same in all recent years of the assessment, except that recruitment season to the fishery has been backshifted from 3rd quarter of the year to 2nd quarter of the year when running SXSA in the autumn in order to gain benefit from the most recent 0-group indices from the 3rd quarter surveys (SGFS and EGFS as explained above) in the assessment. This procedure is still followed. This was not necessary in the SMS assessment. (In the May 2007 assessment with SXSA this backshifting has not been performed).

No time taper or shrinkage is used in the catch at age analysis in general. The four surveys and the seasonally (by quarter) divided commercial fleets (the latter only including data up to year 2006) in are all used in the tuning.

The following parameters are used:

```
Year range:                                                  1983 -
Seasons per year:                                                4
The last season in the last year is season:                      3
Youngest age:                                                    0
Oldest true age:                                                 3
Plus group:                                                      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:

Norway pout IV & IIIaN (Skagerrak). Tuning fleets and indices used in the final 2004 benchmark assessment as well as in the 2005-2012 assessments compared to the 2003 assessment.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-12 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	1982-2012
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2011
	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	1998-2011
	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	1991-2011
	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 $\mathbf{B_{trigger}}$ (=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 as well as section 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.

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 assessment year.

Stock recruitment model used:

The forecast is using the geometric mean recruitment for the stock-recruitment relationship.

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 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 assumes a 2012 (the 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 background for selecting these 3 recent years exploitation pattern is that the exploitation pattern between seasons (and ages) has changed since 2004 which was the last year where the directed Norway pout fishery was open in all seasons of the year in the EU Zone up to 2007. The recent exploitation pattern is very different from the average previous long term (1991-2004) exploitation pattern. The targeting in the small meshed trawl fishery has changed recently where targeting of Norway pout has decreased. See further details of the settings in the ICES WGNSSK Report.

The targeting in the small meshed trawl fishery has changed recently where targeting of Norway pout has decreased. Also, there has in recent years been introduced sorting grids in the fishery also changing the exploitation pattern of Norway pout (Eigaard and Nielsen, 2009; Eigaard *et al.*, 2012).

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:

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 assessment 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 $B_{MSY} = B_{trigger\ MSY} = B_{pa}$ 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 (more in) 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, and (c) 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

From 2010 and onwards:

	Type	Value	Technical basis
MSY	MSY $B_{escapement}$	150 000 t	$= B_{pa}$
Approach	F_{MSY}	Undefined	None advised
	B_{lim}	90 000 t	$B_{lim} = B_{loss}$, the lowest observed biomass in the 1980s
Precautionary	B_{pa}	150 000 t	$= B_{lim}\, e^{0.3*1.65}$
Approach	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. 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

$$B_{pa} = B_{lim}\, e^{0.3*1.65} \text{ (SD).}$$

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 $B_{MSY} = B_{pa}$ (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 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) 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:

<u>Precautionary Approach reference points</u>:

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} $e^{0.3\text{-}0.4*1.65}$ (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} $e^{0.3\text{-}0.4*1.65}$ (SD).

A SD estimate around 0.3-0.4 is considered to reflect the real uncertainty in the assessment. This SD-level also corresponds to the level for SD around 0.2-0.3 recommended to use in the manual for the Lowestoft PA Software (CEFAS 1999). The relationship between the B_{lim} and B_{pa} (90 000 and 150 000 t) is 0.6.

B_{lim} is 90 000 t, the lowest observed biomass

F_{lim} None advised.

F_{pa} None advised.

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 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. (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. 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.** 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.

According to the May 2012 Forecast then it appears that if the objective is to maintain the spawning stock biomass above MSY $B_{trigger} = B_{pa}$ by 1st of January 2013 then no catch can be taken in 2012 corresponding to a F around 0 according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 31 000 t can be taken in 2012. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2012 (corresponding to a F around 0.60) according to the long term management strategies. In recent years the escapement strategy has been practiced in reality in management. Even with zero catch in 2012 then the stock will decrease to below Bpa by 1st of January 2013. Under a fixed F-management-strategy with F around 0.35 in 2012 as well as under a fixed TAC strategy with a TAC of 50 000 t 2012 the stock will accordingly also decrease to be under Bpa by 1st of January 2013 according to the long term management strategies.

Long term management strategies (this part last updated May 2009)

In autumn 2006 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).

Summary of management plan evaluations

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 $B_{pa} = B_{MSY\text{-}trigger} = B_{MSY}$, 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 escapement strategy has higher long term yield compared to the fixed fishing mortality 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. Recent years TAC's indicate choice of a management strategy close to the fixed F strategy.

A detailed description of the long term management strategies and management plan evaluations can be found 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.

Background

On basis of an joint EU and Norwegian Requests in autumn 2006 with respect to Norway pout management strategies and by-catches in the Norway pout fishery as well as on basis of the work by ICES WGNSSK in autumn 2006 and spring 2007 during the ICES AGNOP 2007 (ICES CM 2007/ACFM:39) ACFM has already by May 2007 evaluated detailed output from management plans and harvest control rules evaluations considering two different management strategies for Norway pout, i.e. the real time escapement management strategy and the long term fixed F or E management strategy. This has been based on use of advanced stochastic simulation models and results from here supplied by DTU-Aqua. The fixed TAC long term management strategy was not evaluated in depth by the ICES AGNOP as it was not considered realistic at that time because of substantial loss in yield, but have later in autumn 2007 associated to the ICES WGNSSK in autumn 2007 (ICES CM 2007/ACFM:30) been evaluated and presented with the two other management strategies. Furthermore, in addition to the ICES response on the EC and Norway joint request on management measures for Norway pout, Denmark has, in autumn 2007, requested ICES to provide a full evaluation of the fixed TAC strategy for Norway pout including an estimation of the long term TAC which would be sustainable with a low probability (5%) of the stock falling below B_{lim}. An ICES ACFM subgroup considered the documentation during the autumn 2007 ACFM meeting and found that some further studies would be required in order to provide a well documented answer. All this was provided through the ICES AGSANNOP Report (ICES CM 2007/ACFM:40).

Long Term Harvest Control Rules for Norway pout in the North Sea and Skagerrak

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.

Conclusions from 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.

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. 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.

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):

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

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.

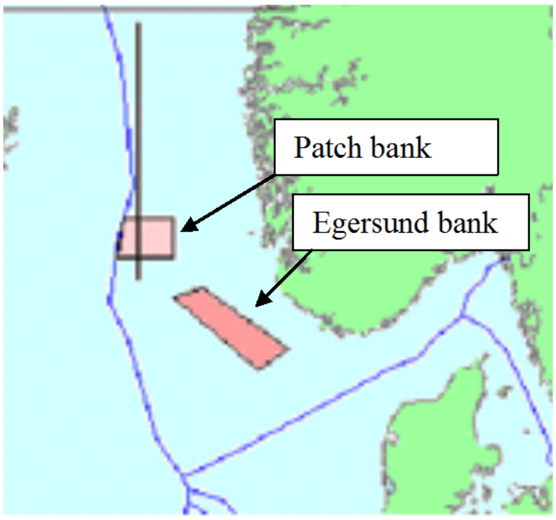
ACFM recommended that effort in 2005 should not exceed 40 % of the effort in 2004. Based upon this advice, the sandeel season in the Norwegian economic zone was further shortened in 2005. The sandeel season, defined as the period when smaller mesh size than 16 mm can be used, was 8 months (March – October) 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.

Additional Danish regulations of the industrial fisheries can be found in section 5, sandeel, STCEF Report 2005).

There is a recommendation from ICES and ongoing Danish initiatives and sea trials aiming at implementing selective grids in the trawls used for Danish Norway pout fishery in the North Sea and in Skagerrak-Kattegat (IIIa). It is expected that a regulation introducing such selective devices will be implemented soon. The difficulty here is to develop a robust selective grid with smaller grid bar widths which have to be used in the Danish trawls in order to reduce by-catch of especially other smaller gadoids (in the areas where the Danish fishery operate) compared to the Norwegian trawls where the main aim is to reduce the by-catch of especially larger saithe in the areas where the Norwegian fishery operate.

G. References

Albert, O. T. 1994. Biology and ecology of Norway pout [Trisopterus esmarki, Nilsson, 1885] in the Norweigian Deep, ICES Journal of Marine Science, 51: 45-61

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O. R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fisheries Research, 68: 99–112.

Eigaard, O. and Nielsen, J.R. 2009. Reduction of by-catch in a small meshed trawl fishery through gear developments facilitating ecosystem based fisheries management. ICES C.M.2009/M:22, 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

ICES 1977. Review of the Norway pout and sandeel within the NEAFC convention area. Appendix to ICES report C.M. 1977/F:7.

ICES 1996. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES C.M. 1996/Assess:6.

ICES 1998. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 1997. ICES CM 1998/Assess :7

ICES 1999. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 1998. ICES CM 1999/ACFM :8

ICES 2006. ICES SGMSNS Report

ICES 2011. ICES WGSAM Report

ICES. 2012a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 27 April–10 May 2012. ICES CM 2012/ACOM:??.

ICES 2012b (EU Request on new management plan evaluations on Norway pout)

ICES 2012c. ICES IBPNorwayPout Inter-benchmark assessment report.

Lambert, G*., Nielsen, J.R..*1, Larsen, L., and H. Sparholt. 2009. Maturity and Growth population dynamics of Norway pout (Trisopterus esmarkii) in the North Sea, Skagerrak and Kattegat. ICES J. Mar. Sci. 66 (9): 1899-1914; doi:10.1093/icesjms/fsp153. (*Authorship equal; 1Corresponding author)

Larsen, L.I., Lassen, H., Nielsen, J.R., and Sparholt, H. 2001. Working Document to the 2000 meeting of the WGNSSK. ICES C.M.2001/ACFM:07).

Nielsen, J.R., and Madsen, N. 2006. Gear technological approaches to reduce un-wanted by-catch in commercial Norway pout fishery in the North Sea. Working Document No. 23 to the 2006 meeting of the WGNSSK, 11 pp. ICES C.M.2006/ACFM:35

Nielsen, J.R.*[1], Lambert, G.*, Bastardie, F., Sparholt, H., and M. Vinther. 2012. Do Norway pout (Trisopterus esmarkii) die from spawning stress? Mortality of Norway pout in relation to growth, maturity and density in the North Sea, Skagerrak and Kattegat. ICES J. Mar. Sci. 69(2): 197-207. *Authorship equal; [1]Corresponding author. Doi:10.1093/icesjms/fss001

Poulsen, E.M. 1968. Norway pout: Stock movement in the Skagerrak and in the north-eastern North Sea. Rapports et Proces-Verbaux des Reunions du Conseil International pour l'Exploration de la Mer, 158: 80-85.

Raitt, D.F.S. 1968. The population dynamics of Norway Pout in the North Sea. Marine Research 5 : 1-23.

Skagen, D. 1993. Revision and extension of the Seasonal Extended Survivors Analysis (SXSA). Working document for Norway pout and Sandeel Working Group. Unpublished

Sparholt, H., Larsen, L.I., Nielsen, J.R. 2002a. Verification of multispiesces interactions in the North Sea by trawl survey data on Norway Pout (*Trisopterus esmarkii*). ICES Journal of Marine Science 59:1270-1275.

Sparholt, H., Larsen, L.I., Nielsen, J.R. 2002b. Non-predation natural mortality of Norway pout (*Trisopterus esmarkii*) in the North Sea. ICES Journal of Marine Science 59:1276-1284.

STCEF, 2005. Report of the *ad hoc* scientific working group on management measures for sandeel, Norway pout, anglerfish and horse mackerel in the North Sea and Skagerrak. Charlottenlund, Denmark, 23 to 27 May 2005. STCEF Working Group Report, EU Commission.

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 fishyer in 2010, 2011 and 2012 as well as with the most recent results published in Eigaard, Hermann and Nielsen (2012).

The fishery is targeting Norway pout and blue whiting. Historically, the fishery includes bycatches especially of haddock, whiting, saithe, and herring. In managing this fishery, by-catches of cod, haddock, whiting, saithe, herring, and blue whiting should be taken into account, and existing technical measures to protect these bycatch species should be maintained or improved. Bycatches of these species have been low in the recent decade. Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009). ICES suggests that these devices (or modified forms of those) should be brought into use in the fishery. In 2010 grids have been used in the Norwegian fishery. The introduction of these technical measures should be followed up by adequate control measures of landings or catches at sea to ensure effective implementation of the existing bycatch measures. An overview of recent relevant management measures and regulations for the Norway pout fishery and the stock can be found in this **Stock Annex.**

By-catches in Norway pout fisheries (2006 Evaluations)

Demersal fisheries in the North Sea are mixed fisheries, with many stocks exploited together in various combinations in different fisheries. Small-mesh industrial fisheries for Norway pout takes place in the northern and north-eastern North Sea and has by-catches of haddock, whiting, herring and blue whiting. Some cod is also taken as a by-catch, predominantly at ages 0 and 1 (ICES, 2006). With respect to un-intended by-catch in the commercial, small-meshed Norway pout trawl fishery in the North Sea and Skagerrak conducted by Denmark and Norway for reduction purposes ICES ACFM writes that management advice must consider both the state of individual stocks and their simultaneous exploitation. Stocks at reduced reproductive capacity should be the overriding concern for the management of mixed fisheries where these stocks are exploited either as a targeted species or as a by-catch (e.g. ICES, 2006).

Existing by-catch regulations:

In the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries by-catch regulations in the Norway pout fishery have been established (e.g. EU Regulation No 850/98 (EU, 1998)). The by-catch regulations in force at present for small meshed fishery (16-31mm in mesh size) in the North Sea is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other by-catch species. Provisions regarding limitations on catches of herring which may be retained on board when taken with nets of 16 to 31 mm mesh size are stipulated in EU Community legislation fixing, for certain fish stocks and groups of fish stocks, total allowable catches and certain conditions under which they may be fished. (EU, 1998) At current 40% herring is allowed in the Norway pout fishery.

Important by-catch species:

By-catch of the following species in the commercial, small meshed Norway pout fishery has been un-wanted and a concern for fisheries management: Cod, Haddock, Saithe, Whiting, Monkfish, Herring, and Blue Whiting, where especially by-catch of juvenile haddock and cod as well as larger saithe has been in focus.

By-catch levels from landings statistics:

In Tables A1 and A2 below are presented recent (2002-2005) by-catch levels by species in Danish and Norwegian small meshed industrial trawl fishery in the North Sea and Skagerrak areas targeting Norway pout. For Norway the landings used for consume purposes in the small meshed fishery can only be allocated to industrial fishery for the last two years. IMR does not have access to logbooks from industrial vessels. The Norwegian data are evaluated rather un-certain.

By-catch levels and factors affecting them from commercial fishing trials 2005:

Danish-Norwegian fishing trials and pilot investigations were performed in autumn 2005 in order to explore by-catch- levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. The results are given in Working Document No. 22 to the WGNSSK (2006) by *Degel, Nedreaas and Nielsen (2006).* The trial fishery was performed by two Norwegian commercial trawlers and a Danish commercial trawler traditionally involved in the small meshed industrial trawl fishery in the North Sea and Skagerrak targeting Norway pout. The investigation was in cooperation between the fisheries research institutes DIFRES and IMR. The South Norwegian Trawl Association (SNTA) and the Danish Fishermen's Association (DF) provided the contact to the fishing vessels used.

The fishery was carried out in autumn 2005 within periods and areas of conducting traditional fishery for Norway pout. The Norwegian vessels conducted each a survey to the area vest of Egersund on the edge of the Norwegian Trench. The Danish vessel conducted two surveys at Fladen Ground in and around the closed box for Norway pout fishery in the North Sea. Comparison fishery between one of the Norwegian vessels and the Danish vessel was performed on a spatio-temporally overlapping scale at the Patch Bank, a closed box for Norway pout fishery in an area between the Egersund Bank and Fladen Ground. The Norwegian vessels conducted both day and night fishery while the Danish vessel only fished during day time.

The results (except for the figure and table showing the diurnal variation in the fishery) comprise only hauls from day time fishery conducted with standard trawl gears used in the commercial small meshed industrial fishery targeting Norway pout. The skipper at the Danish vessel decided the positions and fishing design on a smaller fraction of the conducted hauls based on his evaluation of optimizing the fishery economically, while the rest of the hauls were allocated and pre-distributed in two selected ICES statistical squares.

In general the ratio between the Norway pout target species and the sum of by-catch of certain selected species indicate that the by-catch ratio is high in the commercial Norway pout fishery. However, statistical analyses reveal that the fishermen can significantly minimize the by-catch ratio by targeting in the fishery (spatio-temporal targeting, way of fishing, etc.), i.e. when they determine the fishing stations and the fishery performed. The pilot investigations show no general significant spatio-temporal patterns in the by-catch ratio. However, there are from the results obvious geographical and diurnal differences in the species composition of the by-catch between areas and between day and night fishery. The length distributions of the catch rates by species indicate spatial patterns between some of the species caught. These fishing trials and pilot investigations are based on only very few observations, and data are obviously rather uncertain, variable and noisy. In general, it can be concluded that relatively high by-catches can be reduced by specific targeting in the fishery, both with respect to allocation of the fishery in time and space but also in relation to fishermen knowledge about the fishery and resource availability. This demands though that the skippers/fishermen act accordingly when fishing, and a proper at-sea control. The conclusions above relate to using the Turbotrawl and the Expo1300. The few experiments with Jordfraeser and Kolmuletrål 1100 indicate a different species composition, with unchanged or higher by-catch rates of most species and general significant lover catch rates of Norway pout.

With regard to diurnal differences in the catch rates of Norway pout and by-catches of other species, the few results at present indicate significant lower by-catch of Blue whiting during night hauls. The rest of the by-catch species show no diurnal differences

With regard to possible depth differences in the catch rates of Norway pout and by-catches of other species, this matter relates primarily to the areas close to the Norwegian Deep, and more investigations are about to be carried out to document this better.

Technical measures to reduce by-catches.

Regulation of spatio-temporal effort allocation (closed seasons and areas):

The above investigations indicate spatio-temporal differences in catch levels by species in the commercial small meshed fishery for Norway pout as well as an effect of targeting and use of fishing method on the by-catches. However, these patterns are only based on results from pilot investigations. Knowledge about spatio-temporal patterns in catch rates of target species and by-catch species in the fishery are at present not adequate to implement management measures with respect to regulations on spatio-temporal allocation of fishing effort to reduce by-catches.

During the 1960s a significant small meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large by-catches, especially of haddock and whiting. In order to reduce by-catches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small meshed trawls were banned. The "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56° N and west of 1° W. In the Norwegian economic zone, the Patch bank has been closed since 2002. It is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box both with respect to catch rates of target and by-catch species as well as effects on the stocks (EU, 1985; 1987a; 1987b; ICES, 1979). There has not been performed fully covering evaluation of the effect of closed areas in relation to interacting effects of technological development in the fishery including changed selectivity and fishing behaviour over time in relation to by-catch rates. These effects can not readily be distinguished.

Gear technological by-catch reduction devices:

Investigations of gear specific selective devices and gear modifications to reduce unwanted by-catch in the small meshed Norway pout fishery in the North Sea and Skagerrak have been performed in a number of studies. It was recently investigated based on sea trials in year 2000 and reported through an EU Financed Project (EU, 2002), and the results from here have been followed up upon in a scientific paper from DIFRES and CONSTAT, DK (Eigaard and Holst, 2004). Previous investigations of size selective gear devices in the Norway pout trawl fishery in the North Sea was performed by IMR Norway during sea trials in 1997-1999 also published in a scientific paper (Kvalsvik *et al*., 2006), as well as in a number of other earlier studies on the issue. Main results of previous investigations have been reviewed and summarized in Working Document No. 23 to the WGNSSK (2006) by *Nielsen and Madsen (2006)*.

Early Scottish and Danish attempts to divide haddock, whiting and herring from Norway pout by using separator panels, square mesh windows, and grids were all relatively unsuccessful. More recent Faeroese experiments with grid devices have been more successful. A 74 % reduction of haddock was estimated (Zachariassen and Hjalti, 1997) and 80% overall reduction of the by-catch (Anon., 1998).

Eigaard and Holst (2004) and EU (2002) found that when testing a trawl gears with a sorting grid with a 24 mm bar distance in combination with a 108 mm (nominal) square mesh window through experimental, commercial fishery the results showed improved selectivity of the commercial trawl with catch weight reductions of haddock and whiting of 37 and 57%, but also a 7 % loss of Norway pout. The study showed that application of these reduction percents to the historical level of industrial by-catch in the North Sea lowered on average the yearly haddock by-catch from 4.3 to 2.7% of the equivalent spawning stock biomass. For whiting the theoretical reduction was from 4.8 to 2.1%. The purpose of the sorting grid was to remedy the by-catch of juvenile gadoids in the industrial fishery for Norway pout, while the purpose of square mesh window was to retain larger marketable consume fish species otherwise sorted out by the grid. By-catches in this study was mainly evaluated for haddock, whiting and cod, i.e. not for all above mentioned by-catch species of concern in the Norway pout fishery. However, the experiments have shown that the by-catch of important human consumption species in the industrial fishery for Norway pout can be reduced substantially by inserting a grid system in front of the cod-end. The study also demonstrated that it is possible to retain a major part of the larger marketable fish species like whiting and haddock and at the same time maintain substantial reductions of juvenile fish of the same species. The study also gave clear indications that further improvement of the selectivity is possible. This can be obtained by adjusting the bar distance in the grid and the mesh size in the selective window, but further research would be necessary in order to establish the optimal selective design.

The results reported in Kvalsvik *et al*. (2006) include results for more species of concern in the Norway pout fishery. They carried out experimental fishing with commercial vessels first testing a prototype of a grid system with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars, and then, secondly, testing if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the first experiments, only a bar space of 22mm were used in the later experiments. These showed respectively that a total of 94.6% (weight) of the by-catch species was sorted out with a 32.8% loss of the industrial target species, where the loss of Norway pout was around 10%, and respectively that 62.4% of the by-catch species were sorted out and the loss of target species was 22%, where the loss of Norway pout was around 6%. When testing selectivity parameters for haddock, the main by-catch species, the parameters indicated a sharp size selection in the grid system.

In conclusion, the older experiments indicate that there is no potential in using separator devices and square mesh panels. Recent and comprehensive experiments with grid devices indicate a loss of of Norway pout at around 10% or less when using a grid with a 22-24 mm bar distance. It is also indicated that there is a considerable loss of other industrial species being blue whiting, Argentine and horse mackerel. A substantial by-catch reduction of saithe, whiting, cod, ling, hake, mackerel, herring, haddock and tusk have been observed. The reduction in haddock by-catch is, however, lowered by the presence of smaller individuals. The Danish experiment indicates that it is possible to retain larger valuable consume fish species by using a square mesh panel in combination with the grid. Selectivity parameters have been estimated for haddock, whiting and Norway pout. These can be used for simulation scenarios including estimates of the effect of changing the bar distance in the grid. Selectivity parameters for more by-catch species would be relevant. However, the grid devices have shown to work for main by-catch species.

A general problem by implementing sorting grids in industrial fisheries is the very large catches handled. Durability and strength of the grid devices used under fully commercial conditions are consequently very important and needs further attention. Furthermore, handling of heavy grid devices can be problematic from some vessels. Grid devices are, nevertheless, used in most shrimp fisheries, where catches often are large.

Conclusions from the above section

In conclusion, the commercial, exploratory fishery and provision of recent by-catch information has shown by-catch-ratios to be significant in the fishery, however, spatio-temporal differences in catch levels by species has been observed and by-catches can be reduced through targeting and fishing method. Recent scientific research based on at sea trials in the commercial fishery has shown that use of gear technological by-catch devices can reduce by-catches of among other juvenile gadoids significantly. Accordingly, it is recommended that these gear technological by-catch reduction devices (or modified forms of those) are brought into use in the fishery. Introduction of those should be followed up upon by adequate landings or at sea catch control measures to assure effective implementation of the existing by-catch measures.

References (in relation to by-catch and gear selectivity)

Anon 1998. Report of the study group on grid (grate) sorting systems in trawls, beam trawls and seine nets. ICES CM 1998/B: 2.

Degel, H., Nedreaas, K., and Nielsen, J.R. 2006. Summary of the results from the Danish-Norwegian fishing trials autumn 2005 exploring by-catch-levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. Working Document No. 22 to the 2006 meeting of the WGNSSK, 13 pp. ICES C.M.2006/ACFM:35

Eigaard, O.R., and Holst, R. 2004. The effective selectivity of a composite gear for industrial fishing: a grid in combination with a square mesh window. Fish. Res. 68: 99-112.

Eigaard, O., and Nielsen, J. R. 2009. Reduction of bycatch in a small meshed trawl fishery through gear developments facilitating ecosystem-based fisheries management. ICES CM 2009/M:22. 18 pp.

Eigaard, O., Hermann, B., and Nielsen, J.R. 2012. Influence of grid orientation and time of day in a small meshed trawl fishery for Norway pout (Trisopterus esmarkii). Aquat. Liv. Res. 25: 15-26. doi 10.1051/alr/2011152

EU, 1985. Report of the Working Group on the by-catches in the Norway pout fishery. Submitted to EU STECF, September 1985, DISK. STCF 9 (N. Pout).

EU, 1987a. Bioeconomic evaluation of the Norway pout box. EU Commission. Internal Information on Fisheries: 16.

EU, 1987b. The consequences of increased North Sea herring, haddock and whiting abundances for the fishery for Norway pout in the North Sea. EU Commission Report, Contract No 1946, 12.06.87 between Marine Resources Assessment Group, London, and Danish Institute for Fisheries and Marine Research, Charlottenlund.

EU, 1998. EU Council Regulation (EC) No. 850/98. Official Journal of the European Communities L 125 of 30 March 1998, Vol. 41 of 27th April 1998: 36 pp. ISSN 0378-6988.

EU, 2002. Development and testing of a grid system to reduce by-catches in Norway pout trawls. Final Consolidated Report, EU Study Project No. 98/002: 32pp + 75 pp. EU Commission DG Fisheries, Bruxelles.

ICES 1977. Review of the Norway pout and sandeel within the NEAFC convention area. Appendix to ICES report C.M. 1977/F:7.

ICES, 1979. Report of an ad hoc working group on the Norway pout box problem. ICES C.M. 1979/G:2.

ICES, 2006. ICES ACFM Advice May 2006. Norway pout in the North Sea. International Council for Exploration of the Sea (ICES), Copenhagen, Denmark. Available from http://www.ices.dk/committe/acfm/comwork/report/asp/advice.asp

Kvalsvik, K., Huse, I., Misund, O.A., and Gamst, K. 2006. Grid selection in the North Sea industrial trawl fishery for Norway pout: Efficient size selection reduces by-catch. Fish. Res. 77: 248-263.

Nielsen, J.R., and Madsen, N. 2006. Gear technological approaches to reduce un-wanted by-catch in commercial Norway pout fishery in the North Sea. Working Document No. 23 to the 2006 meeting of the WGNSSK, 11 pp. ICES C.M.2006/ACFM:35.

Zachariassen, K., Jákupsstovu, S.H., 1997. Experiments with grid sorting in an industrial fishery at the Faeroes. Working Paper. FTFB Working Group, ICES. Available from the Fisheries Laboratory of the Faroes, Thorshavn, April 1997.

Table A1. Landings (tons) per species in the Danish small meshed Norway pout fishery in the North Sea by year and quarter. Landings are divided into the part used for reduction purposes and the part used for human consumption purposes. The latter landings are included in catch in numbers of human consumption landings

Year	Species	Purpose	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Blank	Total	% of total catch
2005	Norway pout	Reduction						0	0
2004		Reduction	504		1474	5877		7855	87.5
2003		Reduction		45	1556	6322		7923	87.8
2002		Reduction	2,546		5,603	25,567	9,508	43224	78.6
2005	Blue whiting	Reduction						0	0
2004		Reduction	66					66	0.73
2003		Reduction		19	23	8		50	0.55
2002		Reduction	1966		589	950	1171	4676	8.50
2005	Herring							0	0
2004			11		422	304		737	8.21
2003				1	113	222		336	3.73
2002					217	2337	639	3193	5.81
2005	Cod	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction				1		1.3	0.01
		Hum. Con.	0.3		0.2	0.3		0.8	0.01
2003		Reduction				3		3	0.03
		Hum. Con.			0.5	0.8		1.3	0.01
2002		Reduction				3		3	0.01
		Hum. Con.	2		15.4	22.7		40.1	0.07
2005	Haddock	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	5		49	3		57	0.63
		Hum. Con.	0.2		0.2	0.5		0.9	0.01
2003		Reduction				16		16	0.18
		Hum. Con.			0.1	1.8		1.9	0.02
2002		Reduction			408	1137		1545	2.81
		Hum. Con.	0.7		4.3	9.8		14.8	0.03
2005	Whiting	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	32		59	141		232	2.58
		Hum. Con.	0.4		0.3	0.2		0.9	0.01
2003		Reduction			51	214		265	2.94
		Hum. Con.			0.3	2		2.3	0.03
2002		Reduction			239	1436		1675	3.05
		Hum. Con.			5.4	5.5		10.9	0.02
2005	Saithe	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction						0	0
		Hum. Con.	0.7		5.8	4.2		10.7	0.12
2003		Reduction		0.4	4	22.8		27.2	0.30
		Hum. Con.						0	0
2002		Reduction			45	201		246	0.45
		Hum. Con.	30		84.3	66.3		180.6	0.33
2005	Other human	Hum. Con.						0	0
2004	Cons. Species	Hum. Con.	0.9		2.7	2.5		6.1	0.07
2003		Hum. Con.		0.6	2.2	6.2		9	0.10
2002		Hum. Con.						0	0
2005	All species	All						0	0
2004		All	626		2023	6331		8980	100
2003		All		66	2025	6929		9020	100
2002		All	4511		6815	31887	11767	54980	100

Stock Annex: Plaice IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Working group:	North Sea Demersal Working Group
Updated:	17/05/2011 (partially only. A number of chapters needs major revision)
By:	Clara Ulrich, DTU Aqua

Last Benchmark: This stock has never been benchmarked under the new ICES benchmark system. Last changes in the assessment methodology were in 2006.

A.General

A.1 Ecosystem Considerations and Stock Definition

The spawning occurs between late February and late March in Kattegat waters mainly at depth between 30 and 40 meters (**Nielsen** ***et al.*** 2004). **Ulmestrand** (1992) showed that Skagerrak and Kattegat were not significant spawning areas for plaice between 1990 and 1992. But **Nielsen** ***et al.*** **(2004)** observed the existence of two spawning areas in Kattegat, one in the Northeastern part and another one, of greater importance in terms of production, in the southern part. Kattegat and especially Skagerrak plaice are thought to be partially recruited from the North Sea plaice stock by passive drifting of eggs and larvae (**Ulmestrand** 1992, **Nielsen** ***et al.*** 2004). The contribution of North Sea plaice to Northern Kattegat recruits during larval and eggs drift period is increased in periods of strong winds in Kattegat (**Nielsen** ***et al*** 1998), and this contribution is not regular between years. **Nielsen** ***et al.*** **(**2004) and **Cardinale** ***et al.*** (2009) have evidenced a shift in SSB (spawning stock biomass) in benefit of young spawners. Even if the adult stock is meant to be currently large, young mature fish are less efficient than older ones in gametes producing, so it could depreciate the recruitment of plaice in Kattegat (**Nielsen** ***et al.*** 2004, **Rijnsdorp** ***et al.*** 1991). However, large recruitment of plaice have been observed in the past 15 years, and this could be caused by increases in recruitment from Kattegat spawners and/or from spawners of adjacent plaice stocks such as the North Sea (mainly) or the Belt Sea.

Nursery areas are located both along Danish and Swedish coast, but most part of the recruitment is from the Swedish West (of both Skagerrak and Kattegat) coast nurseries, estimated at 77% (**Wennhage,** ***et al.*** 2007). There is also some information that indicates the possible existence of stock mixing in the Kattegat Skagerrak. Migration of adult plaice between northern Kattegat and Skagerrak and also between the southern Kattegat and the Belt Sea seem to occur based on meristics, genetics and tagging studies (**Simonsen** ***et al.*** 1988, **Boje** ***et al.*** 2007, ICES WGNSSK). These migrations could explain inter annual variations in F.

A.2 Fishery (NOT UPDATED)

The fishery is dominated by Denmark, with Danish landings usually accounting for 80 to 90% of the total. Landings are taken year round with a predominance of the period from spring to autumn, by Danish seiners, flatfish gillnetters and beam trawlers. Plaice is also caught within a mixed cod-plaice fishery by otter trawlers, and is a bycatch of other gillnet fisheries. .Plaice is also caught as by-catch in the directed *Nephrops* fishery. Since 1978, landings have declined from 27 000 to 9 000 tonnes in the late nineties. However, landings in 2001 were the highest since 1992. The fishery exploits traditionally three age classes (ages 4 to 6). The TAC is usually not restrictive.

The use of beam trawl in the Kattegat is prohibited, but allowed in the Skagerrak. Minimum mesh size is 90 mm for towed gears, and 100 mm for fixed gears. The minimum landing size is 27 cm. Danish fleets are prohibited to land females in area IIIa from January 15th to April 30th.

B. Data

B.1 Commercial catch (NOT UPDATED)

ICES official landings are available from Belgium, Norway and Germany, and national statistics are available from Denmark, Sweden and the Netherlands. The age-disaggregated indices were derived by merging logbook statistics supplying catch weight per market category with the age distribution within these categories available from the market sampling. Catch-at-age and mean weight-at-age in the catch information were traditionally provided by Denmark only. For 2003 data were also provided by Sweden, initially for both areas and since 2007 for Kattegat only. The sampling scheme is broken down by quarter, landing harbours, and fishing area. The total international catches-at-age have been estimated for Kattegat and Skagerrak separately since 1984. Raising procedures were historically performed manually, but ICES InterCatch database has been used for 2008 data.

B.2 Biological

Mean Weight at Age

Up to 2005, weights-at-age in the stock were assumed equal to those of the catch. In 2006, the procedure to calculate weight at age was revised (Storr-Paulsen and Hamon, WD#13 to ICES WGNSSK 2006) as follows:

The IBTS data were analysed to complete a weight-at-age in the stock. Weight at age information are directly available from age 2 to 6, older fish are sampled too scared. To complete a weight at age in the stock the survey data needed to be extended to age 11+. The IBTS data showed a large decrease in weight at age for older age groups (age 4, 5 and 6) from 1998 to 2006 (Figure 2). Weight at age information was also available from KASU 1996-2006. Comparing KASU first quarter with the IBTS data revealed that mean weight at age 1 and 2 were very similar, but the decreasing trend at older ages groups were not seen in the KASU survey (Figure 3).

The Danish commercial mean weight-at-age data from sub area IIIa lie within a very narrow weight range for age 2-6 and do not increase very much between ages (Figure 2). From age 7 or 8 until 11+ there is a large average increase in weight between age groups. As no fleet information are available effect of fishing pattern were exposed by comparing weight at age data between different areas and nations (Figure 4).

Mean weight at age in sub area 22 lie for all age groups above the values found in Kattegat and Skagerrak in the time frame1995-2003, but with a decreasing trend. In the later two years mean weight at age in sub area 22 are in the range of the values in Skagerrak and Kattegat.

The commercial samples from the Swedish fleet in Kattegat and Skagerrak are comparable with values from the Danish fleet in the same area. Weight at age information from the Dutch catches is available for 2003 and 2004 and shows a high weight at age for nearly all age classes.

A comparison of weight at age in survey and commercial data reveals for age groups younger than 3 that commercial data are underestimates the mean weight in all years. Between 1991 and1996 mean weight at age for age group 4-6 are closely linked. In 1997-1999 the mean survey estimate are larger for age 5 and 6 than the commercial. The later 3 years mean weight at age estimated in the survey are beyond the values found in the commercial fleets.

One explanation for the discrepancy in growth pattern between age 2-6 and older plaice in the commercial fleet could be the difference in the growth pattern of the two sexes. In the commercial samples, plaice has not been sexed and the growth pattern of the 2 sex are significantly different at older age groups.

Different main target species in the various fleets gives an alternative explanation for the different growth pattern. Large parts of the trawler fleet do not target plaice but *Nephrops* as their main species. They are fishing with a smaller mesh size and are bound to catch smaller plaice. Opposite with the gill-netters, part of the trawlers and Danish seine fleets targeting plaice as main species. They have a larger mesh size and are catching larger fish. This is confirmed by the measure information from the Dutch fleet targeting plaice as main species, with a high mean weight at age.

Mean weight at age from the IBTS has a decreasing trend at older age groups after 1998, this trend is not found in the KASU nor for the North Sea stock (WGNSSK-2005). The inconsistent survey data makes an extension of age groups in the survey mean weight at age difficult. Alternatively, mean weight at age from the commercial fleet for age groups 5-11+ could be used. As age 2 and 3 are underestimated in the commercial fleet comparison can only be made between age 4-6. The last 3 years this correlation between IBTS and commercial data has been very poor (Figure 5). The KASU survey and the mean weight at age in the landings shows a better correlation at age 3-6 in the latter years than the IBTS does (Figure 6). At age 5 and 6 the number of fish caught in the KASU are not very large.

In conclusion, it was decided to compile mean weight at age from the KASU survey age 1-4 with mean weight at age 5-11+ in landings from the Danish fleet in area IIIa and 22 to generate the mean weight at age in stock.

This procedure has not been changed since 2006.

Mortality

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

A fixed natural mortality of 0.1 per year was assumed for all years and ages.

Maturity

Up to 2005, a knife-edge maturity distribution was employed: age group 2 was assumed to be immature, whereas age 3 and older plaice were assumed mature.

The procedure was revised in 2006 (Nielsen and Boje, WD#15 to ICES WGNSSK 2006). A difference in maturity at age are observed between Kattegat and Skagerrak Plaice mature at younger age in Kattegat than in Skagerrak. This could indicate that the two areas belong to different spawning grounds. Although maturity varies from year to year in both areas, no trend is obvious over the time. Therefore it is suggested that a fixed maturity ogive is applied to the stock assessment of plaice in IIIa.

Although it is recognised that the maturity ogive differ between Kattegat and Skagerrak, a combined ogive is suggested weighting the area ogives by catches in the respective areas. The proposed ogive is therefore computed as an average of the two areas weighed by the average catches over the entire period 1993-2005. Even though the resulting ogive does not fit an ideal sigmoid curve, the single maturity proportion by age represents the best estimates available and it is therefore not considered appropriate to smoothen the estimates.

B.3 Surveys

Data from four surveys are available.

NS-IBTS is the standardised national surveys for North Sea, Kattegat and Skagerrak (Anon, 2004). A standard IBTS haul is made with a 36/47 GOV-Trawl, with haul duration at 30 minutes and a trawl speed of 4 knots. The purpose of this survey is to provide an annual abundance index for cod, haddock, juvenile herring, whiting, Norway pout, and the survey provides information on the by-catches species plaice and sole. The rubber discs (20cm in diameter) on the groundrope may lift the ground panel of the trawl and enable flatfish escape.

IBTS in area IIIa is conducted by the Swedish research vessel 'RV Argos', at Fiskeriverket twice a year, in the first and the third quarters and survey indices are available since 1991.

IBTS samplings take place in both the Kattegat and the Skagerrak; final indices are however combined over the whole area. All individuals from the survey in IIIa are chosen in further analysis. To make the estimation comparable length groups always start at 5cm length class. When individuals of a given size are missing, an estimated weight from the weight length relationship of the same year and area is used. For ages 6+ the numbers caught is very low and is therefore excluded from the estimations.

The KASU survey is a standard BITS, which belongs to another group of standardised surveys. The trawl is a standard TV3-520 with rubber discs of 10cm diameter on the groundrope and with a trawl speed at 3knots. This trawl target flatfish better than IBTS and is designed provide an annual abundance indices for cod, plaice and sole. This survey takes place in the Kattegat and Belt Sea twice a year in February and November and is conducted by a Danish vessel, Havfisken from DTU Aqua.

KASU data have been revised this year in 2006 (Folmer, 2006), due to changes in database combined with a change of extraction programs in 2005. The revision of last year indices highlighted data treatment errors and the new time series is considered improved compared to the old one.

KASU time series start in 1996 for the first quarter and 1994 for the fourth quarter data.

Individual weight information are available for age 1-6, the survey area are distributed further to the Danish cost compared to the IBTS (Figure 1).

The KASU weights at age are calculated as the mean weight over all samples from the combined 1st and 4th quarter surveys.

Very few plaice aged 7–9 are caught during the surveys and these ages are removed from the analysis.

B.4 Commercial CPUE (NOT UPDATED)

Three Danish fleets, i.e., trawlers, gillnetters, and Danish seiners, were traditionally available for tuning.

In 2006 effort was made to improve the quality of the commercial tuning fleets used in the assessment, both in terms of data checking, fisheries definition and effort standardisation. Two tuning fleets were retained, the Danish seiners and the Danish gillnetters targeting flatfish with 120 to 220 mm nets (vessels larger than 10m), with effort measured as kW*fishing days. The age-disaggregated indices were derived by merging logbook statistics supplying catch weight per market category with the age distribution within these categories available from the market sampling.

The fishing effort appears to have been fairly stable over the last decade. There has been a decrease in the fishing effort of towed-geared fleets since 1990, but this trend has been reversing since 1998. The fishing effort of gillnetters has steeply increased over 1990-1994, and steadily decreased since then. All commercial fleets show increase in both the yield and the CPUE in 2001. Highest values and increases are observed for the Danish seiners.

B.5 Other relevant data

None.

C. Historical Stock Development

Analytical assessments were performed every year except in 2008, but they have not been accepted since 2005.

D. Deterministic modelling (NOT UPDATED)

Model used: XSA

Software used: IFAP / Lowestoft VPA suite until 2005, FLXSA since 2006.

Model Options chosen:

Tapered time weighting applied, power = 3 over 20 years

Catchability independent of stock size for all ages

Catchability independent of age for ages >= 8

Survivor estimates shrunk towards the mean F of the final 5 years or the 5 oldest ages

S.E. of the mean to which the estimate are shrunk = 0.500

Minimum standard error for population estimates derived from each fleet = 0.300

Prior weighting not applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1978 – last data year	2 – 10+	Yes
Canum	Catch at age in numbers	1978 – last data year	2 – 10+	Yes
Weca	Weight at age in the commercial catch	1978 – last data year	2 – 10+	Yes
West	Weight at age of the spawning stock at spawning time.	1978 – last data year	2 – 10+	Yes
Mprop	Proportion of natural mortality before spawning	1978 – last data year	2 – 10+	No – set to 0 for all ages in all years
Fprop	Proportion of fishing mortality before spawning	1978 – last data year	2 – 10+	No – set to 0 for all ages in all years
Matprop	Proportion mature at age	1978 – last data year	2 – 10+	No – the same ogive for all years
Natmor	Natural mortality	1978 – last data year	2 – 10+	No – set to 0.1 for all ages in all years

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	Danish Gillnetters	1987 – last data year	2 – 10+
Tuning fleet 2	Danish seiners	1987 – last data year	2 – 10+
Tuning fleet 3	IBTS Q1 backshifted	1991 – last data year	1 – 6
Tuning fleet 4	KASU Q4	1994 – last data year	1 – 6
Tuning fleet 5	KASU Q1	1995 – last data year	1 – 5
Tuning fleet 6	IBTS Q3	1995 – last data year	1 – 6

D.1 Uncertainty analysis

D.2 Retrospective analysis

Performed with FLR packages

E. Short-Term Projection

not run since 2005

Settings previously used :

Software used: WGFRANSW

Initial stock size. Stock sizes for age 3 and older are taken from the estimated number of survivors from the XSA. The age 2 recruitments are taken as the geometric average over the entire period.

Natural mortality: Set to 0.1 for all ages in all years

Maturity: The same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages in all years

Weight at age in the stock: Assumed to be the same as weight at age in the catch

Weight at age in the catch: Average weight of the three last years

Exploitation pattern: Average of the three last years, scaled by the Fbar (3-6) to the level of the last year

Intermediate year assumptions: TAC constraint

Stock recruitment model used: None, the long term geometric mean recruitment at age 2 is used

Procedures used for splitting projected catches: Not relevant

F. References

Boje, J., Clausen, L.W., Nielsen, E., Rasmussen, H., Ulrich, C., Belgrano, A., Bland, B., Cardinale, M., Svedang, H. (2007). ICES: DIFRES-IMR Meeting on improvement of plaice IIIA assessment. ICES Headquarters, Copenhagen.

Cardinale, M., Hagberg, J., Svëdang, H., Bartolino, V., Gedamke, T., Hjelm, J., Börjesson, P., Norén, F. (2009). Fishing through time: population dynamics of plaice (Pleuronectes platessa) in the Kattegat–Skagerrak over a century. Population Ecology, 52 (2), pp.251-262.

Hoarau, G., Rijnsdorp, A.D., Van Der Veer, H.W., Stam, W.T., Olsen, J.L. (2002). Population structure of plaice (Pleuronectes platessa L.) in northern Europe: microsatellites revealed large-scale spatial and temporal homogeneity. Molecular Ecology, 11 (7), pp. 1165-1176.

Hunter, E., Metcalfe, J.D., Reynolds, D.R. (2003). Migration Route and Spawning Area Fidelity by North Sea Plaice. Proceedings: Biological Sciences, 270 (1529), pp. 2097-2103.

Kell, L.T., Scott, R., Hunter, E. (2004). Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research, 51 (3-4), pp. 287-299.

Kell, L.T. and Bromley, P.J. (2004). Implications for current management advice for North Sea plaice (Pleuronectes platessa L.): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research, 51 (3-4), pp. 301-312.

Nielsen, E., Støttrup, J.G., Heilmann, J., MacKenzie, B.R. (2004). The spawning of plaice Pleuronectes platessa in the Kattegat. Journal of Sea Research, 51 (3-4), pp.219-228.

Nielsen, E., MacKenzie, B.R. (1998). Wind-induced transport of plaice (Pleuronectes platessa) early life-history stages in the Skagerrak-Kattegat, Journal of Sea Research, 39 (1-2), pp. 11-28.

Nielsen, E. and Boje, J. (2006). Maturity at age for plaice in Skagerrak and Kattegat (IIIa). ICES WGNSSK Working Doc 15

Rijnsdorp, A.D., Daan, N., Van Beek, F.A., Hesse, H.J.L. (1991). Reproductive variability in North Sea plaice, sole and cod. Journal du Conseil International pour l'Exploration de la Mer, 47 (3), pp. 352-375.

Simonsen, V., Nielsen, E., Bagge, O. (1988). Discrimination of stocks of plaice in the Kattegat by electrophoresis and meristic characters. ICES CM 1988/G:29

Ulmestrand, M. (1992). The geographical distribution, size composition and maturity stages of plaice Pleuronectes platessa (L.) during spawning season in the Skagerrak and Kattegat. Meddelande från Havsfiskelaboratoriet. 325, 8 pp.

Wennhage, H., Pihl, L., Stål, J. (2007). Distribution and quality of plaice (Pleuronectes platessa) nursery grounds on the Swedish west coast. Journal of Sea Research, 57 (2-3), pp. 218-229

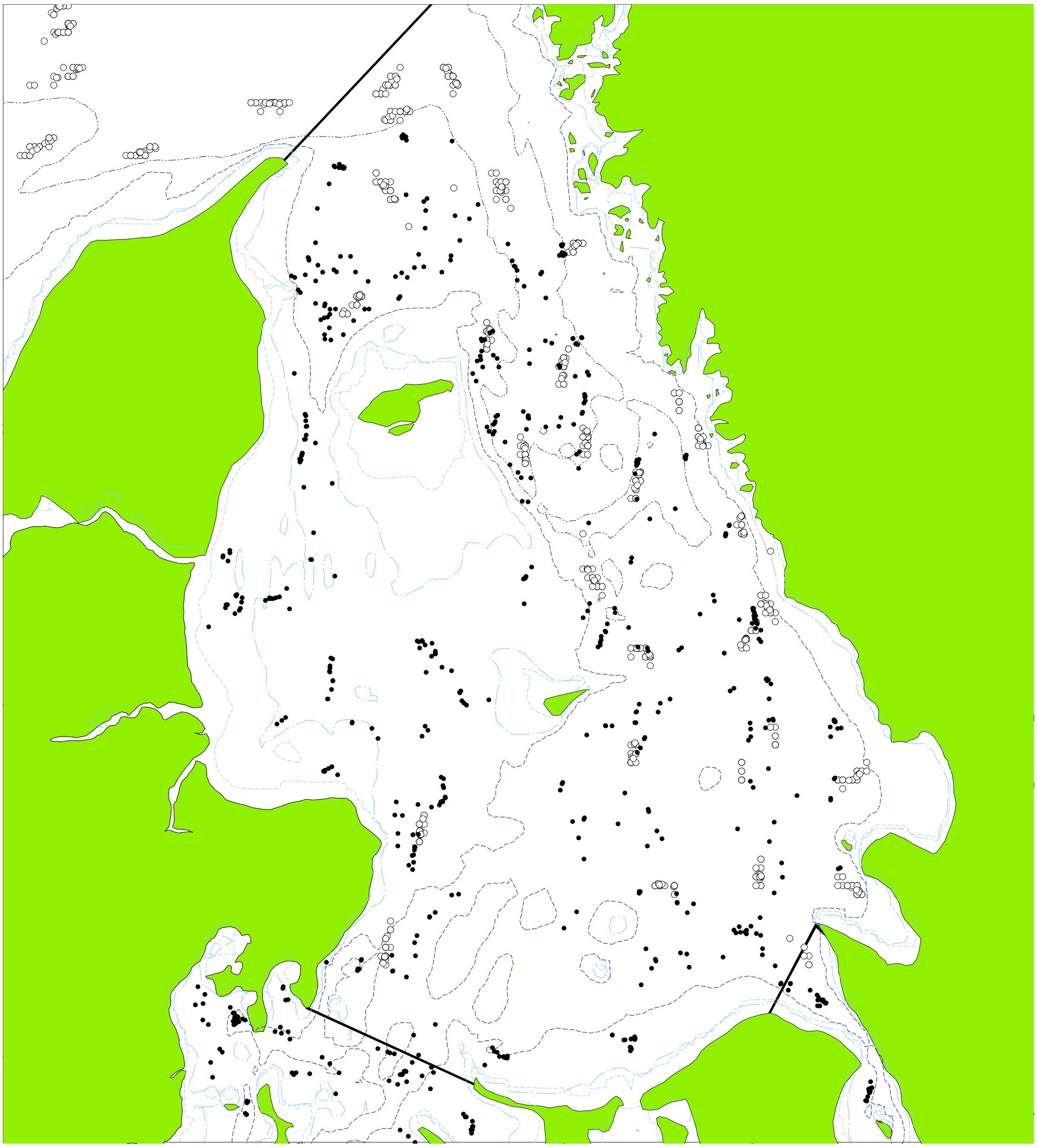


Figure 1. Location for the IBTS (open dots) and KASU stations (black dots).

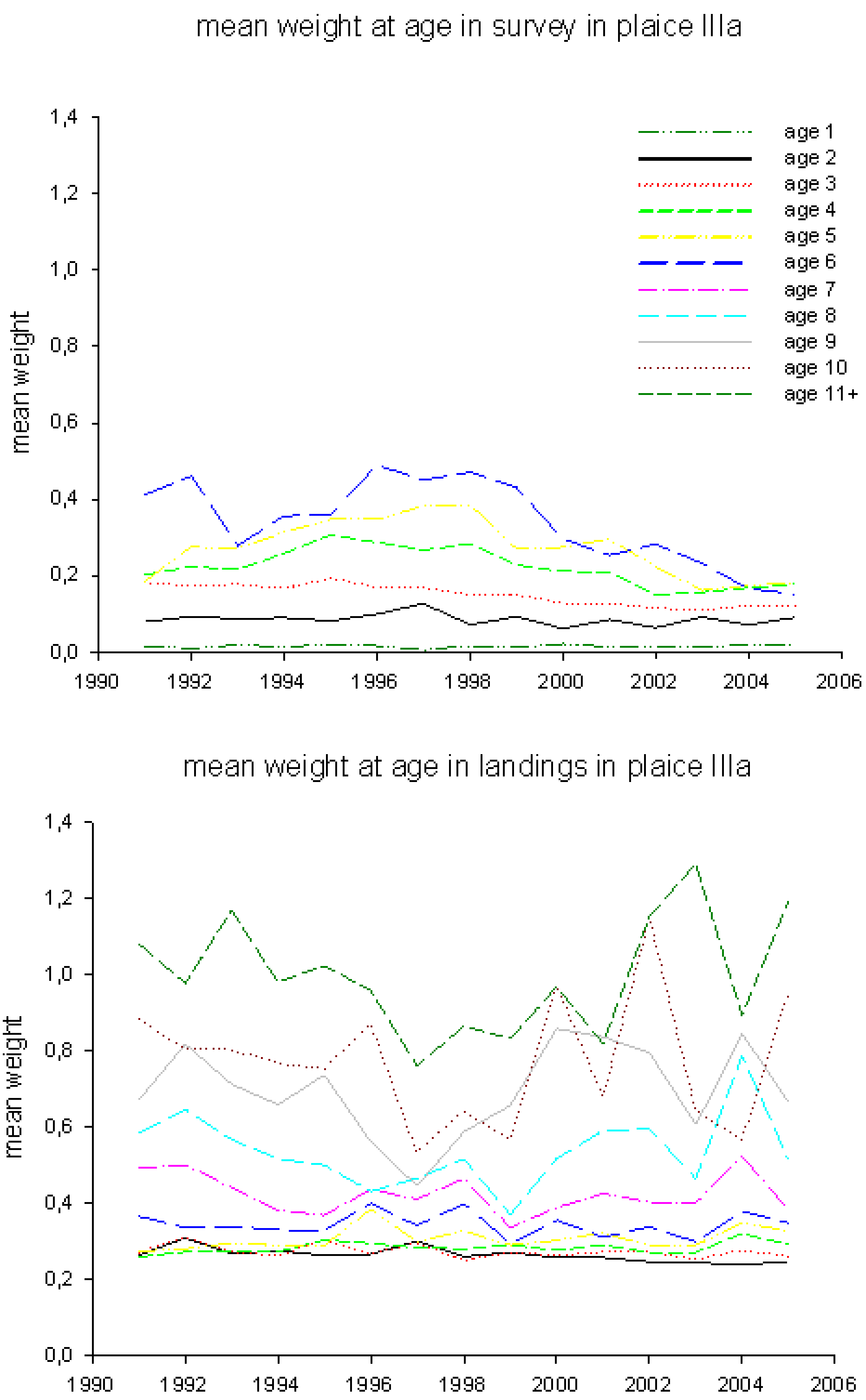


Figure 2: Mean weight at age from IBTS and commercial fleets in IIIa between 1991-2005.

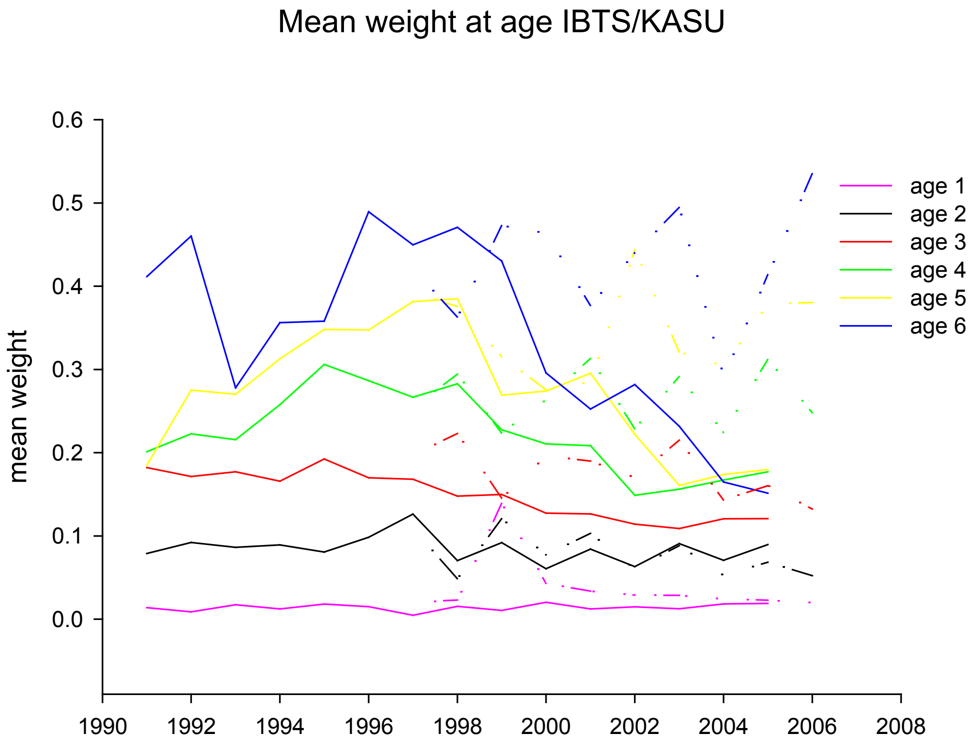


Figure 3. Comparison between IBTS q1 in area IIIa (solid line) 1991-2005 and KASU q1 in IIIa+22 (dotted line) 1996-2006 in area IIIa.

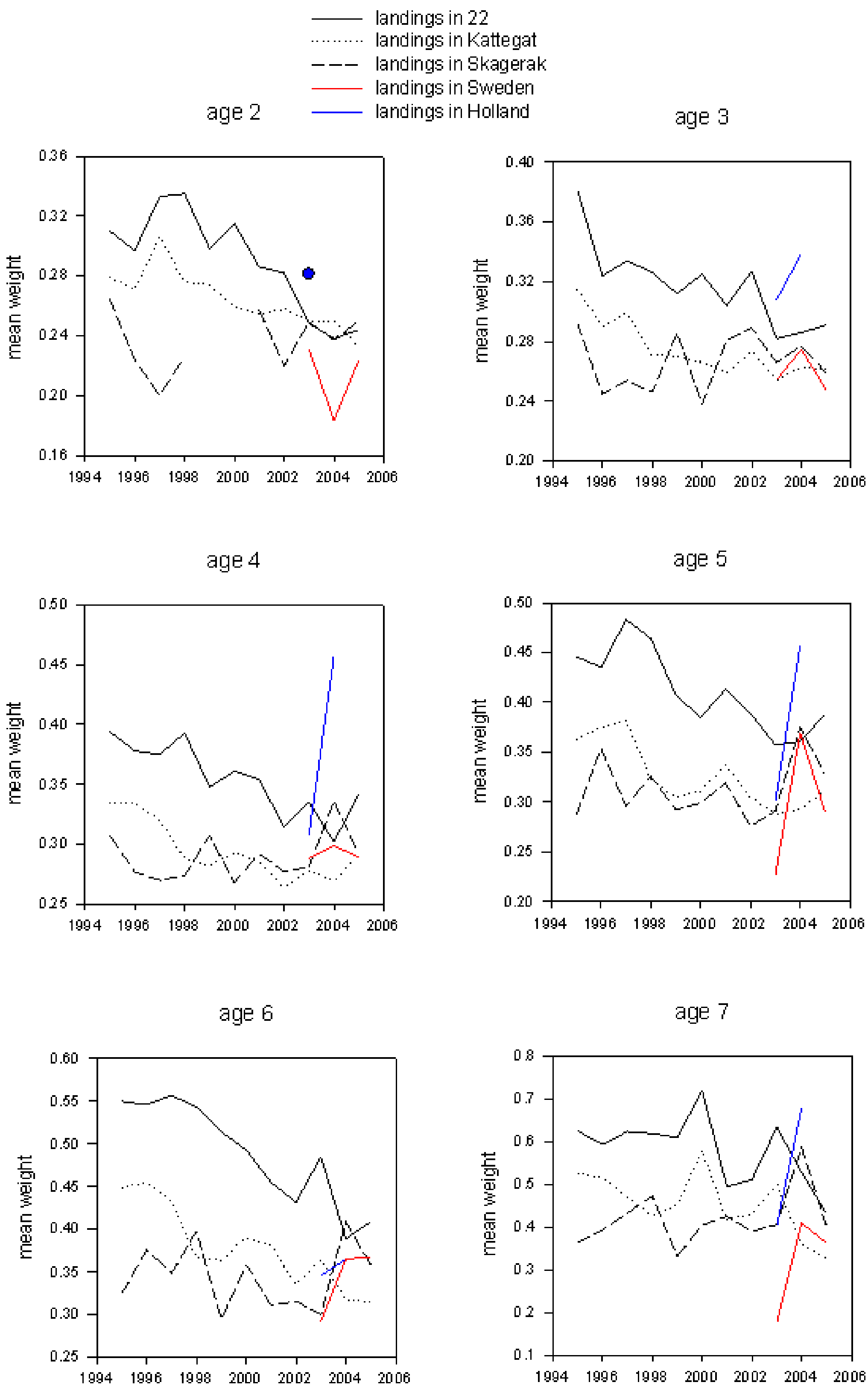


Figure 4: Mean weight at age 2-7 from 5 different commercial fleets.

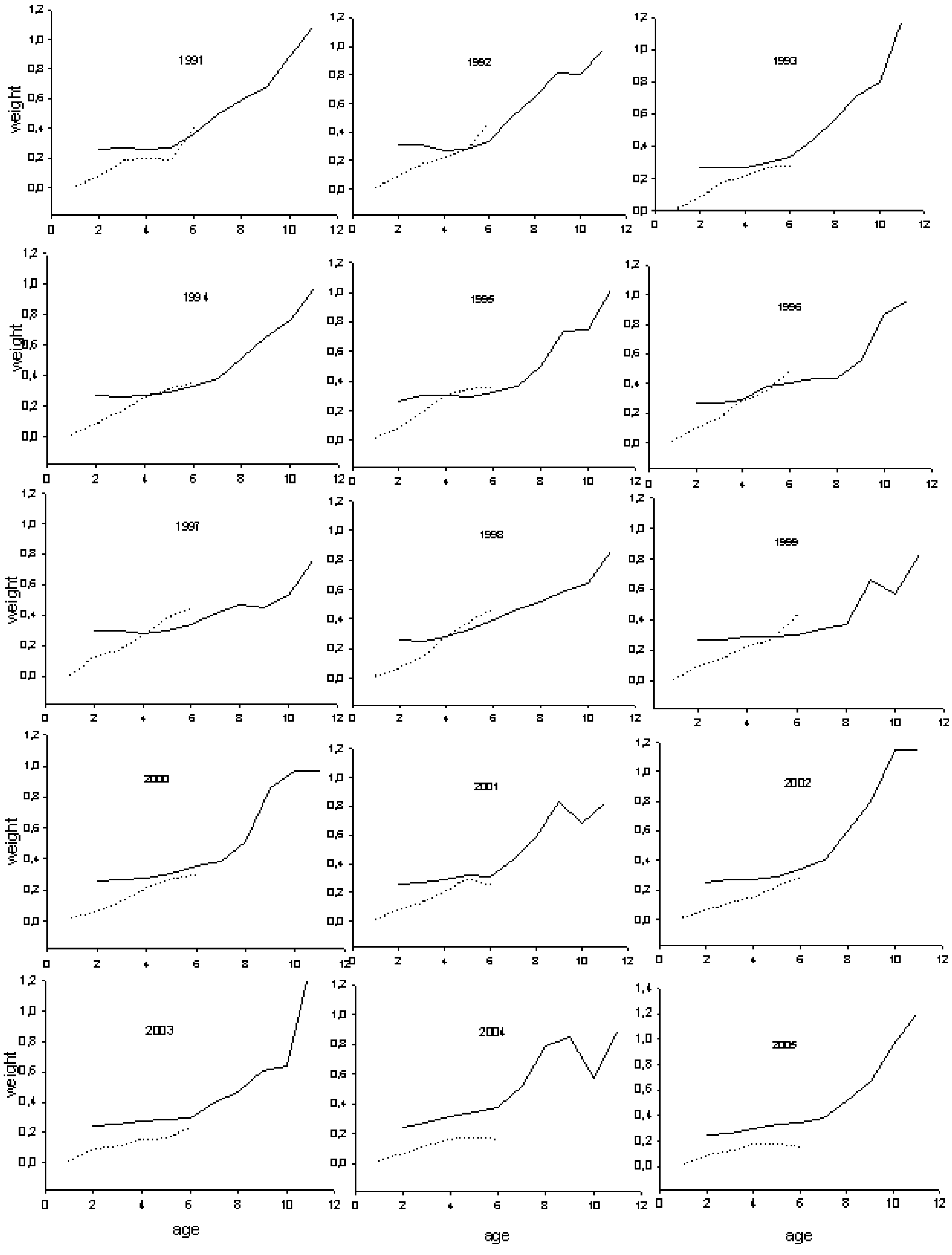


Figure 5. Comparison of mean weight at age between the IBTS survey (dottet line) and commercial samples (solid line) in IIIa in the years 1991-2005

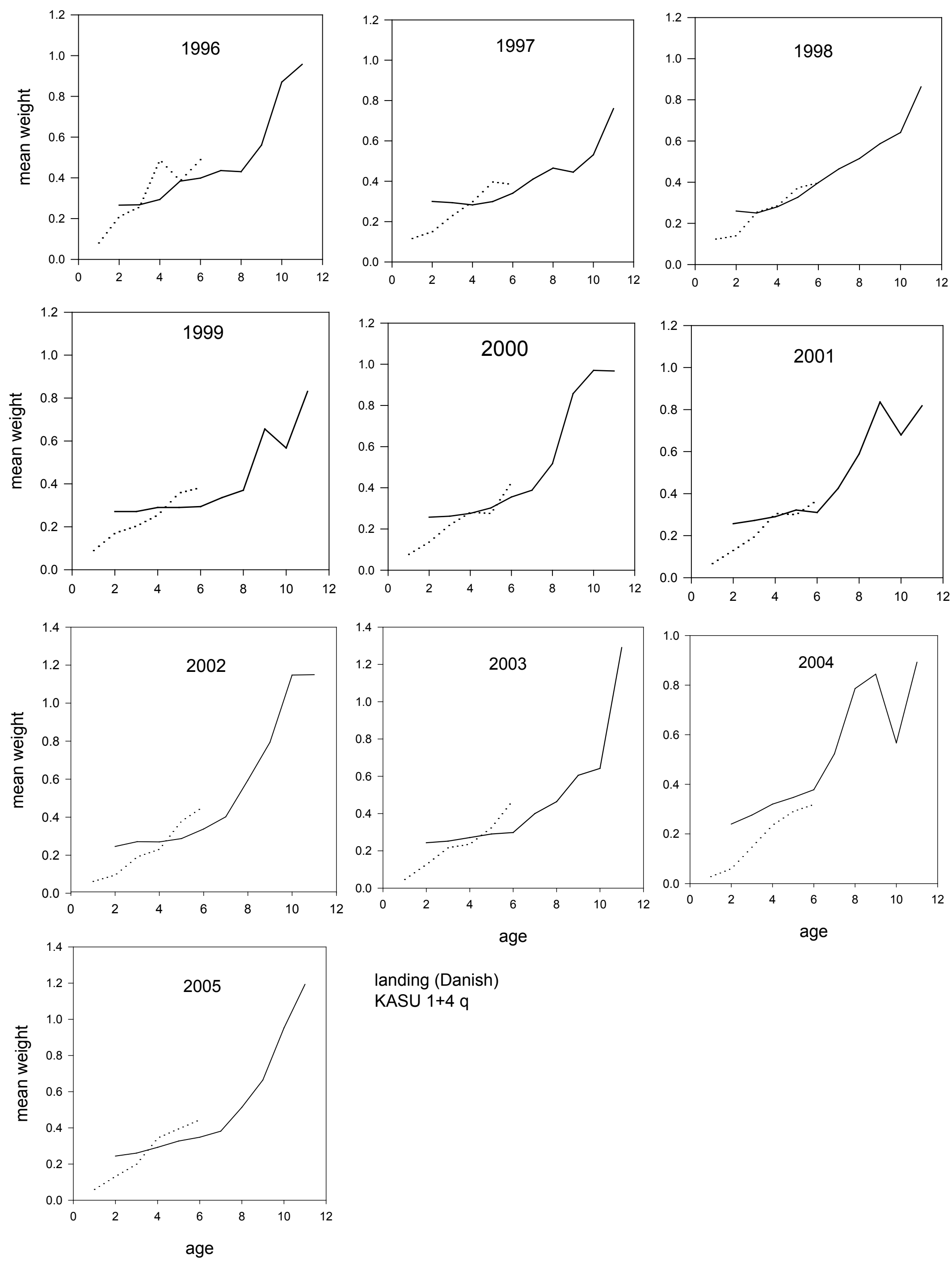


Figure 6. Comparison of mean weight at age between the KASU survey 1+ 4 q (dottet line) and commercial samples (solid line) in IIIa in the years 1996-2005

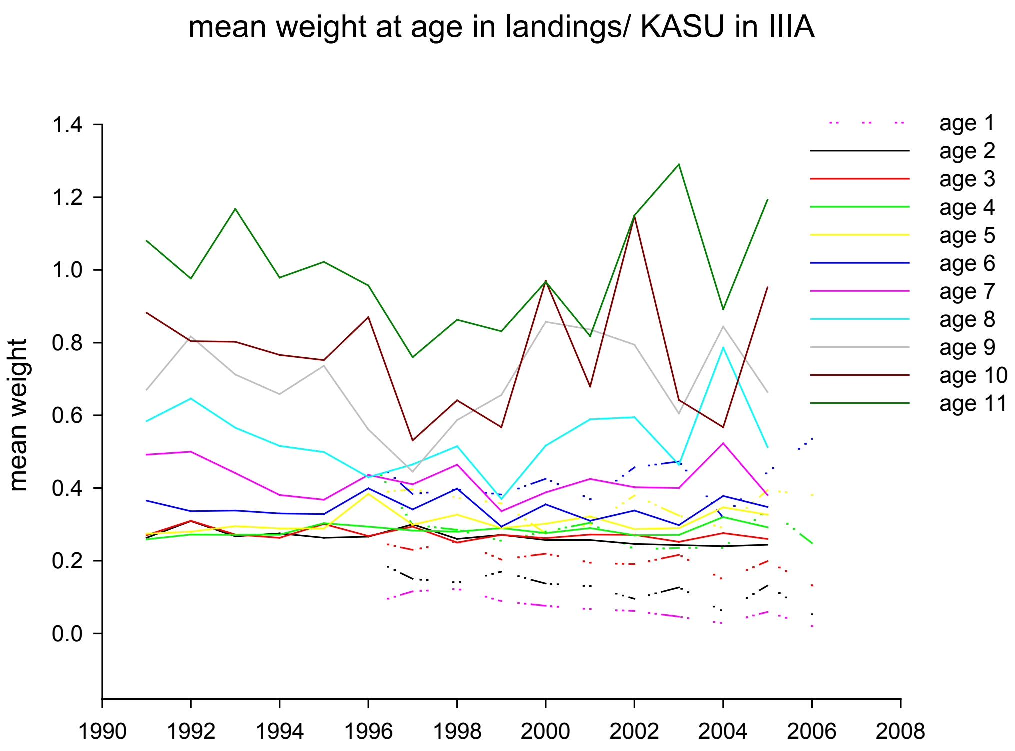


Figure 7. Mean weight at age in KASU 1+4 q and commercial landings from the Danish fleet.

Stock Annex: Plaice in area IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea plaice
Working Group:	WGNSSK
Date:	7 February 2009
By:	Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea plaice is defined to be a single stock in ICES are IV. However, data from data storage tag experiments reveal that about one third of plaice released in the Southern Bight of the North Sea visit the eastern English Channel in December and January. In contrast, analysis of the movements of mark-recapture experiments with plaice of a similar size and released at similar times indicates that only 13% of plaice released in the Southern Bight visit the eastern English Channel at this time (Hunter *et al*., 2004). This difference between DST and mark-recapture experiments is not observed in the central North Sea and German Bight, where the movements of plaice derived from the two approaches are relatively similar (Bolle *et al*., 2005). The differences may possibly be due to the fact that these fish migrate to their spawning grounds by selective tidal stream transport. Studies (Kell *et al*., 2004) have shown that the migration between North Sea and the adjacent areas is more problematic for the smaller adjacent areas than it is for management in IV.

Genetic analysis of plaice population structure in northern Europe using microsatellites and mitochondrial DNA data (Hoarau *et al*., 2004) reveals relatively strong differentiation between "shelf" plaice and those from Iceland and Faeroe, suggesting that deep water may serve as a barrier to movement between these populations. However, within the area of the European continental shelf, only weak differentiation could be detected between North Sea-Irish Sea and other areas (Norway, the Baltic and the Bay of Biscay, Hoarau *et al*., 2004). Although the spatial location of sampling within the North Sea was not sufficient to reveal any sub-structure. The lack of any genetic differentiation between Irish Sea and North Sea plaice populations (Hoarau *et al*., 2004) despite the evidence from mark-recapture studies that indicate extremely low transfer of individuals between these sea areas (0.36% over 17 years, calculated from (Dunn and Pawson, 2002)) shows how differently genetic and tagging studies provide an understanding fish population structure. Nonetheless, it seems unlikely that Irish Sea and North Sea plaice are a single "stock", at least in a fisheries management sense.

A.2 Fishery

North Sea plaice is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea. Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. Due to the minimum mesh size enforced (80 mm in the mixed beam trawl fishery), large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea plaice have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. For example, approximately 85% of plaice landings from the UK (England and Scotland) is landed into the Netherlands by Dutch vessels fishing on the UK register. Vessels fishing under foreign registry are referred to as flag vessels. As described by the ICES WGNSSK in 2001(ICES CM 2002/ACFM:01), the fishing pattern of flag vessels can be very different from that of other fleet segments. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box). Also, the decrease in fleet size may partially have been compensated by slight increases in the technical efficiency of vessels. In the Dutch beam trawl fleet indications of an increase of technical efficiency of around 1.65% by year was found over the period 1990 – 2004 (Rijnsdorp *et al.*, 2006). Because the commercial tuning series are not currently used in the assessment, these estimates do not affect the current assessment.

The Dutch beam trawl fleet, one of the major operators in the mixed flatfish fishery in the North Sea, has seen a shift towards more inshore fishing grounds, changing the catchability of the fleet. This shift may be caused by a number of factors, such as the implementation of fishing effort restrictions, the increase in fuel prices and changes in the TAC for the target species (Quirijns, 2008). However, the contribution of each of these factors is yet unknown. Other factors affecting the catchability of the fleet include the changes in the fishing speed of the vessels, and discarding marketable fish in certain seasons and areas, as a result of the TAC management (Rijnsdorp, 1991)

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001; EC Council Regulation No 51/2006; e.g N°40/2008, annex 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 effect on the recruitment of Plaice but that its overall effect has decreased since it was established. There are two reasons to assume that the Plaice Box has a positive effect on the recruitment of Plaice: 1) at present, the Plaice Box still protects the majority of undersized Plaice. Approximately 70 % of the undersized Plaice are found in the Plaice Box and Wadden Sea, and despite the changed distribution, densities of juvenile Plaice inside the Box are still higher than outside; 2) In the 80 mm fishery, discard percentages in the Box are higher than outside. Because more than 90 % of the Plaice caught in the 80 mm fishery in the Box are discarded, any reduction in this fishery would reduce discard mortality. There is, however, no proof of a direct relationship between total discard mortality and recruitment.

Generally, it is assumed that the majority of discarded animals do not survive (Beek *et al*. 1990; Chopin *et al*. 1996). Reviews of studies that have tested this assumption acknowledge that discard mortality is determined by a range of biological, technical, or environmental factors or 'stressors' (Broadhurst *et al*. 2006). Biological factors relate to e.g. the species, physiology, size, catch weight/ volume, composition; technical stressors relate to e.g. gear design, deployment duration, fishing speed; environmental stressors relate to e.g. temperature, hypoxia, depth, wind force, availability of sunlight.

For the beam trawl fishery, discard mortality is influenced by the duration the organisms are confined in the codend and concurrent injuries (Beek *et al*. 1990; Broadhurst *et al*. 2006). If the fish were brought on board alive, then the processing of the catch on board would also matter. However, in fact, processing on board hardly affects the survival of the discards because approximately 70% of the catch is moribund upon landing already (Beek *et al*. 1990). It is estimated based on experimental studies on board commercial vessels that less than 10% of the plaice and sole discards in the beam trawl fisheries survive the process of discarding (Bult and Schelvis-Smit 2007; Beek *et al*. 1990).

A.3 Ecosystem aspects

Adult North Sea plaice have an annual migration cycle between spawning and feeding grounds. The spawning grounds are located in the central and southern North Sea, overlapping with the distribution area of Sole. The feeding grounds are located more northerly than the sole distribution areas. Juvenile stages are concentrated in shallow inshore waters and move gradually off-shore as they become larger. The nursery areas on the eastern side of the North Sea contribute most of the total recruitment. Sub-populations have strong homing behaviour to specified spawning grounds and rather low mixing rate with other sub-populations during the feeding season (de Veen, 1978, Rijnsdorp and Pastoors, 1995). Genetically, North Sea and Irish Sea plaice are weakly distinguishable from Norway, Baltic and Bay of Biscay stocks using mitochondrial DNA (Hoarau *et al*., 2004).

Juvenile plaice were distributed more offshore in recent years. Surveys in the Wadden Sea have shown that 1-group plaice is almost absent from the area where it was very abundant in earlier years (van Keeken *et al*., 2007). The Wadden Sea Quality Status Report 2004 (Vorberg *et al*., 2005) notes that increased temperature, lower levels of eutrophication, and de-cline in turbidity have been suggested as causal factors, but that no conclusive evidence is available; taking into account the temperature tolerance of the species there is ground for the hypothesis that a temperature rise contributes to the shift in distribution.

A shift in the age and size at maturation of plaice has been observed (Grift *et al*., 2007, Grift *et al*., 2003): plaice become mature at younger ages and at smaller sizes in recent years than in the past. This shift is thought to be a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This results in a population that consists ever more of fish that are genetically programmed to mature early at small sizes. Reversal of such a genetic shift may be difficult. This shift in maturation also leads to mature fish being of a smaller size at age, because growth rate is reduced after maturation.

B. Data

B.1 Commercial catch

Discard sampling programmes started in the late 1990s to obtain discard estimates from several fleets fishing for flatfish. These sampling programmes give information on discard rates from 1999 but not for the historical time series. Observations indicate that the proportions of plaice catches discarded are high (80% in numbers and 50% in weight: (van Keeken *et al*., 2004)) and have increased since the 1970s (51% in numbers and 27% in weight: (van Beek, 1998)) The discards time series are derived from Dutch, Danish, German and UK discards observations for 2000 – 2007. For the period prior to that, a reconstructed discard time series for 1957 – 1999 exists, based on a re-constructed 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 5th percentile of F_{loss} and gave a 50% probability that SSB is around 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

I. References

AARTS, G. and POOS, J. J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES Journal of Marine Science, 66.

AARTS, G. and VAN HELMOND, A. T. M. 2007. Discard sampling of Plaice (*Pleuronectes platessa*) and Cod (*Gadus morhua*) in the North Sea by the Dutch demersal fleet from 2004 to 2006. ICES Document Report number C120/07. 42 pp.

BEVERTON, R. J. H. and HOLT, S. J. 1957. On the dynamics of exploited fish populations, Her Majesty's Stationery Office, London (UK).

BOLLE, L. J., HUNTER, E., RIJNSDORP, A. D., PASTOORS, M. A., METCALFE, J. D. and REYNOLDS, J. D. 2005. Do tagging experiments tell the truth? Using electronic tags to evaluate conventional tagging data. ICES Journal of Marine Science, 62: 236-246.

DE VEEN, J. F. 1978. On selective tidal transport in the migration of North Sea plaice (*Pleuronectes platessa* L.) and other flatfish species. Netherlands Journal of Sea Research, 12: 115-147.

DUNN, M. R. and PAWSON, M. G. 2002. The stock structure and migrations of plaice populations on the west coast of England and Wales. Journal of Fish Biology, 61: 360-393.

GRIFT, R. E., HEINO, M., RIJNSDORP, A. D., KRAAK, S., B. M. and DIECKMANN, U. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Marine Ecology Progress Series, 334: 213–224.

GRIFT, R. E., RIJNSDORP, A. D., BAROT, S., HEINO, M. and DIECKMANN, U. 2003. Fisheries-induced trends in reaction norms for maturation in North Sea plaice. Marine Ecology Progress Series, 257: 247-257.

HOARAU, G., PIQUET, A. M.-T., VAN DER VEER, H. W., RIJNSDORP, A. D., STAM, W. T. and OLSEN, J. L. 2004. Population structure of plaice (Pleuronectes platessa L.) in northern Europe: a comparison of resolving power between microsatellites and mitochondrial DNA data. Journal of Sea Research, 51: 183-190.

KELL, L. T. and BROMLEY, P. J. 2004. Implications for current management advice for North Sea plaice (*Pleuronectes platessa* L.): Part II. Increased biological realism in recruitment, growth, density-dependent sexual maturation and the impact of sexual dimorphism and fishery discards. Journal of Sea Research, 51: 301-312.

KELL, L. T., SCOTT, R. and HUNTER, E. 2004. Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research, 51: 287-299.

RIJNSDORP, A. D. 1991. Selection differentials of male and female North Sea plaice Pleuronectes platessa L. and changes in maturation and fecundity. *In* The exploitation of evolving populations. Ed. by R. LAW, T. K. A. STOKES and J. M. MCGLADE. Springer Verlag.

RIJNSDORP, A. D., DAAN, N. and DEKKER, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES Journal of Marine Science, 63: 556-566.

RIJNSDORP, A. D. and PASTOORS, M. A. 1995. Modelling the spatial dynamics and fisheries of North Sea plaice (*Pleuronectes platessa* L.) based on tagging data. ICES Journal of Marine Science, 52: 963-980.

VAN BEEK, F. A. 1998. Discarding in the Dutch beam trawl fishery. ICES CM 1998/ BB:5: 1-15.

VAN KEEKEN, O. A., QUIRIJNS, F. J. and PASTOORS, M. A. 2004. Analysis of discarding in the Dutch beamtrawl fleet. 96 p. pp.

VAN KEEKEN, O. A., VAN HOPPE, M., GRIFT, R. E. and RIJNSDORP, A. D. 2007. Changes in the spatial distribution of North Sea plaice (*Pleuronectes platessa*) and implications for fisheries management. Journal of Sea Research, 57: 187-197.

VORBERG, R., BOLLE, L. J., JAGER, Z. and NEUDECKER, T. 2005. Chapter 8.6 Fish. *In* Wadden Sea Quality Status Report 2004.

Beek, F.A. van, Leeuwen, P.I. van, and Rijnsdorp, A.D. (1990) On the survival of plaice and sole discards in the otter-trawl and beam-trawl fisheries in the North Sea. Netherlands Journal of Sea Research 26: 151-160.

Broadhurst, M.K., Suuronen, P., and Hulme, A. (2006). Estimating collateral mortality from towed fishing gear. Fish and Fisheries 7: 180-218.

Bult, T.P., and Schelvis-Smit, A.A.M. (2007) Een verkenning van de mogelijkheden van outriggen door vissers uitgevoerd, in het kader van het Advies van de "Task Force Duurzame Noordzeevisserij". IMARES Report C022.07, 34 pp.

Chopin, F, Inoue, Y and Arimoto, T (1996) Development of a catch mortality model. Fisheries Research 25: 377-382.

Stock Annex Plaice in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Plaice in division VIId
Date:	05/03/2010
Revised by	Joël Vigneau (Joel.Vigneau@ifremer.fr) and Youen Vermard (Youen.Vermard@ifremer.fr)
Initial Contributors	Richard Millner (r.s.millner@cefas.cu.uk) and Joël Vigneau (Joel.Vigneau@ifremer.fr) 05/03/2003

A. General

A.1. Stock definition

The management area for this stock is strictly that for ICES area VIId called the eastern Channel, although the TAC area includes the smaller component of VIIe (western Channel).

Major spawning centres were found in the eastern English Channel, the Southern Bight, the central North Sea and the German Bight. Other less important local spawning centres were found in the western English Channel and off the UK coast from Flamborough Head northwards to Moray Firth (Houghton & Harding 1976, Harding & Nichols 1987 in ICES PGEGGS, 2003c). The regions of plaice spawning are generally confined within the 50-meter depth contour (Harding *et al*. 1978, in ICES PGEGGS, 2003c).

The stocks of plaice in the Channel and North Sea are known to mix greatly (Figure 1), especially during the spawning season (January-February). At this time many western Channel and North Sea plaice may be found in the eastern Channel. The comparable lack of spawning habitat in the western Channel alone suggests that this migration from VIIe to VIId during the first quarter may be of considerable importance.

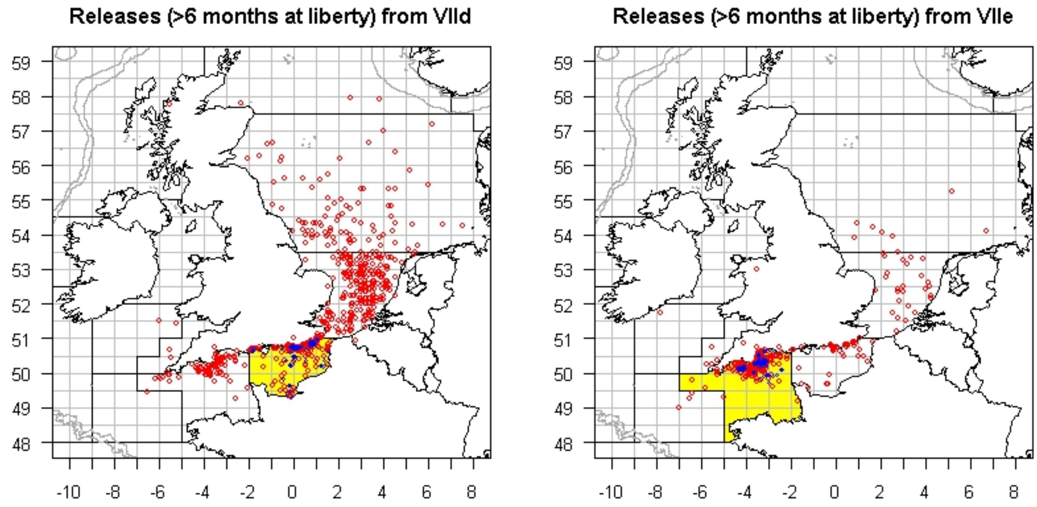


Figure 1 : Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

From tagging experiments, it was possible to derive estimates of the proportion of fish in quarter 1 in VIId that would return, if not caught by the fishery, to VIIe and IV (Table 1). In summary, 14% of males and 9% of females would migrate to VIIe, while 52% of males and 58% of females would migrate to IV. To the nearest 5%, this suggests that 10 to 15% of the catch in Q1 in VIId should be allocated to VIIe, while between 50 and 60% of the catch in Q1 in VIId should be allocated to IV. These estimates are in agreement with previous analyses (based on the same data) reported by Pawson (1995), which suggest that 20% of the plaice spawning in VIIe and VIId spend the summer in VIIe, while 56% migrate to the North Sea. Given the assumptions involved in these calculations and the relatively small numbers of adult tags returned the estimates of movement rates are subject to great variability. The limitations of the data do not permit an estimate of annual movement probabilities. Recent studies based on data storage tags suggest that the retention rate of spawning plaice tagged in the eastern English Channel is 28%, while 62% of spawning fish tagged were recaptured in the North Sea (Kell *et al*. 2004).

Release Information		period			WEIGHTED BY INTN CATCH AND SSB			
					pr(recap) after 6 or more months at liberty			
DIV	Sex	Release	Recapture	N	7A	7E	7D	4
VIIe	B	ALL		**564**	0.001	**0.90**	0.06	0.04
	M	Jan-Mar		**2**	0	**0.74**	0.26	0
	F			**3**	0	**0.60**	0.40	0
	M	Apr_Dec		**180**	0	**0.91**	0.05	0.03
	F			**224**	0.001	**0.93**	0.03	0.04
	M	Jan-Mar	Apr_Dec	**17**	0	**0.66**	0.11	0.23
	F			**8**	0	**0.67**	0.24	0.09
	M	Apr_Dec	Jan-Mar	**68**	0	**0.83**	0.12	0.05
	F			**62**	0	**0.88**	0.07	0.06
VIId	B	ALL		**990**	0.00	0.10	**0.54**	0.36
	M	Jan-Mar		**31**	0	0.04	**0.73**	0.22
	F			**86**	0	0.08	**0.58**	0.34
	M	Apr_Dec		**144**	0	0.10	**0.76**	0.14
	F			**180**	0	0.09	**0.79**	0.12
	M	Jan-Mar	Apr_Dec	**144**	0	0.14	**0.35**	0.52
	F			**305**	0	0.09	**0.33**	0.58
	M	Apr_Dec	Jan-Mar	**31**	0	0.20	**0.57**	0.23
	F			**63**	0	0.11	**0.72**	0.17
IVc	B	ALL		**812**	0	0.01	0.06	**0.93**
	M	Jan-Mar		**54**	0	0	0.03	**0.97**
	F			**17**	0	0	0.28	**0.72**
	M	Apr_Dec		**172**	0	0.01	0.06	**0.92**
	F			**235**	0	0.01	0.04	**0.95**
	M	Jan-Mar	Apr_Dec	**102**	0	0	0	**1**
	F			**38**	0	0	0	**1**
	M	Apr_Dec	Jan-Mar	**54**	0	0.02	0.05	**0.93**
	F			**71**	0	0.01	0.18	**0.80**

Table 1 : Summary of estimated movement probabilities for plaice (≥ 270mm) recaptured after 6 or more months at liberty, for data collected between 1960 and 2006.

A.2. Fishery

Plaice is mainly caught in beam trawl and gillnet fisheries for sole or in mixed demersal fisheries using otter trawls. There is also a directed fishery during parts of the year by inshore trawlers and netters on the English and French coasts. The Belgian beam trawlers fish mainly in the 1st and 4th quarters and their area of activity covers almost the whole of VIId south of the 6 mile contour from the English coast. There is only light activity by this fleet between April and September. The second offshore fleet is mainly large otter trawlers from Boulogne, Dieppe and Fecamp. The target species of these vessels are cod, whiting, plaice, gurnards and cuttlefish and the fleet operates throughout VIId. The inshore trawlers and netters are mainly vessels <12m operating on a daily basis within 12 miles of the coast. There are a large number of these vessels (in excess of 400) operating from small ports along the French and English coast. These vessels target sole, plaice, cod and cuttlefish.

The minimum landing size for plaice is 27cm. Minimum mesh sizes for demersal gears permitted to catch plaice are 80mm for beam trawling and 100mm for otter trawlers. Fixed nets are required to use 100mm mesh since 2002 although an exemption to permit 90mm has been in force since that time.

There is widespread discarding of plaice, especially from beam trawlers. The 25 and 50% retention lengths for plaice in an 80mm beam trawl are16.4cm and 17.6cm respectively which are substantially below the MLS. Routine data on discarding is now available, and show plaice discards ratio between 20 and 60% depending on the metier. Discard survival from small otter trawlers can be in excess of 50% (Millner *et al*., 1993). In comparison discard survival from large beam trawlers has been found to be between less than 20% after a 2h haul and up to 40% for a one-hour tow (van Beek *et al* 1989).

A.3. Ecosystem aspects

Biology : Adult plaice feed essentially on annelid polychaetes, bivalve molluscs, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel, spawning occurs from December to March between 20 and 40 m. depth. At the beginning, pelagic eggs float at the surface and then progressively sink into deeper waters during development. Hatching occurs 20 (5-6°C) to 30 (2-2.5°C) days after fertilization. Larvae spend about 40 days in the plankton before migrating to the bottom and moving to coastal waters when metamorphosing (10-17 mm). The fry undergo relatively fast growth during the first year (*Carpentier et al., 2005*).

Environment: This bentho-demersal species prefers living on sand but also gravel or mud bottoms, from the coast to 200 m depth. The sepcies is found from marine to brackish waters in temperate climate (*Carpentier et al., 2005*)..

Geographical distribution : Northeast Atlantic, from northern Norway and Greenland to Morocco, including the White Sea; Mediterranean and Black Seas (*Carpentier et al., 2005*)..

Vaz *et al*. (2007) used a multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature (Vaz *et al*, 2004). One Group was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry. It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

Community evolution over time : (From Vaz *et al*., 2007). The community relationship with its environment was remarkably stable over the 17 y of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

More details on biology, habitat and distribution of plaice in VIId from the Interreg 3a project CHARM II, may be found in Annex 1.

B. Data

B.1. Commercial catch

The landings are taken by three countries France (55% of combined TAC), England (29%) and Belgium (16%). Quarterly catch numbers and weights were available for a range of years depending on country; the availability is presented in the text table below. Levels of sampling prior to 1985 were poor and these data are considered to be less reliable. In 2001 international landings covered by market sampling schemes represented the majority of the total landings

Belgian commercial landings and effort information by quarter, area and gear are derived from log-books. Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium). Quarterly sampling of landings takes place at the auctions of Zeebrugge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours. Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level. The ALK is used to obtain the quarterly age distribution from the length distribution. From 2003, an on-board sampling programme is routinely carried out following the provision of the EU Regulation 1639/2001.

French commercial landings in tonnes by quarter, area and gear are derived from 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. Although there are only minor differences between the two indices, the revised method was used in 2002 and subsequently.

B.4. Commercial CPUE

Three commercial fleets have been used in tuning: UK and Belgian Beam Trawlers and French Otter Trawlers.

The effort of the French otter trawlers is obtained by the log-book information on the duration of the fishing time weighted by the engine power (in KW) of the vessel. Only trips where sole and/or plaice have been caught is accounted for. The effort of the Belgian Beam Trawlers is corrected for engine power.

B.5. Other relevant data

None.

C. Historical Stock Development

Benchmark 2010

This stock was 'benchmarked' at the WKFLAT 2010 meeting where two main issues have been under review, (i) inclusion of a discards time series in the assessment and (ii) an attempt to overcome the problematic retrospective pattern. Solutions explored included making an 'allowance' for migration patterns between the two Channel plaice stocks and the southern North Sea.

The combined assessment of the two Channel plaice stocks was examined. It was agreed that this would require further investigation as the inclusion of the North Sea stock would also need to be considered. Any combining of stocks would a have a wide ranging impact on the assessment and any subsequent management.

The issue of including discard estimates was based on a working document provided to the benchmark workshop, where all on-board samples from Belgium, France and UK from 2002 to 2008 were gathered in an international dataset. An estimate of annual discards at age was produced for the period 2004 – 2008, and the flexible Statistical Catch-at-Age model developed by Aarts and Poos (2009) has been tested for reconstructing discards prior to 2004. The model did not succeed in providing reasonable and robust fit. The current discard time series was considered too short and too variable to support proper model fitting. Further work on the data and method used for estimating the 2004-2008 series of discards is necessary before inclusion in the statistical model is considered further.

The persistent retrospective pattern in the assessment without discards was largely reduced, when 65% of quarter 1 catches were removed as well as removal of younger ages (1, 2 and 3) from the survey UK BTS. The patterns in log q residuals, already shown in the previous assessment remained unchanged.

In conclusion, the proposed final settings (detailed below) improve the retrospective pattern, and take into account the acknowledged mixing between neighbouring areas, but the model is not entirely satisfactory in terms of quality of the assessment. The reasons are that the model still does not account for discards, removes younger ages from an internally consistent survey, and does not provide solutions for the patterns in log catchability residuals.

The recommendation from WKFLAT is that **this assessment is useful in determining recent trends in F and SSB, and in providing a short-term forecast and advice on relative changes in F**. However, WKFLAT does not recommend this as an analytical assessment, as it will not be useful for calculation of reference points.

Since further work on including the discard estimates, on the relevance of the commercial tuning series, and sensitivity of the assessment to the 65% adjustment to the Q1 catch at age need to be examined, the information concerning the settings of the assessment model is only valid for WGNSSK 2010.

Model used: XSA

Software used: IFAP / Lowestoft VPA suite for final assessment; FLR packages and SURBA software for exploratory analysis

Model Options chosen:

1) Tapered time weighting not applied
2) Catchability independent of stock size for all ages
3) Catchability independent of age for ages >= 7
4) Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages
5) S.E. of the mean to which the estimate are shrunk = 1.0
6) Minimum standard error for population estimates derived from each fleet = 0.300
7) Prior weighting not applied
8) Input data types and characteristics:
9) Catch data available for 1980-present year. However, there was no French age compositions before 1986 and large catchability residuals were observed in the commercial data before 1986. In the final analyses only data from 1986-present were used in tuning.
10) Removal of 65% of quarter 1 catches in tonnes, catches at age and weight at age for all years

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1980-Last yr	1-10+	No
Canum	Catch at age in numbers	1980-Last yr	1-10+	No
Weca	Weight at age in the commercial catch	1980-Last yr	1-10+	No
West	Weight at age of the spawning stock at spawning time.	1980-Last yr	1-10+	No
Mprop	Proportion of natural mortality before spawning	1980-Last yr	1-10+	No
Fprop	Proportion of fishing mortality before spawning	1980-Last yr	1-10+	No
Matprop	Proportion mature at age	1980-Last yr	1-10+	No
Natmor	Natural mortality	1980-Last yr	1-10+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	UK BeamTrawl	Excluded	
Tuning fleet 2	BE Beam Trawl	1981 – Last yr	2-10+
Tuning fleet 3	FR Otter Trawl	Excluded	
Tuning fleet 4.	UK BTS	1988 – Last yr	4-6
Tuning fleet 5	FR GFS	1988 – Last yr	2-3
Tuning fleet 6	Int YFS	1987-2006	1

D. Short-Term Projection

Short term projection were done using the ICES 2012 recommendations

Model used: Age structured

Software used: FLR package

Initial stock size:

1) the survivors at age 2 and greater from the XSA assessment

2) N at age 1 = geometric mean over a long period (1998, last data year)

Maturity: same ogive as in the assessment is used for all years

F and M before spawning: Set to 0 for all ages and all years

Weight at age in the stock: average stock and catch weights over the preceding 3 years.

Weight at age in the catch: average stock and catch weights over the preceding 3 years.

Exploitation pattern: The F vector used will be the average F-at-age in the last 3 years, scaled by the Fbar (2-6) to the level of last year.

Intermediate year assumptions:

Stock recruitment model used: None, the long term geometric mean recruitment at age 1 is used

Procedures used for splitting projected catches:

E. Medium-Term Projections

No Medium-Term Projections can be done for this stock, until the quality of the assessment is improved.

F. Long-Term Projections

No Long-Term Projections can be done for this stock, until the quality of the assessment is improved.

G. Biological Reference Points

Previous Reference Points:

Blim = 5400 t.
Bpa = 8000 t.
Flim = 0.54
Fpa = 0.45

The current assessment is indicative for trends only, therefore the biological reference points are not valid anymore for being used in the advice.

H. Other Issues

I. References

Beek, F.A. van, Leeuwen, P.I. van and Rijnsdorp, A.D. 1989. On the survivalof plaice and sole discards in the otter trawl and beam trawl fisheries in the North Sea. ICES C.M. 1989/G:46, 17pp

Carpentier, A., Vaz, S., Martin, C. S., Coppin, F., Dauvin, J.- C., Desroy, N., Dewarumez, J.- M., Eastwood, P. D., Ernande, B., Harrop, S., Kemp, Z., Koubbi, P., Leader-Williams, N., Lefèbvre, A., Lemoine, M., Loots, C., Meaden, G. J., Ryan, N., Walkey, M., 2005. Eastern Channel Habitat Atlas for Marine Resource Management (CHARM), Atlas des Habitats des Ressources Marines de la Manche Orientale, INTERREG IIIA, 225 pp.

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management,final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom. http://www.ifremer.fr/docelec/doc/2009/rapport-7377.pdf

ICES 2003a. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, October 2002. ICES CM 2003/ACFM:02

ICES 2003b. Report of the Study Group on Precautionary Reference Points For Advice on Fishery Management ICES CM 2003/ACFM:15

ICES, 2003c. Planning Group on North Sea Cod and Plaice Egg Surveys in the North Sea (PGEGGS). Ijmuiden, Netherlands. 24–26 June 2003 ICES CM 2003/G:06 Ref. D. 45 p.

Kell, L.T., Scott, R., and Hunter E. (2004) Implications for current management advice for North Sea plaice: Part I. Migration between the North Sea and English Channel. Journal of Sea Research 51: 287– 299

Millner, R.S., Whiting, C.L and Howlett, G.J. 1993. Estimation of discard mortality of plaice from small otter trawlers using tagging and cage survival studies. ICES C.M. 1993/G:24, 6pp

Pawson, M.G. (1995) Biogeographical identification of English Channel fish and shellfish stocks. Fisheries Research Technical Report No. 99. MAFF Directorate of Fisheries Research, Lowestoft. http://www.cefas.co.uk/Publications/techrep/tech99.pdf

Riou *et al*. 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel : application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125-135

ICES 2012. Report of the Report of the Workshop on the Development of Assessments based on LIFE history traits and Exploitation Characteristics (WKLIFE). ICES CM 2012/ACOM:36

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

© IFREMER

Embranchement-Phylum : Chordata

Classe-Class : Actinopterygii

Ordre-Order : Pleuronectiformes

Famille-Family : Pleuronectidae

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.

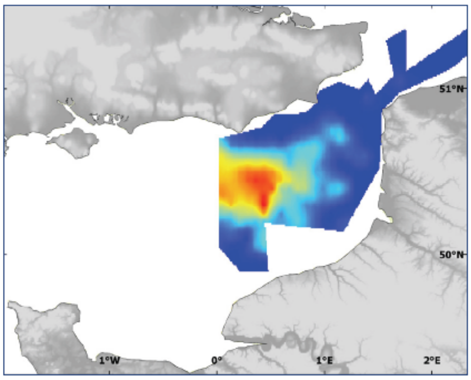
Life history parameters - Maximum length 100 cm; common length 25-45 cm; minimum landing size 22 cm except in Skaggerak and Kattegat 27 cm (EU); maximum lifespan 50 years; age and length at maturity 2-7 years and 18-35 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 71.65 cm, growth rate 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).

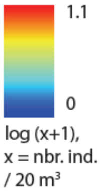
Environment - This bentho-demersal species prefers to live on sand but also on gravely or muddy substrates, from the coast to 200 m in depth. The species is found in marine to brackish temperate waters.

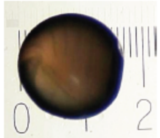
Geographical distribution - North-east Atlantic, from northern Norway and Greenland down to Morocco; Mediterranean including the Black Sea.

Œufs / Eggs - Pleuronectes platessa

Abondance en janvier (IBTS, 2007)
Abundance in January (IBTS, 2007)

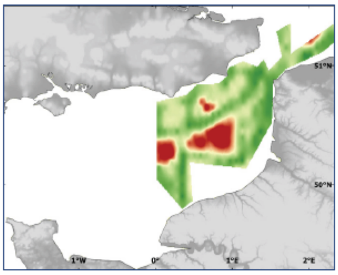


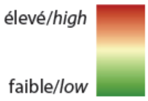




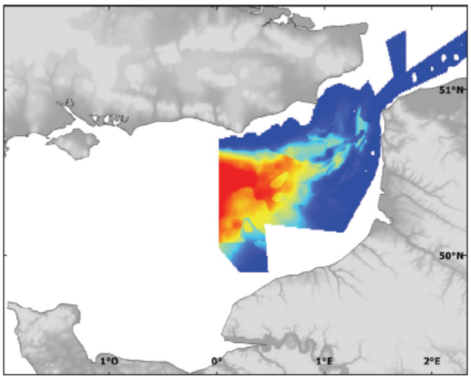
stade 1
stage 1

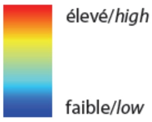
Erreur de krigeage
Kriging error



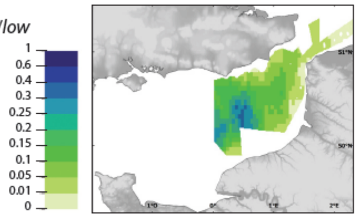


Habitat préférentiel en janvier (GLM)
Preferential habitat in January (GLM)





Erreur du modèle / *Model error*



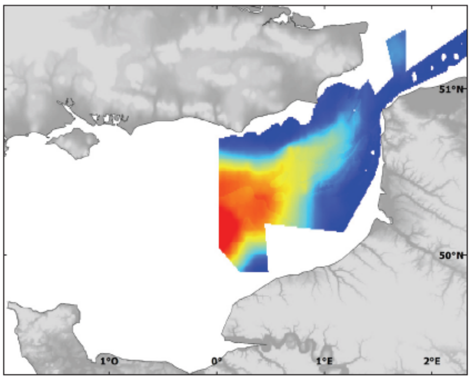
0/1 GLM

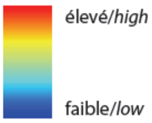
DEP	+2
STR	-
TMP	+
SAL	
CHL	+
SED	

\+ GLM

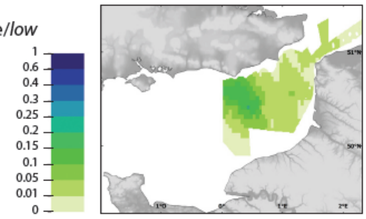
DEP	
STR	
TMP	2
SAL	
CHL	
SED	CS M - G - FS - P

Habitat potentiel en janvier (RQ)
Potential habitat in January (RQ)

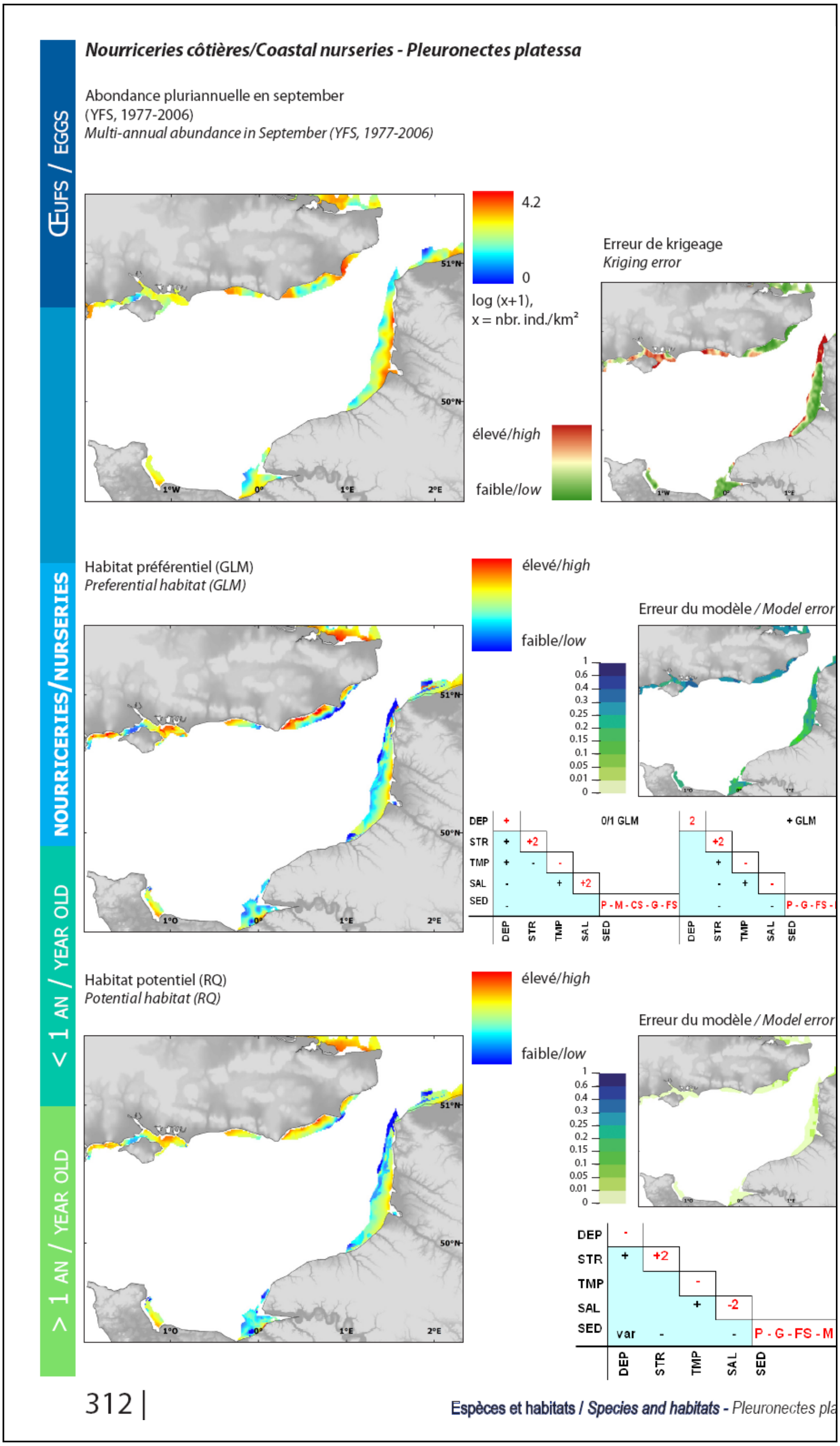




Erreur du modèle / *Model error*



DEP	+2
STR	-2
TMP	-2
SAL	-2
CHL	+2
SED	CS M - FS - G - P


ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
Nourriceries côtières/Coastal nurseries - Pleuronectes platessa
Abondance pluriannuelle en september
(YFS, 1977-2006)
Multi-annual abundance in September (YFS, 1977-2006)
4.2
0
log (x+1),
x = nbr. ind./km²
Erreur de krigeage
Kriging error
élevé/high
faible/low
Habitat préférentiel (GLM)
Preferential habitat (GLM)
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)
var
P - G - FS - M
51°N
50°N
1°W
0°
1°E
2°E
1
0.6
0.4
0.3
0.25
0.2
0.15
0.1
0.05
0.01
0
312
Espèces et habitats / Species and habitats - Pleuronectes pla

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

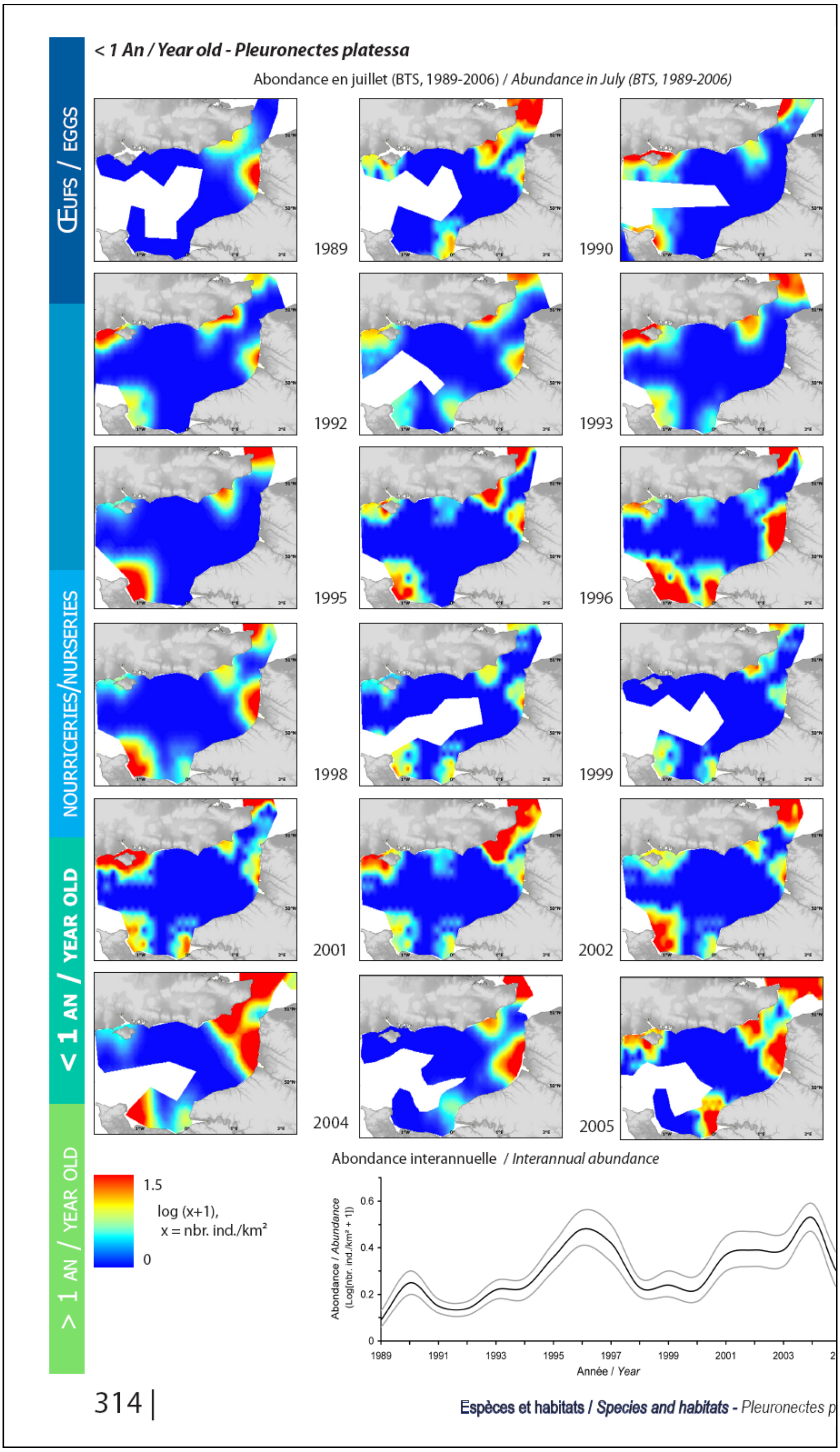
The multi-annual abundance map from the YFS surveys (September) indicates a very coastal spatial distribution of plaice across the sampled area, with some high abundance areas in front of the Bays of Somme, Canche, Authie and Rye. The potential and preferential habitat models are very similar and agree 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

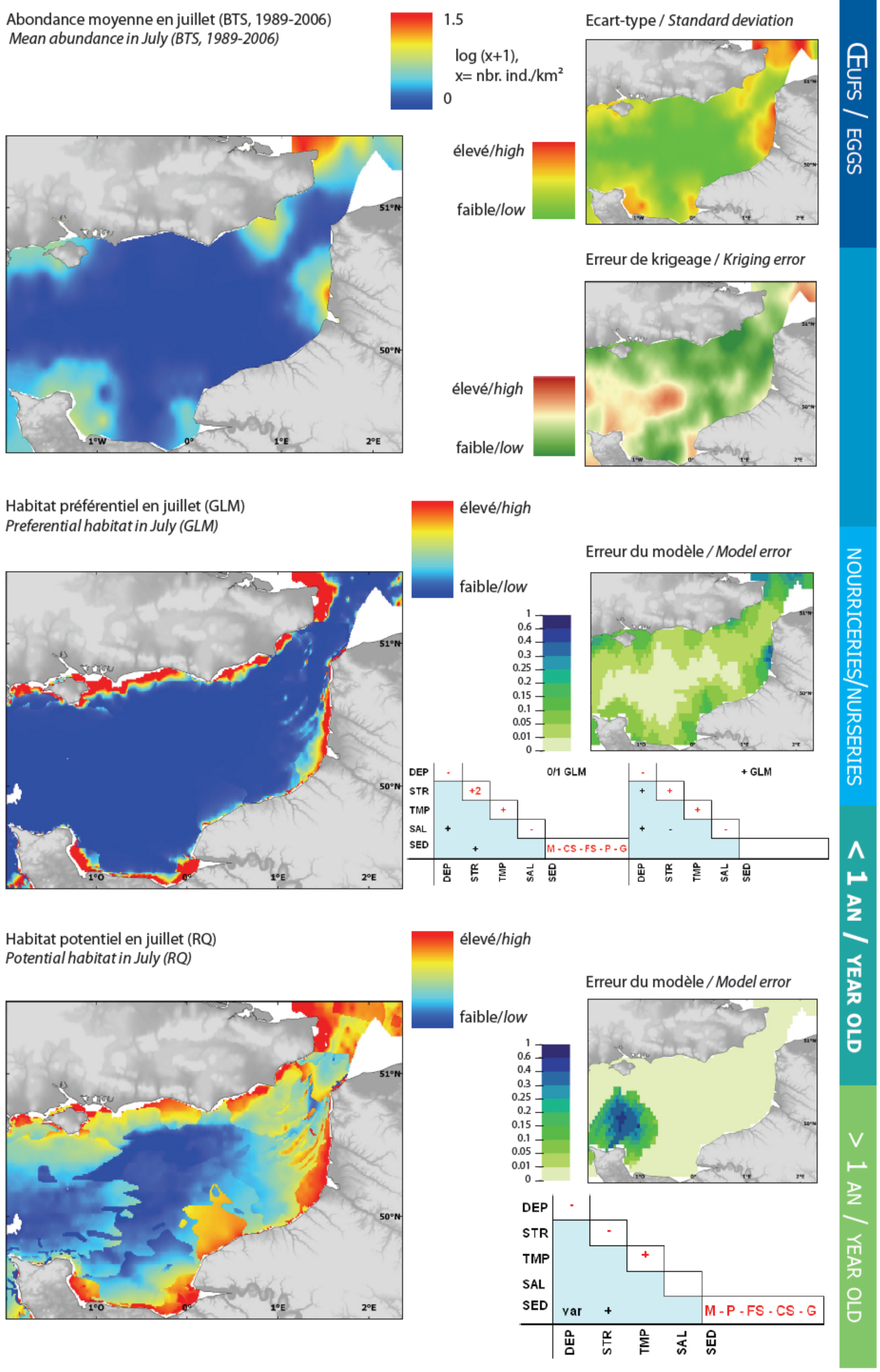
Individuals of less than one year were defined as such on the basis of their length (< 18.0 cm).

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.

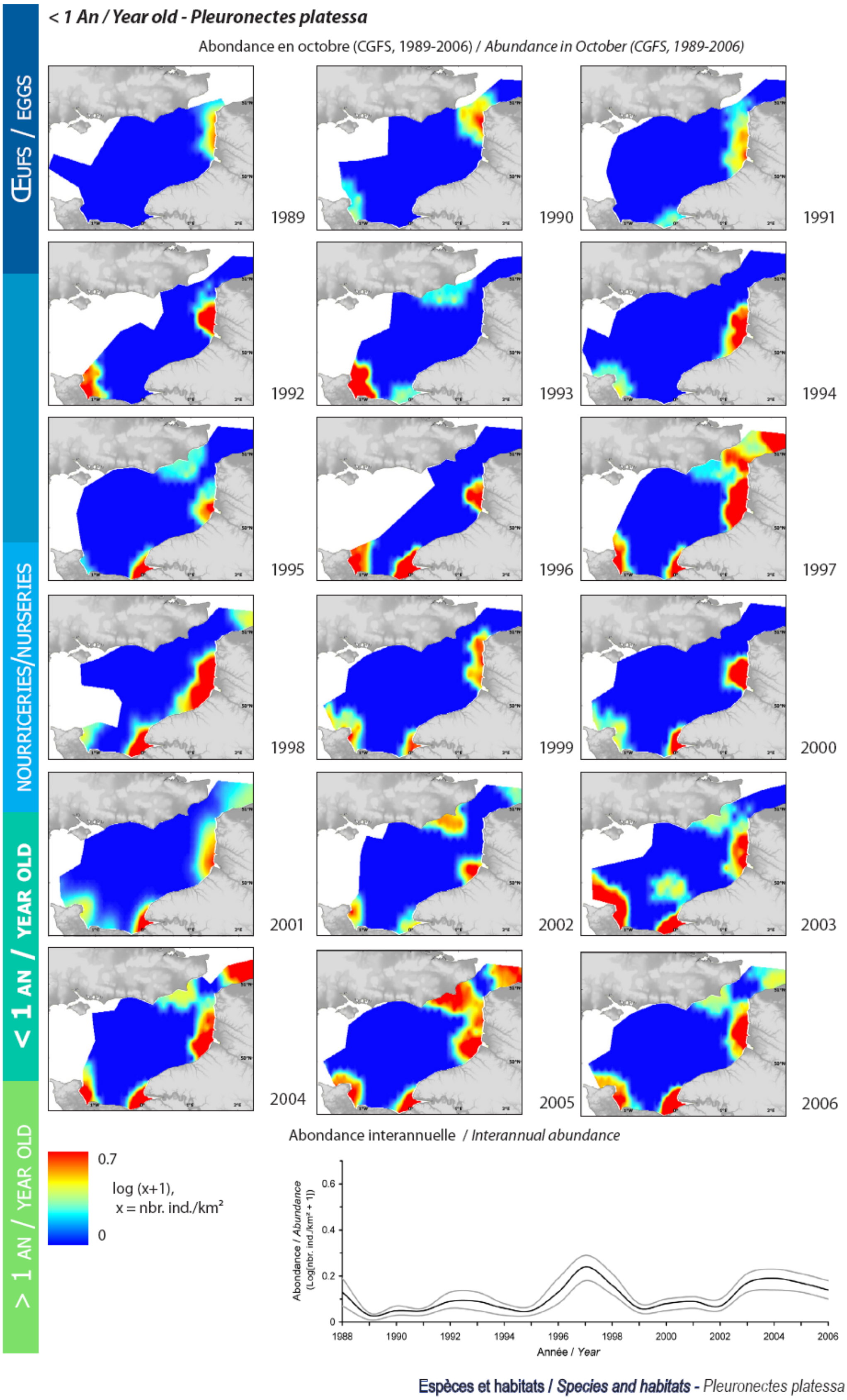
In October, the distribution of young plaice was more spatially restricted than in July, and seemed to be concentrated the Bays of Somme, Canche, Authie and Seine. Some young individuals were also found around the Cherbourg Peninsula. Occurrence areas of young plaice did not change a lot between July 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])
Année / Year
314
Espèces et habitats / Species and habitats - Pleuronectes p

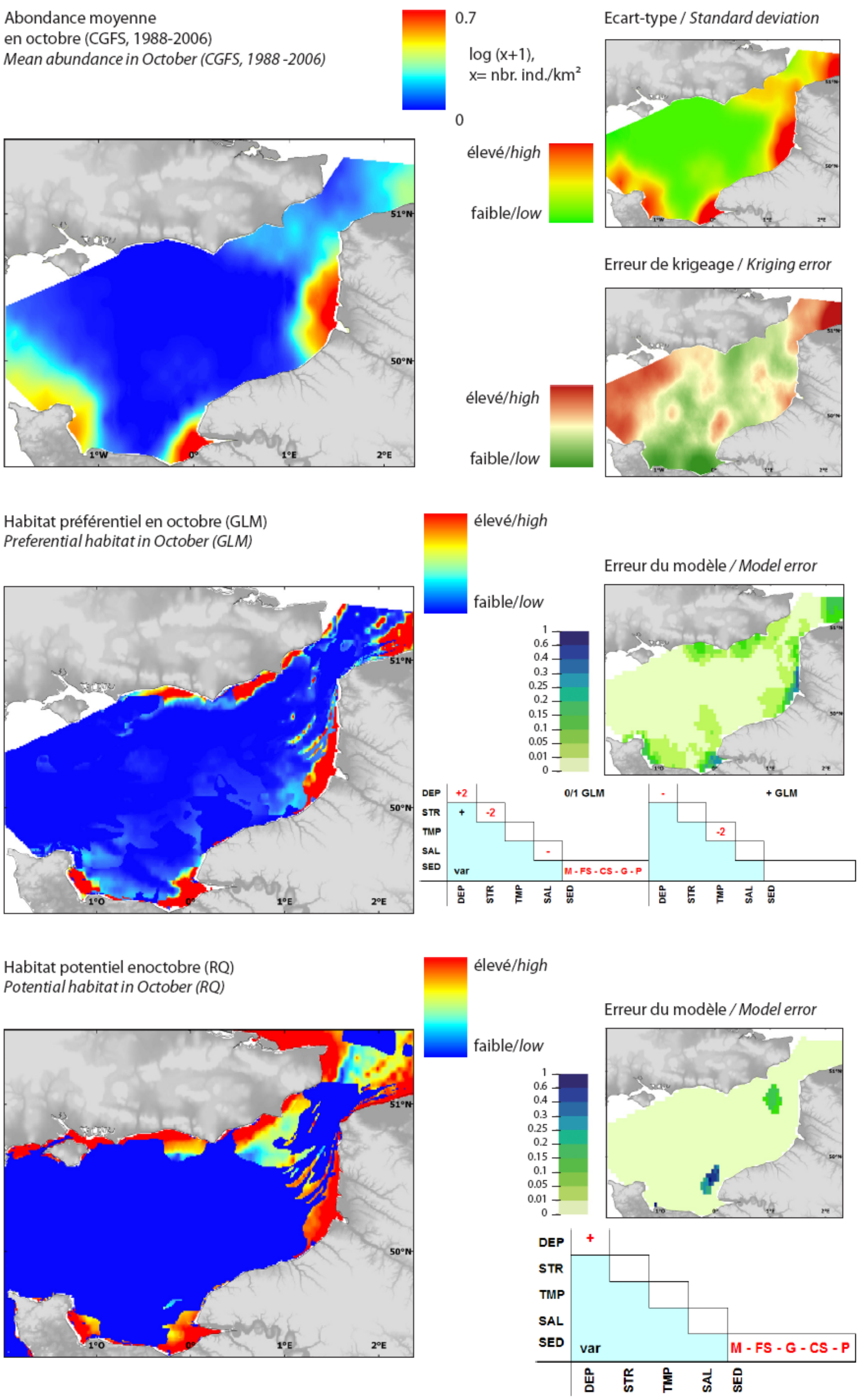
< 1 An / Year old - Pleuronectes platessa



Espèces et habitats / Species and habitats - Pleuronectes platessa


ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
< 1 An / Year old - Pleuronectes platessa
Abondance en octobre (CGFS, 1989-2006) / Abundance in October (CGFS, 1989-2006)
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
0.7
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
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
Année / Year
Espèces et habitats / Species and habitats - Pleuronectes platessa

< 1 An / Year old - Pleuronectes platessa



Œufs / Eggs
Nourriceries/Nurseries
< 1 an / Year old
> 1 an / Year old

Espèces et habitats / Species and habitats - Pleuronectes platessa

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

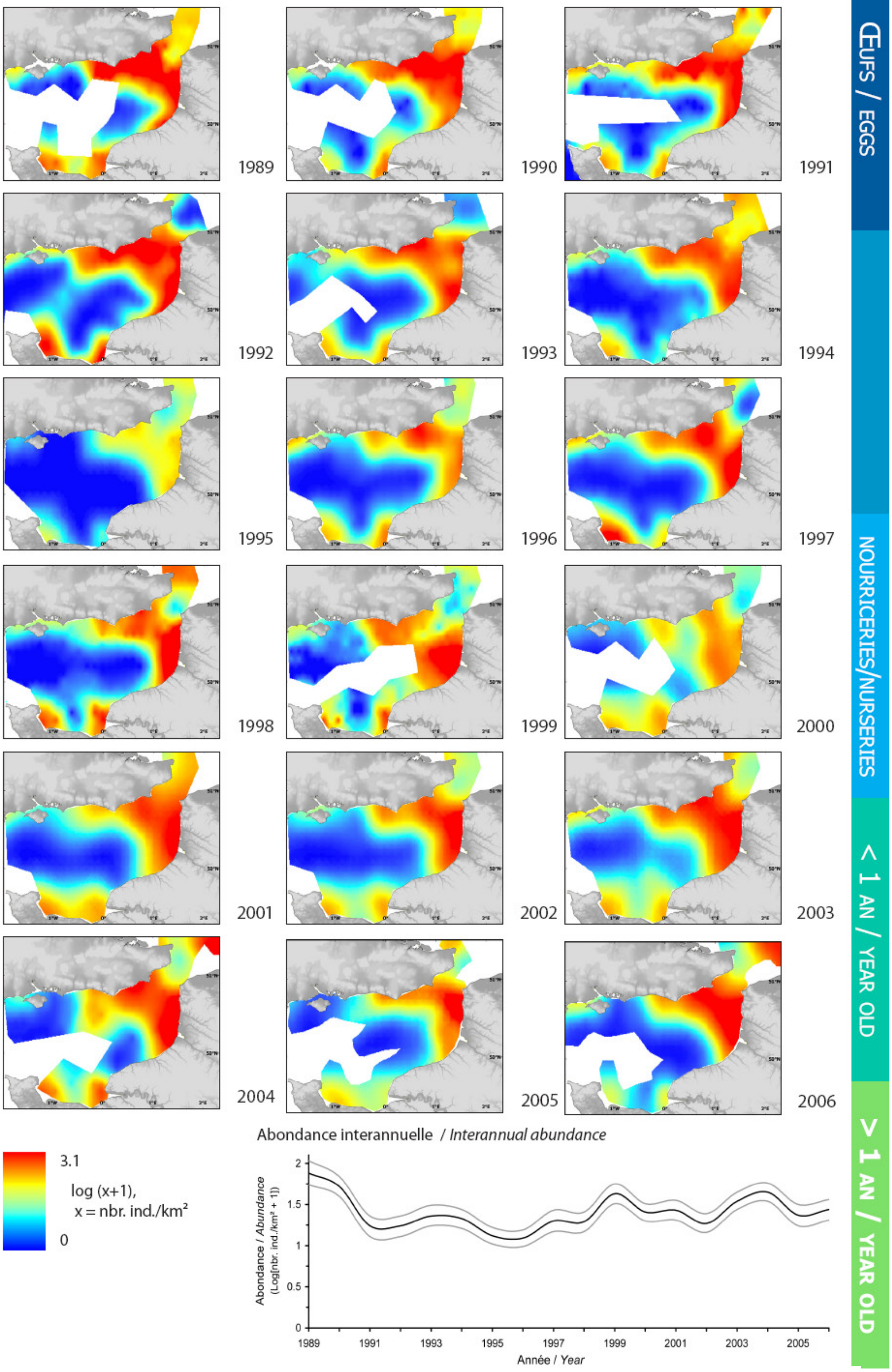
Older than one year individuals (length > 18.1 cm) were found in the same areas as younger ones but had a more offshore distribution pattern.

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.

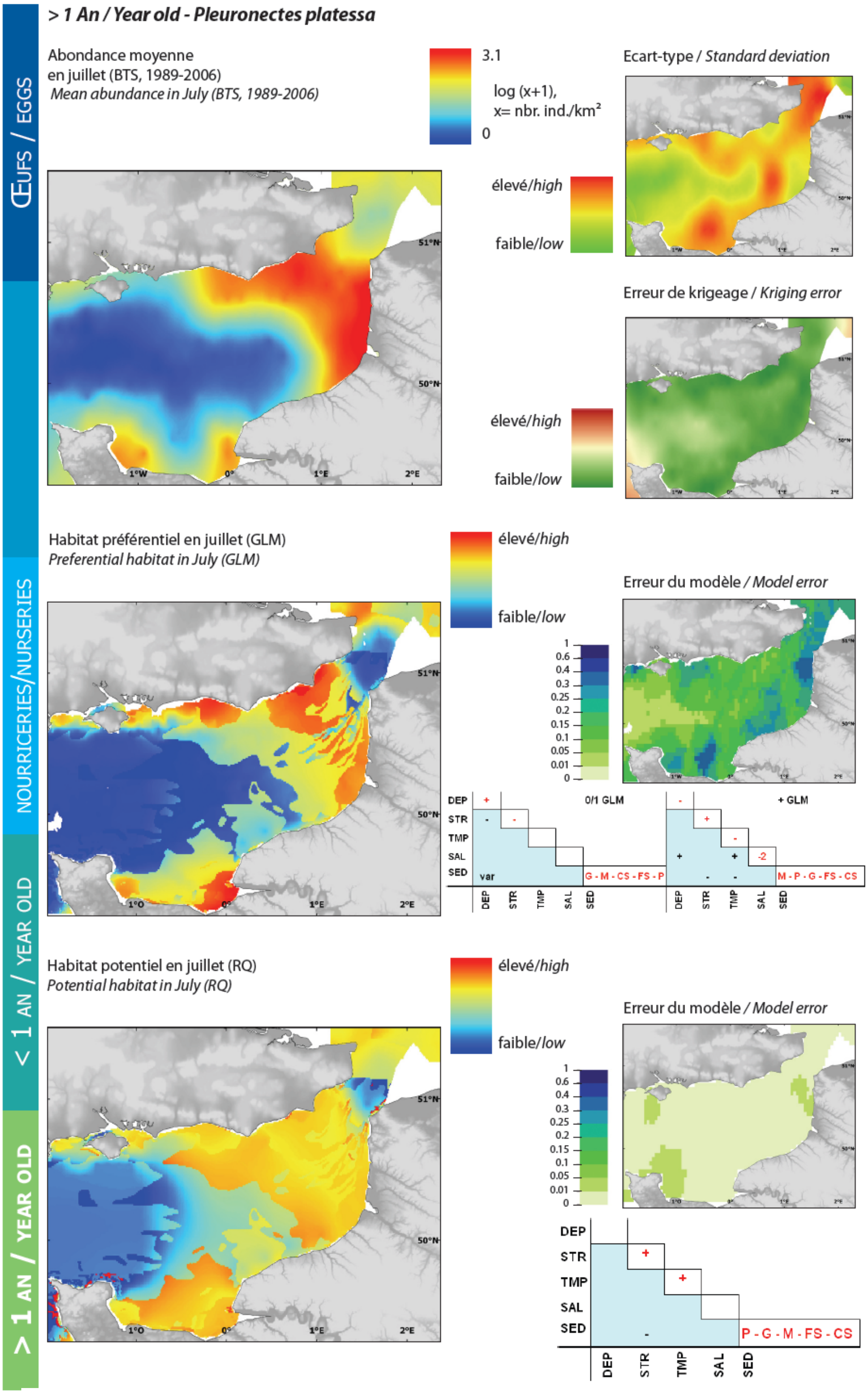
In October, the distribution pattern seemed to contract along the coasts. Many individuals were found along the Opale and Belgium coasts and around Dungeness. Some patches occured in the Bays of Seine and Veys. The kriging error was again associated with more sparse observations. The preferential and 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.

> 1 An / Year old - Pleuronectes platessa

Abondance en juillet (BTS, 1989-2006) / *Abundance in July (BTS, 1989-2006)*



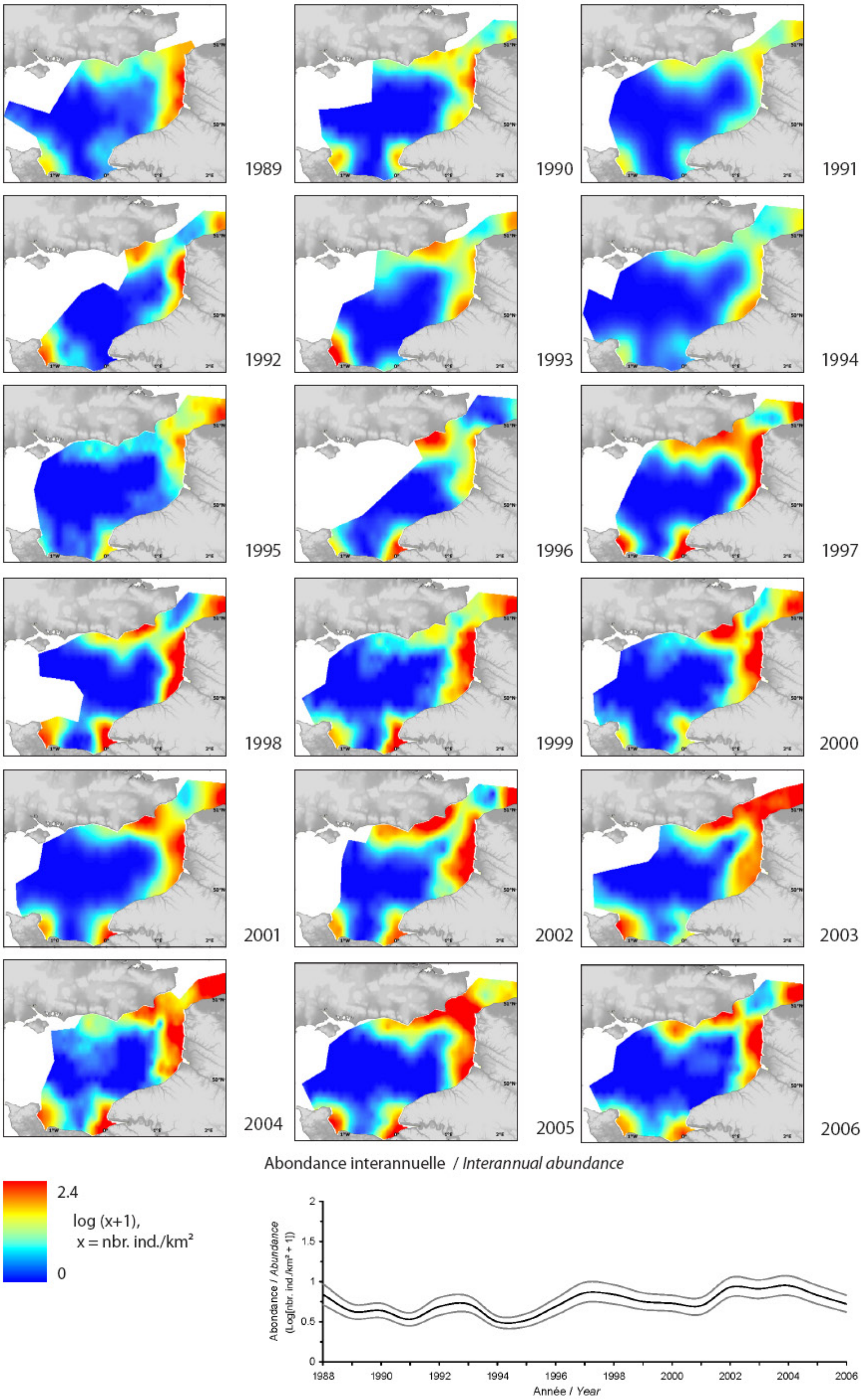
Espèces et habitats / *Species and habitats* - *Pleuronectes platessa*

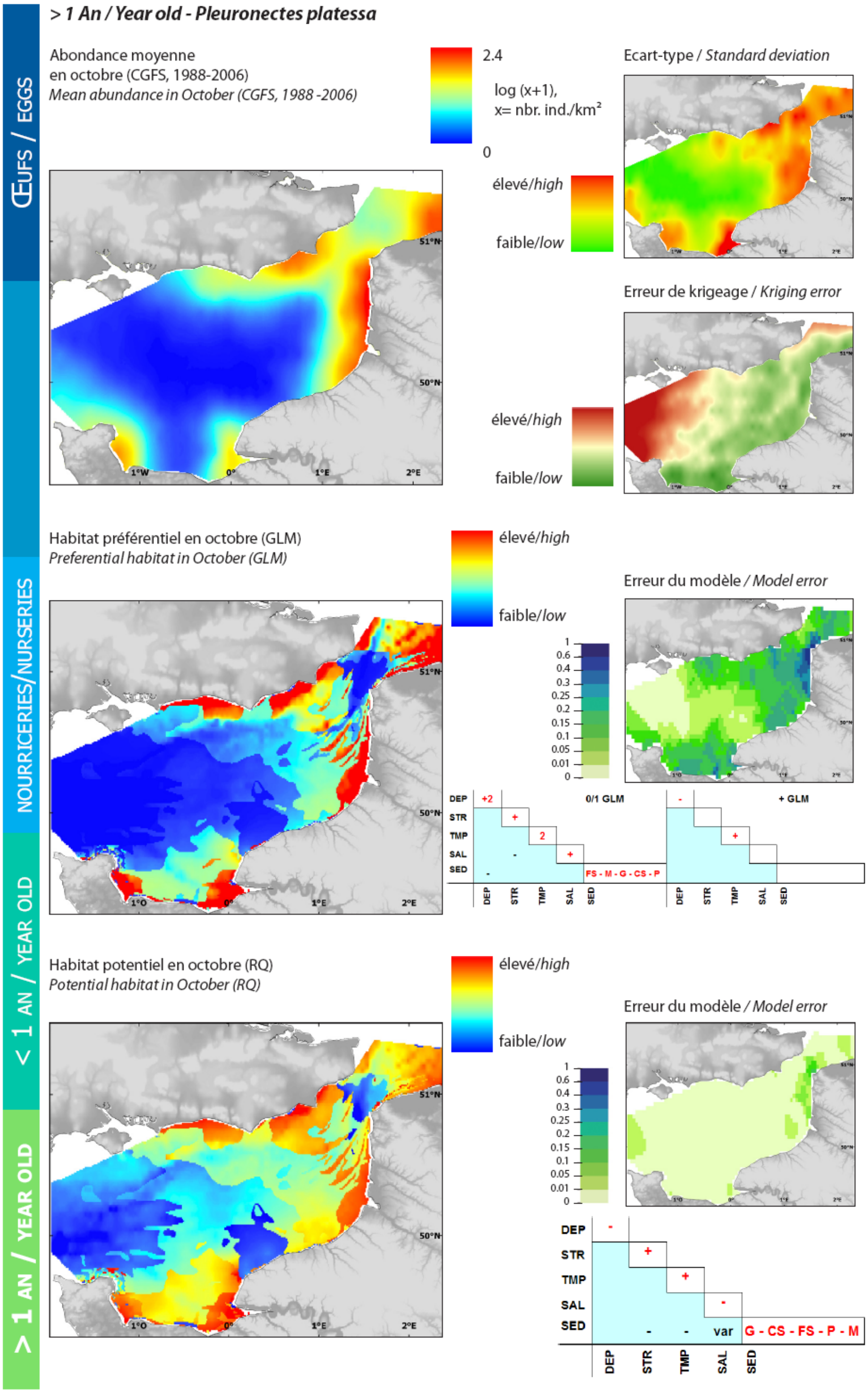


Espèces et habitats / *Species and habitats* - Pleuronectes platessa

> 1 An / Year old - *Pleuronectes platessa*

Abondance en octobre (CGFS, 1989-2006) / *Abundance in October (CGFS, 1989-2006)*




ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
> 1 An / Year old - Pleuronectes platessa
Abondance moyenne
en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)
2.4
log (x+1),
x= nbr. ind./km²
0
Ecart-type / Standard deviation
élevé/high
faible/low
Erreur de krigeage / Kriging error
élevé/high
faible/low
Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)
élevé/high
faible/low
Erreur du modèle / Model error
1
0.6
0.4
0.3
0.25
0.2
0.15
0.1
0.05
0.01
0
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
FS - M - G - CS - P
Habitat potentiel en octobre (RQ)
Potential habitat in October (RQ)
élevé/high
faible/low
Erreur du modèle / Model error
var
G - CS - FS - P - M
1°W
0°
1°E
2°E
50°N
51°N

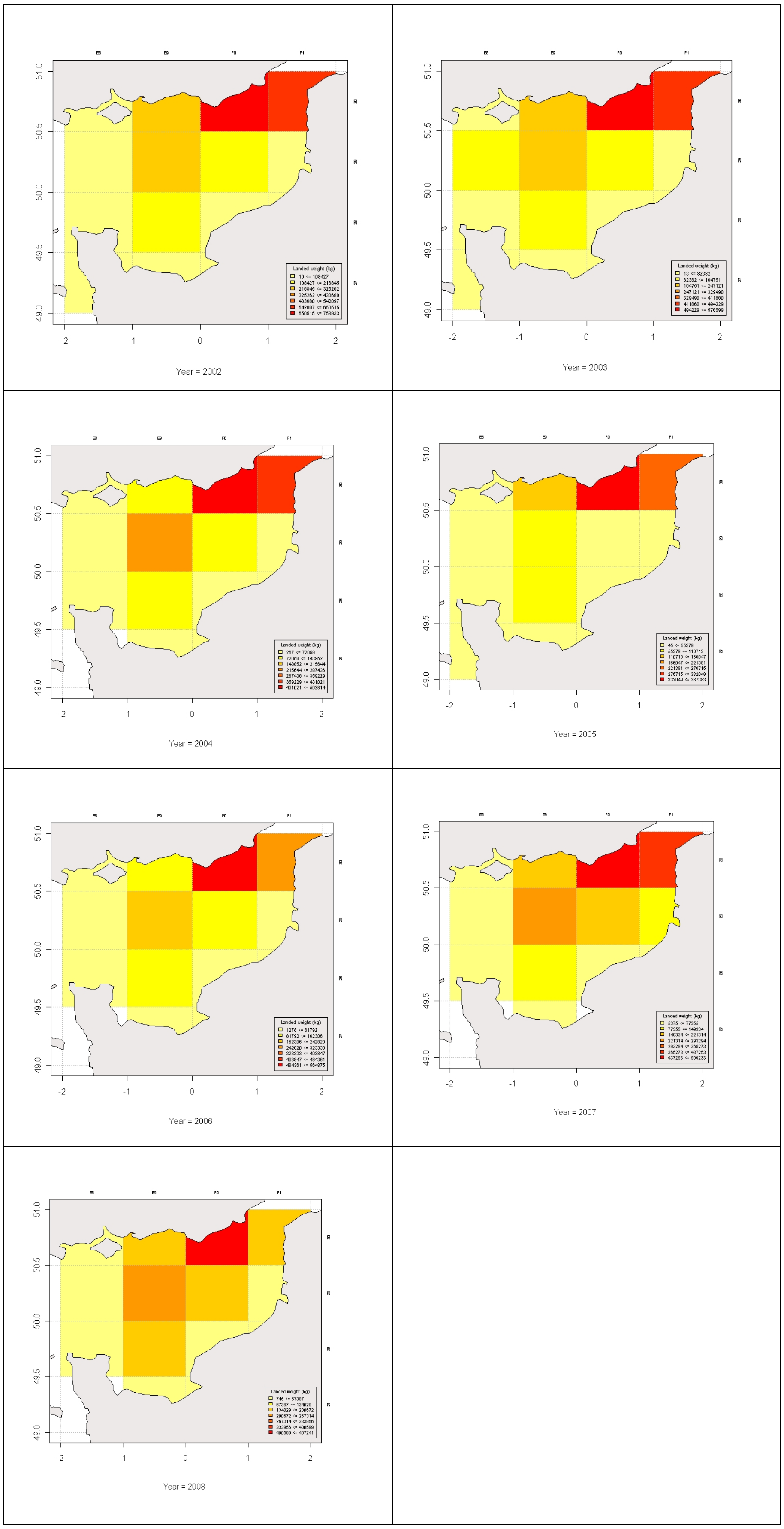


Figure . Plaice in VIId. - International landings from 2002 to 2008.

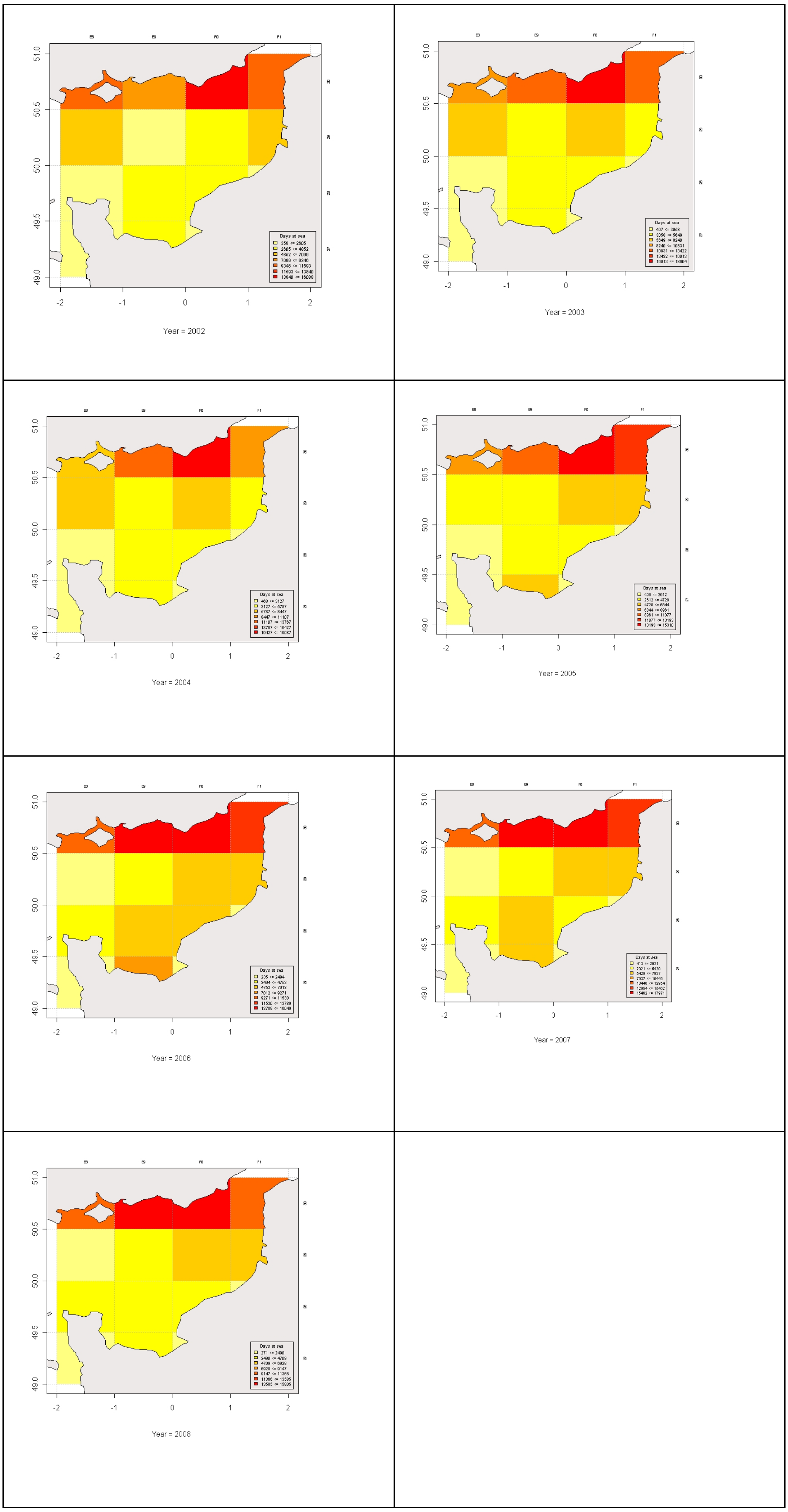


Figure Plaice in VIId - International effort in days at sea from 2002 to 2008.

Stock Annex Pollack in Subarea IV and Division IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Pollack in Subarea IV and Division IIIa Date: 05/03/2010
Working Group	WGNSSK
Date	May 2012
Revised by	Tore Jakobsen

A. General

A.1. Stock definition

There is little published information on pollack (*Pollachius pollachius*, Linnaeus, 1758) biology. The species is restricted to the Northeast Atlantic with a main distribution from the Portuguese continental coast northwards around the British Isles, into the Skagerrak and along the Norwegian coast where it is fairly common up to the Lofoten Islands, and catches have occasionally been recorded as far north as Bear Island. It is rare at Faroe and Iceland and in the Baltic and was never registered in Spanish landings in IXa South (Gulf of Cádiz).

According to FAO Fishbase pollack is benthopelagic, found mostly close to the shore over hard bottom (Svetovidov, 1986) and wrecks and other obstacles (Quero and Vayne, 1997). It usually occurs at 40-100 m depth but is found down to 200 m. A long time series of hauls with a beach seine on the Skagerrak coast shows that 0-group pollack are regularly found in shallow areas close to the shore, but generally in more exposed areas than 0-group cod. Pollack are therefore protected from the fisheries in the early life stages. A single tagging experiment on young (30-35 cm) pollack on the Norwegian west coast gave only local recaptures (Jakobsen, 1985).

According to Fishbase spawning takes place from January to May, depending on the area, and mostly at 100 m depth. Reinsch (1976) gives main spawning in March–April, taking place in the open waters of Skagerrak and the North Sea as well as in coastal waters, FAO Fishbase gives a maximum length of 130 cm, maximum published weight of 18.1 kg and maximum reported age of 8 years based on Cohen *et al*. (1990). This age, however, seems low compared to the maximum size reported. Female length-at-maturity was considered as 35 cm (Cardinale *et al*. 2012), at the age of 3 years. According to Reinsch (1976), the Pollack grows at approximately 7 cm per year after age 3, reaching nearly 90 cm and 5 kg at age 10. Feeding is mainly on fish, and incidentally on crustaceans and cephalopods.

French observations from the Western Channel/Celtic Sea region may also be relevant for the North Sea/Skagerrak. They mainly support the information in Fishbase, although a higher maximum age (15 years) is found. Growth is thus fairly rapid, approaching 10 cm per year. Pollack move gradually away from the coast into deeper waters as they grow. French observations also show that it is most available for fishing when it forms spawning aggregations. Otherwise its preference for wrecks and rocky bottom makes it difficult to catch them with trawls. For this reason trawl surveys are probably not very well suited for monitoring this species.

Charrier *et al*. (2006) used six microsatellite markers to assess the stock structure of pollack in the NE Atlantic by comparing samples collected in four locations along the Atlantic French coast and from one location off southern Norway. Overall results showed limited genetic differentiation among samples which may be related: i) with the existence of gene flow between spawning units due to the larvae dispersal or ii) with a recent origin of populations which prevents significant genetic drift. However, authors remark that results should be carefully analysed due to the small sample sizes and the limited number of microsatellites used which might have hampered the detection of population differentiation for pollack. There are no morphological studies that could be used to separate stocks for this species.

Data from the fishery indicate three main areas of exploitation: one in the northern North Sea/Skagerrak extending north along the Norwegian coast, one in the Western Channel extending into the Eastern Channel, the Celtic Sea, the Irish Sea, and the northern part of the French west coast (areas VIIe-j & VIII a,b - landings from the intermediate areas VIa and IVc are generally small), and one in the Iberian waters (areas VIIIc and IXa. WGNEW proposed, based on a pragmatic approach, to distinguish three different stock units: the southern European Atlantic shelf (Bay of Biscay and Iberian Peninsula), the Celtic Seas, and the North Sea (including VIId and IIIa). This implies that Pollack in Division IIa also is a separate stock unit, but this is not discussed in the WGNEW report.

In the ICES advice it was decided to deal with Pollack in Division VIId as a part of the Celtic Sea ecosystem.

A.2. Fishery

Pollack is mainly a bycatch in various commercial fisheries. Monthly Norwegian catches, averaged over the years 1992-2011, show that catches peak in the months of March and April, coinciding with the spawning time, and this may be associated with spawning aggregations. In Norway the most important gear are gillnets and otter trawl, responsible for 70 and 14 % of the catches respectively. When catches within and outside the 12-miles zone are compared it is seen that, for 2011, in Division IIIa 97% was from within the 12-miles zone (by gillnet and *Pandalus* trawl). In Subarea IV 66% of the catches were made within the 12-miles zone (again by gillnets), whereas in the area beyond the 12-miles zone the main catches were made by otter trawl. The geographical distribution of pollack in Norwegian otter trawl catches closely corresponds to that of saithe.

Pollack is also often caught in recreational fisheries, but no data about these catches are known to the working group.

A.3. Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the working group. Feeding is reported to be mainly on fish, and incidentally on crustaceans and cephalopods.

B. Data

B.1. Commercial catch

Historical landings statistics for pollack are available from ICES, but they are clearly incomplete in earlier years. The introduction of the EEZs in 1977 represented a change in reporting and from 1977 the data series appears to be reasonably consistent and adequate for allocating catches at least to ICES subareas. Considering that pollack is not subject to TAC regulations, a major incentive for mis- or underreporting is not present and landings figures are thus probably reflecting main trends in landings in the different areas.

B.2. Biological

There has been some collection of biological parameters in Subarea IV and Division IIIa by Norway in the most recent years, but the data have not yet been processed.

B.3. Surveys

Pollack is being caught in the IBTS survey in small numbers only. They are distributed mainly over the northwestern North Sea (along the Norwegian Deeps) and into the Skagerrak. Time series of abundance in the IBTS are shown for Subarea IV and Division IIIa separately, for quarter 1 (from 1977 onwards) and quarter 3 (from 1996 onwards).. The catches seem rather irregular, and no clear patterns emerge. A possible exception is the time series for quarter 1 in IIIa that seems to mirror the decrease in abundance of pollack in this area, as also reported in Cardinale *et al.* (2012).

B.4. Commercial CPUE

Not available.

B.5. Other relevant data

C. Assessment: data and method

Only trends in landings and surveys are available as potential indicators of stock trends.

I. References

Cardinale, M., H. Svedäng, V. Bartolino, L. Maiorano, M. Casini and H. Linderholm, 2012. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. J. Appl. Ichthyol. 28(2): 200-208

Charrier, G., Durandc, J.D., Quinioub, L., Larocheb, J. 2011. An investigation of the population genetic structure of pollack (*Pollachius pollachius*) based on microsatellite markers. ICES Journal of Marine Science 63, 1705-1709.

Cohen, D.M., T. Inada, T. Iwamoto and N. Scialabba 1990 FAO Species Catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fish. Synop. 125(10).x+442p. Rome: FAO.

Council Regulation (EU) No 850/1998. Conservation of fishery resources through technical measures for the protection of juveniles of marine organisms.

Council Regulation (EU) No 44/2012. Fishing opportunities available in EU waters and, to EU vessels, in certain non- EU waters for certain fish stocks and groups of fish stocks which are subject to international negotiations or agreements.

ICES. 2010. Report of the Planning Group on Recreational Fisheries (PGRFS), 7-11 June 2010, Bergen Norway. ICES CM 2010/ACOM:34. 168 pp.

Jakobsen, T. 1985. Tagging of pollack on the Norwegian west coast in 1979. ICES CM 1985/G:24.

Quero, J.C. and J.J. Vayne. 1997. Les poissons de mer des pêches françaises. Editions Delachaux et Niestlé. 304 pp.

Reinsch, H.H. 1976. Köhler und Steinköhler. 158 p. Ziemsen Verlag, Wittenberg Lutherstadt 1976.

Svetovidov, A. N. 1986. Gadidae. In Fishes of the North-eastern Atlantic and the Mediterranean (Whitehead, P. J. P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E., eds), pp. 680–710. Paris: UNESCO.

Stock Annex – Sole in Division VIId

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Sole in Division VIId (Easter Channel)
Working Group:	ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK)
Date:	May 2011
Revised by	Willy Vanhee (WKFLAT) updated at WGNSSK-2011

A. General

A.1 Stock definition

The sole in the eastern English Channel (VIId) are considered to be a separate stock from the larger North Sea stock to the east and the smaller geographically separate stock to the west in VIIe. There is some movement of juvenile sole from the North Sea into VIId (ICES CM 1989/G:21) and from VIId into the western Channel (VIIe) and into the North Sea. Adult sole appear to be largely isolated from other regions except during winter, when sole from the southern North Sea may enter the Channel temporarily (Pawson, 1995). The assessment does not take account of these stock movements.

A.2 Fishery

There is a directed fishery for sole by small inshore vessels using trammelnets and trawls, which fish mainly along the English and French coasts and possibly exploit different coastal populations. Sole represents the most important species for these vessels in terms of the annual value to the fishery. The fishery for sole by these boats occurs throughout the year with small peaks in landings in spring and autumn. There is also a directed fishery by English and Belgian beam trawlers who are able to direct effort to different ICES divisions. These vessels are able to fish for sole in winter before the fish move inshore and become accessible to the local fleets. In cold winters, sole are particularly vulnerable to the offshore beamers when they aggregate in localized areas of deeper water. Effort from the beam trawl fleet can change considerably depending on whether the fleet moves to other areas or directs effort at other species such as scallops and cuttlefish. In France, there are some few small beam trawlers operating inshore in a few local areas, and offshore trawlers fishing for mixed demersal species taking sole as a bycatch.

The minimum landing size for sole is 24 cm. Demersal gears permitted to catch sole are 80 mm for beam trawling and 90 mm for otter trawlers. Fixed nets are required to use 100 mm mesh since 2002 although an exemption to permit 90 mm has been in force since that time.

A.3 Ecosystem aspects

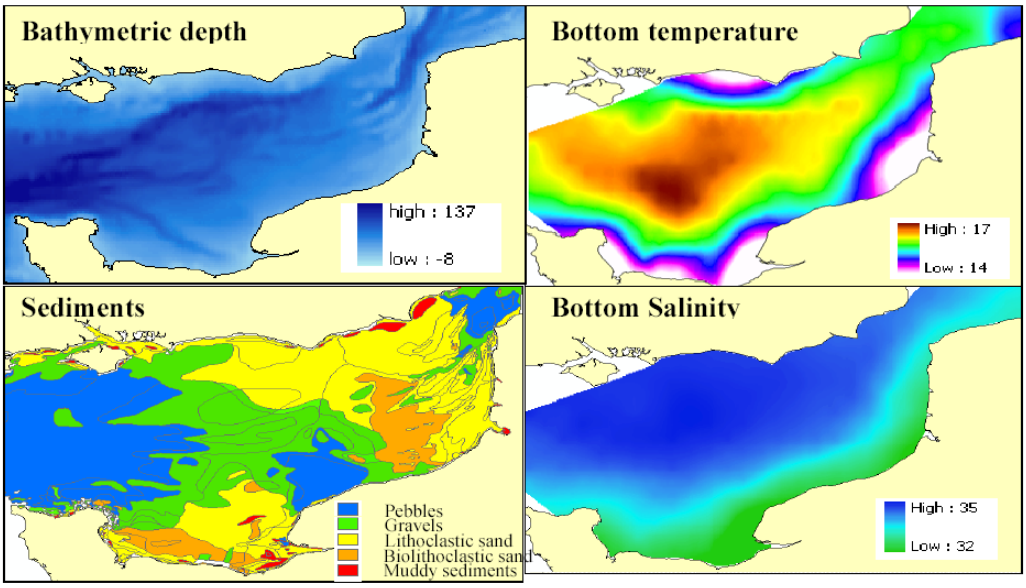


Figure 1. Eastern English Channel physical and hydrological features: Bathymetric depth and simplified sediment types representation. Survey bottom temperature and bottom salinity (averaged for 1997 to 2003) obtained by Kriging. (in Vaz *et al.*, 2004).

Biology: Adult sole feeds on worms, small molluscs and crustaceans. In the English Channel, reproduction occurs between February and April, mainly in the coastal areas of the Dover Strait and in large bays (Somme, Seine, Solent, Mont-Saint-Michel, Start and Lyme Bay). Pelagic eggs hatch after 5 to 11 days leading to larvae that are also pelagic and that will metamorphose into benthic fry after 1 or 2 weeks. Juveniles spend the first 2 or 3 years in coastal nurseries (bays and estuaries) where fast growth occurs (11 cm at 1 year old) before moving to deeper waters.

The spatial distribution of life stages of common sole demonstrates a particular pattern: larval distribution (on spawning grounds) and juvenile distribution (in nursery grounds) overlap. If larvae are found everywhere during spring, the potential habitat for stage 2 larvae is along the Flanders coast and near the Pays de Caux, to the central zone of the English Channel. Older larvae have a more coastal habitat preference, which can be explained by a retention phenomenon linked to estuaries.

Environment: A benthic species that lives on fine sand and muddy seabeds between 0 and 150 meters depth. It ranges from marine to brackish waters in temperatures between 8 and 24°C.

Geographical distribution: Eastern Atlantic, from southern Norway to Senegal, Mediterranean Sea including Sea of Marmara and Black Sea.

Vaz *et al.*, 2007 used multivariate and spatial analyses to identify and locate fish, cephalopod, and macrocrustacean species assemblages in the eastern English Channel from 1988 to 2004. Four sub-communities with varying diversity levels were identified in relation to depth, salinity, temperature, seabed shear stress, sediment type, and benthic community nature. One Group (class 4 in Figure 2 below) was a coastal heterogeneous community represented by pouting, poor cod, and sole and was classified as preferential for many flatfish and gadoids. It displayed the greatest diversity and was characterized by heterogeneous sediment type (from muds to coarse sands) and various associated benthic community types, as well as by coastal hydrology and bathymetry. It was mostly near the coast, close to large river estuaries, and in areas subject to big salinity and temperature variations. Possibly resulting from this potentially heterogeneous environment (both in space and in time), this sub-community type was the most diverse.

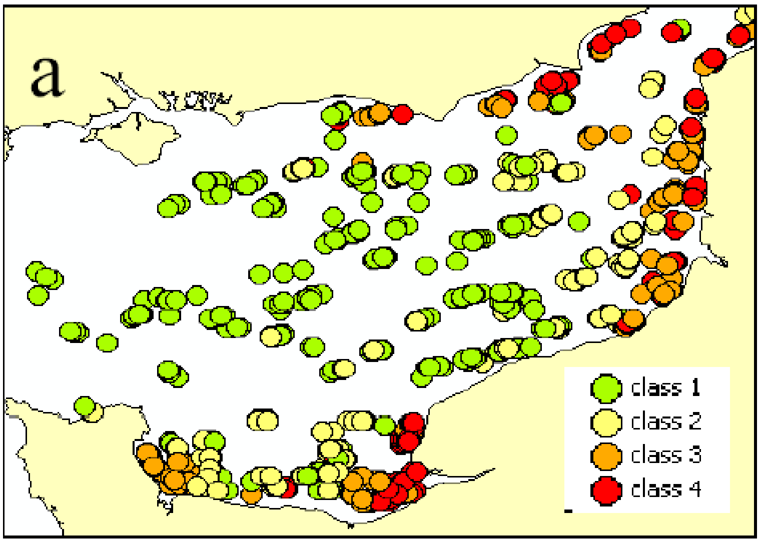


Figure 2. Spatial distribution of Fish Subcommunities in the Eastern Channel from 1988 to 2003. Observed assemblage type at each station, These illustrate the gradation from open sea community to coastal and estuarine communities (In Vaz *et al.*, 2004).

Community evolution over time: (From Vaz *et al.*, 2007). The community relationship with its environment was remarkably stable over the 17 y of observation. However, community structure changed significantly over time without any detectable trend, as did temperature and salinity. The community is so strongly structured by its environment that it may reflect interannual climate variations, although no patterns could be distinguished over the study period. The absence of any trend in the structure of the eastern English Channel fish community suggests that fishing pressure and selectivity have not altered greatly over the study period at least. However, the period considered here (1988–2004) may be insufficient to detect such a trend.

B. Data

B.1 Commercial catch

The landings are taken by three countries: France (50%), Belgium (30%) and England (20%). Age sampling for the period before 1980 was poor, but between 1981 and 1984 quarterly samples were provided by both Belgium and England. Since 1985, quarterly catch and weight-at-age compositions were available from Belgium, France, and England.

An initiative for undertaking combined sampling of VIId sole between France, Belgium and the UK has been agreed from January 2008. The result was a framework for the collection of age data in relation to an international ALK. The division VIId has been stratified in three geographical areas and the data collected in line with them for 2008.

It was the intention that these data would be used to provide the assessment advice in 2009. A limited otolith exchange was arranged between the laboratories involved, specifically looking at VIId sole, in order to assess the likely quality of the ALK provided. The reason for restricting the exchange to those involved in the reading of VIId sole was so that any stock-specific issues could be addressed. The agreement achieved between institutes was 91% across all ages. Due to workload and shortage of manpower, further analysis and the use of a combined ALK was not established yet. If possible this combined ALK will be calculated and proposed for adoption by ACOM before the next assessment.

Belgium

Belgian commercial landings and effort information by quarter, area and gear are derived from logbooks.

Sampling for age and length occurs for the beam trawl fleet (main fleet operating in Belgium).

Quarterly sampling of landings takes place at the auctions of Zeebrügge and Oostende (main fishing ports in Belgium). Length is measured to the cm below. Samples are raised per market category to the catches of both harbours.

Quarterly otolith samples are taken throughout the length range of the landings (sexes separated). These are aged and combined to the quarterly level.

In 2003 a pilot study started on on-board sampling with respect to discarded and retained catch. Since 2004 it is part of the DCR.

France

French commercial landings in tonnes by quarter, area and gear are derived from logbooks for boats over 10m and from sales declaration forms for vessels under 10 m. These self declared productions are then linked to the auction sales in order to have a complete and precise trip description.

The collection of discard data has begun in 2003 within the EU Regulation 1639/2001. The first years of collection were incomplete in term of time and métier coverage. It is expected an increase of sampling effort from 2009 designed for the use of the information for assessment purpose, as required by ICES/ACOM.

The length measurements are done by market commercial categories and by quarter into the principal auctions of Grandcamp, Port-en-Bessin, Dieppe and Boulogne. Samplings from Grandcamp and Port-en-Bessin are used for raising catches from Cherbourg to Fecamp and samplings from Dieppe and Boulogne are used to raise the catches from Dieppe to Dunkerque.

Otoliths samples are taken by quarter throughout the length range of the landed catch for quarters 1 to 3 and from the October GFS survey in quarter 4. These are aged and combined to the quarterly level and the age–length key thus obtained is used to transform the quarterly length compositions. The lengths not sampled during one quarter are derived from the same year close quarter.

Weight, sex and maturity-at-length and -at-age are obtained from the fish sampled for the age–length keys.

England

English commercial landings in tonnes by quarter, area and gear are derived from the sales notes statistics for vessels under 12 m which do not complete logbooks. For those over 12 m (or >10 m fishing away for more than 24 h), data are taken from the

EC logbooks. Effort and gear information for the vessels <10 m is not routinely collected and is obtained by interview and by census. .No information is collected on discarding from vessels <10 m but it is known to be low. Discarding from vessels >10 m has been obtained since 2002 under the EU Data Collection Regulation and is also relatively low.

Length samples are combined and raised to monthly totals by port and gear group for each stock. Months and ports are then combined to give quarterly total length compositions by gear group; unsampled port landings are added in at this stage. Quarterly length compositions are added to give annual totals by gear. These are for reference only, as ALK conversion takes place at the international level. Age structure from otolith samples are combined to the quarterly level, and generally include all ports, gears and months. For sole the sex ratio from the randomly collected otolith samples are used to split the unsexed length composition into sex-separate length compositions. The quarterly separate age–length-keys are used to transform quarterly length compositions by gear group to quarterly age compositions. At this stage the age compositions by gear group are combined to give total quarterly age compositions.

A minimum of 24 length samples are collected per gear category per quarter. Age samples are collected by sexes separately and the target is 300 otoliths per sex per quarter. If this is not reached, the 1st and 2nd or 3rd and 4th quarters are combined.

Weight-at-age is derived from the length samples using the length/weight relationship W=aL^b, where a and b are reference condition factors for the stock.

The text table below shows which countries supply which kind of data:

Kind of data supplied quarterly					
Country	Caton (catch-in-weight)	Canum (catch-at-age in numbers)	Weca (weight-at-age in the catch)	Matprop (proportion mature-by-age)	Length composition-in-catch
Belgium	x	x	x		x
England	x	x	x		x
France	x	x	x		x

Data are supplied as FISHBASE files containing quarterly numbers-at-age, weight-at-age, length-at-age and total landings. The files are aggregated by the stock coordinator to derive the input VPA files in the Lowestoft format. No SOP corrections are applied to the data because individual country SOPs are usually better than 95%. The quarterly data files by country can be found with the stock co-ordinator.

The resulting files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, either under w:\acfm\nsskwg\2002\data\sol_eche or w:\ifapdata\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.

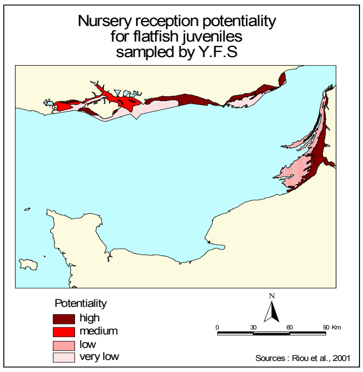
B.3 Surveys

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.

I. References

CEFAS 1999. PA software users guide. The Centre for Environment, Fisheries and Aquaculture Science, CEFAS, Lowestoft, United Kingdom, 22 April 1999.

Riou *et al*., 2001. Relative contributions of different sole and plaice nurseries to the adult population in the Eastern Channel: application of a combined method using generalized linear models and a geographic information system. Aquatic Living Resources. 14 (2001) 125–135.

Vas *et al*., 2007, Modelling Fish Habitat Suitability in the Eastern English Channel. Application to community habitat level. ICES CM 2004/ P:26

Stock Annex – Grey Gurnard

Stock specific documentation of standard assessment procedures used by ICES.

Stock Sole in Division VIId (Eastern Channel)

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

Date: May 2012

Revised by

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.

I. References (not necessarily all mentioned in the text)

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. I La croissance de: *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(2): 127–144.

Baron, J. 1985. Les Triglides (Téléostéens, Scorpaeniformes) de la Baie de Douarnenez. II La reproduction de : *Eutrigla gurnardus*, *Trigla lucerna*, *Trigloprus lastoviza* et *Aspitrigla cuculus*. Cybium 9(3): 255–281.

Daan, N., Bromley, P. J., Hislop, J. R. G., and Nielsen, N. A., 1990. Ecology of North Sea Fish. Netherlands Journal of Sea Research 26(2–4): 343–386.

Damm, U. 1987. Growth of grey gurnard *Eutrigla gurnardus* L. in the North Sea. ICES CM 1987/G:55. 10 pp.

Gee, T. de, and Kikkert, A., 1993. Analysis of the grey gurnard (*Eutrigla gurnardus*) samples collected during the 1991 International Stomach Sampling Project. ICES CM 1993/G:14. 26 pp.

Gordon, J. D. M. 1981. The fish populations of the west of Scotland shelf. Part II. Oceanography and Marine Biology. Annual Review, 19: 405–441.

Harding, D., and Nichols, J. H. 1987. Plankton surveys off the north-east coast of England in 1976: an introductory report and summary of the results. Fisheries Research Technical Report, MAFF Directorate for Fisheries Research, Lowestoft (86), 56 pp.

Heessen, H. J. L. and Daan, N. 1996. Long-term trend in ten non-target North Sea fish species. ICES Journal of Marine Science 53: 1063–1078

Hertling, H. 1924. Über den grauen und den roten Knurrhahn (*Trigla gurnardus* L. und *Trigla hirundo* Bloch). Wissenschaftliche Meeresuntersuchungen Helgoland 15(2), Abhandlung 13: 1–53.

ICES-FishMap 2005. http://www.ices.dk/marineworld/fishmap/ices/pdf/greygurnard.pdf

Knijn, R.J., Boon, T.W., Heessen, H.J.L. and Hislop, J.R.G., 1993. Atlas of North Sea Fishes. ICES Cooperative Research Report. No. 194. (http://www.ices.dk/pubs/crr/crr194/ /CRR194 .PDF)

Land, M. A. van der. 1990. Distribution and mortality of pelagic eggs of by-catch species in the 1989 egg surveys in the southern North Sea. ICES CM 1990/H:19. 11 pp.

MacDonald, D. S., Pope, J. G., Daan, N., and Reynolds J. D. 1994. Impact of fishing on non-target species. Report to the Commission of the European Communities. MAFF Directorate of Fisheries, RIVO and the University of East Anglia, 85 pp.

Russell, F. S. 1976. The eggs and planktonic stages of British marine fishes. Academic Press, London. 524 pp.

Sahrhage, D. 1964. Über die Verbreitung der Fischarten in der Nordsee. I. Juni-Juli 1959 und Juli 1960. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung 17(3): 165-278.

Wheeler, A. 1978. Key to the fishes of northern Europe. Frederick Warne, London. 380 pp.

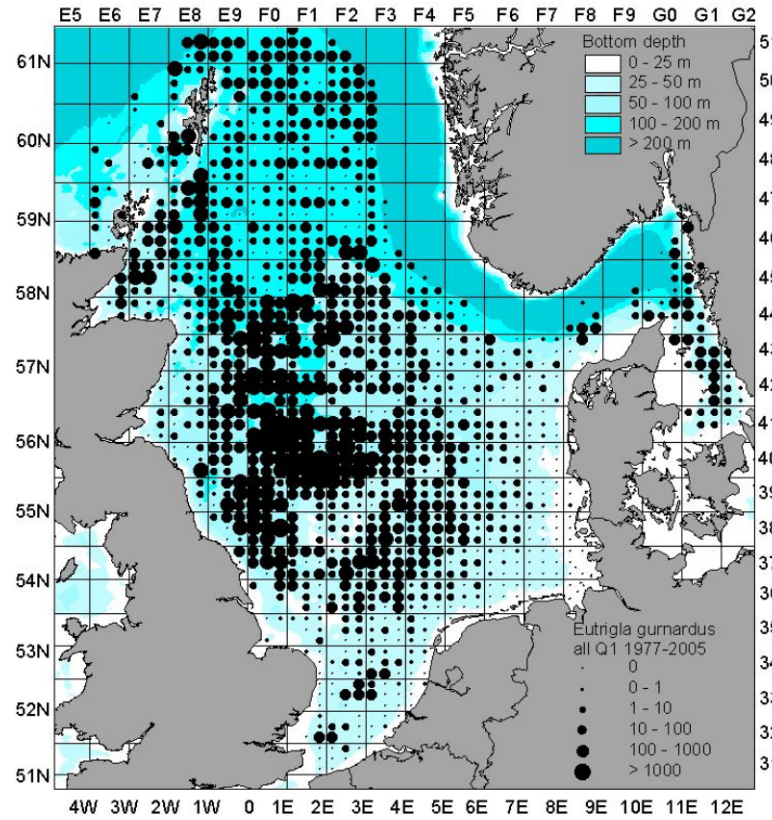


Figure 1. Average annual catch (number per fishing hour for all length classes combined) for grey gurnard in the quarter 1 IBTS survey, 1977–2005 (ICES-FishMap).

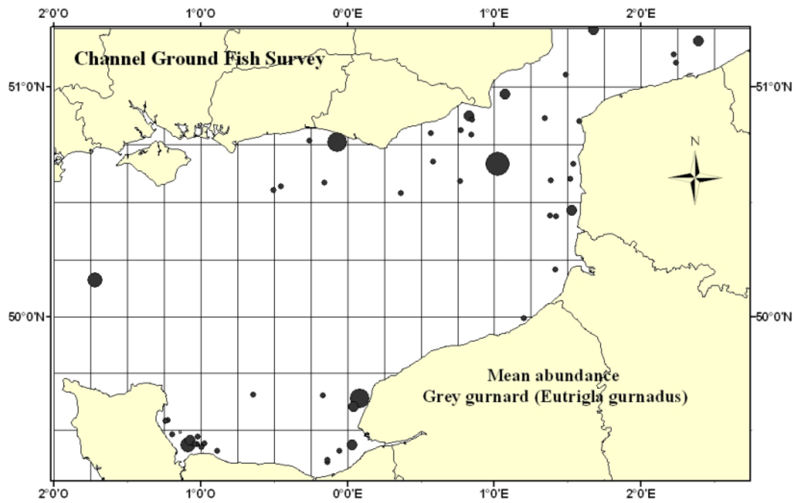


Figure.2. Distribution of grey gurnard in the eastern Channel. CGFS survey 1988–2004

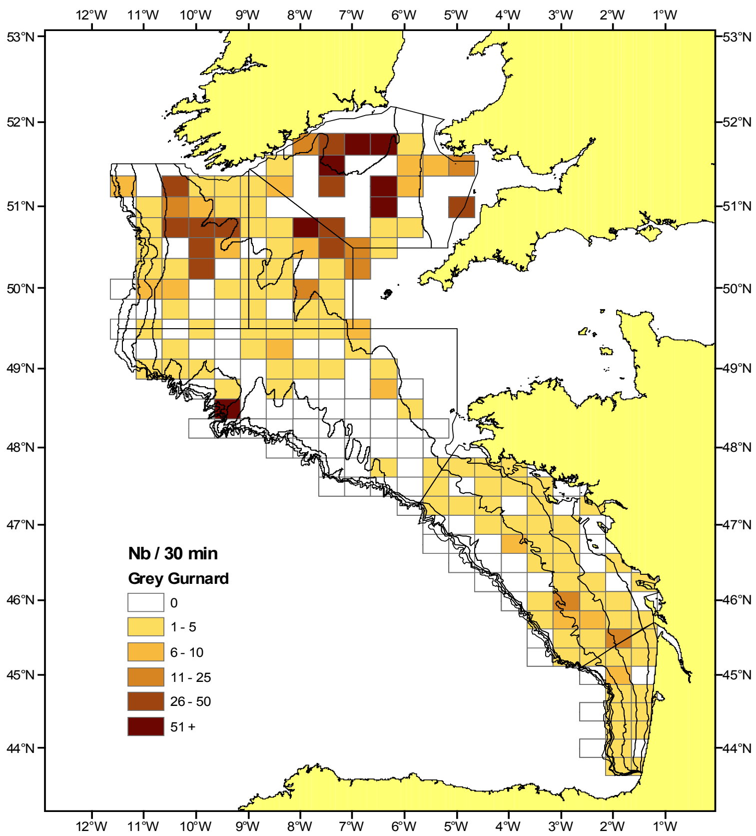


Figure.3. Distribution of grey gurnard in the Celtic Sea and the Bay of Biscay. EVHOE survey, 1997–2004.

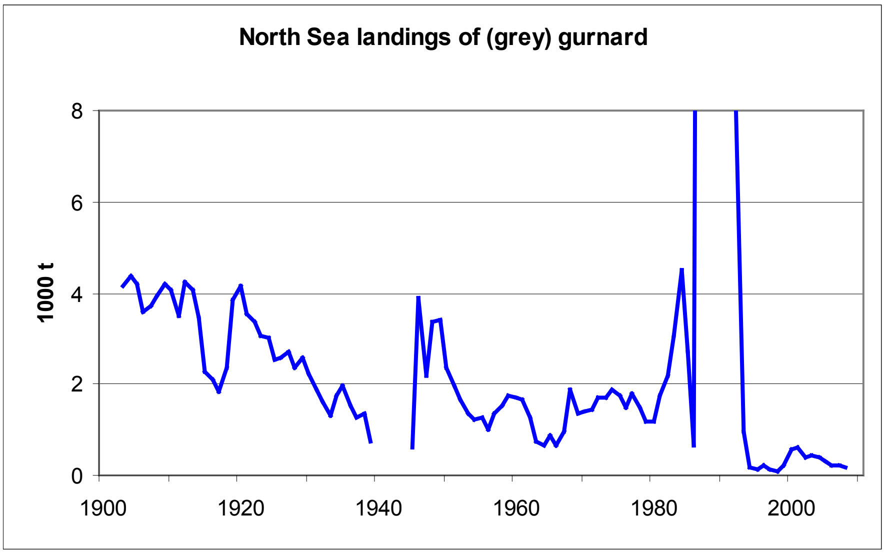


Figure.4. Total international landings of gurnards from the North Sea, probably most of the landings consisted of grey gurnard. See text for further explanation.

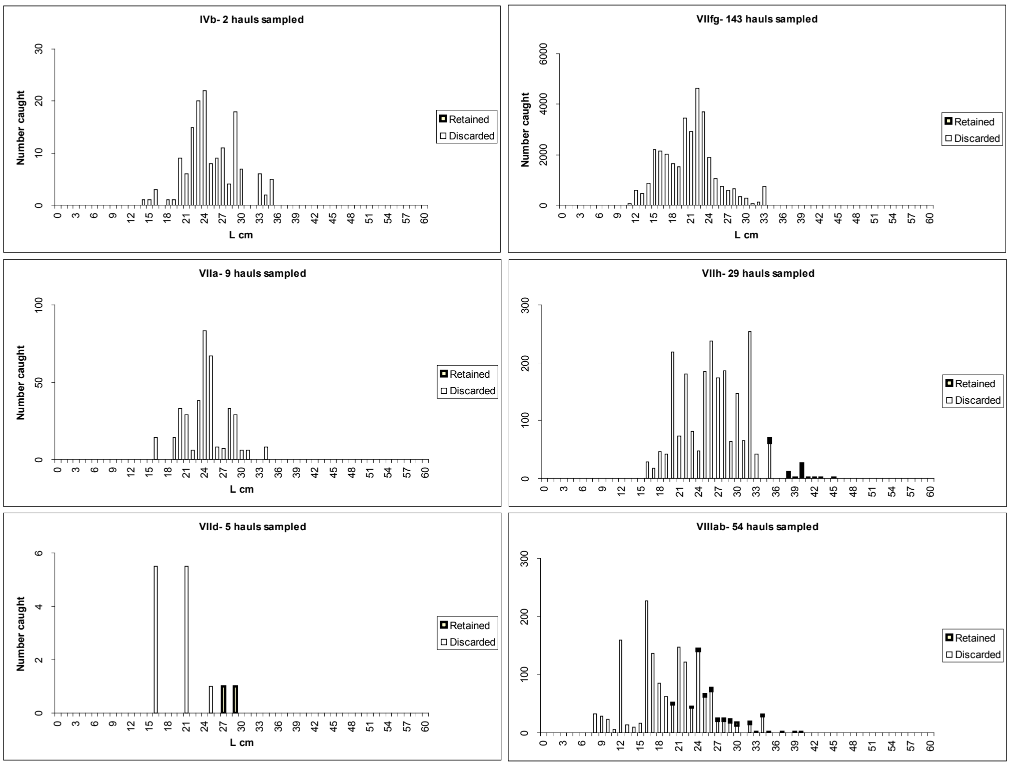


Figure 5 Length composition of French catches of grey gurnard in 2005.

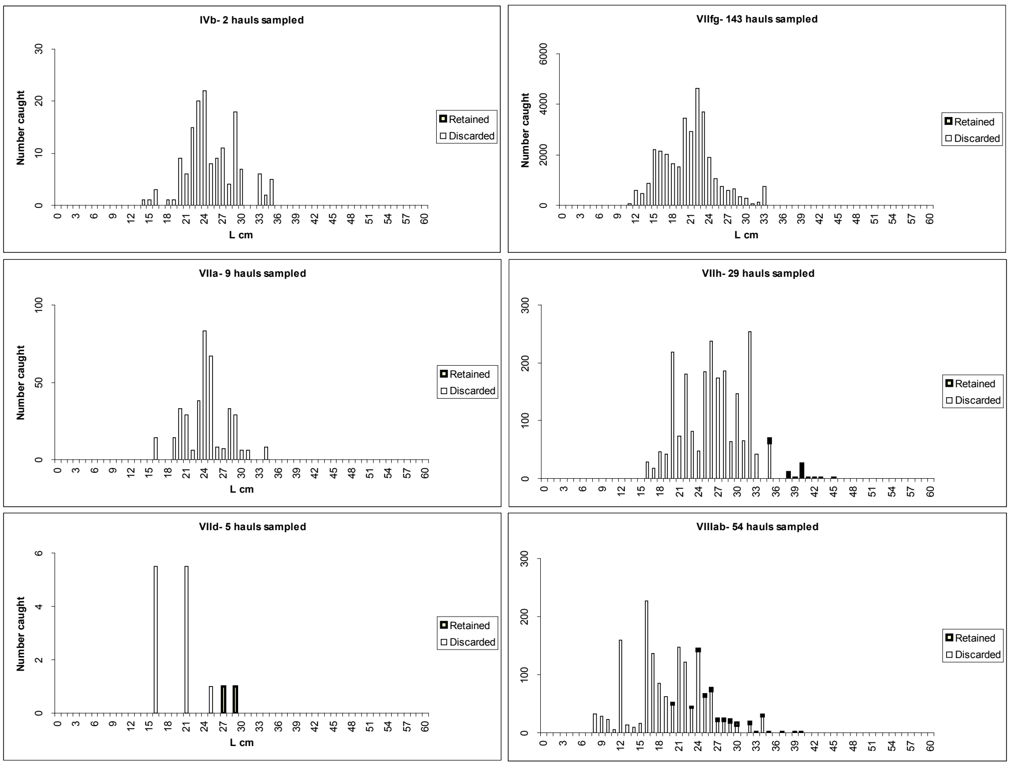


Figure.6 Length composition of French catches of grey gurnard in 2006.

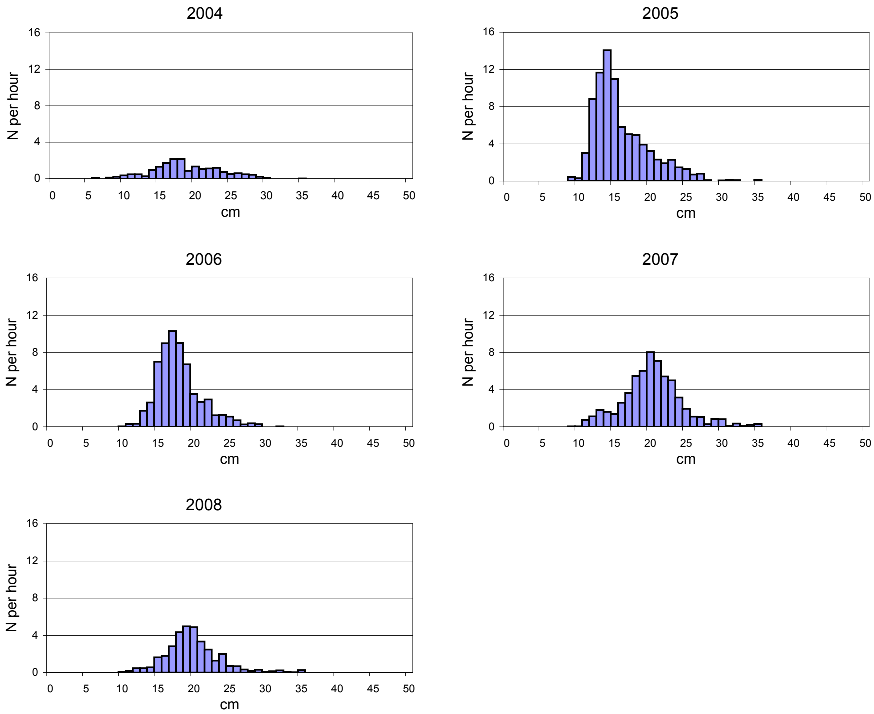
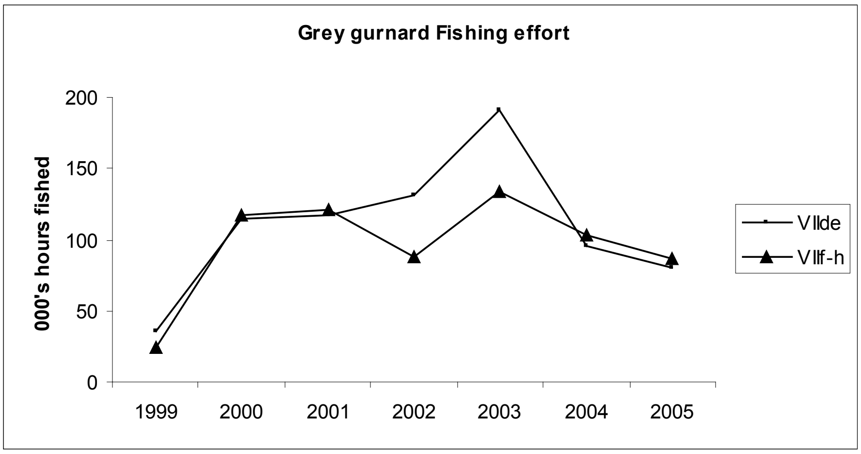


Figure.7 Grey gurnard: number at length discarded per fishing hour by the Dutch beam trawl fishery in the years 2004 to 2008.



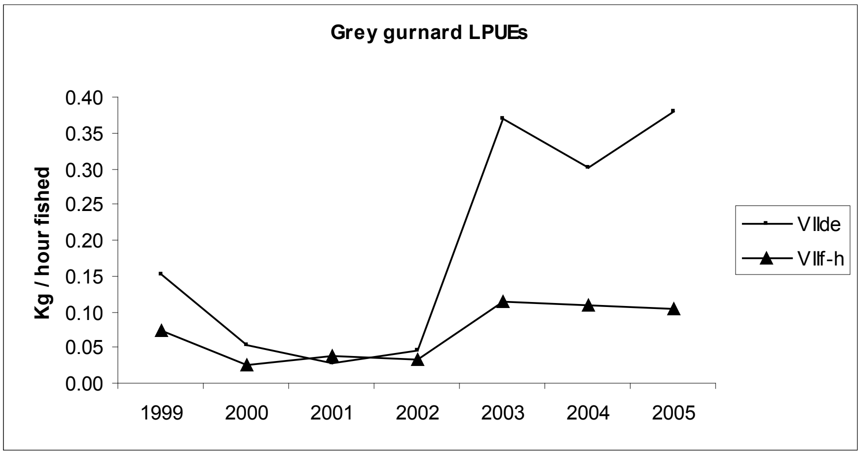


Figure 8. Effort and landings per unit of effort for French single otter trawlers for areas VIId,e and VIIf–h for the years 1999 to 2005.

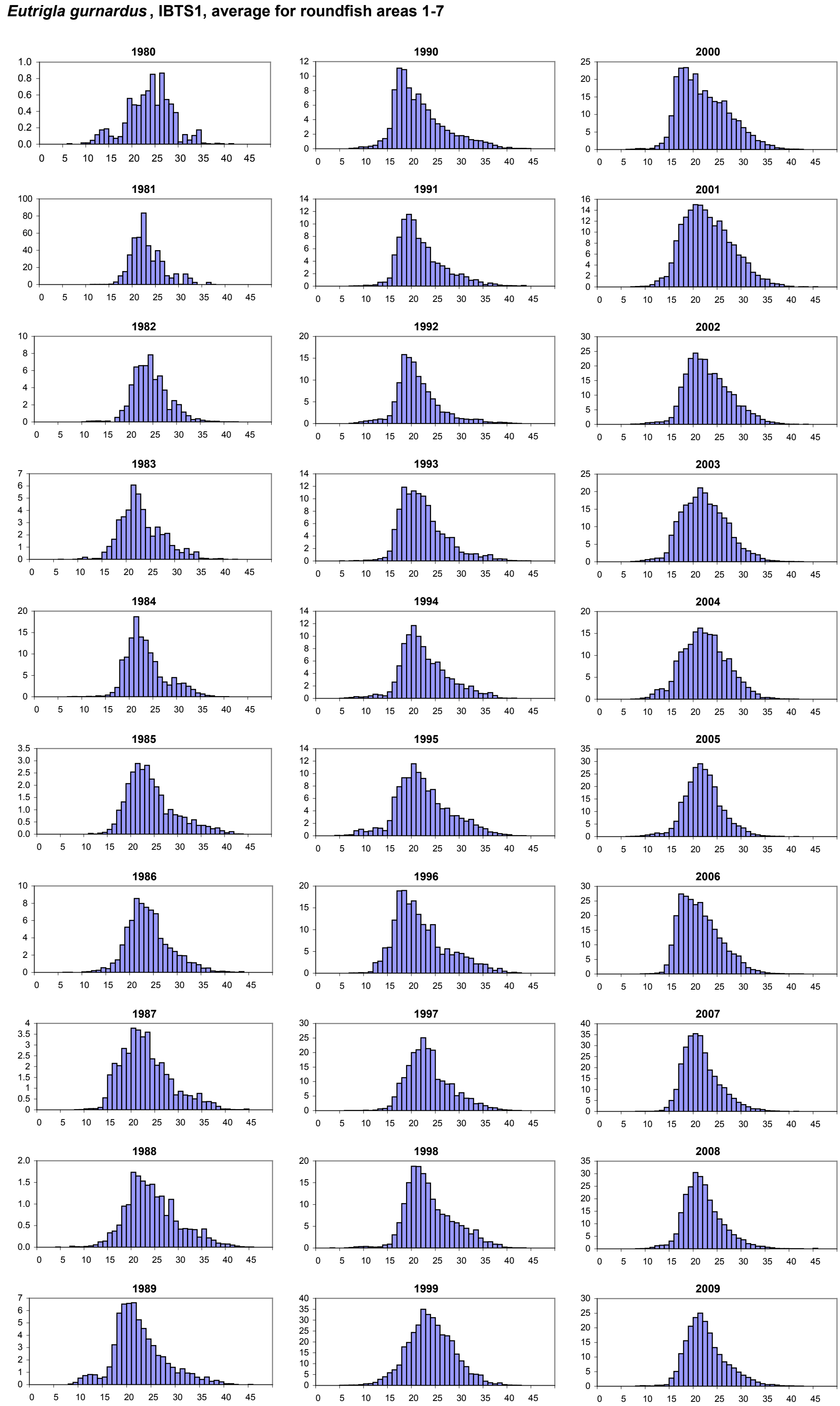


Figure 9 Grey gurnard in IV: number at length during the quarter 1 IBTS survey.

***Eutrigla gurnardus*, IBTS1, average for roundfish areas 8 and 9**

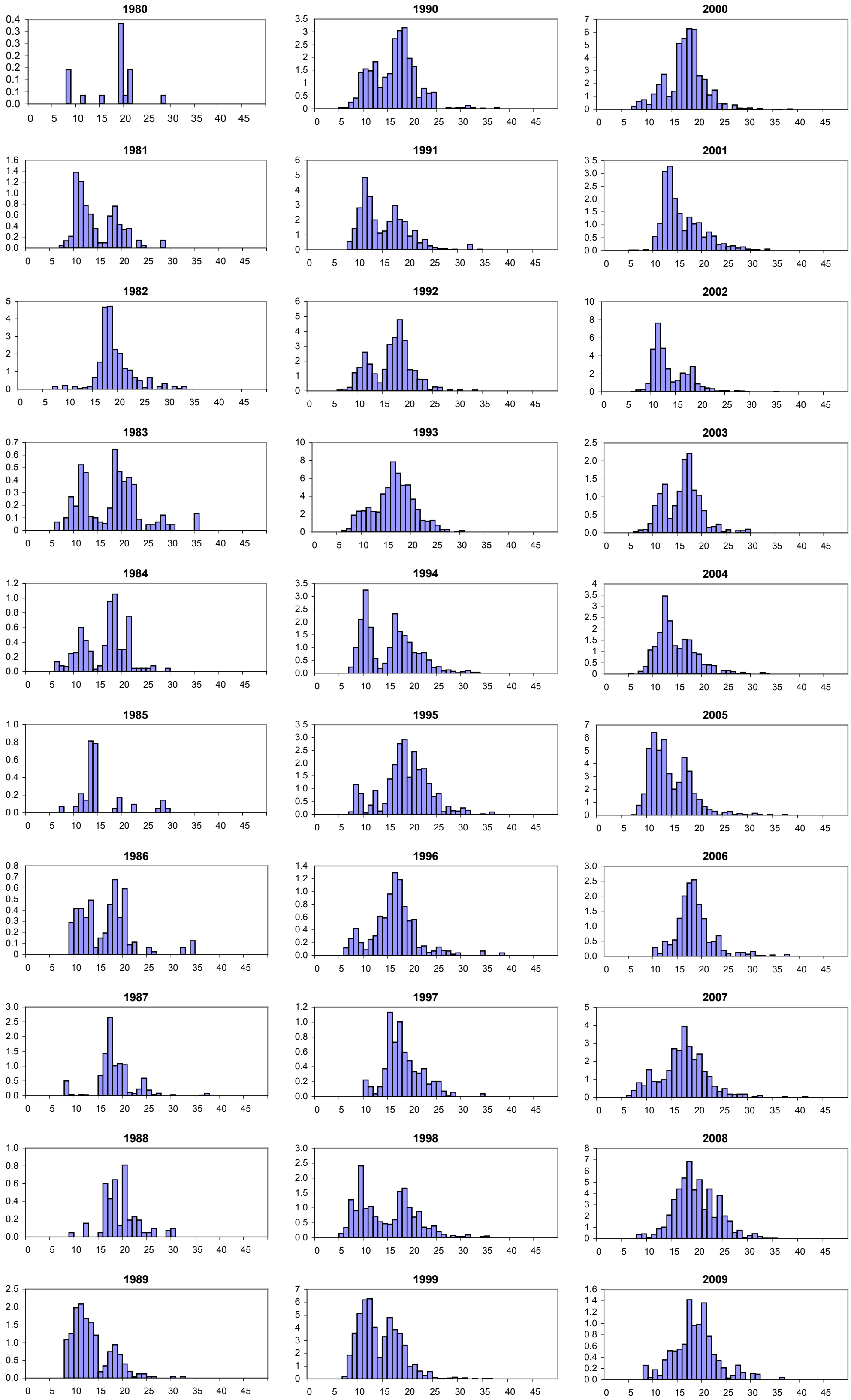


Figure 10 Grey gurnard in IIIa: number at length during the quarter 1 IBTS survey.

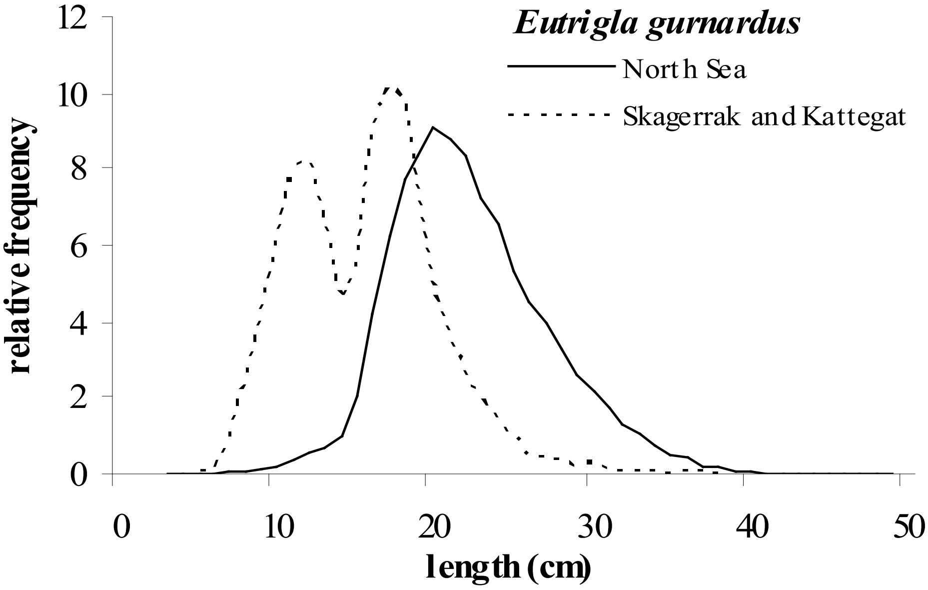


Figure 11. Length frequency distribution of *E. gurnardus* based on the quarter 1 IBTS, 1985–2005 in the North Sea and in Skagerrak/Kattegat. (ICES-FishMap).

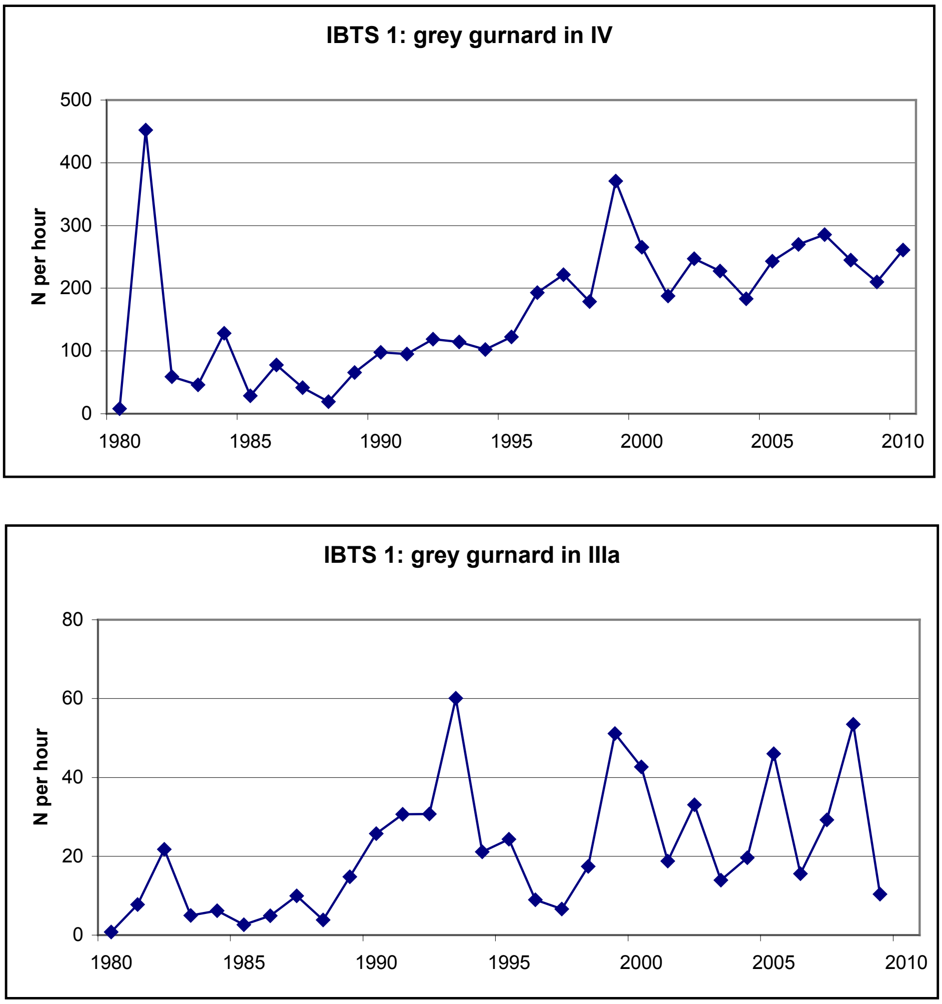


Figure 12. Average catch rate (number per hour for all length classes combined) of grey gurnard in the North Sea (upper panel) and in Skagerrak and Kattegat (lower panel), based on quarter 1 IBTS.

Table -1. Total international landings of grey gurnard from the whole ICES area as reported to FAO for the years 1975–2008.

Country	Bel	Den	Faer	Fra	Icl	Irl	Net	Nor	Por	Russ	Swe	UK E&W	UK Sc	TOTAL
1975	0	0	0	0	0	0	0	0	0	.	14	0	0	14
1976	0	0	0	0	0	0	0	0	0	.	69	0	0	69
1977	0	0	0	0	0	0	0	0	0	.	37	0	0	37
1978	0	0	0	222	0	0	0	0	0	.	54	0	0	276
1979	0	0	0	1,118	0	0	0	0	0	.	49	0	0	1,167
1980	0	0	0	1,172	0	0	0	0	0	.	38	0	0	1,210
1981	0	0	0	0	0	0	0	0	0	.	46	0	0	46
1982	0	360	0	895	0	0	0	0	0	.	43	0	0	1,298
1983	0	1,067	0	852	0	0	0	0	0	.	8	0	0	1,927
1984	0	4,041	0	400	0	0	0	0	0	.	7	0	0	4,450
1985	137	2,358	0	373	0	0	0	0	0	.	9	0	0	2,879
1986	0	314	0	638	0	0	0	0	0	.	10	0	0	962
1987	115	46,598	0	432	0	0	0	0	0	.	6	0	0	47,151
1988	116	38,237	0	655	0	0	0	0	0	.	3	43	0	39,054
1989	119	26,739	0	841	0	0	0	0	0	.	5	.	0	27,704
1990	110	22,076	0	704	0	16	0	0	0	.	3	.	0	22,909
1991	93	14,539	0	443	0	15	0	0	0	.	5	.	4	15,099
1992	118	8,136	0	259	0	17	0	0	0	0	10	.	10	8,550
1993	126	840	0	240	0	10	0	0	<0.5	0	9	.	25	1,250
1994	79	99	0	194	0	0	0	0	<0.5	0	12	.	24	408
1995	58	73	0	204	0	0	0	0	<0.5	0	6	.	21	362
1996	122	70	0	220	1	0	0	0	0	0	4	.	56	473
1997	64	36	0	217	<0.5	0	0	0	0	0	5	.	59	381
1998	50	56	0	159	<0.5	38	0	0	0	0	8	.	0	311
1999	48	86	0	.	0	0	0	0	0	0	132	.	0	266
2000	51	96	0	224	0	0	459	0	0	26,081	5	.	0	26,916
2001	32	289	0	216	0	0	295	<0.5	0	3,155	4	.	46	4,037
2002	64	64	1	179	0	0	286	0	0	60	2	.	41	697
2003	38	92	0	159	0	0	320	<0.5	0	263	7	.	26	905
2004	41	83	0	132	0	0	304	<0.5	<0.5	1,401	5	.	23	1,989
2005	39	73	0	124	0	0	246	0	0	2,456	9	.	22	2,969
2006	25	67	<0.5	103	0	0	165	2	0	138	2	.	27	529
2007	20	38	12	97	0	0	166	5	4	0	3	.	54	399
2008	19	48	15	11	1	0	123	5	8	0	8	.	79	317

Table 2. Age-length key for female grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Females	Age										
Length (mm)	0	1	2	3	4	5	6	7	8	9	10+	Grand Total
110	1											1
120	1											1
130	1											1
150		5										5
160		6	2									8
170		4	4									8
180		2	4		1							7
190		3	3	1	1							8
200		1	5									6
210			1	4								5
220			3	4	1							8
230			1	2	2	1						6
240				1	3							4
250				3	2	1	1					7
260				2	2	2		1				7
270				1	3	3	1					8
280					3	1	1	1			1	7
290					4	1	1	1				7
300					2	1			1			4
310					1		2	1				4
320					1			1	2		1	5
330					1			3	2			6
340					1	1		2		1		5
350						1				2		3
360					1				1		1	3
370							1		1			2
380						2		1		1		4
390							2	1		1	1	5
400												0
410												0
420											2	2
430											1	1
440												0
450												0
460											1	1
Grand Total	3	21	23	18	29	14	9	12	7	5	8	149

Table -2. Age-length key for male grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Males

	Age											
Length (mm)	0	1	2	3	4	5	6	7	8	9	10+	Grand Total
140	1											1
150		3										3
160		1	1									2
170		4										4
180		2	5	1								8
190		1	3	1	1							6
200		1	5									6
210			4	3	1							8
220			1	4								5
230			1	3	3							7
240			1	2		1						4
250			1		1	1	1		1	1		6
260					2	2	1					5
270					1					1	1	3
280					2	2					2	6
290						1	1	1			2	5
300				1	1	1	1		1			5
310					1		1					2
320					1	1				1		3
330					1				2			3
340						1			1			2
350							1	1				2
360							1					1
370										1	1	2
380							1			1		2
390											1	1
400											2	2
410											1	1
Grand Total	1	12	22	15	15	10	8	2	5	5	10	105

Table -3. Maturity data for female grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Females

Length	Immature	Maturing	Mature	Spent	Grand Total
110	1				1
120	1				1
130	1				1
150	5				5
160	5	2		1	8
170	8				8
180	5	1		1	7
190	6	1		1	8
200	4	1		1	6
210	2	3			5
220	3	4		1	8
230	2	1		3	6
240	1	1		2	4
250	2	3		2	7
260	1	3		3	7
270	2	3		3	8
280		3		4	7
290	1	4		2	7
300		2		2	4
310		2		2	4
320		3		2	5
330		5		1	6
340		2		3	5
350		3			3
360		1		2	3
370		2			2
380		3		1	4
390		2	1	2	5
420		1		1	2
430		1			1
460				1	1
Grand Total	50	57	1	41	149

Table 5. Maturity data for male grey gurnard from the North Sea (1992, quarter 4). Data provided by CEFAS.

Males

Length	Immature	Maturing	Mature	Spent	Grand Total
140	1				1
150	3				3
160	2				2
170		4			4
180	6	1		1	8
190	4	1		1	6
200	3	3			6
210	6	2			8
220	3	1		1	5
230	1	2		4	7
240	1	1		2	4
250	1	2		3	6
260	1	1	1	2	5
270		3			3
280	1	3		2	6
290		1		4	5
300	1	2		2	5
310		1		1	2
320	1	2			3
330				3	3
340		2			2
350		2			2
360		1			1
370				2	2
380				2	2
390		1			1
400		2			2
410		1			1
Grand Total	35	39	1	30	105

Stock Annex: Striped Red Mullet in Divisions IIIa, VIId and Subarea IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Red Mullet in Division IIIa, VIId and Subarea IV
Working Group:	WGNSSK
Date:	May 2012
By	

A. General biology

The striped red mullet (*Mullus surmuletus*) is a benthic fish, which is found along the European coasts from the South Norway and North Scotland including the Faroe Islands in the North, to the Strait of Gibraltar in the South. This species is also found in the northern part of western Africa and in the Mediterranean and Black Seas (Quéro & Vayne, 1997). Striped red mullet is considered occasional off Norway, around Ireland, at the north coasts of England and in the West of Scotland (Davis & Edward, 1988; Gibson & Robb, 1997).

Analysis of British commercial landings revealed a strong concentration of this species in the central pit of the western Channel during winter (Dunn, 1999). The scientific survey CGFS (Channel Ground Fish Survey), carried out every year by Ifremer in the eastern Channel since 1988, showed that young individuals are distributed in coastal areas, while adults exhibit preferentially an offshore distribution in the eastern part (Carpentier *et al*., 2009).

Finally, nurseries are located in the Bay of Saint-Brieuc and at the Falklands coasts (Morizur *et al*., 1996). Striped red mullet is accommodated to deep water and elevated temperatures (ICES, 2007b), and tolerates weak and high salinity (corresponding respectively to juvenile and adult habitats) and is rarely found in the transitions zones of intermediate salinity. This species is met mostly on sandy substratum (Carpentier *et al*., 2009). Food of striped red mullet is primarily composed of crustaceans and molluscs.

In the English Channel, the first sexual maturity was identified on fish of 16.2 cm for the male and 16.7 cm for the female (Mahé *et al*., 2005).

A.1 Management regulations

Before 2002, a minimum landing size was set at 16 cm in France. Since, this minimal size requirement has been removed and it resulted on catch of immature individuals (< 14 cm), which has recently been targeted and landed.

A.2 Stock ID and possible management areas

Due to the presence of the striped red mullet in catches all year-round, Dunn (1999) suggested that a single stock should exist within the English Channel, although he could not determine whether this stock was distinct from other western stocks. He also suggested that it might be a newly established stock in the North Sea.

In 2004 and 2005, a study using fish geometrical morphometry was carried out in the Eastern English Channel and the Bay of Biscay. It pointed out a morphological difference on striped red mullets between those from the Eastern English Channel and those from the Bay of Biscay.

In 2010, in the Nespman project, a study based on the shape of the otoliths has been conducted to differentiate stocks. The study area was divided into six geographic sectors: the NS (North Sea; ICES Division IVab), the EEC (Eastern English Channel; ICES Division VIId), the WEC (Western English Channel ; ICES Division VIIe), the CS (Celtic Sea ; ICES Division VIIh), the NBB (North Bay of Biscay ; ICES Division VIIIa) and the SBB (South Bay of Biscay ; ICES Division VIIIb) (Figure 1).

In this work, three techniques have been applied: a Fourier, a PCA and a Geodesic approach (In Benzinou *et al*., submitted). Among these 3, Geodesic approach reached the highest mean correct classification rate (30%). The confusion matrix of Geodesic approach on dataset with six geographic sectors, achieved by K-Nearest Neighbours classifier (*In* Benzinou *et al*., submitted) showed that populations of striped red mullet of Western English Channel and Eastern English Channel could be separated (Table 4).

In the north, it appears a continuum between the North Sea and the Eastern English Channel. In the same way, a continuum has been identified between the north and the south of the Bay of Biscay. Currently, we do not have enough data to separate the Bay of Biscay from the Celtic sea or the Eastern English Channel.

Therefore, for management purposes, two areas could be considered for this species:

- the north area (III, IV &VIId)
- the south area (VI, VIIa,e,g,h,j-VIIIa,b & IXa)

B Fisheries data

According to ICES statistics, in the Atlantic Ocean, fishery of this species was only conducted by Spain and Portugal from 1950 to 1975, then France also part of it. From 1950 to 1975, fishing of striped red mullet was carried out nearby the Spanish coasts and in the Bay of Biscay. From 1990, catches strongly increased, essentially due to France, but also to England and Netherlands fisheries. It could be explained by the beginning of exploitation of the striped red mullet in the English Channel and in the North Sea (Figure 2).

In the Eastern Channel, the main country fishing on striped red mullet was historically France, from 2000, catches are shared by French, Dutch and English fisheries. French fisheries target striped red mullet in spring and autumn, depending on the abundance using bottom trawlers with a mesh size of 70-99 mm in the Eastern Channel and south of the North Sea (Figure 2). In the Eastern English Channel and south of the North Sea, the complementary gears are essentially represented by various trawlers and in Western English Channel by various gears and gillnets. Striped red mullet catches, achieved by these complementary metiers, remain accessory. French trawlers concerned by striped red mullet fishery have a length and a power respectively of about 20 meters and 400 kilowatts yearly average. This has remained stable since 1991. Among this fleet, 71% of the ships which fish in the south of the North Sea show to fish also in the Eastern English Channel. Only 24% of ships fishing in the Western English Channel frequented the Eastern English Channel.

Dutch fisheries are targeting striped red mullet using Scottish seines. This fishery consists of boats between 24-40 meters (most of them being old beam trawlers) fishing most of the time in the North Sea and in the Channel in the winter.

Main areas for the striped red mullet exploitation are areas IV, VIId,e and VIIIa,b. French catches are the most important in the entire zone. Other important countries are the Netherlands and the United Kingdom with regard to the English Channel (VIId,e) and the North Sea (IV), where catches are concentrated in the south (IVb,c). The north of the Bay of Biscay (VIIIa,b) is exploited by France and Spain. The south (VIIIc) is only exploited by Spain. Other countries concerned by this fishery for small catches are Germany, Scotland, Denmark and Ireland.

Since 2008, landings decrease in the north area (IV-VIId) (Figure 3, Figure4 & Figure5). One observed a reverse trend in the south.

This species is not discarded by French vessels. Striped red mullet was rare in the discard samples of Portuguese bottom otter trawl fleet (OTB) in ICES Division IXa and, when present, were found in low strength (Fernandes & Prista, 2012). More investigations on potential discarding should be carried out in other countries areas.

C. Survey data, recruit series

Since 1988, striped red mullet abundance indices are currently available for the Bay of Biscay (EVHOE survey), the Celtic sea (EVHOE survey), the western English Channel (UK-WCBTS survey), the eastern English Channel (CGFS survey), and for the North Sea (IBTS survey Q1 and Q3) (Figure 6).

In the north area (III, IV &VIId), abundance indices (CGFS survey and IBTS surveys Q1 and Q3) of 3 surveys were used. During the last decade, variable abundance during CGFS survey has been observed with 3 large peaks in 2003, 2007 and 2009 (from 50 to 70 per hour, Figure6). For the years 2003 and 2007, a peak of abundance has been observed too, during IBTS survey Q3 in the North sea. Abundance indices of IBTS-Surveys Q3 are higher than these of IBTS-Survey Q1 (Figure 7). Abundance of striped red mullet during of IBTS-Surveys Q3 presented trend to increase from 1990 to 1995 and after this date, abundance trend to decrease. The maps of these surveys show the different spatial distributions with the fish close to the UK coasts during Quarter 1 and in the south-eastern of the North Sea (coasts of Belgium and the Netherlands) during Quarter 3 (Figure 8). Abundance indices of striped red mullet per age class during FR-CGFS from 2006 to 2011 presented Age groups from 0 to 2 only (Figure 9). In consequently, the abundance of this survey give recruitment index. Correlation between Abundance indices of striped red mullet per age class during FR-CGFS and landings in ICES Subareas IV and VIId showed that the landings are strongly correlated to the recruitment (Figure 10). The Age Length Key of striped red mullet in the North Sea during the IBTS-Q1 survey did not show the recruitment only with mainly age groups between 1 and 3 (Figure 11).

In the south area (VI, VIIa,e,g,h,j-VIIIa,b & IXa), abundance indices (EVHOE survey and UK-WCBTS survey) of 2 surveys were used. These 2 surveys do not present trend (Figure 6). There are few peaks of abundance of striped red mullet in Celtic sea and the Bay of Biscay (EVHOE-WIBTS Q4) and the Eastern English Channel (UK-WCBTS Survey). During EVHOE-WIBTS-Q4 Survey, 2001, 2003, 2005 and 2009 present peaks of abundance of striped red mullet (from 16 to 23 per hour, Figure 6). Abundance indices per size class during EVHOE-WIBTS-Q4 show mainly fish between 8 to 17 cm (TL). In consequently, the abundance of this survey gives recruitment index. UK-WCBTS survey in the Eastern English Channel

Since 1979, the PGFS (Portuguese Autumn Groundfish Survey) covers the whole Portuguese continental coast, within depths ranging from 20 to 500m. The PCTS (Portuguese Crustacean Trawl Survey) covers the Southwestern and the South regions of the Portuguese continental coast, with depths ranging from 200 to 750m. Data from these surveys shows that striped red mullet distributes along the Portuguese coast, at depths ranging between 20 and 700 m deep. Some investigations on potential distribution of this species should be carried out in the Spanish coasts between the Portuguese coasts and the Bay of Biscay.

D. Biological sampling

The Netherlands sampled 31 fishes in 2009 during Quarter 3 and 223 fishes in 2010 (month 5: 60; month 6: 60; month 7: 60; month 10: 45) for age estimation in the North Sea. The Azti institute carried out sexual maturity and measures in length in 2009, in the Bay of Biscay.

An inventory of the French data collected from the Bay of Biscay to the North Sea is given in Table 2. French samplings started in 2004 in the Eastern Channel and in south North Sea, and since 2008 in the Bay of Biscay.

A French study on the sampling optimisation (IVc; VIId) was presented in the WGNEW 2010. The results showed a strong yearly adequacy between sampling and catches (Mahé *et al*., 2007).

E. Biological parameters and other research

Since 2004, data (age, length, sexual maturity) are usually collected by France for the Eastern English Channel and the southern North Sea (Table 2). France started to collect data for VIIIa,b at the end of 2007. In 2007-2008, the striped red mullet otolith exchange had for goal to optimise age estimation between countries (ICES, 2009).

In 2011, an Otolith Exchange Scheme has been realised, which was the second exercise for the striped red mullet *Mullus surmuletus*. Four readers of this exchange interpreted an images collection coming from the Bay of Biscay, the Spanish coasts and the Mediterranean coasts (Spain and Italy). A set of *Mullus surmuletus* otoliths (N=75) from the Bay of Biscay presented highest percentage of agreement (82%). On 75 otoliths, 34 were read with 100% agreement (45%) and thus a CV of 0%. Modal age of these fishes was comprised between 0 and 3 years (Mahé *et al*., 2012).

F. Analysis of stock trends / assessment

Currently, age structured analytical stock assessment is not possible due to a too short time series of available data.

By comparing landings from ICES Subareas IV and VIId with the abundance indices of CGFS-survey by age-group, one can noticed that abundance indices of Age-group 1 have the same trend as the landings (Figure 7). This analysis should be supplemented but these results showed that landings were essentially constituted by young fish (Age group 1). These results confirm the analysis of landings composition by age group from 2004 to 2008 from ICES Subareas IV and VIId.

G. Data requirements

Regular sampling of striped red mullet catches must be continued under DCF. Sampling in the Eastern Channel and in south North Sea started in 2004. The effort of sampling (700 otoliths) in these zones is sufficient (ICES, 2007) but must be continued. Effort of sampling in the North Sea (IVb and IVc), the Western Channel, the Celtic Sea and in the bay of Biscay started in 2009. In 2010 and 2011, a sampling level for age and maturity data was diminished compared to 2009, due to the end of the Nespman project.

Since 2009, a concurrent sampling design carried out, should provide more data (length compositions) than in recent years.

The FR-CGFS and FR-EVHOE surveys would continue to provide abundance indice series at age. However, The FR-CGFS survey is not funded by DCF. In the same way, it does not exists any survey in the Western Channel (VIIe) which extended to French and English waters, whereas catches of the striped red mullet in this geographical area in particular, are as significant as catches in the Celtic sea.

H. References

Carpentier A, Martin CS, Vaz S (Eds.), 2009. Channel Habitat Atlas for marine Resource Management, final report / Atlas des habitats des ressources marines de la Manche orientale, rapport final (CHARM phase II). INTERREG 3a Programme, IFREMER, Boulogne-sur-mer, France. 626 pp. & CD-rom

Benzinou A, Carbini S, Nasreddine K, Elleboode R, Mahé, K, 2012. Discriminating stocks of striped red mullet (Mullus surmuletus) in the Northwest European seas using three automatic shape classification methods, Fisheries Research, submitted.

Davis, P.S. & Edward, A.J., 1988. New records of fishes from the northeast coast of England, with notes on the rediscovery of part of the type collection of marine fishes from the Dove Marine Laboratory, Cullercoats. Trans. Nat. Hist. Soc. Northumbria, 55 : 39-46.

Dunn, M.R., 1999. The exploitation of selected non-quota species in the English Channel. Lowestoft: 323pp.

Gibson, R.N. & Robb, L., 1997. Occurrence of juvenile red mullet (Mullus surmuletus) on the west coast of Scotland. Journal of the Marine Biological Association of the United Kingdom, 77(3): 911-912.

ICES, 2007b. Report of the Working Group on Fish Ecology (WGFE), 5–9 March 2007, Nantes, France. ICES CM 2007/LRC:03. 217 pp.

Mahé K., Destombes A., Coppin F., Koubbi P., Vaz S., Leroy D. & Carpentier A., 2005. Le rouget barbet de roche Mullus surmuletus (L. 1758) en Manche orientale et mer du Nord, 186pp.

Mahé, K., Elleboode, R., Charilaou, C., Ligas, A., Carbonara, P. & Intini, S., 2012. Red mullet (*Mullus surmuletus*) and striped red mullet (*M. barbatus*) otolith and scale exchange 2011, 30pp.

Quéro, J.C. & Vayne, J.J., 1997. Les poissons de mer des pêches françaises. IFREMER, Ed. Delachaux & Niestlé, 304pp.

Table 1. Striped red mullet. Confusion matrix (in %) for Geodesic approach on dataset (1) achieved by K-Nearest Neighbours classifier (*In* Benzinou *et al.*, submitted). Mean correct classification rate was 30% (25% for PCA approach and 19% for Fourier approach).

Geodesic approach on Dataset (1)						
	Actual Class					
Estimated Class	NS	EEC08	WEC	CS	NBB	SBB
NS	**15**	20	11	8	5	11
EEC08	28	**44**	17	23	5	5
WEC	9	9	**22**	11	7	9
CS	24	15	24	**32**	15	13
NBB	10	5	16	13	**27**	22
SBB	14	7	10	13	41	**40**

Table 2. Striped red mullet. Biological sampling in France.

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

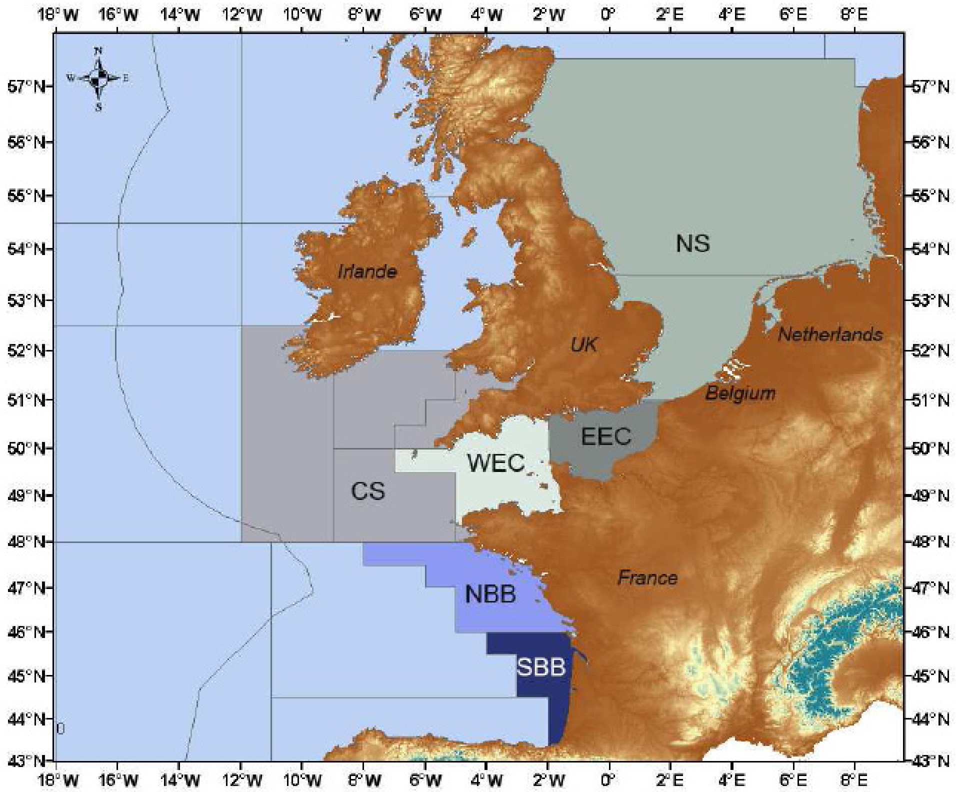


Figure 1. Striped red mullet. Map divided into 6 geographic sectors.

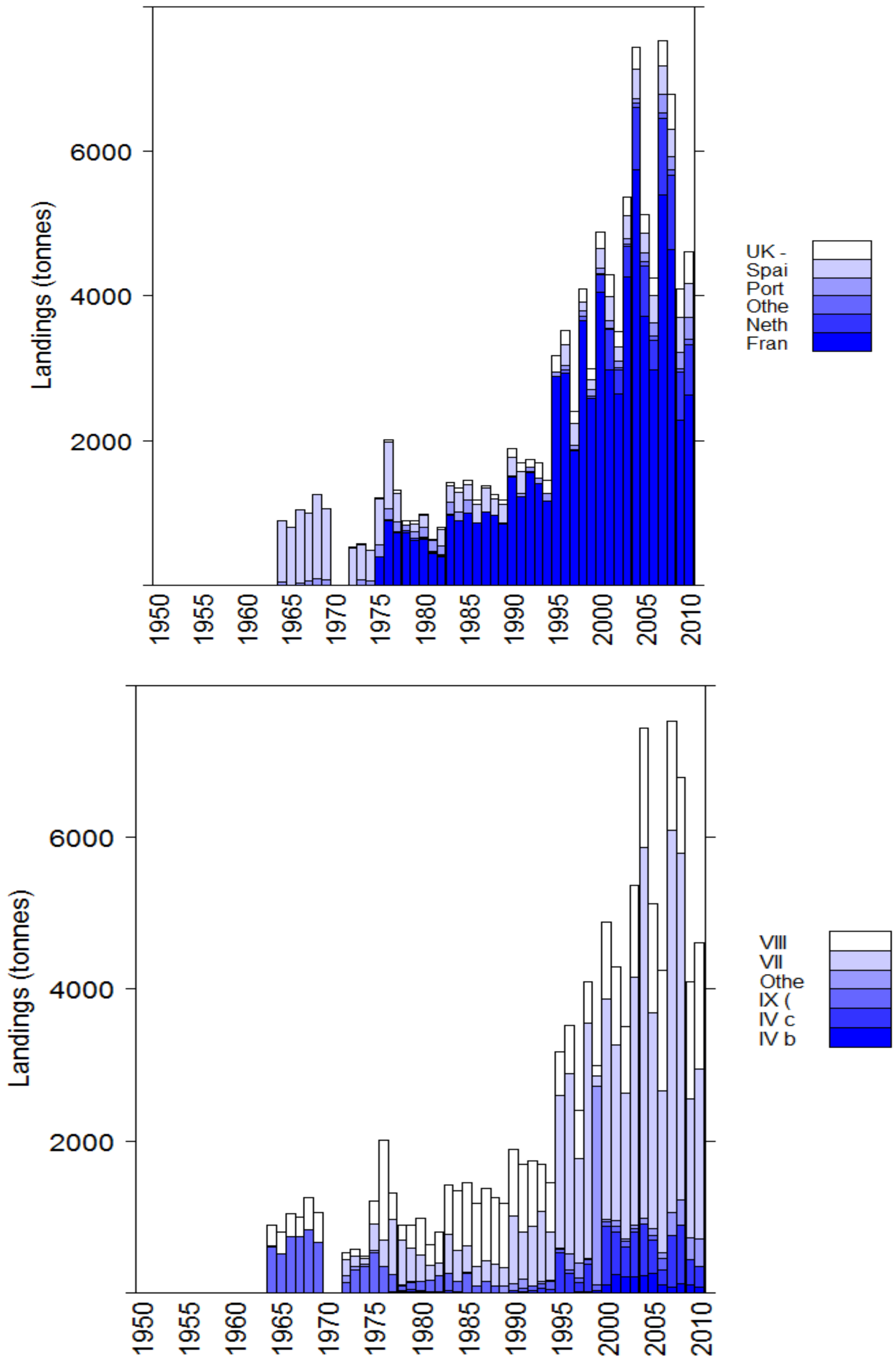


Figure 2. Striped red mullet. Landings per country (top panel) and per ICES area (bottom panel). As officially reported.

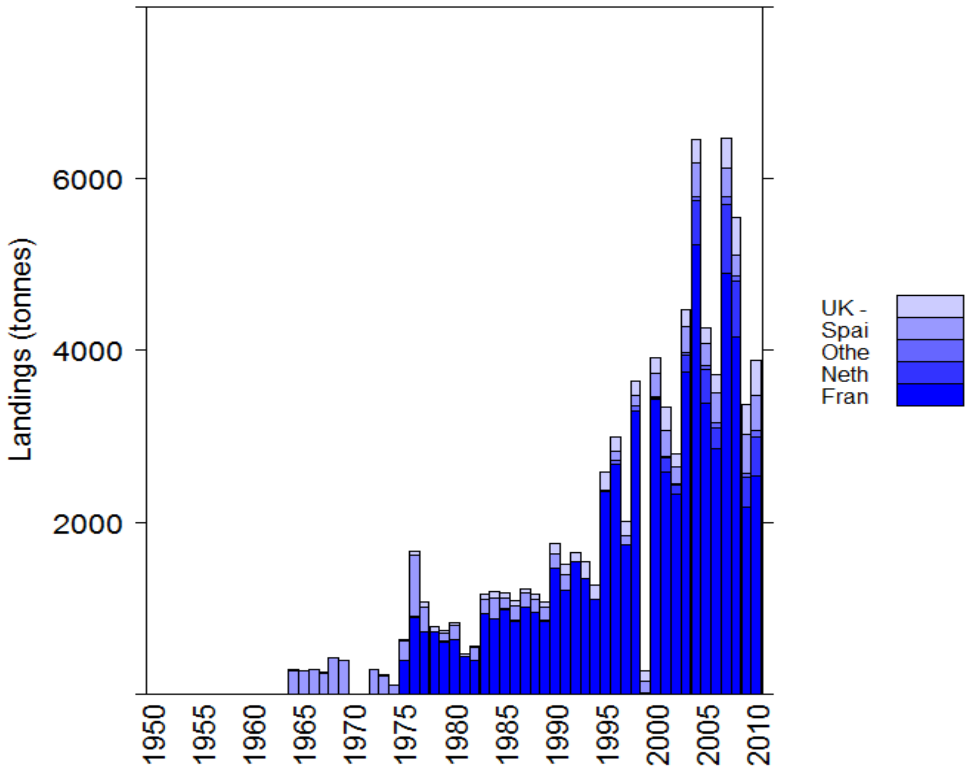


Figure 3. Striped red mullet. Landings in ICES area VIId by country. As officially reported.

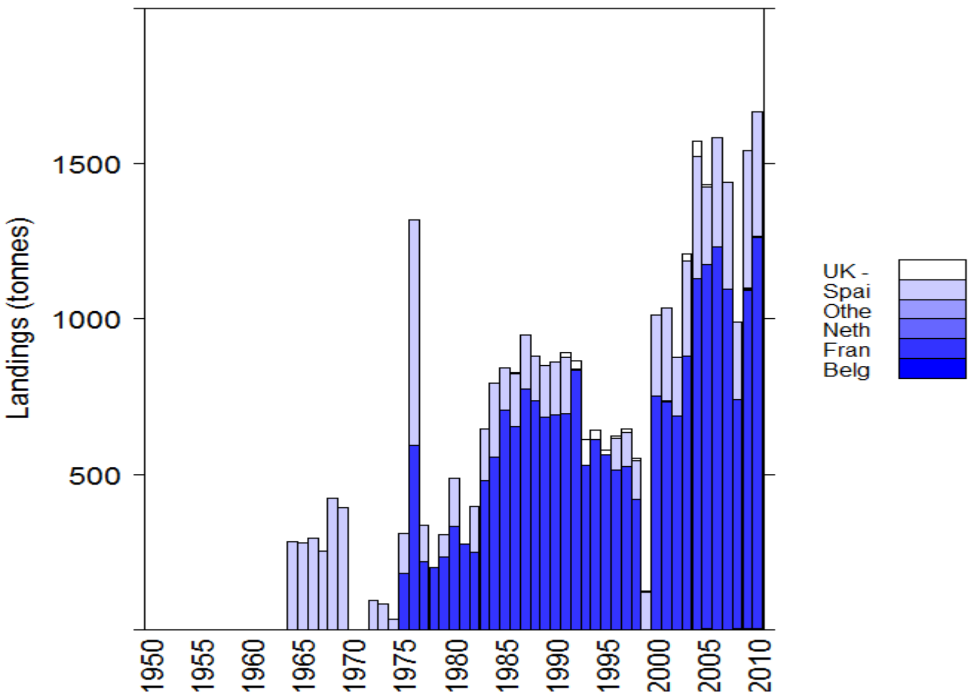


Figure 4. Striped red mullet. Landings in ICES area VIII by countriy. As officially reported.

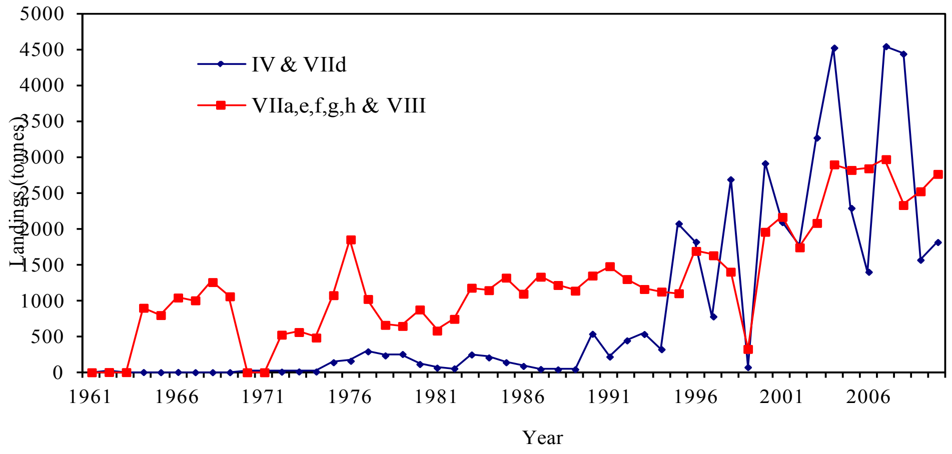
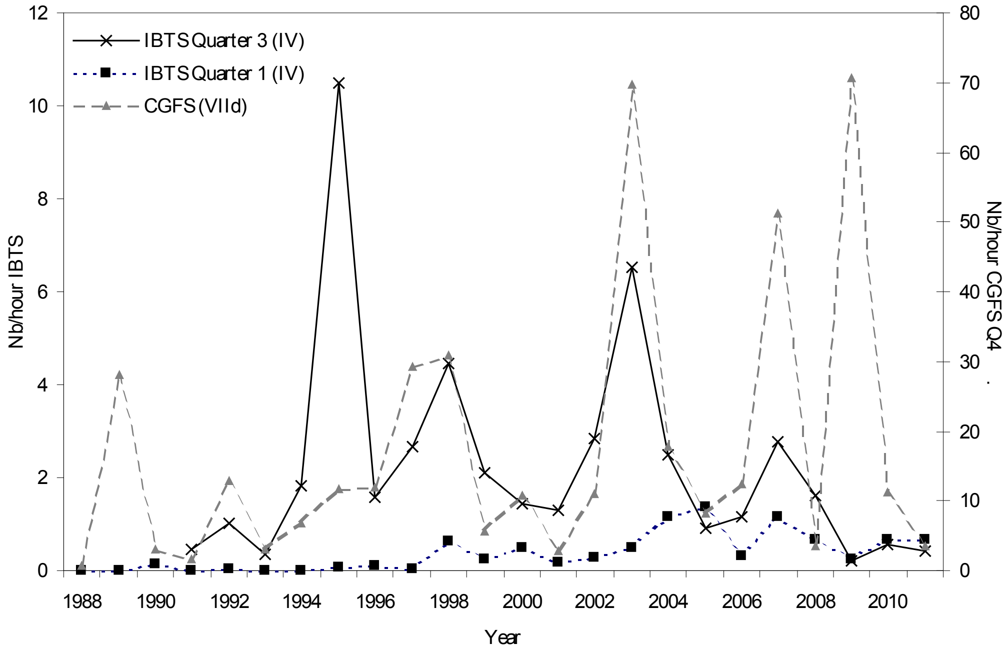


Figure 5. Striped red mullet. Landings from 1960 to 2010 in the north zone (ICES areas : VIId and IV) and in the south zone (ICES areas : VIIa,d,g,h, j & VIII). As officially reported.



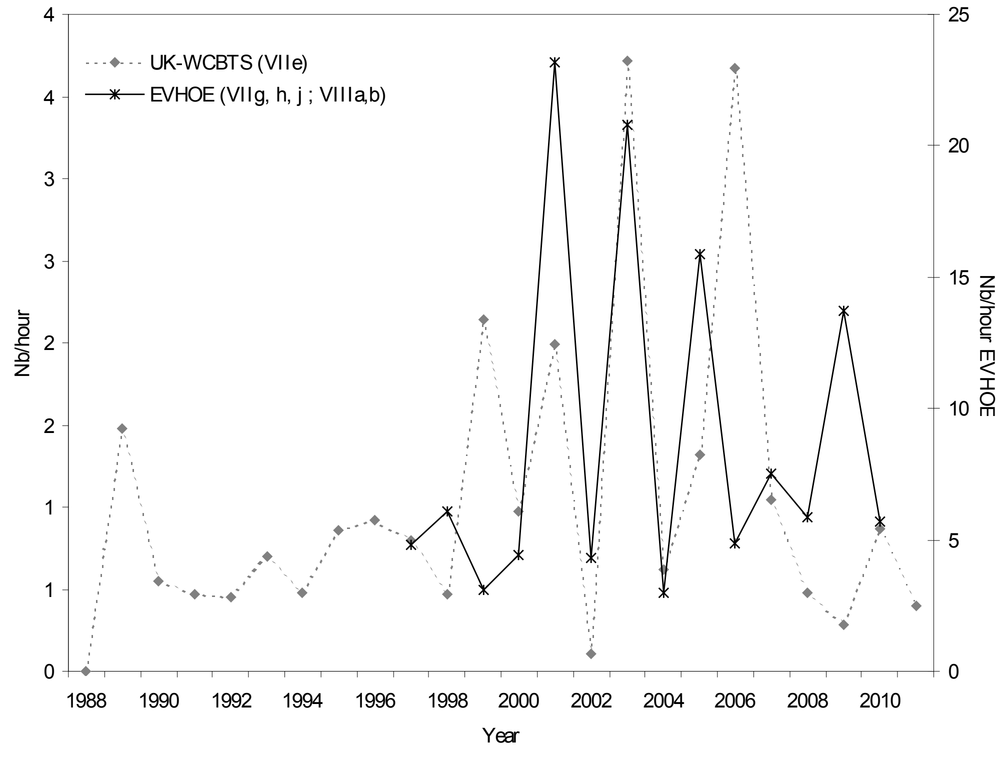
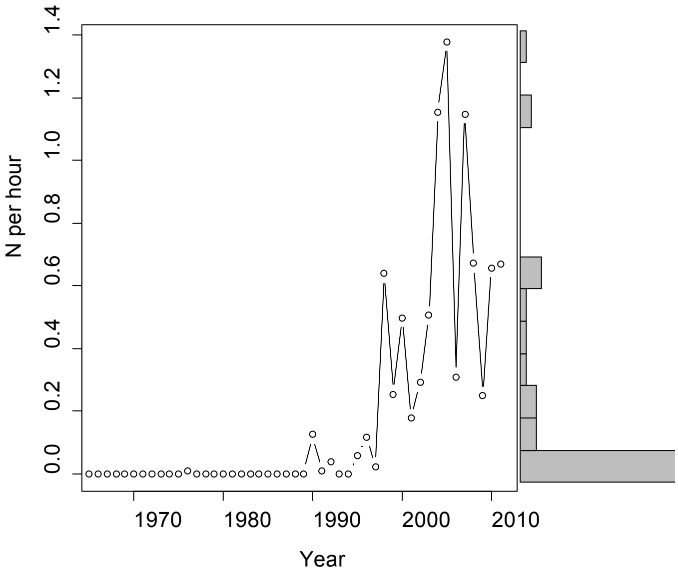
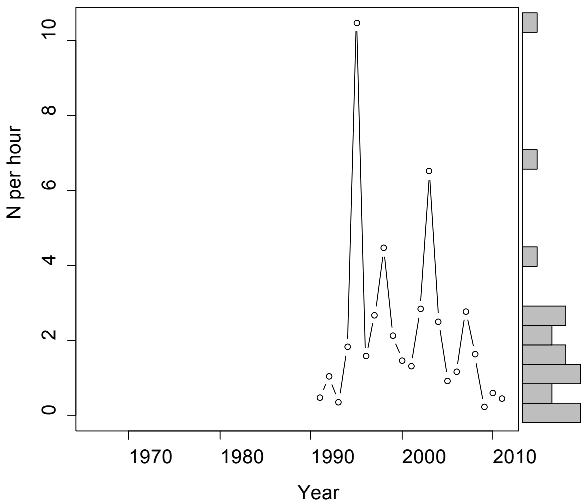


Figure 6. Striped red mullet. Time series of abundance (Nb/hour) of striped red mullet base on Surveys (International Bottom Trawl Survey (IBTS, IV), Channel Ground Fish Survey (FR-CGFS, VIId), UK-WCBTS (VIIe), EVHOE-WIBTS survey (VIIg, h, j ; VIIIa,b) from 1988 to 2011.

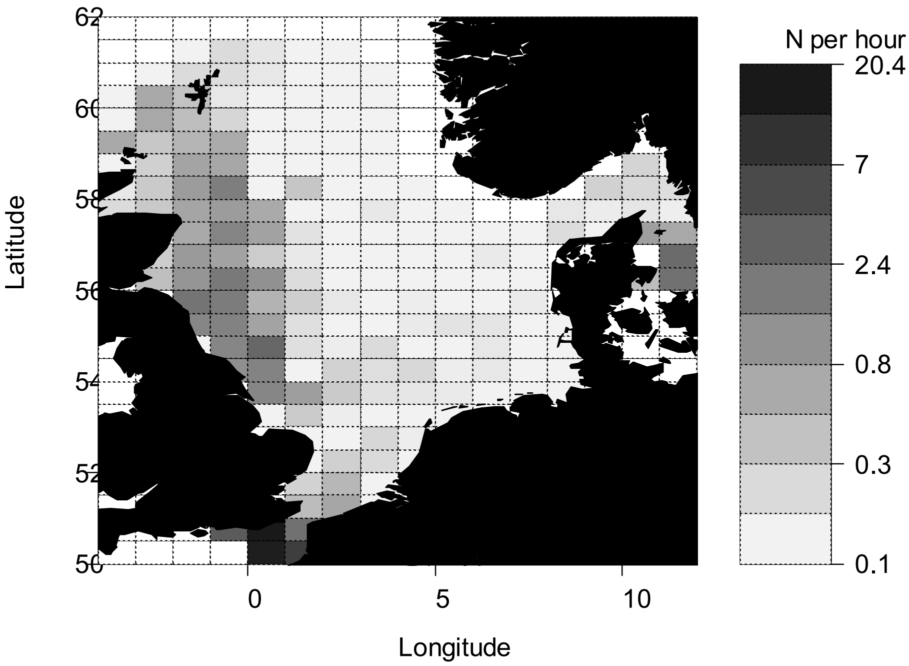


IBTS Q1

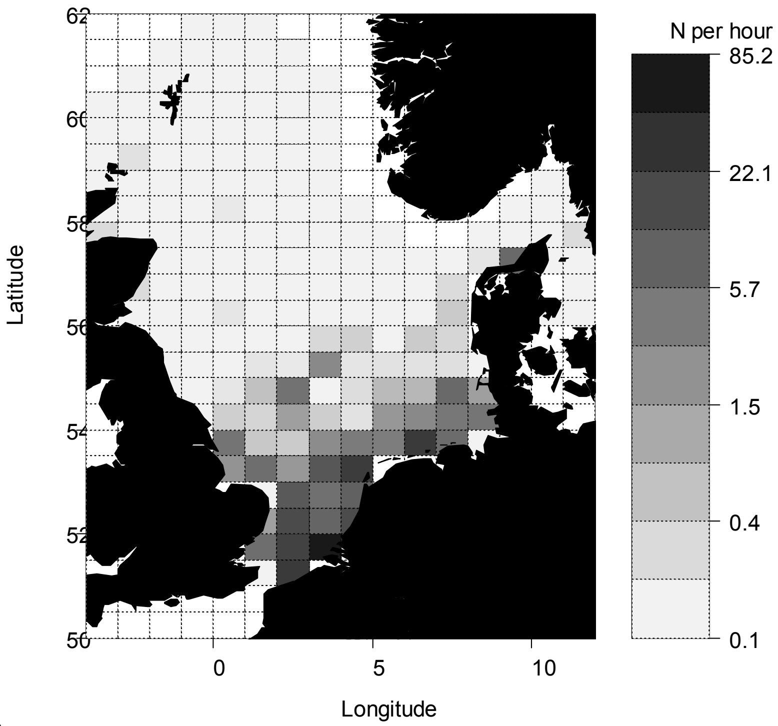


IBTS Q3

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).

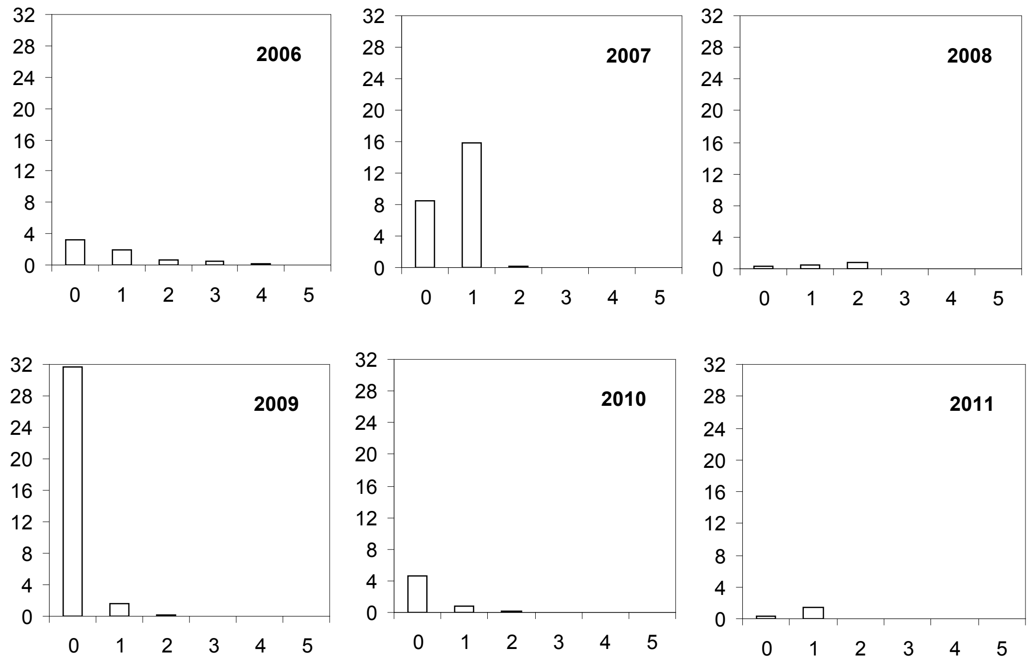


Figure 9. Striped red mullet. Abundance indices (Nb/30 min Trawl) of striped red mullet per age class (Length, cm.) during FR-CGFS from 2006 to 2011.

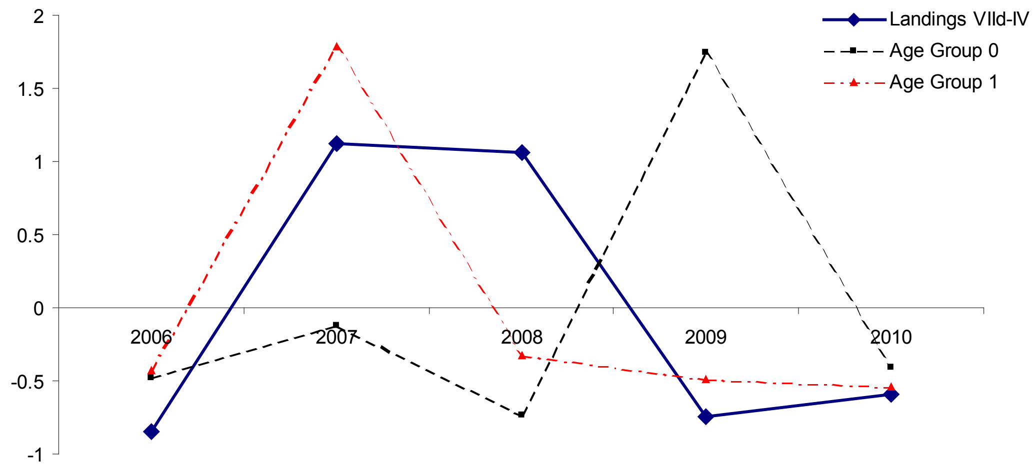


Figure 10. Striped red mullet. Mean standardised of Abundance indices base on CGFS survey (ICES Subarea VIId) from 2006 to 2010 per age class and total landings (ICES Subareas VIId-IV) of striped red mullet.

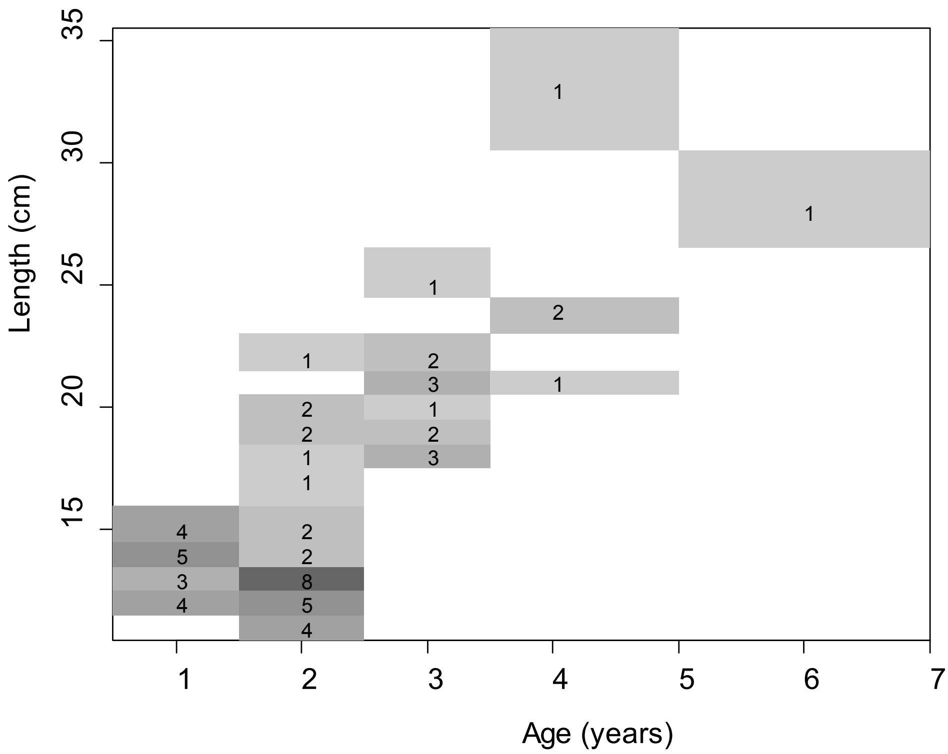


Figure 11. Striped red mullet. Age Length Key of striped red mullet in the north Sea during the IBTS-Q1 survey.

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

© IFREMER

Biologie - Le rouget barbet adulte se nourrit de petits crustacés, annélides et mollusques, utilisant ses barbillons mentonniers pour détecter les proies et fouir la vase. En Manche, la période de frai s'étale de mai à juillet. Les œufs pélagiques incubent en 3 à 8 jours selon la température. Après éclosion, les larves pélagiques résorbent leur vitellus en 4 jours et migrent vers la côte en automne. Les juvéniles de plus de 5 cm de long rejoignent les fonds sableux ou coquilliers de plus de 10 m de profondeur. La croissance la première année est particulièrement rapide.

Caractères démographiques - Taille maximale 42 cm ; taille commune 15-35 cm ; taille commerciale minimale 19 cm (UE) ; longévité maximale 11 ans ; âge et taille à maturité 1-2 ans et 16-19 cm ; paramètres de von Bertalanffy : taille asymptotique L_{inf} = 51.35 cm, taux de croissance k = 0.186 an^{-1}, âge théorique t_0 = -1.21 ; paramètres de fécondité *alpha = n/a* et *beta = n/a*.

Environnement - Poisson benthique vivant sur les fonds rocheux, à graviers ou sableux du plateau continental et du bord du talus, entre 10 et 300 m de profondeur. Espèce préférant les eaux marines ayant des températures comprises entre 8 et 24°C.

Répartition géographique - Atlantique est, de la Norvège et du nord des îles britanniques jusqu'au Sénégal et les îles Canaries ; mer Méditerranée et mer Noire.

Biology - Adult red mullet feed on small crustaceans, annelid worms and molluscs, using their chin barbels to detect prey and search the mud. In the English Channel, spawning occurs from May to July. The pelagic eggs incubate in 3 to 8 days, depending on temperature. After hatching, the pelagic larvae absorb their vitellus in 4 days, and they migrate to the coast in the autumn. Juveniles of length greater than 5 cm return to sandy and shelly substrates deeper than 10 m. Growth during the first year of life is particularly fast.

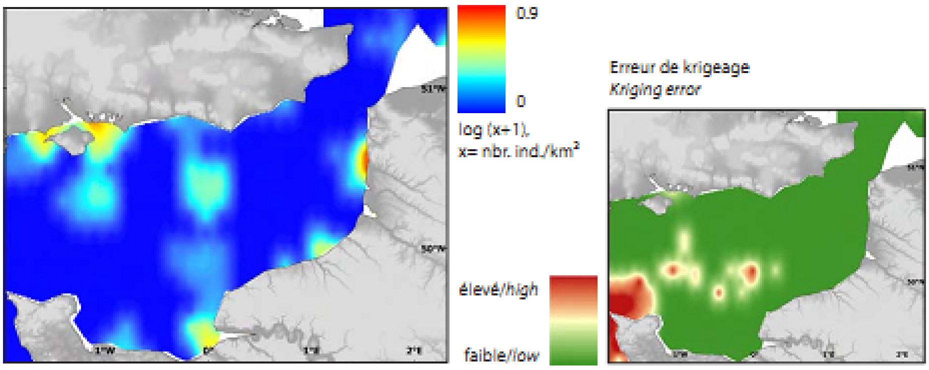
Life history parameters - Maximum length 42 cm; common length 15-35 cm; minimum landing size 19 cm (EU); maximum lifespan 11 years; age and length at maturity 1-2 years and 16-19 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 51.35 cm, growth rate k = 0.186 year^{-1}, theoretical age t_0 = -1.21; fecundity parameters *alpha = n/a* and *beta = n/a*.

Environment - Red mullet is a benthic fish that lives on pebbly, gravelly and sandy substrates of the continental shelf and on the continental slope between 10 and 300 m depth. The species is mostly found in marine waters with temperatures between 8 and 24°C.

Geographical distribution- Eastern Atlantic, from Norway and the northern British Isles, down to Senegal and the Canary islands; also in the Mediterranean and Black Seas.

< 1 An / Year old - Mullus surmuletus

Abondance pluriannuelle
en juillet (BTS, 1989-2006)
Multi-annual abundance in July (BTS, 1989-2006)



Les rougets barbets de taille inférieure à 17.3 cm ont été considérés comme ayant moins d'un an. Les aires de distribution et les modèles d'habitat (en octobre) ont été faits séparément pour les individus de moins de un an et ceux de plus d'un an. Les rougets barbets sont mal échantillonnés par le chalut à perche utilisé pendant les campagnes BTS et donc il n'est pas possible de montrer les distributions annuelles en cette saison. Les deux cartes de juillet présentent donc les abondances moyennées (ou pluriannuelles) sur les années 1989 à 2006 ; aucun modèle d'habitat n'a satisfait les critères de sélection pour présentation dans l'atlas.

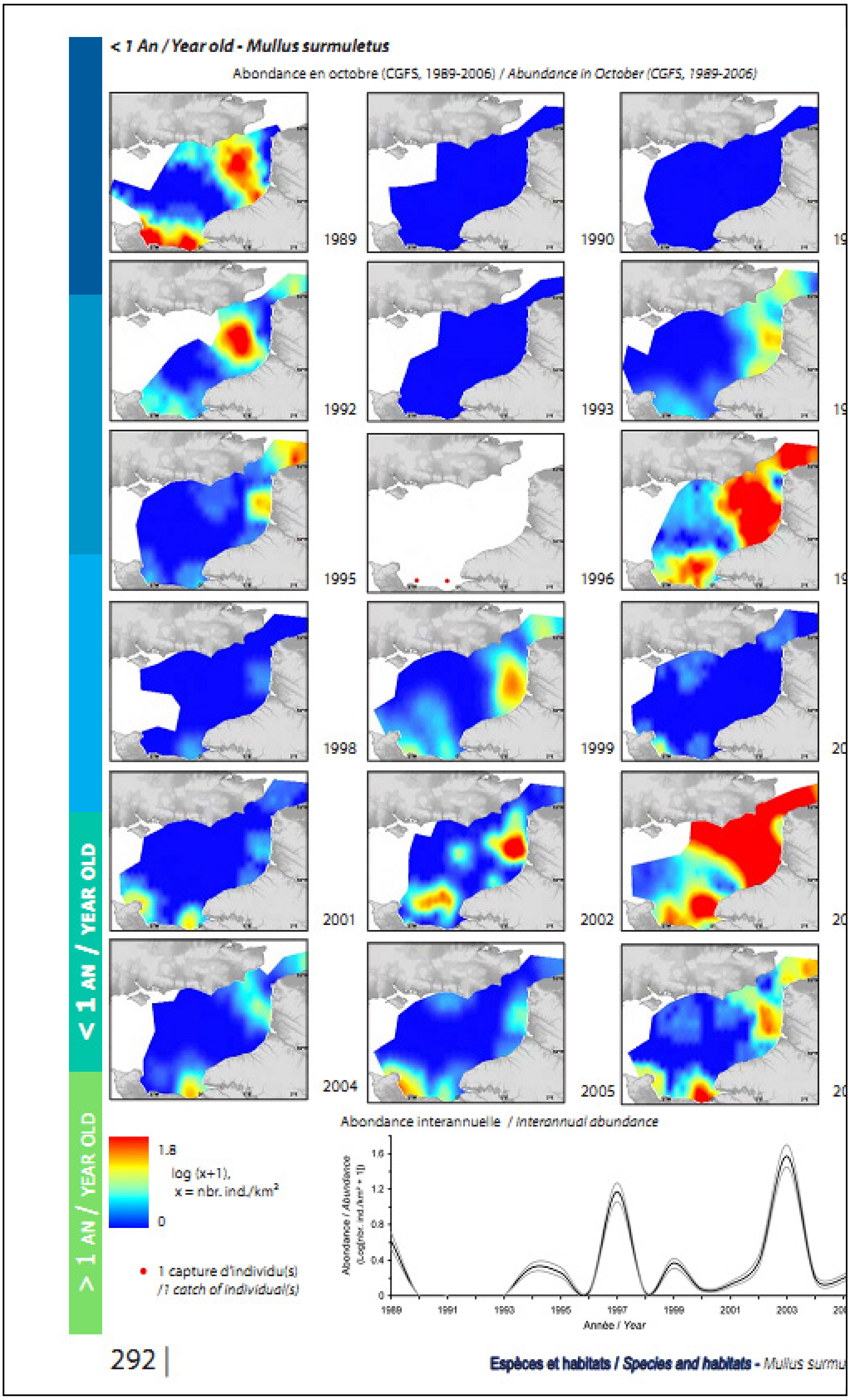
< 1 an

Durant la campagne BTS en juillet, les jeunes de moins d'un an sont présents dans les estuaires et autour de l'île de Wight. Certaines années, très peu de jeunes ont été échantillonnés pendant la campagne CGFS en octobre. Quand ils étaient présents, ils ont surtout été trouvés dans les zones à fonds sableux, au large de la côte d'Opale et de la baie de Seine et dans le sud de la mer du Nord. Le modèle d'habitat préférentiel montre toute la zone du détroit comme étant favorable pour la présence de ce jeune stade, ainsi que la baie de Seine, ce qui est en accord avec les observations de campagnes. Il faut cependant prendre en compte l'erreur du modèle qui est importante dans les zones de fortes abondances. Le modèle d'habitat potentiel est très semblable au modèle d'habitat préférentiel : il favorise les zones à faible influence des courants de marées mais où dominent les graviers et les cailloutis.

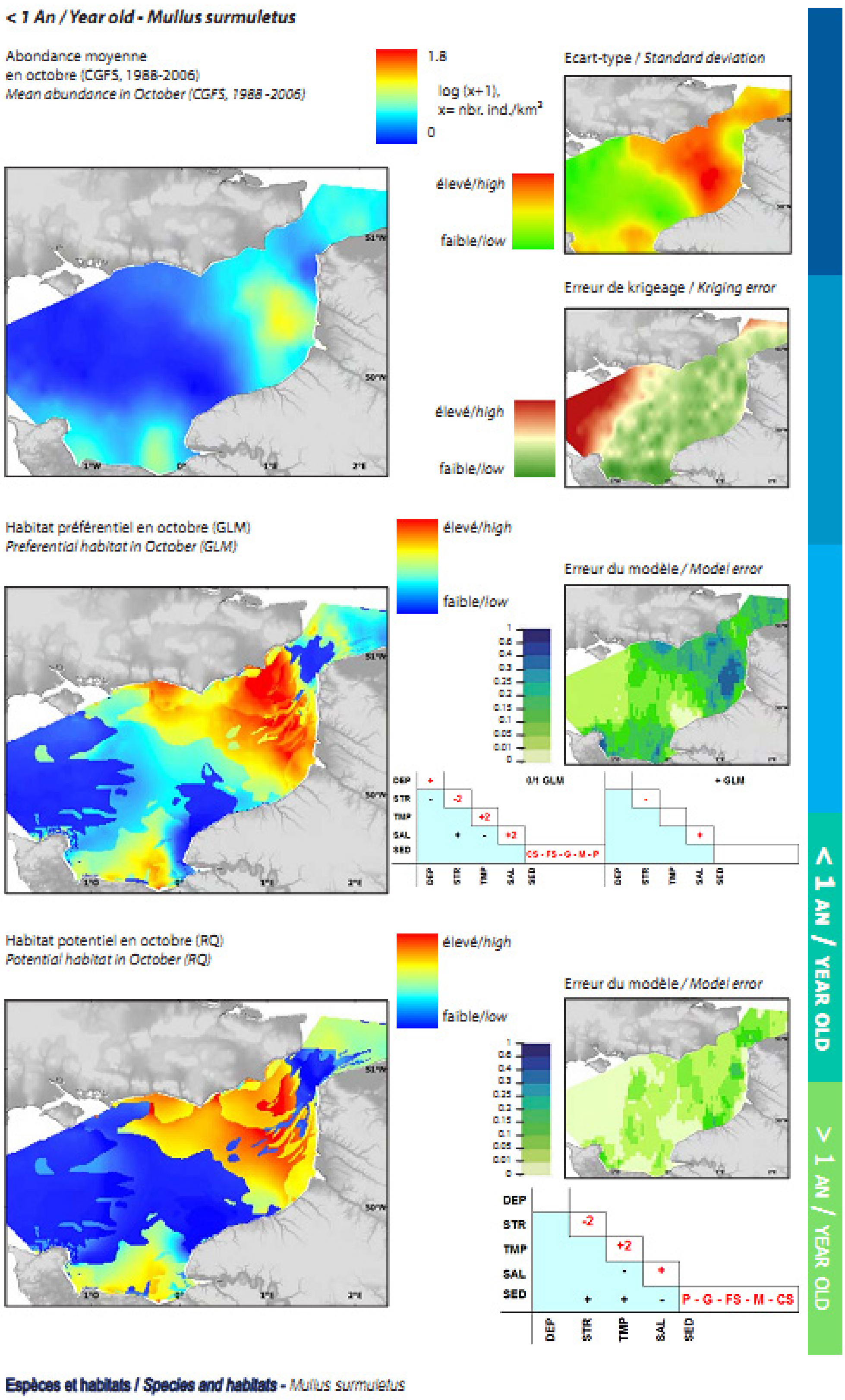
Red mullet less than 17.3 cm in length were considered as being less than one year old, and the distribution patterns and habitats (in October) were defined separately for young and older individuals. Red mullets are not representatively sampled by the beam trawl used during the July BTS survey; as a result, annual maps are not shown for this season. The two July maps hence show average (or multi-annual) distribution over 1989-2006; no habitat model passed the selection criteria for inclusion in the atlas.

< 1 year old

In July, young individuals (less than one year old) were present in estuaries and around the Isle of Wight. In some years, very few young individuals were found during the CGFS surveys (October). When they were present, they were mainly found in areas with sandy sediments, off the Opale coast and the Bay of Seine and in the southern North Sea. The preferential habitat model shows the Dover Strait and the Bay of Seine as favourable for this young stage, which agrees with the survey data. Nevertheless, the model error was great in high abundance areas. The potential habitat model was very similar to the preferential habitat model, favouring areas with weak bed shear stress and the presence of gravels and pebbles.



< 1 An / Year old - Mullus surmuletus
Abondance en octobre (CGFS, 1989-2006) / Abundance in October (CGFS, 1989-2006)
1989
1990
1992
1993
1995
1996
1998
1999
2001
2002
2004
2005
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
1.8
log (x+1),
x = nbr. ind./km²
0
1 capture d'individu(s)
/1 catch of individual(s)
Abondance interannuelle / Interannual abundance
Année / Year
292
Espèces et habitats / Species and habitats - Mullus surmu


< 1 An / Year old - Mullus surmuletus
Abondance moyenne en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)
1.8
log (x+1), x= nbr. ind./km²
0
Ecart-type / Standard deviation
élevé/high
faible/low
Erreur de krigeage / Kriging error
élevé/high
faible/low
Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)
élevé/high
faible/low
Erreur du modèle / Model error
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
CS - FS - G - M - P
Habitat potentiel en octobre (RQ)
Potential habitat in October (RQ)
élevé/high
faible/low
Erreur du modèle / Model error
P - G - FS - M - CS
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
Espèces et habitats / Species and habitats - Mullus surmuletus

Stock Annex – North Sea Sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea sole
Working Group:	WGNSSK
Date:	3 March 2010
By:	Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea sole is defined to be a single stock in ICES area IV. The stock assessment is done accordingly, assuming sole in the North Sea is a closed stock.

A.2 Fishery

North Sea sole is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea (see Figure 1). Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. The minimum mesh sizes enforced in these fisheries (80 mm in the mixed beam trawl fishery) are chosen such that they correspond to the Minimum Landing Size for sole. Due to the minimum mesh size, large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea sole have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box).

In recent times the days at sea regulations, high oil prices, and different patterns in the history of changes in the TACs of plaice and sole have led to a transfer of effort from the northern to the southern North Sea. Here, sole and juvenile plaice tend to be more abundant leading to an increase in discarding of small plaice. A change in efficiency of the commercial Dutch beam trawl fleet has been described by Rijnsdorp *et al.* (2006). This change in efficiency is related to changes in targeting and the change in spatial distribution (Quirijns *et al.* 2008, Poos *et al.* 2010). An analysis of the changes in efficiency by the 2006 North Sea demersal assessment working group showed that the increase in efficiency was especially pronounced between 1990 (the beginning of the time series for which data was available) to 1996-1998, after which the efficiency seemed to decrease slightly. The data for which this could be analyzed spanned 1990 to 2002, so the efficiency changes since 2002 could not be estimated.

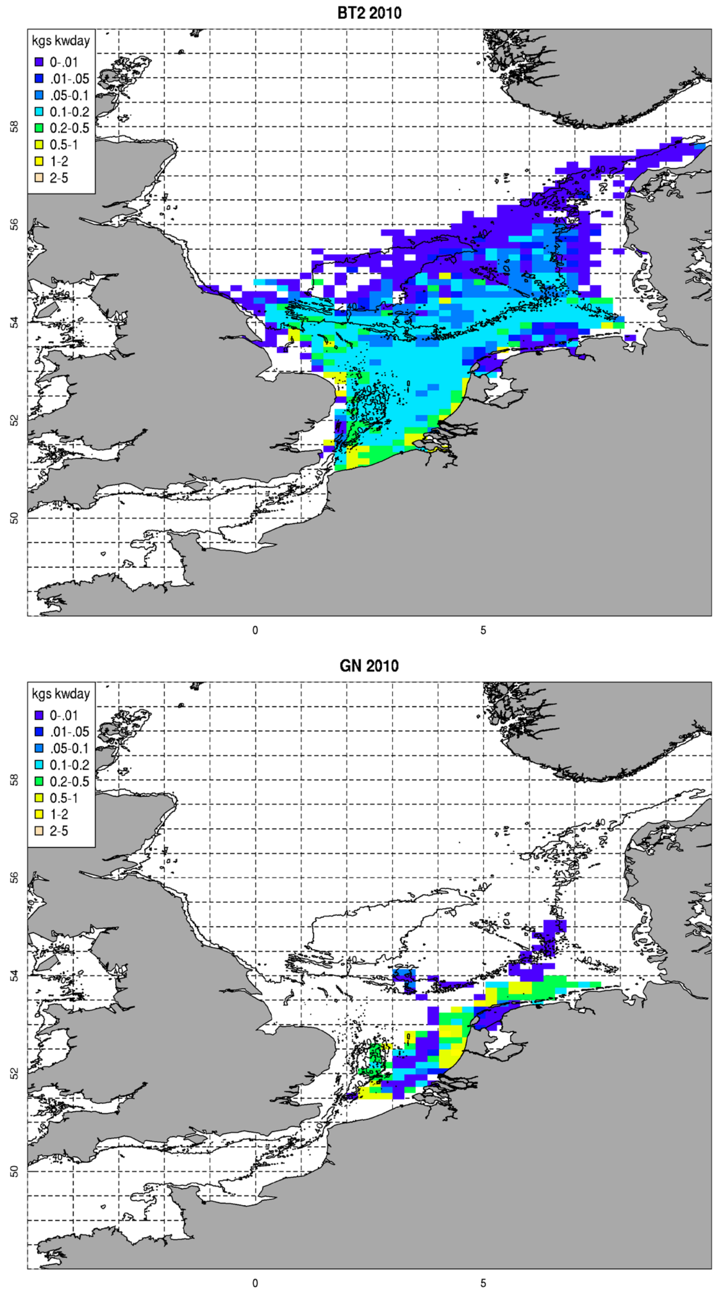


Figure 1. Landing rates (kgs kwday-1) in 2010 by Dutch flagged BT2 (beam trawlers working 80-89mm mesh, top) and GN (gillnetters, bottom). Data are based on combining VMS and logbook data. 40m depth contour also added.

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001, No. 51/2006, No. 41/2007 and No. 40/2008, annex IIa). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammel nets could fish between 140 and 205 days per year.

Several technical measures are applicable to the mixed fishery for flatfish species in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55°N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the sole fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100mm is required.

The minimum landing size of North Sea sole is 24 cm. The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation.

A.3 Ecosystem aspects

Sole growth rates in relation to changes in environmental factors were analysed by Rijnsdorp *et al.* (2004). Based on market sampling data it was concluded that both length at age and condition factors of sole increased since the mid 1960s to a high point in the mid 1970s. Since the mid 1980s, length at age and conditions have been intermediate between the troughs (1960) and peaks (mid 1970s). Growth rates of the juvenile age groups were negatively affected by intra-specific competition. Length of 0-group fish in autumn showed a positive relationship with sea temperature in the 2nd and 3rd quarters, but for the older fish no temperature effect was detected. The overall pattern of the increase in growth and the later decline correlated with 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.

I.1 Surveys

There are 3 trawl surveys that could potentially be used as tuning indices for the assessment of North Sea sole.

- The BTS-ISIS (Beam Trawl Survey)
- The SNS (Sole Net Survey)
- The UK Corystes survey

The BTS-ISIS (Beam Trawl Survey) is carried out in the southern and south-eastern North Sea in August and September using an 8m beam trawl. The SNS (Sole Net Survey) is a coastal survey with a 6m beam trawl carried out in the 3rd quarter. In 2003 the SNS survey was carried out during the 2nd quarter and data from this year were. The research vessel survey time series have been revised by WGBEAM (ICES-WGBEAM, 2009). WKFLAT 2010 decided to use only the BTS-ISIS and the SNS surveys as tuning series, because of lack of information on the raising procedure and spatial coverage of the UK Corystes series. In the assessment, the BTS-ISIS and SNS indices, calculated by WGBEAM, are used for tuning the stock assessment.

B.3 Commercial LPUE

There is one commercial fleet available that can be used as a tuning series for the stock assessment, being the Dutch beam trawl fleet. This fleet takes more than 70% of the landings, and is relatively homogeneous in terms of size and engine power. The data from this commercial fleet can be estimated using two different methods. The first method uses the total landings, and creates the age distribution for these landings by segregating the total landings into market categories, with age distributions being known within market categories through market sampling. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days. Effort nearly doubled between 1978 and 1994 and has declined since 1996. Effort during 2008 was <40% of the maximum (1994) in the series. A decline of circa 25% was recorded in 2008 following the decommissioning that took place during 2008.

Alternatively, the data for the Dutch beam trawl fleet can be raised as described by (WGNSSK 2008, WD1). This allows reviewing the LPUE trends in different areas of the North Sea. The data are based on various sources (WGNSSK 2008, WD1). There is a clear separation in LPUE between areas, with the southern area producing a substantially higher LPUE than the northern area. Average LPUE of a standardized NL beam trawler (1471 kW) over the period 1999 to 2007 was 266 kg day$_{-1}$, and the data have a significant ($P<0.01$) temporal trend of -6.1 kg day^{-1} year^{-1}.

The stock assessment uses the tuning index resulting from using the first method to calculate the commercial index. Owing to the strong changes in catchability in the in the first part of the time series, only the data from 1997 onwards is to be used in the assessment.

C. Historical Stock Development

WKFLAT 2010 decided that XSA should be used for providing advice, while also using the SAM models concurrently. There are currently three methods that could be used to provide an assessment of North Sea sole, being XSA, the ANP model (Aarts and Poos, 2009), and the SAM model (WKROUND 2009, WD14). The XSA assumes the catch-at-age matrix is complete and without error. The Aarts and Poos method is a variety of statistical catch-at-age model, that uses splines to estimate the selectivity patterns in the surveys and for the catch-at-age matrix. WKFLAT tested an adaptation of the original ANP model, where the discards estimation procedures were not incorporated. The SAM model is a state-space assessment model, similar to TSA. The advantage of using ANP and SAM would be that they take into account (and show) the uncertainty of the assessment inputs and outputs. The disadvantage of using ANP is that it can only assess the stock status for those years where survey data is available. Once a new benchmark group decides that there is no problem with the operational aspects of using SAM for North Sea sole, we recommend replacing the use of XSA with SAM.

Model used as a basis for advice

The North Sea sole advice is based on the XSA stock assessment. Settings for the final assessment are given below:

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1- 10).
Tuning indices	BTS-Isis 1985-assessment year 1-9 SNS 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 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 0.4 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

I. References

Aarts, G., and Poos, J.J. 2009. Comprehensive discard and abundance estimation of North Sea plaice. ICES J. Mar. Sci. 66: 763–771.

Horwood, J.W., and Millner, R.S. 1998. Cold induced abnormal catches of Sole. J.Mar.Biol.Ass.U.K. 78: 345-347.

ICES. 1965. Report of the working group on sole. Cooperative research report 55, International Council for the Exploration of the Sea, Copenhagen, Denmark.

ICES. 1979. Report of the North Sea flatfish working group. Demersal fish committee. ICES CM 1979/G:10

ICES. 2009 Report of the Working Group on Beam Trawl Surveys (WGBEAM). ICES CM 2009/LRC:04

Kraak, S.B.M., Pastoors, M.A., Rijnsdorp, A.D. 2002. Effecten van discarding en high-grading op de toestandsbeoordeling van schol: een quick-scan. CVO rapport ; 02.019 p. 8.

Mollet, F.M., Kraak, S.B.M., and Rijnsdorp, A.D. 2007. Fisheries-induced evolutionary changes in maturation reaction norms in North Sea sole Solea solea. Mar. Ecol. Prog. Ser. 351: 189-199.

Poos, J.J., Bogaards, J.A., Quirijns, F.J., Gillis, D.M., and Rijnsdorp, A.D. 2010. Individual quotas, fishing effort allocation, and over-quota discarding in mixed fisheries. ICES J. Mar. Sci. 67: 0000.

Quirijns, F.J., Poos, J.J., and Rijnsdorp, A.D. 2008. Standardizing commercial CPUE data in monitoring stock dynamics: Accounting for targeting behaviour in mixed fisheries. Fish. Res. 89: 1-8.

Rijnsdorp, A.D., Daan, N., and Dekker, W. 2006. Partial fishing mortality per fishing trip: a useful indicator of effective fishing effort in mixed demersal fisheries. ICES J. Mar. Sci. 63: 556-566.

Keeken, O.A. van, Dickey-Collas, M., Kraak, S.B.M., Poos, J.J., Pastoors, M.A. 2003. The use of simulations of discarding to investigate the potential impact of bias, due to growth, on the stock assessment of North Sea plaice (Pleuronectes platessa) ICES CM 2003/X:17

de Veen, J.F. 1967. On the phenomenon of soles (Solea solea L.) swimming at the surface. J. Cons. int. Explor. Mer 31(2): 207-236.

ICES. 2008. Report of the working group on the assessment of demersal stocks in the North Sea and Skagerrak - combined spring and autumn (WGNSSK) ICES CM 2008\ACOM:09. WORKING DOCUMENT 1

Wheeler, A. 1969. The fishes of the British Isles and North-west Europe. MacMillan, London, UK.

WKFLAT 2010

ICES. 2009 Report of the Benchmark and Data Compilation Workshop for Roundfish (WKROUND) ICES CM 2009/ACOM:32, WORKING DOCUMENT 14.

Stock Annex – Whiting IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Whiting IIIa
Working Group:	WGNSSK
Date:	May 2012
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). 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 112 tonnes in 2011, 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 indicate a clear reduction in cpue between 1920 and 1960 (Cardinale *et al*. in prep.).

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).

C. References

Cardinale M., Svedäng H., Bartolino V., Maiorano L., Casini M. & Linderholm H.W. Spatial and temporal depletion of haddock and pollack during the last century in the Kattegat-Skagerrak. 2012 J. Appl. Ichthyol. 28: 1–9

Frometin J-M., Stenseth N. C., *et al*. 1997 Spatial patterns of temporal dynamics of three gadoid species along the Norwegian Skagerrak coast. Mar. Ecol. Prog. Ser. 55:209-222

Fromentin J-M. and Planque B. 1996 *Calanus* and environment in the eastern North Atlantic II. Influence of the North Atlantic Oscillation on *C. finmarchicus* and *C. helgolandicus*. Mar. Ecol. Prog. Ser. 134:111-118

Planque B. and Fromentin J-M. 1996 *Calanus* and environment in the eastern North Atlantic I. Spatial and temporal patterns of *C. finmarchicus* and *C. helgolandicus*. Mar. Ecol. Prog. Ser. 134:101-109

Knutsen H., André C, Jorde P.E., Skogen M.D., Thuróczy E. & Stenseth N.C. 2004 Transport of North Sea cod larvae into the Skagerrak coastal populations. Proc R Soc Lond B 271:1337–1344.

Svedäng H. 2003 The inshore demersal fish community on the Swedish Skagerrak coast: regulation by recruitment from offshore sources. ICES J. Mar. Sci. 60:23-31

Svedäng H., Righton, D. and Jonsson, P. 2007. Migratory behaviour of Atlantic cod *Gadus morhua*: natal homing is the prime stock-separating mechanism. Mar. Ecol. Prog. Ser. 345: 1-12

Svedäng H., André C., Jonsson P., Elfman M. & Limburg K. 2010. Migartory behaviour and otolith chemistry suggest fine-scale sub-population structure within a genetically homogenous Atlantic cod population. Environ. Biol. Fishes 89: 383–397

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:

11) *Every effort shall be made to maintain a minimum level of Spawning Stock Biomass greater than 100,000 tonnes (Blim).*

12) *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 ap-*

propriate age-groups, when the SSB in the end of the year in which the TAC is applied is estimated above 140,000 tonnes (Bpa).

13) *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.*

14) *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.*

15) *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.*

16) *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.*

17) *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.*

18) *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.

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**

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 discard numbers. The initial scheme was implemented from the beginning of February 2008 and granted vessels their 2007 allocation of days (operated as hours at sea) in return for observance of Real Time Closures (RTC) and a one-net rule, adoption of more selective gears (110mm square meshed panels in 80mm gears or 90mm SMP in 95mm gear), agreeing to participate in additional gear trials and participation in an enhanced observer scheme.

For the first part of 2008 the RTC system was designed to protect aggregations of larger, spawning cod (>50cm length). Trigger levels leading to closures were 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:

19) Time-series of proportion of total catch discarded by age.

20) Log catch curves by cohort (total catch).

21) Negative gradients of log catches per cohort, averaged over mean F ages (total catch).

22) 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.

23) 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 (Nielsen 2010) 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(σ^2), where σ^2 ~ 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. This issue will be revisited in time for the WGNSSK meeting in May 2011.

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.

I. References

Darby, C. D. and Flatman, S. (1994) Lowestoft VPA Suite Version 3.1 User Guide. MAFF: Lowestoft.

ICES-WGNSSK (2001). Report of the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES CM 2002/ACFM:01.

ICES-WGSAM (2008). Report of the ICES Working Group on Multispecies Assessment Methods (WGSAM). ICES CM 2008/RMC:06.

Jaworski, A. (in press). Evaluation of methods for predicting mean weight-at-age: an application in forecasting yield of four haddock (*Melanogrammus aeglefinus*) stocks in the Northeast Atlantic. *ICES Journal of Marine Science*.

Needle, C. L. (2003). Survey-based assessments with SURBA. Working Document to the ICES Working Group on Methods of Fish Stock Assessment, Copenhagen, 29 January – 5 February 2003.

Needle, C. L. and Catarino, R. M. D. (2011) Evaluating the effect of real-time closures on cod targeting. *ICES Journal of Marine Science*. DOI: 10.1093/icesjms/FSR092.

Shepherd, J. G. (1992) Extended Survivors' Analysis: An improved method for the analysis of catch-at-age data and catch-per-unit-effort data. Working Paper to the ICES Multispecies Working Group, June 1992.

Stock Annex Cod in Subarea IV, and Divisions VIId and IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Cod in Subarea IV, Divison VIId & Division IIIa West (Skagerrak)

Working Group: Working Group North Sea, Skagerrak and Kattegat

Date: May 2012

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.

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). Furthermore, Holmes *et al*. (2008) found significant differences in SSB trends between spawning areas in the North Sea, consistent with asynchronous population dynamics across spawning areas and providing support for the concept of meta-population structure.

Available information indicates that the majority of spawning takes place from the beginning of January through to April offshore in waters of salinity 34-35% (Brander 1994, Riley and Parnell 1984). Around the British Isles there is a tendency towards later timing with increasing latitude (ICES 2005). Cod spawn throughout much of the North Sea but spawning adult and egg survey data and fishermen's observations indicate a number of spawning aggregations. Results from the first ichthyoplankton survey to cover the whole of the North Sea, conducted in 2004 to map spawning grounds of North Sea cod, are reported in Fox *et al*. (2008). This study compared the results from the plankton survey with estimates of egg production inferred from the distribution of mature cod in contemporaneous trawl surveys. The comparison found general agreement of hot spots of egg production around the southern and eastern edge of the Dogger Bank, in the German Bights, the Moray Firth and to the east of the

Shetlands, which mapped broadly into known spawning areas from the period 1940-1970, but was unable to detect any significant spawning activity off Flamborough (a historic spawning ground off the northeast coast of England). The study showed that most of the major cod spawning grounds in the North Sea are still active, but that the depletion of some localised populations may have made the detection of spawning activity in the corresponding areas difficult (Fox *et al*. 2008).

At the North Sea scale, there has been a northerly shift in the mean latitudinal distribution of the stock (Hedger *et al*. 2004, Perry *et al*. 2005). However the evidence for this being a migratory response is slight or non-existent. More likely, cod in the North Sea are composed of a complex of more or less isolated sub-stocks (as indicated above) and the southern units have been subjected to disproportionately high rates of fishing mortality (STECF-SGRST-07-01). Blanchard *et al*. (2005) demonstrated that the contraction in range of juvenile North Sea cod could be linked to reduced abundance as well as increased temperature, and further noted that the combined negative effects of increased temperature on recruitment rates and the reduced availability of optimal habitat may have increased the vulnerability of the cod population to fishing mortality.

Rindorf and Lewy (2006) linked the northward shift in distribution to the effect of a series of warm, windy winters on larvae and the resultant distribution of recently settled cod, followed by a northwards shift in the distribution of older age groups (because of the tendency for northerly distributed juveniles to remain northerly throughout their life). They noted further that this effect is intensified by the low abundance of older age cod due to heavy fishing pressure. In contrast, Neat and Righton (2007) analysed the temperature experienced by 129 individual adult cod throughout the North Sea, and found that the majority experienced a warmer fraction of the sea than was potentially available to them (even though they had the capacity to find cooler water), with individuals in the south in summer experiencing temperatures considered superoptimal for growth. This suggests that the thermal regime of the North Sea is not yet causing adult cod to move to cooler waters. Despite the drastic decline in stock abundance over the period 1983-2006, and the movement of the centre of gravity of the distribution towards the northeast, Lewy and Kristensen (2009) found that the spatial correlation and dispersion of IBTS Q1 survey catches remained unchanged throughout this 24-year period, with the concentration of the stock remaining constant or declining. They therefore concluded that cod does not follow the theory of density-dependent habitat selection, because stock concentration does not increase with decreasing stock abundance.

Several tagging studies have been conducted on cod in the North Sea since the mid 1950s in order to investigate the migratory movements and geographical range of cod populations (Bedford 1966, ICES-NSRWG 1971, Daan 1978, Righton *et al*. 2007). These studies support the existence of regional populations of cod that separate during the spawning season and, in some cases, intermix during the feeding season (Metcalfe 2006). Righton *et al*. (2007) re-analysed some of the historical datasets of conventional tags and used recent data from electronic tags to investigate movement and distribution of cod in the southern North Sea and English Channel. Their re-analysis of conventional tags showed that, although most cod remained within their release areas, a larger proportion of cod were recaptured outside their release area in the feeding season than the spawning season, and a larger proportion of adults were recaptured outside their release area than juveniles, with the displacement (release to recapture) occurring mostly to the southern North Sea for fish released in the English Channel, and to areas further north for fish released in the southern North Sea (see

Table 5 in Righton *et al*. 2007). This suggests a limited net influx of cod from the English Channel to the southern North Sea, but no significant movement in the other direction (Metcalfe 2006).

The lack of obvious physical barriers to mixing between different sub-populations in the North Sea suggests that behavioural and/or environmental factors are responsible for maintaining the relative discreteness of these populations (Metcalfe 2006). For example, Righton *et al*. (2007) conclude that behavioural differences between cod in the southern North Sea and English Channels (such as tidal stream transport being used by fish tagged and released in the southern North Sea to migrate, but rarely being used by those tagged and released in the English Channel) may limit mixing of cod from these two areas during feeding and spawning seasons. Robichaud and Rose (2004) describe four behavioural categories for cod populations: “sedentary residents” exhibiting year-round site fidelity, “accurate homers” that return to spawn in specific locations, “inaccurate homers” that return to spawn in a broader area around the original site, and “dispersers” that move and spawn in a haphazard fashion within a large geographical area. These categories are not necessarily mutually exclusive and behaviours in different regions may be best described by differing degrees of each category (Heath *et al*. 2008).

Evidence from electronic tags suggest that cod populations have a strong tendency for site attachment (even in migratory individuals), rapid and long-distance migrations, the use of deeper channels as migratory “highways” and, in some cases, clearly defined feeding and spawning “hot spots” (Righton *et al*. 2008). Andrews *et al*. (2006) used a spatially and physiologically explicit model describing the demography and distribution of cod on the European shelf in order to explore a variety of hypotheses about the movements of settled cod. They fitted the model to spatial data derived from International Bottom Trawl Surveys, and found that structural variants of the model that did not recognise an active seasonal migration by adults to a set of spatially stable spawning sites, followed by a dispersal phase, could not explain both the abundance and distribution of the spawning stock. Heath *et al*. (2008) investigated different hypotheses about natal fidelity, and their consequence for regional dynamics and population structuring, by developing a model representing multiple demes, with the spawning locations of fish in each deme governed by a variety of rules concerning oceanographic dispersal, migration behaviour and straying. They used an age-based discrete time methodology, with a spatial representation of physical oceanographic patterns, fish behaviour patterns, recruitment, growth and mortality (both natural and fishing). They found that although active homing is not necessary to explain some of the sub-population structures of cod (with separation possible through distance and oceanographic processes affecting the dispersal of eggs and larvae, such is in the Southern Bight), it may well be necessary to explain the structure of other sub-populations.

A.2. Fishery

Cod are caught by virtually all the demersal gears in Subarea IV and Divisions IIIa (Skagerrak) and VIId, including beam trawls, otter trawls, seine nets, gill nets and lines. Most of these gears take a mixture of species. In some of them cod are considered to be a by-catch (for example in beam trawls targeting flatfish), and in others the fisheries are directed mainly towards cod (for example, some of the fixed gear fisheries).

An analysis of landings and estimated discards of cod by gear category (excluding Norwegian data) highlighted the following fleets as the most important in terms of cod for 2003-5 (accounting for close to 88% of the EU landings), listed with the main use of each gear (STECF SGRST-07-01):

- Otter trawl, ≥ 120mm, a directed roundfish fishery by UK, Danish and German vessels.
- Otter trawl, 70-89mm, comprising a 70-79mm French whiting trawl fishery centered in the Eastern Channel, but extending into the North Sea, and an 80-89mm UK *Nephrops* fishery (with smaller landings of roundfish and anglerfish) occurring entirely in the North Sea.
- Otter trawl, 90-99mm, a Danish and Swedish mixed demersal fishery centered in the Skagerrak, but extending into the Eastern North Sea.
- Beam trawl, 80-89mm, a directed Dutch and Belgian flatfish fishery.
- Gillnets, 110-219mm, a targeted cod and plaice fishery.

For Norway in 2007, trawls (mainly bycatch in the saithe fishery) and gillnets account for around 60% (by weight) of cod catches, with the remainder taken by other gears mainly in the fjords and on the coast, whereas in the Skagerrak, trawls and gillnets account for up to 90% of cod catches.

With regard to trends in effort for these major cod fisheries since 2000, the largest changes to have happened in North Sea fisheries have involved an overall reduction in trawl effort and changes in the mesh sizes in use, due to a combination of decommissioning and days-at-sea regulations. In particular 100-119mm meshes have now virtually disappeared, and instead vessels are using either 120mm+ (in the directed whitefish fishery) or 80-99mm (primarily in the *Nephrops* fisheries and in a variety of mixed fisheries). The use of other mesh sizes largely occurs in the adjacent areas, with the 70-79mm gear being used in the Eastern Channel/Southern North Sea Whiting fishery, and the majority of the landings by 90-99mm trawlers coming from the Skagerrak. Higher discards are associated with these smaller mesh trawl fisheries, but even when these are taken into account, the directed roundfish fishery (trawls with ≥ 120mm mesh) still has the largest impact of any single fleet on the cod stock, followed by the mixed demersal fishery (90-99mm trawls) in the Skagerrak.

Technical Conservation Measures

The present technical regulations for EU waters came into force on 1 January 2000 (EC 850/98 and its amendments). The regulations prescribe the minimum target species' composition for different mesh size ranges. Additional measures were introduced in Community waters from 1 January 2002 (EC 2056/2001).

In 2001, the European Commission implemented an emergency closure of a large area of the North Sea from 14 February to 30 April (EC 259/2001). An EU-Norway expert group in 2003 concluded that the emergency closure had an insignificant effect upon the spawning potential for cod in 2001. There were several reasons for the lack of impact. The redistribution of the fishery, especially along the edges of the box, coupled to the increases in proportional landings from January and February appear to have been able to negate the potential benefits of the box. The conclusion from this study was that the box would have to be extended in both space and time to be more effective. This emergency measure has not been adopted after 2001. A cod protection area was implemented in 2004 (EC 2287/2003 and its amendments), which defined conditions under which certain stocks, including haddock, could be caught in Community waters, but this was only in force in 2004. A recent study on the use of MPAs to address regional-scale ecological objectives in the North Sea (Greenstreet *et al*. 2009) concluded that MPAs on their own are unlikely to achieve significant regional-scale ecosystem benefits, because local gains are largely negated by fishing effort displacement into the remainder of the North Sea.

Apart from the technical measures set by the Commission, additional unilateral measures are in force in the UK, Denmark and Belgium. The EU minimum landing size (mls) is 35cm, but Belgium operate a 40cm mls, while Denmark operate a 35cm mls in the North Sea and 30cm in the Skagerrak. Additional measures in the UK relate to the use of square mesh panels and multiple rigs, restrictions on twine size in both whitefish and *Nephrops* gears, limits on extension length for whitefish gear, and a ban on lifting bags. In 2001, vessels fishing in the Norwegian sector of the North Sea had to comply with Norwegian regulations setting the minimum mesh size at 120mm. Since 2003, the basic minimum mesh size for towed gears targeting cod is 120mm.

Effort regulations in days at sea per vessel and gear category are summarised in the following table, which only shows changes in 2008 compared to 2007 (2006 is included for comparison). The changes (2007-2008) were intended to generate a cut in effort of 10% for the main gears catching cod.

Maximum number of days a vessel can be present in the North Sea, Skagerrak and Eastern Channel, by gear category and special condition (see EC 40/2008 for more details). The table only shows changes in 2008 compared to 2007, but 2006 is also included for comparison.

Description of gear and special condition (if applicable)	Area			Max days at sea		
	IV,II	Skag	VIId	2006	2007	2008**
Trawls or Danish seines with mesh size ≥ 120mm	x	x	x	103	96	86
Trawls or Danish seines with mesh size ≥ 100mm and < 120mm	x	x	x	103	95	86
Trawls or Danish seines with mesh size ≥ 90mm and < 100mm	x		x	227	209	188
Trawls or Danish seines with mesh size ≥ 90mm and < 100mm		x		103	95	86
Trawls or Danish seines with mesh size ≥ 70mm and < 90mm	x			227	204	184
Trawls or Danish seines with mesh size ≥ 70mm and < 90mm			x	227	221	199
Beam trawls with mesh size ≥ 120mm	x	x		143	143	129
Beam trawls with mesh size ≥ 100mm and < 120mm	x	x		143	143	129
Beam trawls with mesh size ≥ 80mm and < 90mm	x	x		143	132	119
Gillnets and entangling nets with mesh sizes ≥ 150mm and < 220mm	x	x	x	140	130	117
Gillnets and entangling nets with mesh sizes ≥ 110mm and < 150mm	x	x	x	140	140	126
Trammel nets with mesh size < 110mm. The vessel shall be absent from port no more than 24h.	x		x	205	205	185*

* For member states whose quotas less than 5% of the Community share of the TACs of both plaice and sole, the number of days at sea shall be 205

** If member states opt for an overall kilowatt-days regime, then the maximum number of days at sea per vessel could be different to that set out for 2008 (see text below and EC 40/2008 for details).

Additional provisions were introduced for 2008 (points 8.5-7, Annex IIa, EC 40/2008) to provide Member States greater flexibility in managing their fleets, in order to encourage a more efficient use of fishing opportunities and stimulate fishing practices that lead to reduced discards and lower fishing mortality of both juvenile and adult fish. This measure allowed a Member State that fulfilled the requirements laid out in EC 40/2008 to manage a fleet (i.e. group of vessels with a specific combination of geographical area, grouping of fishing gear and special condition) to an overall kilowatt-days limit for that fleet, instead of managing each individual vessel in the fleet to its own days-at-sea limit. The overall kilowatt-days limit for a fleet is initially calculated as the sum of all individual fishing efforts for vessels in that fleet, where an individual fishing effort is the product of the number of days-at-sea and engine power for the vessel concerned. This provision allowed Member States to draw up fishing plans in collaboration with the Fishing Industry, which could, for example, specify a target to reduce cod discards to below 10% of the cod catch, allow real-time closures for juveniles and spawners, implement cod avoidance measures, trial new selective devices, etc.

Incentives of up to 12 additional days at sea per vessel were in place for 2008 to encourage vessels to sign up to a Discard Reduction Plan (points 12.9-10, Annex IIa, EC 40/2008). The plan focused on discarding of cod or other species with discard problems for which a management/recovery plan is adopted, and was to include measures to avoid juvenile and spawning fish, to trial and implement technical measures for improving selectivity, to increase observer coverage, and to provide data for monitoring outcomes. For vessels participating in a Cod Avoidance Reference Fleet Programme in 2008 (points 12.11-14, Annex IIa, EC 40/2008), a further 10-12 additional days at sea was possible (over and above that for the Discard Reduction Plan). Vessels participating in this program were to meet a specific target to reduce cod discards to below 10% of cod catches, and be subject to observer coverage of at least 10%.

Under the provisions laid down in point 8.5 of Annex IIa (EC 40/2008), Scotland implemented a national kilowatt-days scheme known as the 'Conservation Credits Scheme'. The principle of this two-part scheme involved credits (in terms of additional time at sea) in return for the adoption of and adherence to measures that reduce mortality on cod and lead to a reduction in discard numbers. The initial, basic scheme was implemented from the beginning of February 2008 and essentially granted vessels their 2007 allocation of days (operated as hours at sea) in return for: observance of Real Time Closures (RTC), observance of a one net rule, adoption of more selective gears (110mm square meshed panels in 80mm gears or 90mm square meshed panels in 95mm gear), agreeing to participate in additional gear trials, and participation in an enhanced observer scheme.

For the first part of 2008, the RTC system was designed to protect aggregations of larger, spawning cod (>50cm length). Commercial catch rates of cod observed on board vessels was used to inform trigger levels leading to closures. Ten closures occurred to the beginning of May and protection agency monitoring suggested good observance. The scheme was extended for the remainder of the year to protect aggregations of all sizes of cod. A joint industry/ science partnership (SISP) had a number of gear trials programmed for 2008 examining methods to improve selectivity and reduce discards, and an enhanced observer scheme was announced by the Scottish Government.

Observance of the above conditions also gave eligibility for vessels to participate in the second, enhanced, part of the Conservation Credits scheme.

Changes in fleet dynamics

The introduction of the one-net rule as part of the Scottish Conservation Credit Scheme and new Scottish legislation implemented in January 2008 were both likely to improve the accuracy of reporting of Scottish landings to the correct mesh size range, although some sectors of the Scottish industry have been granted derogations to continue carrying two nets (seiners until the end of January 2009, and others until the end of April 2008). The concerted effort to reduce cod mortality, through implementation of the Conservation Credit Scheme from February 2008, could have lead to greater effort being exerted on haddock, whiting, monk, flatfish and *Nephrops*.

Shifts in the UK fleet in 2007/8 included: (a) a move of Scottish vessels using 100-110mm for whitefish on west coast ground (subarea VI) to the North Sea using 80mm prawn codends (motivated by fuel costs, and could increase effort on North Sea stocks; the simultaneous requirement to use 110 square mesh panels may mitigate unwanted selectivity implications – see below); (b) a move away from the Farne Deeps *Nephrops* fishery into other fisheries for whitefish because of poor *Nephrops* catch rates (implying increased effort in whitefish fisheries); and (c) a move of Scottish vessels from twin trawls to single rig, and increased use of pair trawls, seines and double bag trawls (motivated by fuel costs). For 2008 in the Scottish fleet, all twin-rig gear in the 80-99mm category have to use a 110mm square mesh panel, but this also applied to single-rig gears from July 2008 onwards, which was likely to have improved whitefish selection. A large number of 110mm square mesh panels have been bought by Scottish fishers at the beginning of 2008 in order to qualify for the Conservation Credit Scheme, which dramatically improved the uptake of selective gear. The ban on the use of multi-rigs in Scotland, implemented in January 2008, may have limited the potential for an uncontrolled increase in effective effort.

The Dutch fleet was reduced, through decommissioning, by 23 vessels from the beginning of 2008, while 5 Belgian beam trawlers (approximately 5% of the Belgian fleet) left the fishery in 2007, both changes implying reductions in effort in the beam trawl sector. The introduction of an ITQ regulation system in Denmark in 2007 might have influenced the effort distribution over the year, but this should not have affected the total Danish effort deployed or the size distribution of catches.

Dutch beam trawlers have gradually shifted to other techniques such as twin trawling, outrigging and fly-shooting, as well as opting for smaller, multi-purpose vessels, implying a shift in effort away from flatfish to other sectors. These changes were likely caused by TAC limitations on plaice and sole, and rising fuel costs. Belgian and UK vessels have also experimented with outrigger trawls as an alternative to beam trawling, motivated by more fuel efficient and environmentally friendly fishing methods.

The increased effort costs in the Kattegat (2.5 days at sea per effort day deployed) in 2008 has led to a shift in effort by Swedish vessels to the Skagerrak and Baltic Sea. There has also been an increase in the number of Swedish *Nephrops* vessels in recent years, attributed to the input of new capital transferred from pelagic fleets following the introduction of an ITQ-system for pelagic species, and leading to further increases in effort. The Swedish trawler fleet operating in IIIa has had a steady increase in the uptake of the *Nephrops* grid since the introduction of legislation in 2004 (use of the grid is mandatory in coastal waters), and given the strong incentives to use the grid (unlimited days at sea). Uptake of the *Nephrops* grid should have resulted in improved selection.

A squid fishery in the Moray Firth has continued to develop using very unselective 40mm mesh when squid species are available on the grounds. Although the uptake was poor in 2007 due to the lack of squid, the potential for high bycatches of young gadoids in future, including those of cod and haddock, remains. This fishery may provide an alternative outlet for the Scottish *Nephrops* fleet seasonally, and hence reduce effort in the *Nephrops* sector.

A.3. Ecosystem aspects

Cod are predated upon by a variety of species through their life history. The Working Group on Multi-species Assessment Methods (ICES-WGSAM 2008) estimated predation mortalities using SMS (Stochastic Multi Species Model) with diet information largely derived from the Years of the Stomach databases (stomachs sampled in the years 1981-1991). Long-term trends have been observed in several partial predation mortalities with significant increases for grey gurnard preying on 0-group cod. In contrast, predation mortalities on age 1 and age 2 cod decreased over the last 30 years due to lower cannibalism. Predation on older cod (age 3-6) increased due to increasing numbers of grey seals in the North Sea.

SMS identified grey gurnard as a significant predator of 0-group cod. The abundance of grey gurnard (as monitored by IBTS) is estimated to have increased in recent years resulting in a rise in estimated predation mortality from 1.08 to 1.76 between 1991 and 2003. A degree of caution is required with these estimates as they assume that the spatial overlap and stomach contents of the species has remained unchanged since 1991. Given the change in abundance of both species this assumption is unlikely to hold and new diet information is required before 0-group predation mortalities can be relied upon.

Several other predators contribute to predation mortality upon 0-group cod, whiting and seabirds being the next largest components. Speirs *et al*. (2010) developed a length-structured partial ecosystem model for cod and nine of its most important fish predators and prey in the North Sea, utilising time series of stock biomass, recruitment and landings, as well as survey data on length distributions and diet data. Their results suggest that herring predation on early life history stages of cod is dynamically important, and that high abundances of herring may lead to the decline of cod stocks, even during periods of declining fishing pressure. Furthermore, they show that the MSY of cod is strongly dependent on herring abundance, and that current levels of cod exploitation may become unsustainable if herring recruitment returns to historic high levels.

The consumption of cod in the North Sea in 2002 by grey seals (*Halichoerus grypus*) has recently been estimated (Hammond and Grellier 2006). For the North Sea it was estimated that in 1985 grey seals consumed 4150 tonnes of cod (95% confidence intervals: 2484-5760 tonnes), and in 2002 the population tripled in size (21-68 000) and consumed 8344 tonnes (95% confidence intervals: 5028-14941 tonnes). These consumption estimates were compared to the Total Stock Biomass (TSB) for cod of 475 000 tonnes and 225 000 tonnes for 1985 and 2002 respectively. The mean length of cod in the seal diet was estimated as 37.1 cm and 35.4 cm in 1985 and 2002 respectively. It should be noted, however, that seal diet analysis must be treated with a degree of caution because of the uncertainties related to modelling complex processes (e.g. using scat analysis to estimate diet composition involves complex parameters, and can overestimate species with more robust hard parts), and the uncertainties related to estimating seal population size from pup production estimates (involving assumptions about the form of density-dependent dynamics). The analysis may also be subject to bias because scat data from haul-out sites may reflect the composition of prey close to the sites rather than further offshore.

The effect of seal predation on cod mortality rates has been estimated for the North Sea within a multi-species assessment model (MSVPA), which was last run in 2007 during the EU project BECAUSE (contract number SSP8-CT-2003-502482) using revised estimates of seal consumption rates . The grey seal population size was obtained from WGMME (ICES-WGMME 2005) and was assumed to be 68,000 in 2002 and 2003 respectively. Estimates of cod consumption were 9657 tonnes in 2002 and 5124 tonnes in 2003, which is similar to the values estimated by Hammond and Grellier (2006). Sensitivity analysis of the North Sea cod stock assessment estimates to the inclusion of the revised multi-species mortality rates were carried out at the 2009 meeting of the WKROUND. Inclusion of the multi-species mortality rates for older ages of cod had a relatively minor effect on the high levels of estimated fishing mortality rates and low levels of spawning stock biomass abundance. This suggests that the estimates of seal predation will not alter the current perception of North Sea cod stock dynamics (also stated by STECF-SGRST-07-01).

The overlap between predator and prey is a key parameter in multispecies assessment models and is notoriously difficult to parameterise. Kempf *et al*. (2010) attempt this by using overlap indices derived from trawl surveys in a North Sea SMS model in order to investigate the recovery potential of North Sea cod. They found that the spatial-temporal overlap between cod and its predators increased with increasing temperature, indicating that foodweb processes might reduce the recovery potential of cod during warm periods. Furthermore, they found that multispecies scenarios predicted a considerably lower recovery potential than single-species ones.

A recent meeting (2007) of the STECF reviewed the broad scale environmental changes in the north-eastern Atlantic that has influenced all areas under the cod recovery plan (STECF-SGRST-07-01), and concluded that:

- Warming has occurred in all areas of the NW European shelf seas, and is predicted to continue.
- A regime shift in the North Sea ecosystem occurred in the mid-1980s.
- These ecological changes have, in addition to the decline in spawning stock size, negatively affected cod recruitment in all areas.
- Biological parameters and reference points are dependent on the time-period over which they are estimated. For example, for North Sea cod FMSY, MSY and BMSY are lower when calculated for the recent warm period (after 1988) compared to values derived for the earlier cooler period.
- The decline in FMSY, MSY and BMSY can be expected to continue due to the predicted warming, and possible future change should be accounted for in stock assessment and management regimes.
- Modelling shows that under a changing climate, reference points based on fishing mortality are more robust to uncertainty than those based on biomass.
- Despite poor recruitment, modelling suggests that cod recovery is possible, but ecological change may affect the rate of recovery, and the magnitude of achievable stock sizes.
- Recovery of cod populations may have implications to their prey species, including *Nephrops*.

With the exception of the general effects noted above, the overall conclusion from the STECF meeting (STECF-SGRST-07-01) for the North Sea was that there is no specific significant environmental or ecosystem change in the Skagerrak, North Sea and eastern Channel (e.g. the effects of gravel extraction, etc.) affecting potential cod recovery. The conclusions from the STECF meeting merit further discussion within ICES, which is ongoing (e.g. ICES-WKREF 2007).

B. Data

B.1. Commercial catch

The WG estimate for landings from the three areas (IV, IIIa-Skagerrak and VIId) in 2006 and 2007 were based on annual data, as opposed to quarterly data prior to 2006, because of ongoing difficulties with international data aggregation procedures, particularly with regard to discard raising.

France, Belgium and Sweden, who respectively landed 9%, 5% and 2% of all cod for combined area IV and VIId, do not provide discard estimates for this combined area. Similarly, Belgium and Germany, who each land 2% of all cod in area IIIa, do not provide discard estimates for this area. Norwegian discarding is illegal, so although this nation landed 14% and 6% of all cod in combined area IV and VIId, and area IIIa respectively, it does not provide discard estimates. Although the Netherlands (7% of all cod landed in IV and VIId, 1% in IIIa) does provide discard data for area IV, these are based on very low sample sizes for cod, and are therefore not reliable enough to be raised to fleet level. All percentages quoted in this paragraph refer to landings in 2007.

Discard numbers-at-age were estimated for areas IV and VIId by applying the Scottish discard ogives to the international landings-at-age for years prior to 2006. For 2006, Denmark was excluded from this calculation as they provided their own discard estimates. For 2007, Scottish, Danish, German and England & Wales discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in subarea IV to account for missing discards. Discard numbers-at-age for IIIa-Skagerrak were based on observer sampling estimates. For 2006 and 2007, Danish and Swedish discard estimates were combined (sum of discards divided by sum of landings) and used to raise landings-at-age from the remaining nations in Division IIIa-Skagerrak to account for missing discards. Although in some cases other nations' discard proportions were available for a range of years, these have not been transmitted to the relevant WG data coordinator in an appropriate form for inclusion in the international dataset.

For cod in IV, IIIa-Skagerrak and VIId, ICES first raised concerns about the mis-reporting and non-reporting of landings in the early 1990s, particularly when TACs became intentionally restrictive for management purposes. Some WG members have since provided estimates of under-reporting of landings to the WG, but by their very nature these are difficult to quantify. In terms of events since the mid-1990s, the WG believes that under-reporting of landings may have been significant in 1998 because of the abundance in the population of the relatively strong 1996 year class as 2-year-olds. The landed weight and input numbers at age data for 1998 were adjusted to include an estimated 3000t of under-reported catch. The 1998 catch estimates remain unchanged in the present assessment.

For 1999 and 2000, the WG has no *a priori* reason to believe that there was significant under-reporting of landings. However, the substantial reduction in fishing effort implied by the 2001, 2002 and 2003 TACs is likely to have resulted in an increase in unreported catch in those years. Anecdotal information from the fisheries in some countries indicated that this may indeed have been the case, but the extent of the alleged under-reporting of catch varies considerably. Since the WG has no basis to judge the overall extent of under-reported catch, it has no alternative than to use its best estimates of landings, which in general are in line with the officially reported landings. An attempt is made to incorporate a statistical correction to the sum of reported landings and discards data in the assessment of this stock. Buyers and Sellers legislation introduced in the UK towards the end of 2005 is expected to have improved the accuracy of reported cod landings for the UK. This has brought the UK in line with existing EU legislation.

Age compositions

Age compositions are currently provided by Denmark, England, Germany, the Netherlands, Scotland and Sweden.

Landings in numbers at age for age groups 1-11+ and 1963-present form the basis for the catch at age analysis but do not include industrial fishery by-catches landed for reduction purposes. By-catch estimates are available for the total Danish and Norwegian small-meshed fishery in Subarea 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:

d) 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);

e) 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;

f) 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 XXX.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:

g) 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;

h) 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;

i) 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;

j) 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;

k) 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 onwards. 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:

$$S_{a,y} = \begin{cases} 1, & y < 1993 \\ \tau_y, & y \geq 1993 \end{cases}$$

It is assumed that the fishing mortalities corresponding to total catches are identical for the two oldest age groups $F_{a=6,y} = F_{a=7+,y}$ in order to make the model identifiable.

The total vector of model parameters for this model is:

$$\vartheta = (Q_{a=1,2,3,4,5}^{(s=1)}, \sigma_R^2, \sigma_S^2, \sigma_F^2, \sigma^2_{\circ,a=1,2,3^+}, \sigma^2_{s=1,a=1,2^+},$$
$$\tau_{1993}, \tau_{1994}, \ldots, \tau_{2009}, \alpha, \beta, \rho)$$

The Q parameters are catchabilities corresponding to the survey fleet. The three variance parameters σ_R^2, σ_S^2, and σ_F^2 are process variances for recruitment, survival, and development in fishing mortality respectively. The remaining σ^2 parameters are describing the variance of different observations divided into fleet and age classes. Finally the τ parameters are the scaling factors for the total catches, α and β are the parameters of the Beverton-Holt recruitment function, and ρ is the correlation parameter for the random walks on the fishing mortalities.

Model used: SAM (with correlated fishing mortality at age)

Software used: Source code and all scripts are freely available at http://www.nscod.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 (* indicates where changes may need to be made to accommodate a further year of data):

```
# Survey q-scaling coefficient (better name wanted)
#
# Rows represent fleets.
# Columns represent ages.
 0  0  0  0  0  0  0
 0  0  0  0  0  0  0

# The following matrix describes the coupling
# of fishing mortality variance parameters
# Rows represent fleets.
# Columns represent ages.
 1  1  1  1  1  1  1
 0  0  0  0  0  0  0

# The following vector describes the coupling
# of the log N variance parameters at different
```

```
# ages
 1  2  2  2  2  2  2

# The following matrix describes the coupling
# of observation variance parameters
# Rows represent fleets.
# Columns represent ages.
 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
17*
  # Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
2009*
  # 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
 14   14   14   14   14   14   14
 15   15   15   15   15   15   15
 16   16   16   16   16   16   16
 17*  17*  17*  17*  17*  17*  17*

# 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, and average of the final three years' catch multipliers are used 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.

I. References

Alphen, J. v., and Heessen, H. J. L. 1984. Variation in length at age of North Sea cod. ICES CM 1984/G:36.

Andrews, J.M., Gurney, W.S.C., Heath, M.R., Gallego, A., O'Brien, C.M., Darby, C., and Tyldesley, G. 2006. Modelling the spatial demography of Atlantic cod (*Gadus morhua*) on the European continental shelf. Can. J. Fish. Aquat. Sci. 63: 1027-1048.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S., and Reid, P.C. 2003. Plankton effect on cod recruitment in the North Sea. Nature, 426: 661–664.

Bedford, B.C., 1966. English cod tagging experiments in the North Sea. International Council for the Exploration of the Sea (CM Papers and Reports), CM 1966/G:9, 28 pp.

Björnsson, B., and Steinarsson, A. 2002. The food-unlimited growth rate of Atlantic cod (*Gadus morhua*). Can. J. Fish. Aquat. Sci. 59: 494–502.

Blanchard, J.L., Mills, C., Jennings, S., Fox, C.J., Rackham, B.D., Eastwood, P.D., and O'Brien, C.M. 2005. Distribution-abundance relationships for North Sea Atlantic cod (Gadus morhua): observation versus theory. Canadian Journal of Fisheries and Aquatic Sciences, 62: 2001–2009.

Brander, K. M. 1994. The location and timing of cod spawning around the British Isles. ICES Journal of Marine Science, 51: 71–89.

Cook, R.M., Kunzlik, P.A., Hislop, J.R.G. and Poulding, D. 1999. Models of Growth and Maturity for North Sea cod. J. Northw. Atl. Fish. Sci. 25: 91-99.

Daan, N. 1978. Changes in cod stocks and cod fisheries in North Sea. Rapports et Procès-verbaux des Réunions du Conseil International pour l'Exploration de la Mer, 172, 39–57.

Dickson, R.R., and Brander, K.M. 1993. Effects of a changing windfield on cod stocks of the North Atlantic. Fisheries Oceanography 2: 124–153.

Fox, C.J., Taylor, M., Dickey-Collas, M., Fossum, P., Kraus, G., Rohlf, N., Munk, P., van Damme, C.J.G., Bolle, L.J., Maxwell, D.L., and Wright, P.J. 2008. Mapping the spawning grounds of North Sea cod (Gadus morhua) by direct and indirect means. Proc. R. Soc. B. 275: 1543-1548.

Fryer R.J., 2002. TSA: is it the way? Appendix D in report of Working Group on Methods on Fish Stock Assessment. ICES CM 2002/D:01.

Greenstreet, S.P.R., Fraser, H.M., and Piet, G.J. 2009. Using MPAs to address regional-scale ecological objectives in the North Sea: modelling the effects of fishing effort displacement. ICES Journal of Marine Science, 66: 90–100.

Gudmundsson, G. (1987). Time series models of fishing mortality rates. ICES C.M. d:6.

Gudmundsson, G. (1994). Time series analysis of catch-at-age observations. Appl.~Statist. 43 117-126.

Hammond, P.S. and Grellier, K. 2006. Grey seal diet composition and prey consumption in the North Sea. Final report to Scottish Executive Environment and Rural Affairs Department and Scottish Natural Heritage; 2006.

Heath, M.R., Kunzlik, P.A., Gallego, A., Holmes, S.J., and Wright, P.J. 2008. A model of meta-population dynamics for North Sea and West of Scotland cod – the dynamic consequences of natal fidelity. Fisheries Research 93: 92-116.

Hedger, R., Mckenzie, E., Heath, M., Wright, P., Scott, E., Gallego, A., and Andrews, J. 2004. Analysis of the spatial distributions of mature cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) abundance in the North Sea (1980e1999) using generalised additive models. Fisheries Research, 70: 17-25.

Hislop, J.R.G. 1984. A comparison of the reproductive tactics and strategies of cod, haddock, whiting and Norway pout in the North Sea. In: Fish reproduction-strategies and tactics, pp. 311–330. Ed. by Potts and Wootton. Academic Press, London: 424 pp.

Holmes, S.J., Wright, P.J., and Fryer, R.J. 2008. Evidence from survey data for regional variability in cod dynamics in the North Sea and West of Scotland. ICES Journal of Marine Science 65: 206-215.

Houghton, R.G., and Flatman, S. 1981. The exploitation pattern, density-dependent catchability and growth of cod (*Gadus morhua*) in the west-central North Sea. Journal du Conseil International Pour l'Exploration de la Mer, 39: 271–287.

Horwood, J., O'Brien, C., and Darby, C. 2006. North Sea cod recovery? ICES J. Mar. Sci. 63: 961–968.

Hughes, N.R. and Grand, T.C. 2000. Physiological ecology meets the ideal-free distribution: predicting the distribution of size-structured fish populations across temperature gradients. Environ. Biol. Fishes 59: 285-298.

Hutchinson, W.F., Carvalho, G.R., & Rogers, S.I. 2001. Marked genetic structuring in localised spawning populations of cod Gadus morhua in the North Sea and adjoining waters, as revealed by microsatellites. Marine Ecology Progress Series. 223: 251-260.

ICES. 1994. Spawning and life history information for North Atlantic cod stocks. ICES Cooperative Research Report 205: 150 pp.

ICES 2005. Spawning and life history information for North Atlantic cod stocks. ICES Cooperative Research Report 274: 152pp.

ICES-NSRWG 1971. Report by the North Sea Roundfish Working Group on North Sea Cod. ICES/Demersal Fish Comm F:5: 1-35.

ICES-WGFTFB 2006. Report of the Working Group on Fish Technology and Fish Behaviour. ICES CM 2006/FTC:06.

ICES-WGFTFB 2007. ICES - FAO Working Group on Fishing Technology & Fish Behaviour [April 2007 report not yet available].

ICES-WGMME 2005. Report of the Working Group on Marine Mammal Ecology (WGMME). ICES CM2005/ACE:05.

ICES-WGNSSK 2001. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, 19-28 June 2001, Hamburg, Germany. ICES CM 2002/ACFM:01.

ICES-WGNSSK 2003. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 9-18 September 2003, Boulogne-sur-Mer, France. ICES CM 2004/ACFM:07.

ICES-WGNSSK 2004. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 7-16 September 2004, Bergen, Norway. ICES CM 2005/ACFM:07.

ICES-WGNSSK 2006. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5–14 September 2006, ICES Headquarters. ACFM:35: 1160pp.

ICES-WGNSSK 2007. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak – Combined Spring and Autumn (WGNSSK), 1-8 May 2007, ICES Headquarters and September 2007 by correspondence. ICES CM 2007/ACFM:18&30: 960pp.

ICES-WGNSSK 2008. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Spring and Autumn (WGNSSK), 7-13 May 2008, ICES Copenhagen and By Correspondence. ICES CM 2008\ACOM:09: 921pp

ICES- WGNSSK 2009. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak - Combined Spring and Autumn (WGNSSK), 6 - 12 May 2009, ICES Headquarters, Copenhagen. ICES CM 2009/ACOM:10: 1028pp.

ICES-WGNSSK 2010. Report of the Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5 -11 May 2010, ICES Headquarters, Copenhagen. ICES CM 2010/ACOM:13: 1058pp.

ICES-WKREF 2007. Workshop on limit and target reference points [2007 report not yet available].

ICES-WGSAM 2008. Report of the Working Group on Multi Species Assessment Methods (WGSAM). ICES CM 2008/RMC:06

Kempf, A., Dingsør, G.E., Huse, G., Vinther, M., Floeter, J., and Temming, A. 2010. The importance of predator–prey overlap: predicting North Sea cod recovery with a multispecies assessment model. ICES Journal of Marine Science, 67: 1989–1997.

Lewy, P., and Nielsen, A. 2003. Modeling stochastic fish stock dynamics using Markov Chain Monte Carlo. ICES Journal of Marine Science 60:743--752.

Lewy, P., and Kristensen, K. 2009. Modelling the distribution of fish accounting for spatial correlation and overdispersion. Can. J. Fish. Aquat. Sci. 66: 1809-1820.

Macer, C.T. 1983. Changes in growth of North Sea cod and their effect on yield assessments. ICES CM 1983/G:8.

Metcalfe, J.D. 2006. Fish population structuring in the North Sea: understanding processes and mechanisms from studies of the movements of adults. Journal of Fish Biology 69 (Supplement C): 48-65.

Myers, R.A., Mertz, G., and Barrowman, N.J. 1995. Spatial scales of variability on cod recruitment in the North Atlantic. Canadian Journal of Fisheries and Aquatic Sciences, 52(9): 1849–1862.

Neat, F., and Righton, D. 2007. Warm water occupancy by North Sea cod. Proc. R. Soc. B. 274: 789-798.

O'Brien, C.M., Fox, C.J., Planque, B., and Casey, J. 2000. Climate variability and North Sea cod. Nature, 404: 142.

Oosthuizen, E., and Daan, N. 1974. Egg fecundity and maturity of North Sea cod, Gadus *morhua*. Netherlands Journal of Sea Research 8: 378–397.

Ottersen, G., Michalsen, K., and Nakken, O. 1998. Ambient temperature and distribution of north-east cod. ICES J. Mar. Sci. 55: 67–85.

Perry, A.L., Low, P.J., Ellis, J.R., and Reynolds, J.D. 2005. Climate Change and Distribution Shifts in Marine Fishes. Science, 308 (5730), 1912-1915.

Planque, B., and Fredou, T. 1999. Temperature and the recruitment of Atlantic cod (Gadus morhua). Canadian Journal of Fisheries and Aquatic Sciences 56: 2069-2077.

Righton, D., Quayle, V.A., Hetherington, S. and Burt, G. 2007. Movements and distribution of cod (*Gadus morhua*) in the southern North Sea and English Channel: results from conventional and electronic tagging experiments. J. Mar. Biol. Ass. U.K. 87: 599-613.

Righton, D., Quayle, V.[A.], Neat, F., Pedersen, M.[W.], Wright, P.[J.], Armstrong, M.[J.], Svedang, H., Hobson, V.J. and Metcalfe, J.D. 2008. Spatial dynamics of Atlantic cod (Gadus morhua) in the North Sea: results from a large-scale electronic tagging programme. ICES CM 2008/P:04: 32pp.

Rijnsdorp, A.D., Daan, N., van Beek, F.A. and Heessen, H.J. 1991. Reproductive variability in North Sea plaice, sole and cod. Journal du Conseil International Pour l'Exploration de la Mer. 47: 352-375.

Riley, J. D., and Parnell, W. G. 1984. The distribution of young cod. Flødevigen Rapportserie, 1: 563–580.

Rindorf, A. and Lewy, P. 2006 Warm, windy winters drive cod north and homing of spawners keeps them there. Journal of Applied Ecology, 43, 445-453.

Speirs, D.C., Guirey, E.J., Gurney, W.S.C., and Heath, M.R. 2010. A length-structured partial ecosystem model for cod in the North Sea. Fisheries Research, 106: 474–494.

STECF-SGRST-07-01. 2007. Evaluation of the report of the STECF-SGRST (07-01) Working Group on evaluation of the cod recovery plan, Hamburg 26-30 March, 2007.

Swain, D.P. 1999. Changes in the distribution of Atlantic cod (*Gadus morhua*) in the southern Gulf of St. Lawrence: effects of environmental change or change in environmental preferences? Fish. Oceanogr. 8: 1–17.

Wieland, K., E.M. Fenger Pedersen, H.J. Olesen & J.E. Beyer (2009): Effect of bottom type on catch rates of North Sea cod (Gadus morhua) in surveys with commercial fishing vessels. Fish. Res. ##: ###-###.

Table XXX.1 Variable natural mortality (M) values for North Sea cod, based on multi-species considerations. The seal diet data were originally collated from information sampled over a period of years (ICES 1997). Data were then transformed to diet by age using age-length keys. Finally this set of data was allocated to one year (1985). Due to the stock structure of cod in this particular year, with a relatively low abundance of age 6, the M2 for this age becomes higher than for both younger and older cod. It is considered that, for assessment purposes, the M2 values for age 6 should be replaced by the M2 values for age 5, as reflected here.

	1	2	3	4	5	6	7+
1963	0.78	0.42	0.33	0.22	0.21	0.21	0.20
1964	0.82	0.43	0.34	0.22	0.21	0.21	0.20
1965	0.85	0.44	0.35	0.22	0.21	0.21	0.20
1966	0.87	0.45	0.36	0.22	0.21	0.21	0.20
1967	0.89	0.46	0.37	0.22	0.21	0.21	0.20
1968	0.91	0.46	0.37	0.22	0.21	0.21	0.20
1969	0.92	0.47	0.38	0.22	0.21	0.21	0.20
1970	0.92	0.47	0.38	0.22	0.21	0.21	0.20
1971	0.92	0.47	0.38	0.22	0.21	0.21	0.20
1972	0.93	0.47	0.38	0.22	0.21	0.21	0.20
1973	0.92	0.46	0.38	0.22	0.21	0.21	0.20
1974	0.92	0.46	0.37	0.22	0.21	0.21	0.20
1975	0.92	0.45	0.37	0.22	0.21	0.21	0.20
1976	0.92	0.45	0.37	0.22	0.21	0.21	0.20
1977	0.92	0.44	0.36	0.22	0.22	0.22	0.20
1978	0.92	0.43	0.36	0.23	0.22	0.22	0.20
1979	0.92	0.43	0.36	0.23	0.22	0.22	0.20
1980	0.91	0.42	0.36	0.23	0.22	0.22	0.20
1981	0.90	0.41	0.36	0.23	0.22	0.22	0.20
1982	0.89	0.41	0.36	0.23	0.22	0.22	0.20
1983	0.87	0.40	0.36	0.23	0.22	0.22	0.20
1984	0.85	0.39	0.36	0.23	0.22	0.22	0.20
1985	0.83	0.38	0.36	0.23	0.23	0.23	0.20
1986	0.81	0.38	0.36	0.23	0.23	0.23	0.20
1987	0.79	0.37	0.36	0.24	0.23	0.23	0.20
1988	0.77	0.36	0.37	0.24	0.23	0.23	0.20
1989	0.75	0.35	0.37	0.24	0.24	0.24	0.20
1990	0.73	0.35	0.38	0.24	0.24	0.24	0.20
1991	0.72	0.34	0.39	0.25	0.24	0.24	0.20
1992	0.70	0.34	0.40	0.25	0.25	0.25	0.20
1993	0.70	0.34	0.41	0.26	0.25	0.25	0.20
1994	0.69	0.33	0.42	0.26	0.25	0.25	0.20
1995	0.68	0.33	0.43	0.26	0.26	0.26	0.20
1996	0.67	0.32	0.44	0.27	0.26	0.26	0.20
1997	0.65	0.31	0.44	0.27	0.26	0.26	0.20
1998	0.63	0.31	0.45	0.27	0.27	0.27	0.20
1999	0.61	0.30	0.45	0.27	0.27	0.27	0.20
2000	0.58	0.29	0.44	0.27	0.27	0.27	0.20
2001	0.56	0.29	0.44	0.27	0.27	0.27	0.20
2002	0.53	0.28	0.43	0.27	0.27	0.27	0.20
2003	0.51	0.28	0.42	0.27	0.27	0.27	0.20
2004	0.50	0.27	0.41	0.27	0.27	0.27	0.20
2005	0.49	0.27	0.40	0.26	0.26	0.26	0.20
2006	0.47	0.27	0.39	0.26	0.26	0.26	0.20
2007	0.46	0.26	0.38	0.26	0.26	0.26	0.20

Stock Annex Saithe in Subarea IV (North Sea)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)
Working Group:	WGNSSK
Date:	January 2012
Revised by:	WKBENCH/ Irene Huse

A General

A.1 Stock definition

The saithe stock is defined to be a single stock in ICES Subarea IV, Division IIIa and Subarea VI. The stock assessment is done accordingly.

A.3 Fishery

Saithe in Subarea IV, Division IIIa and Subarea VI (referred to here as *North sea saithe* for brevity) are mainly taken in a direct trawl fishery in deep water along the Northern Shelf edge and the Norwegian Trench. Norwegian, French, and German trawlers take the majority of the catches. In the first quarter of the year the fisheries are directed towards mature fish in spawning aggregations, while concentrations of immature fish (age 3-4) often are targeted during the rest of the year. A small proportion of the total catch is taken in a limited purse seine fishery along the west coast of Norway targeting juveniles (age 2-4). In the Norwegian coastal purse seine fishery inside the 4 nm limit (south of 62°N), the minimum landing size is 32 cm.

The main fishery developed in the beginning of the 1970s. The fishery in Subarea VI consists largely of a directed French, German, and Norwegian deep-water fishery operating on the shelf edge, and a Scottish fishery operating inshore. In recent years the French fishery has deployed less effort along the Norwegian Trench. There seems to have been a temporal change in the Norwegian fishery, and more of the effort is now in the 2nd quarter. The German fleet in the last few years has concentrated almost all of its effort in the shallow waters south of southern Norway. These changes may have changed the exploitation pattern in the fishery.

Since the fish are distributed inshore until they are about 3 years old, discarding of young fish is assumed to be a small problem in this fishery. However, low prices and mixed catches might lead to high grading. In trawler fleets that are targeting saithe, the quota is less limiting, and the problem may be less in these fleets. Norwegian legislation requires the Norwegian trawlers to move out of the area when the boat quotas are reached, and in addition, the fishery is closed if the seasonal quota is reached.

In 2009 the landings were estimated to be around 105 529 t in Subarea IV and Division IIIa, and 6963 t in Subarea VI, which both are well below the TACs for these areas (125 934 and 13 066 t respectively). Significant discards are observed only in Scottish trawlers. However, as Scottish discarding rates are not considered representative of the majority of the saithe fisheries, these have not been used in the assessment. Ages 1 and 2 are mainly distributed close to the shores and are very scarce in the main fishing areas for saithe.

Conservation schemes and technical conservation measures

Management of saithe is by TAC and technical measures. The available kw-days at sea for community vessels are restricted via the cod management plan (Council regulation 1342/2008). Only some vessels were exempted from these effort restrictions in 2009 due to low bycatch (<1.5%) of cod. In the Norwegian zone (south of 62°N) the current minimum landing size is 40 cm, while in the EU zone it is 35 cm. Discards are not allowed in the Norwegian zone. Minimum mesh size in the in the Norwegian zone is 120 mm for Norwegian trawlers, and 110 mm for community vessels.

A.4 Ecosystem aspects

The geographical distributions of juvenile (< age 3) and adult saithe differ. Typical for all saithe stocks are the inshore nursery grounds. Juvenile saithe in the North Sea are therefore mainly distributed along the west and south coast of Norway, the coast of Shetland and the coast of Scotland. At around age 3, the individuals gradually migrate from the coastal areas to the northern part of the North Sea (57°N - 62°N).

The age at first maturity is between 4 and 6 years, and spawning takes place in January-March at about 200 m depth along the Northern Shelf edge and the western edge of the Norwegian Trench. Larvae and post-larvae are widely distributed in Atlantic water masses across the northern part of the North Sea, and around May the 0-group appears along the coasts (of Norway, Shetland and Scotland). The mechanisms behind the 0-group's migration from oceanic to coastal areas remain unknown, but it seems like they are actively swimming towards the coasts. The west coast of Norway is probably the most important nursery ground for saithe in the North Sea.

When saithe exceeds 60-70 cm in length the diet changes from plankton (krill, copepods, fish larvae) to fish (mainly Norway pout, blue whiting, haddock and herring). Large saithe (>70 cm) have a highly migratory behaviour and the feeding migrations extend from far into the Norwegian Sea to the Norwegian coast.

Tagging experiments by various countries have shown that exchange takes place between all saithe stock components in the northeast Atlantic. In particular, exchange between the saithe stock north of 62°N (Northeast Arctic saithe) and saithe in the North Sea has been observed.

A sharp decline in the mean weight at age was observed from the mid-1990s, but now seems to be halted. There is insufficient information to establish whether this decline is linked to changes in the environment. The reduced growth rates have an effect on stock productivity and the consequences need to be further explored. However, there are no indications that the observed decline in weight at age is density dependent. The same reduction in growth rate is also observed for saithe in Faroese and Norwegian waters north of 62 °N (Figure 1).

The impact of a large saithe stock on prey species such as Norway pout and herring is unknown. Poor spatial and temporal sampling of stomach data of saithe makes the estimation of the saithe diet uncertain.

B Data

B.1 Commercial catch

Landings-at-age data by fleet are supplied by Denmark, Germany, France, Norway, UK (England), and UK (Scotland) for Subarea IV and only UK (Scotland) for Subarea VI.

In the data provided, landings from the industrial fleet are only specified when saithe is delivered separately, and therefore bycatch of saithe that has not been separated from the bulk catch will not be reported as saithe.

B.2 Biological

Weight at age

Weights at age in the landings are measured weights from the various national observer programs, reference fleet and market sampling programs. These weights are also used as stock weights. There has been a decreasing trend in mean weights from the mid-1990s for ages 4 and older, but the decline now seems to be halted.

Natural mortality

A natural mortality rate of 0.2 is used for all ages and years

Maturity

Following maturity ogive is used for all years:

Age	1	2	3	4	5	6	7+
Proportion mature	0.0	0.0	0.0	0.15	0.7	0.9	1.0

The maturity at age ogive was modelled during WKBENCH 2011, with age as a continuous variable and sampling year as an additional effect. The age at 50 % maturity has since 1992 varied between less than 4 (2001) to more than 7 years (1996), but the current, fixed maturity ogive could also not be rejected on statistical grounds

B.3 Surveys

3 Surveys are available:

- Norwegian acoustic survey, 1995-present (NORACU)
- IBTS quarter 3, age range: 1991-present (IBTS-Q3)
- Norwegian acoustic survey for saithe, 2006-present (NORASS)

The NORACU is an acoustic survey that since 2008 has been together with the IBTS Q3 and acoustic herring survey in the North Sea. The IBTS Q3 is coordinated by ICES, and is a bottom trawl survey for young fish in the North Sea. Both NORACU and IBTS Q3 shows a marked decline for saithe the last years (Figure 2). The NORASS is an acoustic survey covering part of the sea mountains at the coast of Norway south of 62 °N. This is the distribution area for young saithe at the east side before it migrates into the North Sea.

B.4 Commercial CPUE:

3 Commercial tuning series are available:

- French demersal trawl, age range: 3-9, year range 1990-present (“FRATRB”)

- German otter trawl, age range: 3-9, year range 1995- present (“GEROTB”)
- Norwegian bottom trawl, age range: 3-9, year range 1980- present (“NORTRL”)

  (Part 1 : 1980-1992, part 2 : 1993- present)

After the 2011 benchmark only age 6-9 are used from the commercial CPUE indexes. All the three commercial indexes are based on trawl data. The Norwegian fleet has in the latest years included some pelagic trawling. The spatial distribution of the catches from the German and Norwegian fleet shows some changes (Figure 3), and the geometric.

C Assessment: data and methods

Model used: XSA (Darby and Flatman, 1994
Software used: FLXSA (http://flr-project.org/OLD/doku.php?id=pkg:flxsa)

Model Options chosen: Max iterations: 75. From 2011: SOP correction.

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1967-present	3-10+	Yes
Canum	Catch at age in numbers	Variable, depending on country	3-10+	Yes
Weca	Weight at age in the commercial catch	Variable, depending on country		
West	Weight at age of the spawning stock at spawning time.	NA		
Mprop	Proportion of natural mortality before spawning	NA		
Fprop	Proportion of fishing mortality before spawning	NA		
Matprop	Proportion mature at age	See section B2 - maturity		No
Natmor	Natural mortality	See section B2 – Natural mortality		No

Tuning data:

Type	Name	Year range	Age range
FRATRB	French demersal trawl	1990-present	6-9
GEROTB	German otter trawl	1995- present	6-9
NORTRL	Norwegian bottom trawl	1980- present	6-9
NORACU	Norwegian acoustic survey	1995-present	3-6
IBTS-Q3	International bottom trawl survey in the North Sea, 3th quarter	1992-present	3-5
NORASS	Norwegian acoustic survey for saithe	2006-present	2-4

XSA settings:

Age range:	3-10+
Catch data:	1967-2010
Fbar:	3-6
Time series weights:	Tricubic over 20 years
Power model for ages:	No
Catchability plateau:	Age 7
Survivor est. shrunk towards the mean F:	5 years / 3 ages
S.e. of mean (F-shrinkage):	1.0
Min. s.e. of population estimates:	0.3
Prior weighting:	No
Number of iterations before convergence:	53 (in 2011)

D Short-term Projection

Because the assessment on which the advice is based is currently a fully deterministic XSA, the short term projection can normally be done in FLR using FLSTF. Weight-at-age in the stock and weight-at-age in the catch are taken to be the mean of the last 3 years. The exploitation pattern is taken to be the mean value of the last three years. Population numbers at ages 4 and older are XSA survivor estimates, numbers at age 3 are taken from the geometric mean for the years 1988 – assessment year.

Model used:

Software used: FLSTF (http://flr-project.org/OLD/doku.php?id=pkg:flstf)

Initial stock size: Population numbers at ages 4 and older are XSA survivor estimates, numbers at age 3 are taken from the geometric mean for the years 1988 – assessment year.

Maturity:

F and M before spawning:

Weight at age in the stock: Mean of the last 3 years

Weight at age in the catch: Mean of the last 3 years

Exploitation pattern: mean value of the last three years

Intermediate year assumptions:

E Medium-Term Projections

No medium-term projections are done for this stock.

F Long-Term Projections

No long- term projections are done for this stock.

G Biological Reference Points

	Type	Value	Technical basis
MSY 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, 1992 onwards)	no change	Uncertain, no Norwegian effort	IBTS Q3 (age: 3-5, 1992 onwards)
				NORASS (age: 3-4, 2006 onwards)
Age range:	3-10+	no change		no change
Catch data:	1967-2007	1967-2008	1967-2009	1967-2010
Fbar:	3-6	no change		no change
Time series weights:	Tricubic over 20 years	no change		no change
Power model for ages:	No	no change		no change
Catchability plateau:	Age 7	no change		no change
Survivor est. shrunk towards the mean F:	5 years / 3 ages	no change		no change
S.e. of mean (F-shrinkage):	1.0	no change		no change
Min. s.e. of population estimates:	0.3	no change		no change
Prior weighting:	No	no change		no change
Number of iterations before convergence:	47	47	No assessment was done	53

I. References

Darby, C. D and S. Flatman. 1994. Lowestoft VPA Suite Version 3.1. User Guide. MAFF: Lowestoft.

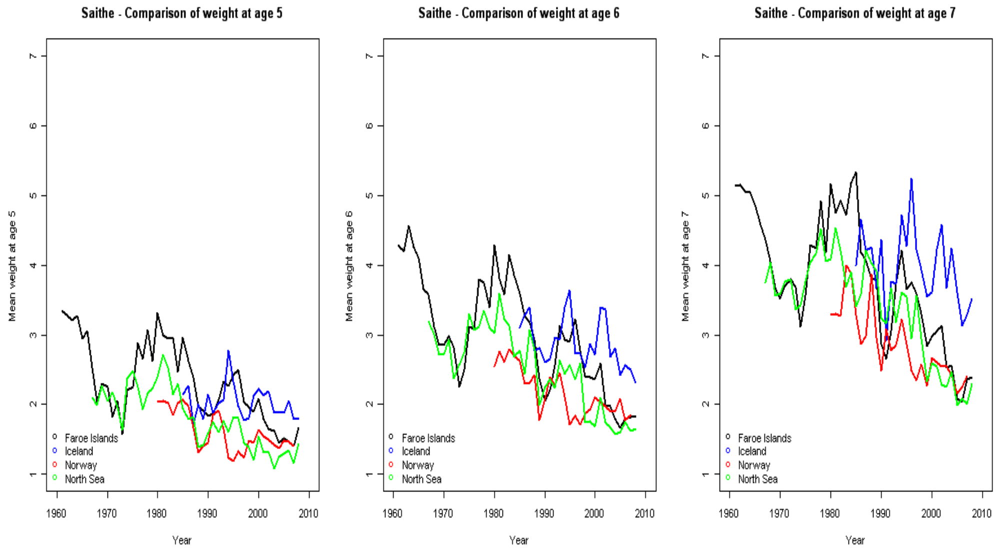


Figure 1. Weight at age by stock: The reduction of weight at age seems to be of importance for three out of four stocks, while one (Icelandic) does not show the same decline. (i Homrum, E. 2011, in prep).

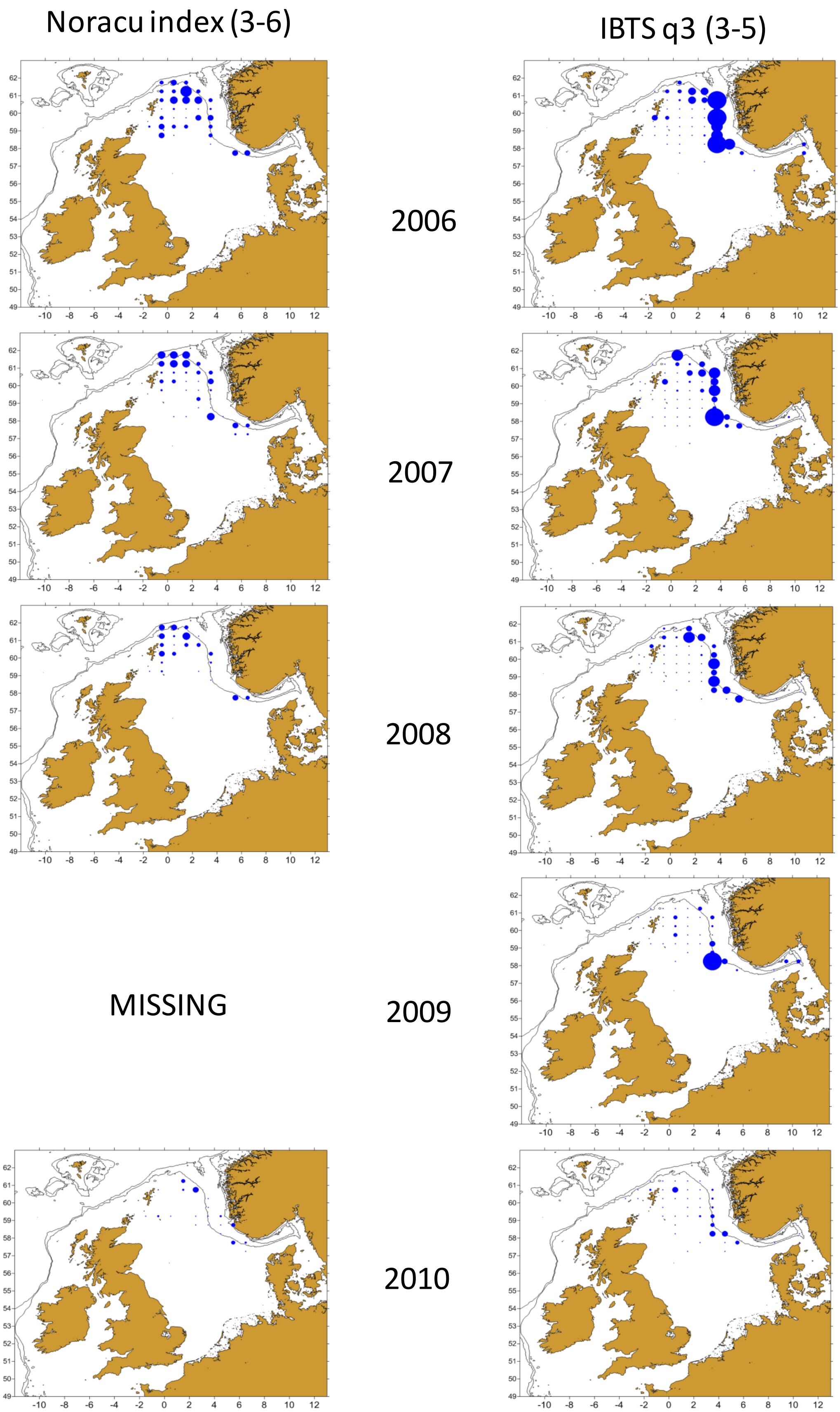


Figure 2. NORACU (left column) and IBTS Q3 (right column) indexes from 2006 to 2010

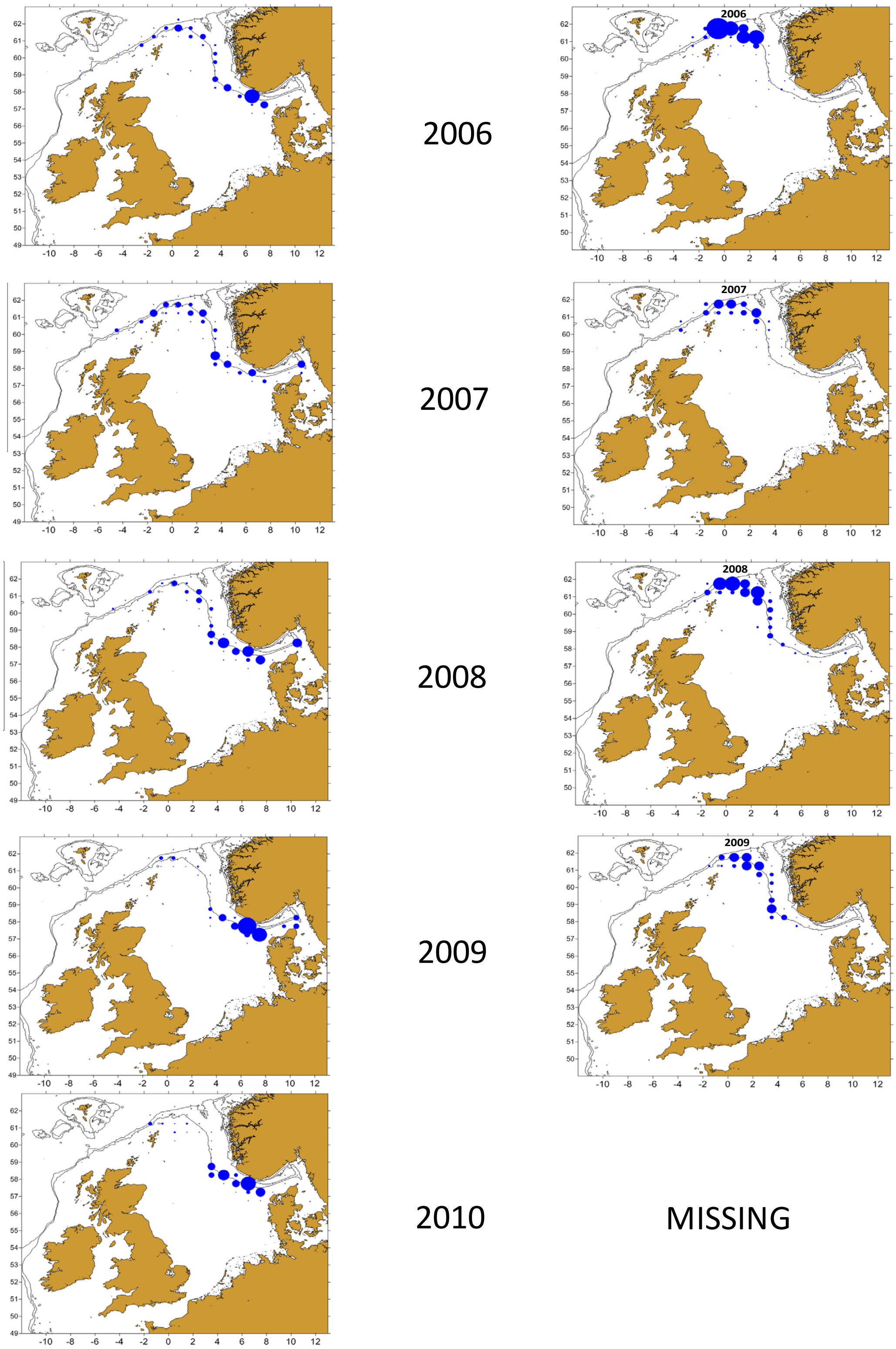


Figure 3. Spatial distribution of the catches for the GEROTR (left column) and NORTRL (right column) indexes from 2006 to 2010.

Stock Annex–Sandeel in IV

Quality Handbook Annex__SAN-NSEA

Stock-specific documentation of standard assessment procedures used by ICES

Working Group	North Sea Demersal Working Group
Updated	09/09/2010 Steen Christensen (sc@aqua.dtu.dk)

General

Stock definition

For assessment purposes, the European continental shelf was divided into four regions for sandeel assessment purposes up to 1995: Division IIIa (Skagerrak), northern North Sea, southern North Sea, and Shetland Islands and Division VIa. These divisions were based on regional differences in growth rate and evidence for a limited movement of adults between divisions (e.g. ICES CM 1977/F:7, ICES CM 1991/Assess:14.). The two North Sea divisions were revised in 1995, and it was decided to amalgamate the two stocks into a single stock unit with two fleets, one fleet in the northern North Sea and one in the southern North Sea. The Shetland sandeel stock was assessed separately. ICES assessments used these stock definitions from 2005 to 2009.

However, larval drift models (Proctor *et al.*, 1998; Christensen *et al.*, 2007, 2008 and 2009) and studies on growth differences (e.g. Boulcott *et al.*, 2007) indicate that the assumption is invalid and that the total stock is divided in several sub-populations as first proposed by Wright *et al*. (1998). On the basis of the latest information ICES (ICES CM 2009\ACOM:51) suggested that the North Sea should be divided into six sandeel assessment areas as indicated in Figure 4.2. ICES assessment used these stock definitions from 2010 onwards (ICES 2010, (WKSAN 2010)).

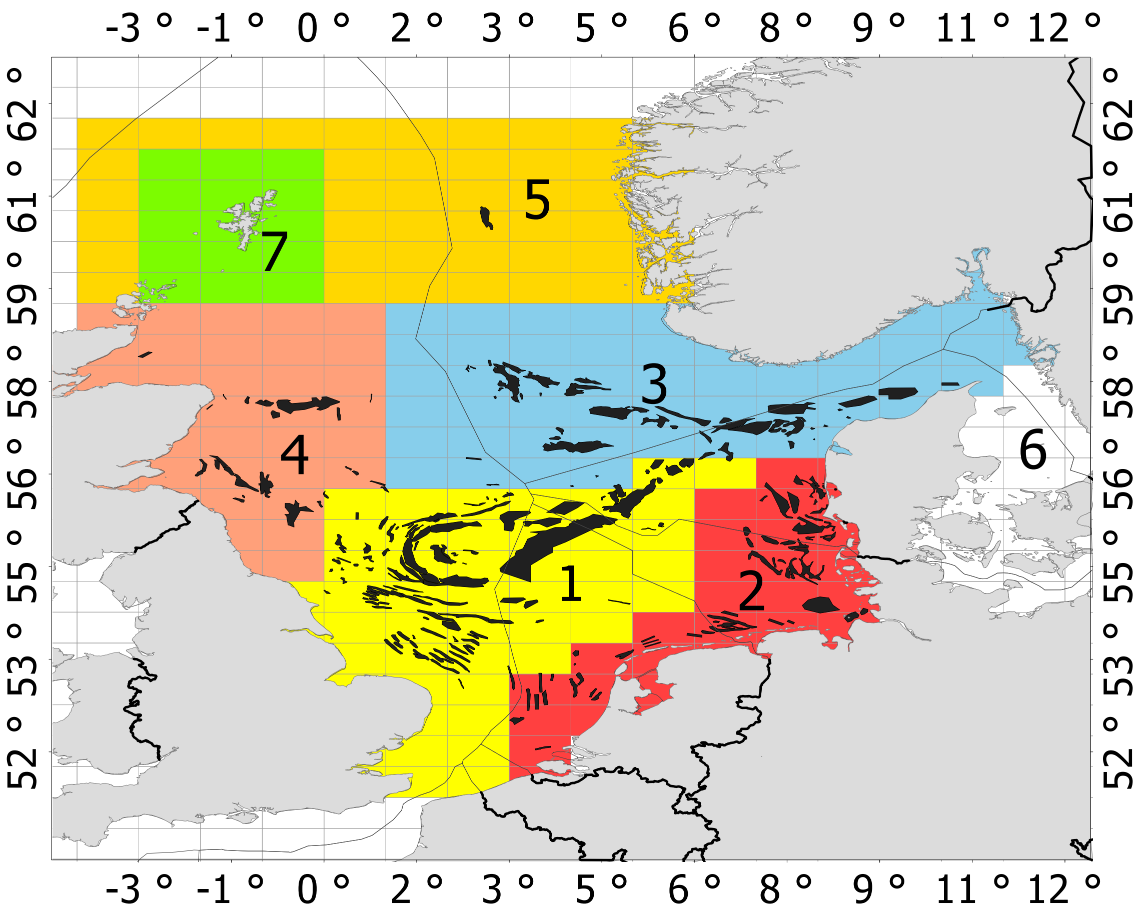


Figure 4. 2. Sandeel fishing banks (black areas), EEZ borders, and assessment areas: eastern area (red), northern area (blue), southern area (yellow), western area (dark orange), Shetland area (green) and Viking bank area (light orange).

Fishery

Technical measures for the sandeel fishery include a minimum percentage of the target species at 95% for meshes <16 mm, or a minimum of 90% target species and maximum 5% of the mixture of cod, haddock, and saithe for 16 to 31 mm meshes.

Most of the sandeel catch consists of the lesser sandeel *Ammodytes marinus*, although small quantities of other *Ammodytoidei* spp. are caught as well. There is little bycatch of protected species (ICES WGNSSK 2004).

The fishery is seasonal. The geographical distribution of the sandeel fishery varies seasonally and annually, taking place mostly in the spring and summer. In the third quarter of the year the distribution of catches generally changes from a dominance of the west Dogger Bank area back to the more easterly fishing grounds.

The sandeel fishery developed during the 1970s, and landings peaked in 1999 with 1.2 million tons. There was a significant shift in landings in 2003. The average landings of the period 1994 to 2002 was 880 000 tons whereas the average landings of the period 2003 to 2009 was 288 000 tons.

As indicated in Figure 3.2, Denmark is the main contributor to the sandeel landings. Up to 2002 Denmark in average contributed 73% of the total landings and after 2002 83%.

Figure 3.3 indicates the sandeel landings by assessment area (Figure 3.1). The Figure indicates that in average 84% of the total landings came from the areas 1 and 3 in the period 1994 to 2009. However, there has been a significant shift in the relative contribution of the two areas over the period. Up to 2002 area 1 and 3 contributed 46 and 37% respectively whereas their contributions were 65 and 20% in the period 2003 to 2009.

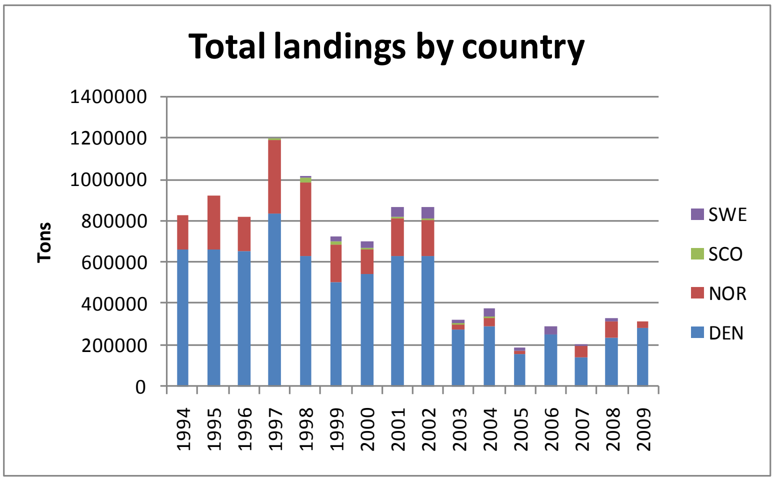


Figure 3.2.

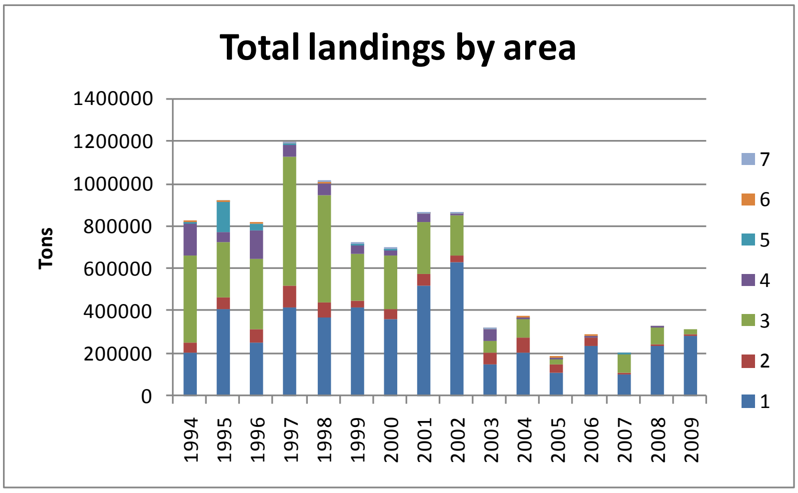


Figure 3.3.

The third most important area for the sandeel fishery is area 2. In the period 2003 to 2009 landings from this area contributed 12% of the total landings in average. The contribution of area 2 over the entire period is 9% in average.

Area 4 has contributed about 6% of the total landings since 1994 but there has been a few outstanding years with particular high landings (1994, 1996 and 2003 contributing 19, 17 and 20% of the total landings respectively). In the periods 1994 to 2002 and 2003 to 2009 the average contributions from area 4 was 8 and 3% respectively. There has been a moratorium on sandeel fisheries on Firth of Forth area along the U.K. coast since 2000.

The spatial distribution of sandeel landings is considered as a good representation of stock distribution, except for areas where severe restrictions on fishing effort is applied (i.e. the Firth of Forth, Shetland areas, and Norwegian EEZ in 2006 and 2009). Up to 2002 and particularly prior to 1998, most landings of sandeels in March were taken from the eastern North Sea banks whilst sandeel landings in April–June were mainly from the west Dogger Bank. In some years a relatively large part of the sandeel landings are taken from the central and eastern North Sea along the Danish west coast. From 1991, grounds off the Scottish east coast have been targeted particularly in June. However, since 2000 the banks in the Firth of Forth area have been closed to fishing.

In the Northern North Sea, mainly NEEZ, the change in the spatial pattern was significantly different from southern part. The highest landings from a single statistical square were taken in 1995 on the Vikingbank, the most northerly fishing ground for sandeel in the North Sea. However, in 1996 landings from the Vikingbank dropped substantially, and since 1997 have been close to nil. The marked reduction in landings around 2000 in NEEZ was accompanied by a marked contraction of the fishery to a small area in the southern part of NEEZ, the Vestbank area. In this area landings remained high in 2001 and 2002 due to the strong 2001 year class. However, the 2001 year-class was only abundant in the Vestbank area, which resulted in a highly concentrated fishery and the decimation of the year-class before it reached maturity in 2003. This may have led to the collapse of the sandeel fishery in NEEZ. In the EU EEZ any contraction of the fishery has been less apparent.

The sandeel fishing season was unusual short in both 2005 and 2006, starting later and ending earlier than in previous years. The late start of the fishery was partly because the Danish fishery first opened the 1st April, in accordance with a national regulation introduced in 2005. Further, weekly data on the oil content of sandeels in the commercial landings, provided by Danish fish meal factories, indicated a late onset of sandeels feeding season in both 2005 and 2006 and that sandeels therefore became available to the fishery later than usual. Landings in the second half year of both 2005 and 2006 were on a low level compared to previous years. Only 14 000 tonnes were recorded in 2005 and 17 000 tonnes in 2006.

There has been a significant reduction in fishing effort in the sandeel fishery in recent years (Figure 3.4 and 3.5).

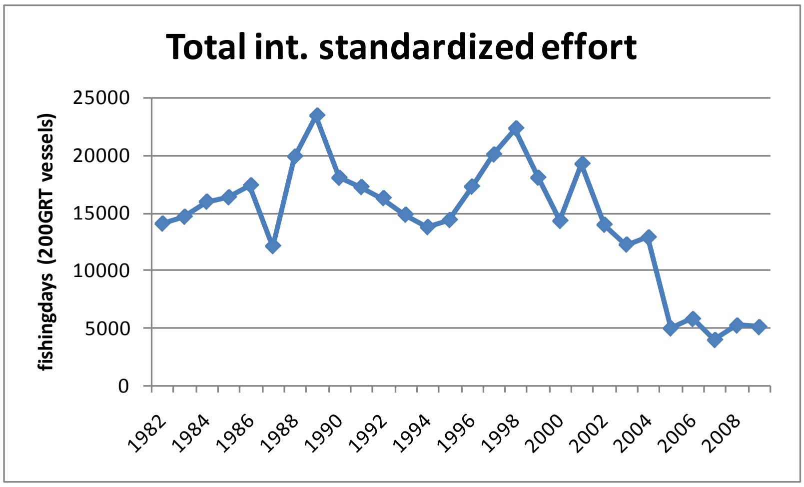


Figure 3.4.

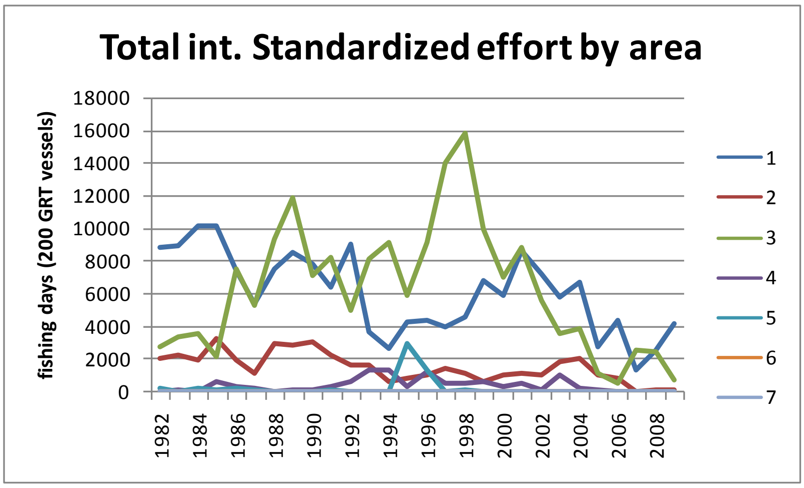


Figure 3.5.

The number of Danish vessels fishing sandeel declined about 50% (from 200 to 84 vessels) from 2004 to 2009. The introduction of an ITQ system in Denmark in 2007 is considered to have contributed to further reducing the fleet capacity and accelerating a change towards fewer and larger vessels. In addition, in 2008, when the TAC was not reached, high fuel prices and low prices of fish meal were claimed by the industry to have limited the fishery.

Also for the Norwegian fleet a drastic decline in number of vessels fishing sandeels has been observed in recent years. Of the 41 Norwegian vessels that fished sandeel in 2007, nine participated for the first time. Since 1998 25 of the 41 vessels entered the fishery during this ten year period, nine vessels were rebuilt (either extended or had larger engines installed) whereas only seven vessels remained unaltered. In addition, there is likely to be a continuous increase in efficiency due to improvement in fishing gear, instruments, etc.

Ecosystem aspects

Sandeels are small, short-lived, lipid-rich, shoaling fish. As such, they represent high quality food for many predatory fish, seabirds and marine mammals (Greenstreet *et al*., 1997, 1998; Brown *et al*., 2001; Stafford *et al*., 2006; Macleod *et al*., 2007; Daunt *et al*., 2008). They are especially important in the diet of top predators during the summer, as sandeels then spend much time feeding during the day on zooplankton but burying in the sand at night (Freeman *et al*., 2004; Engelhard *et al*., 2008; Greenstreet *et al*., 2010). At other times of year they mainly remain buried in the sand, where they are inaccessible to many predators such as surface-feeding seabirds, though they continue to be eaten by some predatory fish, seals, and diving seabirds which apparently can dig them out of the sand (Hammond *et al*., 1994). Although the larvae drift with currents, and following metamorphosis may select on a local scale where to settle on the basis of sediment composition, they do not show extensive horizontal movements after that life-history stage (Gauld, 1990; Wright, 1996; Pedersen *et al*., 1999; Christensen *et al*., 2008, Jensen *et al*., in press).

Top-down effects on sandeels

Demonstrating top-down effects of predators on sandeel stocks is difficult as it is not amenable to experimentation, but relies on detection of correlations; due to different spatial distributions of key predators it is also quite likely that the relative strength of top-down versus bottom-up control of sandeel abundance may vary between different parts of the North Sea (Frederiksen *et al*., 2007). However, we can assess the likelihood of such top-down effects from information on the amounts of sandeel consumed by different predators; it is unlikely that predators taking only small amounts of sandeel would exert significant top-down effects. Predation rates of seabirds and marine mammals on sandeels are trivial by comparison with predation rates by large fish, as shown by the MSVPA analysis. There is no evidence for depletion of sandeels by seabirds or marine mammals, even locally at major breeding colonies. However, some predatory fish consume very large amounts of sandeels. There is evidence that sandeel stocks increased in abundance in the North Sea following major reductions in the stocks of cod, haddock, whiting, herring, and mackerel, apparently a top-down effect resulting from reduced predation by these fish (Sherman *et al*., 1981).

Bottom-up effects on sandeels

There is strong evidence that sandeel stocks are affected by bottom-up processes involving climate and changing plankton stocks. A study of early larval survival suggested that the match between hatching and the onset of zooplankton production may be an important contributory factor to year-class variability in this species (Wright and Bailey, 1996). Frederiksen *et al*. (2005) used Continuous Plankton Recorder (CPR) data to develop an index of sandeel larval abundance for the Firth of Forth area. The sandeel larval index was strongly positively related to the abundance of phyto- and zooplankton, suggesting strong bottom-up control of sandeel larval survival (Frederiksen *et al*., 2005). Van Deurs *et al*. (2009) showed for the "North Sea sandeel" in ICES area IV 1983–2006 (with anomalous data from 1996 excluded) that a positive spawning stock–recruitment relationship is decoupled in years associated with high abundances of age-1 sandeels, and that survival success of early larvae depends on the abundance of *Calanus finmarchicus* but not *C. helgolandicus* or total Calanus density (again measured by CPR). They postulated that 0-group sandeels compete with older sandeels for copepods and so recruitment is reduced by the presence of high abundance of older (normally predominantly 1-group) sandeels. This conclusion contradicts an earlier finding by Arnott and Ruxton (2002) who studied the same sandeel area but for 1983–1999 only, and found a significant positive relationship between sandeel recruitment and total Calanus density over that time period. It is suggested by Van Deurs *et al.* (2009) that this changed pattern of correlation reflects coincidence of the switch in Calanus species at the same time as a run of poor recruitment years of sandeels after 1999. Van der Kooij *et al*. (2008) showed that sandeel distribution and abundance on the Dogger Bank was best explained by seabed substrate, temperature and salinity. However, contrary to the authors' expectation, their data showed that sandeel local abundance was not strongly related to zooplankton local density.

Top-down effects of sandeels on zooplankton

There appears to be no information on sandeels depleting zooplankton densities over their grounds.

Bottom-up effects of sandeels on higher predators: seabirds

Seabirds are long-lived animals with a low reproductive output. Life-history theory predicts that seabirds should buffer their adult survival rates against fluctuations in their food supply (Boyd *et al*., 2006), and since food-fish are short-lived animals with high but also variable recruitment rates (Jennings *et al*., 2001), it is inevitable that seabirds will experience large changes in the abundance of the food fish on which they depend. They must, therefore, have evolved the ability to cope with variation in food abundance. The literature indicates that, seabird breeding success does show a close correlation with food fish abundance (Furness and Tasker, 2000; Rindorf *et al*., 2000; Davis *et al*., 2005; Frederiksen *et al*., 2005), whereas breeding numbers and adult survival may not track these short-term fluctuations (Boyd *et al*., 2006). Nevertheless, several recent studies do show a trade-off between adult survival rate (Frederiksen *et al*., 2008b) and reproductive performance, as a result of adults increasing investment when food supply declines and so incurring costs (e.g. Davis *et al*., 2005). But variation in breeding success is much greater, and easier to measure, and so is likely to provide a much clearer signal of food shortage (Furness, 2002; Mitchell *et al*., 2004; Mavor *et al*., 2006).

Most species of seabirds in the North Sea suffered delayed breeding and widespread reproductive failures in 2003, 2004, 2005 and 2006 (Frederiksen *et al*., 2004; Mavor *et al*., 2005, 2006, 2007; Reed *et al*., 2006). The most severe problems, including total failures of some species, occurred in Shetland and Orkney in the northernmost part of the North Sea. Although bad weather during the chick-rearing period was partly to blame at some colonies, the main proximate cause of the breeding failures was a lack of high-quality food (Davis *et al*., 2005; Wanless *et al*., 2005). Most seabirds in the North Sea feed mainly on sandeels during the breeding season (Wanless *et al*., 1998; Furness and Tasker, 2000; Furness, 2002). Since the 1970s, sandeels have been the dominant mid-trophic pelagic fish in the North Sea, and around Shetland no other high-lipid prey fish occur in sufficient numbers to support successful breeding of most piscivorous seabirds (Furness and Tasker, 2000). There is thus little doubt that the observed seabird breeding failures were linked to low availability of sandeel prey (Frederiksen *et al*., 2004).

Furness and Tasker (2000) reviewed the ecological characteristics of seabirds in the North Sea and ranked species from highly sensitive (e.g. terns, kittiwake, Arctic skua) to insensitive (e.g. northern gannet) to reductions in sandeel abundance. They argued that the most sensitive seabirds would be those with high foraging costs, little ability to dive below the sea surface, little ‘spare’ time in their daily activity budget, short foraging range from the breeding site, and little ability to switch diet. This prediction was supported by empirical data from studies at Shetland (Furness and Tasker, 2000; Poloczanska *et al*., 2004) and at the Isle of May, east Scotland (Frederiksen *et al*., 2004). As one example, Figure 3.1a shows breeding success of kittiwakes on the Isle of May during years of sandeel fishing in the area and in years without sandeel fishing. Breeding success of kittiwakes in both periods varied with sea surface temperature, but was considerably lower when there was a sandeel fishery in the area where these birds were foraging. In Shetland, breeding success of kittiwakes and Arctic skuas (Figure 3.1b) shows very low success during periods of low Shetland sandeel stock biomass (late 1980s and 2000 onwards). Arctic skuas in Shetland feed almost exclusively on sandeels, although they obtain these by stealing them from terns, kittiwakes and auks, and so the link between their breeding success and sandeel stock size is indirect (Davis *et al*., 2005). We can estimate the amount of sandeels consumed by Arctic skuas from data on the numbers and energy requirements of these birds. The annual consumption of sandeels by Arctic skuas at Shetland in the period 1980–2000 is estimated to have been around 65 tonnes per year. This contrasts strongly with the observation that Arctic skua breeding success at Shetland fell to less than half of the level seen in years of high sandeel abundance when the sandeel stock biomass was below about 30 000 tonnes. The data indicate that Arctic skuas require a sandeel stock biomass about 460 times greater than the amount that they consume, in order to be able to gain energy at a rate sufficient to sustain a good level of breeding success. This seems to be the extreme case, with much lower ratios for kittiwake and even lower for guillemots. Throughout this period, breeding success of gannets remained consistently high in Shetland as those birds were able to switch to feed on adult herring and mackerel, fish too large to be caught (or swallowed) by kittiwakes or Arctic skuas.

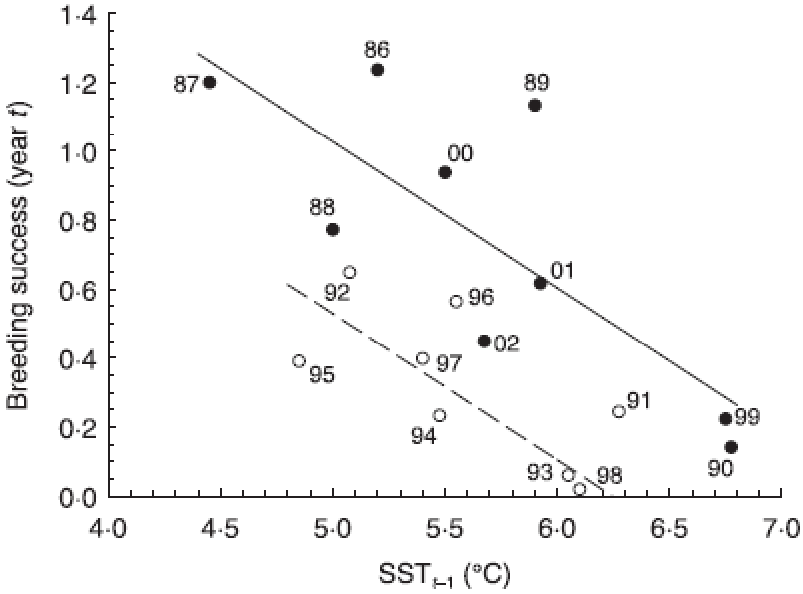


Figure 3.1a. Kittiwake breeding success as a function of local SST in February–March of the previous year and presence/absence of the Wee Bankie sandeel fishery. Data labels indicate current year. Regression lines estimated from weighted multiple regression. Filled circles and solid line, non-fishery years; open symbols and dashed line, fishery years. From Frederiksen *et al.*, 2004.

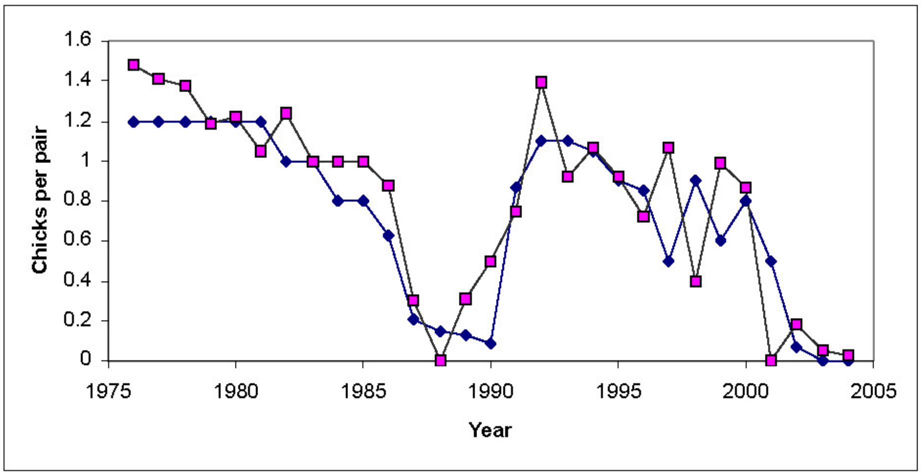


Figure 3.1b. Breeding success of black-legged kittiwakes (pink) and Arctic skuas (blue) at Foula, Shetland, during 1976–2004, showing a close correlation between the success of the two species in this time-series, and periods of particularly low success in 1987–1990 and in 2001–2004.

In 2004, breeding success was exceptionally low for most seabird species on the Isle of May, despite sandeel larvae being abundant in the spring of 2003 so this low breeding success was unexpected. Detailed studies showed that the energy content of both sandeels and sprat fed to seabird chicks in 2004 was extremely low, indicating poor food availability for the fish (Wanless *et al.*, 2005). Data from chick-feeding puffins and CPR samples also indicate that the size-at-date of both larval, 0 group and older sandeels has declined substantially since 1973, although it is unclear what the cause of this decline might be (Wanless *et al.*, 2004). There is thus evidence that both abundance and quality of seabird prey is under bottom-up control in this region, and this is likely to have affected seabird breeding success.

Bottom-up effects of sandeels on higher predators: fish

Sandeel is an important prey species for a range of natural predators (Hislop *et al.*, 1991; WGSAM 2008). Of these, the species most likely to be affected are the species for which the sandeel make up a large proportion of the diet. In the North Sea, this would include whiting, haddock, mackerel, starry ray and grey gurnard (Figure 3.3b). These species all have a diet composition consisting of at least 10% sandeel. However, the proportion only exceeds 20% in the diets of western mackerel and starry ray. Of these two, the diet of western mackerel refers only to the time they spend in the North Sea, and hence the overall average percentage is likely to be lower.

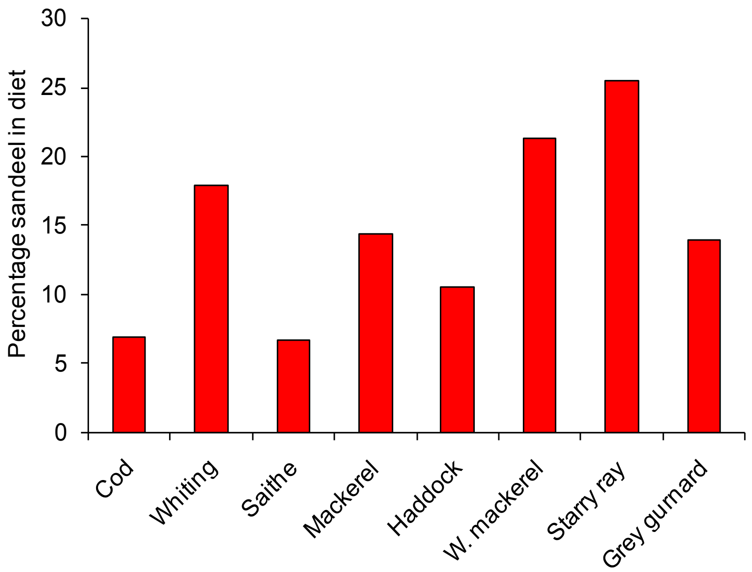


Figure 3.3b. Proportion of the diet consisting of sandeel for different predatory fish (ICES 1997).

Whiting might also be affected by a decline in sandeel availability. However they might also switch prey to consume greater quantities of herring and sprat, since populations of these species have increased in recent years, as has the apparent spatial overlap between whiting and sprat distributions. Two sources of recent data are available to test this hypothesis, from research carried out in the Firth of Forth region as part of the EU FP6 IMPRESS project (1997–2003), and from research carried out on western Dogger Bank ('MF0323' project; 2004–2006).

Three gadoid populations (cod haddock, whiting) were sampled at 19 evenly spaced stations in the Firth of Forth (including Wee Bankie and Marr Bank) on seven research cruises. The contribution of sandeels to the diet of the three gadoid predators varied markedly from year to year, although the importance of sandeels in particular years was consistent across all three species. No evidence of any beneficial effect of the local sandeel fishery closure in 2000 on the abundance or biomass of any of the three gadoid predators was apparent, however, there was evidence that fish condition was greater in years when the proportion of sandeel prey in the diet of each predator was higher (Figure 3.3c; see also Greenstreet 2006).

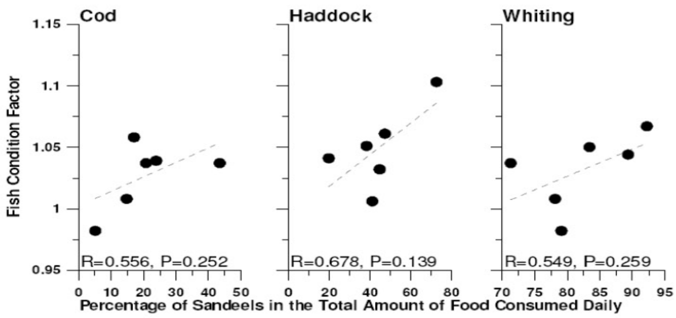


Figure 3.3c. Relationship between the body condition of gadoid predators in the Firth of Forth, and the quantity of sandeels consumed (from Greenstreet *et al.*, 2006).

Between 2004 and 2006, CEFAS conducted investigations into sandeels and their predators on the Dogger Bank ('MF0323' project). Two survey grids were sampled each containing 48 stations, the grids were separated by 28 km. The northernmost survey grid ('grid 1'), on an area known as the 'North-West Riff', was characterised as having high sandeel abundance and was an important area for the sandeel fishing fleet. The southernmost grid ('grid 2') on an area known as 'The Hills' was characterised by much lower sandeel abundance, and was less important to the sandeel fishery. Predator stomachs (mostly whiting, plaice, lesser weeverfish, grey gurnard, haddock, and mackerel) were sampled on six research cruises. The diets of all species were found to vary markedly and consistently between the two sampling grids (Pinnegar *et al.*, 2006). Sandeels were much more important to predators (especially whiting and lesser weeverfish) at grid 1, and this coincides with the greater abundance of sandeels at grid 1, as determined by dredge survey during the night.

Clear seasonal differences were observed in predator diets for all species. Diets were much more diverse during autumn as compared to those in spring. Whiting ate substantially more crabs and sprat during the autumn period as well as hyperid amphipods, and much less sandeel at both sampling grids. Sandeels bury themselves in the sediment during autumn and winter months and are thus less accessible to predators, even though they were more abundant in real terms than was the case during the spring. Preliminary analyses (G. Engelhard, unpublished data) suggest that for some predators, most notably lesser weeverfish *Echiichthys vipera*, body 'condition' was slightly better at the high-sandeel site (grid 1) compared to the low-sandeel site (grid 2). An examination of interannual variability in fish body condition revealed that plaice and weever condition was better in sandeel-rich years and at the sandeel-rich survey grid. Whiting and haddock condition was better in sandeel-rich years, but no site difference was apparent in these mobile species which forage over a large area. Grey gurnard and greater sandeel (*Hyperoplus lanceolatus*) condition appeared not to be significantly linked to sandeel numbers, but positively linked to per-capita sandeel consumption (condition was better when more sandeels were observed to have been consumed). Thus it was concluded that various predatory fish species do have better condition in years/sites where sandeels are more abundant. In a parallel study carried out in August and October 2006, whiting were sampled aboard commercial fishing vessels all along the North East coast of England (from Flamborough to the Firth of Forth, including the Dogger Bank). It was noted by the crew that the fish caught over areas of hard ground with empty stomachs during the August survey were very thin and of poor condition (Stafford *et al*., 2006). Where stomachs were not empty, the main contents were small crustaceans in August and fish in October. Fish consumed were often non-commercial prey species such as pipefish or hagfish, although gadoids and clupeoids were also consumed. The data show changes from the 1981 and 1991 ICES 'year of the stomach' sampling exercises, when far more sandeel and clupeoids and far less crustaceans were consumed. The authors of this study (Stafford *et al*., 2006) speculate that the limited availability of sandeels in 2006 may have been responsible for the poor body condition of the fish in that year and the selection of nutritionally poor prey items such as snake pipefish.

Other impacts on sandeels

Hassel *et al*. (2004) showed that seismic shooting can kill sandeels, and may impact commercial catches on banks where seismic shooting is occurring. There are concerns that marine wind farms could possibly affect sandeels by altering sediment around turbines and possibly by noise/vibrations. Van Deurs *et al*. (2008) reported that they found no adverse effects of beam trawling on sandeels where beam trawling was carried out over sandeel grounds.

Implications for ecosystem-based management

Due to the stationary habit of post-settled sandeels, a patchy distribution of the sandeel habitat (Holland *et al*., 2005), and a limited interchange of the planktonic stages between the spawning areas, the sandeel stock in IV consists of a number of sub-populations (Pedersen *et al*., 1999; Christensen *et al*., 2008). Within these sub-populations, fishing for sandeels may deplete numbers on particular banks. Recent evidence indicates that although closures can lead to rapid recovery of sandeel numbers in some cases (Greenstreet *et al*., 2010), in others, banks may not be recolonised for some years. Although hydrographical features and the general distribution pattern of the sandeel spawning populations are responsible for most of the variation in recolonisation (Christensen *et al*., 2008), possibly some of the variation in recolonisation of banks after depletion may reflect habitat preferences of sandeels that are seeking sites to settle, with optimal substrate being more attractive (Wright *et al*., 2000). This pattern may also result from some local movement of settled sandeels between adjacent but especially within banks from poorer habitat to preferred habitat (Jensen *et al*., in press). There was evidence for such relocation in Shetland, for example, where high fishery catches continued to be taken from Mousa even when all surrounding banks had become depleted, and breeding success of seabirds such as terns and kittiwakes had fallen close to zero due to shortages of sandeels around most of Shetland. Predators dependent on sandeels (such as kittiwakes) may therefore be adversely affected by local or regional depletion of sandeels. Serial depletion of banks in an area seems to be a particular risk. There is a need for sandeel stock assessment and management to take these risks into account. Exact local densities of sandeels needed to sustain healthy populations of predators are not known, and no doubt vary according to a range of ecological conditions and predator communities. But research has shown that certain top predators show particularly strong responses to depletion of sandeels. In particular, kittiwake breeding success tends to correlate strongly with abundance of sandeels over about a 50 km foraging radius around kittiwake colonies. In regions where kittiwakes feed predominantly on sandeels while breeding, which is the case in the North Sea, poor breeding success of these "indicator" seabirds can be used as evidence that the local stock of sandeels is depleted. Such evidence is less direct than can be obtained from dredge or acoustic surveys, but may help to identify problem areas where sandeel aggregations need to be allowed to recover. Sandeel stock assessments and subsequent management should also aim to avoid depletion of stocks to levels where damage to ecosystems becomes evident through its impact on dependent predators. Though the actual level at which these adverse effects occur is presently unknown in most cases, it is clear that a stock below the level where recruitment is impaired will significantly increase the probability of effects on top predators and is hence highly unlikely to be compatible with an ecosystem approach to fisheries.

Northeast UK closure

Due to their importance in North Sea food webs, ICES has advised that management should ensure that sandeel abundance be maintained high enough to provide food for a variety of predator species. During the early 1990s a sandeel fishery developed in Area 4, off the Firth of Forth. The landings from this fishery peaked at over 100 000 t in 1993 and then subsequently fell. The Firth of Forth area is important for breeding seabirds and the removal of such large quantities of sandeels within their foraging range soon became a matter of concern. In 1999, the UK called for a moratorium on sandeel fishing adjacent to seabird colonies along the UK coast and in response the EU requested advice from ICES. An ICES Study Group was convened in 1999 in response to this request with two terms of reference (ICES 1999):

l) assess whether removal of sandeel by fisheries has a measurable effect on sandeel predators such as seabirds, marine mammals, and other fish species;

m) 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 kittiwake breeding success as a harvest control threshold. A three year closure, from 2000 to 2002, was decided and the Commission was requested to produce annual reports to the Council on the effects of the restrictions in the sandeel fishery in the Firth of Forth area. On the basis of the second of these reports (Wright *et al*., 2001) and uncertainty over the impact of the closure the commission proposed a further three year extension of the closure. The wording of the Act is stated in article 29a of: "Council Regulation (EC) no 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms". A further scientific review of the closure was made by STECF in 2007, together with other EU fishery closures. That group proposed that it would be prudent to wait for enhanced recruitment and productivity in the area before any re-opening is considered.

Evaluating changes in sandeel abundance in the region has been difficult due to the lack of a single reliable sampling method for assessing sandeel abundance. Nevertheless, the various research (acoustic, trawl and dredge) and commercial abundance indices suggested an initial increase in sandeel abundance during the period of the closure (Greenstreet *et al*., 2006). This increase began with a relatively large recruitment in the first year of the closure, which would not have been related to any recovery in the spawning stock. Dredge surveys in 1999 and 2000 indicated a detectable decrease on total mortality on 1+ sandeels following the closure. A further indication that sandeel abundance increased in the region came from the observation that in 2003, when landings in the North Sea as whole had severely declined, 39 060 tonnes were taken in the ICES rectangle adjacent to the closed area near Marr and Berwick banks.

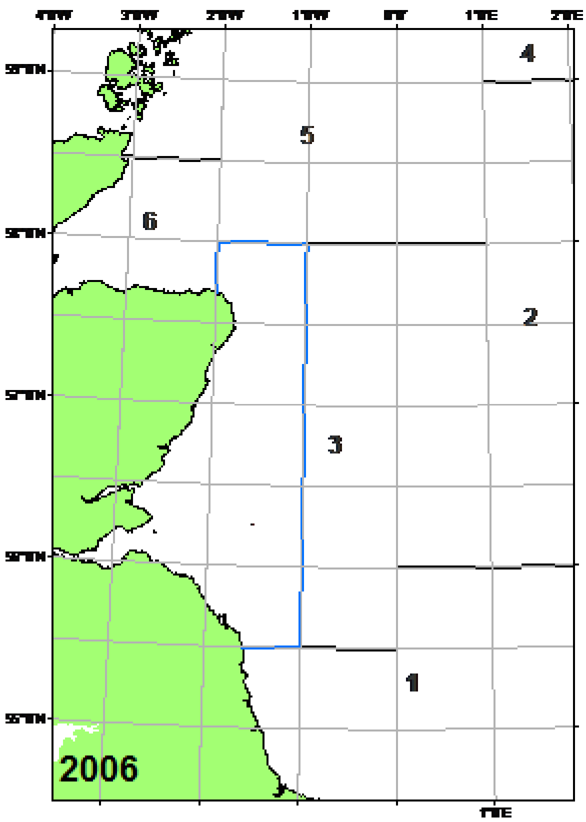


Figure 4. Chart showing the closed area (blue line).

Kittiwake breeding success has tended to be higher since the fishery closure than in the preceding five years. However, poor breeding success in 2004 seen along the whole of the east U.K. coast appears partly related to environmental factors affecting the incoming year class of sandeels. Evidence from studies published since the ICES (1999) study group suggest that the breeding success of this species is not a reliable indicator of sandeel availability to some other coastal seabirds. For example, a downward trend in guillemot breeding success throughout the 1990s has not been reversed by fishery closure (but that species feeds extensively on sprats as well as sandeels in this area). After a series of very poor breeding seasons for seabirds since 2004 on the Isle of May, Firth of Forth, the 2009 season was the most successful in recent years, matching evidence of increased sandeel abundance from the dredge survey. Of six seabird species studied intensively, European shag had its highest productivity on record with only razorbill having productivity below average. All other species studied had their most productive season for at least four years. Sandeels remained the main food of young Atlantic puffins, razorbills and kittiwakes. Comparatively few 1+ group sandeels were present in food samples during the chick-rearing period in 2009, however 0-group appeared in large numbers and were substantially longer than in recent years, again matching dredge results. Kittiwakes had a good season with productivity (0.70 chicks per incubated nest) the highest since 2005 and well above the long-term average. The proportion of sandeel in kittiwake diet (89% by biomass) in 2009 was the highest since 2005.

However, the concern over a possible local impact of sandeel fishing expressed in 1999 has not fundamentally changed. On re-opening, the sandeel aggregations in the 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.

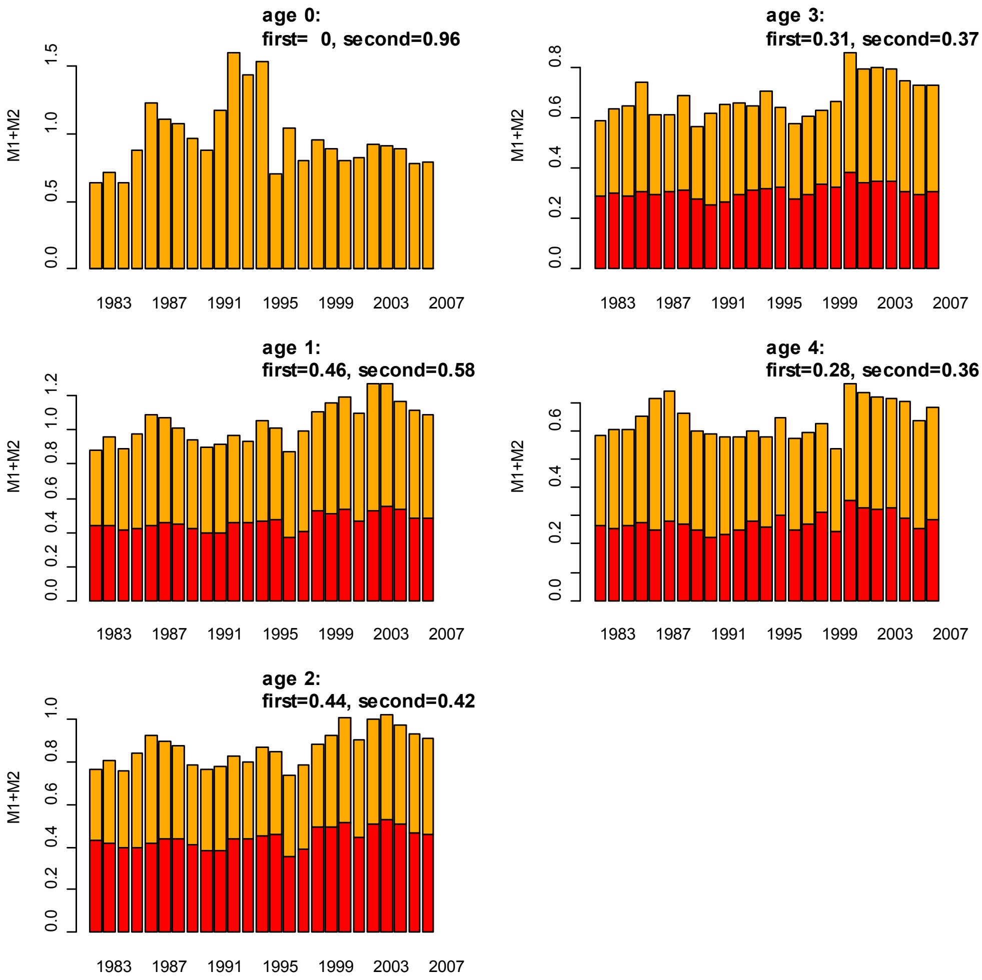


Figure 3.5. Natural mortalities of sandeel by half year. Mean values (1982–2007) for first and second half year are presented in the headings.

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:

(1) $$\overline{CPUE}_a = \frac{\Sigma_{sq}\overline{CPUE}_{a,sq}}{n_{a,sq}}$$

where

(2) $$\overline{CPUE}_{a,sq} = \frac{\Sigma_{pos}\overline{CPUE}_{a,sq,pos}}{n_{a,sq,pos}}$$

where

(3) $$\overline{CPUE}_{a,sq,pos} = \frac{\Sigma_{st}\overline{CPUE}_{a,sq,pos,st}}{n_{a,sq,pos,st}}$$

where n: number of hauls, a: area, sq: square, pos: position and st: station.

Descriptions of the survey and consistency analysis are given in WP on survey and ICES benchmark report.

Commercial cpue

Until 2009 the sandeel assessment was calibrated by the commercial cpue indices. With the introduction of the dredge survey from 2010 commercial cpue are no longer used for calibration.

Other relevant data

None.

Estimation of historical stock development

The Seasonal XSA (SXSA) developed by Skagen (1993) was up to 2001 used for stock assessment of sandeel in IV. Annual XSA was tried in 2002 WG where it was concluded that the two approaches gave similar results. For a standardization of methodology, it was decided to shift to XSA in 2003. From 2004 to 2009 SXSA was used again for the final assessment. In 2010 the SMS model was used as the assessment in 2009 indicated that the SXSA was sensitive to model settings and changes in effort distribution (ICES, 2009).

Previous whole-area assessments of Sandeel showed no consistent relationship between effort and F but, when moving towards a more biologically plausible assessment area, there is evidence that fishing effort may be used as a reasonable proxy for fishing mortality (Benchmark report, ICES 2010). This relationship has been used by the SMS model as the driver for estimating F. The SMS model has options to estimate rates for technical creeping and thereby take into account that the efficiency has increased in the sandeel fishing fleet. The results show that the new model fits to data in a reasonable way, and give results without retrospective bias. The model can be applied for assessment with just catch and effort, and for assessment where additional fisheries independent data are available.

Methodology

The SMS model, presently used for the ICES assessment of blue whiting (WGWIDE), and for the North Sea and Baltic Sea multispecies (WGSAM), was modified slightly to estimate fishing mortality from observed effort. In the original SMS version, fishing mortality, $F_{y,q,a}$ was modelled as an extended separable model including a seasonal, age and year effect. The new version substitutes the year effect by observed effort.

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * YearEffect$_y$ (1, original version)
$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * Effort$_{y,q}$ (2, new version)

where

indices A*1* and *A2* are groups of ages, (e.g. ages 0, 1–2, 3–4) and *Y* is grouping of years (e.g. 1983–1998, 1999–2009). The SMS-effort defines that the years included in the model can be grouped into a number of period clusters (*Y*), for which the age selection and seasonal selection are assumed constant. Fishing mortality is assumed proportional to effort. The grouping of ages for age selection, *A1*, and season selection, *A1*, can be defined independently.

An example of parameterization with maximum annual effort at 1.0 is shown below. (Unique parameters in bold).

	Season effect A1=age 0 and age 1-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.426	0.426	0.426	0.426		1.0*	0.5*	0.5*	0.5*	0.5*
1999–2009	0.00*	0.337	0.337	0.337	0.337		1.0*	0.5*	0.5*	0.5*	0.5*

*** kept constant**

	Age effect A2=age 0, age 1, age2 and age 3-4										
	First half year						Second half year				
YY	Age 0	Age 1	Age 2	Age 3	Age 4		Age 0	Age 1	Age 2	Age 3	Age 4
1983–1998	0.00*	0.488	1.024	1.248	1.248		0.014	0.772	0.847	0.585	0.585
1999–2009	0.00*	0.772	0.857	0.585	0.585		0.010	0.176	0.195	0.133	0.133

"Catchability"-at-age, or more correctly the relation between effort and F by age group, is included in the AgeEffect parameter.

There are two additional options for the SMS-effort version, where technical creeping is taken into account.

$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $\text{Effort}_{y,q}$ * (y-firstYear)$^{\text{commonCreep(Y)}}$ (3)
$F_{y,q,a}$ = SesonEffect(Y,A1) * AgeEffect(Y,A2,q) * $\text{Effort}_{y,q}$ * (y-firstYear)$^{\text{ageCreep(Y,A1)}}$ (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

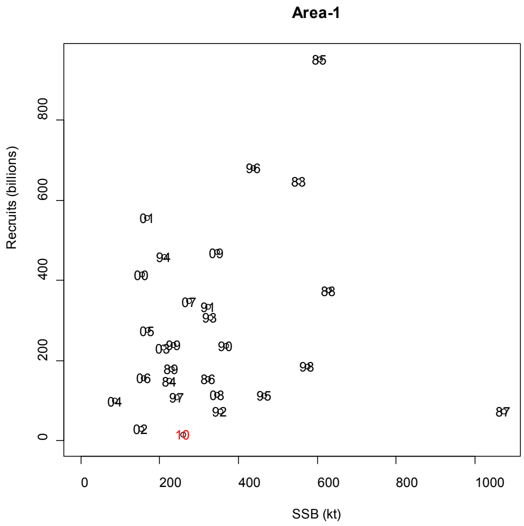
Inspection of the stock–recruitment plots from area 1, 2 and 3 revealed a decrease in recruitment at low SSB in all areas (Figure 6.4.1). However, no clear plateau was visible and this was reflected in a very flat surface of the likelihood when attempting to estimate an inflection point. Hence, the group 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.

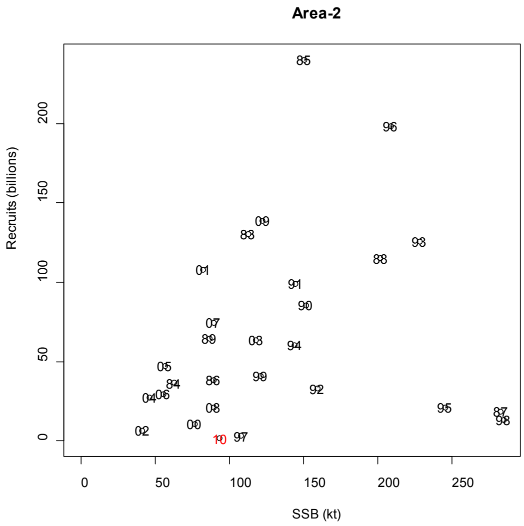
For short-lived species such as Sandeel, the ICES interpretation of the MSY concept uses B_{pa} estimates as the value for $B_{msy\text{-}trigger}$. This means that should advice follow the same escapement strategy as previously used the fishing opportunities for year y must be set at a level which ensures 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.





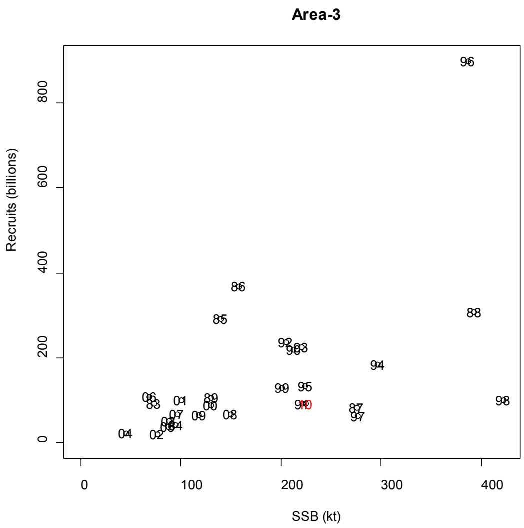


Figure 4. Stock–recruitment relationship in areas 1 to 3. Note that the recruit estimate for 2010 is based on very little input data and is therefore highly unreliable.

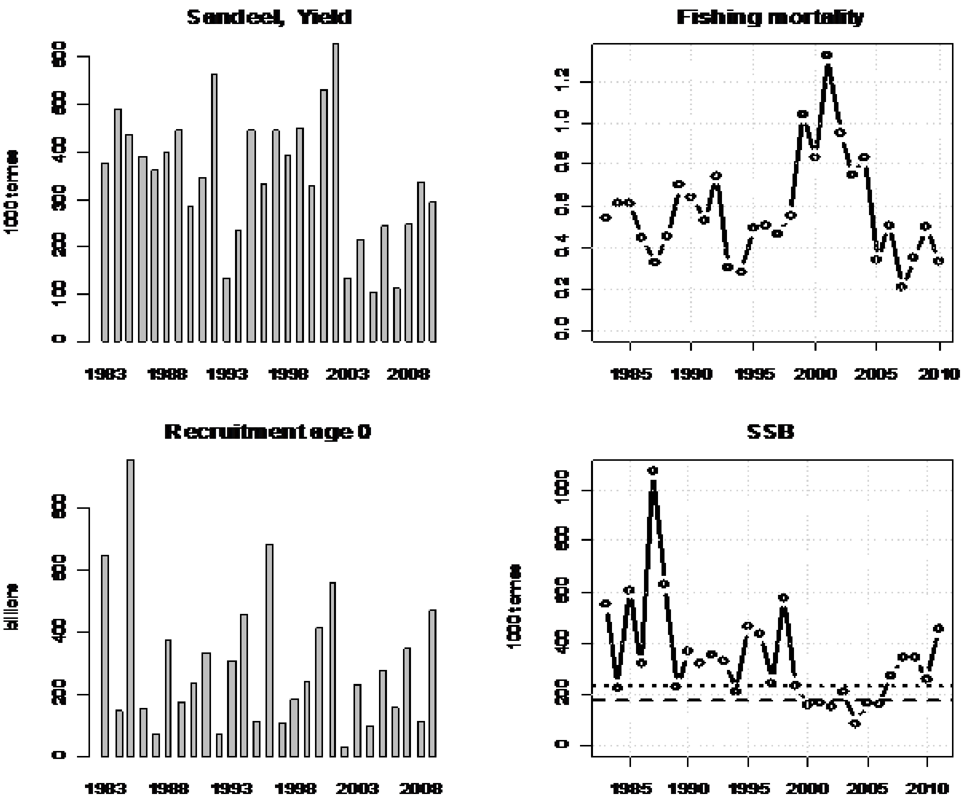


Figure 5. Stock summary for area 1.

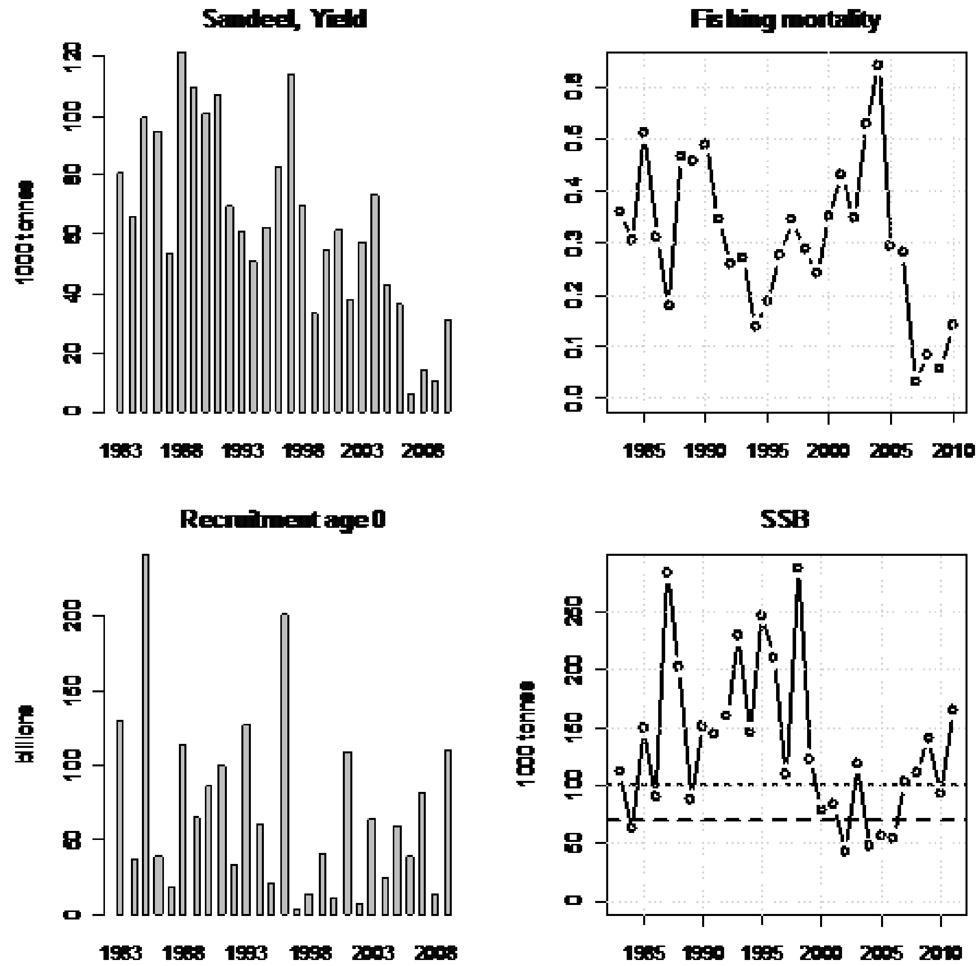


Figure 6. Stock summary for area 2.

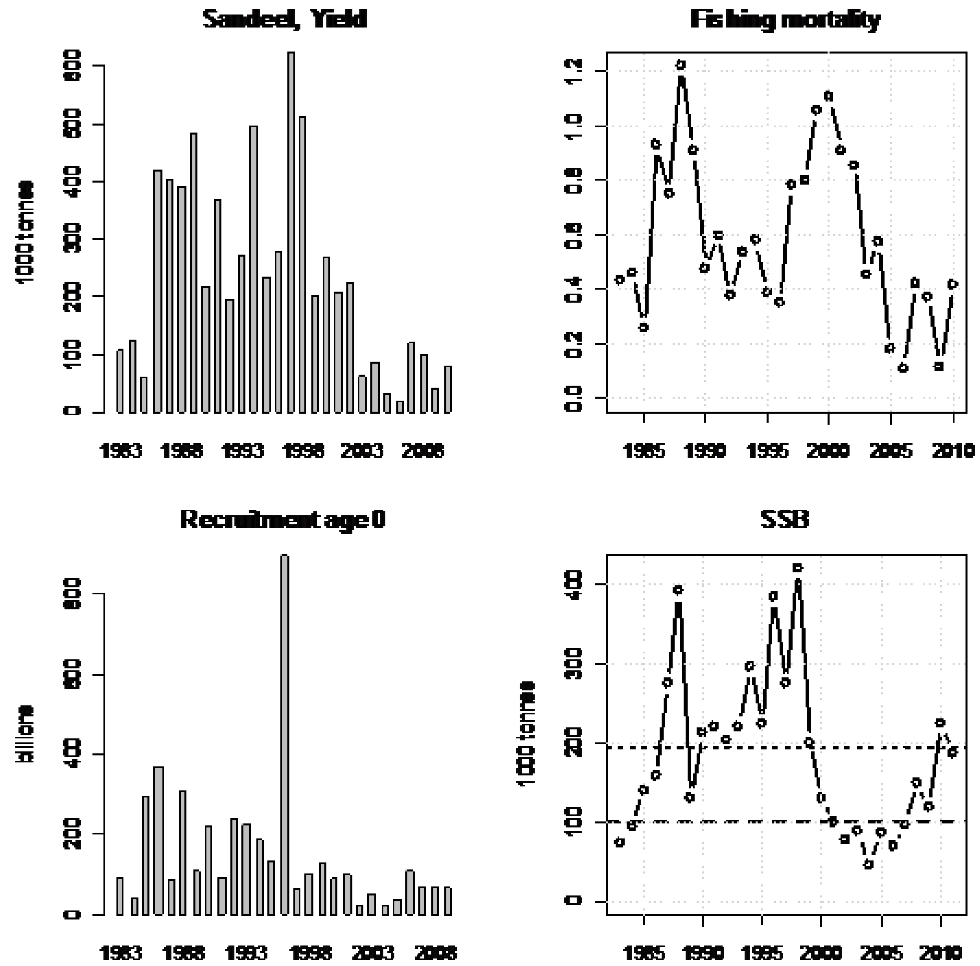


Figure 7. Stock summary for area 3.

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.

References

Arnott, S.A., Ruxton, G.D. 2002. Sandeel recruitment in the North Sea: demographic, climatic and trophic effects. Marine Ecology Progress Series 238:199–210.

Boulcott P., Wright P.J., Gibb F., Jensen H. and Gibb I. 2006. Regional variation in the maturation of sandeels in the North Sea. ICES Journal of Marine Science. 64: 369–376.

Boyd, I.L., Wanless, S., and Camphuysen, C.J. eds. 2006. *Top predators in marine ecosystems: their role in monitoring and management.* Cambridge University Press, Cambridge.

Brown, E. G., Pierce, G. J., Hislop, J. R. G., Santos, M. B. 2001. Inter-annual variation in the summer diets of harbour seals *Phoca vitulina* at Mousa, Shetland (UK). Journal of the Marine Biological Association of the UK, 81: 325–337.

Christensen A., Hochbaum U., Jensen H, Mosegaard H, St. John M., and Schrum C. Hydrodynamic backtracking of fish larvae by individual-based modelling. Accpeted by MEPS.

Christensen A., Jensen H., Mosegaard H., St. John M., and Schrum C. Sandeel larval transport patterns in North Sea from an individual-based hydrodynamic egg and larval model. Submitted.

Christensen, A., Jensen, H., Mosegaard, H., St John, M., Schrum, C. 2008. Sandeel (*Ammodytes marinus*) larval transport patterns in the North Sea from an individual-based hydrodynamic egg and larval model. Canadian Journal of Fisheries and Aquatic Sciences, 65: 1498–1511.

Daunt, F., Wanless, S., Greenstreet, S. P. R., Jensen, H., Hamer, K. C., Harris, M. P. 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Canadian Journal of Fisheries and Aquatic Sciences, 65: 362–381.

Daunt F., Wanless S, Greenstreet S.P.R., Jensen H., Hamer K.C. Hamer and Harris P.H. The impact of fishery closure on seabird food consumption, distribution and productivity in the northwestern North Sea. Submitted.

Davis, S.E., Nager, R.G., Furness, R.W. 2005. Food availability affects adult survival as well as breeding success of parasitic jaegers. Ecology, 86, 1047–1056.

Engelhard, G.H., van der Kooij, J., Bell, E.D., Pinnegar, J.K., Blanchard, J.L., Mackinson, S., Righton, D.A. 2008. Fishing mortality versus natural predation on diurnally migrating sandeels *Ammodytes marinus.* Marine Ecology Progress Series 369: 213–227.

Frederiksen, M., Wanless, S., Harris, M.P., Rothery, P., Wilson, L.J. 2004. The role of industrial fisheries and oceanographic change in the decline of North Sea black-legged kittiwakes. Journal of Applied Ecology, 41, 1129–1139.

Frederiksen, M., Wright, P.J., Heubeck, M., Harris, M.P., Mavor, R.A., Wanless, S. 2005. Regional patterns of kittiwake *Rissa tridactyla* breeding success are related to variability in sandeel recruitment. Marine Ecology Progress Series 300:201–211.

Frederiksen, M., Furness, R.W., Wanless, S. 2007. Regional variation in the role of bottom-up and top-down processes in controlling sandeel abundance in the North Sea. Mar. Ecol. Prog. Ser. 337, 279–286.

Frederiksen, M., Jensen, H., Duant, F., Mavor, D.R. Wanless, S. 2008. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Ecological Applications, 18: 701–710.

Frederiksen M., Jensen. H., Daunt F., Mavor R.A., and Wanless S. Differential effects of a local industrial sand lance fishery on seabird breeding performance. Submitted.

Freeman, S., Mackinson, S., Flatt, R. 2004. Diel patterns in the habitat utilisation of sandeels revealed using integrated acoustic surveys. Journal of Experimental Marine Biology and Ecology 305: 141–154.

Furness, R.W. 2002. Management implications of interactions between fisheries and sandeel-dependent seabirds and seals in the North Sea. ICES Journal of Marine Science 59:261–269.

Furness, R. W., Tasker, M. L. 2000. Seabird–fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series, 202: 253–264.

Gauld, J. A. 1990. Spawning and fecundity in the lesser sandeel, *Ammodytes marinus* (Raitt), in the north-western North Sea. Journal of Fish Biology, 36: 611–613.

Gauld A. 1990. Movements of lesser sandeels (*Ammodytes marinus* Raitt) tagged in the north-western North Sea. J. Cons. int. Explor. Mer. 46: 229–231.

Greenstreet, S. P. R. 2006. Does the prohibition of industrial fishing for sandeel have any impact on local gadoid populations? In Management of Marine Ecosystems, pp. 223–235. Ed. by I. L. Boyd, S. Wanless, and C. J. Camphuysen. Cambridge University Press, Cambridge, UK.

Greenstreet, S. P. R., Armstrong, E., Mosegaard, H., Jensen, H., Gibb, I. M., Fraser, H. M., Scott, B., *et al*. 2006. Variation in the abundance of sandeels *Ammodytes marinus* off southeast Scotland: an evaluation of area-closure fisheries management and stock abundance assessment methods. ICES Journal of Marine Science, 63: 1530–1550.

Greenstreet, S. P. R., Bryant, A. D., Broekhuizen, N., Hall, S. J., Heath, M. R. 1997. Seasonal variation in the consumption of food by fish in the North Sea and implications for foodweb dynamics. ICES Journal of Marine Science, 54: 243–266.

Greenstreet, S. P. R., McMillan, J. A., Armstrong, F. 1998. Seasonal variation in the importance of pelagic fish in the diet of piscivorous fish in the Moray Firth, NE Scotland: a response to variation in prey abundance? ICES Journal of Marine Science, 55: 121–133.

Greenstreet, S.P.R., Holland, G.J., Guirey, E.J., Armstrong, E., Fraser, H.M., Gibb, I.M. 2010. Combining hydroacoustic seabed survey and grab sampling techniques to assess "local" sandeel population abundance. ICES Journal of Marine Science 67: 971–984.

Hammond, P. S., Hall, A. J., Prime, J. H. 1994. The diets of grey seals around Orkney and other island and mainland sites in north-eastern Scotland. Journal of Applied Ecology 31: 340–350.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O. A., Østensen, Ø., Fonn, M., Haugland, E. K. 2004. Influence of seismic shooting on the lesser sandeel (*Ammodytes marinus*). ICES Journal of Marine Science 61: 1165–1173.

Hislop, J. R. G., Robb, A. P., Bell, M. A., Armstrong, D. W. 1991. The diet and food consumption of whiting (*Merlangius merlangus*) in the North Sea. ICES Journal of Marine Science, 48: 139–156.

Holland, G. J., Greenstreet, S. P. R., Gibb, I. M., Fraser, H. M., Robertson, M. R. 2005. Identifying sandeel *Ammodytes marinus* sediment habitat preferences in the marine environment. Marine Ecology Progress Series, 303: 269–282.

ICES 1986. Report of the Industrial Fisheries Working Group. ICES C.M. 1986/Assess:15.

ICES 1987. Report of the Industrial Fisheries Working Group. ICES C.M. 1987/Assess:17.

ICES 1988. Report of the Industrial Fisheries Working Group. ICES C.M. 1988/Assess:15.

ICES 1989. Report of the Industrial Fisheries Working Group. ICES C.M. 1989/Assess:13.

ICES 1990. Report of the Industrial Fisheries Working Group. ICES C.M. 1990/Assess:13.

ICES 1991. Report of the Industrial Fisheries Working Group. ICES C.M. 1991/Assess:14.

ICES 1992. Report of the Industrial Fisheries Working Group. ICES C.M. 1992/Assess:9.

ICES 1994. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1994/Assess:7.

ICES 1995. Report of the Working Group on the Assessment of Norway Pout and Sandeel. ICES C.M. 1995/Assess:5.

ICES 1999. Report of the Study group on effects of sandeel fishing. ICES 1999/ACFM:19.

ICES-ACFM 2005. Report of the ICES Advisory Committee on Fishery Management, Advi-sory Committee on the Marine Environment and Advisory Commit tee on Ecosystems, 2005. ICES ADVICE 2005 AVIS DU CIEM Volumes IV.

ICES-AGSAN 2007. Report of the Ad Hoc Group on Sandeel. ICES CM 2007/ACFM:38.

ICES WGECO 2004. Report of the Working Group on the Ecosystem Effects of Fishing Activities. ICES C.M. 2004/ACE:0*, Ref. D,E,G.

ICES WGNSSK 1996. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1996/Assess:6.

ICES WGNSSK 1997. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1997/Assess:6.

ICES WGNSSK 1998. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 and 3. ICES C.M. 1998/Assess:7.

ICES WGNSSK 1999. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 1999/ACFM:8.

ICES WGNSSK 2000. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2000/ACFM:7.

ICES WGNSSK 2001. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 2. ICES C.M. 2001/ACFM:7.

ICES-WGNSSK 2003. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. Part 1 to 3. ICES C.M. 2003/ACFM:2.

ICES-WGNSSK 2005. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2005/ACFM:07.

ICES-WGNSSK 2006. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak. ICES CM 2006/ACFM:09.

ICES WGNSSK 2007. Report of the Working Group on the Assessment of the Demersal Stocks in the North Sea and Skagerrak.ICES CM 2007/ACFM:35.

ICES-SGMSNS 2005. Report of the Study Group on Multispecies Assessments in the North Sea (SGMSNS). ICES CM 2005/D:06.

ICES-SGRECVAP 2006. Report of the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP). ICES CM 2006/LRC:03.

Jensen H.; Rindorf A.; Horsten M.B.; Mosegaard H.; Brogaard P.; Lewy P.; Wright P.J.; Kennedy F.M.; Gibb I.M.; Ruxton G.; Arnott S.A. and Leth J.O. 2001. Modelling the population dynamics of sandeel (Ammodytes marinus) populations in the North Sea on a spatial resolved level. DG XIV no. 98/025.

Jensen H., Mosegaard H., Rindorf A., Dalskov J. and Brogaard P. 2002. Indsamling af detaljerede oplysninger om tobisfiskeriet i Nordsøen. DFU rapport no. 97-02.

Jensen and Vinther. 2003. Estimation of fishing effort for the Danish sandeel fishery in the North Sea based on catch per unit effort data. Working document for the 2003 ICES WGNSSK meeting in Bolougne.

Jensen H. and Rolev A.M. 2004. The Sandeel fishing grounds in the North Sea. Information about the foraging areas of the lesser sandeel Ammodytes marinus in the North Sea. Working document prepared for the BECAUSE project, November 2004.

Jensen, H., Rindorf, A., Wright P. J., Mosegaard, H. Inferring the location and scale of mixing between habitat areas of lesser sandeel through information from the fishery. ICES Journal of Marine Science. (in press).

Jennings, S., Kaiser, M.J., Reynolds, J.D. 2001. *Marine fisheries ecology*. Blackwell, Oxford.

Lewy, P. and M. Vinther. 2004. A stochastic age–length-structured multispecies model applied to North Sea stocks. ICES CM 2004/FF:20.

Macleod, C.D., Santos, M.B., Reid, R.J., Scott, B.E., Pierce, G.J. 2007. Linking sandeel consumption and the likelihood of starvation in harbour porpoises in the Scottish North Sea: could climate change mean more starving porpoises? Biology Letters 3: 185–188.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2005. *Seabird numbers and breeding success in Britain and Ireland, 2004.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2006. *Seabird numbers and breeding success in Britain and Ireland, 2005.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mavor, R.A., Parsons, M., Heubeck, M., Schmitt, S. 2007. *Seabird numbers and breeding success in Britain and Ireland, 2006.* UK Nature Conservation Report. Joint Nature Conservation Committee, Peterborough.

Mitchell, P.I., Newton, S.F., Ratcliffe, N., Dunn, T.E. 2004. Seabird populations of Britain and Ireland. T and AD Poyser, London.

Pedersen, S. A., Lewy, P., Wright, P. 1999. Assessments of the lesser sandeel (*Ammodytes marinus*) in the North Sea based on revised stock divisions. Fisheries Research, 41: 221–241.

Pinnegar, J.K., van der Kooij, J., Engelhard, G.H., Blanchard, J.L., Warr, K.J., Righton, D. 2006. Small-scale variability in fish diet and whether or not this reflects local patterns of prey availability. ICES CM 2006/F:07.

Poloczanska, ES, Cook, RM, Ruxton, GD and Wright, PJ. 2004. *Fishing vs. natural recruitment variation in sandeels as a cause of seabird breeding failure at Shetland: a modelling approach.* Ices Journal Of Marine Science, 61. pp. 788–797.

Pope, J. G. 1980. Some consequences for fisheries management of aspects of the behaviour of pelagic fish. Rapp. P.-v. Reun. Cons. Explor. Mer 177, 466–476.

Proctor, R., Wright, P.J. and Everitt, A. 1998. Modelling the transport of larval sandeels on the north west European shelf. Fisheries Oceanography.7, 347–354.

Reed, T.E., Wanless, S., Harris, M.P., Frederiksen, M., Kruuk, L.E.B., Cunningham, E.J.A. 2006. Responding to environmental change: plastic responses vary little in a synchronous breeder. Proceedings of the Royal Society Series B, 273, 2713–2719.

Rindorf, A., Wanless, S., Harris, M. P. 2000. Effects of changes in sandeel availability on the reproductive output of seabirds. Marine Ecology Progress Series, 202: 241–252.

Sherman, K., Jones, C., Sullivan, L., Smith, W., Berrien, P., Ejsymont, L. 1981. Congruent shifts in sandeel abundance in western and eastern North Atlantic ecosystems. Nature, 291: 486–489.

Stafford, R., Whittaker, C., Velterop, R., Wade, O., Pinnegar, J. 2006. Final Report, Programme 13: North Sea Whiting Stomach Contents. *Fisheries Science Partnership: 2006/07.* 25pp.

STECF 2004. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2003 Year-class of North Sea Sandeel".

STECF 2005a. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2004 Year-class of North Sea Sandeel".

STECF 2005b. REPORT of the STECF Ad-Hoc Working Group on Sandeel Fisheries. November 7th–9th 2005, Charlottenlund. Denmark.

STECF 2006. Report of the Scientific, Technical and Economic Committee For Fisheries. Evaluation of the report of the Ad Hoc Working Group on Sandeel Fisheries "Estimate of the Abundance of the 2005 Year-class of North Sea Sandeel".

Ulltang, Ø. 1980. Factors affecting the reaction of pelagic fish stocks to exploitation and requiring a new approach Rapp. P.-v. Reun. Cons. Explor. Mer 177, 489–504.

Van der Kooij, J., Scott, B.E., Mackinson, S. 2008. The effects of environmental factors on daytime sandeel distribution and abundance on the Dogger Bank. Journal of Sea Research 60: 201–209.

Van Deurs, M., van Hal, R., Jensen, H., Tomczak, M.T., Dolmer, P. 2008. A spatially and temporally explicit analysis of beam-trawling on sandeel fishing grounds in the North Sea. Working Document to ICES AGSAN2.

Van Deurs, M., van Hal, R., Tomczak, M.T., Jónasdóttir, S.H., Dolmer, P. 2009. Recruitment of lesser sandeel *Ammodytes marinus* in relation to density dependence and zooplankton composition. Marine Ecology Progress Series 381: 249–258.

Wanless, S., Harris, M. P., Greenstreet, S. P. R. 1998. Summer sandeel consumption by seabirds breeding in the Firth of Forth, south-east Scotland. ICES Journal of Marine Science, 55: 1141–1151.

Wanless, S., Wright, P.J., Harris, M.P., Elston, D.A. 2004. Evidence for decrease in size of lesser sandeels *Ammodytes marinus* in a North Sea aggregation over a 30-yr period. Marine Ecology Progress Series, 279, 237–246.

Wanless, S., Harris, M.P., Redman, P., Speakman, J. 2005. Low energy values of fish as a probable cause of a major seabird breeding failure in the North Sea. Marine Ecology Progress Series, 294, 1–8.

Wright, P. J. 1996. Is there a conflict between sandeel fisheries and seabirds? In:, Aquatic predators and their prey, pp. 154–165. Ed. by S. P. R. Greenstreet and M. L. Tasker. Fishing News Books, Blackwell Science, Oxford. 191 pp.

Wright, P.J. and Bailey, M.C. 1996. Timing of hatching in *Ammodytes marinus* from Shetland waters and its significance to early growth and survivorship. Marine Biology 126, 143–152.

Wright, P. J., Jensen, H., Tuck, I. 2000. The influence of sediment type on the distribution of the lesser sandeel, *Ammodytes marinus*. Journal of Sea Research, 44: 243–256.

Wright P., Verspoor E., Andersen C., Donald L., Kennedy F., Mitchell A., Munk P., Pedersen S.A., Jensen H., Gislason H. and Lewy P. 1998. Population structure in the lesser sandeel (*Ammodytes marinus*) and its implications for fishery-predator interactions. DG XIV no. 94/071.

Wright P.J., Jensen H., Mosegaard H., Dalskov J. and Wanless S., 2002. European Commission's annual report on the impact of the Northeast sandeel fishery closure and status report on the monitoring fishery in 2000 and 2001.

Appendix A. Configuration file for Area 1

```
# SMS.dat option file
# the character "#" is used as comment character, such that all text
and numbers after # are skipped by the SMS program
#
########################################
# Produce test output (option test.output)
#  0 no test output
#  1 output file SMS.dat and  file fleet.info.dat as read in
#  2 output all single species input files as read in
#  3 output all multi species input files as read in
#  4 output option overview
#
# 11 output between phases output
# 12 output iteration (obj function) output
# 13 output stomach parameters
# 19 Both 11, 12 and 13
#
# Forecast options
# 51 output HCR_option.dat file as read in
# 52 output prediction output summary
# 53 output prediction output detailed
0
########################################
# Single/Multispecies mode (option VPA.mode)
# 0=single species mode
# 1=multi species mode, but Z=F+M (used for initial food suitability
parameter estimation)
# 2=multi species mode, Z=F+M1+M2
0
########################################
## first year of input data (option first.year)
1983
########################################
## last year of input data (option last.year)
2010
########################################
## last year used in the model (option last.year.model)
2010
########################################
##  number of seasons (option last.season). Use 1 for annual data
2
########################################
## last season last year (option last.season.last.year). Use 1 for
annual data
2
########################################
## number of species (option no.species)
1
########################################
# Species names, for information only. See file species_names.in
########################################
## first age all species (option first.age)
0
########################################
## recruitment season (option rec.season). Use 1 for annual data
2
########################################
## maximum age for any species(max.age.all)
4
########################################
## various information by species
# 1. last age
# 2. first age where catch data are used (else F=0 assumed)
# 3. last age with age dependent fishing selection
```

```
# 4. Last age included in the catch at age likelihood (normally last
age)
# 5. plus group, 0=no plus group, 1=plus group
# 6. predator species, 0=no, 1=VPA predator, 2=Other predator
# 7. prey species, 0=no, 1=yes
# 8. Stock Recruit relation, 1=Ricker, 2=Beverton & Holt, 3=Geom mean,
#                            4= Hockey stick, 5=hockey stick with
smoother,
#                            >100= hockey stick with known breakpoint
(given as input)
##
4 0 3 4 1 0 0  170000
########################################
## adjustment factor to bring the beta parameter close to one (option
beta.cor)
         1e+08
########################################
## year range for data included to fit the R-SSB relation (option
SSB.R.year.range)
# first (option SSB.R.year.first) and last (option SSB.R.year.last)
year to consider.
# the value -1 indicates the use of the first (and last) available
year in time series
# first year by species
            -1
# last year by species
            2009
########################################
## Objective function weighting by species (option 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

#
```

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:
I. RECOMMENDATIONS DEALING WITH WGNSSK ORGANISATION AND PLANNING	
In spite of some potentially more time pressure on data providers, the WGNSSK aknowledged the benefits of meeting slightly earlier in 2012. In particular, the WGNSSK recommends not to hold the meeting in 2013 immediately back to back with the WGCSE but maintain some days between the two groups. It is however necessary to insure that the data can be ready on time.	ICES secretariat, ICES Data Centre, National Data Submitters
II. RECOMMENDATIONS DEALING WITH COMMERCIAL DATA	
The WGNSSK recognised that great progresses were achieved with InterCatch in 2012. However, in order to bring the workload involved in the metier-based data raising down to an acceptable level, a number of technical improvements must be developed to streamline the processes. WGNSSK and WGMIXFISH willl liaise with ICES Data Centre to suggest and test such changes. Regional Data workshops ahead of the assessment WG, as suggested by PGCCDBS, would be extremely useful.	ICES Data Centre, WGMIXFISH, PGCCDBS, RCM North Sea
In 2012, the species included in the combined WGNSSK-WGMIXFISH data call covered the main demersal stocks traditionally assessed by WGNSSK. Addtional relevant species could be added, including the new stocks under WGNSSK (pollack, grey gurnard, mullet) some stocks distributed in the North Sea but assessed by WGCSE (monkfish, megrim) as well as Norway Pout.	WGMIXFISH, WGCSE, WGNEW
III. RECOMMENDATIONS DEALING WITH SURVEYS DATA	
WGNSSK has again experienced significant issues regarding IBTS indices delivered from DATRAS, largely linked to unanticipated and poorly documented resubmission of old data sets by national labs. WGNSSK recommends a strengthening in filter checks when uploading data, a version control allowing an simpler comparison of datasets, and a better communication flow (notably between people dealing with IBTS data and people attending WGNSSK within the labs themselves) allowing information on which data changes have been submitted and why. WGNSSK recommends also a "resubmission ban" or a gateway scheme where no recalculations are perfomed within the two weeks before the WG meeting (consistently with EG's ToRs), to avoid changes in the indices after the data compilation has started.	ICES data Centre, National Data Submitters, WGIBTS
In 2010, WGNSSK evidenced changes in cod catchability in IBTS Q3 over time. In 2012, WGNSSK does not believe that this has been addressed by WGISDAA and recommends therefore that this is investigated further	WGIBTS, WGISDAA, ACOM
WGNSSK recommends that the extended area for North Sea cod IBTS calculation is now the default option on the online query rather than having to request it specifically	ICES Data centre

IV. RECOMMENDATIONS DEALING WITH WGNSSK CONTENT AND ToRS	
In 2010 the WG experienced significant discussions around differences in results from various statistical tools available to fit Stock Recruitment Relationships, and was concerned by the risk of poor fitting of this SRR, which can undermine the statistical estimation of Fmsy. The WG reiterates its recommendation that the WG on Methods for Fish Stock Assessments (WGMG) investigates this further and provides guidelines on optimal fitting procedures.	WGMG
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.	ICES secretariat, ICES clients, STECF stock review, STECF plenary
At the 2011 WGNSSK meeting there was some uncertainty over the basis for advice for North Sea sole and plaice. This uncertainty stemmed from the ICES secretariat moving the management plan off the list of agreed and accepted management plans and onto the list of plans that should not be used for advice. Ultimately the decision to change the status of the management plan was considered incorrect. Following this experience WGNSSK recommends that ICES should develop a protocol on what to do by default under certain circumstances with regards to all management plans. It is recommended that plans remain on their assigned lists/tables unless a client specifically request a change in the status of the plan in question. The clients need to be aware of the lists, as well as of their importance in the hierarchy for bases of advice in the ICES system.	ACOM, ICES secretariat, ICES clients

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	Ass status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
cod-347d	Accepted SAM model	Inter-benchmark in Feb 2011	No	Proposal to ACOM	Future proposals for internal use	
had-34	Accepted FLXSA model but continued exploratory assessments with SAM and SURBAR	2011 WKBENCH	No	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	YES			Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-7	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No			Fuller exploration of other input data (landings, discards, raising procedure

						s, etc)
nep-8	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No			Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-9	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No			Fuller exploration of other input data (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	No benchmark ever on this stock, mainly due to lack of data	yes			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			Fuller exploration of other input data (landings, discards, raising procedures, etc)
nop-34	OK	2012				
ple-eche	Assessment only accepted for trends	2010	No		Unresolved stock identity, discard time sery too short to be used in the assessment	

ple-SD20 (Skagerrak)	Assessment not accepted	New stock suggested in 2012	Not planned but if the suggested changes in stock definition are enterined in 2012 it might be necessary to benchmark the new assessments straight away in 2013?	Yes if this cannot be achieved in 2013	Uncertainty in the catch-at-age information and inappropriate survey spatial coverage, discards data not included, assessment needs more analyses	
ple-SD21-23	Assessment not accepted	New stock suggested in 2012	Not planned but if the suggested changes in stock definition are enterined in 2012 it might be necessary to benchmark the new assessments straight away in 2013?	Yes if this cannot be achieved in 2013	discards data not included, assessment needs more analyses	
ple-nsea	OK	2009	No,	No	-	Changes in catchability for indices of young ages (1-3) may need to be addressed again in a future benchmark. Potentially combine the two BTS indices (Isis and Tridens) and split SNS.
sai-3a46	OK	2011	no	no	Further analyses are planned to detect bias in commercial CPUE indices and correct for it if possible	-
san-nsea						
sol-eche	OK	2009	no	no	no	no
sol-nsea	OK	2010	No	No	-	A revised CPUE index

						for the stock will be presented at WGNSSK 2013. If approved by the group, this may require an inter-benchmark procedure to be implemented in the assessment. In the future if a reliable time series of discards can be created, this may need to be included in the assessment.
whg-47d	Update deviating from benchmark	2009		2013		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						

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	Nep 3&4, 6, 32,34	
Benchmark	Year:2013	
Stock coordinators	Mats Ulmestrand, Nick Bailey, Ewen Bell, Guldborg Søvik	
Stock assessor	Mats Ulmestrand, Nick Bailey, Ewen Bell, Guldborg Søvik, Sten Munch-Petersen	
Data contact		

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
Fuller exploration of other input data (landings, discards, raising procedures, etc)	Previous benchmark did not explore basic data	Explore raising procedures to ensure appropriateness and uncertainty	Mainly host nations hold thie own data, possibly some need for data exchange	Assssment scientists plus data preparation experts
Tuning series	NA			
Discards	Evaluate appropriateness	Explore raising procedures to ensure appropriateness and uncertainty	Mainly host nations hold thie own data, possibly some need for data exchange	Assssment scientists plus data preparation experts
Biological Parameters	Revisit maturity parameters	Data mining and modelling	Mainly host nations hold thie own data, possibly some need for data exchange	Assssment scientists plus data preparation experts
Ecosystem/mixed fisheries considerations	NA			
Assessment method	**NA**			
Forecast method	**NA**			
Biological Reference Points	Review new Data limited approach	Explore robustnsess of data limited approach through modelling.	Already exist	Modelling

Stock	**Whiting in the North Sea and Eastern Channel**	
Stock coordinator	Name: Coby Needle	Email: needlec@marlab.ac.uk
Stock assessor	Name: Coby Needle	Email: needlec@marlab.ac.uk
Data contact	Name: Coby Needle	Email: needlec@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**
(New) data to be Considered and/or quantified[1]	Stock structure	Determination of stock structure – possible north-south split, also links with VIa	Survey and catch data	None
Tuning series	Apparent changes in IBTS catchability	Not yet clear – possibly gear selectivity evaluations	Existing gear trial data from Scotland and England	Gear scientist (e.g. Barry O'Neill, Aberdeen)
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**
(New) data to be Considered and/or quantified[1]	Stock structure	Determination of stock structure – possible north-south split, also links with VIa	Survey and catch data	None
Biological Parameters	Evaluation of updated maturity and growth parameters	Growth and maturity curve fitting	Survay data on length, weight and maturity	Growth modelling (e.g. Andrzej Jaworski, Aberdeen)
Assessment method	The uneven nature of the North Sea whiting distribution is potentially one of the key factors in limiting the utility of the existing assessment method. A spatial assessment method would help to determine the parameters of this distribution, and could improve the assessment itself.	Development of a spatial assessment method for whiting.	Spatially-defined survey and catch data, bathymetry, other environmental characeristics (e.g. temperature)	Colleagues with past experience in developing spatial assessment approaches (e.g. Morten Vinther, Copenhagen; Colin Millar, Ispra)
Biological Reference Points	Reference points are not currently defined for this stock.	Definition of suitable reference points following the determination of the most appropriate stock assessment method.	Stock assessment outputs.	None.

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	Establish NORASS as standard survey	ACOM (Norway)
Saithe in Subarea IV, VI and Division IIIa	Age sampling from commercial fleets	Possible cluster sampling due to few vessels in the reference fleet (Norway), needs review / redesign	ACOM (Norway); PGCCDBS

Stock	Data Problem	How to be addressed in	By who
Saithe in Subarea IV, VI and Division IIIa	No discard data used in assessment	Quality control of available data sources, including Norwegian reference fleet data	ACOM (Norway); ACOM (Fance); ACOM (UK- Scotland); ACOM (Germany); PGCCDBS
Plaice in IIIa	No survey coverage where the fisheries are	The Western Skagerrak represents by far the huge majority of the catches but there is no survey there, while there is 4 surveys in Kattegat which represent <5% of catches. There is an urgent need to a better coverage through survey or reference fleet	IBTSWG; WGBEAM
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	PGCCDBS
Plaice in VIId	Discard time series too short to be included in the assessment	Sampling levels have increased in the recent years and more work needs to be done to raise the samples to the population and get reliable estimates of the discards levels	PGCCDBS; ACOM (France); ACOM (UK); ACOM (Belgium)

Stock	Data Problem	How to be addressed in	By who
Sol-eche	*The French Young Fish survey as conducted now is probably not providing the correct recruitment estimates as it only covers part of VIId*	The UK component of the YFS index is not available since 2007, resulting in the unavailability of the combined YFS-index. This combined index has been estimating the incoming year class strength very consistently, hereby providing reliable estimates to the forecasts. Although results of using the YFS indices separately (FR-YFS for 1987-present and UK-YFS for 1987-2006) did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS will affect the quality of the recruitment estimates and therefore the forecast. The Working Group suggests that the assessment could benefit if the French Young Fish survey could be extended to include some of the sampling points from the former UK Young Fish survey along the English coast. The extended French survey could then mimic therefore the earlier available combined Young Fish survey which was an excellent estimator of the incoming recruitment	ACOM (France); SCICOM
Haddock in IV and IIIa	Stock structure	There is increasing evidence that the IV-IIIa and VIa haddock stocks should be assessed as one joint Northern Shelf haddock stock. A preliminary attempt was made at this during WGNSSK 2011, but a more complete data collation and analysis job is required, along with consideration of what this would entail for advice.	ACOM (UK - Scotkand);
Nep 7-10, 34	Lack of Scottish effort data	Anomalies in effort extractions from different Marine Scotland databases require further investigation to be resolved. Ability to provide an LPUE series for FU 10 (no UWTV survey) would improve basis for advice.	ACOM (UK - Scotkand); RCM-NS&EA

Stock	Data Problem	How to be addressed in	By who
Nop34	Missing Norwegian CPUE data by vessel category for 2008, 2010 and 2011 should be made available. Missing Norwegian data time series of samplings should be made available in Intercatch.	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)
Nep 32	*Lack of Danish sampling of landings and discards*	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 catch sampling in 2011 was very limited and is expected to be equally low in 2012. This is due to the very few Danish 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	RMC-NS&EA; ACOM (Denmark)

Stock	Data Problem	How to be addressed in	By who
Nep 32	*Deficient Norwegian log book data*	The Norwegian logbook system was changed in 2011 with the introduction of electronic logbooks compulsory for all vessels > 15 m. 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. This situation is not likely to change in the near future, but on a longer time scale, simplified log books should be introduced also for trawlers < 15 m.	ACOM (Norway)
Pollack in Subarea IV and Division IIIa	General lack of biological data needed for better understanding of growth and maturity.	In routine surveys, such as the quarter 1 and quarter 3 IBTS in Subarea IV and Division IIIa, apart from reporting catches at length, no biological data are collected for this species. In order to understand better their growth and maturity WGNEW recommended that otoliths and maturity information should be collected during these surveys for a few years. WGNSSK also recommends that biological data from commercial catches should be processed.	IBTSWG; RCM-NS&EA

Annex 6: Technical Minutes of the North Sea Review Group

Review of ICES	**WGNSSK Report 2012**
Reviewers:	Gary Melvin (Canada, chair)
	Anthony Wood (USA)
	Höskuldur Bjornsson (Iceland)
Chair WG:	Clara Ulrich (Denmark)
Secretariat:	Barbara Schoute

General

The North Sea Technical group reviewed several stocks examined by the 2012 Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). This was one of 4 working group reports used by the NSRG to conduct their review of North Sea Stocks. The RG would like to acknowledge the effort by the working group to produce a coherent report and for mostly completing their documentation in a timely manner. The NSTG would also like to thank the ICES Secretariat for their support throughout the review process.

The Review Group considered the following stocks:

cod-347d	Cod in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West (Skagerrak)
had-34	Haddock in Subarea IV (North Sea) and Division IIIa (Skagerrak - Kattegat)
nep-iiia	*Nephrops* in Division IIIa (Skagerak Kattegat, FU 3,4)
nep-5	*Nephrops* in Division IVbc (Botney Gut - Silver Pit, FU 5)
nep-6	*Nephrops* in Division IVb (Farn Deeps, FU 6)
nep-7	*Nephrops* in Division IVa (Fladen Ground, FU 7)
nep-8	*Nephrops* in Division IVa (Firth of Forth, FU 8)
nep-9	*Nephrops* in Division IVa (Moray Firth, FU 9)
nep-10	*Nephrops* in Division IVbc (Noup, FU 10)
nep-32	*Nephrops* in Division IVa (Norwegian Deeps, FU 32)
nep-33	*Nephrops* in Division IVb (Off Horn Reef, FU 33)
nep-34	*Nephrops* in Division IVb (Devil's hole, FU 34)
nop-34	Norway Pout in Subarea IV (North Sea) and IIIa (Skagerrak - Kattegat)
ple-eche	Plaice in Division VIId (Eastern Channel)
ple-kask	Plaice in Division IIIa (Skagerrak - Kattegat)
ple-nsea	Plaice Sub-area IV (North Sea)
ple-skag	Alternatively - Plaice in Division IIIaW (Skagerrak)
ple-2123	Alternatively – Plaice in Subareas 21-23 (Kattegat, Belts and Sound)
Pol-nsea	Pollack in Subarea IV (North Sea) and Division IIIa West (Skagerrak)
sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)
sol-eche	Sole in Division VIId (Eastern Channel)
sol-nsea	Sole in Sub-area IV (North Sea)
Gug-347d	Grey gurnard in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West

	(Skagerrak)
Mut-347d	Striped red mullet in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West (Skagerrak)
whg-47d	Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel)
whg-kask	Whiting in Division IIIa (Skagerrak - Kattegat)

Cod in Subarea IV (North Sea), Division VIId (Eastern Channel), and IIIa West (Skagerrak) cod_347d

1) **Assessment type: Update**
2) **Assessment**: Analytical:
3) **Forecast**: As in 2011 short term forecast (deterministic) not presented due to continued uncertainty in final year F. Stochastic projection undertaken from which short term projections were extracted.
4) **Assessment model**: SAM with 1 tuning index (IBTS Q1 survey as in 2011)
5) **Consistency**: Replaced B-Adapt assessment model with SAM in 2011and used only IBTS Q1 as tuning index. Same model and inputs this year except for natural mortality. IBTS Q3 not included due to change in catchability/availability. Natural mortality has been updated for this assessment following a new key run conducted by WGSAM (ICES-WGSAM, 2011).
6) **Stock status**: SSB (56,331 t) < Bpa (150,000t) and < than Blim (70,000 t). F(0.572) is well above Fmsy (0.19). FMP= 0.4 and SSBMP= 150,000t. Stock status has improved over the past few years. SSB has increased from historical lows in 2006 and is expected to continue this increase because of the large 2009 year class. R increased in 2010 but declined again in 2011to a relatively low level.
7) **Man. Plan.**: EU Plan (2008): established effort management and a target fishing mortality of 0.4, reducing fishing mortality in a 75% in 2009, 65% in 2010 compared with 2008 level, and applying successive decrements of 10% for the following years. TAC levels for 2010 and subsequent years should not be 20% above or below the levels established the previous years.

General comments

This stock has undergone a number of significant changes in recent years with respect to both management and assessment models. Major initiatives have been initiated to reduce the amount of discarding of cod by a number of fleets that have to some extent been successful, but discarding of young cod in 2011 still remains high 82% for age 1 and 66% for age 2.

The report on cod is general well organized and when combined with the Annex provides a comprehensive of the resource. HCR are well defined for setting the TAC based on stock status following the precautionary approach. However the TAC level shall not exceed a 20% increase or decrease of the previous year's TAC. The percentages change under poor data conditions.

In 2008 an EU cod recovery plan was implemented along with an EU/Norway Cod Management Plan. An ICES_STECF review concluded that for NS cod, despite the gradual reduction in F the plans have not controlled F as envisaged and Fmsy is unlikely to be reached in 2015.

There are two larger scale research surveys mentioned in the section as having potential to be eventually used as tuning indices (NWS and REX). The value of these as commercially representative surveys is recognized and maintaining these surveys/partnerships going forward would be beneficial to the assessment.

It would be helpful if the status of the stock section included the current estimates from the assessment. Landings have exceeded the TAC slightly in IIIa-Skagerrak and

IV. Total landings in 2011 were 32,900t with estimated discards at 9,500t (the estimated discards for 2011 from table 14.12 are 11,679t, which is different from the value in the text of document). The TAC for these regions in 2011 was 3,800t (IIIa) + 26,800t (IIa+IV) + 1,600t (VIId) = 32,200t.

Discards information has been improving and Intercatch used for raising landings in 2011. Misreporting in the past was a known uncertainty, but appears to be minimal, although the report suggests it may still be unclear, as the WG looked at a catch multiplier. Unallocated removal from SAM estimates suggest that there may also include changes to natural mortality and misreporting Discards by number still account for a 55% of landings in 2011. The decreasing bias in landings in recent years was not supported by a declining trend in the catch multiplier when IBTS Q3 was included in the assessment. All sources of unallocated catches are a major source of uncertainty for this assessment.

The general downward trend in F since about 2000 is encouraging and an indication that some of the initiatives may be working, but it is still well above the level to achieve the long term objective of maximum yield. SSB has been increasing since a low in 2006 but remains below B_{lim} and B_{MP}. The increase in SSB is largely derived from the strong 2005 year class and 2009 year-classes and much of the fishery is dependent upon recruiting year-classes. The low mean age of mature spawning fish and first time spawners may also decrease reproductive success. Than if more older fish were in the stock. If recruitment continues to be impaired through multiple sources (fishing and natural mortality), the prognosis will remain poor (relative to B_{pa}).

In recent years a survey has been removed from the assessment (IBTS-Q3) and now natural mortality inputs have changed. Reference points should be re-estimated for this stock. The WG recognizes this should be done in the "near future."

Technical comments

Natural mortality updated in 2012 run according to output from WGSAM 2011. Natural mortality based on new WKROUND key run in 2011 with a revision of M. Values appear to have increased for ages 1-3.

Expansion of CCTV/fully documented Fisheries in Scotland Denmark and England is expected to reduce cod mortality as UK vessels are not permitted any cod and Denmark only undersize cod.

The 2009 year class may not be as strong as anticipated. The year-class was not identified as anything exceptional by the UK North East Coast Cod survey by industry, but only cover a small portion of the NS cod distribution.

The extended indices for Q1 and Q3 which includes additional squares were calculated in both 2011 and 2012 after correction of misallocation of age length keys. There also appear to have been a change in distribution and possibly catchability that has led to conflicting residual trends. The IBTS Q1 suggested declining and stable mortality rates while the Q3 indicated rapidly increasing mortality rates for the same time period. Two studies demonstrated that there has been an increase in catchability (change in distribution possible) for Q3 in recent years. Only IBTSD Q1 was used in the 2011 update.

Fishermen do not believe that the IBTS's are representative of the cod abundance as it does not cover the rough bottom where the highest commercial catches occur. However there is good internal correspondence for cohorts in both IBTS suggest they are tracking trends in the stock

Mean length at age for 3-5 shows a general increasing trend in recent years. It is reported that this is likely the result of high grading. Again supporting the uncertainty of total removals.

There are no major retrospectives patterns except a general tendency to over-estimate F which may be attributed to the continuing period of declining F as was previously noted.

The figures and tables in this section are well formatted and easy to interpret.

In the Catch and age compositions section there are table and section references to old documents (eg. Table 2.1.3##, section 1.2.4##) which makes things more difficult than necessary for reviewers.

Conclusions

The RG concludes that the update assessment has been performed correctly and agrees with the Working groups conclusion on stock status. With recent changes to assessment inputs biological and MSY reference points should be re-evaluated.

Haddock in Subarea IV (North Sea) and Division IIIa (Skagerrak – Kattegat) had-34

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Short term projections presented .
4) **Assessment model**: FLXSA – tuning by 3 fleets (Scotland, England, International) compared to SAM, and SURBAR to corroborate update assessment.
5) **Consistency**: Retrospective patterns are small and show consistency between annual assessments.
6) **Stock status**: The historical perception of the stock remains unchanged from last year's assessment. Stock has full reproductive capacity and is harvested sustainably. SSB (205,468 t) is above B_{pa} (140,000 t) and Blim (100,000 t) and has increased from SSB in 2010 (182,559 t). F (0.298) is below F_{pa} (0.7) and equal to Fmsy (0.3). Recent recruitment has been very low with the lowest value ever observed in 2011 (680,950).
7) **Man. Plan.** Maintain a minimum level of SSB greater than 100,000t (Blim) and restrict fishing on the basis of a TAC consistent with an F ≤ 0.30. Inter-annual TAC variability is also limited to ± 15%.

General comments

This is a detailed and well written assessment report. This stock has undergone two extensive reviews in recent years (RGNS 2011 and WKBENCH 2011). The working group was unable to address the minor issues raised by RGNS 2011 for this assessment. These reviews should be addressed before they get lost in the process.

A comparison between the intercatch system and spreadsheet approach returned similar values. This comparison was a point of review from last year so it is good to see it was done.

The comment in the review from last year needs to be made again and should have been addressed further in this year's assessment. RGNS2010: The difference in SSB estimates at the end of the time series between FLXSA and SAM/SURBA is troubling. The agreement of SSB estimates between the two corroborating models (SAM/SURBA) suggests that FLXSA is overestimating convergence. The WG feel it may be because of slow convergence in the FLXSA model but more simulation testing is needed. The RG agrees with the WG that the question surrounding FLXSA convergence needs to be addressed "at the earliest possible opportunity."

There is good consistency between annual assessments.

The Quality of assessment section needs to be updated as it references work to be done in the "forthcoming" benchmark in 2011.

Technical comments:

The technical aspects of this report are strong. Everything is well laid out and easily interpretable including sections of the text, tables, and figures. However there are a number of issues that should be examined in the next benchmark.

Need to investigate the model setting of the SAM model as the SAM model estimates the 1967 year class much smaller than VPA. There must be some constraint on SSB-recruitment likelihood here or extremely unusual selection pattern. How are landings in tonnes from the Sam model in this period, far below observations? SSB around 1970 is only like 15% less from the SAM assessment compared to the XSA assessment in spite of a large difference in recruitment.

The difference in SSB between SAM and XSA from 2001-2007 is very large with similar recruitment and should be examined. In 2007 and 2008 the plus group (1999 year-class) could be a problem as they are a real problem in XSA (at least some versions). XSA assumes the last true age below the plus group is the same for the plus group.

All survey indices are for age 6 and younger and do not limit age 7 (and plus group). From Table 13.3.5.1 it can be seen that fishing mortality on 7 and 8+ is between 0.047 and 0.126, often only 1/3 of the estimated fishing mortality of age 5 and 6.

In table 13.2.2 (there are no discards for these age groups) the landings of year-class 1999 are from age 6 onwards 58.7, 30.2, 6.7, 2.4, 0.53. M is 0.2 on those age groups so the fish disappears really fast from the fisheries based on the fact that Z=0.3. There is no survey and fishing mortality free to go down for older age groups. The model can therefore make up large quantity of old fish not seen anywhere. This is most likely relatively recent problem as earlier fishing mortality was high enough to make age 7 and older negligible.

SAM is a model where many parameters can be modelled as time series leading to all kind of constraints of the model compared to VPA. For stocks with large variability in recruitment these outliers in recruitment can cause problems as the model (tuned with log ratios) treats them as measurement noise (which they are not).

The residuals from XSA need to be checked if the different tuning fleets represent different areas. This may lead to negative correlations between residuals (if they are caused by change in spatial distribution). Ignoring this can lead to large errors if the stock distribution changes suddenly. Having a retro on the weight of each survey in estimating each age group can be useful. In this case there is some indication of extensive negative and positive blocks and many of the surveys seem to have some kind of year factor. Much reduction of fishing mortality in last decade can lead to blocks of residuals in younger age groups if for example the assumed value of natural mortality is wrong.

There may be problem with the really high values of M used for age 0 and 1 yet these high values might make the effect of discards less. We must remember that the discarded individuals of age 1 are the fastest growing i.e those that are retained by the trawl (the few really fast growing ones are retained) but those eaten are the slow growing (at least M drops a lot between age 1 and 2). If there has been a real effort reduction discard should decrease if the retaining curve by the fishermen is the same. Look at the 1999 year-class, 419 million fishes are landed but 979million are discarded 707 million at age 2 and later when natural mortality is becoming 0.4 or lower. Somehow the effects of this discard are talked down in the report.

Conclusions

The assessment has been performed correctly and the RG agrees with WG conclusions for this stock. The convergence issues and possible over-estimation of SSB from the FLXSA model need to be explored and addressed as soon as possible.

Nephrops in Division IIIa (Skagerrak – Kattegat, (FU3,4) nep-iiia

1 **Assessment type:** Update

2 **Assessment**: Analytical/trends

3 **Forecast**: N/A

4 **Assessment model**: UWTV survey. UWTV Survey from 2011 and LPUE trends (Denmark and Sweden) from 1990 to 2011.

5 **Consistency**: Legal size maintained. No reference to previous assessment review.

6 **Stock status**: The current levels of exploitation for this stock appear to be sustainable. Logbook recorded effort has decreased since 2002 and is currently low while LPUE has increased in recent years. Mean sizes are fluctuating without trend. Total landings in 2011 were 3,986 t, a decrease from 5,123 t landed in 2010.

7 **Man. Plan**: Management is at the combined functional unit level, FU3 and FU4. TAC was increased from 5,170t in 2011 to 6000t for 2012. There are no precautionary reference points estimated for this stock. Fmsy proxies proposed by the working group were Fmax, F0.1 and F35%spr. Combined Fmax (by sex) was 7.9% with a F2011 (UWTV) HR = 5.0%.

General comments

The text does not address last year's review and incorrectly states "There was no review of this stock in 2011."

Decrease in LPUE in FU4 not mentioned, everything is though at high level. Landings decreased also in FU4.

The method of using the TV survey and some proxy for MSY seems like a good one. TV surveys seem to give an indication of absolute stock size, something that is rare even though results from analytical stock assessment is often considered so

The assessment section is titled "2010 assessment"

Table 3.1.2: specify landings in tones in heading. Date range states 1991-2008 when the actual range in the table is 1981-2011.

Table 3.2.1.1 and 3.2.1.3 are the same table?

Functional unit labels on Figure 3.1.1 would be helpful.

Cod is a significant by-catch in the *Nephrops* Kattegat fishery and ICES recommends a TAC of 0 for cod. Incentives/methods to reduce the by-catch of cod are encouraged.

Technical comments:

This is the second year this stock has been assessed with a UWTV survey and the time series is still too short to draw conclusions regarding stock trajectory.

On Fmax vs. F35ssb. Low and relatively clear value of Fmax is an indication of poor selection pattern (growth over fishing) which is the case here with all the discarding. This value can of course be used as a management target but all reference to MSY seems rather strange. Much higher yields can be obtained with better a selection pattern, even though there was no discard. How are the yield per recruit calculations set up, discards as certain percent or two selection patterns, one for the fishing operation and one for the retaining operation?

All reference to MSY here seems to indicate that the discard observed is unavoidable, which it is not, so the SY should be used instead of MSY. This same situation occurs in many other North Sea stocks.

The 2011 harvest rate is relatively low at 5.0% suggesting the stock is being harvested sustainability.

Conclusions:

The UWTV survey and other indicators seem to indicate this stock is being exploited at a sustainable level. Discards continue to be a problem and the RG agrees with the WG that continued work on size selectivity in *Nephrops* trawls to reduce the large amount of undersized discards is important.

Nephrops in Divisiion IVbc (Botney Gut - Silver Pit, (FU 5) nep-5

1) **Assessment type: Category 3/*Nephrops***
2) **Assessment**: trends
3) **Forecast**: not presented
4) **Assessment model**: Underwater TV (UWTV) absolute abundance. Short time series 2010-11. LPUE trends from 4 fleets – Belgian, Dutch, Danish, and English.
5) **Consistency**: There was no reference to previous reviews.
6) **Stock status**: The status of the stock is uncertain, but the stock shows no signs of being over-exploited. Total landings peaked in 2007 at over 1400t. Since 2008 landings have declined to below 1000t in 2010 and slightly over 1000t in 2011.
7) **Management Plan**: Management is at the Sub-area level. The TAC for *Nephrops* in sub-area IIIa and IV was 21,929t in EC waters with 1200t in Norwegian waters. No biological reference points have been defined for this stock.

General comments

Length composition from Dutch landings shows an increasing trend, but may not be representative due to low sampling in last 2 years, especially true for the 3rd quarter which is the main fishing period.

No discard data available for this area.

Poor visibility during survey resulted in high uncertainty for underwater TV observations. There are also discrepancies between the centre of abundance and where the VMS shows the fleet operating. The time series for the UWTV survey is short (2 years) and several complications have been encountered however the method appears to provide the best approach to monitoring *Nephrop* stocks and should be encouraged to continue.

In the text: Section 3.2.1.1 heading should read 2010 and 2011 not 2009 and 2010.

Technical Comments:

Signals from the LPUE time series are mixed and changes in the fleet composition too variable to use them as an index of abundance.

The lack of length sampling in recent years has been problematic for this assessment. This lower sampling intensity is coupled with changes in the UWTV survey timing and distribution as well as contradictions in the LPUE signals over the past decade.

Based on the estimated guidance approach of using available data and input estimates from adjacent areas, the harvest rates in FU 5,with relatively high densities (0.7), are low (3.8%) for landings were in the order of 1000t. This harvest rate is considered to be well below any proxy for Fmsy.

Conclusions

Improvements in length sampling intensity and the consistency of the timing and distribution of the UWTV survey are necessary to improve the performance of this assessment. There may not be adequate information to assess this stock at the FU level.

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.

Nephrops in Division IVb (Farn Deeps, FU6) nep 6

1) **Assessment type:** Update
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented.
4) **Assessment model**: Stock abundance is estimated from TV surveys.
5) **Consistency**: The methodology for calculating abundance from UWTV is consistent with new methodology presented in the 2011 assessment.
6) **Stock status** The TV survey indicates that stock status has improved. The current estimated abundance of 870 million individuals is above the 2010 estimate of 753 million individuals and just below the MSY Btrigger value of 890 million individuals (bias adjusted UWTV abundance as observed in 2007, the first year when the stock was considered to be depleted). The current estimate of stock abundance is below MSY Btrigger and ICES Fmsy framework dictates that the recommended F should be the current Fmsy proxy (Male F35%SpR = 8.0%).
7) **Management Plan**: Management is at the Sub-area level. The 2011 EC TAC for *Nephrops* in sub-area IIa and IV was 23,454t in EC waters with 1200t in Norwegian waters. There has been a further reduction to 21,929t in EC waters and no change (1200t) for Norwegian waters.

General comments

This stock would benefit from management at the FU level as opposed to the sub-area level.

Technical comments

The final estimated abundance for 2011 was 870 million individuals, not 892 million individuals as indicated in the text (Final Assessment section).

What are the * indicating in Table 3.3.2.4?

2011 landings in Table 3.3.2.1 are 2,070t and in Table 3.3.2.5 landings in 2011 are 2,072t. They should be consistent.

In the UWTV section Table 3.3.2.5 is incorrectly defined as showing a time series of indices.

In the UWTV section the decrease in estimated abundance for 2010 (892 to 753 million) is defined as 18.5% where in the Exploratory analyses of RV data section it is defined as a 16% reduction. It should be an 18.5% reduction.

Conclusions

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.

Nephrops in Division IVa (Fladen Ground, FU7) nep-7

1) **Assessment type: Update**
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented.
4) **Assessment 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.
6) **Stock status**: The stable mean sizes in length of smaller individuals over a long period of time suggest the stock is being harvested sustainably. The estimated bias adjusted abundance for 2011 is 3,382 million individuals which is lower than the 2010 estimate of 5,224 million individuals but still higher than the MSY Btrigger value of 2,767 million individuals. ICES Fmsy framework dictates that the recommended F should be the current Fmsy proxy (F0.1(T) = 10.3%). Current HR taken as average from 2009-2011 = 8.5%
7) **Man. Plan.**: Management is at the Sub-area level. The 2011 EC TAC for *Nephrops* in sub-area IIIa and IV was 23,454t in EC waters with 1200t in Norwegian waters. There has been a further reduction to 21,929t in EC waters and no change (1200t) for Norwegian waters. No Biological Reference Points defined for this stock.

General comments:

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.

Technical comments:

Unable to find Figure 3.5.

Conclusions:

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.

Nephrops in Division IVb (Firth of Forth, FU8) nep-8

1 **Assessment type: Update**

2 **Assessment**: analytical/trends

3 **Forecast**: Short term forecast presented

4 **Assessment model**: Bias corrected absolute abundance from Underwater TV survey

5 **Consistency**: Same approach for assessment since 2009

6 **Stock status**: Density estimates from TV surveys are generally higher than most Northern FU's. Abundance for this stock has been declining since it peaked in 2008. The 2011 estimate was 24% less than 2010 at 533 million individuals. The stock is close to the average abundance and above MSY $B_{trigger}$ (292 million). Landings decreased slightly in 2010 and 1011 (1888t) and are just below the long term mean of 1906t. 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 of 21,929t. There is no agreed management plan for this stock. No biological reference points have been defined.

General comments

Nephrop densities observed in the FU8 UWTV survey are relatively high, dominated by males and no sign of a decrease of >35mm individuals. This information combined with a long time series of stable landings suggest a productive stock. Fmax was chosen as the Fmsy proxy.

Discard rate of undersize *Nephrops* has decreased in the last 5 years and continues to do so in 2011. The average rate is 30% but the 2011 is just below 20%. This population appear to have smaller individuals than other FU's due to slower growth.

This stock appears to be showing no signs of over-exploitation, however the 2010 and 2011 harvest ratio was greater than Fmsy proxy. Forecasts indicated a reduction in landings from 1888 in 2011 to 1324 for the harvest ratio the be equivalent to the Fmsy.

Technical comments

In previous years the RG was concerned about the occurrence of *Nephrops* just out side the boundaries of FU 8. It appears that the area known as Arbroath is outside the Firth of Forth FU and is considered as part of another area. It was not considered with FU 8.

The mean density of burrows/m2 in 2011 and the subsequent abundance estimate was the lowest since 2002.

The Fmsy proxies obtained from the per-recruit analysis were updated this year using the 2008-10 catch-at length data. A number of Fmsy proxies have been identified for this stock. Although there has been similar effort to last year, landings have increased slightly, the harvest ratio increased from0.184 in 2001 to 0.221 in 2011 which is above Fmax.

Conclusions

The assessment has been performed correctly with the available data.

The current estimate of stock abundance is above MSY Btrigger 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."

Nephrops in Division IVa (Moray Firth, FU9) nep-9

1) **Assessment type:** Update
2) **Assessment**: analytical/trends
3) **Forecast**: Short term forecast presented.
4) **Assessment model**: Bias corrected absolute abundance from Underwater TV survey
5) **Consistency**: Same Approach since 2009. Per-recruit updated using 2008-10 catch-at-length data resulted in some minor changes in per-recruit Fmsy proxies. New procedures implemented for raising the Scottish commercial data in 2010. Data revised from 2000 to present.
6) **Stock status**: TV survey data indicates the stock to stable but at a lower level then seen from 2003-2005. There are however indications that the stock has been decreasing since 2007 although not statistically significant. Total landings increased from 1017 in 2010 to 1391t in 2011 and LPUE from 282.5 to 352.8. The current adjusted abundance of 372 million individuals is down again in 2011, but higher than the MSY Btrigger value of 262 million individuals. The harvest ratio in 2011 increased substantially in 2011 (0.11to 0.19), the highest since 2006, and was greater than the Fmsy proxy (F35%SpR(T)) of 11.8%.
7) **Management Plan**: Management is at the Sub-area level. The TAC for *Nephrops* in sub-area IIIa and IV was 21,929t in EC waters with 1200t in Norwegian waters. No biological reference points have been defined for this stock.

General comments

Landings increased from 2010 to 2011 by 35%, a substantial increase of the previous 2 years. Mean size of both males and females decreased from 2010 to 2011. Males, which represent the largest portion of the catch, mean length in landings was the lowest since 1997. The number of burrows in 2011 was the lowest since 2003.

Discards in 2011decreased from 0.2 to 0.14 and may account for the smaller mean size observed in the catch and landings.

Refining the effort data series further back in time and by quarter will be beneficial to the assessment.

Management at the FU level would help protect this stock.

The recommended F_{msy} proxy is $F_{35\%SPR(T)}$ and historic landings have been near this harvest rate are thought to be sustainable. The estimated 2011 harvest ratio (19%) is well above the Fmsy proxy of 11.8%.

The current harvest rate has increased dramatically from 2010 and may be a result of shortages of *Nephrops* in the much larger FU7 (Fladen Ground).

Technical comments

Although some the factors affecting the high values of LPUE related to the incomplete databases between Marine Scotland Science and Marine Scotland Compliance have been resolved and the data revised back to 2000, the time series need to be extended back to provide quarterly data.

The survey density estimates were the lowest since 2003 and may reflect a decrease in recruitment given the fact that discarding seems to have decreased substantially.

There has been a slight decrease in the catch and landed length composition from 2010 to 2011 that if it continues could imply the current exploitation may not be sustainable. There are however no major changes in the mean length of males or females greater than 35mm.

Conclusions

The RG 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

Nephrops in Division IVa (Noup, (FU 10) nep-10

1 **Assessment type: Category 6/*Nephrops***

2 **Assessment**: N/A

3 **Forecast**: N/A

4 **Assessment model**: Underwater TV (UWTV) absolute abundance

5 **Consistency**: Surveys are sporadic. Last survey occurred in 2007.

6 **Stock status**: Unknown. No reliable estimate for this stock due to the lack of data. Total landings were 69t.

7 **Man. Plan.**: There is no agreed management plan for this stock. 2010 advice biennial. Precautionary reference points have not been defined.

General comments

There is very limited data for this FU and the fishery is small. Landings are from a mixed fishery taken by demersal trawlers. Landings for 2011 were 69t, an increase from 38t in 2010 (lowest reported since1997). LPUE increased slightly in 2011 but interpretation of these data are difficult because of the lack of targeting.

Densities from earlier surveys indicated the number of burrows per m2 is relatively low for this stock at 0.2.

Technical comments:

The working group took a different approach to provide guidance on biomass for different harvest ratios using landings and information from adjacent FU. Harvest ratios greater than 10% are identified. For this FU landings in the order of current landings would result in a harvest ratio of 4.2%

Conclusions

Under the new approach for data poor stocks FU 10 (Noup) 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.

Nephrops in Division IVa (Norwegian Deeps, (FU 32) nep-32

1 **Assessment type: Category 6/*Nephrops***

2 **Assessment**: N/A

3 **Forecast**: N/A

4 **Assessment model**: Trends in logbook LPUE. No Analytical assessment model. Norwegian shrimp trawl survey but catches too small to be useful.

5 **Consistency**: Lack of consistency is sampling over the time series.

6 **Stock status**: Based on trends in Danish LPUE. Current fishery appears to be sustainable based on limited information.

7 **Man. Plan.**: Fishery occurs in the Norwegian zone of North Sea a 1200t EU vessel TAC. Currently there is no Norwegian vessel TAC, but the TAC has not been restrictive and managed by separate quota (TAC). No reference points have been defined for this stock. .

General comments

Landings from this FU in 2011are the lowest since 1993 at 395t. This may be due to a reduction in the number of vessels and increasing fuel cost. Whatever advice is given could be exceeded, if oil prices decrease. Oil price may the best protection of marine species

This stock is data poor. Current trends based on LPUE from Danish logbooks. Norwegian logbooks considered unsuitable for LPUE analysis due to small and variable portion of the landings. There may be some technology creep due to changes in vessel size for both the Danish and the Norwegian fleets that could affect trends in LPUE.

Table 3.3.7.2 legend needs to be updated to incorporate the addition of 2011 data.

Danish landings comprised about 80 of total in 2011. Minimum mesh size larger than some areas at 120mm. Poor sampling of Danish landings in 2011 likely 2012 due to changes in the Danish at-sea sampling programme. Sampling can be intermittent. Discards appear to have decreased in recent years but there are no discard data for 2011.

Technical comments

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 32are very low at <2% even when landings were in the order of 1000 to 1200t.

LPUE do not indicate that density is lower than in other areas but they are around 250 kg/day. Is that because fisheries are only taking place when CPUE is high enough so effort tells us more about state of the stock than cpue. Of course price of fuel and *Nephrops* plays a role here.

Conclusions

The RG agrees with the WG conclusion that the level of exploitation is sustainable based on very limited data. Under the new approach for data poor stocks FU 32 (Norwegian Deep) 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.

Nephrops in Division IVb (Off Horn Reef, FU33) nep-33

1) **Assessment type: Category 6/*Nephrops***
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: Trends in logbook LPUE. No Analytical assessment model.
5) **Consistency**:
6) **Stock status**: Data Poor. Unknown
7) **Man. Plan.**: North Sea TAC not restrictive for this stock.

General Comments

Total landings increased from 806 in 2010 to 1191t in 2011.

This is a data poor stock. Mean size in landings for both sexes appear not to be changing but the data are limited and incomplete.

Danish LPUE has long time series (1989-present), but highly uncertain. Netherland LPUE began in 2005 but shows similar trends on a different scale for the overlap. There may be some technology creep in the data and changing country fishing fleet effort. The Danish has traditionally dominated the fishery, however in recent years the Netherlands have taken an increased portion of the landings.

Figure 3.3.8.2 was not found in the documents provided.

Technical comments

Landings since 2000 seem to be sustainable, the question is what effort means. Using VMS data to get the size of the area would be a useful proxy for the stock size as the density is probably rather high - at least if LPUE's are reflecting density. Is there a possibility that other factors affecting the LPUE and mentioned in the report. Oxygen content may play a role here. Increased temperature could do the same.

LPUE in 2011 was the highest in the time series and high compared to other areas. Why is effort decreasing when LPUE is so high? Is effort a measure of stock size rather than LPUE. Is the stock available for very short period each year? A Figure of LPUE from different areas on the same plot would be useful.

Conclusions

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 bases of precautionary considerations – catches should be reduced.

Nephrops in Division IVb (Devils Hole, FU34) nep-34

1) **Assessment type: Category 6/*Nephrops***
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: Underwater TV absolute abundance
5) **Consistency**: Surveys are opportunistic and not annual. Sampling is poor and likely to occur in 2012
6) **Stock status**: Data Poor. Unknown
7) **Man. Plan.**:

General Comments:

This is a newly designated FU due to the increasing *nephrop* landings outside the traditional FU's. Landings data available from 1991, peaked in 2009 at 1306t, but declined to 433 in 2011. Intermittent opportunistic TV surveys (2003, 2005, 2009, 2010 and 2011) have been undertaken over the years with densities of <0.4.

Figure 3.3.9.5 needs to be updated to include 2011.

Market and discard sampling poor. Only available for Scottish fleet and may be biased due incomplete quarterly sampling. No samples in 2011.

Estimation of appropriate bottom area for raising density estimates was thought to be in error and re-evaluated using several methods. Using approximately 1100km^{2}and the 2011 density of 0.26 produced a biomass estimate of 350 million individuals, without bias correction for edge effects etc.

Based on the estimated guidance approach of using the available data and input estimates from adjacent areas, the harvest rates in FU 34 is unlikely to exceed 10% when landings average, however, the current landings (1300t) carry a higher risk of exceeding Fmsy proxies.

Technical comments:

Area estimates of suitable bottom habitat are variable over time. The geographical distribution of *Nephrops* suitable bottom type needs to be determined as it forms the bases for estimating absolute biomass.

Conclusions

The RG agrees with the general conclusions of the WG. Under the new approach for data poor stocks FU 34 (Devil's Hole) 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.

Norway Pout in ICES sub area IV and division IIIa nop-34

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: SXSA + 3 commercial (1st, 3rd and 4th quarters) + 4 surveys (1 in 1st quarter and 3 in 3rd quarter).
5) **Consistency**: 2011 assessment accepted. For May 2012 parameter settings for natural mortality, maturity at age, and mean weight at age have been changed in the assessment.
6) **Stock status**: Based on estimates of SSB from September 2011 ICES classified stock at full reproductive capacity with SSB well above B_{pa} (150,000 t). Q1 (2012) SSB (168,629 t) is also > than B_{pa}, but is expected to decrease to below B_{pa} in 2012 (even at F=0) because of high natural mortality, 20% maturation at age 1, and recent low recruitment.
7) **Man. Plan.**: There is no specific management plan for this species. Bi-annual information is used to provide real-time monitoring and management of the stock.

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.

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.

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.

Conclusions

The RG agrees with the WG conclusions for this stock.

Plaice in Subareas 21–23 (Kattegat, Belts and Sound) ple-2123

1 **Assessment type: Category 3**

2 **Assessment**: Exploratory

3 **Forecast**: not presented

4 **Assessment model**: SAM with same settings as WKPESTO. Only the 4 surveys indices were used for tuning.

5 **Consistency**: First year of new stock definition yet to be approved.

6 **Stock status**: Unknown/unreliable due to short time series. Change is stock structure in accordance with recommendations of WKPESTO -2012 have not been approved.. Total landings for all 3 SD were 1534t in 2010 and 1586t in 2011. This represents a general decrease in SD 21, an increase in SD 22, and a decrease SD 23.

7 **Man. Plan.**: No management for this yet to be approved fish stock. Landings in 2011 should not exceed 8000t, the average of landings over 2007-2009.

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 ple-2123 was part of the Division IIIa. 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.

Unfortunately, neither the assessment nor the diagnostics for the assessment were provided to the reviewers for the exploratory run so it is difficult to evaluate the outputs. That being said there is relatively good internal consistency with ages in the surveys with the Q1 appearing to bet better than Q3 of the IBTS and Q4 of the KASU. The KASU also has better consistency for younger ages 1-3.

Misreporting is not believed to be significant. Discard data available for 2011 only consequently no discard data included in the assessment.

Landings vary among the SD have varied widely over fishery. SD 21 dominated the landings the mid-1990’s but has general been declining since 1992. SD22 landings increased in the late 1990’s to early 2000’s then declined again, whereas SD 23 has dropped dramatically since 2007, although it proportion of the total catch has always been small.

The time series is short thus confidence intervals are broad and the model would not converge for the retrospective analysis.

No final assessment was presented, however, the output summary from the exploratory SAM assessment appear to follow the general perception of observations. Based on the model the SSB has been increasing and F decreasing due the reduced landings of the past 4 years. Recruitment estimates have been generally increasing since 2008 and are about average.

Technical comments

Only scientific tuning fleets were used in the exploratory assessment and uses the same settings as the WKPESTO SAM run. Inclusion of age 1 and updating the time series seems to have improved the assessment.

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.

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.

Plaice in Division IIIaW (Skagerrak) ple-skag

1 **Assessment type: Category 5 – Catch Data only**

2 **Assessment**: N/A

3 **Forecast**: N/A

4 **Assessment model**: N/A

5 **Consistency**: First year of new stock definition yet to be approved.

6 **Stock status**: Unknown. Change is stock structure in accordance with recommendations of WKPESTO -2012 have not been approved.

7 **Man. Plan.**: No management for this yet to be approved fish stock. Proposed to us the North Sea as a global index/trigger, commercial CPUE as a proxy in western Skagerrak, and the IBTS index for eastern Skagerrak.

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*. (2010) 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.

Plaice in Division IIIa (Skagerrak – Kattegat) ple-kask

1 **Assessment type: Category 4**

2 **Assessment**: N/A

3 **Forecast**: N/A

4 **Assessment model**: Exploratory XSA and Exploratory SAM

5 **Consistency**: No final assessment since 2003.

6 **Stock status**: Unknown. Total landings in 2011 were 8,709t, a small decline from 2010 landings of 9,168t and below the TAC of 9,938t. The perception from a North Sea fisher surveys is that the abundance is decreasing in Skagerrak and Kattegat .

7 **Man. Plan.**: No explicit management objectives for this stock. ICES advises on precautionary considerations to reduce catch.

General comments:

The proposed changes to plaice stock represents a divergence from the traditional stock structure where IIIaW is not considered part of the traditional Division IIIa complex. The recommendation to redefine the stock structure is based on extensive work by the WKPESTO which reviewed all of the available information, but has yet to be approved. 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.

No final assessment. Last analytical assessment that was accepted was in 2004.

The text is well organized and easy to follow however the figure and table references are off in places. Problems relatively well described so it is relatively easy to identify the problems but they are not easily solved.

The difficult problem for Division IIIa is still mixing with North sea plaice. The survey indices might be representing plaice in IIIa but variable proportion of the landings is NSEA plaice and therefore the system does not make sense, it is just like running assessment with wrong catch numbers. No solution apparent, but moving the borders between stocks typically solve one problem, but introduce others.

There seem to be data and sampling limitations for this stock that are well documented in the report. The survey coverage issues and stock boundary/migration issues present hurdles for the assessment. There are some recommendations from other review groups like PGCCDB. One of them is to increase survey effort where most of the catches take place but those are also the areas of mixing with North Sea Plaice so interpretation of the survey indices would not be easy.

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.

Perhaps a large scale tagging study could provide new information on migratory patterns as well as a new source of data to estimate natural mortality.

The minimum landing size is 27cm still majority of boats operating with around 80 mm mesh. Why is the mesh size not increased as the small plaice is anyway discarded.

Technical comments

Stock assessment shows notable difference in F between SAM (falling since 1995) and XSA (Stable but noisy since 1995). Probably normal due to conflicting signals.

As mentioned length-based models could be useful if the reliability of age readings is questionable. They are also very useful for describe the discard process. They do not on the other hand solve the problem with variability in growth seen between samples except the variability is mostly caused by too few samples.

Figure 7.1.1 not referenced in text.

Table 7.2.1 not referenced in text.

Table 7.2.3 referenced before table 7.2.2.

Landings weight at age and stock weights at age seem to cross each other quite a bit. It appears that sampling is not adequate to capture the true patterns or there is high variability in growth.

Exploratory XSA has a large and inconsistent retro pattern in recruits.

Conclusions

The RG agrees with the WG conclusions for this stock.

Plaice Sub-area IV (North Sea) ple-nsea

1) **Assessment type:** Update
2) **Assessment**: Analytical
3) **Forecast**: Presented (short term)
4) **Assessment model**: FLXSA – tuning by 3 surveys (2 beam trawl and 1 sole net)
5) **Consistency**: Update of 2011 assessment. Belgian data for DFS recruitment index available this year. These data were not available in 2011.
6) **Stock status**: The stock is well within precautionary boundaries. F = 0.23 which is close to Fmsy = 0.25 and well below F_{pa} = 0.60 (based on 5th percentile of Floss = 0.74). SSB= 476,063t which is well above MSY Btrigger = 230,000t = B_{pa} (based on 1.4 B_{lim}) and B_{lim}=160,000t (based on lowest observed biomass in time series).
7) **Management Plan**: EU Council Regulation implies increasing F to target value of 0.3, with a maximum TAC increase of 15%. For 2012 the maximum TAC increase results in TAC of 84,410t. Fishing mortality in 2012 should not be more than F_{pa} (0.6) corresponding to landings less than 155,500t. SSB is expected to be above B_{pa} in 2013.

General comments

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.

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.

Length based model where the selection of the retaining operation (or discard operation) 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.

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?

The introduction paragraph to the section needs to be expanded. See section 12 for an introduction paragraph that is very useful to reviewers.

Tables are not presented in the text in the numerical order that they appear in the section.

Estimates of F, recruits and SSB have consistent retro patterns.

Technical comments

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?

Using indices from separate areas for tuning as if they both represent the 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.

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 (page 27) they show many year-classes dropping incredibly slowly in recent years. Their numbers drops much more in the landings (table 8.2.6). 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 seens to be in survey data.

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.

As mentioned by reviewers last year, the assumption of M = 0.1 may need to be reexamined 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.

Section 8.10, Status of the Stock, has not been updated with 2011 values.

Conclusions

The assessment was performed correctly. The RG agrees with the WG on the conclusions for this stock and the suggestions for improvement moving forward.

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**: Settings in XSA assessment changed from 2011. BE Beam trawlers age range changed from 2-10 to 2-5, UK Beam Trawl survey age range changed from 1-6 to 4-6. Plus group changed from 10+ to 7+. Catchability plateau changed from Age 7 to Age 5. No exploratory SURBAR runs done this year but exploratory SAM runs were added.
6) **Stock status**: Trends only. Reference points not valid for advice. F decreasing for last few years with SSB is increasing.
7) **Management Plan**: No explicit management objectives for this stock. The TAC for 2012 is set at 4,625t.

General comments

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.

While setting the plus group to 7 did reduce the retrospective patterns in SSB and F, there is still a fairly large retro pattern in recruitment. Recruitment is poorly estimated for this stock and this problem was likely exacerbated by truncated the survey age ranges as well as the inability to include discard information.

The fact that discarding in the stock is substantial and yet information on discards cannot be included in the assessment is problematic.

The disagreement between survey trends and the commercial fleet, which seems to be a timing issue, suggests the survey indices are not capturing the full dynamics of the stock. Can the timing of a survey be planned to overlap with the fishery? A better temporal overlap between the surveys and when plaice are being landed in VIId would be helpful.

SAM model is not detailed in the stock annex for this species and there was no description about the model in this section.

Technical comments

This is the report for section 6 but the section labels are for section 7?

Under section 7.2.5 (Should be 6.2.5 as referenced above): Figure 6.2.5.1 shows LPUE not CPUE.

Conclusions

The RG agrees with the WG conclusions for this stock. As a reviewer noted last year, it may be worthwhile to explore the SCA model that is used for North Sea Plaice to estimate discards and abundance for this stock.

Pollack in ICES sub area IV and Division IIIa Pol-nsea

1) **Assessment type:** Category 4 – Survey based analysis
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: Landing trends
5) **Consistency**: N/A
6) **Stock status**: Unknown. Landings in IIIa in 2011 (395 t) were lower than 2010 (552t). Landings in IV in 2011 (1671 t) were higher than landings in 2010 (1485 t).
7) **Management Plan**: No management plan specified.

General comments

No analytical assessment has ever been carried out for these stocks.

Looking at the general trends in landings it appears that both IIIa and IV show a declining trend over the time series. The landings pattern follow each other very closely except at a different magnitude. The report characterizes subarea IV as having no clear trend. I would characterize that over the time period examined landings in subarea IV have showed a general decline.

Collection of biological data on growth and maturity recommended by WKNEW and WGNSSK should be a priority going forward. Pollack is considered primarily a bycatch in other fisheries.

Technical Comments

In the "Survey data/recruit series" section the figure references are off. 15.1 should read 15.2 and 15.2 should read 15.3.

Table headings and figure headings referencing landings need to specify that landings are in tonnes.

Conclusions

RG agrees with WG conclusions for this stock. Increased collection of biological information on these stocks will help improve the assessment.

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 3 survey fleet for tuning.
5) **Consistency**: . Final assessment used same settings as in the revised assessment from autumn 2011. WGNSSK decided to use full age range in the commercial indices.
6) **Stock status**: SSB (216,972t) > B_{pa} (200,000t), > B_{lim} (106,000t), and F(0.284) < F_{pa} (0.40) and <F_{lim}(0.60). SSB and F have declined in recent years with F showing a steep decline from 0.595 in 2011 to 0.284 in this assessment.
7) **Man. Plan.**: Plan agreed to 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. The final assessment which is consistent with the revised assessment from Fall 2011 and includes a full age range in the commercial indices and an alternative where ages 3-5 are excluded.

Poor estimates of recruitment are still a serious concern for this assessment. An inconsistent retro pattern is present for recruitment estimates coming out of the final assessment. However, the retro patterns coming out of the final assessment are smaller and more consistent than the patterns coming out of the alternative assessment.

F is currently very close to the target F of 0.3.

The WG did an excellent job in this section outlining how each comment from the review of last year's assessment was addressed for the 2012 assessment. It is indicated that a number of the comments, suggestions will be addressed at a possible inter-benchmark assessment.

Technical comments

Figures 11.1.1 and 11.1.3 would benefit from a legend quantifying the relative bubble sizes.

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.

Conclusions

RG agrees with the WG on the conclusions. Hopefully information from the IMR acoustic survey will help improve the reliability of the age 3 recruitment estimates.

Sole in Division VIId (Eastern Channel) sol- eche

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Short-term forecasts presented,
4) **Assessment model**: XSA– 2 commercial and 3 survey fleet for tuning. Data for UK-YFS not available for 07-11
5) **Consistency**: Last year's assessment was accepted. Same settings for this year's assessment. Somewhat inconsistent retrospective patterns in F, SSB, and recruitment.
6) **Stock status**: SSB(11,854) >B_{pa}(8,000) since 2001, F_{lim}(0.55)>F(0.42)>F_{pa} (0.40), F has generally increased over past 5 years to a high of 0.57 but declined slightly in 2011. SSB increased in 2011 and is predicted to increase for 2012. Recruitment is well above the 1982-2009 GM.
7) **Man. Plan.**: No defined management plan. Stock managed by TAC, minimum mesh size and minimum landing size.

General comments

The text of the report was well constructed and written and very easy to follow. 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.

Many of the figures are also very small and would be better served spread out on multiple pages so they are easier to interpret (Figures from Section 10 are small but well organized and easy to follow).

The Quality of the Assessment section was very detailed. The working group did a good job explaining issues with the current assessment

This stock has benefited from better than average recruitment in 5 of the past 7 years. Landings (4133t) are below the agreed TAC of 4852t and SSB above the B_{pa} since 2001.F increased from 2002, peaked in 2009 and has decreased in the last 2 years. Forecasts indicate it will be below the F_{pa} in 2012.

There continues to be the concern for large amount of undersize plaice discards in the mixed beam trawl fishery. A reduction in the number of discards would benefit the plaice fishery.

Technical comments

Update exploratory assessment generally consistent with last year's assessment. There are however several unexplained extremes. These include the relatively high fishing mortality estimated compared with the other ages for age 4 in 2010 and age 5 in 2011, and the downward revision of 2008 year class and the upward revision of the 2009 upward by 173%. These changes should be investigated further for a plausible explanation.

No SURBA-runs were carried out for the update. Last year's assessment indicated SSB and recruitment trends from both XSA and SURBA runs showed similar patterns.

Small revisions were made to the UK-effort and LPUE series for 2010. Effort data from the French fleet in the Eastern Channel were not available for 2009 and 1011. The UK-YFS component last conducted in 2006. The effects of changes and the absence of updated information to the time series are uncertain, but may affect the comparability of the data. This is particularly true for the YFS where the absence of UK information will affect recruitment estimates and subsequent forecasts.

Discards are not believed to be significant for this high valued species, however the occasional discarding of 1-year olds is known to occur and has been documented to a maximum of 9% by weight in one fishery. This may seem like an insignificant amount but when converted to number could be much higher. The lack of any age 1 fish in the catch at age may indicate an increase in discarding. Discards not included in the assessment.

Short term forecasts were based on realistic inputs and used the agreed TAC rather than status quo fishing mortality for intermediate year. Under these assumptions fishing mortality should be reduced to 0.38 in 2012. SSB will increase at status quo for 2013 and decrease some in 2014, however all estimated indicate the stock to be well above B_{pa}.

In section 9.8 BRPs, F_{lim} is defined to be 0.55 while in the status of the stock section F_{lim} is defined to be 0.57.

The assessment value for natural mortality was set at 0.1. On page 8 of the annex natural mortality is listed as being set at 0.2 in the table, and 0.1 in the text following the table.

The catch weights at age and stock weights at age should be put in to a figure so they can be more easily interpreted.

Conclusions

RG agrees with the WG on the conclusions. Overall the assessment appear to be consistent the previous year's assessment. Minor revisions were made to the input parameters. And, the fishing mortality for this stock is predicted to be less than the F_{pa} in 2012. Strong year classes in 2008, 2009 and 2010 will help maintain SSB above B_{pa} in the short term even though F has increased above F_{pa}. The RG agree with using the agreed TAC rather than the status quo for the intermediate year as it is more reflective of the situation. However, fishing at status quo would increase F slightly for 2013.

Sole in Subarea IV (North Sea) sol-nsea

1 **Assessment type: Update**

2 **Assessment**: Analytical

3 **Forecast**: Short-term forecast presented

4 **Assessment model**: XSA and SAM (State Space Model). Two survey time series (BTS-ISIS and SNS) and 1 commercial (NL Beam Trawl) for tuning.

5 **Consistency**: The assessment and input parameters have remained constant since the 2010 benchmark assessment. Retrospective patterns are minimal in F, SSB and recruitment. Only XSA result used.

6) **Stock status**: F (0.3) below F_{pa} (0.4), SSB in 2011 (34,747) just below B_{pa},and > B_{lim} (25,000 t). Strong year classes 2005 and possibly 2009, with 2008 slightly above average. Recruits in 2011 estimated to be just below geometric mean of 94 million. F has declined over last few years of the time series and SSB and recruitment has remained fairly stable.

7) **Man. Plan.**: Multiannual plan for plaice and sole in the North Sea adopted by EU Council in 2007 describes 2 stages: 1. a recovery plan, and 2. a management plan. This year's assessment confirms the recovery plan has been met, despite an SSB hovering around B_{pa}. Biological and MSY (proposed) reference points, EU management plan Target F of 0.2.

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.

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.

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)?

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.

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.

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?

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.

Whiting in Division IIIa (Skagerrak – Kattegat) whg-kask

1) **Assessment type: Category 6 –** data limited
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: Exploratory SURBAR, IBTS Q1 1967-2001 and Q3 1991-2011.
5) **Consistency**: N/A
6) **Stock status**: Unknown. Landings in 2011 (112.9 t) were lower than 2010 (245.4 t) and around 600t lower than the past ten year average landings (710 t).
7) **Man. Plan: N/A**

General comments

Total reported landing for 2011 was 112.91t. It is unclear if the dramatic decrease in landings from 20,000t in the 1980's to present was due to a decline in the whiting stock biomass in IIIa or a changed fishing patterns.

Re-examination of tagging data may provide some insight into the stock dynamics for this species.

Technical comments

Based on SURBAR analysis there a great deal of uncertainty for SSB, Z, relative TSB and relative recruitment indicated by the 90%CI.

There is a real lack of internal consistency between cohorts for both surveys. This inconsistency may be attributed to ageing problems or the mixing of several stock components.

Conclusions:

The RG agrees with the WG conclusion that the internal consistency of the surveys prevents an age based analytical assessment.

Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel) whg-47d

1) **Assessment type: Update**
2) **Assessment**: analytical
3) **Forecast**: Short-term forecast presented, but medium term forecast
4) **Assessment model**: XSA - tuned with IBTS Q1 and Q3
5) **Consistency**: Update is general consistent with last year's inputs except Intercatch was used in 2011 and the latest SMS multispecies model key run for natural mortality. The latter was substantially different from the previous years and had a noticeable scale change in the model outputs.
6) **Stock status**: Unknown with respect to BRPs and MSY reference points. Reference points established in 1999 where B_{lim}=225000t, B_{pa}=315,000t, F_{lim}=0.90, and Fpa=0.65. However, the working group does not consider these reference points valid for the current assessment and as such considers the stock status unknown with respect biological and MSY reference points. The stock was at a historical low between 2005-2008, but has increased in more recent years
7) **Man. Plan.**: No defined reference points (EU/Norway defined BRPs in 1999 using data during time of major discrepancy between survey and catch data and considered inappropriate by WG). There is a provisional long term management plan agreed at EU-Norway negotiations 2010 (not presented in the report nor in the stock annex.).

General comments:

The 2011 total catch was similar to 2010 with a slight increase in the North Sea and a decrease in the Eastern Channel.

WGNSSK in 2001 conclude that commercial CPUE indices should not be used to calibrate assessment model. These arguments remain valid, thus only the 2 survey indices are used.

No defined reference points (EU/Norway defined BRPs in 1999 using data during time of major discrepancy between survey and catch data and considered inappropriate by WG)

Major changes in perception of stock abundance in 2011 due to revised natural mortalities increasing SSB and decreasing F. Figure 12.4.2 show the comparison for the old and new "M" illustrating that the trends are similar however scale is distinctly different. Recruitment and SSB are much higher while F is reduced by about 72%. This makes it extremely difficult to compare with previous assessments and supports the WG request to have the reference points recalculated.

Landing samples were from France and UK but limited sampling of industrial by-catch with no age composition for the by-catch landings. Mean weights at age in the catch and landings are poorly defined for ages which can likely be attributed to inadequate sampling of the fisheries. .This has caused some uncertainty in the applied age composition and weights at age for the by-catch landings in between 206 and 2010. In 2011 by-catch age composition was inferred by Intercatch which may have led to an upward bias in the final year weights-at-age.

Section 12.8 refers to a discussion about the precautionary reference points in section 12.9, the discussion is in section 12.10.

Technical comments

Some of the major issues for this stock will be addressed in a benchmark next year.

The issue of change in catchability in IBTS Q1 since 2007 identified in last year review does not seem to have been addressed this year (due to time constraints). Given that this is model misspecification it remains an issue and needs should be addressed.

Exploratory survey based analysis show some inconsistencies between the surveys for the catch curve analysis and CPUE although for the latter the trends are generally similar. Bothe surveys show good internal consistency in tracking year-classes.

The final XSA assessment diagnostics indicates that Q3 is a better fit to the model and depends less on Q1. Examination of the single fleet XSA runs show relatively similar trends for SSB and Recruitment up to 2011where they change dramatically. F however diverges starting around 2004 and remains divergent until 2011. For Q1 there is an obvious residual pattern with age beginning about the same time. Based on the final XSA run F has been declining, SSB has been increasing, and recruitment declining over the last 4-5 years. According to the WG the retrospective pattern appears to have corrected itself according to Figure 12.3.18. While it may have improved, and is a consistent pattern for both F and SSB, the RG does not think the problem has been rectified. Perhaps it is the weighting on the model in favour of Q3 vs Q1 where the extremes occur that has improved the retrospective pattern.

Although recruitment has improved since the low of 2004 it has remained below the geometric mean of 4.2 million is it appropriate to continue to use the long term mean as an estimate of recruits for projections/forecasts. The pattern for recruitment is still problematic but the WG does a good job of explaining this pattern and the issues will be further explored in the upcoming benchmark in 2013.

The retrospective pattern has improved and is a consistent pattern for both F and SSB. I do not think the problem has been rectified, as is indicated in the text.

Conclusions

RG agrees with the WG on the conclusions for this stock. The assessment has been performed correctly, though it deviates somewhat from the annex. There does appear to be some inconsistencies between last year assessment and this year. The retrospective pattern seems to have corrected itself without explanation. The addition of another year's data and a revised natural mortality are unlikely to fully account for this observed change. Further investigation into the differences are required.

Grey gurnard in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West (Skagerrak) Gug-347d

1) **Assessment type: Category 4**
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: Landing trends
5) **Consistency**: N/A
6) **Stock status**: Unknown. Based on CPUE and survey trends
7) **Man. Plan** No management plan specified.

General comments

There are a number of uncertainties associated in tracking trends in abundance for this stock. There have been no studies on stock identification. Currently considered a single stock, but likely 3 or more if split along Ecoregions (eg., North Sea, Celtic Sea, and the Southern European Atlantic) given the observed variability in the abundance indices among the regions.

Landings data are not really reliable with known large discards, mis-reporting, and pooled species reporting of this low value market limited species. Official statistics are thought to have improved gradually but when needs to be determined. Landings since 2000 have averaged 361t in the North Sea, 65t in the Celtic Sea and 63t from the southern European Atlantic. Landings tables and figures only go up to 2010? What were landings in 2011?

The species is taken primary as a by-catch and a large portion is believed discarded. There are no management regulations for this species.

Sampling is of the commercial fishery is very limited given the amount of discarding.. Age length key shows a broad overlap in length distribution especially between 5 and 10 year olds making the tracking of year classes difficult if samples are biased.

Grey gurnard plays the role of important predator on a variety of important commercial stocks throughout the region. More information on diet, consumption and distribution would be beneficial to a number of assessments.

Technical comments

There are a number of surveys to monitor trends in abundance for the ecoregions. In the North Sea the IBTS Q1 and Q3 provides information of distribution and trends in abundance. However there are major distributional changes from summer to winter which may be a function of water temperature. Both Q1 and Q3 surveys have shown general increases since the early 1990's. However the index can be plagued by a few large sets in any given year.

The CGFS indicates grey gurnard abundance in the eastern Channel has remained low since about 2006. The EVHOE_WIBTS Time series indicate a slight increase over the past couple of years Celtic Sea and the Bay of Biscay. Trends in the indices, although noisy, appear to follow a similar trajectory, but show the former to be higher than the latter.

Real absence of fish older than 5 in the Celtic Sea and |Bay of Biscay Fr-EVHOV surveys. Examining the ALK and the length distribution there seems to be a disconnect between the age 5-10 and the length interval 20-30cm, especially in the EVHOV survey. This should be checked.

The data do not appear to have been updated for 2011.

Several mislabels and omissions in this section.

-Figure 16.2 refers to "catches" in the figure heading and is referenced as showing landing in the text.

-Figures 16.2 and 16.3 are poor figures and difficult to read.

-Section 16.4.1, second paragraph: "…to around 40,000 t (Figure)". What fig ure?

-Section 16.4.2, Survey data/recruit series, end of page: CFGS survey is Figure 16.9, not 16.8. Abundance index at length is Figure 16.10, not 16.9.

-Biological sampling: the ALK is figure 16.15 not 16.14.

-Figure 16.16 is not referenced in the text anywhere?

Conclusions:

Caution is warranted when interpreting the representative of the individual indices for the global resource. There is no evidence that it is a single stock. In fact there are suggestions that the abundance may be varying independently geographically suggesting multiple stocks. Landings are uncertain and could be extremely variably from year to year. Individual surveys tend to reflect trends in their area of coverage, but how this relates to the stock as a whole is uncertain. However based on the survey, the North Sea, the apparent largest component of the stock the trend has been increase for the past 20 years to the highest levels observed in the time series while it has remained at a relative low level in the Celtic Sea and the Bay of Biscay.

The RG agrees with the WG conclusions.

Striped red mullet in Subarea IV (North Sea), Divison VIId (Eastern Channel) and IIIa West (Skagerrak) Mut-347d

1) **Assessment type: Category 4**
2) **Assessment**: N/A
3) **Forecast**: N/A
4) **Assessment model**: N/A
5) **Consistency**: This is the first time ICES has provided advice for striped red mullet.
6) **Stock status**: Unknown. Based landings and survey trends
7) **Man. Plan** No specific management objectives and no quotas for this stock. Minimum size of 16cm before 2002.

General comments

Preliminary data on stock identity suggests there is more than one stock in the ICES area. Here they have been put together as one.

Landings data although listed as Provisional, are definitely incomplete for 2011 with no reported landings from Belgium, Netherlands and the UK. France continues to dominate the fishery. Most landings originate from VIId (80% in 2011) or the southern North Sea (IVc). Landings decreased from a high (4550t) in 2007 to 1558t in 2010.

Limited biological data are available for striped red mullet, primarily from France, especially prior to 2004.

Technical comments

There are a number of surveys that have potential to monitor the abundance of the species. The IBT IV Q1 and CGFS (VIId) from 1988 and IBTS Q3 from 1991. The surveys although noisy appear to track one another visually but this would have to confirmed.

Conclusions:

The RG agrees with the WG conclusions. There is insufficient information to evaluate the status of red striped mullet in Subarea IV (North Sea), and Divisions VIId (Eastern Channel and IIIa (Skagerrak-Kattegat).

Annex 7: Technical Minutes of the North Sea Review Group

Review of ICES	**WGNSSK Report 2012 – Section 4: Sandeel**
Reviewers:	Beatriz Roel (UK)
	Ellen Kenchington (Canada)
Chair WG:	**Clara Ulrich, Denmark**
Secretariat:	Barbara Schoute

General comments

- The results are well presented in the report and figures generally referenced appropriately.
- the WG answered those TORs relevant to providing advice
- The assessments were carried out according to the stock annex description
- General ecosystem information was provided and it was used in the individual stock sections.

The poor fit of SMS-effort to the data is cause of concern. The assumption that fishing mortality is proportional to fishing effort may be driving the assessment results.

Effect of vessel size on CPUE. Fishing effort is standardized in terms of vessel size; other factors that could be influencing vessel efficiency should be taken into account when modeling CPUE.

Pg 177, Eq bottom of the page: define *r* and *sq*

Effect of country on CPUE. This needs to be estimated within the CPUE model.

Sandeel in the Dogger Bank area (SA 1) san-ns1

1) **Assessment type: Update**
2) **Assessment**: Analytic.
3) **Forecast**: Short term forecast presented
4) **Assessment model**: SMS-effort, dredge survey used to tune the assessment.
5) **Consistency**: The assessment model is based on a recent benchmark (WKSAN, 2010). The internal consistency evaluation of the dredge survey, i.e. the ability of the survey to follow cohorts, showed a modest consistency between age 0 and age 1 which has deteriorated in recent years.
6) **Stock status**: The stock at the start of 2012 is expected to be at full reproductive capacity owing to the large recruitment in 2009. Fishing mortality decreased in 2005 from a high level and has since fluctuated without trend.
7) **Man. Plan.**: No.

Technical comments

Table 10 is Table 4.2.2.

Sec 4.2.6. A sensitivity test was conducted to investigate the effect of adverse weather conditions during the survey. The resulting difference between 48,000 tons and 23,000 tons in TAC is rather substantial and not moderate as stated in the Report.

Sec 4.2.7 Data analysis. Fit to the dredge survey data. The residual plot from the fit to the data show strong patterns for age 1; the model appears to expect much higher numbers of sandeel age 1 in the survey; whether this is a model configuration / assumed stock dynamics problem or a problem with the survey catchability for this age needs to be clarified.

Fit to the catch data. There are clusters of negative and positive residuals that suggest changes in selection in the most recent separable period.

Retrospective analysis. There is evidence of slight retrospective bias with a tendency of overestimating SSB in the assessment. This is mirrored by a retrospective pattern in F.

Conclusions

The assessment and the short-term forecast appear to have been performed correctly.The update assessment give a valid basis for advice.

Sandeel in the South Eastern North Sea (SA 2) san-ns2

1) **Assessment type: Update**
2) **Assessment**: Analytic
3) **Forecast**: Short term forecast presented
4) **Assessment model**: SMS effort, dredge survey is tuning fleet.
5) **Consistency**: the internal consistency of the survey was evaluated as medium to high..
6) **Stock status**: Due to low values of F (~ 0.1) since 2007 and the strong 2009 year class, SSB in 2011 is estimated around twice as high as B_{pa}. SSB in 2012 is estimated below trigger and between B_{pa} and B_{lim}.
7) **Man. Plan.**: No.

Technical comments

The WG admits that there is a lack of a reasonable survey time-series to tune Area 2 assessment. The WG should make more use of the information contained in the fishery data such as catch curves to look for a mortality signal and trends on CPUE to set the TAC. I agree with the WG that the fit to the catch at age data is very poor with very large residuals.

A strong correlation between recruitments in Area-1 and Area-2 is shown in the Report, please provide clarification of how the recruitments were estimated.

Figure 4.3.6 Delete 3rd and 4th plots as they are repetition.

Conclusions

Given the paucity of fishery independent data for this stock, the assessment results should be supported by analysis of the fishery data to provide advice. However, effort has been fluctuating at low levels in recent years and CPUE is likely to be very noisy. Advice based on the SA 1 dredge survey may be appropriate based on a good correlation between recruitment in Area-1 and Area-2 mentioned in the WG Report.

Sandeel in the Central Eastern North Sea (SA 3) san-ns3

1) **Assessment type: Update**
2) **Assessment**: Analytic
3) **Forecast**: Short term forecast presented
4) **Assessment model**: SMS effort analytic model
5) **Consistency**
6) **Stock status**: The stock has increased from a record low SSB in 2004 to above B_{pa} in 2010. SSB in 2011 is estimated to be just above B_{pa} and MSY $B_{escapement}$. SSB in 2012 is estimated below trigger and between B_{pa} and B_{lim}.
7) **Man. Plan.**: No.

Technical comments

Reference to Table 4.1.8 (stratified catch rates from a dredge survey) the Table is missing.

The results of including the acoustic survey in the assessment are discussed in the WG Report. The model that includes acoustic data results in a lower log-likelihood / number of parameters ratio than the default model suggesting a better fit to the data. The model seems to fit this index well (CVs at age are low) however, it is not clear from the text in the Report that the survey may provide appropriate indices for the stock in SA 3. If that was the case, the results of this exploratory assessment suggest a lower SSB than estimated by the dredge survey only.

It may be appropriate that in-season monitoring continues in area 3.

Conclusions

The assessment results presented are sufficient as a basis for advice. In-season monitoring may be used to confirm the update assessment at the time of providing advice.

Sandeel in the Central Western North Sea (SA 4) san-ns4

1) **Assessment type: Update**
2) **Assessment**: Trends based
3) **Forecast**: No short term forecast presented
4) **Assessment model**: trends from dredge surveys results.
5) **Consistency**:
6) **Stock status**: Unknown
7) **Man. Plan.**: No.

Technical comments

The CPUE index has shown a declining trend until 2007. More recently it has fluctuated widely suggesting a noisy index as a result of very low effort in the fishery. It is difficult to draw conclusions on trends in stock abundance from a short time-series of age-disaggregated survey indices. The WG statement that stock size is increasing in recent years may be premature. The very limited fishing effort in the area suggests low F.

Conclusions

The state of the stock is unknown and there is no analytical assessment. There is indication of a good 2009 year class which appears to be contributing to the stock in 2011. However, subsequent year classes appear weak. These considerations should be taken into account when providing advice.

Sandeel in the Viking and Bergen Bank area (SA 5) san-ns5

1) **Assessment type: Update**
2) **Assessment**: No assessment
3) **Forecast**: No short term forecast presented
4) **Assessment model**: n /a
5) **Consistency**: ......
6) **Stock status**: ......
7) **Man. Plan.**: no

General comments

Only catch data were presented.

Sandeel in Division IIIa East (Kattegat, SA6) san-ns6

1) **Assessment type: Update**
2) **Assessment**: No assessment
3) **Forecast**: No short term forecast presented
4) **Assessment model**: .n/a
5) **Consistency**: ......
6) **Stock status**: unknown
7) **Man. Plan.**: No.

General comments

Only catch data are available.

Sandeel in the Shetland area (SA 7) san-ns7

1) **Assessment type: Update**
2) **Assessment**: No assessment
3) **Forecast**: No short term forecast presented
4) **Assessment model**: n/a
5) **Consistency**: ......
6) **Stock status**: ......
7) **Man. Plan.**: Yes... national UK.

General comments

Only catch data were presented.

Annex 8: Technical Minutes of the Norway Pout Review Group

Review of ICES	Norway pout assessment, September 2012
Reviewers:	Carmen Fernández (chair)
	Massimiliano Cardinale (reviewer)
	Norman Graham (reviewer)
	Asgeir Aglen (ADG member)
	Morten Vinther (ADG member)
Chair WG:	Clara Ulrich (Denmark)
Secretariat:	Poul Degnbol, Michala Ovens

Norway Pout in Subarea IV (North Sea) and Division IIIa (Skagerrak-Kattegat) (Assessment type: update

1) **Assessment**: analytical
2) **Forecast**: presented
3) **Assessment model**: Seasonal XSA with one commercial tuning fleet and two survey series
4) **Consistency**: This stock is assessed twice a year. The spring assessment provides in year advice i.e. stock status, and the autumn assessment provides a catch forecast for the following year based on the addition of the Q3 survey data from the Scottish and English Groundfish surveys
5) **Stock status**: B>MSY Btrigger There are no F reference points for this stock
6) **Man. Plan.**: There is no agreed management plan for this stock

General comments

The stock was benchmarked in 2012 and the autumn assessment is simply an update of the methods agreed during the benchmark (IBP Norway Pout, ICES 2012). Model setting were checked against the stock annex and all were found to be in accordance with the agreed protocol

Technical comments

The main substantive changes relate to changes in the stock weights at age, maturity at age and natural mortality. It is noted that stock weights at age are highly variable and an average of the previous 8 years is used in the assessment. Given that the year estimates are highly variable and the stock is characterised by occasionally periods of very high recruitment i.e. 2012, it is possible that density dependent growth can in part explain the variance in under-annual stock weights. This, combined with the application of a new maturity ogive, will make SSB estimates for the forecast year highly sensitive to these two parameters. Further sensitivity analysis should be undertaken to explore this possibility.

The assessment uses one commercial tuning fleet (until 2006) and the IBTS Q1 and Q3, the Scottish Groundfish and English Groundfish Q3 surveys. Recent survey data from both the EGFS and SGFS indicate that the 2012 recruitment is very strong. While the EGFS 2012 estimate is high, it is within the range of historic observations, the data from the 2012 SGFS is twice that of the highest previously observed thus making the forecast for 2013 is highly dependent on this estimate.

Norway pout are also caught and discarded in other fisheries e.g. *Nephrops* trawl fisheries, while it is likely that these catches are comparatively low, analysis of observer data from the *Nephrops* fleet is recommended.

Given the large 2012 recruitment, it is possible that the fishery could open for the last quarter of 2012. This presents issues for the estimating fishing opportunities for 2013. Two forecast options are presented in the EG report, one assuming no fishery in Q4 2012 and the second where an intermediate quarter F is derived from historic patterns. This needs to be considered in the updated advice for 2013.

For forecast it is assumed that the recruitment next year is the 25% percentile of long-term recruitment, where a geometric mean is normally used in cases with no information on recruitment. The 25% percentile was introduced in the period with consecutive low recruitments as a precautionary approach. However, recent recruitments do not indicate that we are in a low recruitment regime. WGNSSK should consider using the geometric mean for future recruitments.

Conclusions

The assessment has correctly followed the stock annex and no substantive issues have been identified. Future benchmarks should explore the potential for density dependent growth as inter-annual variation in weight at age can be substantive.

Annex 9 Joint WGNSSK/WGMIXFISH Data Call

2 PDF documents in Final Report Pdf.

Annex 10 Real time monitoring of the Area-1 sandeel stock in 2012

Background

The ICES assessment and advice, March 2012 (ICES 2012), estimates of a low TAC (23 000 t) of sandeel in Area for 2012, due to very low 2010 and 2011 year classes. Information for the 2011 year-class is entirely based on observation from a dredge survey, December 2011. However, bad weather conditions during the 2011 survey might have biased the estimate of the 2011 year-class and may indicate the relevancy of an analysis of Real Time Monitoring (RTM) for 2012 (ICES 2012).

This document outlines data and method to be used for the 2012 RTM.

Data and methods

The aim RTM of sandeel is to estimate stock abundance of sandeel from observations of catch per unit effort (CPUE) from the fishery in April 2012. This information is then used as a stock abundance index together with similar information for the period since 1999 to update the ICES assessment, which finally will be the basis for the final setting of the TAC for 2012.

Stock abundance is measured as CPUE in number per age class. Effort is measured as number days absent from harbour for the individual fishing trips, standardised to an average vessel size of 200 GT:

$$\overline{CPUE} = \frac{1}{N}\frac{\sum_1^N Catch_i}{\sum_1^N Daysabsent_i * \left(\frac{GT_i}{200}\right)^{0.449}}$$

Where *N* is the number of trips, *Catch* is the catch in tonnes on a given trip, *Daysabsent* is the number of days absent on a given trip, GT is the gross tonnage of the vessel and 0.449 is the average effect of vessel size as measured over the period 2002 to 2011 using data from all months and the method described in ICES (ICES 2010). Effort (days absent), vessel GT and total catch weight of sandeel by trip are obtained from log book data extracted from the Danish AgriFish Agency's database. Age distribution of the catch is obtained from samples taken by the Danish AgriFish Agency; ideally one sample from each landing. Samples taken at sea by the industry from every third haul, with detailed information on catch position and time will also be used when available to estimate the age distribution of the catch.

The default ICES assessment did not include the new time series of CPUE in April. Figure 2 presents the output of the default assessment and an assessment using the new index for the period 1999-2011. It is clearly seen that the two assessments give almost identical result, however fishing mortality is slightly higher in the assessment with use of the new abundance index. Survey residuals for the Dredge survey in the new assessment (Figure 3) show a very similar picture compared to the default assessment (ICES 2012, Figure 4.2.5). The "RTM April" index shows in general a good correlation between CPUE in April and the year class strength. The CV of the catchability of the RTM age 1 index (0.35) is lower than the CV for the 0-group from the dredge survey (0.44) (Table 1).

The Danish fishery will be opened the 15 April. Catches and effort for the period up to the 1st May (or when the Danish quota has been taken) will be used to calculate the

RTM abundance indices for 2012. After the 1st May it will take at least a week before biological samples are analysed so data can be applied in the new assessment and advice. During the period from May 1st to the new assessment and advice is available, DTU Aqua considers that the fishery can continue (even if the Danish Quota has already been taken) without probable harm to the stock if the CPUE in the second half of April exceeds the average of the same period in the years 2007 to 2011, where the stock was above Bpa. This level amounts to an average of 18 ton/day absent for a standard vessel of 200 GT. Catch rates of vessels of other size are standardised using the equation given above.

References

ICES 2010. Report of the Benchmark Workshop on Sandeel. ICES CM 2010/ACOM:57.

Table 1. Statistics for abundance indices in sandeel assessment including the RTM time series.

```
Survey catchability:
--------------------           age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2011       2.068    1.604
 RTM April. 1999-                       1.734    1.610    1.041    1.041

sqrt(Survey variance) ~ CV:
---------------------------    age 0    age 1    age 2    age 3    age 4
 Dredge survey 2004-2011        0.44     1.26
 RTM April. 1999-                        0.35     0.66     0.66     0.66
```

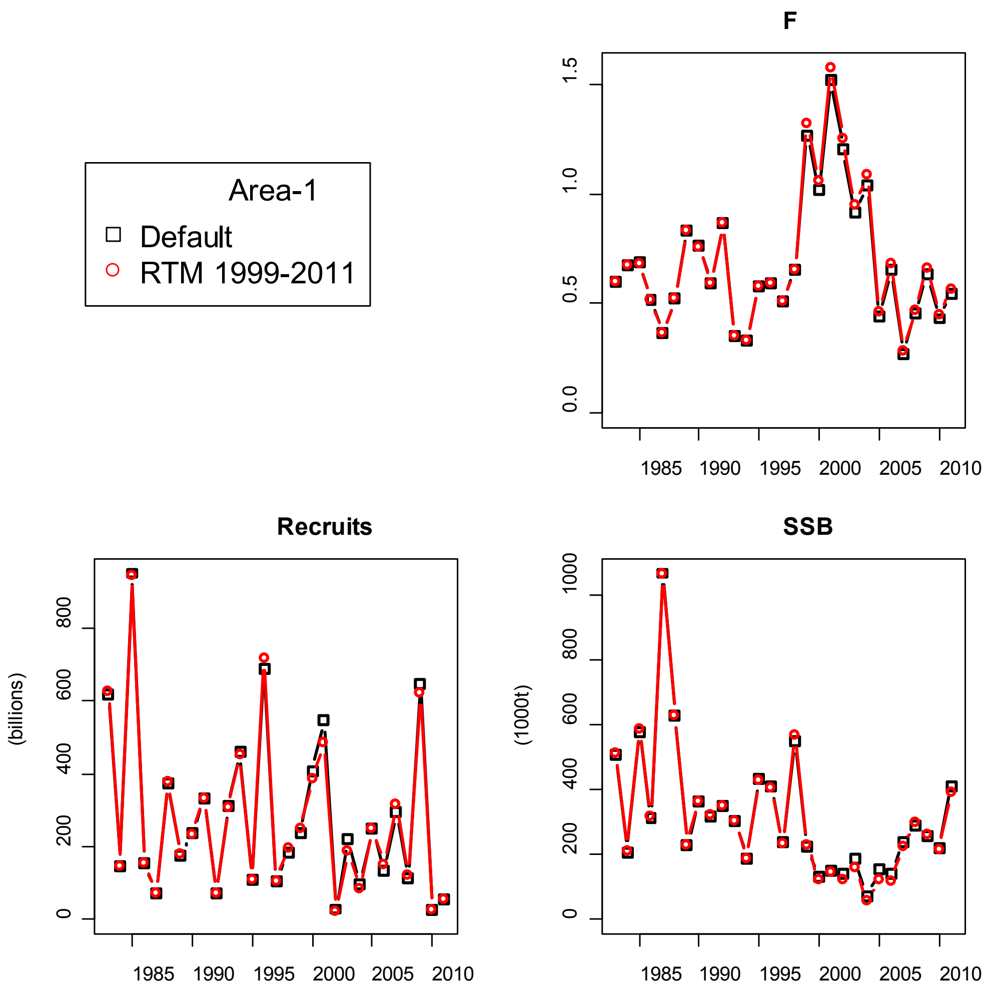


Figure 2. Assessment results from the default ICES assessment of area 1 sandeel (ICES, 2012) and the same assessment updated with e new Real Time Monitoring abundance index obtained from the fishery in April.

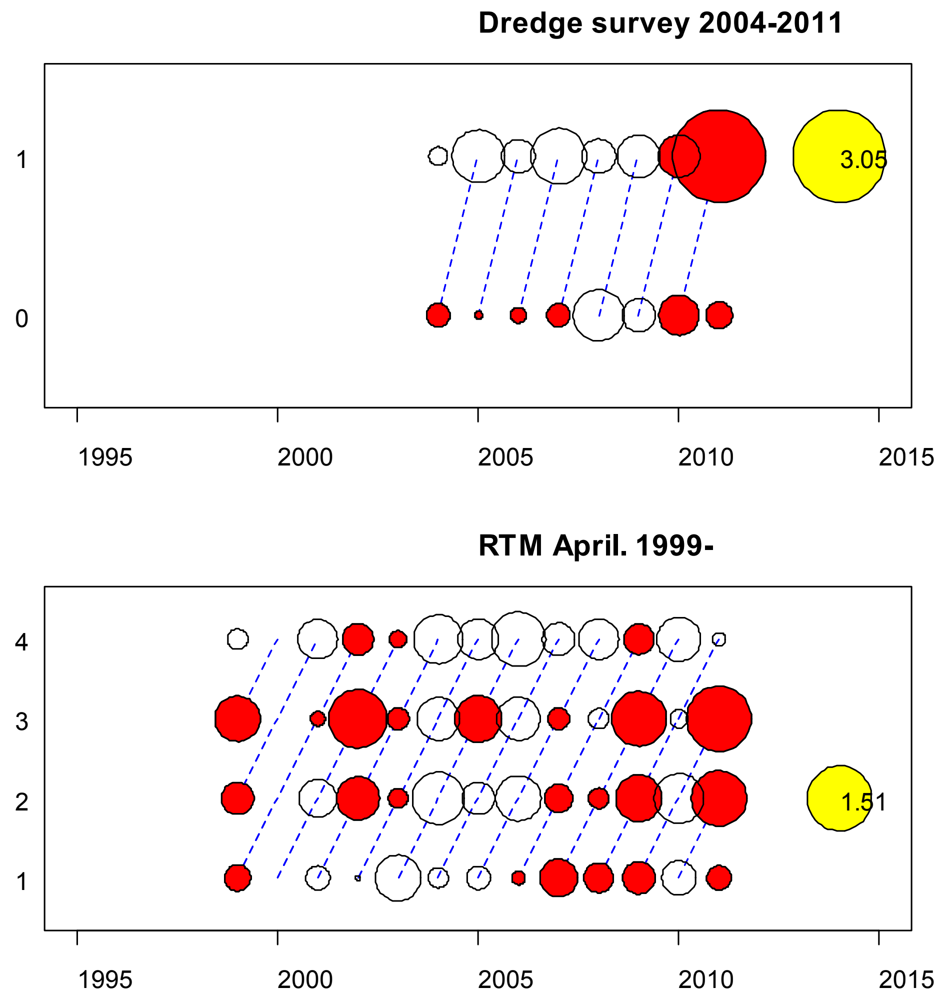


Figure 3. Residual plots from abundance indices. The area of the dots is proportional to the absolute value of the residual. Red dots show that the observed CPUE is higher than the expected.