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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

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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

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0 Executive Summary

The ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) met at ICES Headquarters in Copenhagen, Denmark, during 4-10 May 2011. 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

One new stock was added to the groups Terms of Reference, Pollock (*Pollachius pollachius*) in the North Sea ecoregion. Normally a "new" stock would be dealt with by WGNEW, but given the immediacy of the requirement for advice of this stock it was passed directly to WGNSSK. Given the circumstances a full analytical assessment was not possible (and will not be for several years to come) and the Group was restricted to compiling landings and some effort data.

The data quality issues raised in 2010 were largely repeated in 2011:

a. the scheduling of the meeting in May imposing severe stress at some national laboratories as a result of the concentration of the majority of ICES assessment working groups into May

b. the timing of the meeting being close to the date at which survey information from the IBTS quarter 1 survey was first complete

c. inconsistencies in IBTS indices caused by re-submission of data were only picked up in the days before the start of the meeting and a final solution only resolved *during* the meeting

d. some severe inconsistencies in the stock trends coming out of the various sources of information.

e. Problems were encountered with extraction of data from Intercatch.

Although the deadline for submission of data for assessment was set well in advance of the meeting, several data sets were delivered beyond this point and in some cases not until during the meeting. The National Laboratories work hard to provide the data for all ICES assessment working groups, but the concentration of these groups into a few weeks in April and May causes significant problems. Although the Chairs set deadlines for the submission of data the Groups are, ultimately, hostages to the data actually arriving; without complete sets of landings data the assessments can not be performed.

As in previous years, the system of benchmark/update assessments could not be entirely followed by the WG. Various changes in data availability and/or consistency raised important issues for the assessment of a number of stocks.

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. The mid-year update of the Norway Pout assessment shows the stock to be well above Btrigger at the start of 2011, however a very low recruitment estimate for 2010 means that only a minimal fishery (6000t) can be supported in order to maintain the SSB above MSY $B_{escapement}$ at the start of 2012.

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 yearclass 0-group in areas SA1 (Dogger) and SA2 (SE North Sea). The stock assessments of Sandeels are therefore performed in January. Landings of sandeel were capped at 400kt in 2010 and the TAC was taken. The stock in areas 1 and 2 appear to be in good condition whilst the other areas are more marginal or unknown.

Assessment of **cod in Sub-area 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. Fishing mortality is estimated to be continuing its downward trend (albeit at a slower rate than expected) and SSB is increasing. Unallocated removals still form a significant portion of total mortality.

The assessment of Haddock in IV and IIIa was benchmarked in 2011. The assessment remains largely unchanged from the previous settings. SSB remains above $B_{trigger}$ and fishing mortality is below the F_{MSY} estimate. Recruitment in recent years has been generally low although moderate in 2009.

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.

The assessment of Saithe in IIIa, IV and VI continued to be problematic albeit for different reasons than in 2010. The benchmark in 2011 resulted in a change of tuning indices to a greater reliance upon scientific surveys. Changes in the distribution of the fishery and results from the surveys indicate possible hyper-stability (contraction of stock distribution maintaining good catch rates whilst the stock abundance reduces). The 3 year forecast used as the basis for advice in 2010 appears to have been over-optimistic and despite relatively constant landings the stock is now estimated to be below MSY $B_{trigger}$ and F to have increased.

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}.

The assessment of **Plaice in VIId** is considered indicative of trends only as the absolute level of stock is dependent upon the levels of exchange with the North Sea component (and to a lesser extend the component in VIIe). Again fishing mortality is estimated to have decreased, recruitment has been average or good and the SSB is responding.

It has been postulated that a mismatch between the biological entity of the **Plaice stock in Division IIIa** and the defined management area might exist. Most catches are taken at the boundary with the North Sea where some mixing with North Sea plaice may occur, and this may undermine the quality of age-based information. Furthermore, the limited survey coverage of main fishing grounds has regularly prevented the presentation of a stock assessment. There is evidence for sustained biomass in the Kattegat and in Eastern Skagerrak, where the populations intermingle between both areas. But the status of the stock in the Southwestern Skagerrak, cannot be determined.

Landings data for **Pollock** (Pollachius pollachius) in **IV and IIIa** were compiled for the first time 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

2010/2/ACOM13 The **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak** (WGNSSK), chaired by Clara Ulrich, Denmark and Ewen Bell, UK, met at ICES Headquarters, 4–10 May 2011 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 18 May and 16 September 2011 (Sandeel/Norway pout) for the attention of ACOM. The group will report on the AGCREMP 2008 procedure on reopening of the advice before 8 October and will report on reopened advice before 29 October.

Fish Stock	Stock Name	Stock Coordinator	Assessment Coord. 1	Assessment Coord. 2	Perform assessment	Advice
cod-347d	Cod in Subarea IV, Divison VIId & Division IIIa (Skagerrak)	UK(Scotland)	UK(England)	Denmark	Y	Update
had-34	Haddock in Subarea IV (North Sea) and Division IIIa	UK(Scotland)	UK(Scotland)	UK(England)	Y	Update
nep-5	*Nephrops* in Division IVbc (Botney Gut - Silver Pit, FU 5)	UK(England)	UK(England)	Denmark	Y	Update
nep-6	*Nephrops* in Division IVb (Farn Deeps, FU 6)	UK(England)	UK(England)	Denmark	Y	Update
nep-7	*Nephrops* in Division IVa (Fladen Ground, FU 7)	UK(Scotland)	UK(Scotland)	Denmark	Y	Update
nep-8	*Nephrops* in Division IVb (Firth of Forth, FU8)	UK(Scotland)	UK(Scotland)	Denmark	Y	Update
nep-9	*Nephrops* in Division IVa (Moray Firth, FU9)	UK(Scotland)	UK(Scotland)	Denmark	Y	Update
nep-10	*Nephrops* in Division IVa (Noup, FU 10)	UK(Scotland)	UK(Scotland)	Denmark	Y	Update
nep-32	*Nephrops* in Division IVa (Norwegian Deeps, FU 32)	Norway	Norway	Denmark	Y	Update
nep-33	*Nephrops* in Division IVb (Off Horn Reef, FU 33)	Denmark	Denmark	Sweden	Y	Update
nep-iiia	*Nephrops* in Division IIIa (Skagerak Kattegat, FU 3,4)	Denmark	Denmark	Sweden	Y	Update
nop-34	Norway Pout in Subarea IV and Division IIIa	Denmark	Denmark	Norway	Y	Update
ple-eche	Plaice in Division VIId (Eastern Channel)	France	France	Belgium	Y	Update
ple-kask	Plaice in Division IIIa (Skagerrak - Kattegat)	Denmark	Denmark	Sweden	Y	Same advice as last year
ple-nsea	Plaice Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Y	Update

sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)	Norway	Norway	Germany	Y	Update
san-nsea	Sandeel in Division IIIa and Subarea IV	Denmark	Denmark	Norway	Y	Update
sol-eche	Sole in Division VIId (Eastern Channel)	Belgium	Belgium	France	Y	Update
sol-nsea	Sole in Subarea IV (North Sea)	Netherlands	Netherlands	Belgium	Y	Update
whg-47d	Whiting Subarea IV (North Sea) & Division VIId (Eastern Channel)	UK(Scotland)	UK(Scotland)	UK(England)	Y	Update
whg-kask	Whiting in Division IIIa (Skagerrak - Kattegat)	Sweden	Sweden	Denmark	N	Catch statistics only
Pol-nsea	Pollack in the North Sea	Norway				Collate data

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,

ToRs b) to f) and h) for stocks with same advice as last year.

ToRs b) to c) and f) for stocks with no advice.

a) Produce a first draft of the advice on the fish stocks and fisheries under considerations according to ACOM guidelines and implementing recommendations from WKMSYREF.

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).

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.

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 2012 catch options;
   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) Where appropriate, check for the need to reopen the advice in autumn based on the new survey information and the guidelines in AGCREFA (2008 report).

h) For the stocks where the advice is marked 'collate data', available data should be collected and presented as far as possible. If information is available for more than or only part of the area, the header for the stock can be adapted (please discuss with the secretariat).

i) Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision (available at http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF;

j) Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

k) take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP) http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf

l) provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

m) identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

The ToRs specific to the individual stocks are dealt with within the relevant stock sections. New sections compared to previous years assessment include 1) an extension of the whiting section (section 12) to collate additional data and perform new analyses for the whiting stock in IIIa (Skagerrak and Kattegat) and 2) a new section describing the data and knowledge related to Pollack. This species was included as a new MoU species from 2011, and WGNSSK was requested to collate available data for the greater North Sea area.

Below is a overview of the ToRs of more generic aspects (ToRs c) and i) to m) as well as of other general matters.

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.

1.2 InterCatch

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. During the 2010 meeting, a specific effort had been made to try to improve the coverage of the data uploaded in InterCatch, through short workshops dedicated to particular stocks in order to identify the potential issues in the use of InterCatch. This opportunity was reconducted in 2011. InterCatch's new functionalities were presented; these include now the possibility to estimate discards in weight for strata which do not provide these, based on their landings and some discard rates borrowed from other strata. This functionality is expected to overcome one of the primary concerns against the use of InterCatch within WGNSSK.

The WGNSSK discussed also the main issues hampering the uptake of InterCatch as the primary tool for raising and documenting catch data. There has been obviously some misunderstanding between stock coordinators and national data submitters around which preferred format is requested and whether there is a demand for uploading data in InterCatch. The WG recalled that national data submitters have the responsibility to upload their own data into InterCatch, but that it is essential that stock coordinators circulate a clear request for this in due time.

However, the WGNSSK has also experienced significant design issues in InterCatch, concerning correction or update of data already uploaded. Obviously, correction of previous data can only be performed manually for each number, but a direct upload of a new file is not possible. The WGNSSK doesn't consider this a good database practice, and considers that file resubmission should absolutely be enabled, together with a proper version control. This is particularly important if countries start now providing data by regional metier standardised across stocks. Experience elsewhere indicates with certainty that mistakes occur and corrections are often required with such type of information.

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.
sai-3a46		InterCatch was used		
Whg-47d		Intercatch was not used because some historic data is missing.		
NOP34		Some historical data is missing, and Norwegian data is missing		
Ple-3a		Used		
Ple-nsea (plaice in area IV)		Another tested tool for international raising has been used; We are still getting used to intercatch; not all member states upload their data		
Sol-nsea (sole in area IV)		Another tested tool for international raising has been used; We are still getting used to intercatch; not all member states upload their data		
NEP 5		Definitions for *Nephrops* only agreed upon during WGNSSK 2011		
NEP 6		Definitions for *Nephrops* only agreed upon during WGNSSK 2011		

1.3 IBTS data

WGNSSK has again experienced significant delays and issues regarding IBTS indices delivered from ICES DATRAS. This year, these were 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 allowing information on which data changes have been submitted and why.

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 2011 WGNSSK supports entirely this suggestion and recommends therefore that this group is established.

MSY reference points

In 2010, the WGNSSK had spent a considerable share of its meeting at estimating provisional Fmsy values for all stocks (WGNSSK 2010).. This resulted in comprehensive analyses. However, in a number of cases these analyses weren't conclusive enough to draw simple results. Rather, they raised a lot of questions and discussions regarding e.g. i) the underlying assumptions behind the various stock-recruitment relationships, ii) the differences in SRR model fit obtained with different statistical software, iii) the influence of the parameterisation of the stochastic analyses and iv) the differences in results obtained with stochastic and equilibrium approaches. Finally, a exhaustive framework was suggested for setting MSY harvest rates targets for all *Nephrops* stocks (WGNSSK 2010).

These analyses were reviewed, first by the Review Group (RGNS 2010) and then Advice Drafting Group (ADGNS 2010). The latest took also decision to select a single value out of the ranges often suggested by WGNSSK 2010, based on a number of biological considerations.

Finally, the analyses performed by WGNSSK in 2010 were presented to WKFRAME-2 (2011), where they served as a basis for reviewing and adjusting the technical guidelines for the implementation of the ICES MSY framework.

In 2011, much less time was dedicated to this ToR by WGNSSK. A main reason for this is linked to the ACOM decision of not providing three bases for advice in the Advice Sheets in 2011, but only one. A consequence of this is that for the stocks subject to an agreed long-term management plan (LTMP), the advice linked to this management plan overrides the advice linked to the Fmsy reference point. This aspect is particularly important for the stocks covered by WGNSSK, as LTMP are implemented for many of them. And therefore, the ICES Advice is more robust to the uncertainties linked to Fmsy estimation.

However, there has still been in most cases little operational progresses achieved on the estimation of MSY Btrigger in 2011, neither during WKFRAME 2 nor during WGNSSK. As last year, the WG still considers that the basis for chosing Bpa is inconsistent with the general MSY framework and recommends that further scientific discussions are undertaken for providing more consistent estimates.

Updated analyses and alternative Fmsy reference points were presented for the North Sea sole and plaice stocks only, leading to a revision of Fmsy for plaice from 0.2. to 0.25, and agreement around the Fmsy range of 0.2-0.3 for plaice and 0.2-0.25 for sole (see sections 8, 10 and 16).

1.4 Ecosystem considerations, MSFD and SIASM

1.4.1 The marine strategy framework directive (MSFD)

Under the Marine Strategy Framework Directive (MSFD) the EU Commission published a catalogue of criteria and methodological standards on good environmental status (GES) of marine waters (Commission Decision: notified under document C(2010) 5956; text with EEA relevance; 2010/477/EU; L 232/14 Official Journal of the European Union of 2.9.2010) where Part B of the document includes a list of 11 descriptors that are (bold denotes of relevance to WGNSSK):

1. **Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.**
2. Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
3. **Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.**
4. **Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.**
5. Descriptor 5: Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
6. **Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.**
7. Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

ICES has been asked

- to identify elements of the EGs work that may help determine status for the 11 descriptors set out in the Commission Decision
- to provide views on what good environmental status might be for those descriptors, including methods that could be used to determine status.

In general, the Assessments carried out in WGNSSK are pure single species assessments and WGNSSK can mainly contribute to the estimation of indicators at a species level. However, there are other ICES working groups such as WGINOSE, WGSAM, WGECO, WGMIXFISH that deal with various aspects of multi species and ecosystem assessments and already incorporate information from WGNSSK and vice versa. WGNSSK feels that these links should be intensified to achieve an integrated ecosystem assessment (IEA) of the North Sea. WGINOSE (2011) suggested to base IEA on the approach from Levin *et al*. (2009, Figure 1.1). WGINOSE also aims for a Biological Ensemble Modelling of Climate Impacts to improve fisheries science and management by accounting for uncertainty. WGNSSK highly welcomes these efforts. Next to this, many WGNSSK members participate in numerous EU projects such as VECTORS, COEXIST, HARMONY ……that deal with topics relevant for the MSFD. Therefore, it can be expected that outcomes from these projects will influence the future work of the group.

Given the ICES request, among the above 11 descriptors WGNSSK felt that it could mainly comment on four descriptors (1, 3, 4 and 6 as shown in bold in the list above):

Descriptor 1 – Biodiversity. WGNSSK regularly carries out assessments that are linked to the three sub-categories "Species Level", "Habitat Level" and "Ecosystem Level". Related to "Species Level" WGNSSK assesses/determines annually

- the distributional range and pattern of the stocks and stock components dealt within the WG
- the population size and biomass including the status of the recruitment and the spawning stock biomass (SSB)
- the population condition including demographic characteristics (e.g. length, age class structure, sex ratio, fecundity rates, natural and fishing mortality rates)

Because of the current single species nature of the WGNSSK assessments, with respect to "Habitat level" and "Ecosystem level", WGNSSK contribution to support the work is limited. This includes mainly data on the hydrographic properties at sampling stations of the surveys and information for the assessed species.

Descriptor 3 –commercial fish. WGNSSK annually explores the status of demersal stocks in the North Sea. It is assessed what the fishing mortality (F) is in relation to F_{MSY} and F_{target} for the stocks where management plans are implemented. The F values are in most cases estimated from analytical assessments. Where the knowledge of the population dynamics of the stock do not allow to carry out analytical assessments, yield-per-recruit curve (Y/R) analysis, combined with other information on the historical performance of the fishery or on the population dynamics of similar stocks, is used. For some *Nephrops* stocks in the North Sea, information from dedicated TV surveys are utilized to estimate harvest rates in relation to MSY. As part of the annual stock assessments the reproductive potentials of the stocks are determined in relation to reference points as B_{pa} (still kept at the default MSY $B_{trigger}$) using the Spawning Stock Biomass (SSB) as proxy. [*Nephrops*....]

Descriptor 4 –food webs. WGNSSK studies the dynamics of the important forage fish sandeel and Norway pout, and their main predators (cod, whiting, haddock, saithe). Thus it provides important data on the dynamics of populations relevant to the ecosystems in the North Sea. Information on predation mortalities from the multi species model SMS is being provided by ICES WGSAM, and is used in the assessment of North Sea cod and North Sea whiting. Latest estimates could be provided also for Norway pout, sandeel, haddock and herring.

Descriptor 6 – sea bed integrity. Demersal fisheries do often impact the sea bed considerably. Spatial distribution of effort is available per rectangle. Many WGNSSK EC members participates also directly to the work of the STECF for the evaluation of effort management, where EC effort distribution by gear and ICES rectangle is collected and mapped (STECF (2011), available at https://stecf.jrc.ec.europa.eu/reports/effort). In addition, most national labs hold VMS data with a finer spatial resolution, which can be linked to logbooks information very very detailed mapping of effort and catches (cf review in ICES WKCPUEFFORT 2011). Tools have been developed by a group including some WGNSSK members to estimate the DCF Indicators 5 (Distribution of fishing activities), 6 (Aggregation of fishing activities) and 7 (Areas not impacted by mobile bottom gears) based in standardised VMS data (Beare *et al*., 2011).

WGNSSK recommends that an assessment of the potential pressure on the seabed by demersal fishing is carried out in the future.

1.4.2 The strategic initiative on area based science and management (SI-ASM).

ACOM and SCICOM have setup a Strategic Initiative on Area-based Science and Management (SIASM). The steering Group of SIASM held a workshop on Marine Spatial Planning in 2010, which produced a concrete work programme. Working closely with the ICES Data Centre and other relevant groups, SIASM aims at defining and quantify viable ecosystem features necessary to deliver goods and services, and to define and quantify its vulnerability, cumulative impacts, and synergies. SIASM will translate this capacity into advice, and communicate it to clients, Member Countries, stakeholders, and the scientific community. However, the last paragraphs of the 2010 Marine Spatial Planning Workshop report summarize the potential spatial planning needs; in a set of questions it is pointed out how ICES WGs can contribute.

WGNSSK has reviewed these, and the bullet points relevant to WGNSSK are:

- ICES should define scenarios and set priorities for both pressures and ecosystems status. These should reflect the needs of planners, managers and decision-makers. Has or can the WG considered, identified or developed priorities or scenarios (or behaviour or ecosystem models that could be used) in terms of natural or anthropogenic pressures and/or ecosystem status, function, structure, and/or process that could be helpful in setting good environmental status (MSFD-GES) or for marine spatial planning.
- ICES should identify what indicators are available for assessment purposes and suggest ones where these are lacking and also identify which species and habitats need protection, i.e. what are the key species and habitats. Has or can the WG identify indicators for assessing which species or habitats need protection or which might be key indicator species for assessing the effects of human activities. Particular consideration should be give to assessing the impacts of very large renewable energy plans with a view to identifying/predicting the potentially catastrophic outcomes. For such plans tipping point/carrying capacity analyses, models and indicators are needed.
- ICES should also prepare spawning site maps, fishery activity maps and habitat maps covering system function and process, methods to assess resistance and resilience of ecosystems (vulnerability mapping), assessment of connectivity (e.g. life history traits), carrying capacity, impacts (including cumulative) and potential synergies. Can the WG provide or identify where any such maps may exist? Suggestions on how such maps could be generated or where data for their production could be found should also be provided.
- ICES should prepare a spatial/temporal map of fisheries management/regulation under the CFP or national regulation –

scale/extent/duration/ closures/restrictions etc. In addition the maps showing the areas of each of the RAC would be helpful. This will facilitate the incorporation of fisheries management into the planning process at an early stage. Has the WG prepared or is it aware of the existence of such maps or could it provide data / information that assist in their preparation?

This led to the addition of ToRs k), l) and m) to WGNSSK work.

Given this, the following 2011 ToRs to ICES EGs which have been added by SIASM and were circulated by ICES are welcome by WGNSSK:

1) take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP) http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf

2) provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

3) identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

With regards to ToR l) (provide information that could be used in setting pressure indicators), WGNSSK could, as explained above, provide catch (by rectangle and quarter) and VMS (geo-referenced at different time intervals) data comprising information from fishing activities that can be used to set pressure indicators. However, WGNSSK discussed also the possibility to link with other groups to provide this information in a routine and structured way (see below).

In addressing ToR m) (identify spatially resolved data) of the SIASM ToRs, WGNSSK could further provide:

- IBTS data that contain spatially resolved survey catch data; the IBTS also includes information on hydrodynamic properties at the sampling stations. Nursery areas and spawning areas could be identified.
- It should possible to provide additional spatial information on effort, catches and discards utilizing Logbook and VMS data. WGMIXFISH is one possible group that could deal with preparing a data call for this issue, given that international information for the North Sea is already being collected at the scale of the ICES division. A data workshop is being organised by WGMIXFISH on August 30th 2011, where this may be discussed more directly.
- Acoustic data originating from various surveys in the study area of WGNSSK can also help to map spawning aggregations.

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).

In 2011, the WGNSSK mainly discussed the possibilities for improving the current schemes of data calls. There is currently three data calls issued with regards to North Sea demersal fisheries data, 1) age composition by country for ICES WGNSSK, 2) catch and effort data, including age composition, for the STECF effort management data call, and 3) catch and effort data, without age composition, for ICES WGMIX-FISH.

The WGNSSK reviewed the issues linked to the three data calls. Data call 1) does in many cases not make use of metier-based information, and the raising of unsampled strata is usually done at the country level, not at the metier or gear level. There is still unsufficient knowledge in WGNSSK on how the data are raised before being provided to stock coordinators. Data call 2) doesn't encompass Norway, doesn't distinguish between the various *Nephrops* FU, and is stratified into a large number of categories, and thus suffers from low or missing samples in many strata. Data call 3) suffers from confusion around the various sources of metiers definitions and lacks therefore of consistent age-based information.

WGNSSK opened up therefore for possibilities to merge together the ICES data calls 1) and 3), which would allow to i) make a better use of metier-based stratification for raising unsampled catch information by stock, ii) provide consistent age-based information for a limited number of key metiers which would be defined commonly across all WGNSSK stocks, iii) perform timely mixed-fisheries analyses which could then be available for the North Sea advice in June.

WGMIXFISH is organising a data workshop under its premises on August 30th 2011, aiming at gathering national data providers and ICES data users around these issues, and WGNSSK supported the initiative.

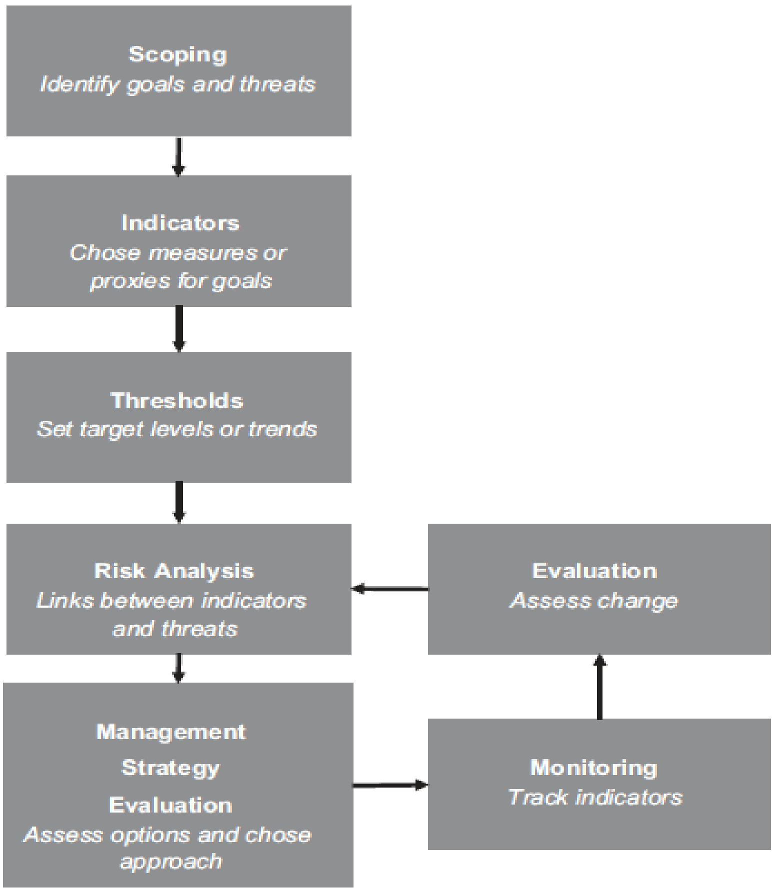

Figure 1.1. Integrated Ecosystem assessment after Levin et al. (2009)

1.6 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 (WGI-NOSE), 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 will now be 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.

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, and exploratory runs using updated natural mortality estimates are presented for some stocks.

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 STECF[1]; Quantitative description of the main fleets and fisheries and their recent trends until 2009 was also summarised in the ICES WG report on Mixed Fisheries Advice for the North Sea (ICES WGMIXFISH 2010), largely based on the data collected for STECF SGMOS 10-05 for the

1 Scientific, Technical and Economic Committee for Fisheries (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

evaluation of effort management, with additional data provided for some countries. 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. WGMIXFISH defined 27 national fleets from nine countries. These fleets engaged in one to five different métiers each, resulting in 73 combinations of country*fleet*métier catching cod, haddock, whiting, saithe, plaice, sole and *Nephrops*.

ICES WGMIXFISH produced a number of synthetic figures describing main trends, between 2003 and 2009, of effort by fleet in absolute levels (Figure 2.1.2.1) and relative trends (Figure 2.1.2.2), effort share by fleet (Figure 2.1.2.3) and landings by fleet and stock (Figure 2.1.2.4). Data are also summarized by main metier and stock in the table 2.1.2.4.

The total effort (expressed in KW*days at sea) for these 27 fleets decreased by 25% between 2003 and 2009, with largest decreases between 2006 and 2008, but less that 2% decrease between 2008 and 2009.

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 (Table 2.1.2.1). 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. The evolution of the number of gear categories and special conditions used in these regulations are given in Table 2.1.2.2, illustrating the trend towards increasingly detailed micromanagement that has taken 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. Table 2.1.2.3 lists the new fleet effort categories and shows how they map to the previous gear groups. The effort allocations available by nation and gear are given in Appendix 1A of Annex IIa of Council Regulation 43/2009 and 23/2010. In relation to this, some member states have implemented real-time closure schemes. The closures apply to areas with high cod catch rates with the intention that closing these will lead to an overall reduction in the catchability of cod.

More detailed overview and analyses of the various measures implemented in the frame of the cod recovery plan can be found in the joint STECF/ICES evaluation of this plan, that has taken place over the first semester 2011 (ICES WKROUNDMP 2011)

2.1.2.2 Stock-based management plans

Cod, saithe, haddock, 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, and have never been evaluated in an integrated mixed-fisheries approach (ICES WGMIXFISH 2010). 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	24mm (carapace length) -40mm in IIIa

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. 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. Fishing mortality is now estimated to have been declining since 2000. Recruitment since around 2000 has been low compared to the long term average with 2004, 2005, 2006 and 2008 being particularly low. The 2005 and 2009 year classes are stronger but still below the long-term averageRecent reductions in realised fishing mortality should enable biomass to increase in the short-term. The higher levels of discarding observed since 2007 is maintaining the fishery induced mortality at a high level.

Haddock fishing mortality in 2010 (0.23) is close to the historical low (0.21 in 2009). The decline in abundance of the dominant 1999 year class has been offset to a certain extent by an improved 2005 year class. However, the reduction in mortality rate has not prevented a continued decline in SSB. The 2009 year class is estimated to be quite strong (33,000 million), similar to the strong 2005 year class.

After several years of problematic assessments of **whiting** in Subarea IV and Division VIId, the 2011 assessment is consistent with the 2010 assessment and appears to have broken the pattern of sequentially under-estimating recruitment and SSB and over-estimating F. Recruitment since 2007 has been strong and SSB has risen whilst F has continued to fall.

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. A new assessment has been made with the missing data restored and the 2010 forecast over-estimated the stock. F is rising sharply whilst landings remain fairly constant. Survey data suggests a contraction in stock distribution and hyper-stability (maintenance of good catch rates whilst the stock abundance declines) is a strong possibility.

The **sole** assessment in IV shows the stock to be almost unchanged from 2010 with the same F (above F_{msy}) and a small rise in SSB to just above MSY $B_{trigger}$. Landings in 2010 were slightly lower than in 2009. The 2009 year class is estimated to be fairly strong B_{pa} but the preceding three recruitments were relatively low.

Landings of plaice in Subarea IV increased over the past two years and are low compared to historical levels although discarding levels are quite high. SSB has increased dramatically over the last four 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 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. A TV survey has been undertaken in the area and the estimated harvest rate for FUs 3&4 in 2010 is low (6.7%) and below the 8% level chosen as a proxy for F_{msy}. Discarding levels in this fishery are particularly high.

Landings in 2010 from FU 6 (Farn Deeps), FU 7 (Fladen) and FU 8 (Firth of Forth) were all reduced from the 2009 level and overall *Nephrops* landings were 12% (3,400t) down. A new FU (34, the Devil's Hole) has been designated. TV surveys for FUs 7, 8 and 9 all decreased slightly again in 2010 following several years of increases in observed abundance. The TV survey in FU6 increased slightly but this stock is considered to have been in a depleted state for the last 4 years due to high levels of fishing effort. There are signs that females in FU6 struggled to successfully mate again in 2010 having showed similar signs in 2006.

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 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 2010 is well above $B_{pa.}$ The fishing mortality in 2008 and 2009 was low compared to the historical trajectory, and the general pattern has been for a decline in F since the 1980. SSB at the start of 2010 (259kt) is estimated to be well above Bpa (150kt), but the 2010 year class is estimated to be the lowest on record, so the prognosis for a fishery in 2011 is poor.

The overview of industrial fisheries is displayed on Tables 2.1.6.1 to 2.1.6.4.

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 and no significant progress has been made this year. It is hoped that a basin-scale Plaice assessment model which encompasses Divisions VIId, VIIe, IV and IIIa can be developed to address the issues.

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.

Catches of the Danish industrial fisheries are presented in Table 2.2.1.

In addition, recent trends in European effort and landings can also be found in STECF - SGMOS report (2009)[1]

2.3 Stocks in the Eastern Channel (Division VIId)

In addition, recent trends in European effort and landings can also be found in STECF - SGMOS report (2009).

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 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.

Sole in VIId is assessed to be in a similar state to 2010 with SSB above MSY $B_{trigger}$ but F above F_{msy}. The large 2008 recruitment is now supporting the SSB. The cessation of the English Young Fish Survey in 2007 has irrevocably increased the uncertainty regarding the assessment of incoming yearclasses.

2.4 Industrial fisheries in Division VIa

This section has not been updated in 2010. 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.

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1 Scientific, Technical and Economic Committee for Fisheries (STECF) Report of the SG-MOS-09-05 Working Group on Fishing Effort Regime Edited by Nick Bailey & Hans-Joachim Rätz 28 september – 2 october 2009, Ispra, Italy.Available at http://fishnet.jrc.it/web/stecf

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. A new report from 2010 was available to the Group and contains 7 pages describing developments in the North Sea fisheries. (ICES 2010, 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 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 (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.

3.2 *Nephrops* in Subarea IIIa

3.2.1 General

FU 3 and FU 4 have been maintained as separate stock units for many years, mainly on the basis of historical differences in for example size distributions. However, these differences may be linked to gear selectivity rather than to differences in population structure. Indeed, for many years the trends both in fisheries data (LPUE) and size data have been very similar and do not indicate any significant differences between the two areas. Consequently, in the assessments and advice the two FUs have always been merged. Therefore, the WG suggests and recommends that both assessment data and assessments for these two FUs formally are merged into a single FU, comprising both Skagerrak and Kattegat (ICES Division IIIa).

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). A specially 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 2010. ICES concluded that:

'The combined logbook recorded effort has decreased since 2002 and is currently at a low level. Mean sizes are fluctuating without trend, and there are no signs of overexploitation of *Nephrops* in IIIa. The new national management system introduced in Denmark in January 2007 where each fisher is allocated an annual share of the national quota, ('vessel quota share') has lead to a more efficient effort use by fishers, making lpues more difficult to interpret as stock indicators. However, this has been accounted for in the analyses.

ICES currently advises a zero TAC for cod in the Kattegat, which is a significant bycatch species in the *Nephrops* fisheries. The current effort regulation (limiting days at sea for gears not using selective sorting grids) may increase the incentives to use sorting grids, which may reduce bycatch of cod.

Discards of *Nephrops* are known to be very high and any improvement of the size selectivity in the trawls would benefit the stock and medium-term yield.'

Management for FU 3 and FU 4

The 2011 TAC for *Nephrops* in ICES area IIIa remained as 5170 tonnes in 2010. 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) s maintained strictly following advice from the industry . However, this leads to a high discard rate and at present 64% 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. 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.

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

Landings

Official landings supplied to ICES for Division IIIa are shown in Table 3.2.1.1. Supplied by ICES staff. 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 67 % and 28 % by weight of the landings in 2010. 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 2010 (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 2010, Denmark accounted for about 80 % of total landings in FU4, while Sweden took 19 % (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 (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 1991-2010. 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 1990-1992 and 2004-2010, and from Denmark for 1992-2010. 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 and 2010. Information on mean size is shown in Figure 3.2.2.5 and table 3.2.2.5. Notice, that except for small mean sizes from 1993 to 1996 all categories have been fluctuating without trend the last 14 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 is 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. Geographically, the samples from the Swedish fishery mainly cover the north-eastern part of the Skagerrak. 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_∞ = 73mm CL, k = 0.138.

Immature females: L_∞ = 73mm CL, k = 0.138.

Mature females: L_∞ = 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 1978-2010s (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 2010. 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 but increased in 2010 (Figure 3.2.2.4 and Table 3.2.3.4).

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.

3.2.3 Combined assessment (FU 3 & 4)

Reviews of last year's assessment

In the last year of this assessment (2010) it was stated that:

> *"Expansion of the underwater TV survey is planned, and the survey data will be used in the next assessment. This survey will provide a valuable source of fishery-independent data to assess this stock. The RG agrees that the survey should continue to be expanded in the future. Most of the survey takes place in the Kattegat, and the RG suggests that efforts should be made to survey the Skagerrak as well."*

Exploratory analysis.

Schaefer´s and Fox´s production models from effort and lpue in IIIa

Combined Danish and Swedish landings and effort data (from the national log books) in hours fished 1990-2010 were used in both a Shaefer´s and Fox´s production models to estimate $EFFORT_{MSY}$. The Danish effort in fishing days was transformed to fishing hours from Swedish lpue to estimate average trawling hours per day. The slope and intercept from lpue vs. effort (Shaefer) and ln(lpue)vs. effort (Fox) were used in the production models. The total effort to obtain MSY was for Shaefer´s and Fox´s production models 405 and 347 khrs respectively (figure 3.2.3.1). Current total effort in IIIa for 2010 was 327 khrs, suggesting that the stock is exploited sustainably.

3.2.3.1 TV survey in IIIa

The UWTV surveys of the *Nephrops* stock in FU 3 & FU 4 have been conducted since 2007 albeit with a rather restricted coverage rate relative to total distribution. The survey uses a similar technological basis as those applied in the U.K. A standard operating protocol has successfully been established and, due to good weather conditions, high quality footages of the *Nephrops* burrow systems have been accomplished for 2010. For the TV-survey, the distribution of the *Nephrops* stock have been divided in 6 sub areas (figure 3.2.3.2) based on the spatial distribution of VMS pings from the Danish and Swedish *Nephrops* fishery in IIIa. In 2007, 2008 and 2009 the TV-survey covered only the northern part of Kattegat (sub area 2), and this is this limited coverage which was used in the exploratory assessment in WGNSSK (2010). In SGNepS (2010) a number of issues were highlighted to improve the TV survey in FU 3 & 4; *i*) improve coverage of the survey, *ii*) a better definition of the population area and *iii*) a more detailed argumentation of the stratification methods of the survey areas, which include e.g. differences in the population structure and fleet dynamics across the stratified survey areas. Since then, a number of improvements have been conducted:

a) The TV-survey in 2010 was expanded also to cover the major *Nephrops* grounds in the western part of Skagerrak (FU 3) by the Danish TV-survey and the *Nephrops* grounds in the eastern part of Skagerrak (FU3) was covered by the Swedish TV-survey. Unfortunately, the footages from the Swedish TV-survey have not yet been analysed. This means that this year assessment in IIIa is only based on 2010 data from the Danish TV-survey in sub-area 1 and 2.

b) 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 were used, providing VMS position for almost every hour and filtered on vessel speeds between 2 and 4 knot as a proxy for fishing activity. These are naturally restricted to vessels above 15 meters as vessels below this size are note part of the VMS scheme. The VMS data was combined with official logbooks information to extract only trips targeting *Nephrops* (with a minimum 50% of *Nephrops* of the total landings). These trips represented ~ 80% of the total landings of vessels above 15 meters. The distribution map of the VMS pings is presented in Figure **3.2.3.3** and the density plot based in 2x2nm squares grids shows the magnitude of fishing intensity (VMS pings) in area IIIa .

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 survey for sub-area 1 and 2 are shown in table 3.2.3.1 and Figure 3.2.3.4.

Time series trend in the density in sub area 2 is presented in Figure 3.2.3.5. It should be noted that different survey designs have been applied during the period. With a fixed station grid from 2007-2009, and in 2010 with random stratified station grid. The trends in abundance indicate no changes in the density of the *Nephrops* stocks since the beginning of the survey in 2007.

To validate for any differences in the population structure between the survey area and *Nephrops* ground outside the survey area it has been tested for differences in length distribution of Danish catches (Figure 3.2.3.6) and catch rates (kilo per kilowatts days) estimated from the Danish VMS/logbooks information across the defined subareas (Figure 3.2.3.7). None of these analyses indicated any noticeable differences in the population structure of *Nephrops*, which in turn gives no indication of problems for the adopted scaling procedure.

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

3.2.3.2 2010 Assessment.

The assessment of the state of the *Nephrops* stock in the Skagerrak and Kattegat area is based on UWTV survey during 2010 and patterns in fluctuations of total combined LPUE by Denmark and Sweden during the period 1990-2010 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 2010 (Figure 3.2.4.1) while combined relative LPUE has increased over the last 8 years (at around 4% per year) and is at present at the highest level (Figure 3.2.4.2) although 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 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 2012 this corresponds to landing of 5970 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 last 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 ratio (%)	Landings 2012 (tonnes)
	2.0	1 511
	4.0	3 023
$F_{0.1}$	5.6	4 232
F_{2010} (TV survey)	6.4	4811
F_{max}	**7.9**	**5 970**
$F_{35\%SpR}$	10.5	7 935

Estimated HR from TV survey 2010.

	HR (%)	Landing (t)
Harvest ratio 2010 (-95%CI)	5.4	4104
Harvest ratio 2010 (mean)	6.4	4811
Harvest ratio 2010 (+95%CI)	7.7	5813

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 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.

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

3.2.4 Biological reference points

No biological reference points are used for this stock.

3.2.5 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 2010 was conducted in two of six subareas in IIIa and scaled up to the total population area in IIIa. This may result in a biased total abundance estimate. Correction factor of 1.1 for estimated bias was used. The estimated proxies for Fmsy for this stock gives relatively low Harvest Ratio which may depend on the high amount of discards (39% 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.

3.2.6 Status of the Stock

The *Nephrops* stock in Div. IIIa was assessed with UWTV survey for the first time this year and the time series of UWTV estimates is insufficient to draw conclusions regarding stock trajectory. The 2010 Harvest Ratio was estimated to be relatively low (6.4% from TV survey) implying the stock appears to be exploited sustainably. The analysis of commercial lpue and effort data indicate that lpue is increasing while effort shows a decreasing trend and the WG concludes that current levels of exploitation appear to be sustainable.

3.2.7 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 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.

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 the sorting grid as this gear is not subject to the otherwise restrictive effort limitations in force.

3.3 *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 2009 EC TAC for *Nephrops* in ICES Subarea IIa and IV was 24837 tonnes in EC waters (plus 1210 tonnes in Norwegian waters). For 2010, this was been reduced to 24688 tonnes in EC waters and 1200 tonnes in Norwegian waters. In 2011, there has been a further reduction to 23454 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.

3.3.1 Botney Gut (FU5)

3.3.1.1 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 2009 and 2010, the UK and Netherlands continued to dominate the fishery taking ~80% of the landings from this area. Germany increased it's share from an average of 10% to 14% whilst Denmark's share reduced from 5% to 0.4%. *Nephrops* in FU5 are caught by trawling. There is no creeling in the area.

3.3.1.2 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. Since 2008 landings have dropped to below 1000t. 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 low levels in recent years. In the most recent years UK and Netherlands have accounted for most of the landings from this FU. In 2010 total landings amounted to around 960 t just below the long term average.

Discards

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 2010 (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 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 the sampling measurements drop to 3668 individuals.

3.3.1.3 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).

3.3.1.4 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 2000-2010), Danish bottom trawlers with mesh size > 70 mm (1996-2010) and English vessels using *Nephrops* gears 2000-2010, 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 has been in general decline since then. Dutch effort in 2010 was around 60% of the 2001 effort and slightly lower than the 2009 value.

Danish effort grew between 1996 and 2001 and has been in general decline since then with the exception of a single year (2005) with a particularly high level.

The spike 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.

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. 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)

LPUE trends in recent years are not consistent between fleets. Danish and English LPUEs have been generally increasing (particularly the English) whilst the Dutch

LPUE has been decreasing. All fleets demonstrate an increase in LPUE for 2010 compared to 2009.

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

In autumn 2010, for the first time, a TV *Nephrops* survey was undertaken at FU5 (Botney Gut Silver Pit grounds). At this stage 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). 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.

The survey coverage will be adapted in the 2011 survey, to ensure a better definition of the limits of this fishery as dictated by the VMS data and also extend the survey into Dutch National waters. Once further developed, the TV survey should generate an absolute index of abundance as with other FUs, however in order to determine sustainable Harvest Rates, reliable length frequency data will be required from this FU, preferably covering at least two years.

Intercatch

FU5 data were not put onto Intercatch as there was no consensus as to how *Nephrops* data should be entered on the system and what fleets should be used. Now that consensus has been reached this will be possible.

3.3.1.6 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 although they all show an increase in LPUE for 2010 compared to 2009. The Dutch LPUEs have been declining since 2005, whilst Danish and English LPUEs have increased. It is unlikely that the single high value of the Danish LPUE in 2008 reflects a genuine increase in stock abundance of that magnitude.

3.3.1.7 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.

3.3.2 Farn Deeps (FU6)

3.3.2.1 Fishery in 2009 & 2010

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 2010 total landings were 1,443 tonnes, a substantial decrease on the 2009 value (2,703t) and about half of 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. vessels fishing with *Nephrops* gears) in 2010 increased slightly on the 2009 value following the sharp decrease observed in 2008 but the current effort level is well below that of the mid 1990's (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 had risen steadily through time (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 from Scotland and Northern Ireland had decreased in 2008 but increased again in 2009 albeit not to the levels seen in 2006 and 2007.

The Farn Deeps fishery is essentially a winter fishery commencing in September and running through to March, hence the 2010 fishery comprised the end of the 2009-2010 fishery and the start of the 2010-2011 fishery. The quarterly pattern of effort continued relatively unchanged in 2009, the 2^{nd} and 3^{rd} quarters remained at similar levels to previous years whilst the 1^{st} and 4^{th} quarter effort increased over the low 2008 levels. (Figure 3.3.2.6).

3.3.2.2 ICES Advice in 2010

The last assessment of *Nephrops* in FU6 was in 2010.

The basis for advice in 2010 was the "Transition to an **MSY approach** with caution at low stock size". This corresponded to landings of less than 1 900 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.

3.3.2.3 Assessment

Review of the 2010 assessment

"*Discard data were not presented but discard survival is 0% based on fishermen behaviour.*"

Technical comments

"*Btrigger is set to be 968 million, i.e. the 2007 bias adjusted TV abundance when the stock was first considered depleted. The 2010 F should be based on current F and FMSY and is calculated using the HR equation. F35%SpR is discussed above this but it is unclear which F is being recommended. The survey is assumed to overestimate abundance by 20%. Status of* *the stock is based on effort data with no investigation into the extent that technological changes affect these estimates over time. The change in legislation in 2006 may also have an impact on these estimates, however, there is no mention of this for FU5."*

Discard data are now presented (see below).

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. Annual discard ogives for the period 2002-2010 are shown in figure 3.3.2.3 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.

Length composition

Trends in the mean lengths for the <35 mm categories (Figure 3.3.2.1) are used to infer possible changes to recruitment. Changes to the raising procedure in 2000 and 2002 confound comparison with years prior to 2002. Between 2002 and 2007 the catch component <35 mm has increased considerably in mean length whilst the landed component has only increased slightly. This difference between the landings and catches may be attributable to improved selectivity of the fishery rather than reduced recruitment. The mean length of all catch components appear to have remained fairly constant between 2007 and 2010.

The bi-modal length frequency distribution for females observed in 2009 is repeated to an extend in 2010 whilst the males continue a typically unimodal form (Figure 3.3.2.7) 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. The low proportion of small individuals within the catches indicates that recruitment in 2010 was relatively poor.

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 out-performing 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. All the gear types show a reduction in LPUE in 2010 compared to 2009.

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 was an anomaly in the 2006-2007 fishery with a predominance of females throughout the season. This anomaly reappeared in the 2009-2010 fishery, albeit not as marked as the 2006-2007 season (Figure 3.3.2.4). Sex ratio in the catches has become considerably more variable in the past 5 years compared to the previous 5.

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 which is in contrast with the previous 5 years where effort was evenly spread between the first and fourth quarters or even higher in the fourth quarter. 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 quarter 2009 was moderately high and in particular higher than for males at a time when they are supposed to have reduced availability due to egg-brooding. For females in 2010 the LPUE in quarters 1-3 was above that of males but declined sharply in quarter 4 where male LPUE increased. This is hopefully indicative of successful mating and that the females were brooding eggs again.

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. The 2010 survey shows more contrast in burrow density compared to 2007 and although the main grounds are as dense if not more so than in 2007 the fringes of the grounds are less abundant.

The harvest rate (removals in numbers divided by the TV abundance, figure 3.3.2.10) fluctuates considerably but the 2010 level was low (8.3%%) and has generally been falling since the peak of 25% in 2006..

Intercatch

FU6 data were not put onto Intercatch as there was no consensus as to how *Nephrops* data should be entered on the system and what fleets should be used. Now that consensus has been reached this will be possible.

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.

The low 2009 survey result was explored in 2010 and suggests that the decrease observed in 2009 may partially be due to enforced changes to the survey distribution in addition to a genuine reduction in stock density.

Final Assessment.

The estimated abundance in 2010 was 892 million individuals (95% confidence interval of ±37 million), above the 2009 estimate and above the 2007 estimate used as MSY $B_{trigger}$ (876 million). The estimated harvest rate for 2010 was, at 8.3% just below the MSY proxy level of 8.4. There are signs though, that the stock 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)

3.3.2.4 Historical stock trends.

The time series of TV surveys is (8 consecutive years) and the new geostatistical method has only been applied retrospectively to 2007. Whilst there is expected to have been an 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 partly real.

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.

3.3.2.5 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 17% 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 $B_{trigger}$ ($B_{trigger}$ = 879 million). As the stock is currently estimated to be above $B_{trigger}$ the ICES F_{msy} transition framework dictates that the recommended F for 2010 be the F_{msy} proxy.

Short term forecasts.

Catch and landing predictions for 2012 are given in the text table below. This assumes that the bias corrected survey index made in October 2010 is relevant to the stock status for 2012. Discard rates and mean weight in the landings are the mean of the last three years.

Discard proportion = 25.5%, mean weight in retained portion =25.0g

	Harvest ratio	Bias corrected survey index	Retained number	Landings
	0%	892	0	0
	2%		18	332
	4%		36	665
	6%		54	997
Male F0.1	6.38%		57	1059
Combined F0.1	7%		64	1198
Male F35%SpR	**8.00%**		**71**	**1329**
Male Fmax	9.47%		84	1574
Combined F35%Spr	11.46%		102	1905
Combined Fmax	12.08%		108	2008
Female F0.1	12.68%		113	2107
Female F35%SpR	18.74%		167	3113
Female Fmax	20.02%		179	3326

$F_{0.1(T)}$: 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.

3.3.2.6 BRPs

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

3.3.2.7 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 most recent North Sea Stock Survey was carried out in mid 2010. The opinion of industry is that the stock is increasing in the area with good recruitment, a higher level of discarding and a good spread of sizes. This is not supported by the reported LPUE levels for 2010 which show a decline and the lack of small *Nephrops* in the catch samples.

Without suitable controls on the movement of effort between Functional Units there is nothing to prevent the effort in 2012 returning to levels observed prior to 2008 most of which were 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.

3.3.2.8 Status of stock

The TV survey indicates the stock to have improved and is above the level of MSY $B_{trigger}$, however there are signs that the recruitment is relatively poor and may continue to be so in the short term.

3.3.2.9 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.

Increases in abundance in other FUs (i.e. Firth of Forth and the Fladen grounds) are likely to translate to increases in TAC, increasing the risk of higher effort being deployed in this FU. The high cost of fuel combined with the relative coastal proximity of this ground may result in it attracting additional fishing effort which would be inadvisable given the current low level of the stock.

3.3.3 Fladen Ground (FU7)

3.3.3.1 Ecosystem aspects

Information on ecosystem aspects can now be found in the Stock Annex.

3.3.3.2 The Fishery in 2009 and 2010

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 have been reported in the Scottish fishery in 2010. Over 100 vessels continue to participate in the fishery which takes a mixed catch consisting of haddock, whiting, cod, anglerfish and megrim as well as *Nephrops*. Changes to more selective gear which are required under the Scottish Conservation Credits scheme (CCS; see Section 13.1.4) are likely to reduce bycatch (and therefore) discards of whitefish. The majority of these vessels (80%) fish out of Fraserburgh. Six new *Nephrops* vessels in the 20-25 m size category joined the fleet in 2008 but there has only been a single addition to the fleet in 2010. In addition a number of vessels have installed freezer capabilities enabling longer trip to be carried out. However, a number of vessels have also left the Scottish fleet and are now registered in England to avoid the ban on multiple-rig (>2) trawling. 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.

3.3.3.3 ICES advice in 2010

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

'The perception of the state of the stock has not changed substantially since the assessment in 2009. The UWTV abundance is still at a high level relative to the historical time series although there has been a 25 % reduction in 2009 from the 2008 value. The stable mean sizes in the length compositions of catches (of individuals >35 mm CL) and recent estimated harvest ratios (removals/TV abundance) relative to per-recruit reference points suggest that the stock is being exploited sustainably.'

The ICES advice for 2010 (Single-stock exploitation boundaries) was as follows:

MSY approach

'Following the ICES MSY framework implies the harvest ratio to be increased to 10.2 %, resulting in landings of less than 13 300 t in 2011.'

3.3.3.4 Management

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

3.3.3.5 Assessment

Review of the 2010 assessment

'The group outlined an appropriate management strategy considering the data poor nature of the fishery. An improvement to the management of this FU would be to manage at the FU level as opposed to the Subarea level .'

The RG also raised a number of issues regarding incomplete coverage of the stock distribution by the survey and the likely poor quality of the Scottish effort data. These issues are addressed in the relevant sections later in the report.

Approach in 2011

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG and described in the Stock Annex.

3.3.3.6 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 2010 were over 12,800 tonnes (approximately 500 tonnes lower than the 2009 total), consisting of 12,690 tonnes landed by Scotland and 124 tonnes landed by Denmark. Approximately 25 % of the Scottish landings are taken by twin rig vessels. Given the concerns about the previously presented Scottish effort data (due to non-mandatory recording of hours fished in recent years) and following recommendations made by previous RGs, effort data in terms of days absent were presented to the WG in 2010. These data gave unrealistically high values of LPUE (2,000-3,000 kg/day). On investigation, it appears that the in-house Marine Scotland Science database holds an incomplete record of days absent when compared to the official data held in the database populated by Marine Scotland Compliance. This anomaly occurs due to problems transferring effort data (between databases) from trip records which contain landings reported from multiple statistical rectangles. Although Scottish LPUE data are not considered further for the Fladen, the effort data are still likely provide a good indication of seasonal trends. Figure 3.3.3.2 suggests effort is generally greatest in quarters 2 and 3.

Danish LPUE data are presented in Figure 3.3.3.1 and Table 3.3.3.2. These show an increase in the mid-2000s, with values remaining high in 2010.

Males consistently make the largest contribution to the landings, although the sex ratio does seem to vary. 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).

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 three years discard rates have been below the long term average and in 2010 are: 6 % by number and 3 % by weight. This reduced discard rate appears to be due to a change in the discard pattern with greater numbers of small individuals being retained (See below on length compositions).

Following the implementation of new procedures for raising the Scottish commercial data in 2010, a number of issues came to light regarding previous raising procedures. This has resulted in a revision to the Fladen 2006-2008 discard estimates (absolute values although not mean sizes) provided to the 2009 WG.

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 2009 were successfully uploaded into Intercatch following the 2010 WG, however no attempt was made to generate the raised international data. The 2010 data have not been imported into Intercatch, but it is anticipated this will be carried out following the WG and the process of raising the data further explored with the aim of using Intercatch fully for 2012 WG. This will require national data coordinators to upload data to Intercatch well ahead of the 2012 WG

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch data analysis are not presently possible, 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 2010. 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 fairly 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.

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 3.3.3.3. This parameter might be expected to reduce in size if overexploitation were taking place but there is no evidence of this. The mean size of smaller animals (<35 mm) in the catch is also quite stable through time although between 2008 and 2009 there was a clear increase which may be associated with lower recruitment than previous years. 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.

Mean weights in the landings through time are shown in Figure 3.3.3.4 and Table 3.3.3.4 and these show 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 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 3.3.3.5. On average, about 65 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.

The RG 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 is not surveyed (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.

3.3.3.7 Data analyses

Exploratory analyses of survey data

Table 3.3.3.6 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 3.3.3.5 and Figure 3.3.3.6 show the time series estimated abundance for the TV surveys, with 95% confidence intervals on annual estimates.

A revised time series of UWTV abundance estimates (corrected for changes in the camera field of view which had previously gone unnoticed) was presented at WGNSSK in 2009 and compared with the 'old' time series. This 'old' time series is not included in the WG report this year.

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 2010 TV survey data presented at this meeting shows that the abundance is still at a high level relative to the historical time series although around 25 % lower than the high values observed in 2007 and 2008.

3.3.3.8 Historical Stock trends

The TV survey estimates of abundance for *Nephrops* in the Fladen suggest that the population has been generally increasing (although fluctuating) over a period of 15 years. The decrease observed in 2009 follows the two highest estimates in 2007 and 2008. The bias adjusted abundance estimates from 2003-2010 are shown in Table 3.3.3.7. The current stock size is estimated to be 5224 million individuals.

Table 3.3.3.7 also shows the estimated harvest ratios over this period. These range from 4-9% 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 3.3.3.7 also shows the dead discard rate which is the quantity of dead discards as a proportion (by number) of the removals (landings + dead discards).

3.3.3.9 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 2009 may be indicative of lower recent recruitment.

3.3.3.10 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 1 of the 2010 WG 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 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) Male	Female	HR (%)	SPR (%) Male	Female	Total
$F_{0.1}$	Male	0.14	0.09	9.5	40.3	47.6	43.3
	Female	0.19	0.12	12.1	32.6	40.0	35.7
	Total	0.16	0.10	10.3	37.8	45.2	40.9
F_{max}	Male	0.28	0.18	16.2	23.6	30.8	26.5
	Female	0.49	0.32	24.1	13.5	19.5	16.0
	Total	0.33	0.21	18.5	20.0	26.9	22.8
$F_{35\%SpR}$	Male	0.18	0.11	11.4	34.5	41.9	37.6
	Female	0.24	0.15	14.4	27.1	34.5	30.1
	Total	0.20	0.13	12.4	31.7	39.1	34.8

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 new F_{msy} proxy harvest ratio is 10.3 % compared to 10.2 % used last year.

The $B_{trigger}$ point for this FU (bias adjusted lowest observed UWTV abundance) is calculated as 2767 million individuals.

3.3.3.11 Short-term forecasts

A landings prediction for 2012 was made for the Fladen Ground (FU7) using the approach agreed at the Benchmark Workshop and outlined in the Stock Annex. 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 1 of the 2010 WG report and the harvest ratio in 2011 (assumed equal to the 2010 value). The landings prediction for 2012 at the F_{msy} proxy harvest ratio is 14101 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 (07-09) = 27.59 g

Dead discard rate (by number) = 5 % (average 08-10)

Survey bias = 1.35.

$F_{sq} = F_{2010}$ = 9.8 %. The most recent year's harvest ratio is taken as the best estimate of F_{2011} as there is an increasing trend in harvest ratio in the last three years.

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	5224	248	6846
	8.0%	5224	397	10953
	9.0%	5224	447	12322
F_{2011}	9.8%	5224	486	13403
	10.0%	5224	496	13692
F_{msy}=$F_{0.1(T)}$	10.3%	5224	511	14101
$F_{35\%SPR(T)}$	12.4%	5224	617	17020
	15.0%	5224	744	20537
$F_{max\ (T)}$	18.5%	5224	916	25264
	20.0%	5224	993	27383

$F_{0.1(T)}$: 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 1 of the 2010 WG report.

3.3.3.12 Biological Reference points

Biological reference points have not been defined for this stock.

3.3.3.13 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 2010 compared to 2009. The time series of perceived abundance in Area 1 increases up to 2010. Opinion on discards appears to be split fairly evenly between lower, higher and no change.

3.3.3.14 Status of the stock

The perception of the state of the stock has not changed substantially since the assessment in 2010. The 2010 TV survey data presented at this meeting shows that the abundance is still at a high level relative to the historical time series although around 25 % lower than the very high values observed in 2007 and 2008.. 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 2009 may be indicative of lower recruitment. The estimated harvest ratio in 2010 (removals/TV abundance) is lower than $F_{0.1}$.

3.3.3.15 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 has implemented 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.

3.3.4 Firth of Forth (FU 8)

3.3.4.1 Ecosystem aspects

Information on ecosystem aspects can now be found in the Stock Annex.

3.3.4.1.1 The Fishery in 2009 and 2010

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. Four vessels left this fleet in 2010 leaving around 30 vessels although this varies seasonally as vessels move around the UK with fluctuating catch rates. The fishery continues to be characterised by catches of small *Nephrops* which often leads to high discard rates. Although the whitefish by-catch is typically low, anecdotal information suggests increasing cod by-catch in recent years. 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.

3.3.4.2 Advice in 2010

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

'The perception of the state of the stock has not changed substantially since the assessment in 2009. The UWTV abundance has been at a relatively high level since 2003 and the 15 % reduction observed in 2009 is within the confidence bounds of the 2008 value. 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 2009 (dead removals/TV abundance) is above F_{max}.'

The ICES advice for 2010 (Single-stock exploitation boundaries) was as follows:

MSY approach

'Following the ICES MSY framework implies the harvest ratio should be reduced to 15 %, resulting in landings of less than 1400 t in 2011.

Following the transition scheme towards the ICES MSY framework implies the harvest ratio should be reduced to 21.7 % (0.8* F_{2010}+ 0.2*F_{msy}), resulting in landings of 2000 t in 2011.'

3.3.4.3 Management

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

3.3.4.4 Assessment

Review of the 2010 assessment

'The group outlined an appropriate management strategy considering the data poor nature of the fishery. An improvement to the management of this FU would be to manage at the FU level as opposed to the Subarea level. Discards in this FU need to be reduced.'

The RG also raised a number of issues regarding fished areas outside the survey coverage area and the poor quality of the Scottish effort data. These issues are addressed in the relevant sections later in the report.

Approach in 2011

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG and described in the Stock Annex.

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, together with a breakdown by gear type. Reported landings have decreased by 30 % between 2009 and 2010 following a period of increasing landings since 2003 (although this may have been due to increased reporting as well as increased actual landings). The value for 2009 of over 2,600 tonnes was the highest in the available time series whilst the 2010 landings are approximately equal to the long term average.

Given the concerns about the previously presented Scottish effort data (due to non-mandatory recording of hours fished in recent years) and following recommendations made by previous RGs, effort data in terms of days absent were presented to the WG 2010. These data gave unrealistically high values of LPUE (2,000-3,000 kg/day) for other *Nephrops* FUs. On investigation, it appears that the in-house Marine Scotland Science database holds an incomplete record of days absent when compared to the official data held in the database populated by Marine Scotland Compliance. This anomaly occurs due to problems transferring effort data (between databases) from trip records which contain landings reported from multiple statistical rectangles. Although Scottish LPUE data are not considered further for the Firth of Forth, the effort data are still likely provide a good indication of seasonal trends. Figure 3.3.4.2 suggests effort is generally greatest in quarters 2 and 3.

Males consistently make the largest contribution to the landings (Figure 3.3.4.2), although the sex ratio does vary. The proportion of females in the landings in 2008 was somewhat higher than in other years. 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).

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. Discard rates are 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 four years, discard rates appear to have dropped to well below this value (30 % on average by number). As in FU 7 this appears to be due to increased retention of small *Nephrops* rather than an absence of small *Nephrops* from the catches.

Following the implementation of new procedures for raising the Scottish commercial data in 2010, a number of issues came to light regarding previous raising procedures. This has resulted in minor revisions to 2006-2008 discard estimates for this FU (absolute values but not mean sizes) provided to the 2009 WG.

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 2009 were successfully uploaded into Intercatch following the 2010 WG, however no attempt was made to generate the raised international data. The 2010 data have not been imported into Intercatch, but it is anticipated this will be carried out following the WG and the process of raising the data further explored with the aim of using Intercatch fully for 2012 WG. This will require national data coordinators to upload data to Intercatch well ahead of the 2012 WG

Length compositions

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Although assessments based on detailed catch data analysis are not presently possible, 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 2010. 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 3.3.4.2. This parameter might be expected to reduce in size if over-exploitation were taking place but over the last 20 years has in fact been quite stable. The mean size in the catch in the < 35 mm category (Figure 3.3.4.1) also shows no particular trend.

Mean weight in the landings is shown in Figure 3.3.3.4 and Table 3.3.3.4 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 3.3.4.3. On average, about 40 stations have been considered valid each year. In 2010, there were 39 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.

The RG noted a further non-surveyed area of sediment illustrated 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 3.3.4.4 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 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. Table 3.3.4.3 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 perception of the state of the stock has not changed substantially since the assessment in 2010. The UWTV abundance has been at a relatively high level since 2003. The value calculated for 2010 is 7 % lower than 2009 abundance, but still within the confidence bounds of the very high 2008 value. 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.

3.3.4.5 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 682 million individuals.

Table 3.3.4.5 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 2010 is 18 % which above the estimated value at F_{max} (16.3 %).

In addition to the discard rate, table 3.3.4.5 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).

3.3.4.6 Recruitment estimates

Survey recruitment estimates are not available for this stock.

3.3.4.7 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 1 of the 2010 WG 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		Male	Female		Male	Female	Total
F0.1	Male	0.14	0.06	7.7	40.8	62.3	49.9
	Female	0.31	0.13	15.2	20.5	40.7	29.0
	Total	0.17	0.07	9.4	34.6	56.6	43.9
Fmax	Male	0.25	0.11	12.7	25.3	46.8	34.4
	Female	0.64	0.28	26.7	9.1	22.9	14.9
	Total	0.34	0.14	16.3	18.8	38.5	27.1
F35%SpR	Male	0.17	0.07	9.4	34.6	56.6	43.9
	Female	0.39	0.17	18.3	16.0	34.5	23.9
	Total	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 new F_{msy} proxy harvest ratio is 16.3 % compared to 15 % used last year.

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

3.3.4.8 Short-term forecasts

A landings prediction for 2012 was made for the Firth of Forth (FU8) using the approach agreed at the Benchmark Workshop and outlined in the Stock Annex. 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 2011 at the F_{msy} proxy harvest ratio is 1558 tonnes. The F_{msy} transition stage harvest ratio results in a landings option of 1679 tonnes.

The inputs to the landings forecast were as follows:

Mean weight in landings (08-10) = 18.8 g

Dead discard rate (by number, average 08-10) = 25.3 %

Survey bias = 1.18

F_{sq} = average harvest ratio of 2008-2010 = 21.8 %

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

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	682	25	478
$F_{0.1(T)}$	9.4%	682	48	895
	10.0%	682	51	957
F35%SPR(T)	12.7%	682	65	1216
Fmsy	16.3%	682	83	1558
F_{msy} transition	17.5%	682	89	1679
	20.0%	682	102	1914
F_{2011}	23.3%	682	119	2233

$F_{0.1(T)}$: 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 1 of the 2010 WG report.

3.3.4.9 Biological Reference points

Biological reference points have not been defined for this stock.

3.3.4.10 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.

3.3.4.11 Status of the stock

The perception of the state of the stock has not changed substantially since the assessment in 2010. The UWTV abundance has been at a relatively high level since 2003. The value calculated for 2010 is 7 % lower than 2009 abundance, still within the confidence bounds of the very high 2008 value. 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}.

3.3.4.12 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 still 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.

3.3.5 Moray Firth (FU 9)

3.3.5.1 Ecosystem aspects

Information on ecosystem aspects can now be found in the Stock Annex.

3.3.5.2 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 2009 and 2010 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. The squid fishery appeared in the summer and lasted for six months with a large proportion of vessels switching effort to this fishery during the second half of the year.

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

3.3.5.3 Advice in 2010

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

'The perception of the state of the stock has not changed substantially since the assessment in 2009. 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 although the current low discard rate suggests that recruitment may be lower than it has been previously. There has also been an apparent increase in female catchability which when observed in other FUs has been associated with the stock having been overexploited.'

The ICES advice for 2010 (Single-stock exploitation boundaries) was as follows:

MSY approach 'Following the ICES MSY framework implies the harvest ratio should be decreased to 12.7 %, resulting in landings of less than 1200 t in 2011.

Following the transition scheme towards the ICES MSY framework implies the harvest ratio to be increased to 13.7 % (0.2 x harvest ratio(F_{2010})+ 0.8 x harvest ratio(F_{msy})), resulting in landings of less than 1300 t in 2011.'

3.3.5.4 Management

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

3.3.5.5 Assessment

Review of the 2010 assessment

'The group outlined an appropriate management strategy considering the data poor nature of the fishery. An improvement to the management of this FU would be to manage at the FU level as opposed to the Subarea level'

The RG also raised a number of issues regarding changing discard rates in this FU and the uncertainty in landings data. These issues are addressed in the relevant sections later in the report.

Approach in 2011

The assessment and provision of advice through the use of the UWTV survey data and other commercial fishery data follows the process defined by the benchmark WG and is described in the Stock Annex.

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, together with a breakdown by gear type. Total landings (as reported to the WG) in 2010 were just over 1,000 tonnes, 3 % lower than 2009, but a 30 % reduction on the 2008 landings. Following a number of years (2004-2007) of increasing reported landings (which may have been due to increased reporting due to the introduction of 'buyers and sellers' legislation as well as increased actual landings), the landings have fallen by over 40 % in a three year period. The long term landings trends are shown in Figure 3.3.5.1.

Given the concerns about the previously presented Scottish effort data (due to non-mandatory recording of hours fished in recent years) and following recommendations made by the RG, effort data in terms of days absent were presented to the WG in 2010. These data gave unrealistically high values of LPUE (2,000-3,000 kg/day) for other *Nephrops* FUs. On investigation, it appears that the in-house Marine Scotland Science database holds an incomplete record of days absent when compared to the official data held in the database populated by Marine Scotland Compliance. This anomaly occurs due to problems transferring effort data (between databases) from trip records which contain landings reported from multiple statistical rectangles. Although Scottish LPUE data are not considered further for the Firth of Forth, the effort data are still likely provide a good indication of seasonal trends. Figure 3.3.5.2 suggests effort is generally greatest in quarters 2 and 3.

Males consistently make the largest contribution to the landings (Figure 3.3.5.2), although in 2007 and 2009, the proportion of females is considerably higher than in the recent past. Although this may be due to a change in the seasonal pattern in the fishery to a time when females are particularly available, 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). In 2010, the proportion of females in the catch has returned to more usually observed levels (around 50 % of the male landings).

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. The RG suggested that there had been a systematic decline in discards suggesting reduced recruitment. 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).

Following the implementation of new procedures for raising the Scottish commercial data in 2010, a number of issues came to light regarding previous raising procedures. This has resulted in revisions to 2006-2008 discard estimates for this FU (absolute values but not mean sizes) provided to the 2009 WG.

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

Intercatch has not been used for this FU. Scottish data for 2009 were successfully uploaded into Intercatch following the 2010 WG, however no attempt was made to generate the raised international data. The 2010 data have not been imported into Intercatch, but it is anticipated this will be carried out following the WG and the process of raising the data further explored with the aim of using Intercatch fully for 2012 WG. This will require national data submitters to upload data to Intercatch well ahead of the 2012 WG.

Length compositions

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

Figure 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 3.3.5.2. 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 3.3.3.4 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 3.3.5.3. On average, about 40 stations have been considered valid each year. 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 3.3.5.4 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. (This year's mean value is about 2 % lower than last year's). The TV survey suggests that the population is stable, but at a lower level than that evident from 2003-2005.

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

3.3.5.6 Historical Stock trends

The TV survey estimate of abundance for *Nephrops* in the Moray Firth suggests that the population increased between 1997 and 2003 but has fallen to a fairly stable lower level since 2006. The bias adjusted abundance estimates from 2003-2009 are shown in Table 3.3.5.5. The stock is currently estimated to consist of 406 million individuals.

Table 3.3.5.5 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 2010 is 11 % and is below the F_{msy} proxy value of 11.8 %.

In addition to the discard rate, Table 3.3.5.5 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).

3.3.5.7 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.

3.3.5.8 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 1 of the 2010 WG report.

		Fbar(20-40 mm)		HR (%)	SPR (%)		
		Male	Female		Male	Female	Total
$F_{0.1}$	Male	0.13	0.07	7.16	42.35	61.48	49.89
	Female	0.24	0.12	11.61	27.45	47.01	35.16
	Total	0.14	0.07	7.84	39.46	58.93	47.13
F_{max}	Male	0.26	0.13	12.31	25.80	45.16	33.42
	Female	0.68	0.36	23.82	11.42	25.16	16.83
	Total	0.34	0.18	14.92	20.79	39.10	28.01
$F_{35\%SpR}$	Male	0.17	0.09	9.11	34.69	54.48	42.48
	Female	0.41	0.22	17.12	17.62	34.83	24.40
	Total	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 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.

3.3.5.9 Short-term forecasts

A landings prediction for 2012 was made for the Moray Firth (FU9) using the approach agreed at the Benchmark Workshop and outlined in the Stock Annex. 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 1 of the 2010 WG report and the status quo harvest ratio. The landings prediction for 2012 at the F_{msy} proxy harvest ratio is 1082 tonnes. The inputs to the landings forecast were as follows:

Mean weight in landings (08-10) = 25.23 g

Dead discard rate (by number, average 08-10) = 10.3 %

Survey bias = 1.21

F_{sq} = F_{2010} (point value rather than average as declining trend) = 11.2 %

	Harvest rate	Survey Index (adjusted)	Implied fishery	
			Retained number	Landings (tonnes)
	5.0%	406	18	459
F0.1(T)	7.8%	406	29	719
	10.0%	406	36	918
F2011	11.2%	406	41	1027
Fmsy framework	11.8%	406	43	1082
	15.0%	406	55	1377
Fmax(T)	14.9%	406	54	1370
	20.0%	406	73	1836

$F_{0.1(MT)}$: 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 1 of the 2010 WG report.

3.3.5.10 Biological Reference points

Biological reference points have not been defined for this stock.

3.3.5.11 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 2010.

3.3.5.12 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 2009 and 2010 have been at around the F_{msy} proxy.

3.3.5.13 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 by-catches of cod under the Scottish Conservation credits scheme, include the implementation of larger meshed square mesh panels and real time closures to avoid cod.

The 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.

3.3.6 Noup (FU 10)

3.3.6.1 Ecosystem aspects

Information on ecosystem aspects can now be found in the Stock Annex.

3.3.6.2 The Fishery in 2009 and 2010

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 2009 and 2010, Further general information on the fishery can be found in the Stock Annex.

3.3.6.3 Advice in 2010

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:

'No reliable assessment can be presented for this stock. The main cause of this is a lack of data. The time series of UWTV survey data is incomplete and no survey has been conducted in 2008 or 2009. There are no reliable effort data for this FU and therefore no resulting lpue.'

The ICES advice for 2008 (Single-stock exploitation boundaries) was as follows:

There was no advice given by ICES in relation to either the MSY approach or precautionary consideration.

3.3.6.4 Management

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

3.3.6.5 Assessment

There is no assessment of this FU.

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 2010 were 38 tonnes, a reduction of over 50 % since 2009. *Nephrops* are almost exclusively landed by 'non-*Nephrops*' trawlers (only 4 tonnes recorded by *Nephrops* trawlers in 2010). 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.

Given the concerns about the previously presented Scottish effort data (due to non-mandatory recording of hours fished in recent years) and following recommendations made by the RG, effort data in terms of days absent were presented to the WG. These data (not illustrated) gave unrealistically high values of LPUE (2,000-3,000 kg/day). On investigation, it appears that the in-house Marine Scotland Science database holds an incomplete record of days absent for the Noup (and Fladen) when compared to the official data held in the database populated by Marine Scotland Compliance. The data are not considered further in this section. See section 3.3.5.5 on the Moray Firth for further details.

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 3.3.6.2. Sampling levels have been low in 2009 and 2010 resulting in an apparent absence of females in 2010 – no samples were obtained in the summer months when females are typically more available to the fishery.

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 3.3.6.3.

Data analyses

No assessment has been presented in 2011.

3.3.6.6 Historical stock trends

Total landings for this FU have fallen to below 50 tonnes which is < 1% of the total landings from the North Sea.

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

3.3.6.7 Recruitment estimates

There are no recruitment estimates for this FU.

3.3.6.8 Short-term Forecasts

No short-term forecasts are presented for this FU.

3.3.6.9 Status of the stock

The current state of the stock is unknown.

3.3.6.10 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 Noup 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.

3.3.7 Norwegian Deep (FU 32)

3.3.7.1 General

3.3.7.1.1 Ecosystem aspects.

See stock annex (section A.3).

3.3.7.1.2 Norwegian Deep (FU 32) fisheries

See stock annex (section A.2).

3.3.7.1.3 Advice in 2008

In 2008 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 2007 amounted to 755 t, mainly due to a reduction of Danish landings."
- "Perceptions of this stock (FU 32) are based on Danish LPUE data."
- "The overall picture is that of a stable LPUE fluctuating around a mean of 200 kg/day. [....] The trend in Danish LPUE figures does not indicate any decline in stock abundance."
- "Recent trends in overall size distribution in the catches indicate that the *Nephrops* stock in the Norwegian Deep is not over-exploited."
- "However, the effect of technological creep on the effective effort of the fishery is not known."

The WG concluded that the level of exploitation on this stock is sustainable. No specific advice for this stock was given, and no TAC was suggested for 2009 or 2010.

It was noted that recent average landings have been approximately 1,000 t (average landings 2002-2007).

3.3.7.1.4 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 2009-2010 it was 1200 t. There are no quotas for the Norwegian fishery.

3.3.7.2 Assessment

3.3.7.2.1 Data available

Catch

Landings data for the 2010 assessment (all fleets, all years) have not 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 and total landings in 2010 amounted to only 406 t, due to a reduction of Danish landings. This is the lowest figure since 1994. The decreased Danish landings are probably due to economic reasons, for instance increased fuel prices. The number of Danish fishing vessels has also decreased lately. Danish vessels used to take 80-90 % of total landings, but in 2009-2010 this percentage has decreased to 69 %. Norwegian landings increased from 2007 to 2008-2009 and then decreased again in 2010.

Length composition

The average size of *Nephrops* as recorded from Danish landings (100-120 mm mesh size) showed a decreasing trend for both males and females in the period 2000-2006, but increased again in 2007 and remained on this level in 2010 (Figure 3.3.7.1). Average sizes in catches of both sexes (landings and discards) also increased in 2007 and remained on the same level in 2010. There were no sex specific Danish size data for FU 32 for 2008 and 2009. The size distributions in the Danish catches (100-120 mm mesh size) from 2002 to 2010 do not show any conspicuous changes (Figure 3.3.7.2). Size data from Norwegian coast guard inspections of Danish and Norwegian trawlers are available for 2006-2009, but there were no data from 2010. (Figure 3.3.7.3.). The Danish and Norwegian length distributions for 2008-2010 are very similar (Figure 3.3.7.4). Figure 3.3.7.5 shows a time series of length compositions for this stock. There is little evidence of notable change in sizes, and maximum sizes have remained quite constant.

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.

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 1989-2010 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 2006-2008. 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). A similar development has been occurring in the Norwegian fleet. 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. The standardised LPUE series has been updated this year. 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.

3.3.7.2.2 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.

3.3.7.2.3 Historic stock trends

The slight increase in mean size in the catches and landings from 2006 to 2007 in females and from 2005 to 2007 in males could indicate a lower exploitation pressure in recent years and coincides well with the decreasing landings in the same time period. The Danish LPUE decreased from 2005 to 2006, increased in 2007, and then decreased again in 2008 to 2010. The overall picture is that of a stable LPUE fluctuating around a mean of 200 kg/day. Thus the stock seems to be stable and shows no sign of overexploitation.

3.3.7.2.4 Recruitment estimates

There are no recruitment estimates for this stock.

3.3.7.2.5 Forecasts

There were no forecasts for this stock.

3.3.7.2.6 Biological reference points

No reference points are defined for this stock.

3.3.7.2.7 Quality of assessment

The data available for this stock remains limited.

3.3.7.2.8 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. The WG therefore advises that catches should remain at the present level. Historic average annual landings have been approximately 1000 t (2002-2007), while recent average landings are 520 t (2008-2010).

3.3.7.3 Management considerations

For 2006-2008 the agreed catch for EU vessels was 1300 t, while this decreased to 1200 t in 2009 and 2010. The WG considers that the stock should be monitored more closely. The Norwegian logbook system should be improved. Sampling of Norwegian commercial catches from this area should be intensified.

3.3.8 Off Horns Reef (FU 33)

3.3.8.1.1 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 in 2010 fell to less than 200 t. During the same period landings from Netherlands increased. In 2010 total landings from this FU amounted to less than 600 t (Table 3.3.8.1), of which the Netherlands accounted for around 300 t. The other countries contributed with around 300 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 2009-2010 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 2008-2010. Dutch effort data are available from 2005-2010 and was around 1500 days in recent 5 years. The Danish LPUEs show an increasing trend during the whole period until a high record in 2008 of more than 700 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 200 kg/day in 2010.

3.3.8.1.2 Data analysis

Reviews of the 2010 assessment (FU33)

"This is a data-poor stock and needs more data collection in order to conduct an analysis.

The group outlined an appropriate management strategy considering the data poor nature of the fishery. An improvement to the management of this FU would be to manage at the FU level as opposed to the Subarea level."

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

3.3.8.1.3 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 and shows a decreasing trend in 2009 and 2010. 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 decreasing from a high level for both countries in 2010.

The size distribution in the 2010 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 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. This interpretation of the 2005 catches is supported by the increase in LPUEs in 2006, 2007 and 2008. The development in 2009 and 2010 then suggests that the contribution of the 2005 recruitment to the stock now has faded and LPUE may therefore decline in coming years.

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.

3.3.9 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. This section represents a first attempt at collating the available information on the stock and fishery in this area with the aim of providing a fuller stock assessment and advice in the near future.

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).

3.3.9.1 Ecosystem aspects

3.3.9.2 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. Anecdotal information from the fishing industry and scientific observers suggests that catch rates were poorer in 2010 than in the recent past.

3.3.9.3 Advice in 2010

ICES has not yet provided advice for this FU.

3.3.9.4 Management

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

3.3.9.5 Assessment

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

3.3.9.6 Data available

Commercial catch and effort data

Landings from this fishery for 2010 are presented in Table 3.3.9.1 and a longer time series of Scottish landings is shown in Figure 3.3.9.2. Scottish landings declined from over 1300 tonnes in 2009 to 730 tonnes in 2010, although they still made up around 95 % of the total international landings from this functional unit last year. Effort data was extracted for this functional unit, but proved to have the same problems as the Scottish data for other *Nephrops* functional units. See section 3.3.5.5 on the Moray Firth for further details. Landings per unit effort data are therefore not considered further, although the effort data are still likely to provide a good indication of seasonal trends. Figure 3.3.9.3 shows that in the two most recent years (2009 and 2010) for which data are available, the effort pattern has been inconsistent though fishing activity in this area is highly dependent on weather conditions.

As in other *Nephrops* fisheries, males make up the majority of landings in the sampled years (Figure 3.3.9.3).

Discarding of undersize and unwanted *Nephrops* occurs in this fishery, and Marine Scotland conducts discard sampling on the Scottish *Nephrops* trawler fleet in this area when time permits. The discard trips suggest highly variable discard rates of between < 1 % and > 15 % by number (or < 1% to 10 % by weight).

Length compositions

Both levels of market and discard sampling are low, although increasing in recent years. Sampled data are only available from the Scottish fleet. Mean sizes in the catch and landings are shown Table 3.3.9.2. 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). In 2009, VMS data were used to define the location of the survey stations. The positions were randomly selected from the set of VMS pings from 2008 for *Nephrops* trawlers (data filtered using speed of 0.2-0.45 knots). These locations remained fixed in 2010. It is not known how station locations were selected on the earlier surveys in this area.

3.3.9.7 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 3.3.9.3 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 out with 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.

<table>
<tr><th></th><th colspan="3">AREA ESTIMATES (KM²)</th></tr>
<tr><th></th><th>TPS model
(>50 pings grid sq)</th><th>α hull
(α=0.01)</th><th>Average > 2
pings/year</th></tr>
<tr><td>2006</td><td>336.3</td><td>666.8</td><td rowspan="4">1061.8</td></tr>
<tr><td>2007</td><td>1390.7</td><td>1149.3</td></tr>
<tr><td>2008</td><td>1379.8</td><td>1296.1</td></tr>
<tr><td>2009</td><td>1211.8</td><td>1145.0</td></tr>
</table>

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 inter-sessionally. In addition, appropriate bias-correction factors also need to be derived to account for edge-effects, burrow misidentification, etc.

3.3.9.8 Historical stock trends

Scottish landings from this area have risen substantially over the last ten years but fell by over 40 % in 2010. Estimates of mean density in the stock are similar in 2009 and 2010, but significantly greater 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 in 2009 and 2010, producing the high densities.

3.3.9.9 Recruitment estimates

There are no recruitment estimates for this FU.

3.3.9.10 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. If sampling continues at current levels, it may be possible to conduct such analysis in 2012, otherwise, the potential to 'borrow' harvest ratios from other functional units with apparently similar biological and fishery characteristics will be explored.

3.3.9.11 Short-term Forecasts

No short-term forecasts are presented for this FU.

3.3.9.12 Status of the stock

The current state of the stock is unknown.

3.3.9.13 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 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.

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	16356
1992	1893	1012	612	1473	3363	1757	1591	188				401	13277
1993	2288	924	721	3030	3493	2369	1808	376	339	160		434	15970
1994	1981	893	503	3683	4569	1850	1538	495	755	137		703	17104
1995	2429	998	869	2569	6440	1763	1297	280	489	164		844	18144
1996	2695	1285	679	2483	5217	1688	1451	344	952	77		808	17681
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	18793
1999	3194	1755	1244	2391	6521	2205	1008	279	1119	724		988	21412
2000	2894	1816	1121	2178	5569	1785	1541	275	1084	597		900	19771
2001	2282	1774	1443	2574	5541	1528	1403	177	1190	791		1268	19975
2002	2977	1471	1231	1954	7247	1340	1118	401	1170	861		1383	21139
2003	2126	1641	1144	2245	6294	1126	1079	337	1089	929		1390	19411
2004	2312	1653	1070	2153	8729	1658	1335	228	922	1268		1224	22555
2005	2546	1488	1099	3094	10685	1990	1605	165	1089	1050		1120	25890
2006	2392	1280	974	4903	10791	2458	1803	133	1028	1288		1249	28264
2007	2771	1741	1294	2966	11910	2652	1842	155	755	1467		1637	29207
2008	2851	2025	963	1218	12240	2450	1514	173	675	1444		1673	26953
2009	3004	1842	728	2703	13327	2662	1067	89	477	1163		2367	29428
2010	2938	2185	959	1443	12825	1871	1032	38	407	806	757	709***	

*** Provisional**

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

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

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

Table 3.2.1.2. - Division IIIa: Total *Nephrops* landings (tonnes) by Functional Unit, 1991-2010.

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

Table 3.2.1.3. - Division IIIa: Total *Nephrops* landings (tonnes) by country, 1991-2009.

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

Table 3.2.2.1. ***Nephrops*** **in Skagerrak (FU 3): Landings (tonnes) by country, 1991-2009.**

Year	Denmark	Norway			Sweden			Total
		Trawl	Creel	Sub-total	Trawl	Creel	Sub-total	
1991	1639	185	0	185	949	151	1100	2924
1992	1151	104	0	104	524	114	638	1893
1993	1485	101	2	103	577	123	700	2288
1994	1298	62	0	62	531	90	621	1981
1995	1569	90	0	90	659	111	770	2429
1996	1772	102	0	102	708	113	821	2695
1997	1687	117	0	117	690	118	808	2612
1998	2055	184	0	184	864	145	1009	3248
1999	2070	214	0	214	793	117	910	3194
2000	1877	181	0	181	689	147	836	2894
2001	1416	125	13	138	594	134	728	2282
2002	2053	99	17	116	658	150	808	2977
2003	1421	90	9	99	471	135	606	2126
2004	1595	85	10	95	449	173	622	2312
2005	1727	71	12	83	538	198	736	2546
2006	1516	80	11	91	583	201	784	2391
2007	1664	127	18	145	709	253	962	2771
2008	1745	124	34	158	675	273	948	2851
2009	2012	101	27	128	605	260	864	3004
2010	1981	105	20	124	563	266	829	2934

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, 1991-2009. (*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

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

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, 1991-2009.

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

Table 3.2.2.4. - Skagerrak (FU 3): Mean sizes (mm CL) of male and female *Nephrops* in catches of Danish and Swedish combined, 1991-2009.

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

Table 3.2.2.5. ***Nephrops*** **Kattegat (FU 4): Landings (tonnes) by country, 1991-2009.**

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

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, 1991-2009 (*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

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

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, 1991-2009.

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

Table 3.2.2.8. *Nephrops* Kattegat (FU 4): Mean sizes (mm CL) of male and female *Nephrops* in discards, landings and catches, 1991-2009. 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

Table 3.2.3.1. Summary output of the TV-survey in IIIa from 2010.

Subarea	area (km^2)	Number of stations	Mean density	Bias correction	95%Confidens interval	Population numbers (mill.)	Population estimates (tons)
1	3079	43	0.312	0.281	0.103	865	33645
2	1982	29	0.360	0.324	0.111	642	24955
3	2462		0.336	0.302	0.107	744	28951
4	676		0.336	0.302	0.107	204	7949
5	670		0.336	0.302	0.107	203	7879
6	973		0.336	0.302	0.107	294	11442
Total	9842	72	0.336	0.302	0.107	2952	114821
Mean weight (2008-2010)			38.9g		Harvest rate	0.06367	
Removals (landings +dead discard*)			7310tons				

***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
Belgium	638	679	344	437	500	574	610	427	384	418	304	410	185
Denmark	7	50	323	479	409	508	743	880	581	691	1128	1182	1315
Faeroe Islands	-	-	-	0	0	0	0	0	0	1	3	12	0
France	-	-	-	7	0	0	0	0	0	0	0	0	0
Germany	.	.	.	0	0	0	0	2	2	16	24	16	69
Germany (Fed. Rep.)	5	4	5	1	2	1	2	0	0	0	0	0	0
Netherlands	-	-	-	0	0	0	9	3	134	131	159	254	423
Norway	1	1	1	2	17	17	46	117	125	107	171	74	83
Sweden	-	1	-	0	0	0	0	4	0	1	1	1	0
UK (Eng + Wales + NI)	.	.	.	0	0	2938	2332	1955	1451	2983	3613	2530	2462
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
UK	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	6286	8156	8865	8403	9852	11103	10613	10889	9575	12598	14253	14497	13518

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*
Belgium	311	238	350	252	283	284	229	213	180	214	205	200	265	115
Denmark	1309	1440	1963	1747	1935	2154	2128	2244	2339	2024	1408	1078	875	604
Faeroe Islands	1	1	1	0	-	-	-	-	-	-	-	-	-	-
France	0	0	0	0	-	-	-	-	-	-	-	-	-	+
Germany	64	58	104	79	140	125	50	50	109	288	602	266	410	373
Netherlands	627	695	662	572	851	966	940	918	1019	982	1147	737	882	701
Norway	64	93	144	147	115	130	100	93	132	96	99	143	139	123
Sweden	1	3	4	37	26	14	1	1	3	1	5	26	2	1
UK (Eng + Wales + NI)	2206	2094	2431	2210	2691	1964	2295	2241	3236	4937	3295	1679	3437	-
UK (Scotland)	10466	8980	10715	9834	9681	11045	10094	12912	10565	16165	17930	17960	18587	-
UK	-	-	-	-	-	-	-	-		-	-	-	-	18914
Total	15049	13602	16374	14878	15722	16682	15838	18674	17583	24707	24691	22089	24597	20832

* Landings data for 2010 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
* 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	38.90
2008	38.71	39.81
2009	38.18	39.91
2010	41.10	41.10

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	261.0			
1997	399	31.8	12.5				24	59	412.0			
1998	309	28.6	10.8				78	174	447.0			
1999	322	31.8	10.1				44	107	408.0			
2000	174	21.8	8	402	7936	50.7	76	247	306.0	43	1416	30.5
2001	195	21.5	9.1	553	9797	56.5	78	283	275.0	73	2349	31.2
2002	144	15.8	9.1	617	8999	68.6	47	200	237.0	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	7912	82.7	87	297	290.9	59	1193	49.4
2006	no data	no data	no data	444	6849	64.8	24	66	365.6	171	3320	51.4
2007	no data	no data	no data	464	6922	67.0	3	13	253.6	176	2494	70.5
2008	no data	no data	no data	268	5020	53.3	29	41	777.0	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	61.8	5	14	365.5	135	1576	86.0

* 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	1218	0	1218
2009	2289	414	2703	0	2703
2010*	1258	185	1443	0	1443

* 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*	793	45	17.8

* 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	33.3	32.5
2008	31.1	30.3	33.0	32.7
2009	30.5	31.0	32.5	33.2
2010*	31.2	31.5	32.7	33.1

* 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*	0.34	876	23	Geostatistics
2008	95	Autumn*	0.37	949	39	Geostatistics
2009	76	Autumn*	0.29	759	38	Geostatistics
2010	95	Autumn*	0.34	892	37	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	66.40%	20.67	373	*22.2%*
2002	*1048*	1953	45.00%	20.53	182	*17.3%*
2003	*1085*	2245	41.30%	22.27	177	*16.3%*
2004	*1377*	2152	33.90%	23.58	160	*11.6%*
2005	*1657*	3094	33.90%	23.74	200	*12.1%*
2006	*1244*	4858	31.40%	22.55	317	*25.5%*
2007	876	2966	26.10%	25.00	158	19.8%
2008	949	1213	27.30%	25.41	61	6.4%
2009	759	2711	26.60%	24.60	131	17.3%
2010	892	1443	22.60%	25.00	74	8.3%

Table 3.3.3.1 *Nephrops*, Fladen (FU 7), Nominal Landings (tonnes) of *Nephrops*, 1981-2010, 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

* provisional na = not available

** Other countries includes Belgium, Norway and UK England

Table 3.3.3.2 *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, 1991-2010.

Year	Logbook data	
	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

Table 3.3.3.3 ***Nephrops*****, Fladen (FU 7): Mean sizes (CL mm) above and below 35 mm of male and female** ***Nephrops*** **in Scottish catches and landings, 1993-2010.**

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1993	na	na	30.4	29.6	38.7	38.2
1994	na	na	30.0	28.9	39.2	37.8
1995	na	na	30.6	29.8	39.9	38.1
1996	na	na	30.4	29.1	40.6	38.8
1997	na	na	30.2	29.1	40.9	38.8
1998	na	na	30.8	29.4	40.7	38.4
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
* provisional, na = not available						

Table 3.3.3.4. *Nephrops*, FUs 7-9 and 34. Mean weight (g) in the landings.

Year	Fladen	Firth of Forth	Moray Firth	Devil's Hole
1990	31.59	20.29	20.05	
1991	26.50	20.03	18.53	
1992	29.61	20.96	23.49	
1993	25.38	24.30	23.42	
1994	23.72	19.51	22.25	
1995	27.51	19.55	20.59	
1996	29.82	20.81	21.40	
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	25.10	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	28.20	19.41	23.46	39.62
2010	26.38	19.76	26.94	33.40
Mean (08-10)	27.59	18.80	25.23	

Table 3.3.3.5. ***Nephrops*, Fladen (FU 7): Results of the 1992-2010 TV surveys (not bias-adjusted).**

Year	Stations	Abundance	Mean density	95% confidence interval
		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

Table 3.3.3.6. ***Nephrops*****, Fladen Ground (FU 7):Summary of TV results for most recent 3 years (2008-2010) 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
2008 TV survey							
>80	3248	12	0.68	0	2209	4028	0.008
55<80	4967	18	0.32	0.04	1589	50866	0.107
40<55	4304	17	0.60	0.04	2562	38458	0.081
<40	15634	27	0.22	0.04	3497	380988	0.803
Total	28153	74			9857	474340	1
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	0.010	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

Table 3.3.3.7 *Nephrops*, Fladen (FU 7): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2010.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	5547	6294	0.10	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	0.10	0.07	0.09
2010	5224	12825	0.06	0.05	0.10

Table 3.3.4.1 *Nephrops*, Firth of Forth (FU 8), Nominal Landings (tonnes) of *Nephrops*, 1981-2010, as reported to the WG.

Year	UK Scotland				UK (E, W & NI)	Total **
	Nephrops trawl	Other trawl	Creel	Sub-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

* provisional   na = not available

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

Table 3.3.4.2 *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, 1991-2010.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	31.5	31.0	39.7	38.7
1982	na	na	30.4	30.1	40.0	39.1
1983	na	na	31.1	30.8	40.2	38.7
1984	na	na	30.3	29.7	39.4	38.4
1985	na	na	30.6	29.9	39.4	38.2
1986	na	na	29.7	29.2	39.1	38.5
1987	na	na	29.9	29.6	39.1	38.2
1988	na	na	28.5	28.5	39.1	39.0
1989	na	na	29.2	28.9	38.7	38.9
1990	28.3	27.2	29.8	28.6	38.3	38.8
1991	28.7	27.5	29.8	28.7	38.3	38.7
1992	29.5	27.9	30.2	28.7	38.1	38.7
1993	28.7	28.0	30.3	29.5	39.0	38.6
1994	25.7	25.1	29.1	28.5	38.8	37.8
1995	27.9	27.1	29.4	28.9	38.7	37.9
1996	28.0	27.4	29.8	28.8	38.6	38.6
1997	27.2	27.0	29.2	28.7	38.8	38.2
1998	27.7	26.4	29.0	27.9	38.5	38.4
1999	27.2	26.5	29.6	28.8	38.0	37.9
2000	28.5	27.2	30.6	29.8	38.2	38.3
2001	28.1	27.0	30.6	29.2	38.0	37.9
2002	27.1	26.3	29.8	29.3	38.3	37.9
2003	27.2	25.4	30.2	29.1	38.1	38.0
2004	28.6	27.8	30.7	30.0	38.4	37.6
2005	27.6	26.9	30.3	30.0	38.7	38.2
2006	27.3	27.0	29.8	29.9	38.7	37.8
2007	29.2	28.3	29.8	28.6	39.1	38.6
2008	27.7	27.2	28.1	26.9	39.4	37.9
2009	27.5	26.2	29.7	28.5	38.3	38.0
2010*	28.3	26.9	29.8	28.4	38.6	38.2
	* provisional na = not available					

Table 3.3.4.3. *Nephrops*, Firth of Forth (FU 8): Results of the 1993-2010 TV surveys.

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	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	0.60	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	0.90	816	156
2008	38	1.14	1040	350
2009	45	0.94	864	168
2010	39	0.88	804	173

Table 3.3.4.4. ***Nephrops*****, Firth of Forth (FU 8):Summary of TV results for most recent 3 years (2008-2010) showing strata surveyed, numbers of stations in each strata, mean density and observed variance, overall abundance and variance raised to stratum area. Proportion indicates relative amounts of overall raised variance attributable to each stratum.**

Stratum	Area (km^2)	Number of Stations	Mean burrow density ($no./m^2$)	Observed variance	Abundance (millions)	Stratum variance	Proportion of total variance
2008 TV survey							
M & SM	171	3	0.92	1.67	156	24333	0.793
MS(west)	139	9	1.04	0.82	144	1757	0.057
MS(mid)	211	11	1.69	0.47	355	1898	0.062
MS(east)	395	15	0.97	0.26	384	2685	0.088
Total	915	38			1040	30673	1
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	0.180
MS(mid)	211	13	1.318	0.348	278	1189	0.159
MS(east)	395	14	0.679	0.215	268	2397	0.320
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

Table 3.3.4.5 *Nephrops*, Firth of Forth (FU 8): Adjusted TV survey abundance, landings, total discard rate (proportion by number), dead discard rate and estimated harvest ratio 2003-2010.

	Adjusted abundance (millions)	Landings (tonnes)	Discard rate	Dead discard rate	Harvest ratio
2003	767	1126	0.54	0.47	0.12
2004	630	1658	0.35	0.29	0.16
2005	710	1990	0.42	0.35	0.19
2006	827	2458	0.55	0.48	0.27
2007	692	2652	0.25	0.2	0.23
2008	881	2450	0.29	0.24	0.21
2009	732	2662	0.34	0.28	0.26
2010	682	1871	0.3	0.24	0.18

Table 3.3.5.1 *Nephrops*, Moray Firth (FU 9), Nominal Landings (tonnes) of *Nephrops*, 1981-2010, 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

* provisional

** No landings by other countries from this FU

Table 3.3.5.2 *Nephrops*, Moray Firth (FU 9): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in Scottish catches and landings, 1991-2010.

Year	Catches		Landings			
	< 35 mm CL		< 35 mm CL		=> 35 mm CL	
	Males	Females	Males	Females	Males	Females
1981	na	na	30.5	28.2	39.1	37.7
1982	na	na	30.2	29.0	40.0	37.9
1983	na	na	29.9	29.1	40.6	38.3
1984	na	na	29.7	29.3	39.4	38.1
1985	na	na	28.9	28.7	38.7	37.8
1986	na	na	28.7	27.8	39.1	38.4
1987	na	na	29.0	28.3	39.4	38.6
1988	na	na	29.1	28.7	38.9	38.4
1989	na	na	29.8	28.8	40.1	39.4
1990	28.0	27.5	30.3	29.1	38.4	38.7
1991	28.3	27.4	30.1	28.6	38.2	38.2
1992	29.4	28.6	31.0	30.5	38.3	38.0
1993	29.8	29.9	31.3	30.9	38.6	37.7
1994	28.9	30.1	30.8	31.0	39.4	37.5
1995	25.8	25.0	29.9	29.3	39.1	38.0
1996	29.3	28.4	30.6	29.7	38.5	38.0
1997	28.5	27.9	29.5	28.9	38.8	38.2
1998	28.7	28.2	30.1	29.3	38.8	38.2
1999	29.5	28.8	30.4	29.7	38.9	37.6
2000	29.8	29.1	31.5	30.6	39.2	38.3
2001	30.0	29.2	30.9	30.2	39.5	37.9
2002	27.2	27.0	31.2	30.9	41.0	38.7
2003	29.3	29.2	30.3	30.1	39.8	38.0
2004	29.3	28.4	31.3	30.8	39.0	39.2
2005	30.0	28.7	31.0	29.6	39.2	38.5
2006	29.7	28.9	30.6	29.6	39.3	38.6
2007	30.1	28.8	30.3	29.0	39.4	38.6
2008	29.3	27.7	30.2	28.2	39.8	40.2
2009	29.7	28.9	30.7	29.3	39.6	38.5
2010*	29.7	29.1	31.1	30.5	40.0	38.9
	* provisional na = not available					

Table 3.3.5.3 *Nephrops*, Moray Firth (FU 9): Results of the 1993-2010 TV surveys.

Year	Stations	Mean density	Abundance	95% confidence interval
		burrows/m²	millions	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	0.40	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

Table 3.3.5.4 ***Nephrops*****, Moray Firth (FU 9):Summary of TV results for most recent 3 years (2008-2010) 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
2008 TV survey							
M & SM	169	2	0.35	0.08	58	1200	0.144
MS(west)	682	16	0.35	0.17	239	5023	0.603
MS(mid)	698	13	0.20	0.01	141	413	0.050
MS(east)	646	14	0.22	0.06	141	1699	0.204
Total	2195	45			579	8335	1
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	0.590
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	0.20	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

Table 3.3.5.5 *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 2003-2010.

	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	0.20
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

Table 3.3.6.1 *Nephrops*, Noup (FU 10), Nominal Landings (tonnes) of *Nephrops*, 1981-2010, 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

Table 3.3.6.2 *Nephrops*, Noup (FU 10): Mean sizes (CL mm) above and below 35 mm of male and female *Nephrops* in landings, 1997-2010. No females in samples in 2010.

Year	Landings			
	< 35 mm CL		**=> 35 mm CL**	
	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

Table 3.3.6.3 *Nephrops*, Noup (FU 10): Results of the 1994, 1999, 2006 & 2007 TV surveys.

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	83	40	123	1	1		407

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

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

* 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	
	Effort	LPUE
1993	971	170
1994	830	165
1995	816	194
1996	471	157
1997	1702	161
1998	1601	208
1999	2710	252
2000	3088	230
2001	3635	233
2002	4162	256
2003	4435	271
2004	5275	323
2005	3449	387
2006	2550	446
2007	1909	507
2008	858	708
2009	637	579
2010*	508	461

* 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 2010.

Year	UK Scotland				UK (E, W & NI)	Denmark	Netherlands	Total **
	Nephrops trawl	Other trawl	Creel	Sub-total				
2010*	712	18	0	730	25	1	1	757

* provisional

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

Table 3.3.9.2. *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.

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 3.3.9.3. ***Nephrops*, Devil's Hole (FU 34). Results of the 2003, 2005 and 2009-10 surveys.**

Year	Stations	Mean density burrows/m²	95% confidence interval 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

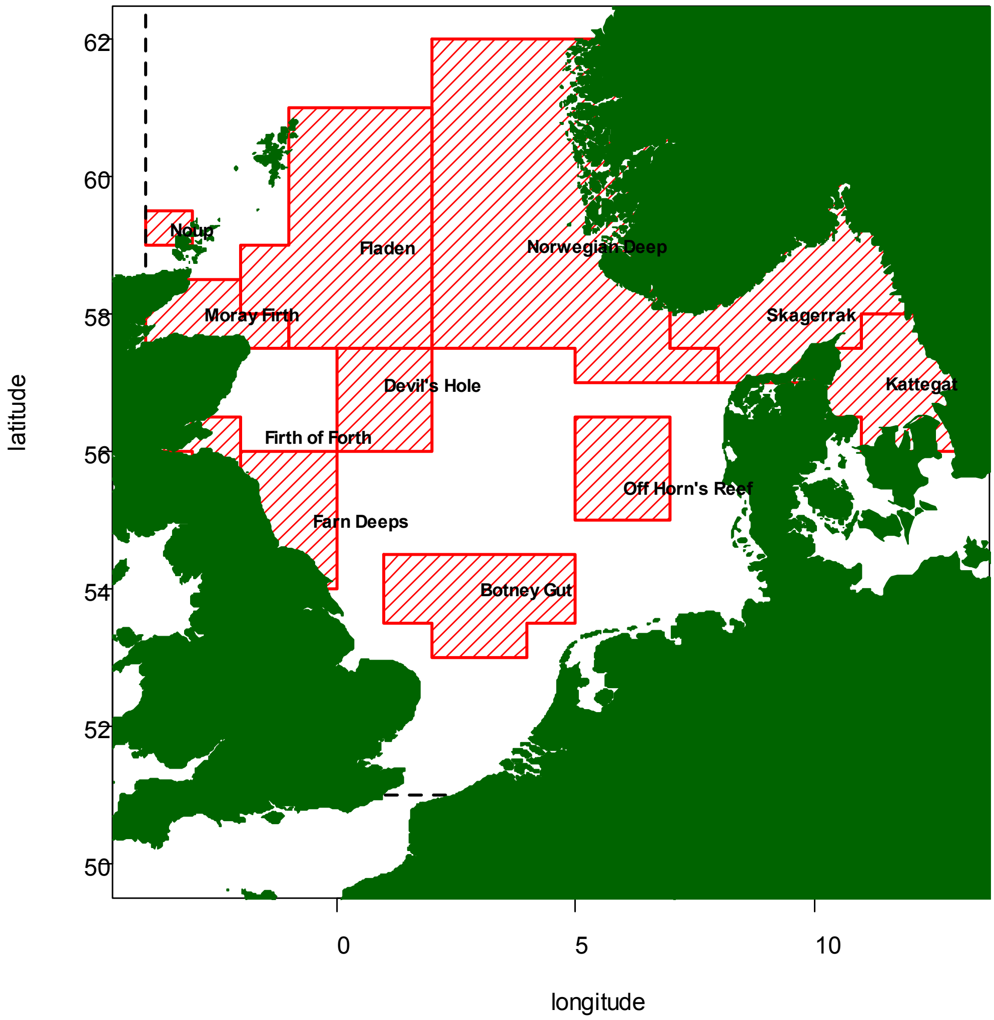


Figure 3.1.1. ***Nephrops*** **Functional Units in the North Sea and Skagerrak/Kattegat region.**

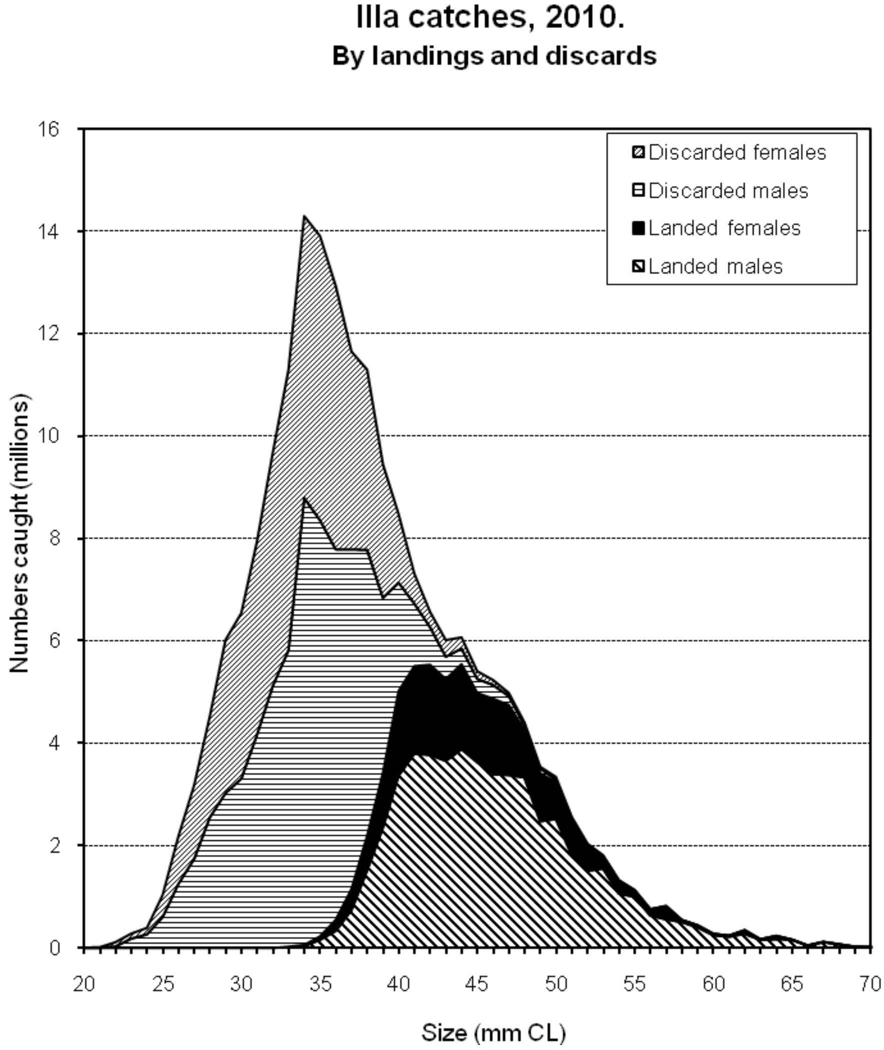


Figure 3.2.1.1. - Skagerrak (FU 3) and Kattegat (FU4): Length frequency distributions of *Nephrops* catches, split by catch fraction (landings and discards) and sex. Data for Denmark and Sweden combined for 2010.

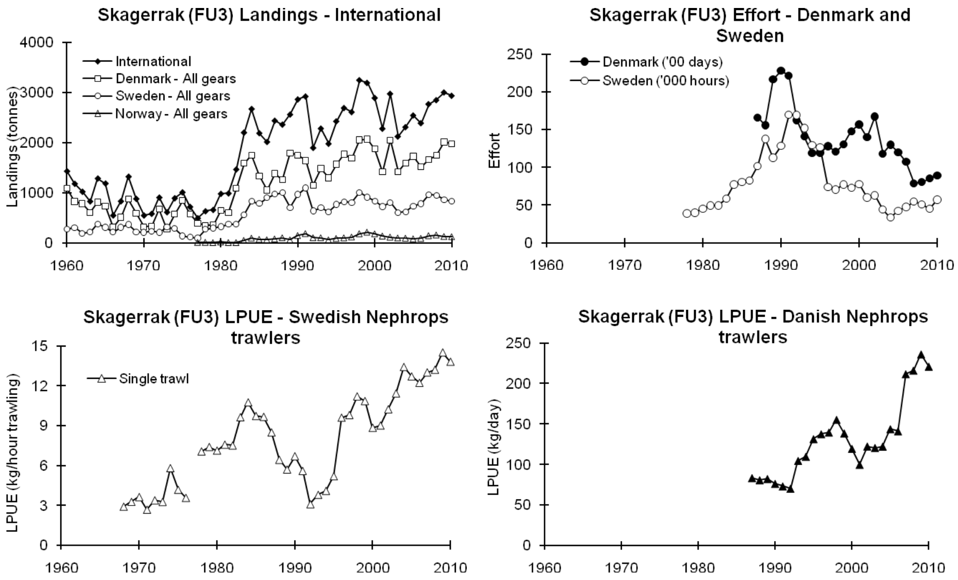


Figure 3.2.2.1. ***Nephrops*** **Skagerrak (FU 3): Long-term trends in landings, effort, LPUEs, and mean sizes of** ***Nephrops*****.**

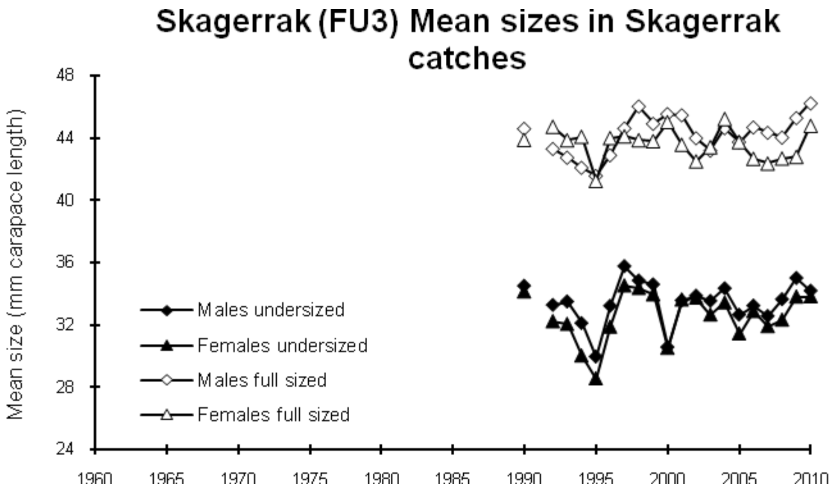


Figure 3.2.2.2 ***Nephrops*** **in FU 3. Mean sizes in the catches.**

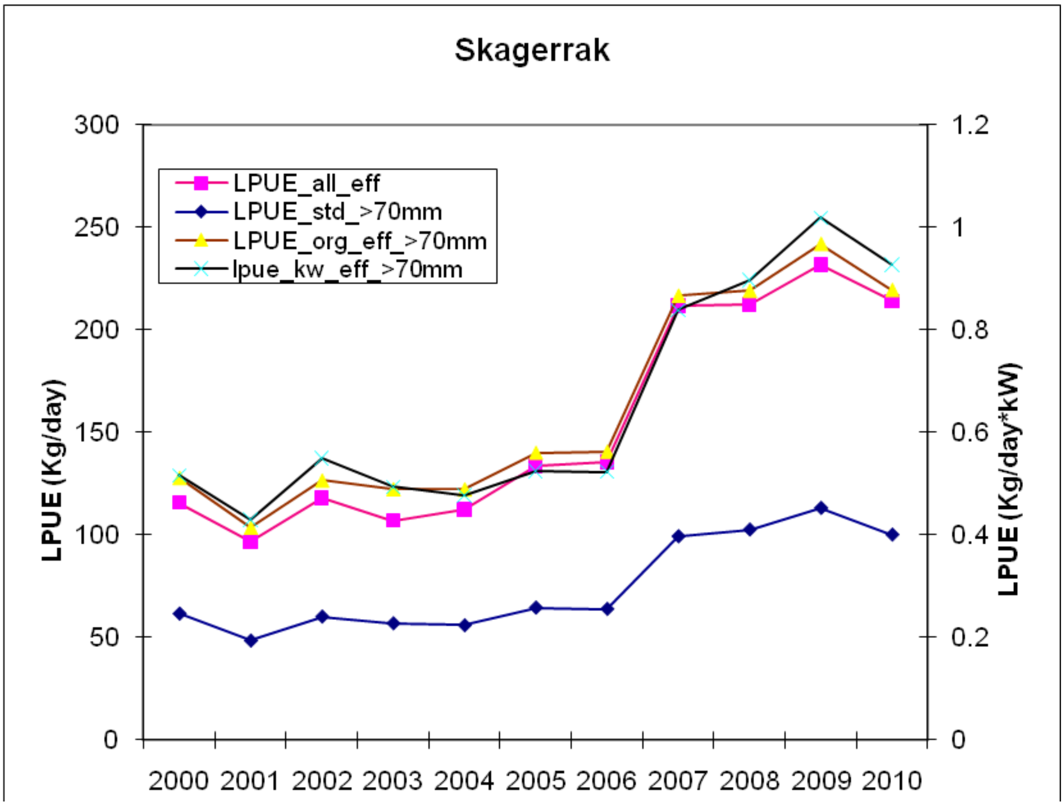


Figure 3.2.2.3 ***Nephrops*** **in FU 3. LPUE trends.**

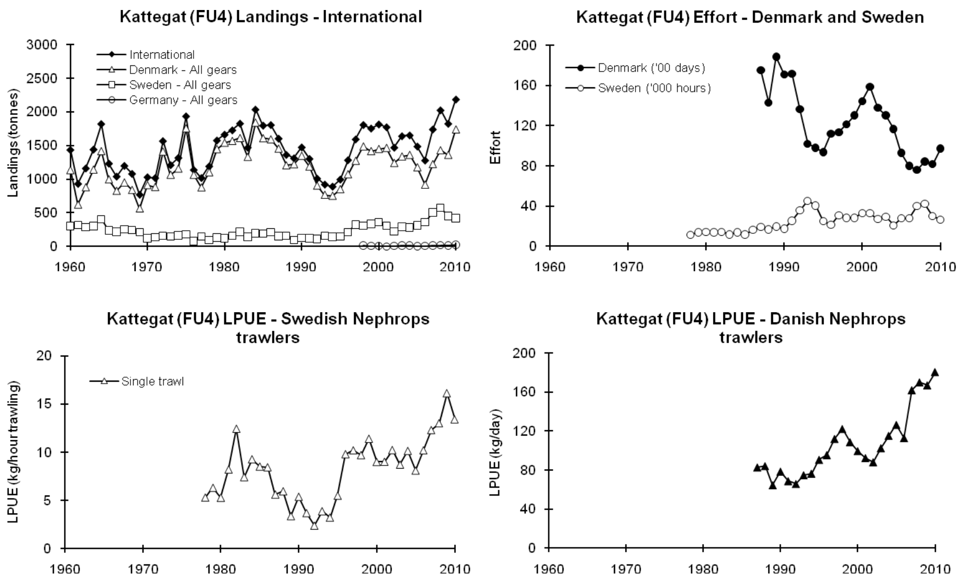


Figure 3.2.2.4. ***Nephrops*** **Kattegat (FU 4): Long-term trends in landings, effort, LPUEs, and mean sizes of** ***Nephrops*****.**

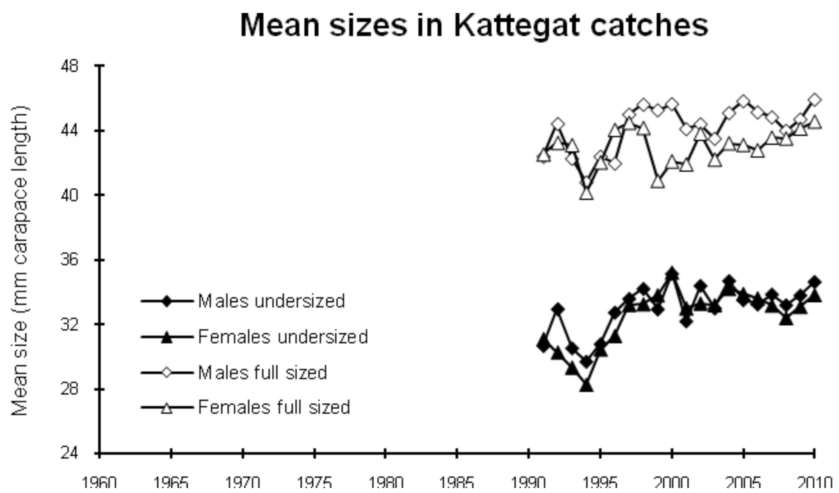


Figure 3.2.2.5 ***Nephrops*** **in FU 4. Mean sizes in the catches.**

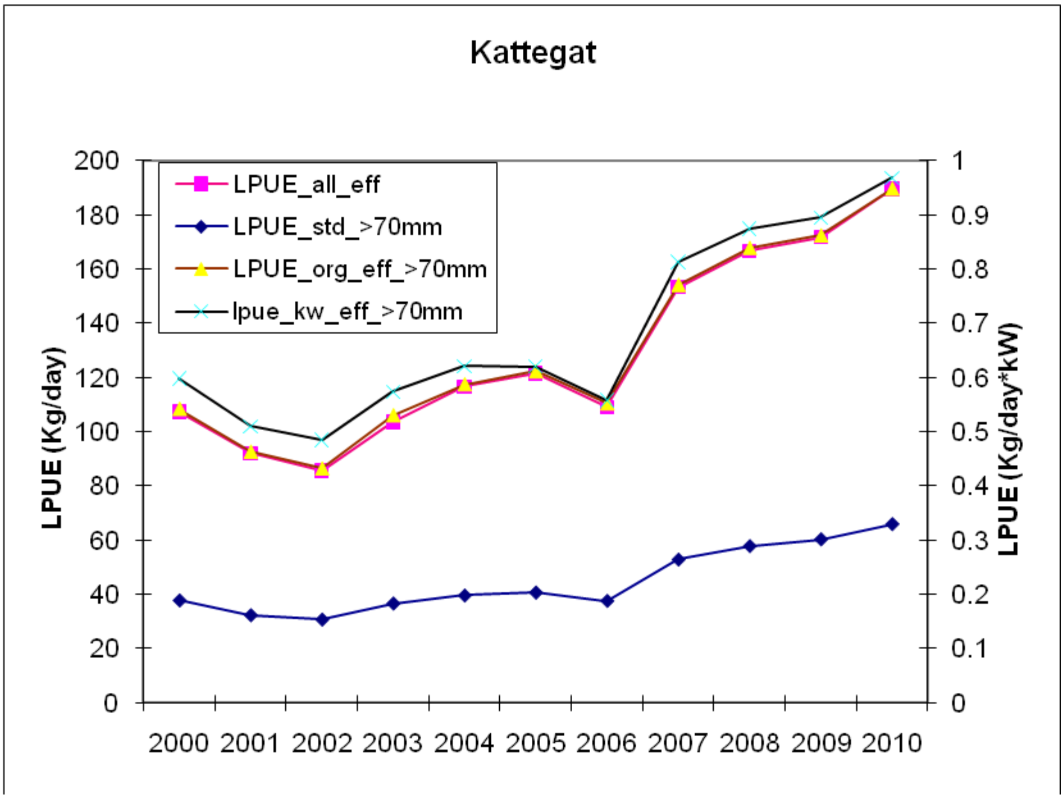


Figure 3.2.2.6 ***Nephrops*** **in FU 4. LPUE trends.**

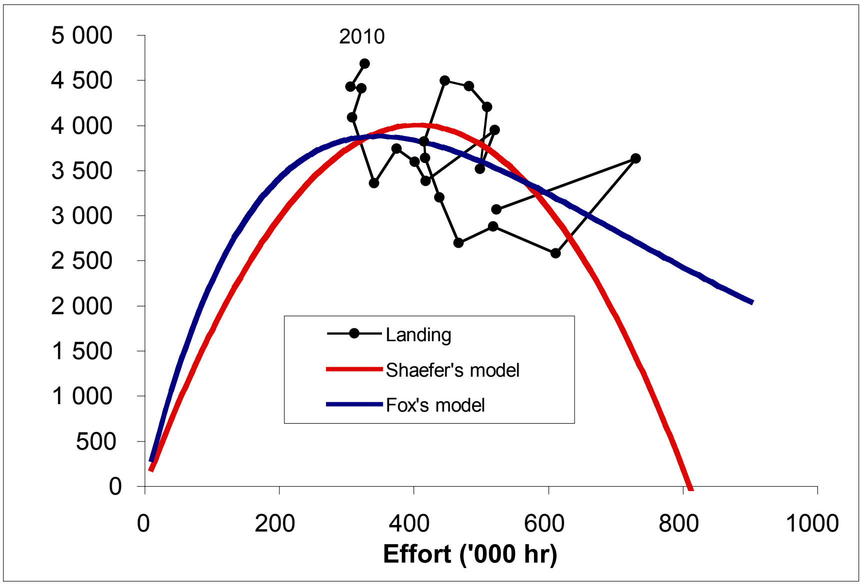


Figure 3.2.3.1. ***Nephrops*** **in FU 3&4. Results of two stock production models.**

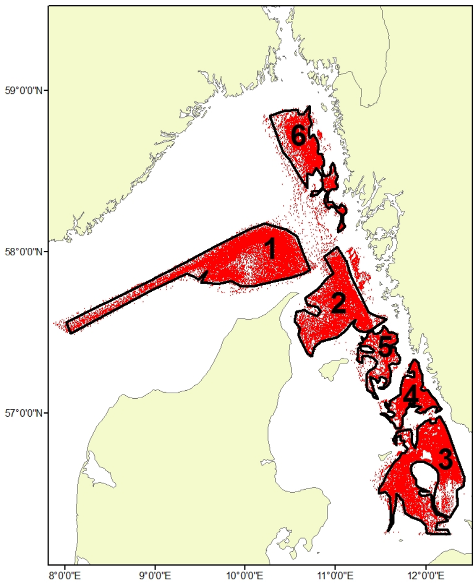


Figure 3.2.3.2. The defined sub areas of the *Nephrops* stock in IIIa.

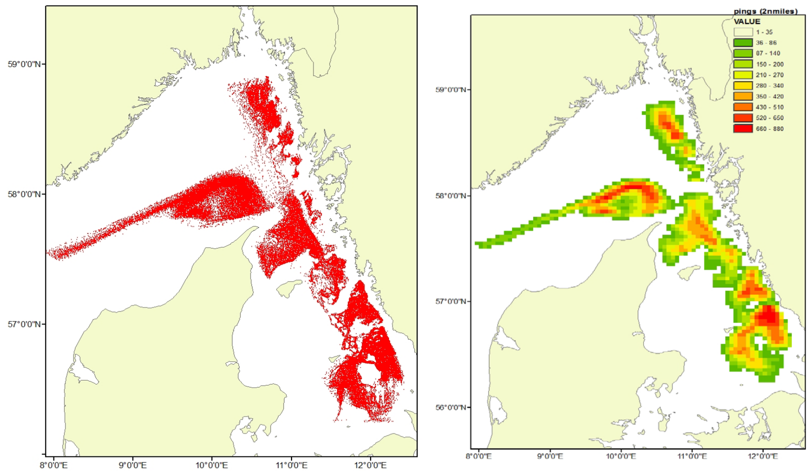


Figure 3.2.3.3. The spatial distribution of the Danish and Swedish *Nephrops* fishery in 2010. Left map shows vms pings and the right map shows density of vms pings.

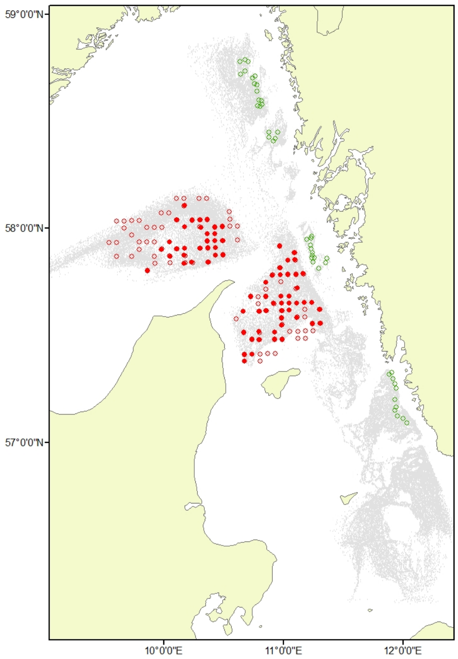


Figure 3.2.3.4. Stations of the TV-survey in 2010. Red circle are the valid stations for the Danish TV-survey in 2010, and the empty red circle are those excluded either due to technical failure with the equipment or non-fishable habitats. The empty green circle presents the Swedish tv-survey for 2010.

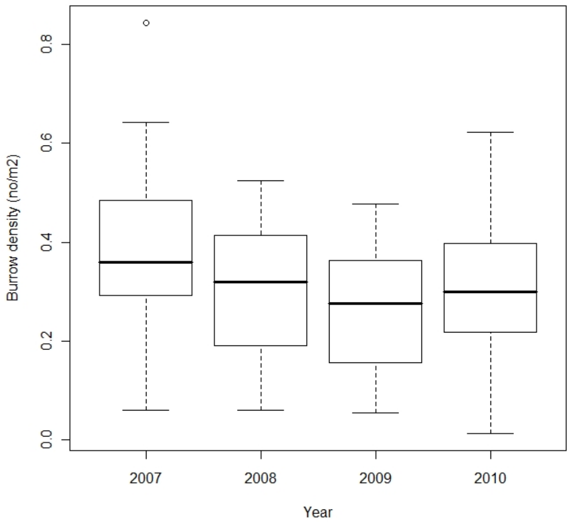


Figure 3.2.3.5. Boxplot of the density (no. of burrows/m²) bias corrected for sub-area 2 from 2007 to 2010.

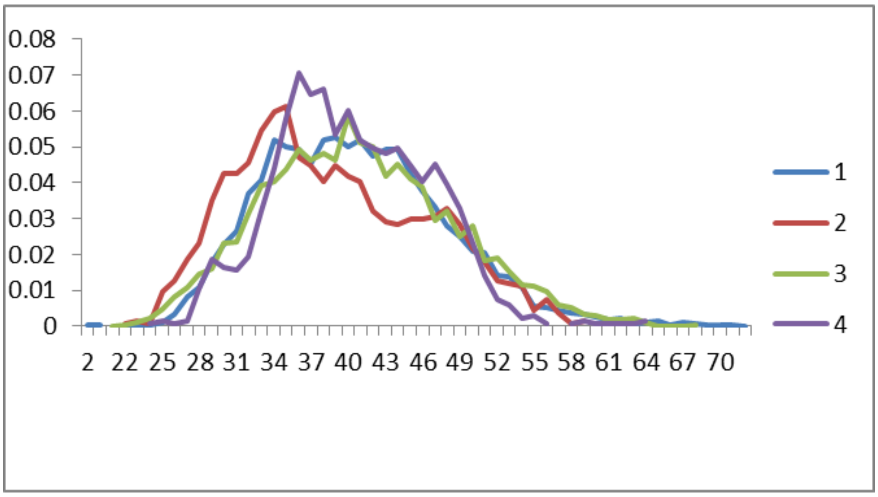


Figure 3.2.3.6. Length distributions of the Danish sea-samples in 2010 by subarea(1-4). No information exist for subarea 5 and 6.

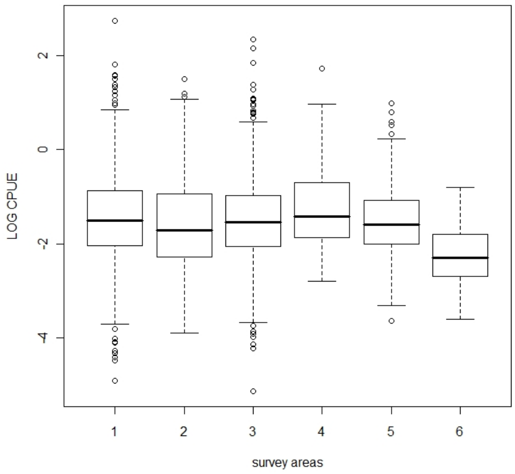


Figure 3.2.3.7. Boxplot of the catch rate (kilo *Nephrops*/kilowatt days) for the Danish fleet in 2010 by subarea.

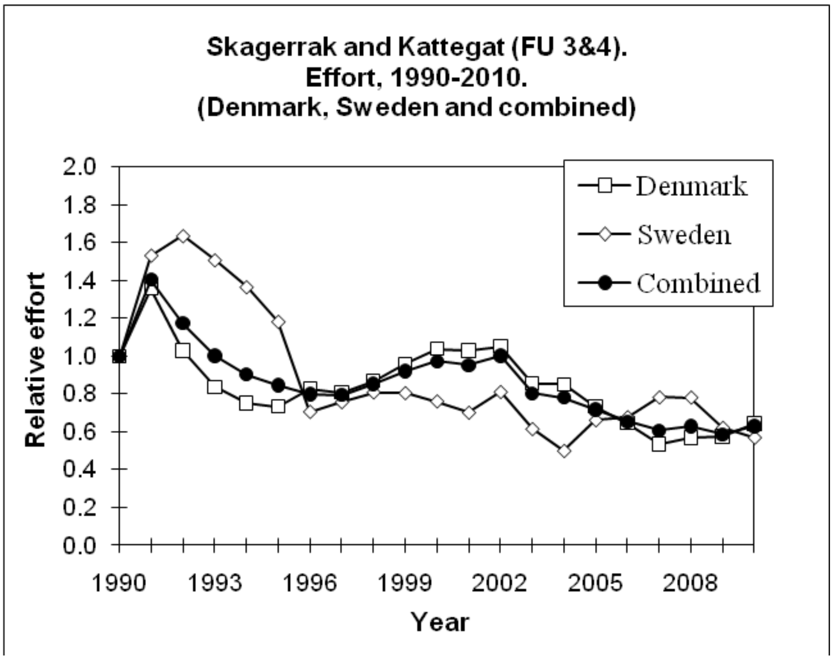


Figure 3.2.4.1 ***Nephrops*** **in Area IIIa. Combined Effort for FU 3&4**

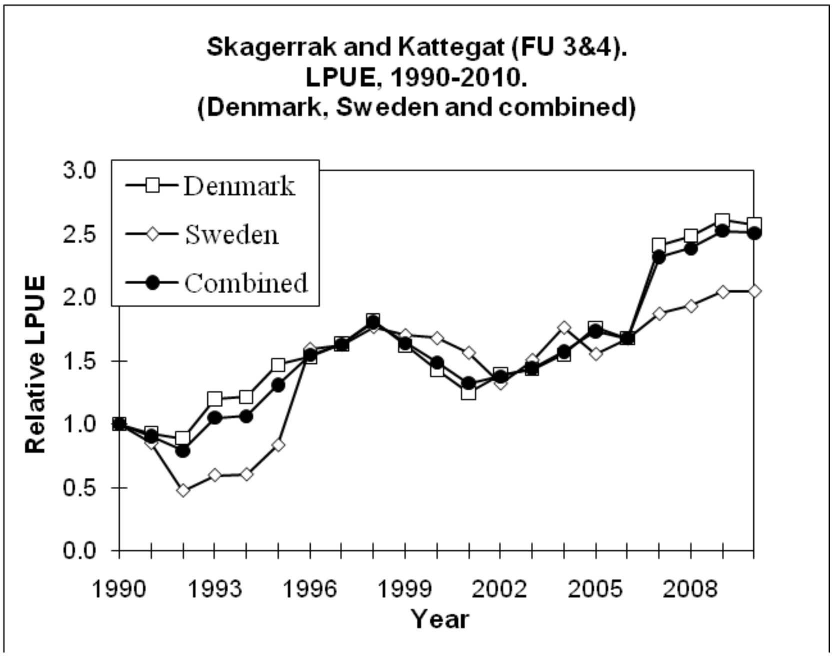


Figure 3.2.4.2 ***Nephrops*** **in Area IIIa. Combined LPUE for FU 3&4**

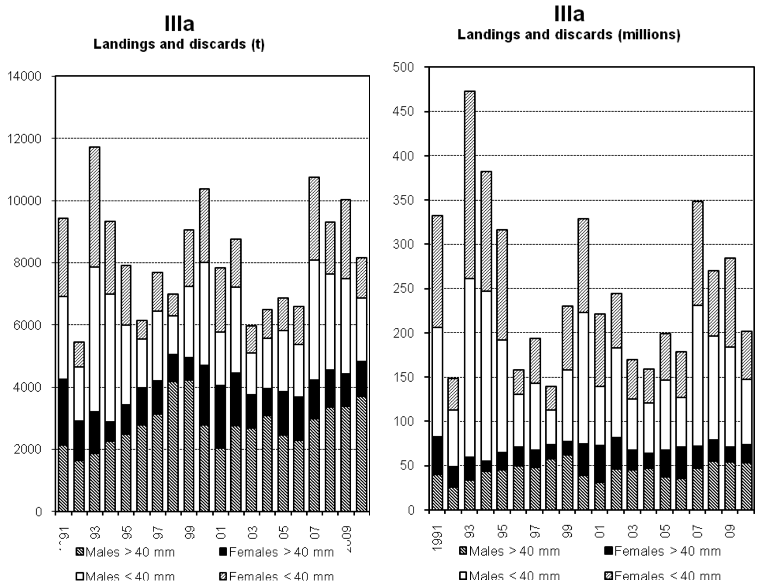


Figure 3.2.4.3 ***Nephrops*** **in IIIa FUs 3&4. Catch by sex and size category in numbers and biomass.**

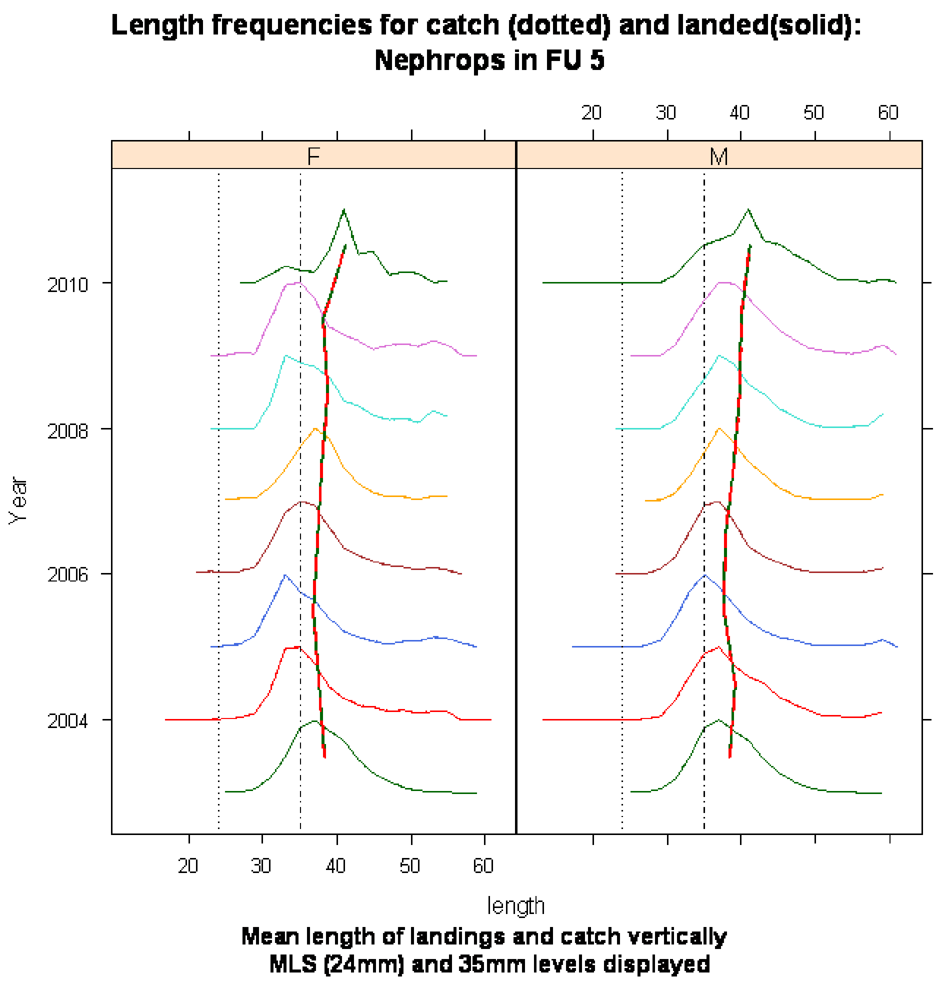


Figure 3.3.1.1 – FU5 Botney Gut/Silver Pit. Size distribution for Dutch landings, from 2003 to 2010. For 2003 the length distribution is given by sex combined.

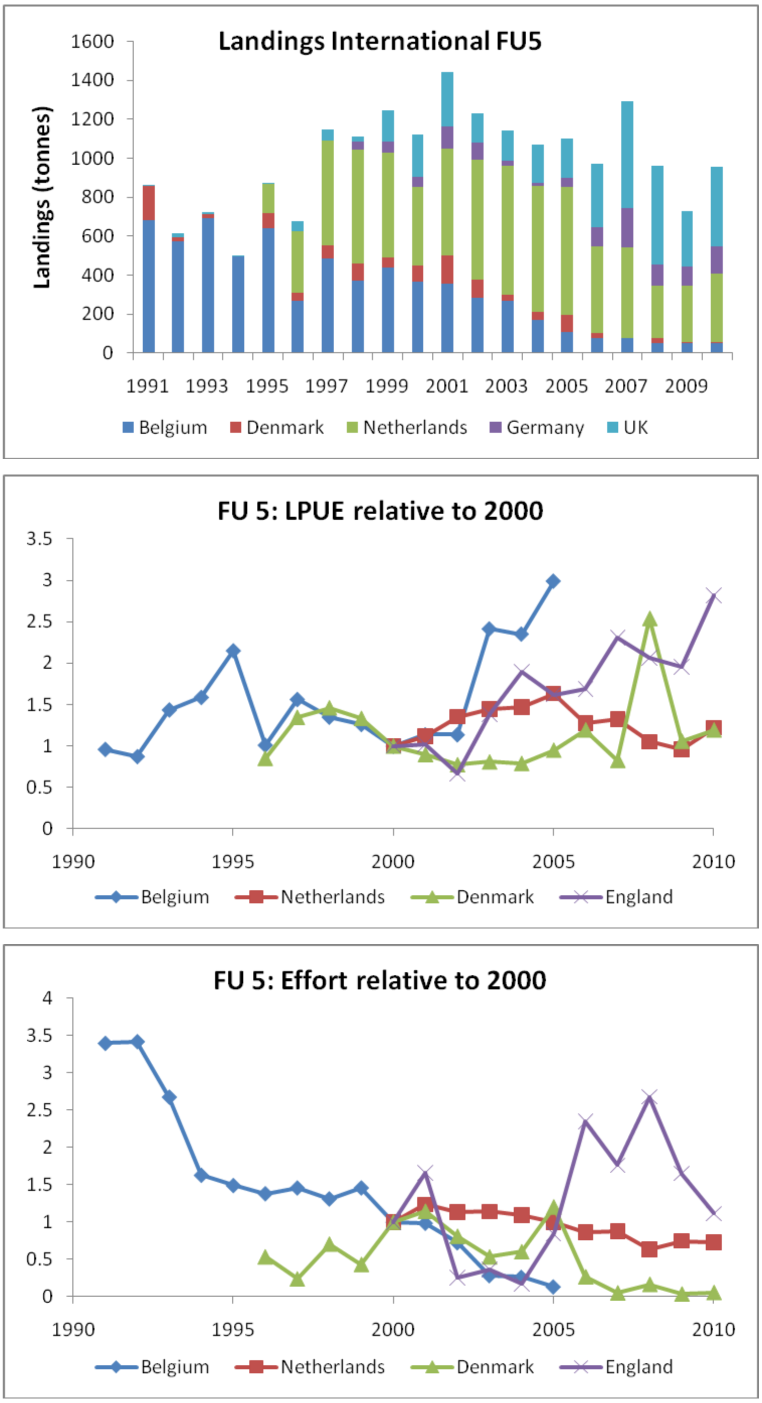


Figure 3.3.1.2 - FU5 Botney Gut/Silver Pit. Long-term trends in landings, effort and LPUEs.

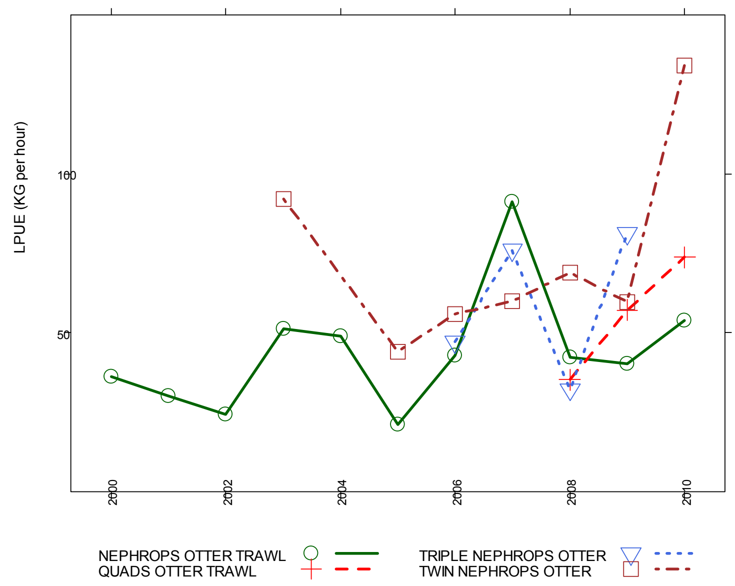


Figure 3.3.1.3. ***Nephrops*** **in FU5:LPUE by different gear types for English Vessels.**

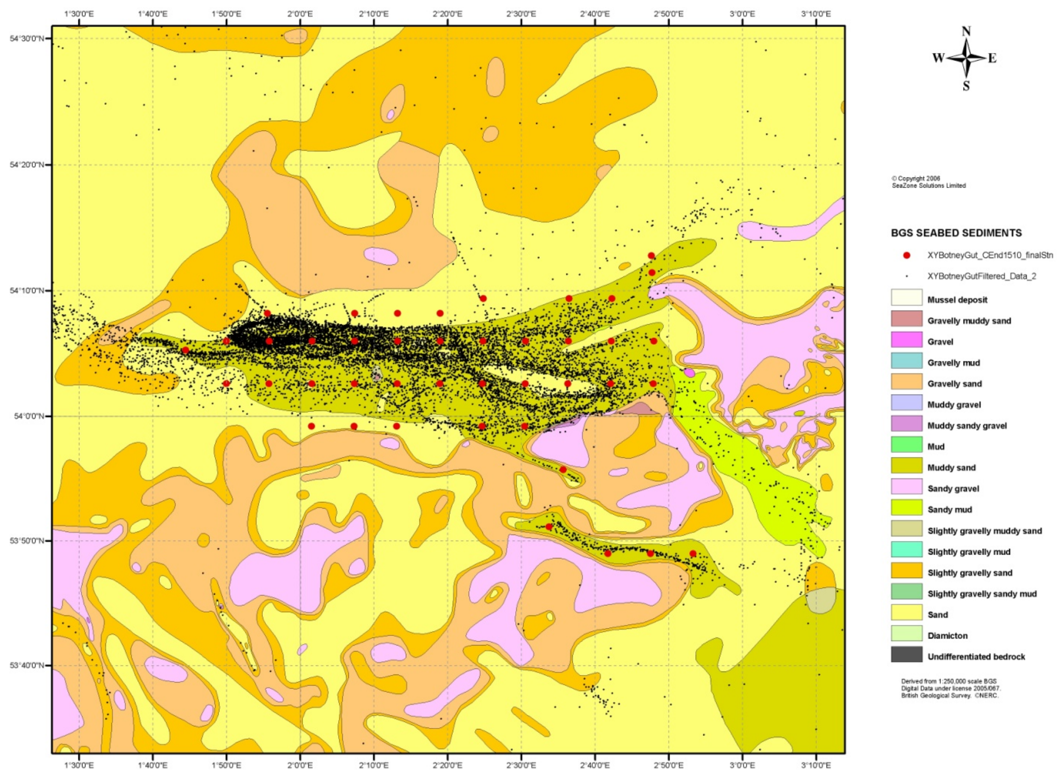


Figure 3.3.1.4 - FU5 Botney Gut/Silver Pit. Map showing BGS sediment data, fishing vessel activity from satellite data and the 42 survey station locations.

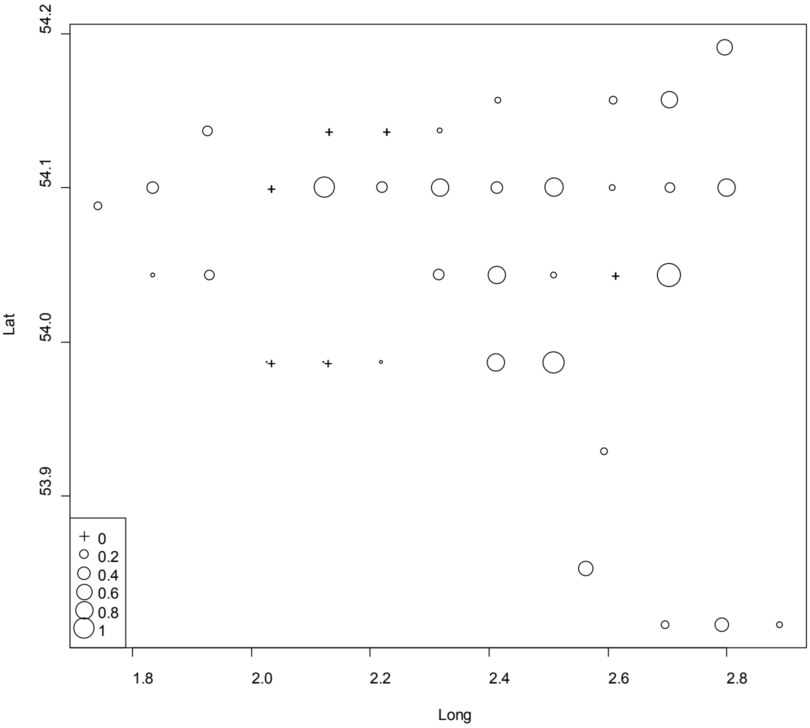


Figure 3.3.1.5. Preliminary UWTV survey results for FU5.

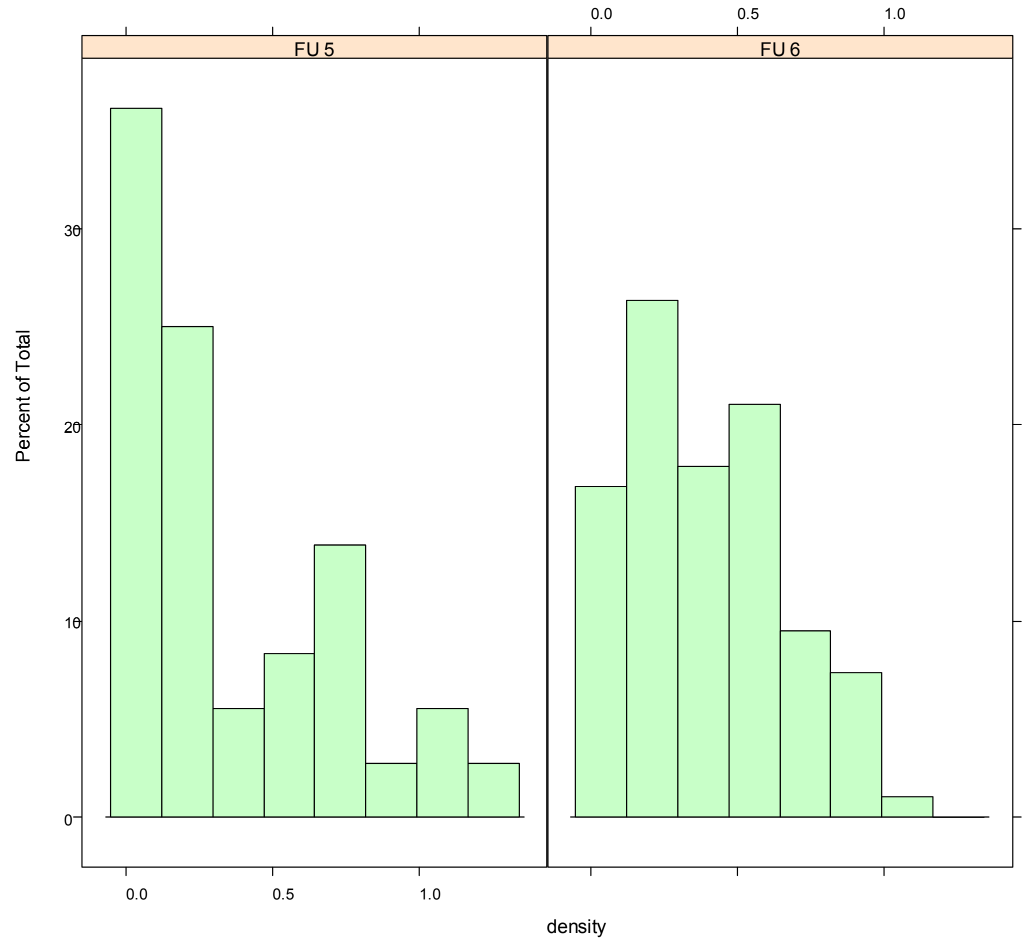


Figure 3.3.1.6. Comparison of burrow density composition between functional units 5 and 6

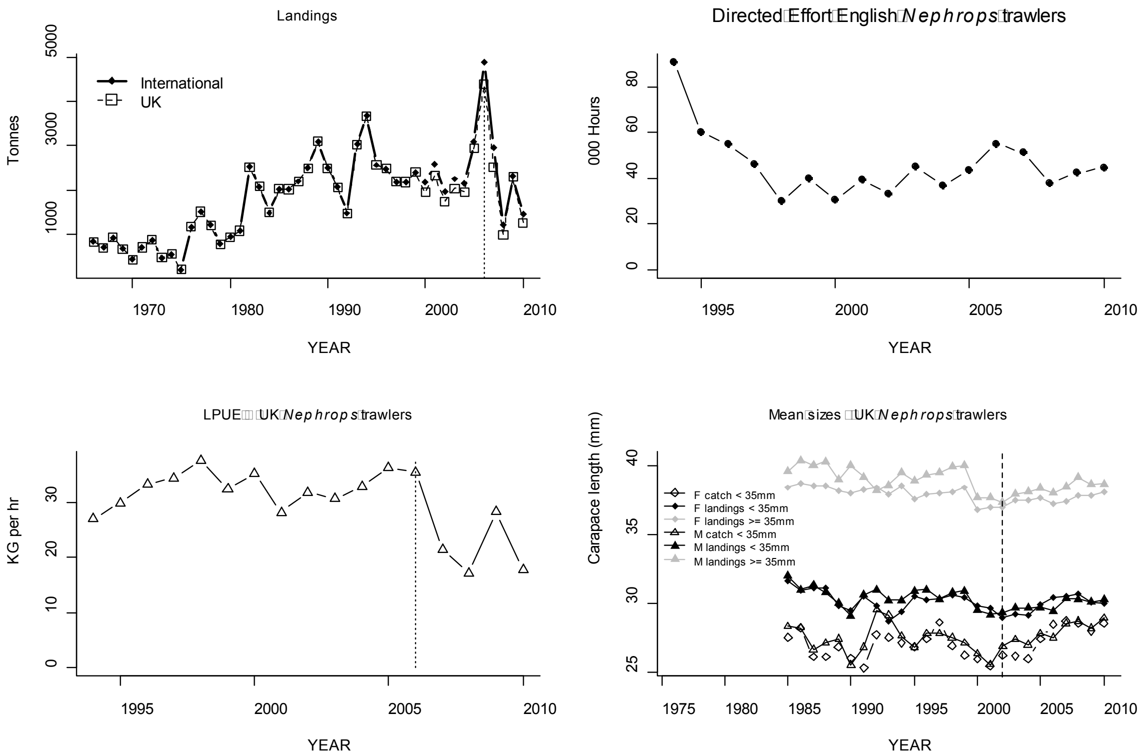


Figure 3.3.2.1 ***Nephrops* in FU6. Landings, directed effort, directed LPUE and mean sizes of different catch components.**

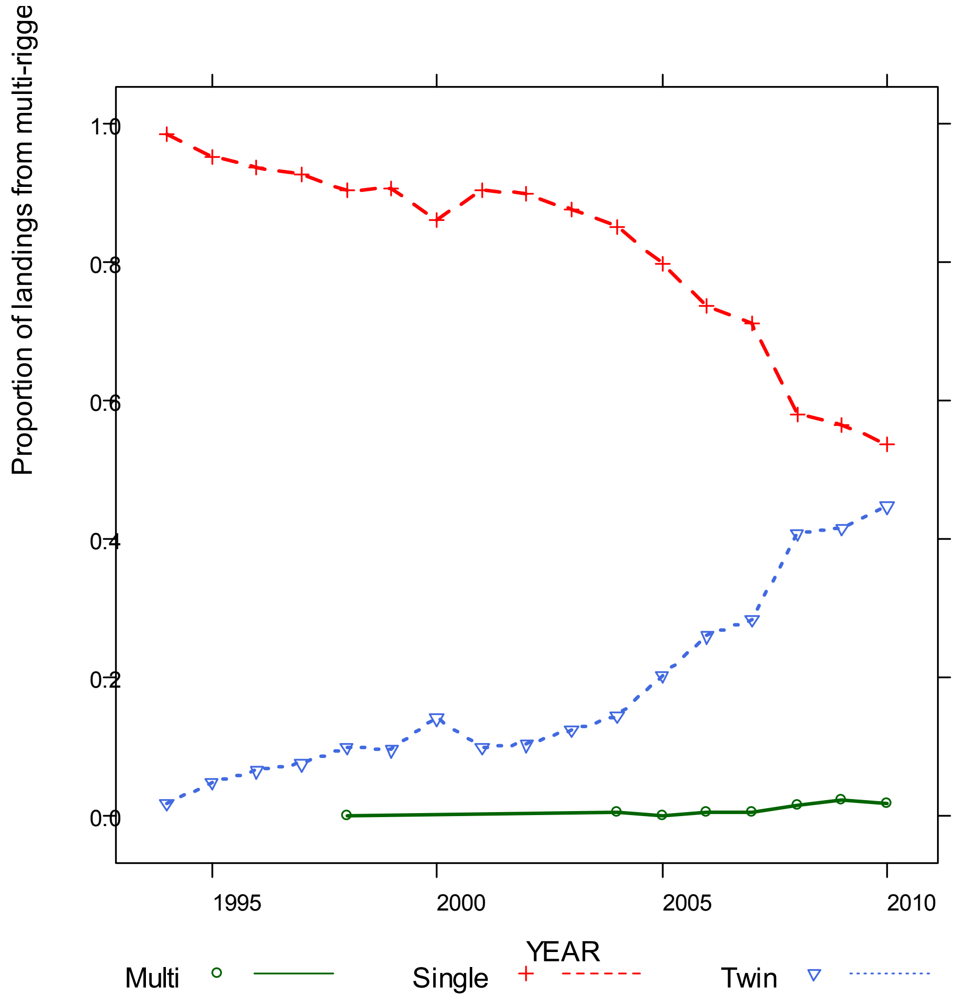


Figure 3.3.2.2 ***Nephrops*** **in FU6. Proportion of landings from different gear types.**

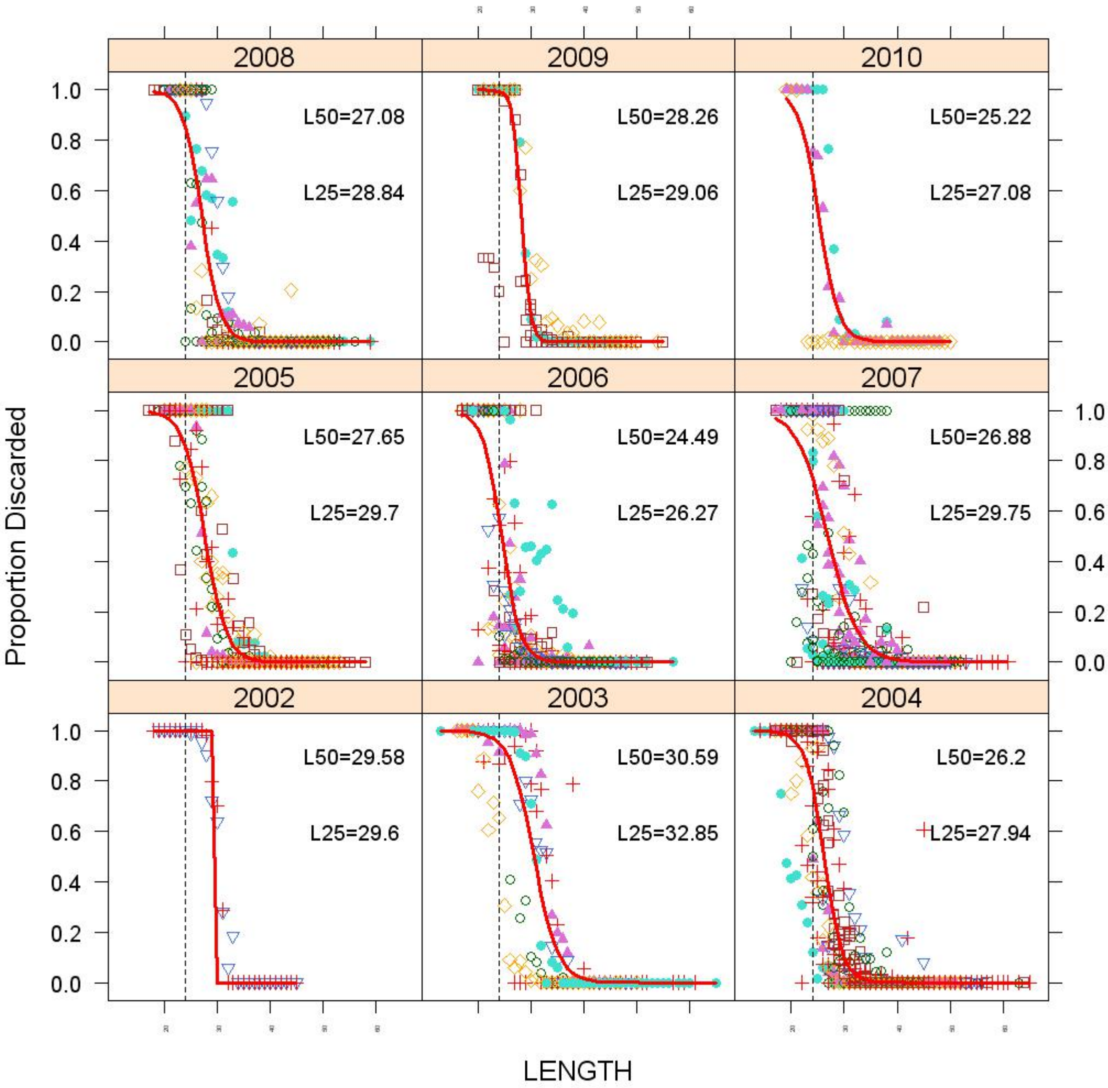


Figure 3.3.2.3 ***Nephrops*** **in FU6, annual discard ogives. The different point shapes represent different sampling trips within any year.**

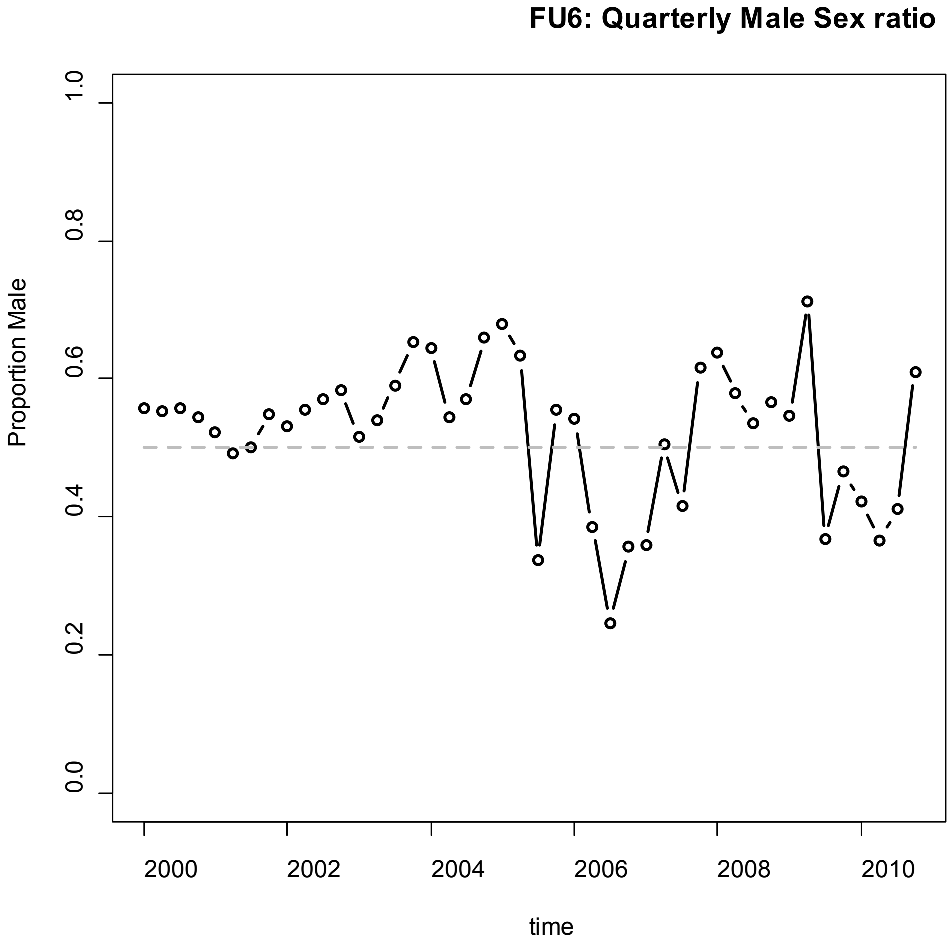


Figure 3.3.2.4 ***Nephrops*** **in FU6: Quarterly sex ratio in the catches.**

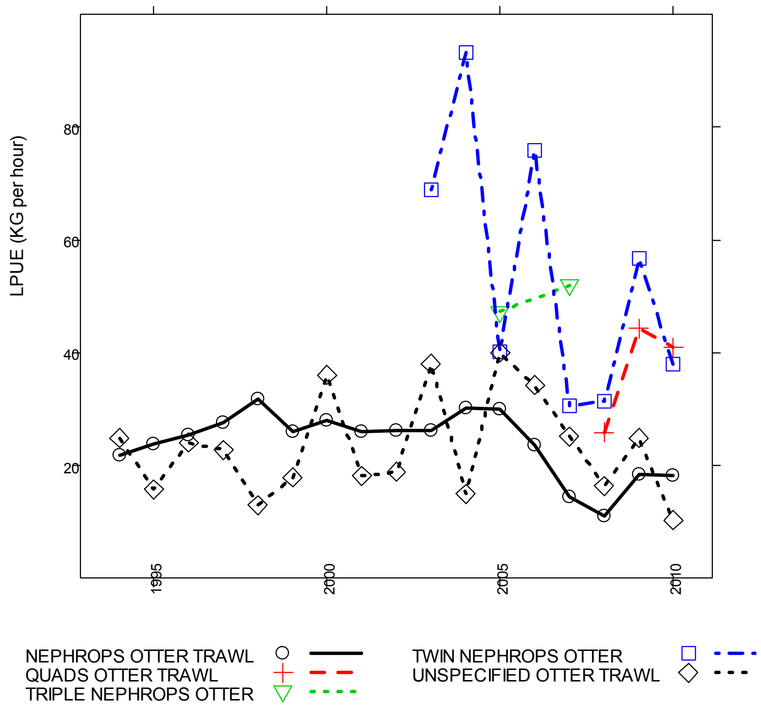


Figure 3.3.2.5 ***Nephrops*** **in FU6: LPUE for directed English trawlers by gear type.**

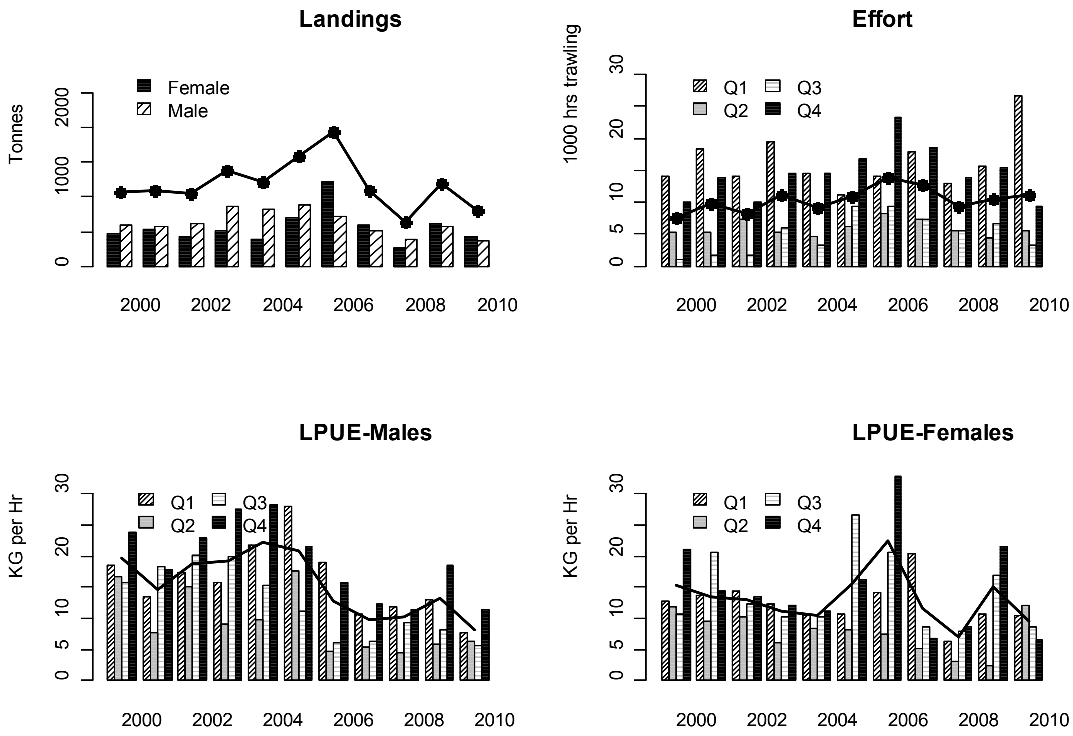


Figure 3.3.2.6 ***Nephrops*** **in FU6: LPUE by sex and quarter.**

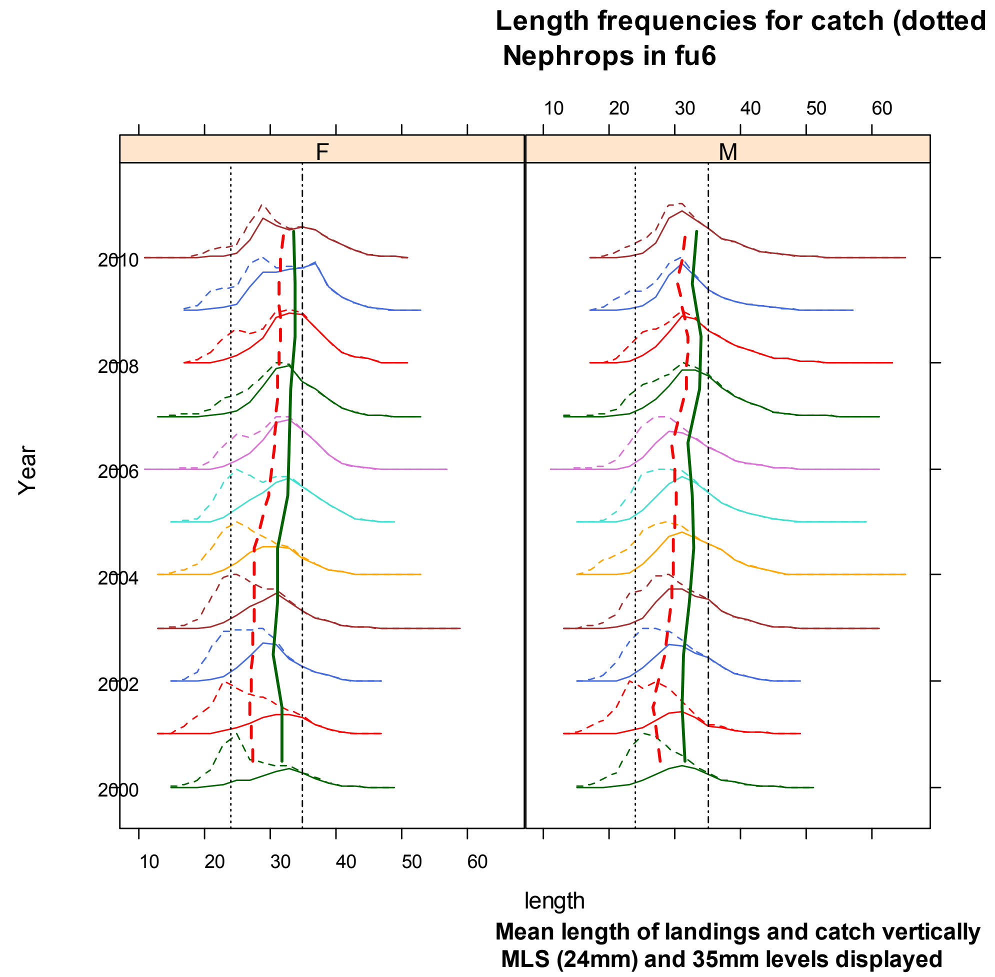


Figure 3.3.2.7 ***Nephrops*** **in FU6: Annual length frequencies for landings and discards.**

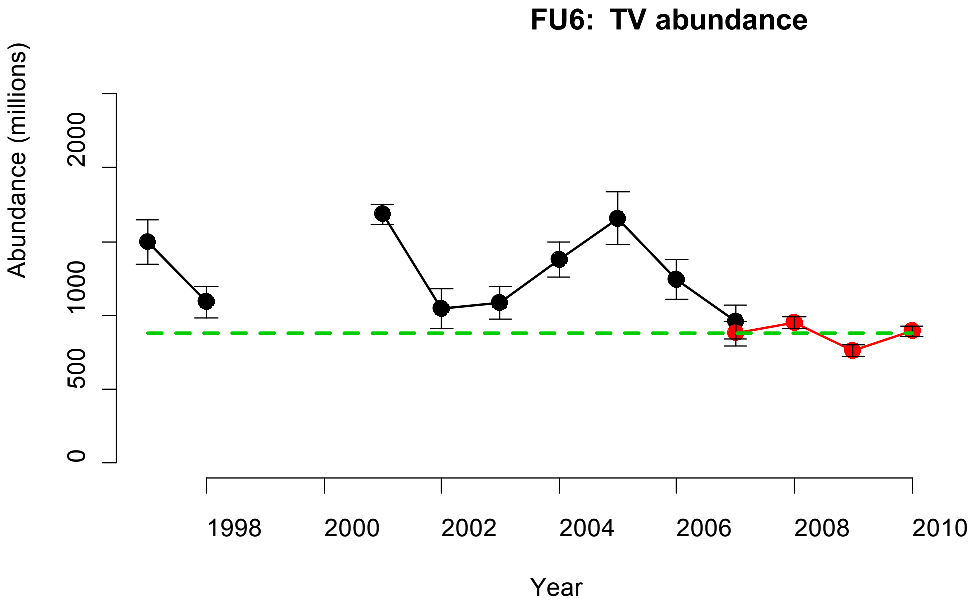


Figure 3.3.2.8 *Nephrops* in FU6: Time series of UWTV results. The dashed green line is the proxy for MSY $B_{trigger}$ (879), the abundance estimate for 2007. The red line since 2007 gives the Geo-statsistical abundance estimate using GPS measured distance. Prior to 2007 the estimate was raised using straight-line estimates of distance and stratified raising.

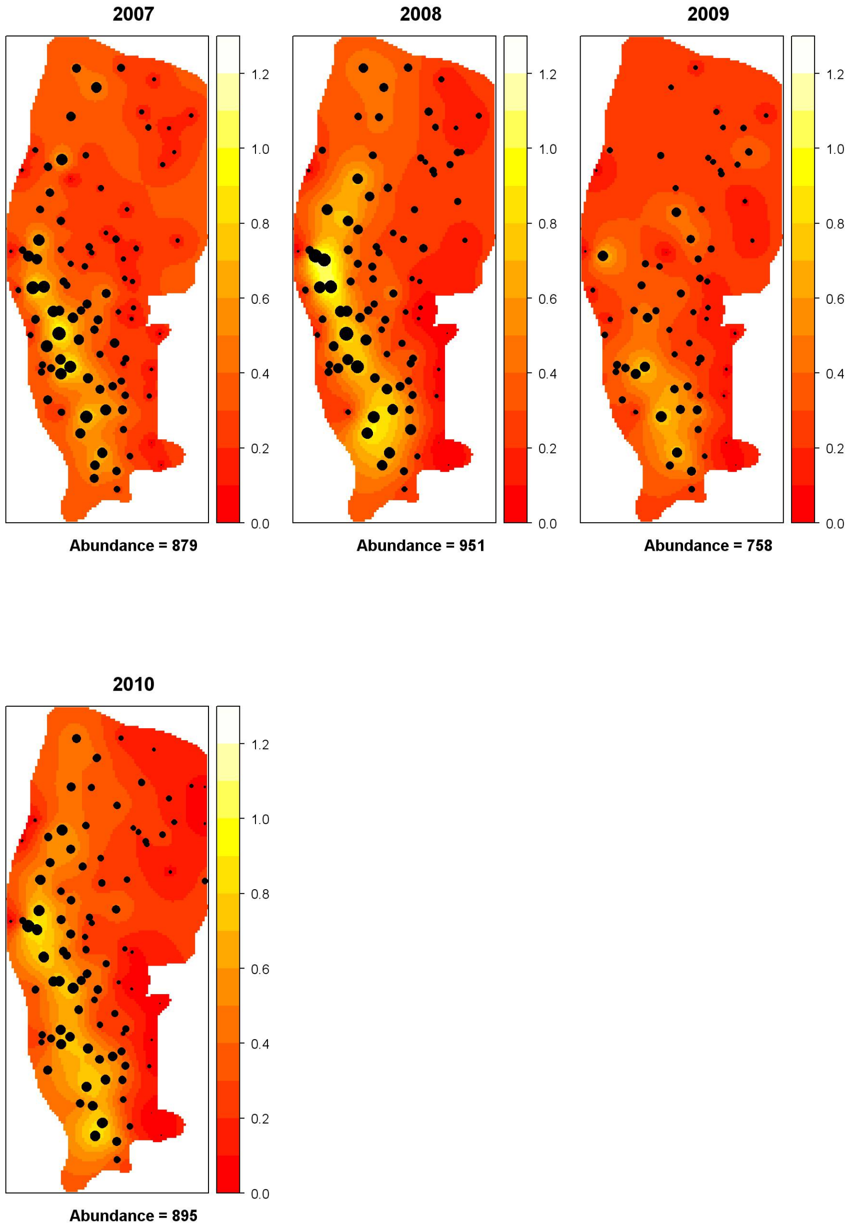


Figure 3.3.2.9 ***Nephrops*** **in FU6: Results of the UWTV survey.**

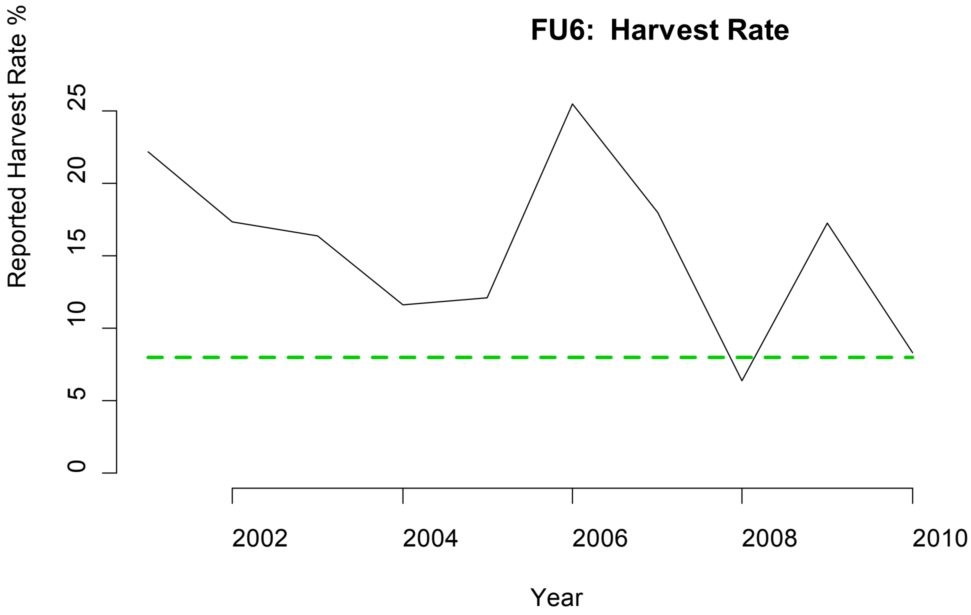


Figure 3.3.2.10 *Nephrops* in FU6: Observed harvest ratio (removals divided by abundance estimate).

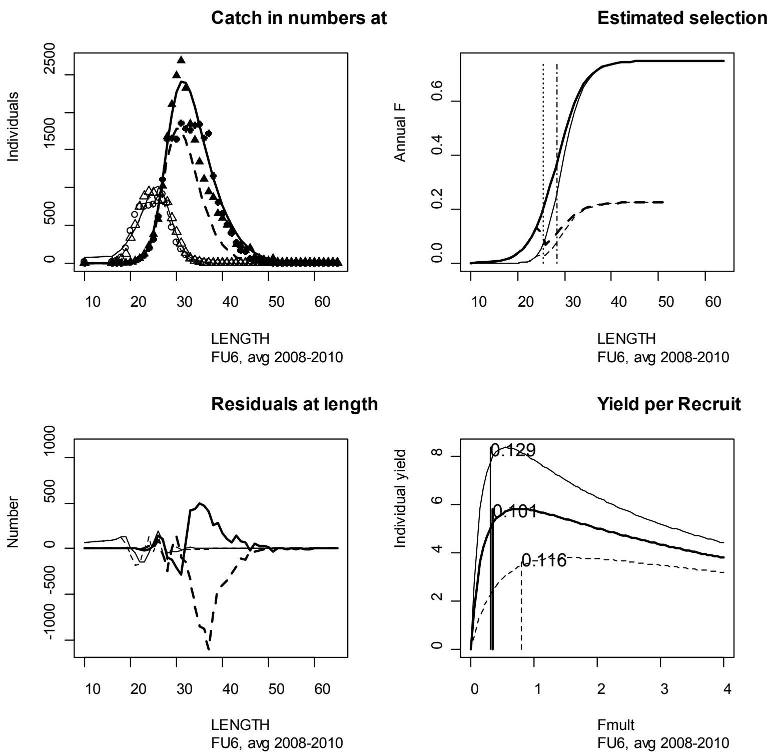


Figure 3.3.2.10 *Nephrops* in FU6: Separable Cohort analysis model fit. Solid lines are for males, dashed lines are females, thick lines represent the landings component, the thin lines represent the discarded compoent. The top left panel gives observed and predicted numbers at length in the discards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

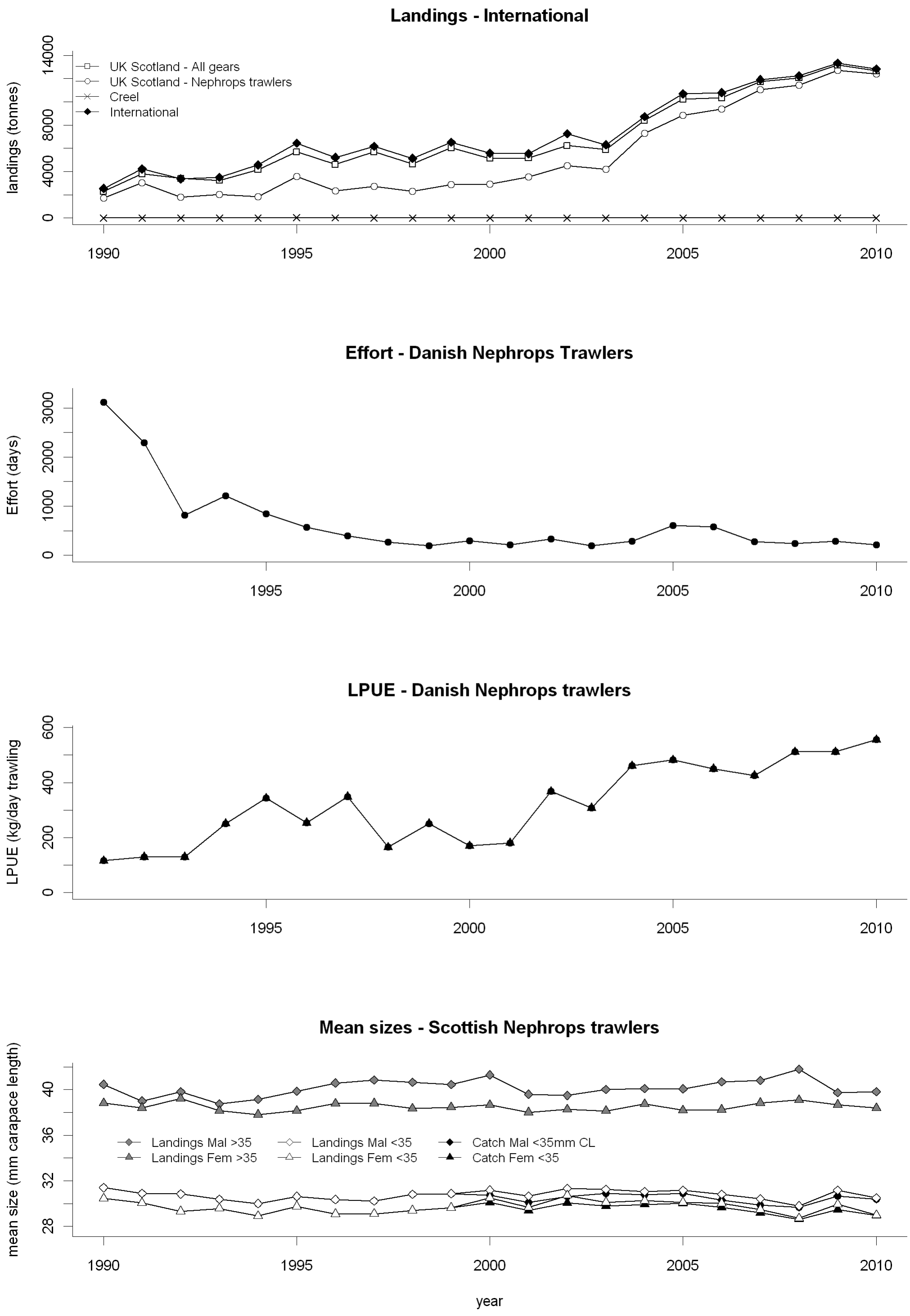


Figure 3.3.3.1 ***Nephrops*****, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.**

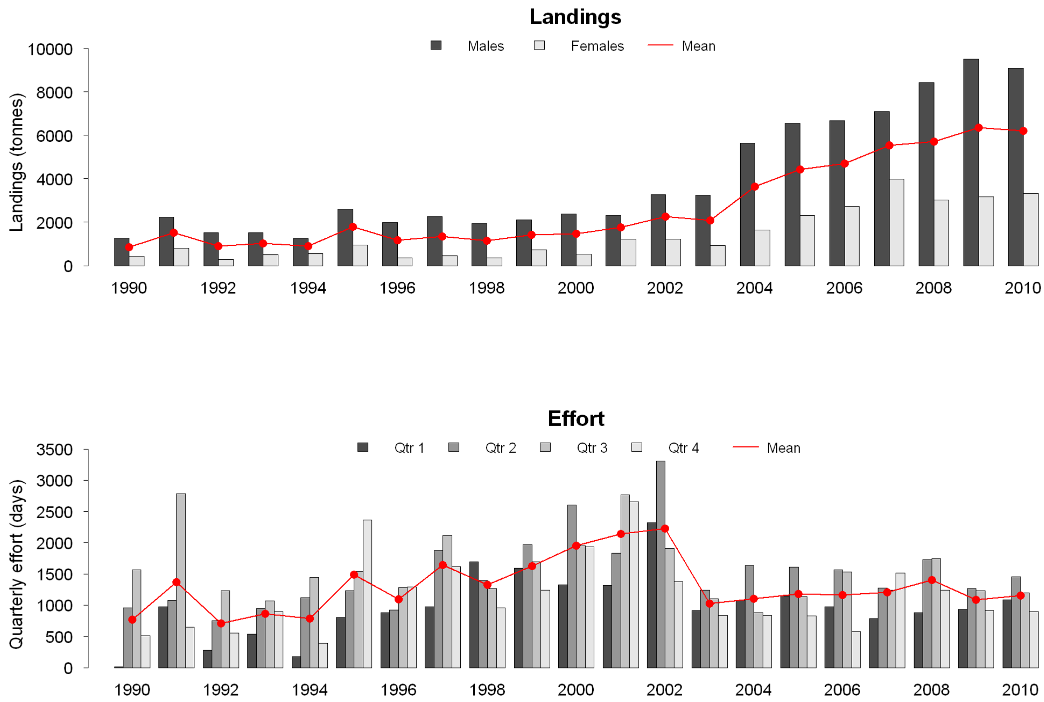


Figure 3.3.3.2 ***Nephrops*****, Fladen (FU 7), Landings by sex and effort by quarter from Scottish** ***Nephrops*** **trawlers.**

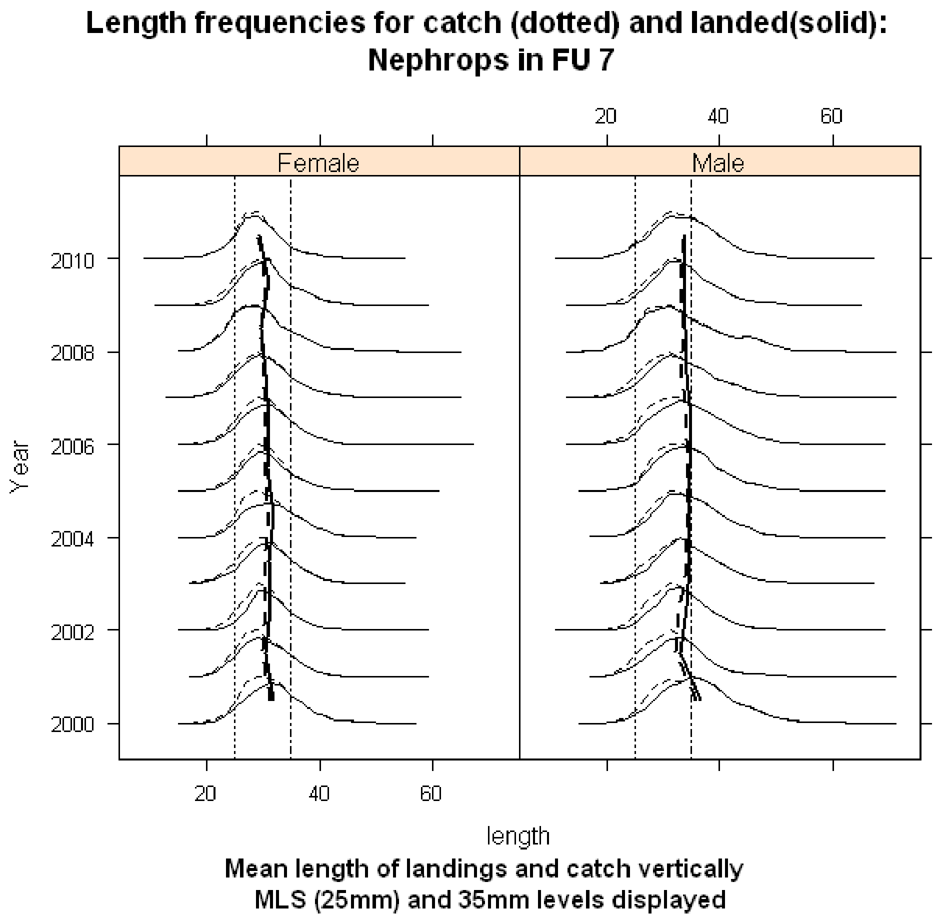


Figure 3.3.3.3. ***Nephrops*** **Fladen Ground (FU 7)Length composition of catch of males (right) and females left from 2000 (bottom) to 2009 (top). Mean sizes of catch and landings are displayed vertically.**

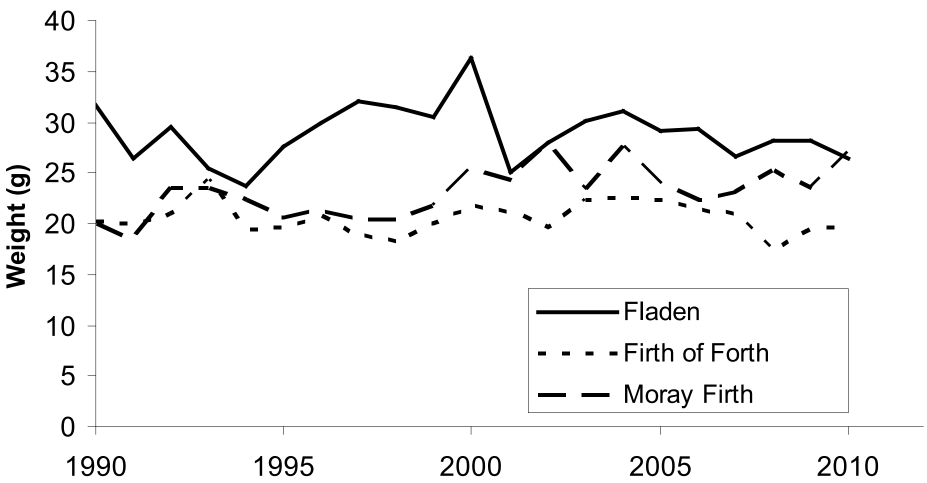


Figure 3.3.3.4 ***Nephrops*****, (FUs 7-9), individual mean weight in the landings from 1990-2010 (from Scottish market sampling data).**

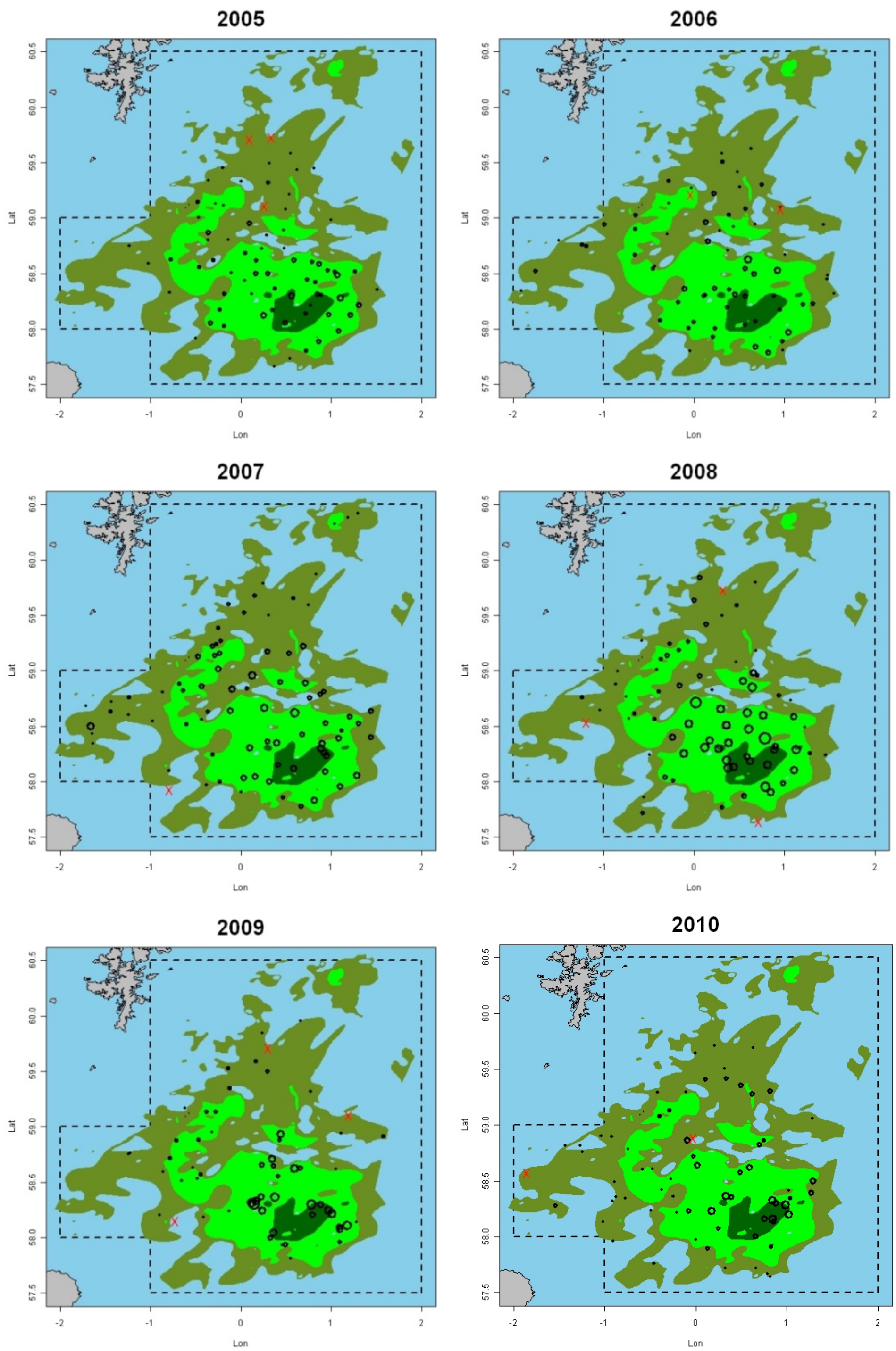


Figure 3.3.3.5 ***Nephrops*****, Fladen (FU 7). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

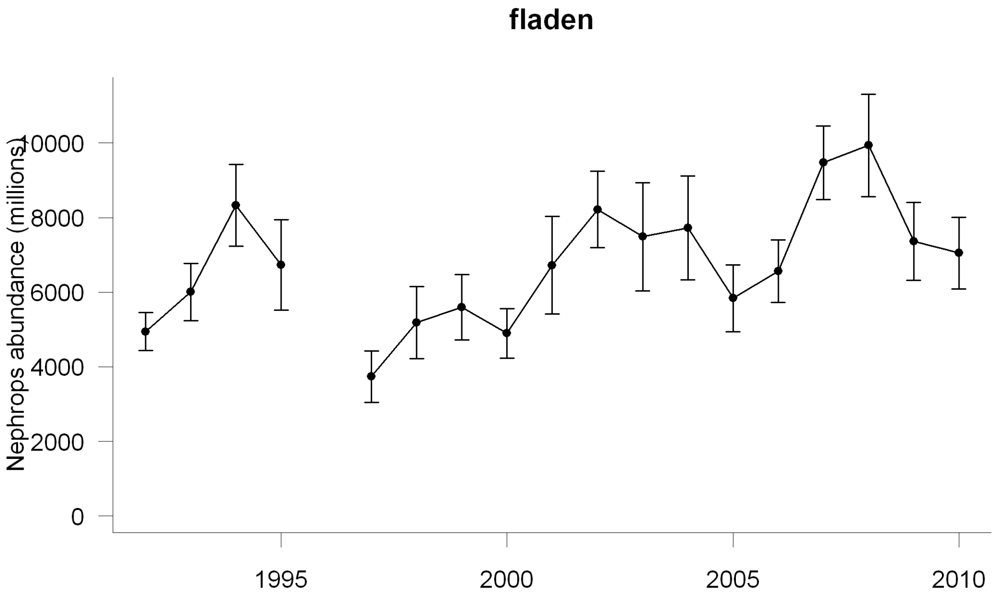
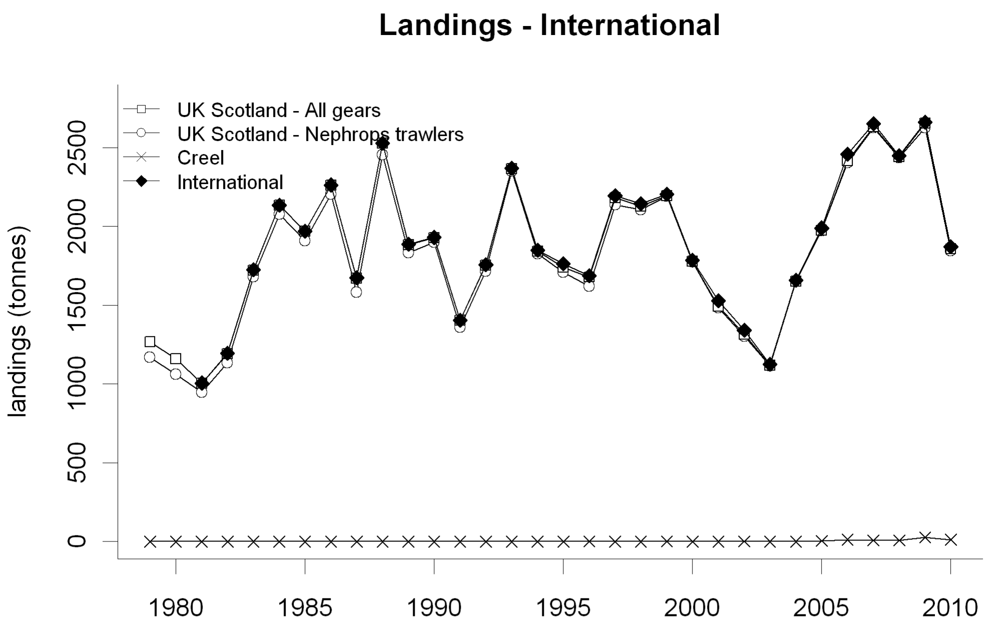


Figure 3.3.3.6 ***Nephrops*****, Fladen (FU 7), Time series of TV survey abundance estimates (not bias adjusted), with 95% confidence intervals, 1992 – 2010.**



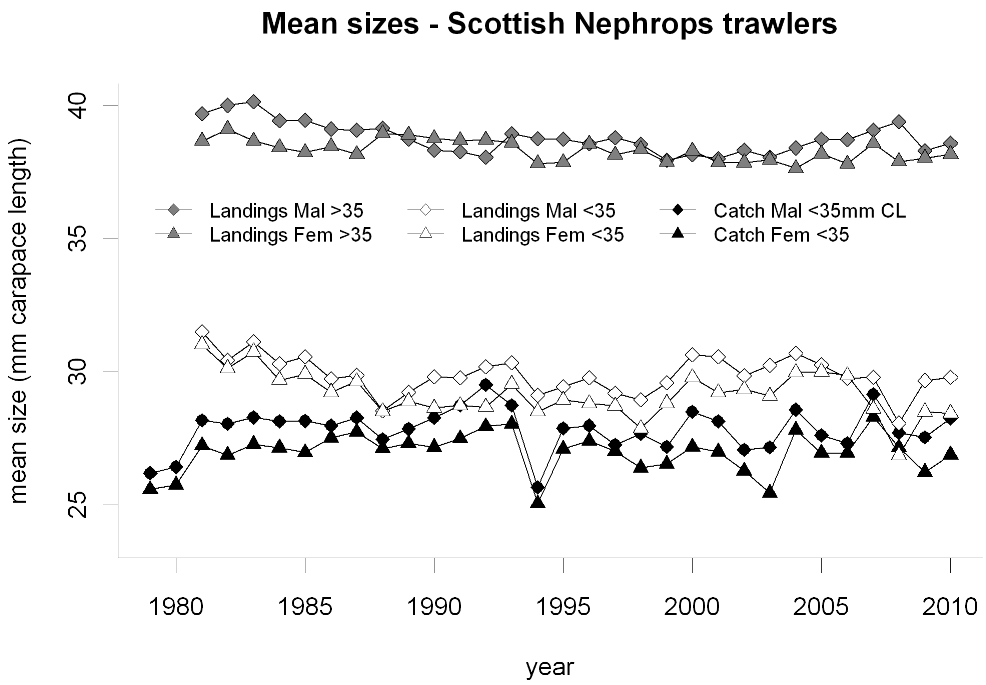


Figure 3.3.4.1 *Nephrops*, Firth of Forth (FU 8), Long term landings and mean sizes.

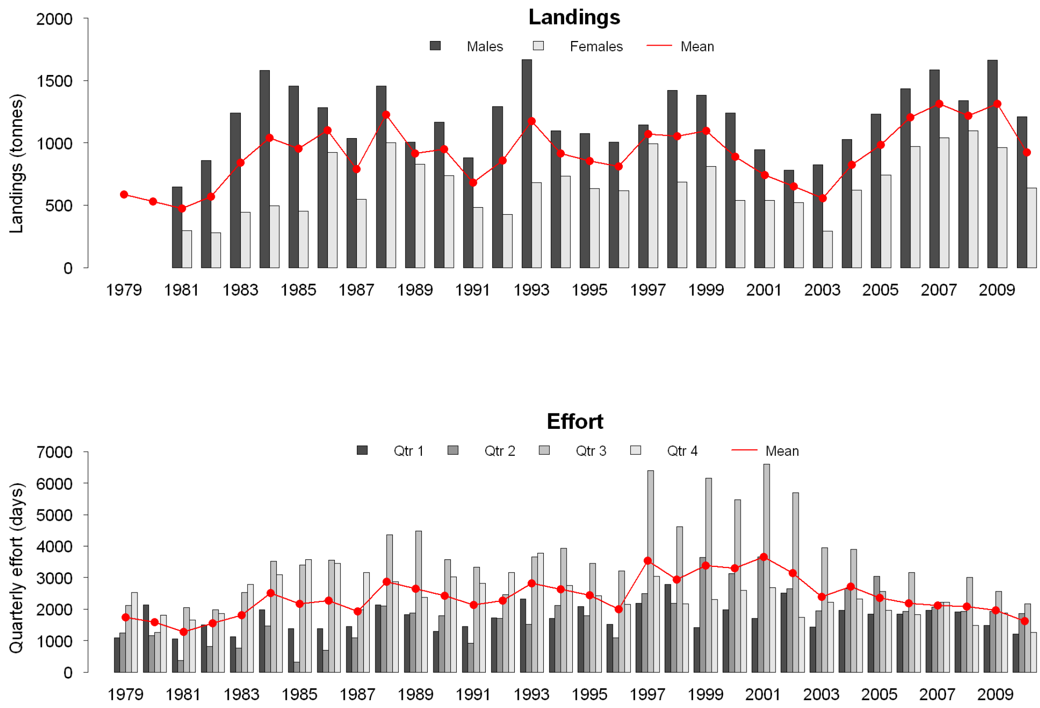


Figure 3.3.4.2 ***Nephrops*****, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

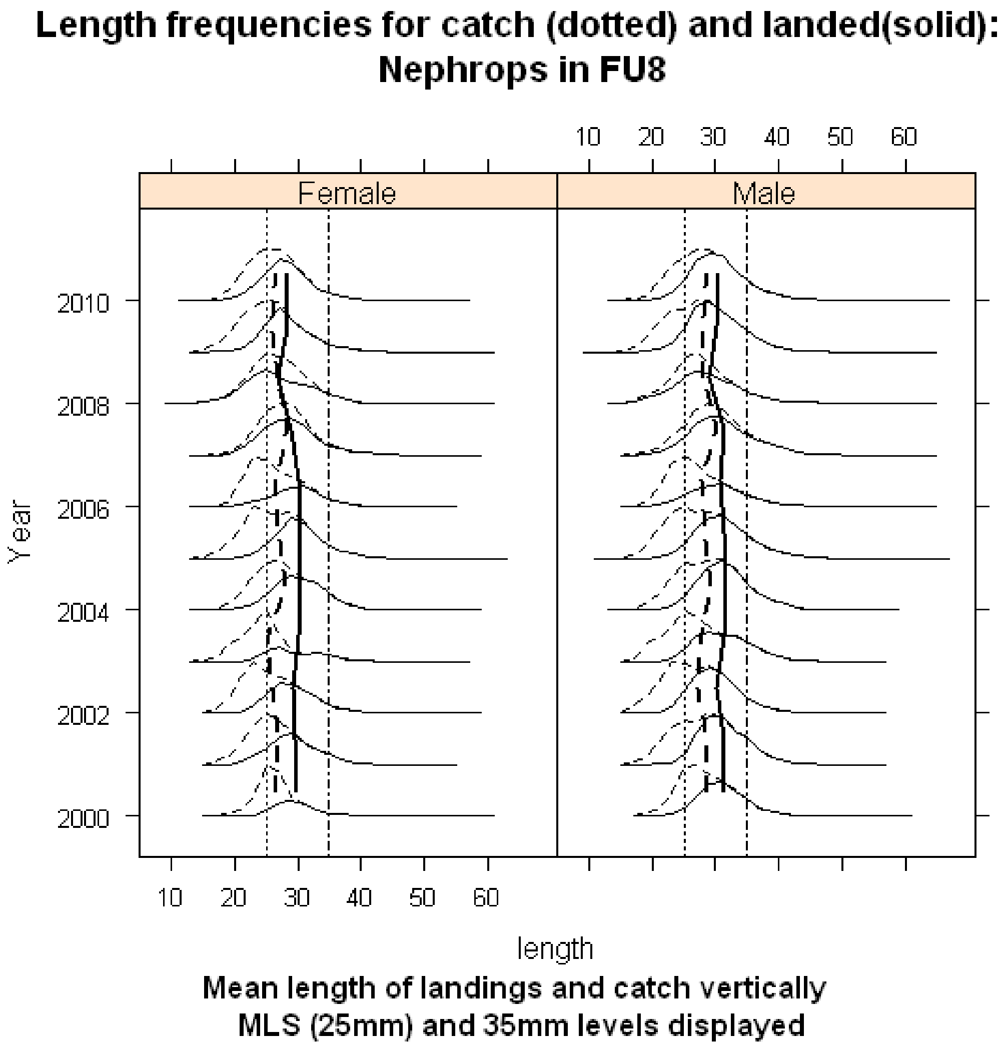


Figure 3.3.4.3 ***Nephrops*** **Firth of Forth (FU 8)Length composition of catch of males (right) and females left from 2000 (bottom) to 2010 (top). Mean sizes of catch and landings are displayed vertically.**

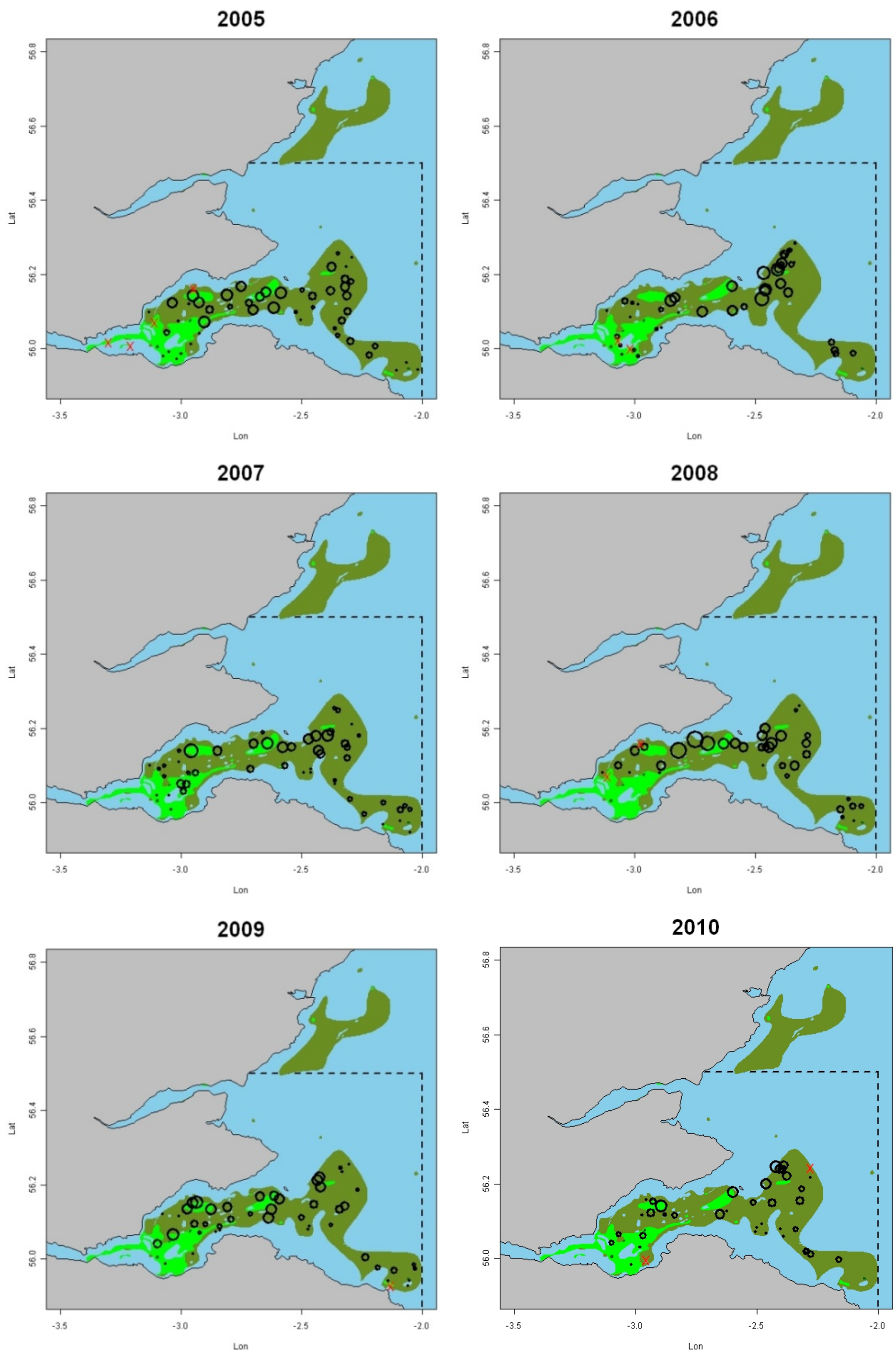


Figure 3.3.4.4 *Nephrops*, Firth of Forth (FU 8). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.

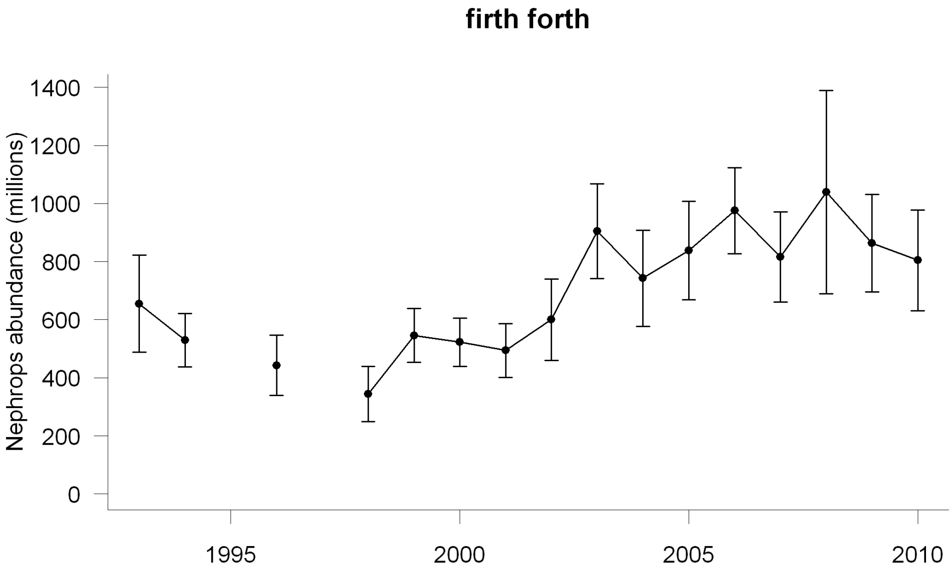
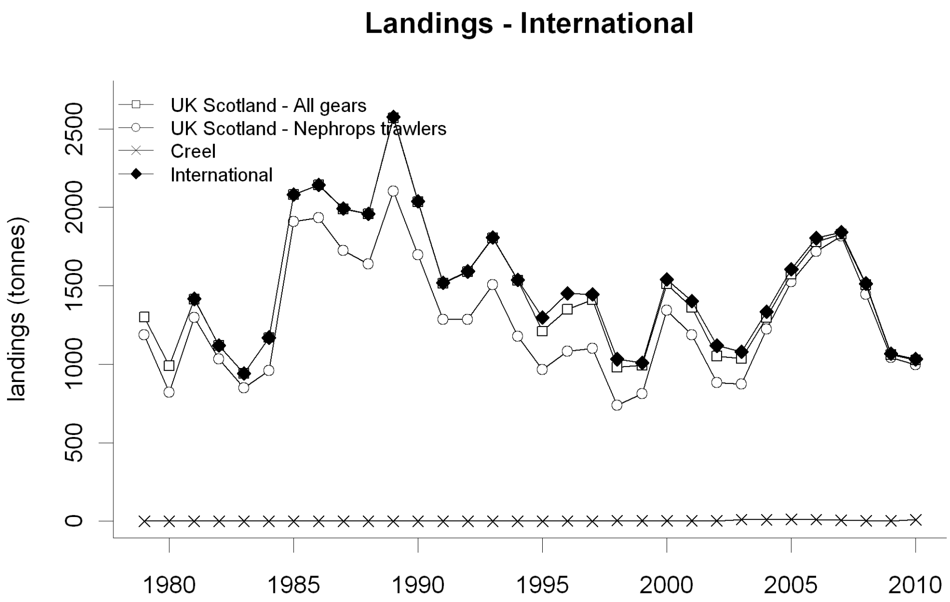


Figure 3.3.4.5 *Nephrops*, Firth of Forth (FU 8), Time series of TV survey abundance estimates, with 95% confidence intervals, 1995 – 2010.



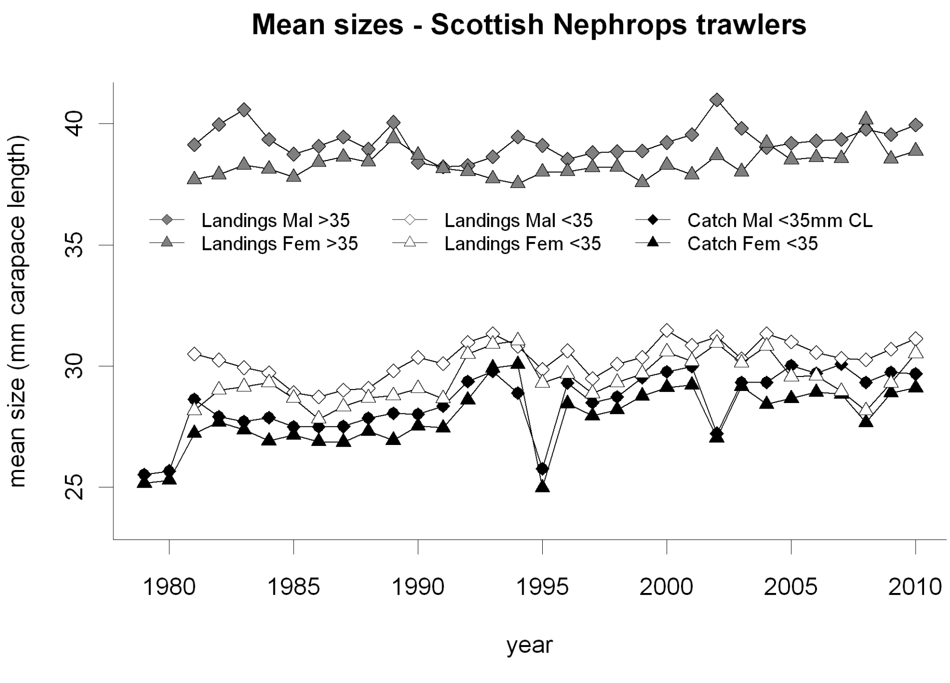
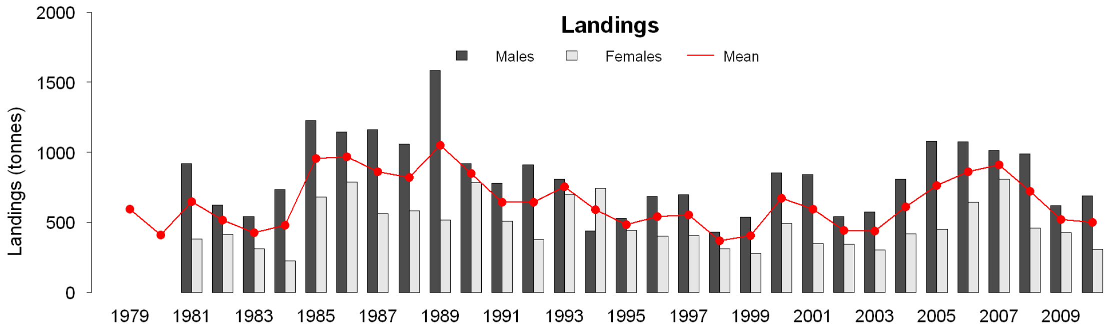


Figure 3.3.5.1 *Nephrops*, Moray Firth (FU 9), Long term landings and mean sizes.



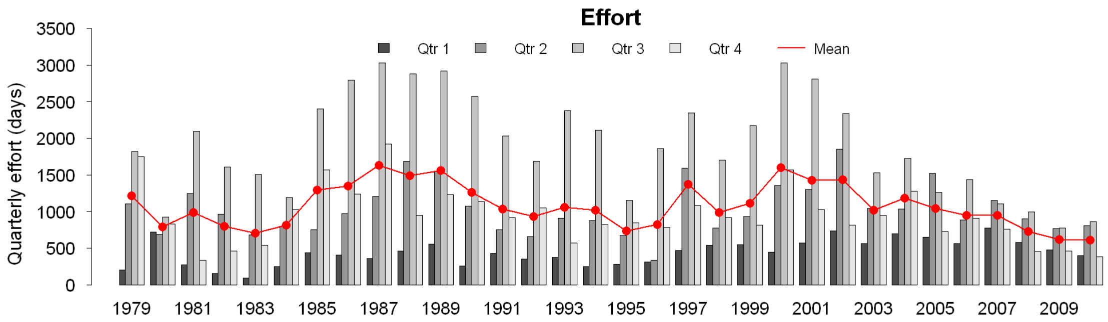


Figure 3.3.5.2 *Nephrops*, Moray Firth (FU 9), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.

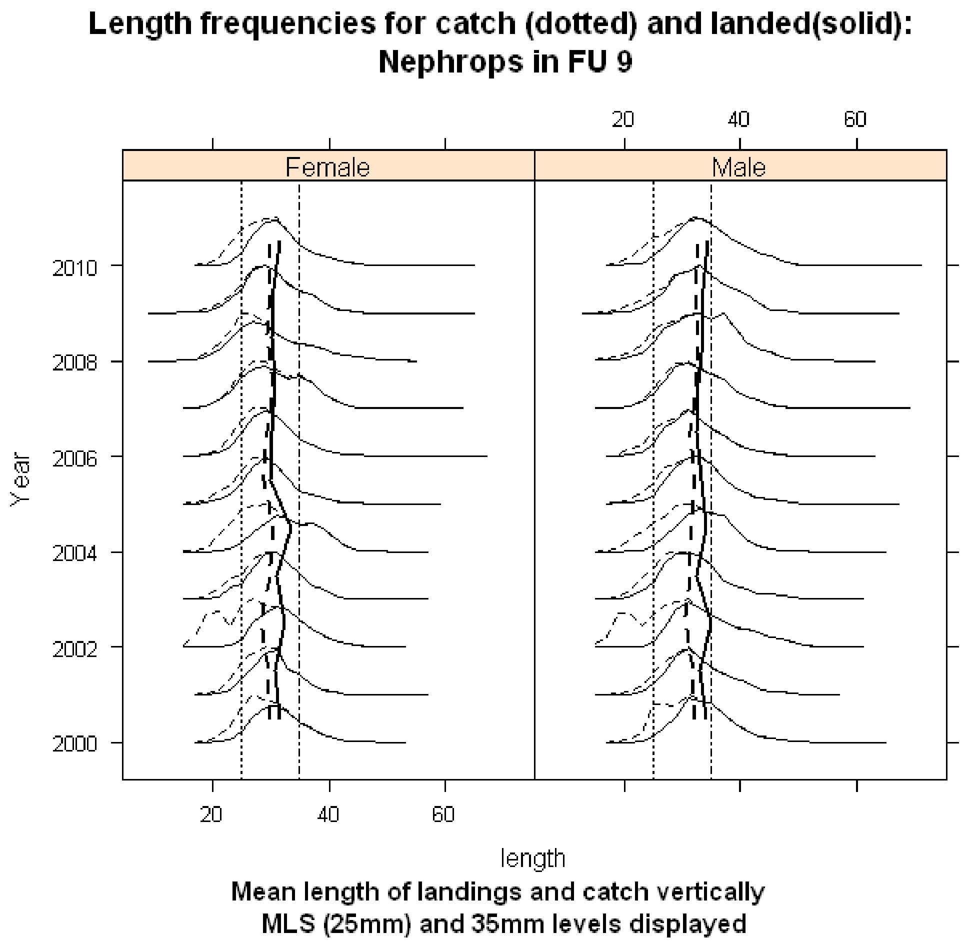


Figure 3.3.5.3 ***Nephrops*** **Moray Firth (FU 9) Length composition of catch of males (right) and females left from 2000 (bottom) to 2010 (top). Mean sizes of catch and landings are displayed vertically.**

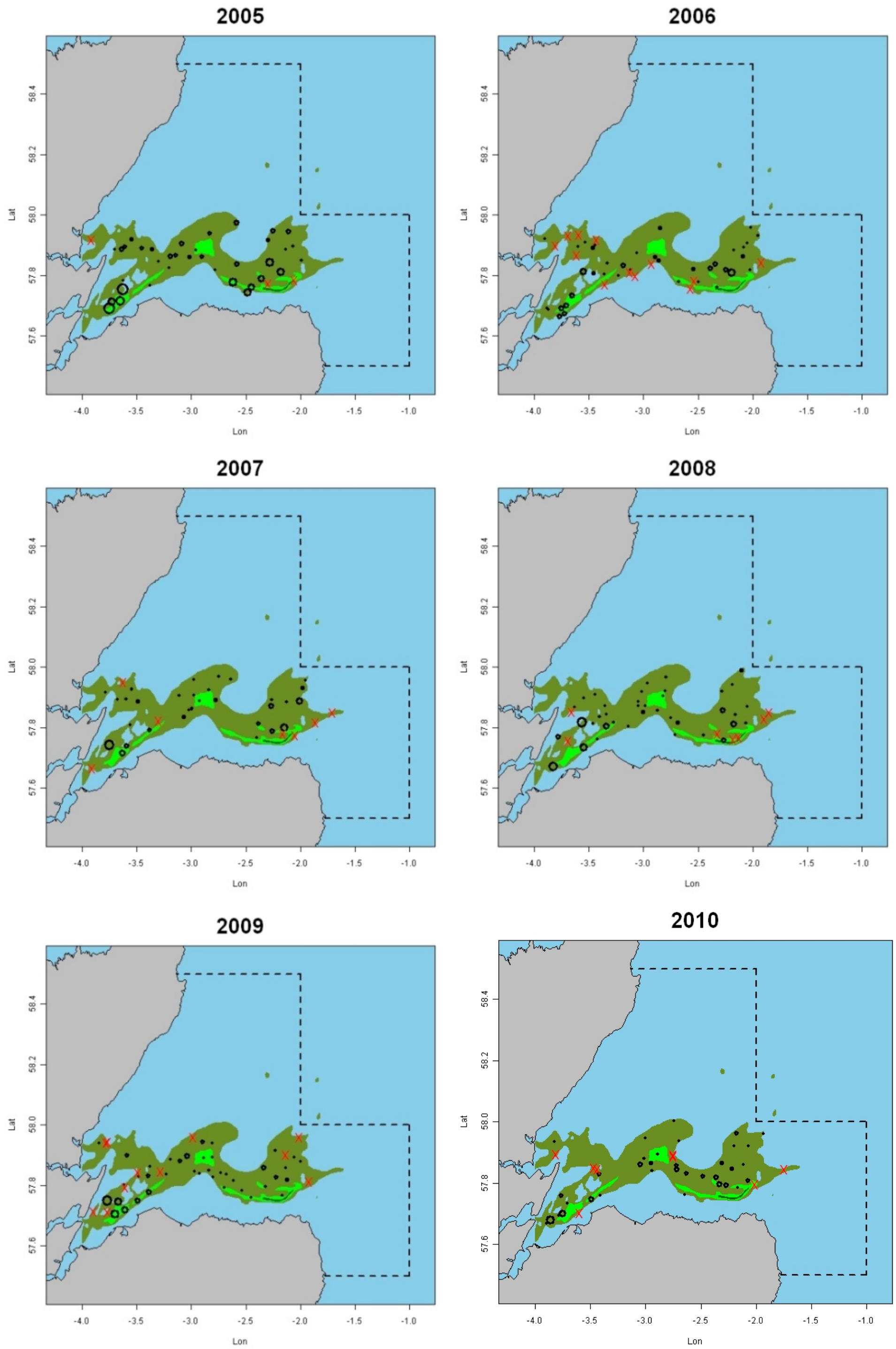


Figure 3.3.5.4 ***Nephrops*****, Moray Firth (FU 9). TV survey distribution and relative density (2005-2010). Green and brown areas represent areas of suitable sediment for** ***Nephrops*****. Density proportional to circle radius. Red crosses represent zero observations.**

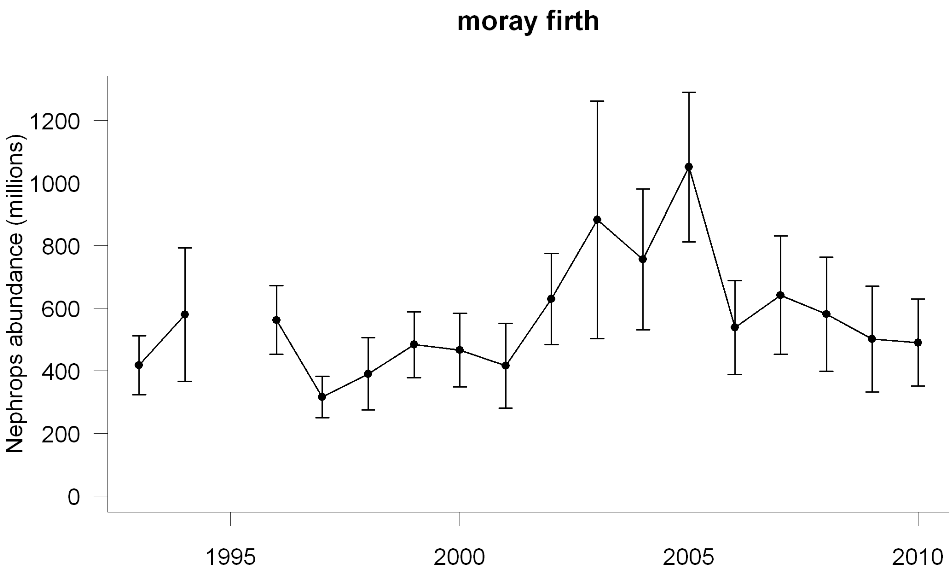


Figure 3.3.5.5 *Nephrops*, Moray Firth (FU 9), Time series of TV survey abundance estimates, with 95% confidence intervals, 1993 – 2010.

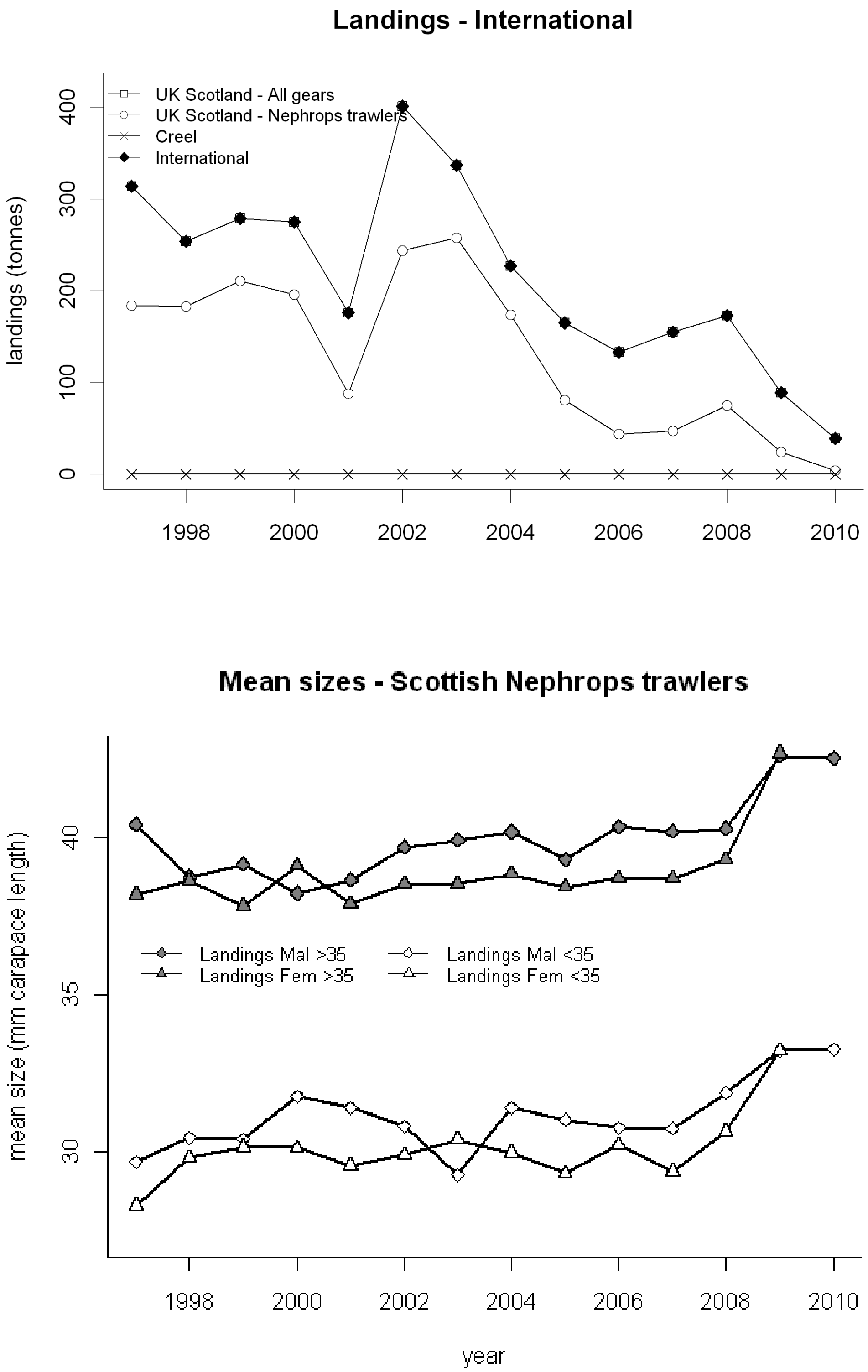


Figure 3.3.6.1 *Nephrops*, Noup (FU 10), Long term landings and mean sizes (no females in samples in 2010).

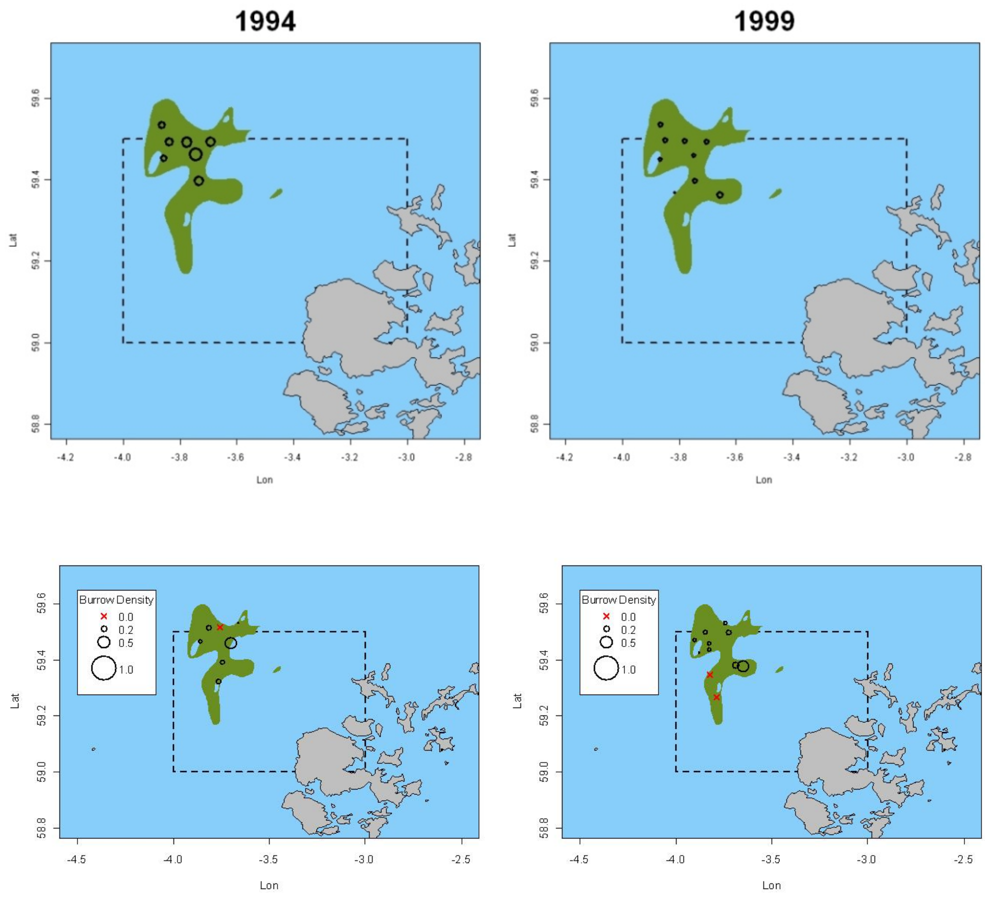


Figure 3.3.6.2 ***Nephrops*, Noup (FU 10). TV survey distribution and relative density (1994, 1999, 2006, 2007). Green and brown areas represent areas of suitable sediment for *Nephrops*. Density proportional to circle radius. Red crosses represent zero observations.**

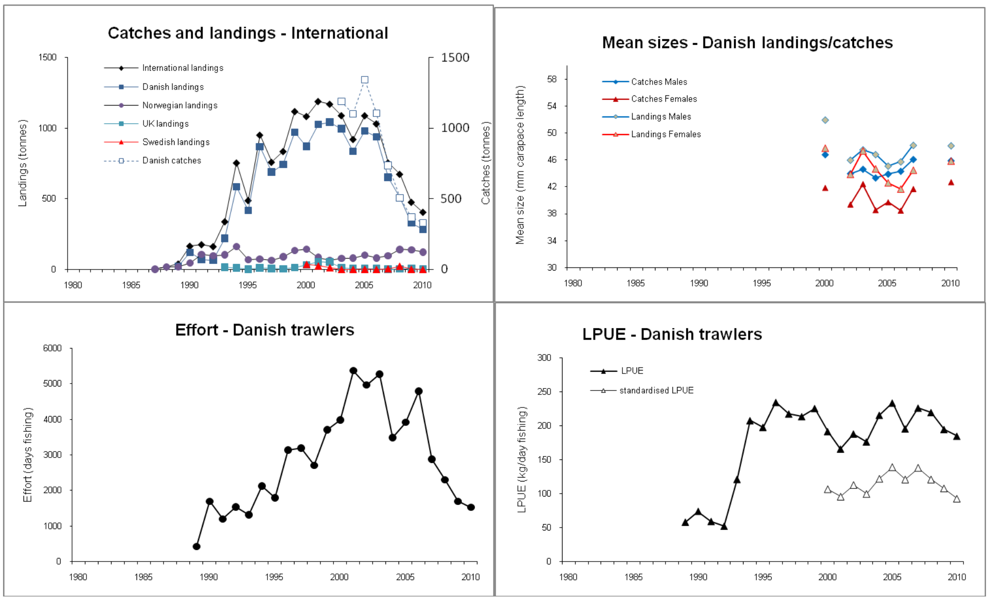


Figure 3.3.7.1, *Nephrops* in FU 32 (Norwegian Deep): Landings, effort, LPUE and mean size.

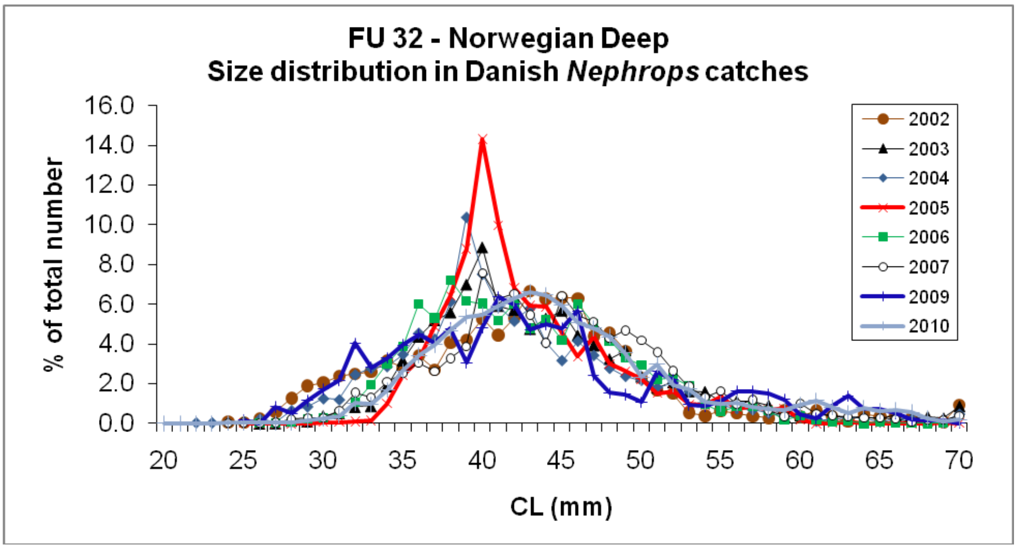


Figure 3.3.7.2, *Nephrops* in FU 32 (Norwegian Deep): Size distribution in Dansish catches.

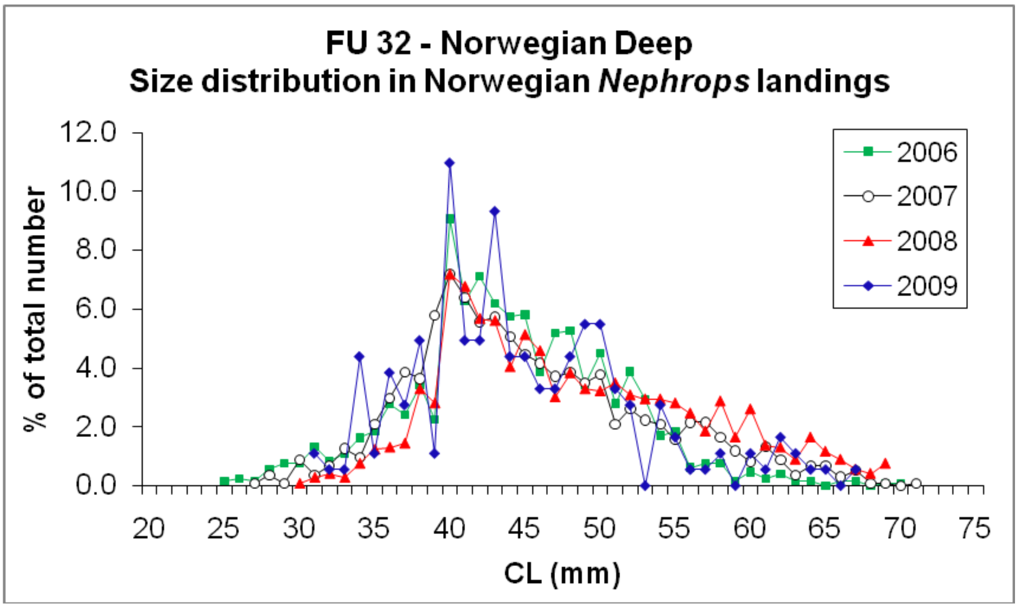


Figure 3.3.7.3, ***Nephrops*** **in FU 32 (Norwegian Deep): Size distribution in Norwegian Landings**

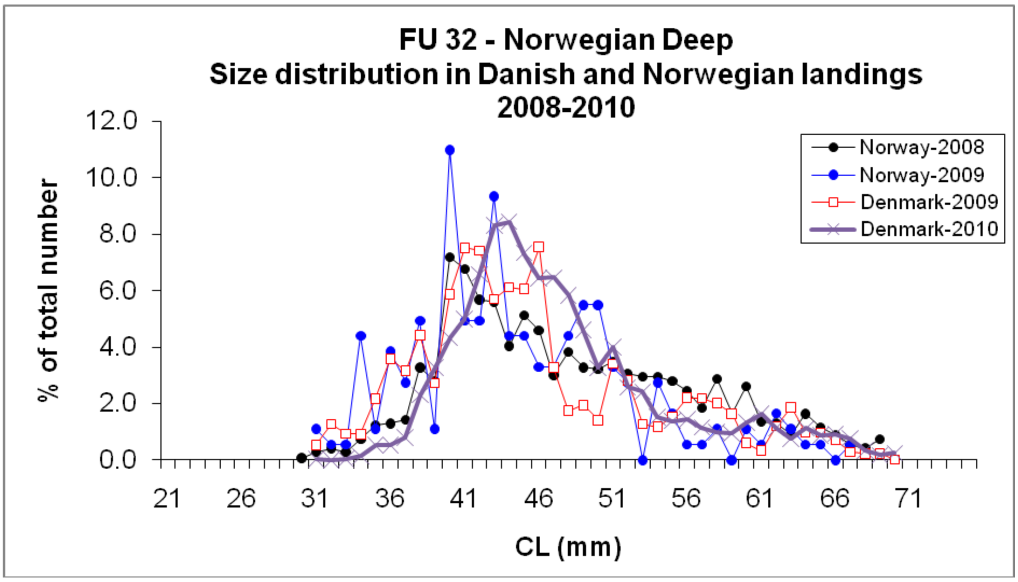


Figure 3.3.7.4, ***Nephrops*** **in FU 32 (Norwegian Deep): Size distribution in Combined Danish and Norwegian Landings**

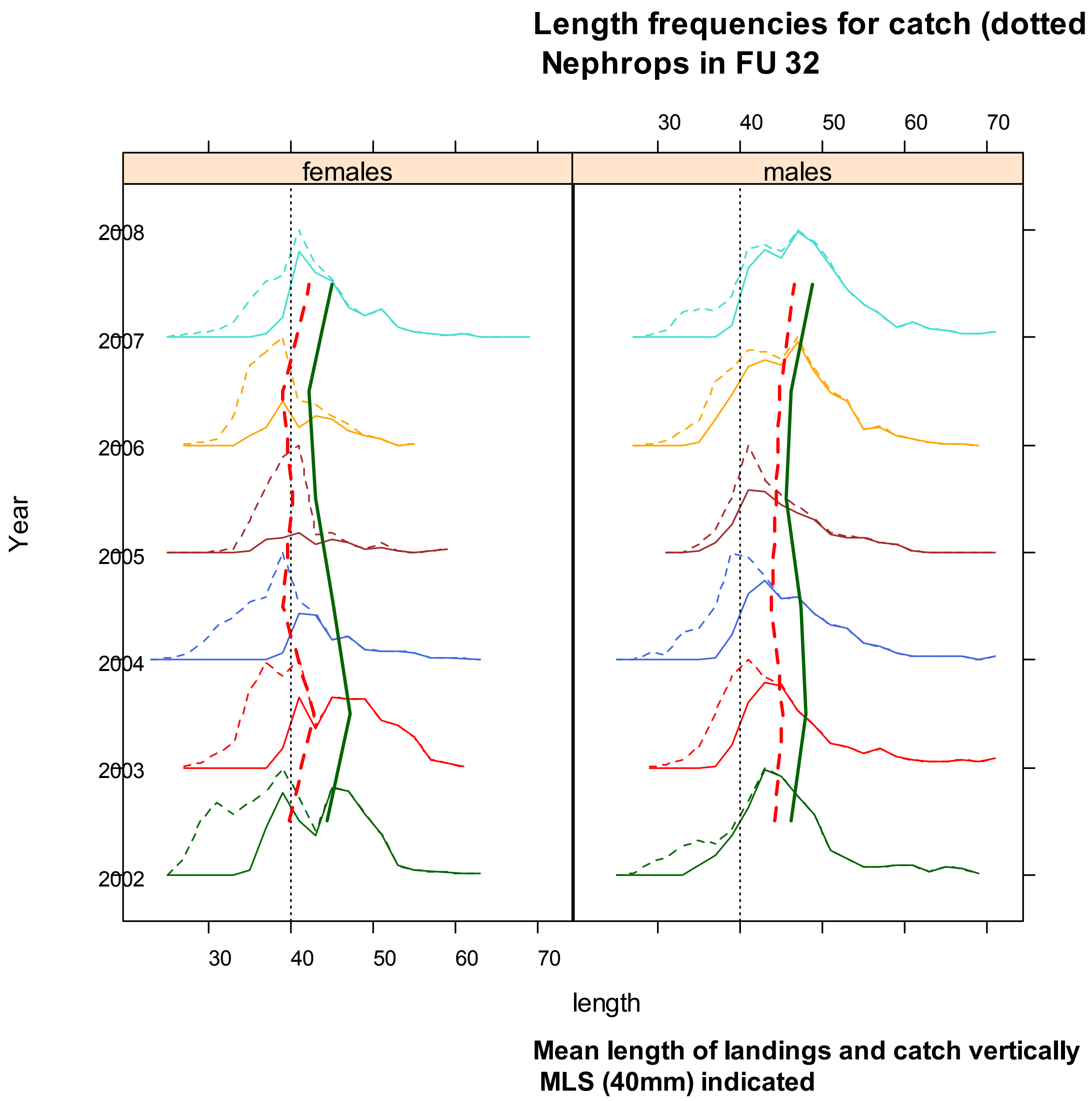


Figure 3.3.7.5, *Nephrops* in FU 32 (Norwegian Deep): Evolution of size composition in landings and discards.

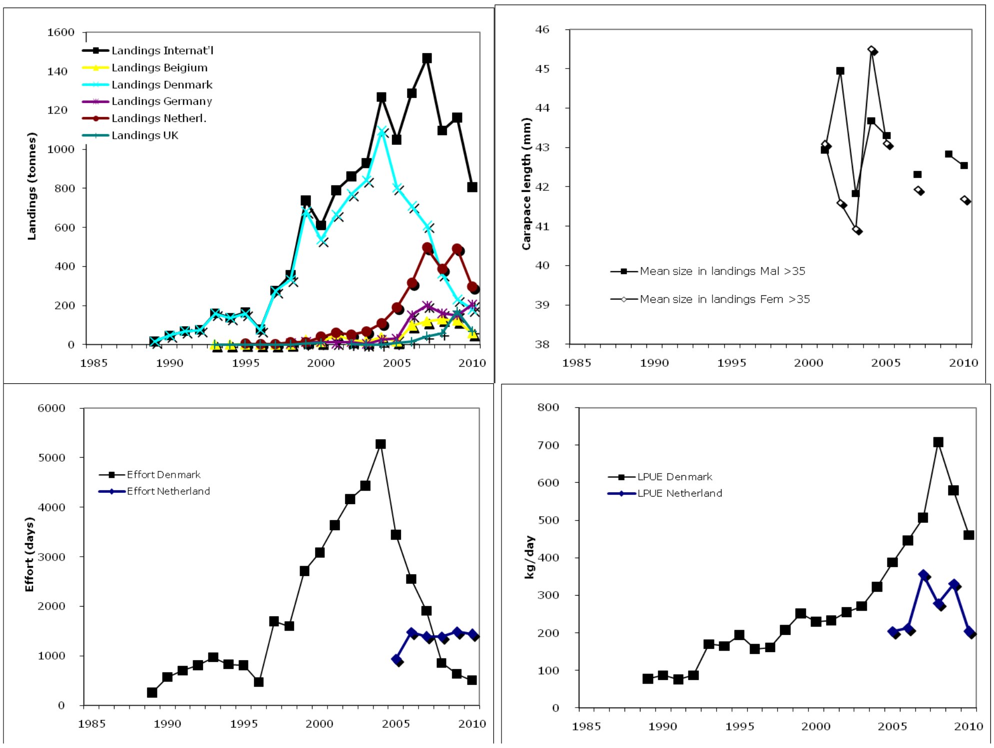


Figure 3.3.8.1 ***Nephrops*** **in FU 33 (Off Horns Reef): Landings, effort and mean size.**

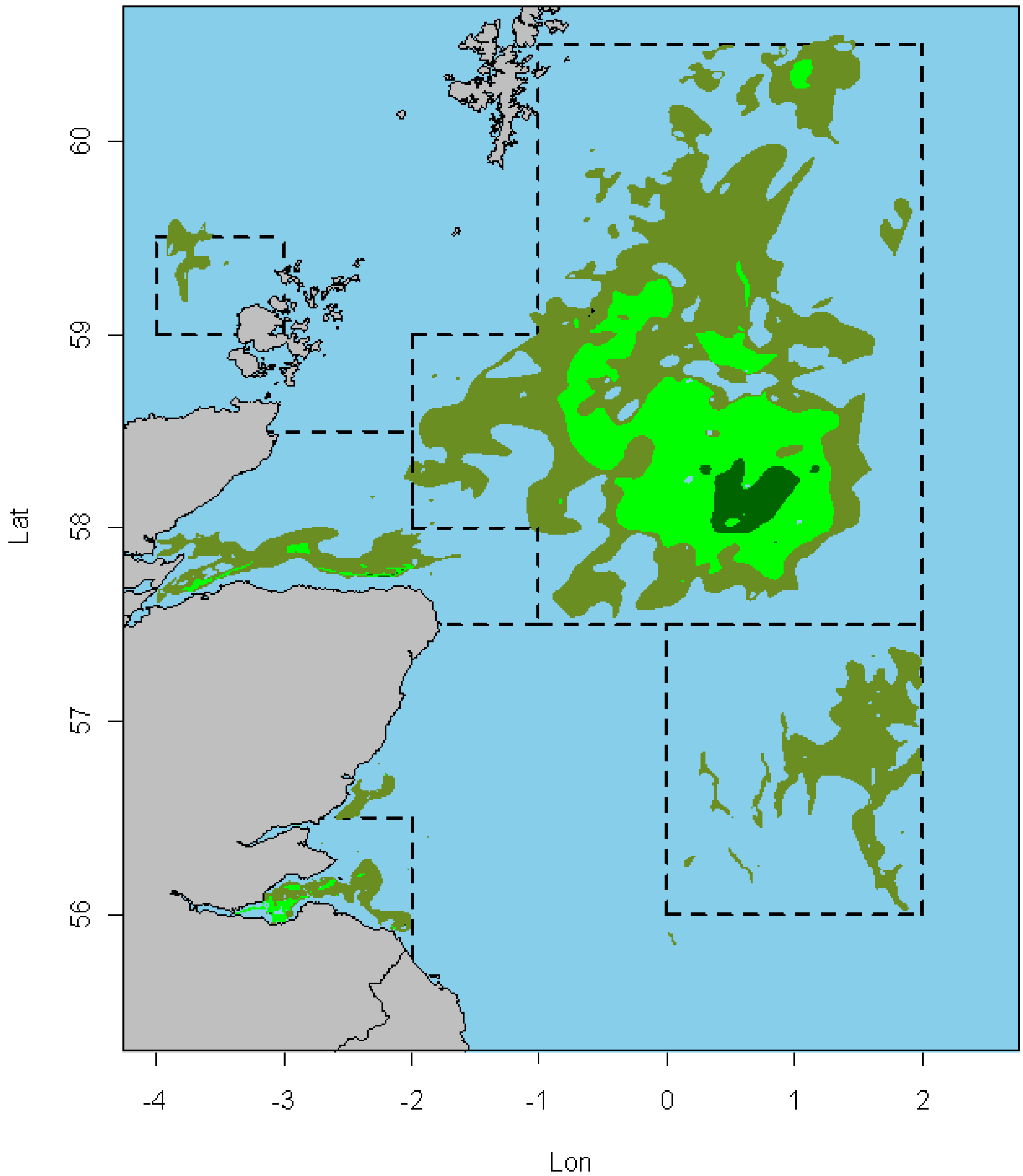


Figure 3.3.9.1. *Nephrops*, Devil's Hole (FU 34). British Geological Survey (BGS) map of sediment suitable for *Nephrops* in the northern North Sea. The Devil's Hole is located between 0 and 2 degrees east and 56 and 57.5 degrees north. Olive – muddy sand, lime green – sandy mud, dark green – mud.

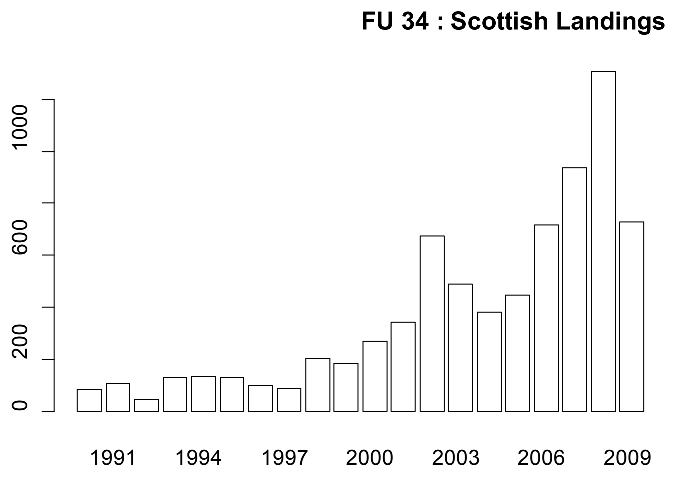


Figure 3.3.9.2. ***Nephrops*, Devil's Hole (FU 34). Scottish landings from 1991 to 2010.**

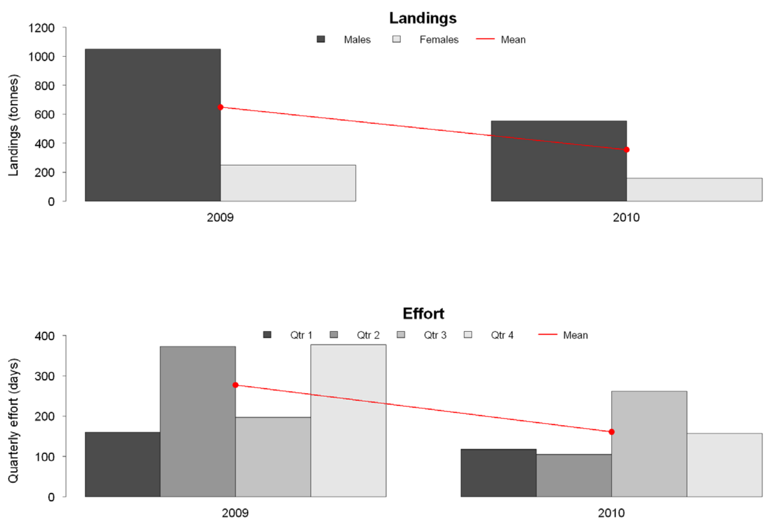


Figure 3.3.9.3. ***Nephrops*, Devil's Hole (FU 34). Landings by sex and effort by quarter from Scottish *Nephrops* trawlers.**

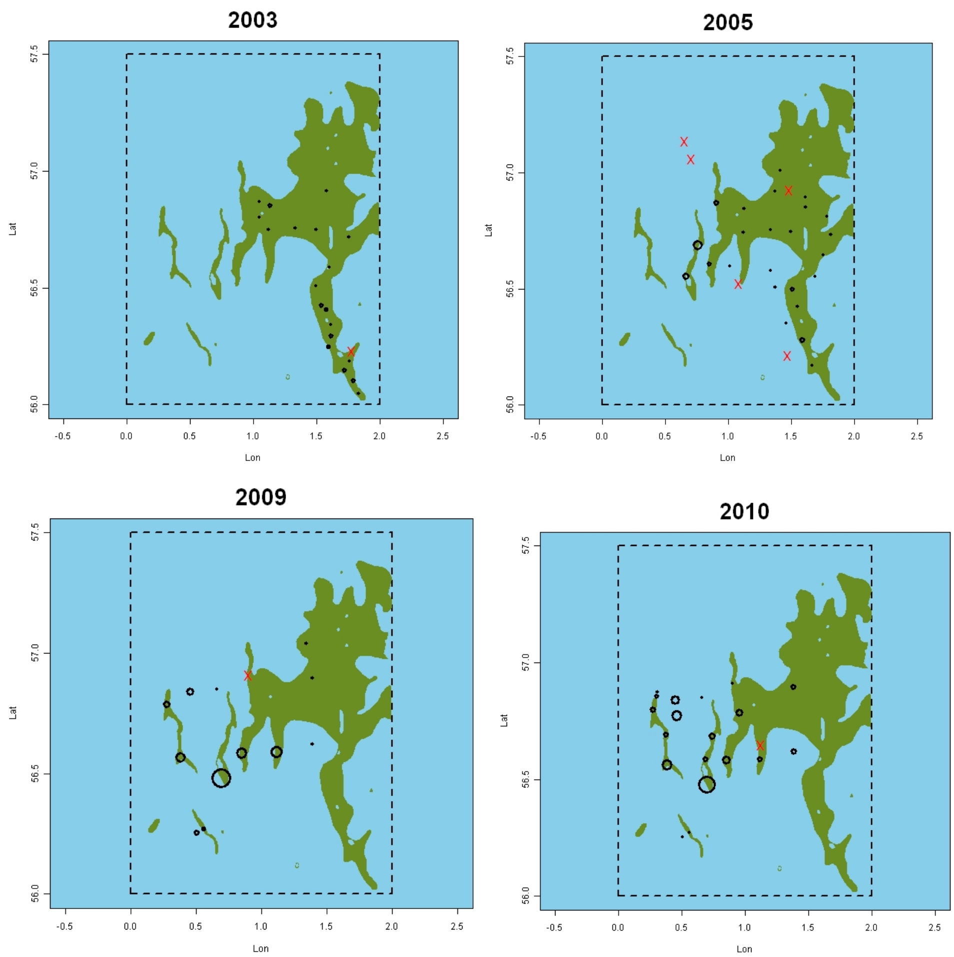


Figure 3.3.9.4. *Nephrops*, Devil's Hole (FU 34). TV survey distribution and relative density (2003, 2005, 2009-2010). Olive areas indicate areas of suitable sediment for *Nephrops*. 2009 and 2010 survey station locations generated from VMS data. Density proportional to circle radius.

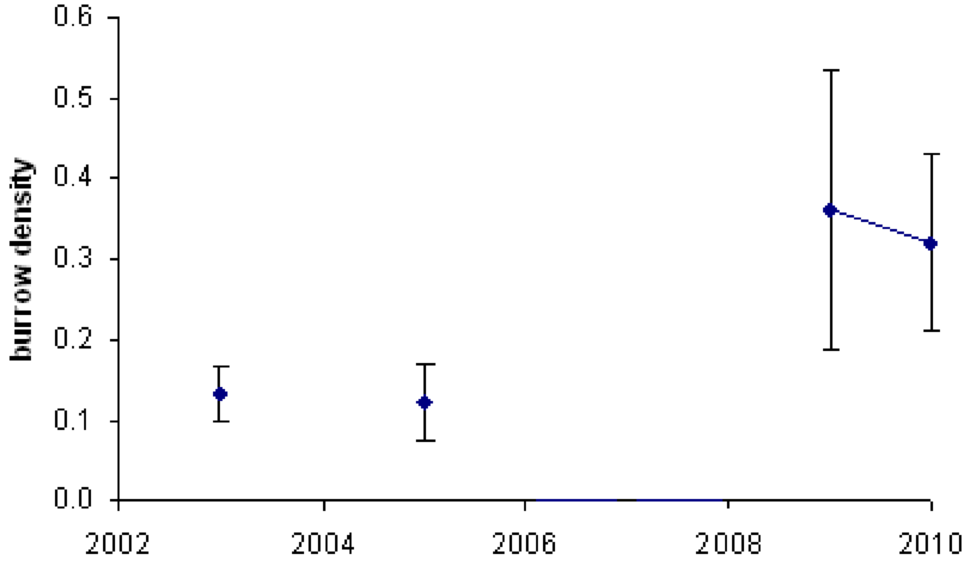


Figure 3.3.9.5. *Nephrops*, Devil's Hole (FU 34). Time series of TV survey density estimates, with 95 % confidence intervals, 2003, 2005, 2009-10.

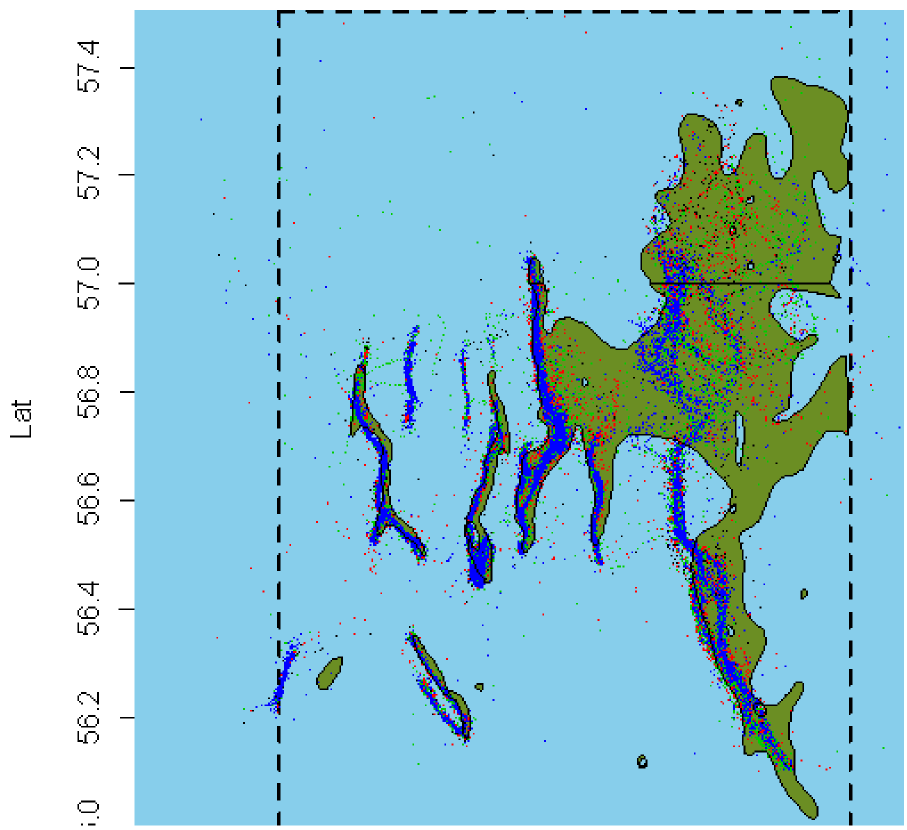
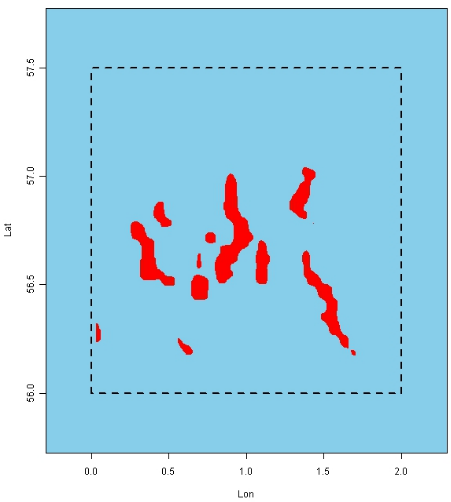
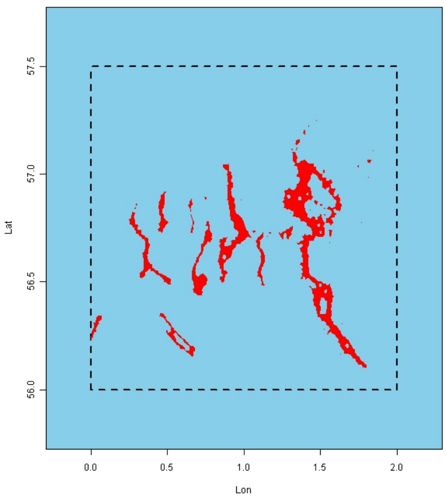


Figure 3.3.9.6. *Nephrops*, Devil's Hole (FU 34). Comparison of BGS muddy sediment and VMS data from Scottish *Nephrops* trawlers (2006-2009).

a) **b)**





c)

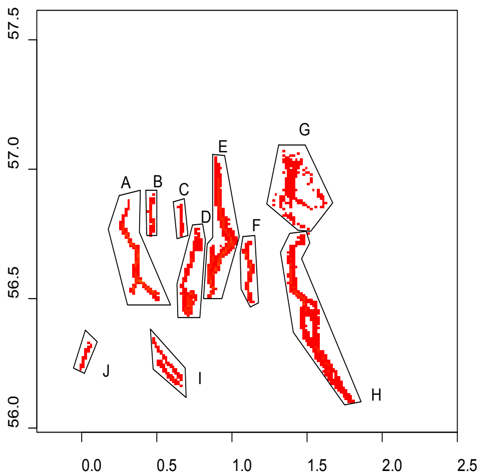


Figure 3.3.9.7. ***Nephrops*, Devil's Hole (FU 34). Estimated fished area by a) thin plate regression spline method (2009 data), b) alpha convex hull (2009 data) and c) cells containing on average > 2 pings/year.**

4 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 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, and 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 may 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 tonnes, 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. Based on the acoustic survey results an additional quota on 20 000 t was given. This fishery started 15 May and closed 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.

The sandeel fishery in 2010 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 2010 should be allowed only if analysis of data from the in-year monitoring programme indicated that the stock could be rebuilt to $\mathbf{B}_{pa}$ by 2011.

Subsequently, based on results from the in-year monitoring programme ICES recommended that the catches in 2010 should not exceed 253 000t.

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 TAC and quotas regarding sandeels in 2010 are given by the Council Regulation (EC) No. 23/2010.

However, considering the uncertainty of the Sandeel assessment, the late onset of the fishery, and the high catch rates obtained by the end of the monitoring period total TAC in the EU share of the North Sea was set at 400 000 tons in 2010.

For 2011 the EU Council Regulation set a preliminary TAC at 265 000 t in the EU waters of IIaa, IIIa and IV. 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 set a preliminary TAC at 60 000t in 2011. Based on scientific survey the TAC will be revised in the beginning of May 2011.

Closed periods

Since 2004 the fishery in the Norwegian EEZ opened April 1 and closed again June 23.

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 was closed to fishery in 2009.

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 in 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 686 000 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 2010 were 400 000 t.

Spatial distribution of landings

Yearly landings for the period 1995–2009 distributed by ICES rectangle are shown in Figure 4.1.2. Since 2008 the Dogger Bank area remained the main fishing area. However, the number of fishing grounds fished in the Dogger Bank area has increased and the fishery has expanded into the central North Sea north east of the Dogger Bank area. In 2006 there was only a limited monitoring fishery in the Norwegian EEZ and in the southern North Sea the fishery was concentrated at the fishing grounds in the Dogger Bank area in both 2006 and 2007.

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. In average, together these two areas have contributed 84% of the total sandeel landings in the period 1983 to 2010. 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 20% in the period 2003 to 2010. In Area-3 landings in the Norwegian EEZ have been 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 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.

Several banks in the Norwegian EEZ have not provided landings for the last 8-12 years (Figure 4.4). These fishing banks are considered commercially depleted, i.e. the concentrations are too low to provide a profitable fishery. For several years after 2001 almost all landings from the Norwegian EEZ came from the Vestbank area (Figure 4.1.5).

Some of the more southerly banks in the Norwegian EEZ were repopulated by new recruitment in 2006, but commercially depleted again in 2007 or 2008; Inner Shoal East and Outer Shoal were commercially depleted in 2007, and English Klondyke, which was closed after the RTM fishery in 2007, was commercially depleted in 2008. The main concentrations of sandeel in the Norwegian EEZ are again found in the Vestbank area (Figure 4.1.6). There are high concentrations on Inner Shoal West too, but this is a very small fishing ground. In the Vestbank area and Inner Shoal West there are natural refuges that prevent the fleet from depleting the local sandeel stocks.

Most of the fishing grounds in the Norwegian EEZ were commercially depleted during a period when the assessment suggested that SSB was well above Bpa. In addition, evidence from 2007 and 2008 suggests that fishing grounds can be commercially depleted within a few weeks without marked decreases in CPUE in tonnes (AGSAN 2009).

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 2010 the proportion of 1-group in the catch was more than 90% (Figure 4.2.1). Such high proportion has been observed in other years as well.

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 are applied the means of the period 2005-2010 (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 2005 to 2010 effort has been fluctuating around a mean of 3200 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 24 tons/day. Since 2004 the CPUE has increased and reached the all time highest (100 tons/day) in 2010.

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.

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

4.2.6 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 2010. 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 4.2.5. 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 4.2.5) is low (0.30) for age 0 and medium (0.60) for age 1, indicating a high 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 2010 survey estimate of the 2009 year calss is considerably higher than the estimate from all data sources.

The model CV of catch at age is low (0.257) 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 fits 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 4.2.5) is high (0.77) which is also indicated by the stock recruitment plot (Figure 4.2.7). The estimated recruitment in 2010 is the second lowest in the time series.

The retrospective analysis (Figure 4.2.8) 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 (2004-2010) 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 Blim 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 1999-2010, 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.

4.2.7 Final assessment

The output from the assessment is presented in Tables 4.2.6 (fishing mortality at age by half year), 4.2.7 (fishing mortality at age by year), 4.2.8 (stock numbers at age) and 4.2.9 (Stock summary).

4.2.8 Historic Stock Trends

The stock summary (Figure 4.2.12 and Table 4.2.9) 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 $B_{pa.}$ $F_{(1-2)}$ is estimated to have been below the long time average since 2005.

4.2.9 Recruitment estimates

Recruitment estimates are given in the summary table (Table 4.2.8) Based on results from the dredge survey December 2010 which is included in the assessment the recruitment in 2010 is estimated at 50 billion which is the second lowest estimate for the entire time series.

4.2.10 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.2.10. Stock numbers in the TAC year are taken from the assessment for age 1 and older. Recruitment in the second half year of 2011 is the geometric mean of the recruitment 1983-2009 (222 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2010. 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 2008-2010. The maturity estimate 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.

Output

The short term forecast shows that a TAC of 319 000 t in 2012 is consistent with a SSB at B $MSY_{trigger}$ at 215 000 tons. Such at TAC will require twice the F (effort) applied in 2011 compared to 2010.

4.2.11 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.

4.2.12 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 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.

4.2.13 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 2010 is only 10% of the recruitment in 2009. SSB has been above Bpa since 2007.

4.2.14 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, talking 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, and 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). Such high proportion has been observed in other years as well.

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 2010 the effort was 519 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.

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 2001 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 Data analysis

The diagnostics output from SMS-effort are shown in Table 4.3.4. 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 1999-2010.

The CV of the dredge survey (Table 4.3.4) is medium (0.35) 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 (0.436) 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 fits 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 4.3.4) is very high (0.974) 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 (2004-2010) 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, 1998-2010, 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 of technical creep, i.e. a standard 200 GT vessel has become more efficient over time.

4.3.7 Final assessment

The output from the assessment is presented in Tables 4.3.5 (fishing mortality at age by half year), 4.3.6 (fishing mortality at age by year), 4.3.7 (stock numbers at age) and 4.3.8 (Stock summary).

4.3.8 Historic Stock Trends

The stock summary (Figure 4.3.12 and Table 4.3.8) 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 Blim. From 2004 SSB has increased and SSB was just below Bpa in 2010 and clearly above Bpa in 2011. $F_{(1-2)}$ is estimated to have been below the long time average since 2005.

4.3.9 Recruitment estimates

The recruitment estimate obtained from the dredge survey December 2010 indicates a recruitment at 11.5 billion being the lowest since 2002.

4.3.10 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.3.9. Stock numbers for age 1 and older in the TAC year are taken from the assessment. Recruitment in the second half year is the geometric mean of the recruitment 1983-2009 (44.499 billion at age 0).Age 1 is .... ?. The exploitation pattern and Fsq is taken from the assessment values in 2010. 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 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 for 2011 (Table 4.3.10) indicates that a TAC at 30 000 tonnes is possible given the B $MSY_{trigger}$ at 100 000 tonnes.

4.3.11 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.

4.3.12 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 one year (2010) 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.

4.3.13 Status of the Stock

Due to low value of F (around 0.1) since 2007 and the strong 2009 year class, SSB in 2010 is around twice as high as Bpa. The 2010 year class is estimated to be around one quarter of the long term mean..

4.3.14 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 2010 the proportion of 1-group in the catch was around 80%, and age 2 and age 3 with around 10% each (Figure 4.4.1). The proportion of 0-groups in the catch has been very low since 2004.

Section 4.1.5 gives a detailed description of landings by fishing banks in the northern part of Area-3.

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 are applied the means of the period 2005-2010 (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 high consistency for age 0 and medium 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 Data analysis

The diagnostics output from SMS-effort model are shown in Table 4.4.5. 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). Right now this cannot be explained. 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, to a fishery mainly targeting age 1 and age 2 in the most recent years.

The CV of the dredge survey (Table 4.4.5) is low (0.30) for age 0 and high (0.98) 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. Catchability for the ages has been combined, as the independent estimates were not statistical different. The residual plot (Figure 4.4.5) shows no clear bias for this relatively short time series.

The model CV of catch at age is high (0.49) 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 4.4.6) 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 4.4.4) is high (0.75) which is also indicated by the stock recruitment plot (Figure 4.4.7). The very high recruitment in 1996 is a clear outlier. The estimated recruitment in 2010 is the lowest observed.

The retrospective analysis (Figure 4.4.8) 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 (2004-2010) of the dredge survey is actually too short to make a proper retrospective analysis.

Uncertainties of the estimated SSB, F and recruitment (Figure 4.4.9) are in general large, which gives wide confidence limits (Figure 4.4.10) on output variables.

The plot of standardised fishing effort and estimated F (Figure 4.4.11) 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 1999-2010, 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.

4.4.7 Final assessment

The output from the assessment is presented in Tables 4.4.6 (fishing mortality at age by half year), 4.4.7 (fishing mortality at age by year), 4.4.8 (stock numbers at age) and 4.4.9 (Stock summary).

4.4.8 Historic Stock Trends

The stock summary (Figure 4.4.12 and Table 4.4.9) shows that SSB have been at or below B_{lim} from 2001 to 2007 after which it has increased. SSB in 2010 and 2011 are estimated above Bpa. $F_{(1-2)}$ 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.

4.4.9 Recruitment estimates

Based on the dredge survey December 2010 the recruitment is estimated at 4.4 billion which is the lowest recruitment on record. (Table 4.4.9).

4.4.10 Short-term forecasts

Input

Input to the short term forecast is given in Table 4.4.9. 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 1983-2009 (105 billion at age 0). The exploitation pattern and Fsq is taken from the assessment values in 2010. 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 copied from the 2010 values (this will be updated by observations from the dredge survey in the January forecast). 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 2011, SSB will be below $MSY_{trigger}$ (195 000 tonnes) in 2012

4.4.11 Biological reference points

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

4.4.12 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. There is no Norwegian effort data available with the right resolution. In the absence Norwegian effort has been estimated on the basis of Norwegian landings and the assumption that Danish and Norwegian CPUE are the same. Observed Norwegian effort would probably increase the quality of the assessment as the Norwegian fleet in general fish more northerly than the Danish, especially in the most recent years with limitations on the access to the Norwegian EEZ.

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.

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.

4.4.13 Status of the Stock

The stock has increased from the record low SSB in 2004 at half of Blim to above Bpa in 2010 and 2011. Recruitment was at the long term mean in 2008 and has been below since. F has been below the long term mean since 2004, however highly variable between years.

4.4.14 Management Considerations

A management plan needs to be developed for area 3 sandeel. Area 3 comprises both Norwegian and EU EEZ however 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, but even though the new assessment for area 3 sandeel is considered uncertain, it might be 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 is not covered at all. Extension of the area covered by the dredge survey 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 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 coverage. The acoustic survey in April/May in Norwegian EEZ will give an answer to this question.

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.

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 Banks 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 on 2009 and 10. 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 2010 year class was lower than the 2009 year class but higher than that in 2008 (Table 4.5.3 column a). Based on the Firth of Forth stations only, the 2010 year class was also higher than the 2001 and similar to the 2002 year class (Table 4.5.3 column b). The 2009 year class dominated the 2010 dredge catch. The difference in ratios of age 0 and 1 CPUE between the 1999, 2000 and 2009 year classes could either be linked to a difference in mortality or simply the limited sampling regime in the early years.

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

Table 4.1.1. SANDEEL in the North Sea. Landings ('000 t), 1952-2010. (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	273.0	-	1.4	-	-	17.2	1.1	4.2	-	296.9
1974	424.1	-	6.4	-	-	78.6	0.2	15.5	-	524.8
1975	355.6	-	4.9	-	-	54.0	0.1	13.6	-	428.2
1976	424.7	-	-	-	-	44.2	-	18.7	-	487.6
1977	664.3	-	11.4	-	-	78.7	5.7	25.5	-	785.6
1978	647.5	-	12.1	-	-	93.5	1.2	32.5	-	786.8
1979	449.8	-	13.2	-	-	101.4	-	13.4	-	577.8
1980	542.2	-	7.2	-	-	144.8	-	34.3	-	728.5
1981	464.4	-	4.9	-	-	52.6	-	46.7	-	568.6
1982	506.9	-	4.9	-	-	46.5	0.4	52.2	-	610.9
1983	485.1	-	2.0	-	-	12.2	0.2	37.0	-	536.5
1984	596.3	-	11.3	-	-	28.3	-	32.6	-	668.5
1985	587.6	-	3.9	-	-	13.1	-	17.2	-	621.8
1986	752.5	-	1.2	-	-	82.1	-	12.0	-	847.8
1987	605.4	-	18.6	-	-	193.4	-	7.2	-	824.6
1988	686.4	-	15.5	-	-	185.1	-	5.8	-	892.8
1989	824.4	-	16.6	-	-	186.8	-	11.5	-	1039.1
1990	496.0	-	2.2	-	0.3	88.9	-	3.9	-	591.3
1991	701.4	-	11.2	-	-	128.8	-	1.2	-	842.6
1992	751.1	-	9.1	-	-	89.3	0.5	4.9	-	854.9
1993	482.2	-	-	-	-	95.5	-	1.5	-	579.2
1994	603.5	-	10.3	-	-	165.8	-	5.9	-	785.5
1995	647.8	-	-	-	-	263.4	-	6.7	-	917.9
1996	601.6	-	5.0	-	-	160.7	-	9.7	-	776.9
1997	751.9	-	11.2	-	-	350.1	-	24.6	-	1137.8
1998	617.8	-	11.0	-	+	343.3	8.5	23.8	-	1004.4
1999	500.1	-	13.2	0.4	+	187.6	22.4	11.5	-	735.1
2000	541.0	-	-	-	+	119.0	28.4	10.8	-	699.1
2001	630.8	-	-	-	-	183.0	46.5	1.3	-	861.6
2002	629.7	-	-	-	-	176.0	0.1	4.9	-	810.7
2003	274.0	-	-	-	-	29.6	21.5	0.5	-	325.6
2004	277.1	2.7	-	-	-	48.5	33.2	+	-	361.5
2005	154.8	-	-	-	-	17.3	-	-	-	172.1
2006	250.6	3.2	-	-	-	5.6	27.8	-	-	287.9
2007	144.6	1.0	2.0	-	-	51.1	6.6	1.0	-	206.3
2008	234.4	4.4	2.4	-	-	81.6	12.4	-	-	335.2
2009	285.7	12.2	2.5	-	1.8	27.4	12.1	3.6	2.0	347.4
2010	275.1	13.0	-			78.0	32.0		0.2	398.3

+ = 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	349397	74479	100330	2588	2815	0	37201	566810
1984	467664	63077	118651	2443	6103	0	33161	691098
1985	424058	96658	57835	37060	2929	0	17320	635858
1986	382912	93104	414911	12505	10517	0	14023	927973
1987	357714	53292	400402	8108	1535	0	7367	828417
1988	398221	120387	387994	1324	2450	0	4953	915330
1989	446151	109830	492999	4389	2040	909	0	1056318
1990	283148	100920	219023	3313	605	499	0	607508
1991	347102	107812	368801	41429	2532	17	0	867694
1992	564287	69848	195733	68905	4551	4277	0	907600
1993	136600	59848	296232	133197	401	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	310471	10239	34052	0	0	260	0	355022
2010	285794	30530	78067	262	0	132	0	394785
arith. mean	337917	62670	235559	36917	7590	973	4702	686327

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	290179	60159	61072	2588	2815	0	37201	454014
1984	391851	44714	89171	2443	6103	0	33161	567443
1985	354907	71396	32224	36844	2929	0	17320	515619
1986	347787	70461	242720	12328	6564	0	14023	693884
1987	302494	34079	396376	7789	1535	0	7367	749639
1988	368887	104551	312107	1244	2450	0	4953	794192
1989	433511	100567	447941	4387	510	897	0	987812
1990	257760	96481	138344	2925	0	485	0	495995
1991	268214	69466	290400	17164	2532	17	0	647794
1992	520041	56894	163533	67068	4551	4270	0	816357
1993	119275	43221	209228	123199	195	4393	0	499510
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	292593	9873	22124	0	0	259	0	324849
2010	282020	21730	75472	262	0	132	0	379616
arith. mean	301930	45365	182126	30385	7125	924	4540	572394

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	59218	14319	39258	0	0	0	0	112796
1984	75813	18363	29480	0	0	0	0	123655
1985	69151	25262	25610	216	0	0	0	120239
1986	35125	22643	172191	176	3954	0	0	234089
1987	55220	19212	4026	319	0	0	0	78778
1988	29334	15836	75888	80	0	0	0	121138
1989	12640	9263	45058	2	1530	12	0	68506
1990	25387	4439	80679	388	605	14	0	111513
1991	78888	38346	78400	24266	0	0	0	219900
1992	44245	12954	32200	1837	0	6	0	91243
1993	17325	16627	87004	9998	207	97	0	131258
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	17878	366	11929	0	0	0	0	30173
2010	3773	8800	2595	0	0	0	0	15168
arith. mean	35987	17305	53433	6532	465	49	162	113933

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

Year	Area 1	Area 2	Area 3	Area 4	All
1983	8277	2089	3214	59	13639
1984	9629	1851	3436	46	14961
1985	9889	3150	2090	633	15762
1986	7318	1937	7420	278	16953
1987	5358	1133	5287	175	11953
1988	7459	2884	9311	41	19695
1989	8574	2847	11903	56	23380
1990	7853	3031	7078	51	18013
1991	6402	2216	8220	344	17181
1992	9065	1619	5011	570	16265
1993	3669	1712	8124	1327	14833
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	4204	234	658	0	5096
2010	2837	519	2067	4	5427
arith. mean	6344	1610	5346	421	13722

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	6399	1701	2284	59	10443
1984	7461	1097	2455	46	11059
1985	7908	2307	1228	630	12074
1986	6548	1331	4657	276	12812
1987	4217	625	5156	159	10157
1988	6628	2451	7014	39	16133
1989	8186	2587	10296	56	21124
1990	7224	2926	4839	46	15034
1991	4870	1350	6567	112	12900
1992	8000	1317	4245	308	13871
1993	3195	1232	5409	1155	10992
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	3987	228	474	0	4689
2010	2733	338	1992	4	5067
arith. mean	5509	1122	3948	346	10924

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	1878	388	931	0	3196
1984	2168	754	981	0	3902
1985	1981	842	862	3	3688
1986	770	606	2763	3	4141
1987	1142	509	131	16	1797
1988	831	433	2297	2	3562
1989	389	260	1607	0	2256
1990	630	105	2239	5	2979
1991	1531	866	1652	232	4282
1992	1064	302	766	262	2394
1993	474	480	2715	172	3841
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	217	6	184	0	407
2010	104	181	75	0	360
arith. mean	836	488	1398	76	2799

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	9738	2435	256	28479	2846	766	519	314	2
1984	0	46342	9275	1726	95	9736	567	324	43
1985	7074	6035	1140	30210	1959	1932	1331	214	177
1986	176	45968	3938	7643	217	1650	173	31	13
1987	160	4538	1670	23378	3486	1188	102	170	27
1988	688	1924	67	8158	169	14246	1353	2201	45
1989	194	61943	912	6230	85	1380	15	4601	52
1990	1398	15554	1331	12330	426	1825	63	551	19
1991	8660	16366	6827	6827	206	1001	66	344	0
1992	1451	50586	3022	8649	295	873	121	542	26
1993	1958	2054	439	5621	312	1464	178	440	52
1994	0	24171	1885	2841	137	1284	56	970	100
1995	22	37430	3776	6355	1002	747	117	293	28
1996	5096	12531	1271	14658	1232	4965	239	954	76
1997	0	38993	8912	2388	176	3641	168	726	56
1998	250	9627	466	28301	1228	2143	124	1470	70
1999	1135	45248	2880	5480	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	90	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	312	0	171	0
2008	8	27196	267	4057	61	1213	23	217	5
2009	1075	19242	2471	14088	313	1546	14	393	4
2010	10	38644	521	2041	17	905	1	105	0
arit. mean	3933	27393	2200	9430	707	2486	233	657	43

Table 4.2.2 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	3.1	6.3	6.8	12.3	10.3	13.8	12.9	17.1	16.4
arith. mean	2.9	5.8	7.0	10.1	10.5	12.8	13.1	16.0	17.3

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

	age				
Year	0	1	2	3	4
1983-2004	0	2	83	100	100
2005	0	6	98	100	100
2006	0	1	90	100	100
2007	0	1	94	100	100
2008	0	2	97	100	100
2009	0	0	61	100	100
2010	0	1	56	100	100
2011	0	0	58	100	100

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

Table 4.2.5. Area-1 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  9.96968
Number of parameters: 53
Maximum gradient: 1.71433e-005
Akaike information criterion (AIC):   125.939
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             280      14      27       0     321

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
               15.3    -5.4     6.6     0.0  0.00e+000    16.5


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.05   -0.38    0.23    0.00


F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2010:   0.000 1.000
age: 1 - 4
    1983-1988:   0.490 0.500
    1989-1998:   0.473 0.500
    1999-2010:   0.395 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.027  0.292  1.264  2.110  2.110
1989-1998:  0.056  0.846  1.365  1.441  1.441
1999-2010:  0.059  1.816  1.992  1.251  1.251


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:  0.000  0.289  1.250  2.087  2.087
          season 2:  0.016  0.087  0.375  0.625  0.625

1989-1998 season 1:  0.000  0.728  1.176  1.241  1.241
          season 2:  0.005  0.037  0.059  0.062  0.062

1999-2010 season 1:  0.000  0.808  0.887  0.557  0.557
          season 2:  0.009  0.145  0.160  0.100  0.100
```

Table 4.2.5 (continued). Area-1 Sandeel. SMS settings and statistics.

sqrt(catch variance) ~ CV:

	season	
age	1	2
0		1.085
1	0.257	0.717
2	0.257	0.717
3	0.684	1.153
4	0.684	1.153

Survey catchability:

	age 0	age 1
Dredge survey 2004-2009	1.814	0.988

sqrt(Survey variance) ~ CV:

	age 0	age 1
Dredge survey 2004-2009	0.30	0.60

Recruit-SSB	alfa	beta	recruit s2	recruit s
Hockey stick -break.:	1444.888	1.600e+005	0.598	0.773

Table 4.2.6. 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	0.155	0.046	0.668	0.200	1.116	0.334	1.116	0.334
1984	0.010	0.175	0.052	0.758	0.225	1.266	0.376	1.266	0.376
1985	0.009	0.182	0.047	0.786	0.201	1.313	0.336	1.313	0.336
1986	0.003	0.149	0.018	0.643	0.077	1.073	0.129	1.073	0.129
1987	0.005	0.095	0.026	0.411	0.114	0.686	0.190	0.686	0.190
1988	0.004	0.149	0.019	0.646	0.083	1.078	0.138	1.078	0.138
1989	0.003	0.511	0.026	0.825	0.041	0.870	0.044	0.870	0.044
1990	0.005	0.452	0.042	0.729	0.067	0.769	0.071	0.769	0.071
1991	0.013	0.304	0.101	0.491	0.163	0.518	0.172	0.518	0.172
1992	0.009	0.500	0.070	0.807	0.113	0.852	0.120	0.852	0.120
1993	0.004	0.200	0.031	0.322	0.050	0.340	0.053	0.340	0.053
1994	0.003	0.191	0.024	0.308	0.039	0.325	0.041	0.325	0.041
1995	0.006	0.335	0.043	0.541	0.069	0.571	0.073	0.571	0.073
1996	0.006	0.340	0.045	0.549	0.073	0.580	0.077	0.580	0.077
1997	0.013	0.258	0.095	0.416	0.154	0.439	0.162	0.439	0.162
1998	0.005	0.388	0.035	0.626	0.056	0.661	0.059	0.661	0.059
1999	0.010	0.845	0.152	0.926	0.167	0.582	0.105	0.582	0.105
2000	0.008	0.668	0.130	0.732	0.143	0.460	0.090	0.460	0.090
2001	0.026	0.862	0.405	0.945	0.444	0.593	0.279	0.593	0.279
2002	0.002	0.884	0.025	0.969	0.028	0.609	0.017	0.609	0.017
2003	0.008	0.599	0.119	0.657	0.130	0.412	0.082	0.412	0.082
2004	0.004	0.732	0.064	0.803	0.070	0.504	0.044	0.504	0.044
2005	0.000	0.320	0.006	0.351	0.007	0.221	0.004	0.221	0.004
2006	0.001	0.469	0.018	0.514	0.020	0.323	0.013	0.323	0.013
2007	0.000	0.199	0.000	0.218	0.000	0.137	0.000	0.137	0.000
2008	0.001	0.324	0.011	0.356	0.012	0.223	0.008	0.223	0.008
2009	0.002	0.445	0.032	0.488	0.035	0.306	0.022	0.306	0.022
2010	0.001	0.306	0.015	0.336	0.016	0.211	0.010	0.211	0.010
arith. mean	0.006	0.394	0.061	0.601	0.100	0.609	0.109	0.609	0.109

Table 4.2.7. 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	0.234	0.952	1.576	1.577	0.593
1984	0.010	0.265	1.077	1.781	1.782	0.671
1985	0.009	0.269	1.090	1.798	1.797	0.679
1986	0.003	0.204	0.822	1.347	1.345	0.513
1987	0.005	0.143	0.581	0.963	0.963	0.362
1988	0.004	0.206	0.830	1.361	1.359	0.518
1989	0.003	0.664	1.002	1.044	1.042	0.833
1990	0.005	0.604	0.914	0.954	0.952	0.759
1991	0.013	0.466	0.714	0.753	0.754	0.590
1992	0.009	0.687	1.042	1.090	1.088	0.864
1993	0.004	0.280	0.425	0.445	0.444	0.352
1994	0.003	0.263	0.399	0.417	0.417	0.331
1995	0.006	0.460	0.697	0.729	0.728	0.578
1996	0.006	0.468	0.710	0.742	0.741	0.589
1997	0.013	0.404	0.619	0.654	0.654	0.511
1998	0.005	0.519	0.785	0.819	0.818	0.652
1999	0.010	1.174	1.223	0.769	0.768	1.198
2000	0.008	0.941	0.979	0.615	0.614	0.960
2001	0.026	1.400	1.473	0.933	0.934	1.437
2002	0.002	1.116	1.156	0.724	0.722	1.136
2003	0.008	0.848	0.882	0.553	0.553	0.865
2004	0.004	0.965	1.001	0.626	0.625	0.983
2005	0.000	0.412	0.424	0.263	0.263	0.418
2006	0.001	0.606	0.626	0.389	0.388	0.616
2007	0.000	0.254	0.261	0.162	0.161	0.258
2008	0.001	0.421	0.434	0.269	0.269	0.427
2009	0.002	0.588	0.608	0.379	0.378	0.598
2010	0.001	0.401	0.413	0.257	0.256	0.407
arith. mean	0.006	0.545	0.791	0.800	0.800	0.668

Table 4.2.8. 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	624999	16985	57061	2757	244
1984	146868	237258	4911	10133	358
1985	949287	55694	66799	777	1030
1986	154159	360349	15666	10533	180
1987	73517	58831	107826	3227	1632
1988	374394	28012	18417	26999	1039
1989	178837	142844	8365	3761	4215
1990	237255	68244	29526	1489	1655
1991	333141	90345	14730	5635	702
1992	73641	125867	21302	3242	1618
1993	307426	27936	25154	3590	945
1994	458848	117227	7839	7333	1564
1995	112303	175128	33411	2343	3146
1996	682124	42757	42413	7679	1494
1997	108893	259625	10278	9632	2426
1998	185283	41174	64469	2460	3375
1999	240085	70620	9539	13795	1473
2000	414021	91020	9213	1353	3909
2001	556016	157186	14491	1626	1586
2002	29121	207347	15662	1529	694
2003	230977	11132	29522	2445	610
2004	101371	87756	1920	5686	952
2005	274993	38653	13999	339	1956
2006	152165	105249	9855	4140	961
2007	347812	58193	22863	2445	1862
2008	104680	133175	16859	7779	1937
2009	523224	40052	33659	4938	3939
2010	49689	199920	8787	8442	3297
2011		19007	51271	2615	4823

Table 4.2.9. Area-1 : 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	624999	705504	516578	349232	0.593
1984	146868	1502250	212681	467609	0.671
1985	949287	1002100	588145	424114	0.679
1986	154159	2291220	318719	382735	0.513
1987	73517	1607230	1071200	357671	0.362
1988	374394	782061	631713	398271	0.518
1989	178837	816099	232759	445695	0.833
1990	237255	705553	368557	283040	0.759
1991	333141	1083600	323676	347096	0.590
1992	73641	1315990	354859	564298	0.864
1993	307426	551211	305634	124082	0.352
1994	458848	826458	190239	209538	0.331
1995	112303	1802890	432631	410513	0.578
1996	682124	699271	410037	298702	0.589
1997	108893	2102340	238242	431808	0.511
1998	185283	899570	548917	371117	0.652
1999	240085	606838	225830	427691	1.198
2000	414021	704641	138388	284521	0.960
2001	556016	873627	159572	513068	1.437
2002	29121	1376710	145830	596049	1.136
2003	230977	265522	193364	121863	0.865
2004	101371	508802	79690	195274	0.983
2005	274993	400372	162804	100835	0.418
2006	152165	772613	153474	231448	0.616
2007	347812	598874	266195	108600	0.258
2008	104680	1151790	328004	237447	0.427
2009	523224	671086	302830	291247	0.598
2010	49689	1534960	246330	285540	0.407
2011			473850*		
arith. mean	286612	1005685	331750	330682	0.668
geo. Mean**	222948				

***using weights from 2010**

****period 1983-2009**

Table 4.2.10. Sandeel in Area-1. Input values for preliminary short term forecast

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers (2011)	222948	19007	51271	2615	4823
Exploitation patttern 1st half		0.306	0.336	0.211	0.211
Exploitation patttern 2nd half	0.001	0.015	0.016	0.010	0.010
Weight in the stock 1st half		6.22	10.84	13.04	15.34
Weight in the catch 1st half		6.22	10.84	13.04	15.34
weight in the catch 2nd half	3.08	6.69	10.15	12.67	16.17
Proportion mature(2011)	0	0	0.58	1	1
Proportion mature(2012)	0	0.02	0.83	1	1
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 4.2.11. Sandeel in Area-1. Forecast for 2011 for various levels of F.

Basis: Fsq=F(2010)=0.336; Yield(2010)=286 kt; Recruitment(2010)=50 billions;

Recruitment(2011)= geometric mean (GM 83-09) = 223 billion; SSB(2011)=430 kt

4.8.2	4.8.3	4.8.4	4.8.5	4.8.6	4.8.7	4.8.8
F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	413	-4%	-100%
0.25	Fsq*0.25	0.084	50	382	-11%	-83%
0.50	Fsq*0.50	0.168	96	353	-18%	-67%
0.75	Fsq*0.75	0.252	138	326	-24%	-52%
1.0	Fsq*1.0	0.336	178	301	-30%	-38%
1.25	Fsq*1.25	0.420	214	278	-35%	-25%
1.50	Fsq*1.50	0.504	249	257	-40%	-13%
1.75	Fsq*1.75	0.589	280	238	-45%	-2%
2.0	Fsq*2.0	0.673	309	221	-49%	8%
2.083	MSY-approach	0.701	319	215	-50%	12%

***SSB in 2012 relative to SSB in 2011**

**** TAC in 2011 relative to landings in 2010**

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	2417	480	66	5920	650	159	117	65	0
1984	0	5302	2237	210	24	1090	136	36	10
1985	2674	1221	426	6036	727	392	501	46	67
1986	213	9356	2429	1508	135	313	102	6	8
1987	56	512	581	2633	1213	134	36	19	9
1988	156	555	15	2332	92	4019	789	621	26
1989	127	14288	669	1399	63	342	11	1015	39
1990	351	5752	206	4669	64	691	10	209	3
1991	4202	4556	3322	1648	100	251	32	86	0
1992	458	5408	869	1136	85	122	35	76	8
1993	153	736	220	1249	531	692	185	211	43
1994	0	1849	2243	296	342	172	192	78	86
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	130	813	173
2001	2242	259	356	1157	620	147	81	473	257
2002	3	2448	1329	120	189	110	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	92
2006	2	1796	1014	383	118	157	56	47	23
2007	0	298	0	198	0	36	0	6	0
2008	0	985	208	148	78	66	48	9	7
2009	17	410	106	680	2	22	0	1	0
2010	1	2393	1540	137	42	360	32	58	5
arith. mean	489	2670	1005	1517	361	494	142	201	52

Table 4.3.2. Area-2 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	2.5	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
arith. mean	3.7	7.4	8.8	12.3	12.3	15.2	15.1	17.9	18.8

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. Area-2 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  93.0625
Number of parameters: 45
Maximum gradient: 5.91451e-005
Akaike information criterion (AIC):   276.125
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             280       6      27       0     313

objective function weight:
                          Catch  CPUE   S/R
                          1.00  0.25  0.01

unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
               93.8    -3.3    13.1     0.0 0.00e+000   103.6


unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.33   -0.55    0.47    0.00


contribution by fleet:
----------------------
Dredge survey 2004-2009     total:  -3.319   mean:  -0.553

F, season effect:
-----------------
age: 0
    1983-1998:   0.000 1.000
    1999-2010:   0.000 1.000
age: 1 - 4
    1983-1998:   0.549 0.500
    1999-2010:   0.336 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1998:  0.020  0.281  0.690  0.653  0.653
1999-2010:  0.004  0.736  1.504  1.270  1.270
Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1998 season 1:  0.000  0.479  1.177  1.113  1.113
          season 2:  0.014  0.100  0.245  0.231  0.231

1999-2010 season 1:  0.000  0.409  0.836  0.706  0.706
          season 2:  0.003  0.248  0.506  0.428  0.428
```

Table 4.3.4 (continued). Area-2 Sandeel. SMS settings and statistics.

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

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

 0               2.091
 1       0.436   0.887
 2       0.436   0.887
 3       1.145   1.091
 4       1.145   1.091


Survey catchability:
--------------------           age 0
 Dredge survey 2004-2009       8.421

sqrt(Survey variance) ~ CV:
---------------------------    age 0
 Dredge survey 2004-2009        0.35


Recruit-SSB                                  alfa       beta        recruit s2
recruit s
Area-2          Hockey  stick  -break.:        674.045     7.000e+004     0.974
0.987
```

Table 4.3.5. 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	0.161	0.033	0.393	0.081	0.363	0.075	0.363	0.075
1984	0.009	0.104	0.065	0.254	0.158	0.234	0.146	0.234	0.146
1985	0.010	0.218	0.072	0.533	0.177	0.492	0.163	0.492	0.163
1986	0.007	0.126	0.052	0.308	0.127	0.284	0.117	0.284	0.117
1987	0.006	0.059	0.044	0.144	0.107	0.133	0.098	0.133	0.098
1988	0.005	0.232	0.037	0.566	0.091	0.523	0.084	0.523	0.084
1989	0.003	0.244	0.022	0.598	0.055	0.552	0.050	0.552	0.050
1990	0.001	0.276	0.009	0.676	0.022	0.624	0.020	0.624	0.020
1991	0.011	0.128	0.074	0.312	0.182	0.288	0.168	0.288	0.168
1992	0.004	0.124	0.026	0.304	0.063	0.281	0.058	0.281	0.058
1993	0.006	0.116	0.041	0.285	0.101	0.263	0.093	0.263	0.093
1994	0.006	0.039	0.042	0.094	0.102	0.087	0.094	0.087	0.094
1995	0.008	0.054	0.054	0.132	0.133	0.122	0.123	0.122	0.123
1996	0.008	0.108	0.053	0.265	0.129	0.245	0.119	0.245	0.119
1997	0.017	0.085	0.115	0.208	0.282	0.192	0.261	0.192	0.261
1998	0.011	0.090	0.078	0.221	0.190	0.204	0.175	0.204	0.175
1999	0.001	0.100	0.061	0.201	0.122	0.163	0.099	0.163	0.099
2000	0.001	0.120	0.114	0.241	0.228	0.195	0.185	0.195	0.185
2001	0.001	0.141	0.146	0.283	0.293	0.230	0.239	0.230	0.239
2002	0.001	0.090	0.142	0.180	0.284	0.146	0.231	0.146	0.231
2003	0.001	0.244	0.109	0.489	0.218	0.397	0.177	0.397	0.177
2004	0.002	0.261	0.167	0.523	0.334	0.425	0.271	0.425	0.271
2005	0.001	0.128	0.067	0.256	0.135	0.208	0.110	0.208	0.110
2006	0.001	0.097	0.090	0.195	0.181	0.158	0.147	0.158	0.147
2007	0.000	0.021	0.000	0.042	0.000	0.034	0.000	0.034	0.000
2008	0.000	0.033	0.023	0.066	0.046	0.054	0.037	0.054	0.037
2009	0.000	0.035	0.001	0.071	0.003	0.058	0.002	0.058	0.002
2010	0.000	0.053	0.042	0.105	0.084	0.086	0.068	0.086	0.068
arith. mean	0.004	0.124	0.064	0.284	0.140	0.251	0.122	0.251	0.122

Table 4.3.6. 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	0.232	0.534	0.490	0.490	0.383
1984	0.009	0.183	0.429	0.400	0.401	0.306
1985	0.010	0.335	0.775	0.716	0.716	0.555
1986	0.007	0.202	0.469	0.434	0.435	0.335
1987	0.006	0.110	0.258	0.241	0.242	0.184
1988	0.005	0.325	0.745	0.683	0.682	0.535
1989	0.003	0.329	0.752	0.687	0.686	0.540
1990	0.001	0.359	0.816	0.744	0.742	0.587
1991	0.011	0.221	0.518	0.482	0.483	0.369
1992	0.004	0.180	0.414	0.380	0.380	0.297
1993	0.006	0.181	0.421	0.389	0.389	0.301
1994	0.006	0.082	0.194	0.183	0.184	0.138
1995	0.008	0.112	0.264	0.248	0.249	0.188
1996	0.008	0.180	0.420	0.390	0.390	0.300
1997	0.017	0.198	0.472	0.447	0.450	0.335
1998	0.011	0.176	0.415	0.390	0.391	0.296
1999	0.001	0.176	0.337	0.277	0.277	0.256
2000	0.001	0.242	0.469	0.388	0.390	0.355
2001	0.001	0.294	0.571	0.474	0.476	0.433
2002	0.001	0.225	0.440	0.368	0.371	0.332
2003	0.001	0.396	0.756	0.618	0.619	0.576
2004	0.002	0.463	0.890	0.731	0.733	0.676
2005	0.001	0.216	0.414	0.339	0.339	0.315
2006	0.001	0.195	0.377	0.312	0.313	0.286
2007	0.000	0.027	0.051	0.041	0.041	0.039
2008	0.000	0.060	0.116	0.095	0.096	0.088
2009	0.000	0.047	0.088	0.070	0.070	0.067
2010	0.000	0.100	0.193	0.159	0.160	0.147
arith. mean	0.004	0.209	0.450	0.399	0.400	0.329

Table 4.3.7. 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	127058	4256	11720	758	48
1984	36278	48418	1239	3086	264
1985	238563	13762	14464	347	1165
1986	38332	90402	3640	3010	410
1987	18705	14568	26752	997	1166
1988	116061	7117	4647	8806	888
1989	64956	44203	1923	1019	2688
1990	84749	24792	11967	424	1059
1991	97869	32408	6587	2519	406
1992	32427	37076	9362	1702	945
1993	126814	12370	11276	2743	969
1994	60542	48270	3735	3246	1332
1995	20914	23042	15745	1299	1957
1996	201859	7946	7308	5111	1323
1997	3145	76708	2391	2085	2285
1998	13433	1185	22193	620	1439
1999	40814	5086	354	6227	734
2000	10702	15619	1531	108	2725
2001	107467	4094	4371	406	1020
2002	6658	41094	1086	1040	465
2003	63967	2546	11526	289	529
2004	26297	24468	633	2406	240
2005	50677	10054	5643	114	671
2006	31683	19392	2924	1615	299
2007	80246	12121	5682	850	719
2008	18446	30726	4195	2305	782
2009	126414	7062	10270	1587	1442
2010	11481	48402	2406	4036	1473
2011		4394	15565	842	2419

Table 4.3.8. 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	127058	151775	108802	74481	0.383
1984	36278	326571	62947	63046	0.306
1985	238563	248260	149408	96645	0.555
1986	38332	586268	90031	93146	0.335
1987	18705	415460	282628	53284	0.184
1988	116061	240438	202090	120382	0.535
1989	64956	271447	88007	109703	0.540
1990	84749	277160	153555	100917	0.587
1991	97869	418513	145842	107795	0.369
1992	32427	436339	159113	69825	0.297
1993	126814	353954	220981	59652	0.301
1994	60542	516387	141866	50656	0.138
1995	20914	452347	235459	60138	0.188
1996	201859	309225	202961	80012	0.300
1997	3145	649194	94993	102726	0.335
1998	13433	349607	287570	68953	0.296
1999	40814	177520	120354	32108	0.256
2000	10702	236062	73132	52228	0.355
2001	107467	134520	80838	56934	0.433
2002	6658	318847	39240	35494	0.332
2003	63967	159762	116110	55924	0.576
2004	26297	228285	45770	71413	0.676
2005	50677	135432	55374	41420	0.315
2006	31683	220979	53449	35351	0.286
2007	80246	208715	91560	5911	0.039
2008	18446	308837	87941	13064	0.088
2009	126414	193851	128541	10240	0.067
2010	11481	401504	94852	30531	0.147
2011			184604[1]		
arith. mean	66306	311688	130966	62571	0.329
geo. Mean[2]	44626				

[1]Using weights from 2010

[2]Period 1983 – 2009

Table 4.3.9. Sandeel in Area-2. Input values for preliminary short term forecast.

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2011)	44626	4394	15565	842	2419
Exploitation patttern 1st half		0.0526	0.1054	0.0857	0.0857
Exploitation patttern 2nd half	0.0004	0.0420	0.0842	0.0684	0.0684
Weight in the stock 1st half		6.79	11.10	13.16	13.58
Weight in the catch 1st half		6.79	11.10	13.16	13.58
weight in the catch 2nd half	2.45	5.45	7.75	9.69	11.80
Proportion mature(2011)	0	0.02	0.83	1	1
Proportion mature(2012)	0	0.02	0.83	1	1
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 4.3.10. Sandeel in Area-2. Short term forecast.

Basis: Fsq=F(2010)=0.142; Yield(2010)=31; Recruitment(2010)=11; Recruitment(2011)= geometric mean (GM 83-09) = 45 billion; SSB(2011)=188

4.8.9

4.8.10	4.8.11	4.8.12	4.8.13	4.8.14	4.8.15	4.8.16
F multiplier	Basis	F (2011)	Landings (2011)	SSB (2012)	%SSB change*	%TAC change**
0	F=0	0	0	126	-33%	-100%
0.25	Fsq*0.25	0.036	7	121	-36%	-79%
0.50	Fsq*0.50	0.071	13	116	-38%	-58%
0.75	Fsq*0.75	0.107	19	111	-41%	-38%
1.0	Fsq*1.0	0.142	25	107	-43%	-18%
1.25	Fsq*1.25	0.178	31	102	-45%	0%
1.50	Fsq*1.50	0.213	36	98	-48%	18%
1.75	Fsq*1.75	0.249	41	94	-50%	36%
2.0	Fsq*2.0	0.284	47	90	-52%	53%
1.396	MSY-approach	0.198	34	100	-47%	11%

***SSB in 2012 relative to SSB in 2011**

**** TAC in 2011 relative to landings in 2010**

Table 4.4.1. 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
arith. mean	3.9	6.2	9.4	12.6	17.4	19.6	20.9	25.2	23.5

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	26.6	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	12.5	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	3.1	6.3	8.2	15.9	17.0	17.0	22.1	23.6	23.2
1994	4.1	6.3	10.6	14.3	24.2	22.2	40.0	23.0	31.6
1995	5.3	6.1	8.8	10.9	10.9	15.2	14.7	17.3	17.4
1996	3.1	8.4	6.2	14.1	17.8	27.2	20.3	39.4	30.7
1997	3.1	5.3	7.1	9.6	10.2	14.1	14.9	18.8	15.1
1998	3.3	5.2	7.2	10.4	15.4	14.1	17.6	20.8	21.3
1999	5.2	7.7	9.4	10.4	12.7	14.6	13.8	26.8	20.1
2000	4.3	7.6	10.3	11.5	13.7	17.0	17.4	22.6	17.3
2001	3.5	6.9	5.2	14.3	10.2	18.8	10.4	24.0	15.1
2002	4.1	7.1	9.7	12.8	14.3	12.9	14.8	20.4	21.3
2003	3.8	5.5	5.4	15.1	15.7	20.9	24.3	27.6	32.3
2004	5.3	6.9	7.5	9.4	12.9	14.2	16.8	14.4	11.6
2005	3.8	7.8	8.6	16.3	11.2	19.5	12.8	22.5	14.4
2006	4.1	7.0	10.3	13.1	12.6	16.9	14.4	25.6	15.9
2007	6.0	7.2	11.6	15.4	17.1	22.8	20.7	15.5	23.0
2008	4.1	6.9	9.5	15.3	12.1	22.8	15.9	26.5	13.7
2009	9.9	7.4	6.9	12.0	14.7	25.3	24.4	14.2	14.2
2010	2.9	6.3	5.7	17.5	9.4	21.0	13.8	24.7	16.4
arith. mean	4.1	6.4	9.6	13.1	17.1	20.4	20.7	26.1	23.0

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	1
2005	0.12	0.96	1	1
2006	0.08	0.78	1	1
2007	0.02	0.80	1	1
2008	0.03	0.69	1	1
2009	0.01	0.48	1	1
2010	0.04	0.92	1	1
2011	0.00	0.82	1	1

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

Table 4.4.5. Area-3 Sandeel. SMS settings and statistics.

```
objective function (negative log likelihood):  113.953
Number of parameters: 52
Maximum gradient: 4.27495e-005
Akaike information criterion (AIC):   331.905
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             280      14      27       0     321

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
              116.4    -2.5     5.7     0.0 0.00e+000   119.6

unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
                 0.42   -0.18    0.20    0.00

contribution by fleet:
----------------------
Dredge survey 2004-2009     total:  -2.458   mean:  -0.176

F, season effect:
-----------------
age: 0
    1983-1988:   0.000 1.000
    1989-1998:   0.000 1.000
    1999-2010:   0.000 1.000
age: 1 - 4
    1983-1988:   0.890 0.500
    1989-1998:   1.235 0.500
    1999-2010:   0.837 0.500

F, age effect:
--------------
                0      1      2      3      4
1983-1988:  0.086  0.572  1.174  2.076  2.076
1989-1998:  0.286  0.407  0.328  0.260  0.260
1999-2010:  0.062  1.618  1.076  0.589  0.589


Exploitation pattern (scaled to mean F=1)
-----------------------------------------
                        0      1      2      3      4
1983-1988 season 1:  0.000  0.533  1.094  1.935  1.935
          season 2:  0.037  0.122  0.251  0.443  0.443

1989-1998 season 1:  0.000  1.042  0.839  0.666  0.666
          season 2:  0.092  0.066  0.053  0.042  0.042

1999-2010 season 1:  0.000  0.687  0.457  0.250  0.250
          season 2:  0.040  0.514  0.342  0.187  0.187
```

Table 4.4.5 (continued). Area-3 Sandeel. SMS settings and statistics.

sqrt(catch variance) ~ CV:

age	season 1	season 2
0		1.798
1	0.490	1.084
2	0.490	1.084
3	0.881	1.601
4	0.881	1.601

Survey catchability:

	age 0	age 1
Dredge survey 2004-2009	1.969	1.969

sqrt(Survey variance) ~ CV:

	age 0	age 1
Dredge survey 2004-2009	0.30	0.98

Recruit-SSB	alfa	beta	recruit s2	recruit s
Hockey stick -break.:	1188.884	1.000e+005	0.562	0.749

Table 4.4.6. Area-3 Sandeel. Fishing mortality at age by hal-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	0.234	0.052	0.480	0.108	0.848	0.190	0.848	0.190
1985	0.014	0.117	0.046	0.240	0.095	0.424	0.167	0.424	0.167
1986	0.044	0.443	0.148	0.910	0.303	1.609	0.536	1.609	0.536
1987	0.002	0.491	0.007	1.007	0.014	1.781	0.025	1.781	0.025
1988	0.037	0.668	0.123	1.370	0.252	2.423	0.446	2.423	0.446
1989	0.086	0.969	0.061	0.780	0.049	0.619	0.039	0.619	0.039
1990	0.120	0.455	0.085	0.367	0.069	0.291	0.055	0.291	0.055
1991	0.088	0.618	0.063	0.497	0.051	0.395	0.040	0.395	0.040
1992	0.041	0.399	0.029	0.322	0.023	0.255	0.019	0.255	0.019
1993	0.145	0.509	0.103	0.410	0.083	0.325	0.066	0.325	0.066
1994	0.056	0.620	0.040	0.499	0.032	0.396	0.025	0.396	0.025
1995	0.027	0.420	0.019	0.338	0.016	0.269	0.012	0.269	0.012
1996	0.191	0.265	0.136	0.213	0.110	0.169	0.087	0.169	0.087
1997	0.140	0.788	0.100	0.634	0.080	0.503	0.064	0.503	0.064
1998	0.227	0.747	0.162	0.601	0.130	0.477	0.103	0.477	0.103
1999	0.043	0.753	0.564	0.501	0.375	0.274	0.205	0.274	0.205
2000	0.003	1.341	0.033	0.892	0.022	0.488	0.012	0.488	0.012
2001	0.043	0.574	0.561	0.382	0.373	0.209	0.204	0.209	0.204
2002	0.001	1.048	0.016	0.697	0.010	0.381	0.006	0.381	0.006
2003	0.015	0.370	0.199	0.246	0.133	0.135	0.073	0.135	0.073
2004	0.009	0.598	0.119	0.398	0.079	0.218	0.043	0.218	0.043
2005	0.000	0.220	0.005	0.147	0.003	0.080	0.002	0.080	0.002
2006	0.001	0.127	0.010	0.084	0.007	0.046	0.004	0.046	0.004
2007	0.000	0.522	0.000	0.347	0.000	0.190	0.000	0.190	0.000
2008	0.000	0.459	0.001	0.305	0.001	0.167	0.000	0.167	0.000
2009	0.002	0.120	0.028	0.080	0.019	0.044	0.010	0.044	0.010
2010	0.001	0.504	0.011	0.335	0.008	0.184	0.004	0.184	0.004
arith. mean	0.049	0.521	0.099	0.483	0.091	0.500	0.094	0.500	0.094

Table 4.4.7. 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	0.317	0.613	1.072	1.072	0.465
1984	0.016	0.339	0.656	1.148	1.147	0.498
1985	0.014	0.186	0.362	0.641	0.641	0.274
1986	0.044	0.678	1.316	2.304	2.305	0.997
1987	0.002	0.624	1.187	2.032	2.027	0.906
1988	0.037	0.935	1.796	3.102	3.100	1.365
1989	0.086	1.247	0.957	0.754	0.753	1.102
1990	0.120	0.643	0.492	0.389	0.388	0.568
1991	0.088	0.826	0.631	0.497	0.496	0.728
1992	0.041	0.529	0.403	0.316	0.315	0.466
1993	0.145	0.724	0.555	0.438	0.438	0.639
1994	0.056	0.809	0.618	0.486	0.484	0.713
1995	0.027	0.547	0.416	0.326	0.325	0.482
1996	0.191	0.445	0.343	0.274	0.274	0.394
1997	0.140	1.062	0.815	0.643	0.642	0.938
1998	0.227	1.063	0.817	0.647	0.646	0.940
1999	0.043	1.396	0.897	0.498	0.500	1.147
2000	0.003	1.658	1.063	0.580	0.579	1.361
2001	0.043	1.170	0.753	0.420	0.422	0.961
2002	0.001	1.302	0.830	0.452	0.450	1.066
2003	0.015	0.628	0.400	0.221	0.221	0.514
2004	0.009	0.847	0.537	0.293	0.293	0.692
2005	0.000	0.285	0.178	0.096	0.096	0.232
2006	0.001	0.170	0.107	0.058	0.058	0.138
2007	0.000	0.657	0.414	0.224	0.223	0.536
2008	0.000	0.580	0.365	0.197	0.197	0.473
2009	0.002	0.176	0.111	0.060	0.060	0.143
2010	0.001	0.645	0.406	0.220	0.219	0.525
arith. mean	0.049	0.732	0.644	0.657	0.656	0.688

Table 4.4.8. 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	92758	22613	6346	182	13
1984	42576	34990	6119	1552	37
1985	296767	16048	9290	1439	285
1986	373688	112069	4819	2814	487
1987	83827	136877	21935	606	197
1988	307226	32029	29409	3342	67
1989	105207	113378	5136	2458	98
1990	213244	36965	14306	948	672
1991	90715	72434	7609	3918	591
1992	233592	31796	12959	1861	1486
1993	221185	85850	7321	3884	1313
1994	179289	73243	16448	1892	1799
1995	134746	64923	13389	4094	1251
1996	894735	50205	14783	3977	2064
1997	63391	282914	11880	4529	2401
1998	99007	21102	41172	2461	2020
1999	126854	30214	3008	8387	1294
2000	87267	46509	2859	530	3052
2001	95479	33331	4163	485	1139
2002	18789	35016	3787	828	560
2003	47851	7186	4274	790	485
2004	16809	18043	1437	1238	533
2005	36661	6378	3114	377	700
2006	103184	14032	1799	1134	516
2007	60029	39478	4326	695	806
2008	94415	22985	8278	1293	643
2009	72280	36148	5129	2580	841
2010	4420	27616	11020	1967	1659
2011		1691	5828	3309	1551

Table 4.4.9. 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	92758	212748	73212	105946	0.465
1984	42576	303276	98284	123635	0.498
1985	296767	256659	144227	59083	0.274
1986	373688	777859	162984	420341	0.997
1987	83827	1082840	283715	403908	0.906
1988	307226	655548	395663	391081	1.365
1989	105207	814245	132104	481893	1.102
1990	213244	449784	209168	219183	0.568
1991	90715	752755	216384	368105	0.728
1992	233592	396339	196446	195700	0.466
1993	221185	739822	209529	263954	0.640
1994	179289	701169	257567	444119	0.713
1995	134746	591643	204541	218922	0.482
1996	894735	776379	351306	247397	0.394
1997	63391	1661550	262786	604159	0.938
1998	99007	595816	399834	499333	0.940
1999	126854	405745	186104	223160	1.147
2000	87267	416370	108675	242732	1.361
2001	95479	299116	85852	245290	0.961
2002	18789	298045	67089	209302	1.066
2003	47851	126557	77218	58942	0.514
2004	16809	148769	38127	79234	0.692
2005	36661	120188	75562	29677	0.232
2006	103184	148729	56591	18863	0.138
2007	60029	360019	82761	113232	0.536
2008	94415	318333	133409	94491	0.473
2009	72280	321592	86326	33350	0.143
2010	4420	440423	260710	78051	0.525
2011			197580*		
arith. mean	149857	506154	174267	231182	0.688
geo. Mean**	105252				

***Using weights from 2010**

****Period 1983-2009**

Table 4.4.10. Sandeel in Area-3. Input values for preliminary short term forecast

	Age 0	Age 1	Age 2	Age 3	Age 4
Stock numbers(2011)	105252	1691	5828	3309	1551
Exploitation patttern 1st half		0.504	0.335	0.184	0.184
Exploitation patttern 2nd half	0.001	0.011	0.008	0.004	0.004
Weight in the stock 1st half		6.23	13.76	20.83	20.29
Weight in the catch 1st half		6.23	13.76	20.83	20.29
weight in the catch 2nd half	4.42	6.26	11.63	15.81	14.23
Proportion mature(2011)	0.00	0.00	0.82	1.00	1.00
Proportion mature(2012)	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 4.4.11. Sandeel in Area-3. Short term forecast

Basis: Fsq=F(2010)=0.429; Yield(2010)=78; Recruitment(2010)=4;

Recruitment(2011)= geometric mean (GM 83-09) = 105 billion; SSB(2011)=166

F multiplier	Basis	F(2011)	Landings(2011)	SSB(2012)	%SSB change*	%TAC change**
0	F=0	0	0	121	-27%	-100%
0.25	Fsq*0.25	0.107	10	114	-32%	-87%
0.50	Fsq*0.50	0.215	20	107	-36%	-74%
0.75	Fsq*0.75	0.322	29	101	-40%	-63%
1.0	Fsq*1.0	0.429	37	95	-43%	-52%
1.25	Fsq*1.25	0.537	45	89	-46%	-42%
1.50	Fsq*1.50	0.644	53	84	-49%	-33%

***SSB in 2012 relative to SSB in 2011**

**** TAC in 2011 relative to landings in 2010**

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	50	0	12	0	1	0	1	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	9.4	16.0	13.5	18.6	17.2	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

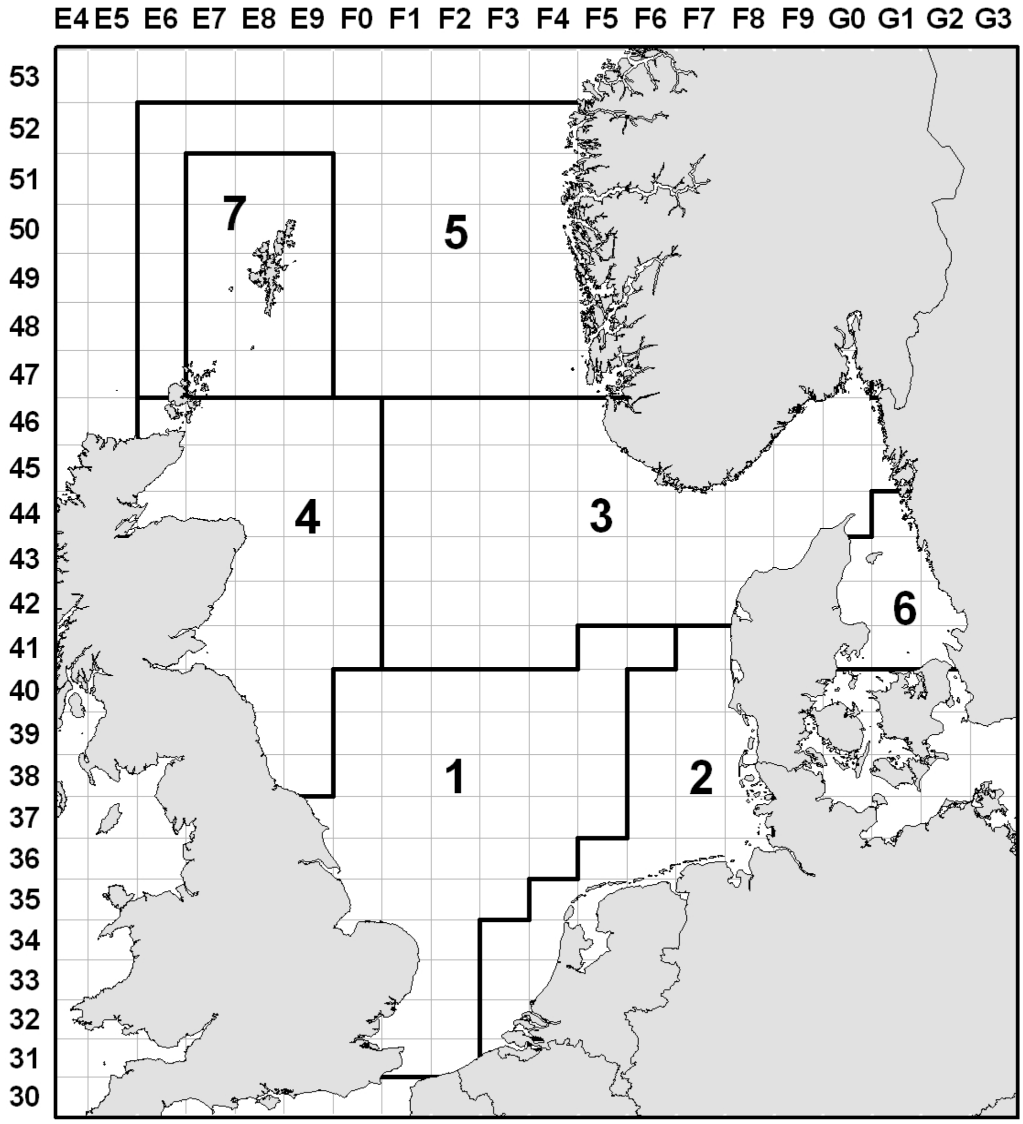


Figure 4.1.1 Sandeel in Division IV. Sandeel assessment areas.

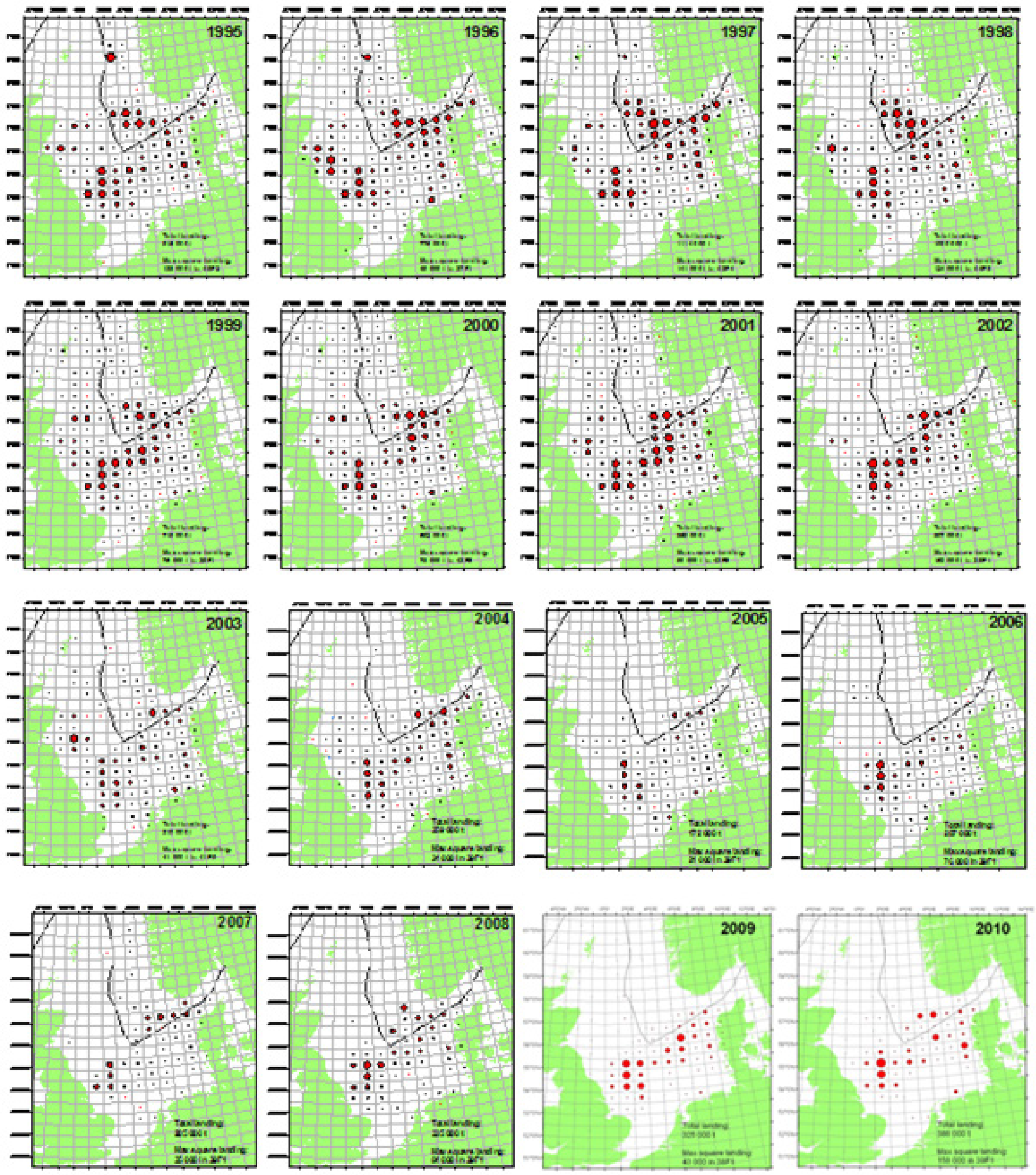


Figure 4.1.2. Sandeel in IV. Landings by ICES rectangles 1995-2010.

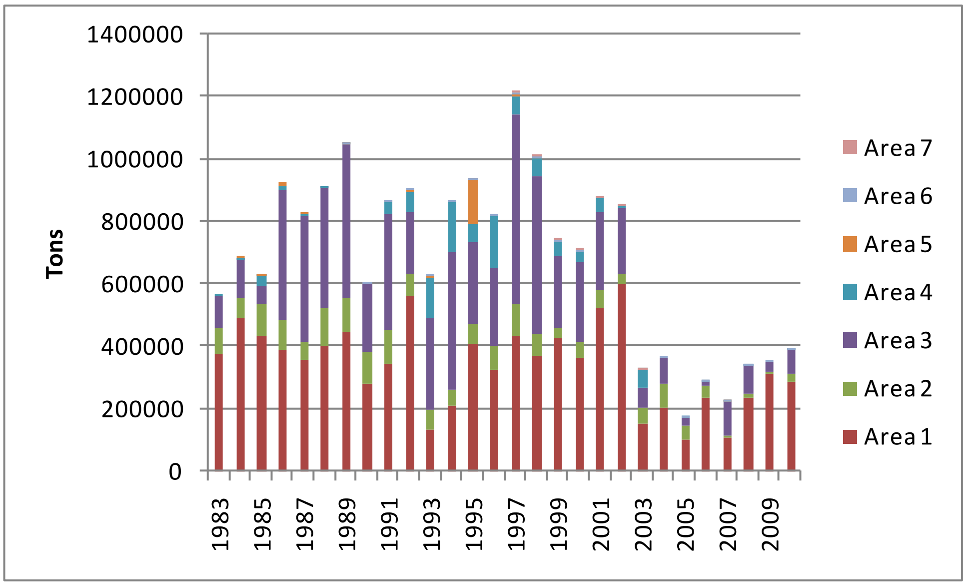


Figure 4.1.3. Sandeel in IV. Total annual landings by area.

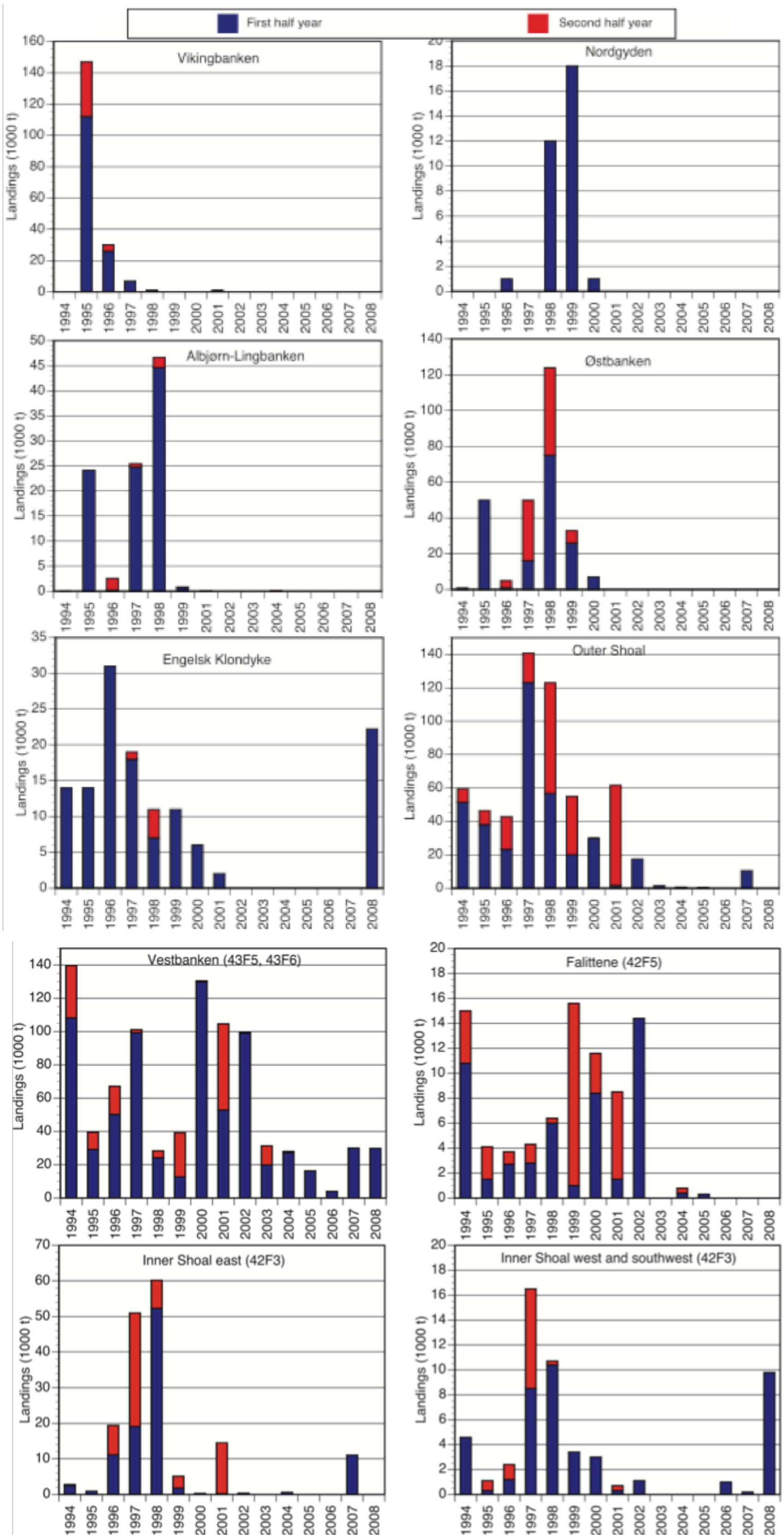


Figure 4.1.4. Sandeel in IV. Sandeel landings from Norwegian fishing banks 1994-2008 in the 1st (blue) and 2nd (red) half-year. Landings in 2nd half-year are mainly 0-group

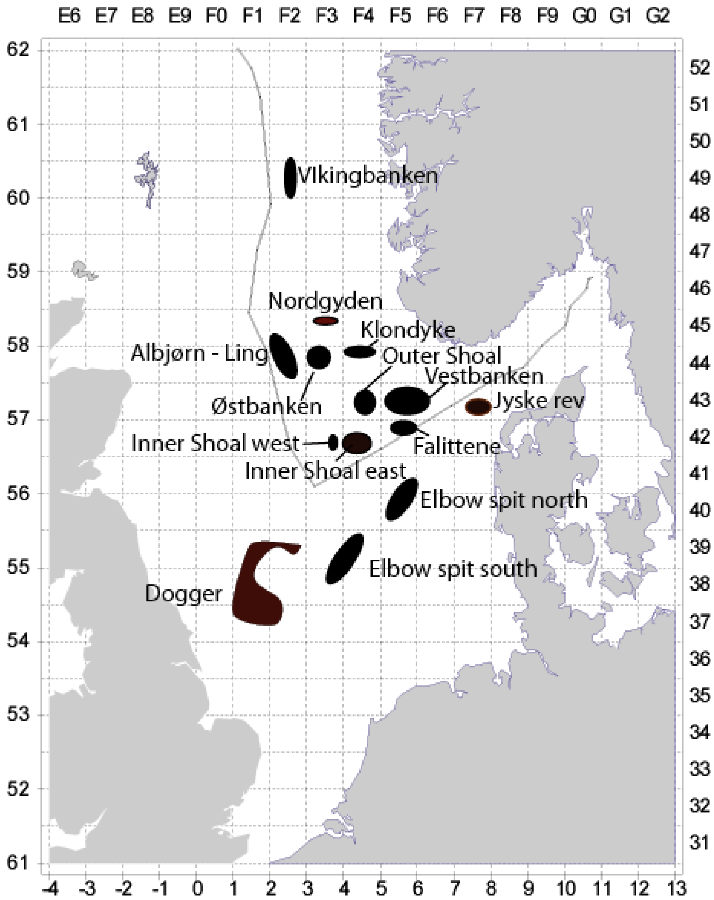


Figure 4.1.5. Sandeel fishing grounds in the Norwegian EEZ and the main fishing grounds in the EU EEZ.

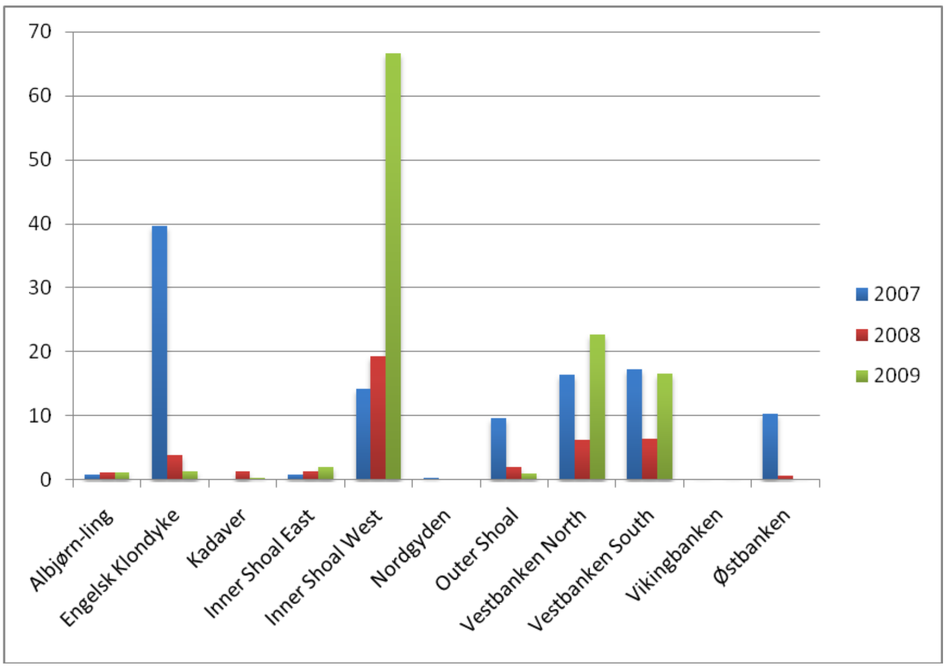


Figure 4.1.6. Relative densities (sA) of sandeel on various fishing grounds in the Norwegian EEZ in April-May 2007, 2008 and 2009.

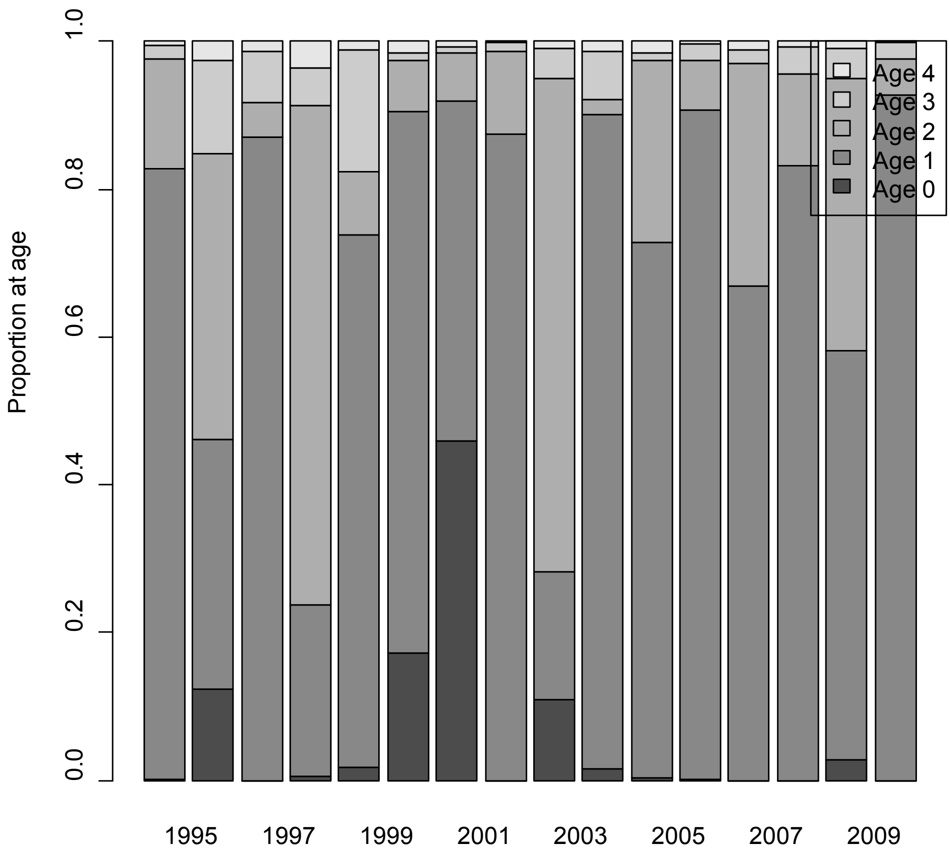


Figure 4.2.1 . Sandeel in Area-1. Catch numbers, Proportion at age.

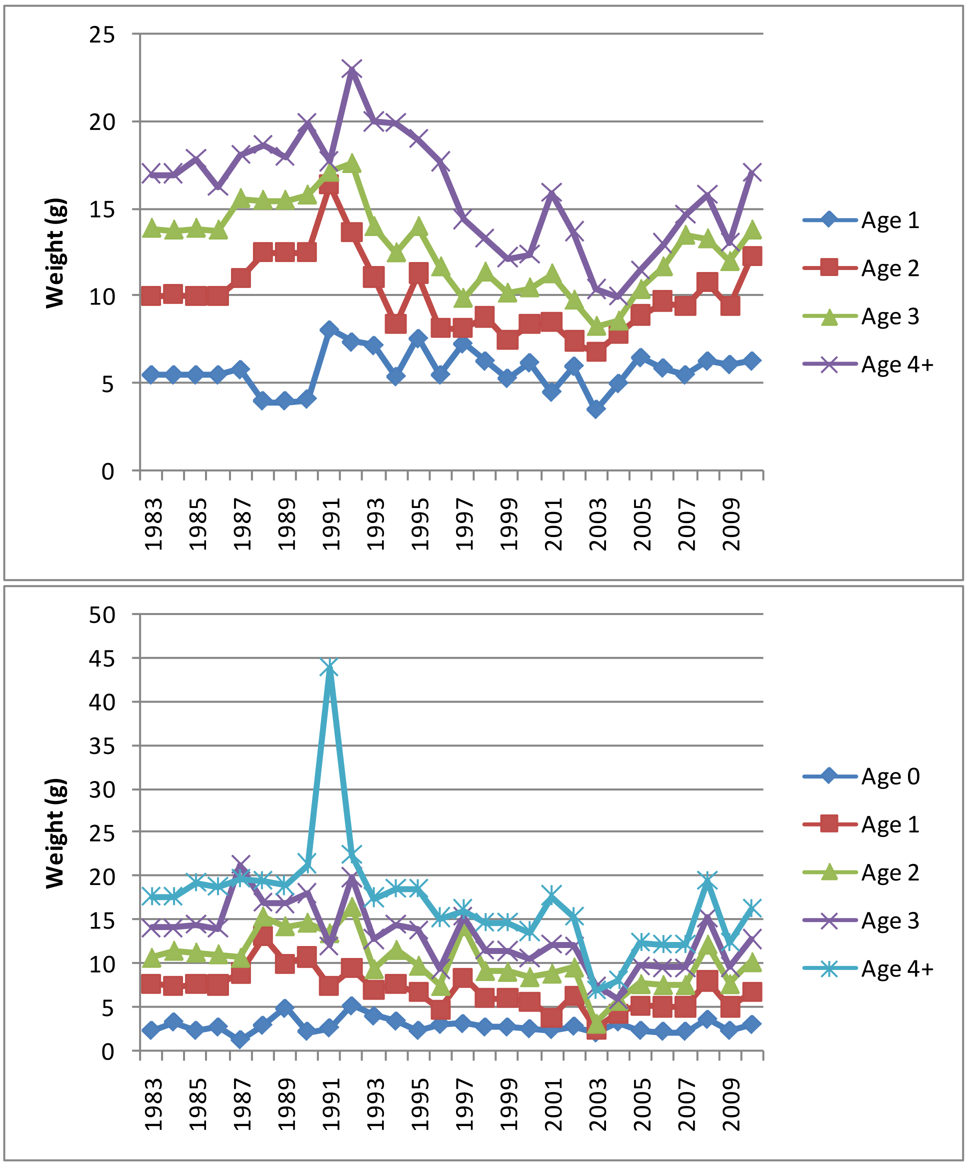


Figure 4.2.2. Sandeel in Area-1. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

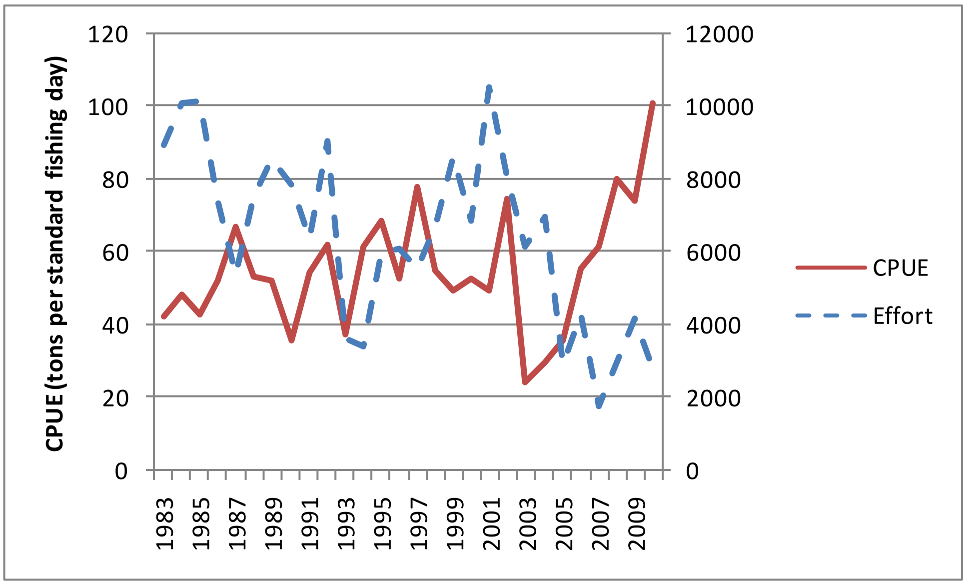


Figure 4.2.3. Sandeel in Area-1. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

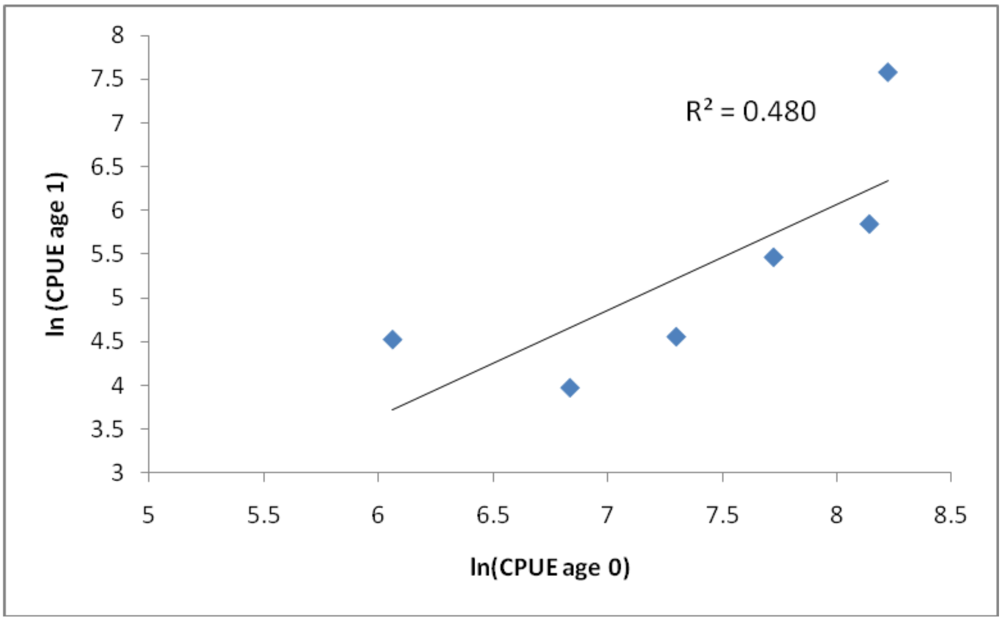


Figure 4.2.4. Sandeel in Area-1. Internal consistence by age of the Danish dredge survey.

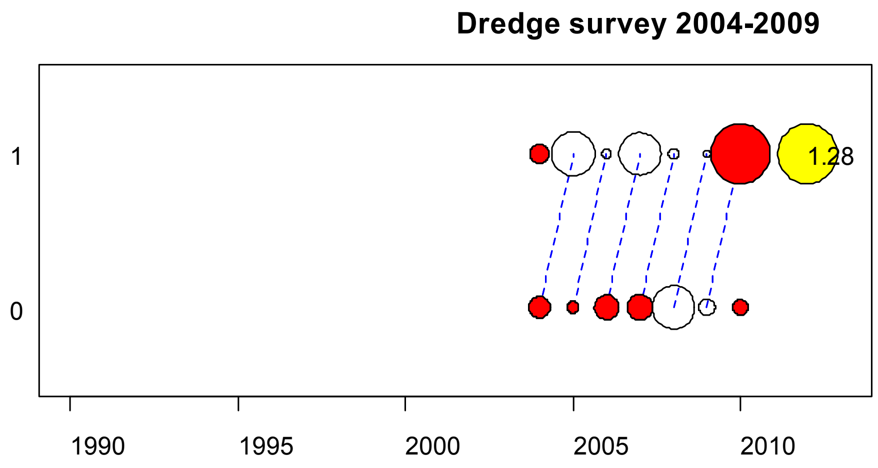


Figure 4.2.5. Sandeel in Area-1. Dredge survey residuals (log(observed CPUE) - log(expected CPUE). 'Red' dots show a positive residual.

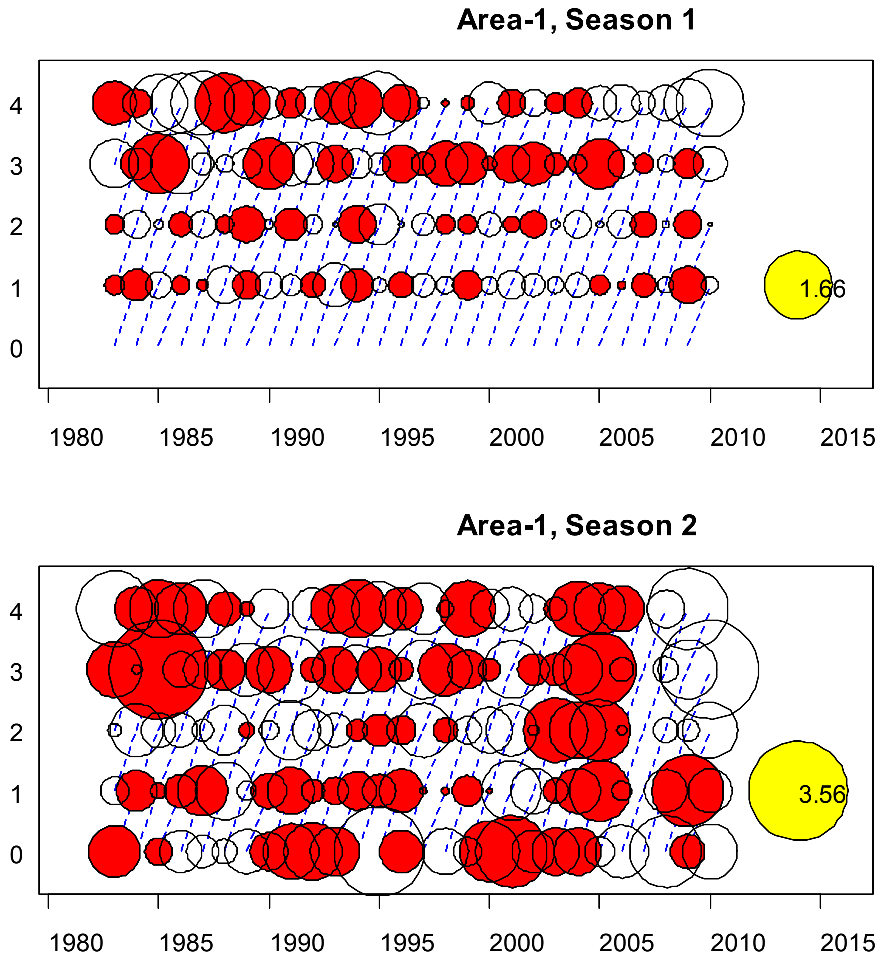


Figure 4.2.6. Sandeel in Area 1. Catch at age residual (log(observed catch) - log(expected catch). 'Red' dots show a positive residual.

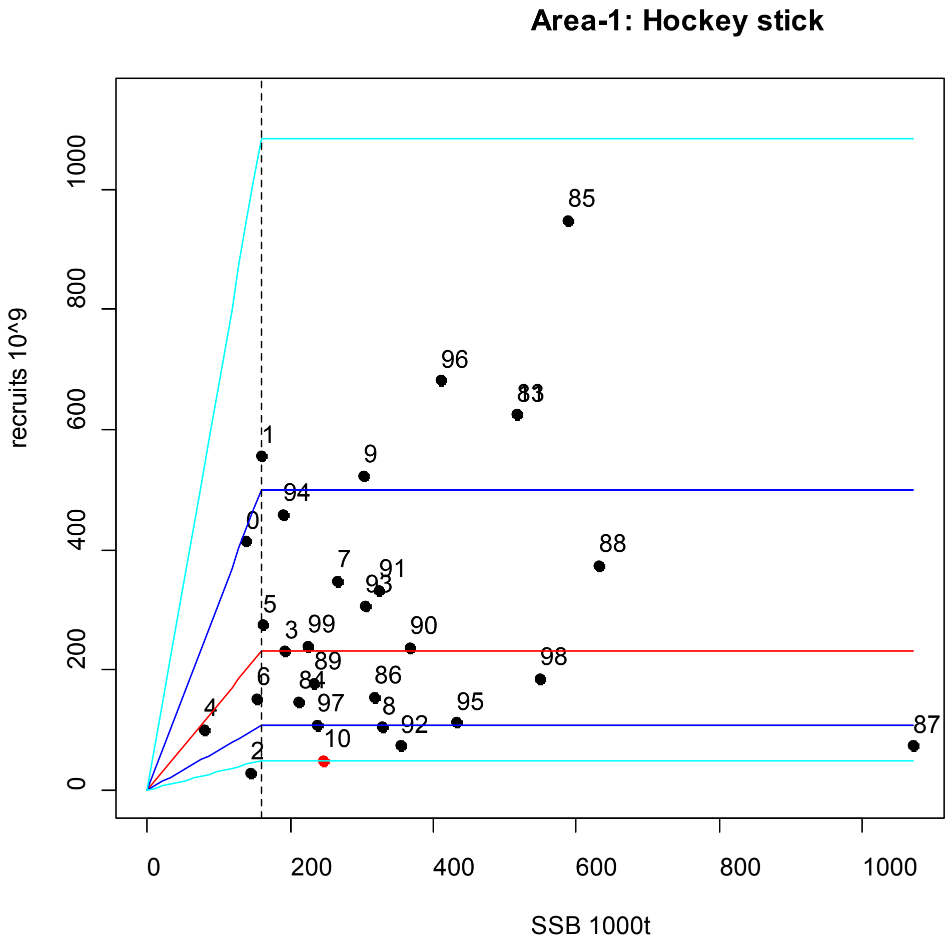


Figure 4.2.7. Sandeel in Area 1. Estimated stock recruitment relation. The 2010 recruitment is highly uncertain and has not been used for the estimation.

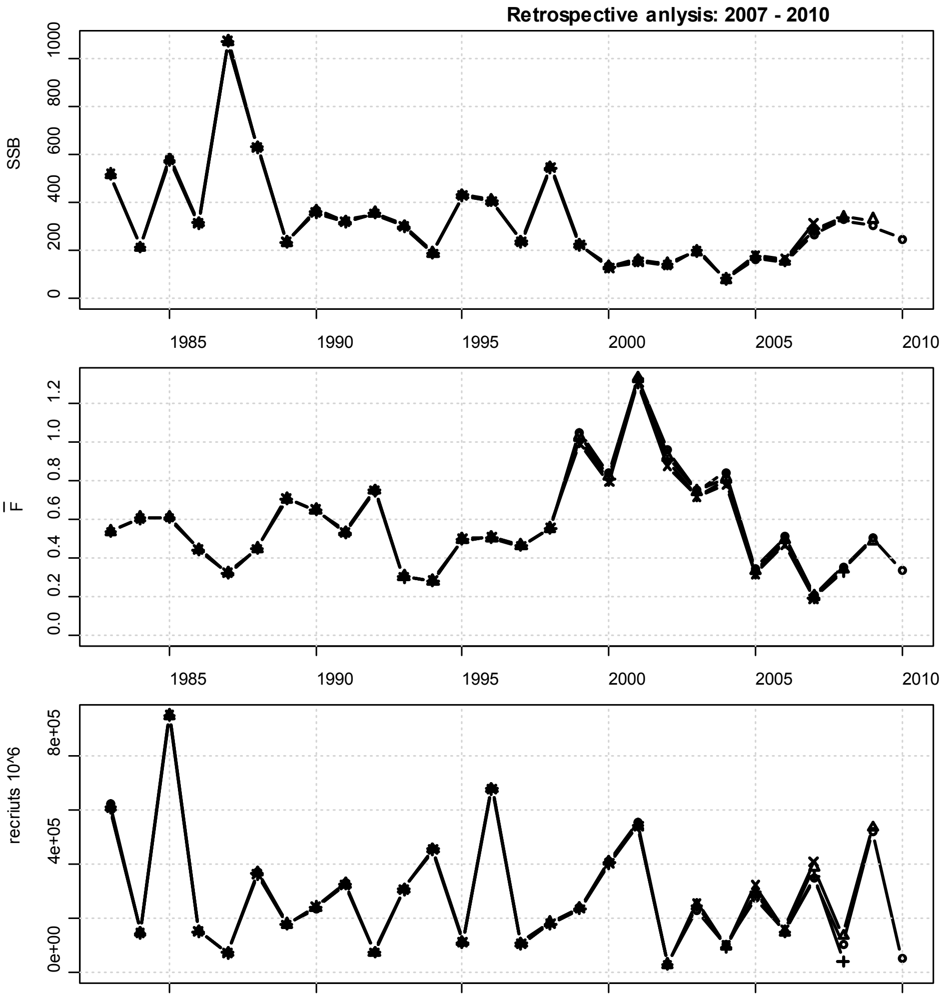


Figure 4.2.8. Sandeel in Area-1. Sandeel retrospective plot. Recruitment in 2010 is a random number.

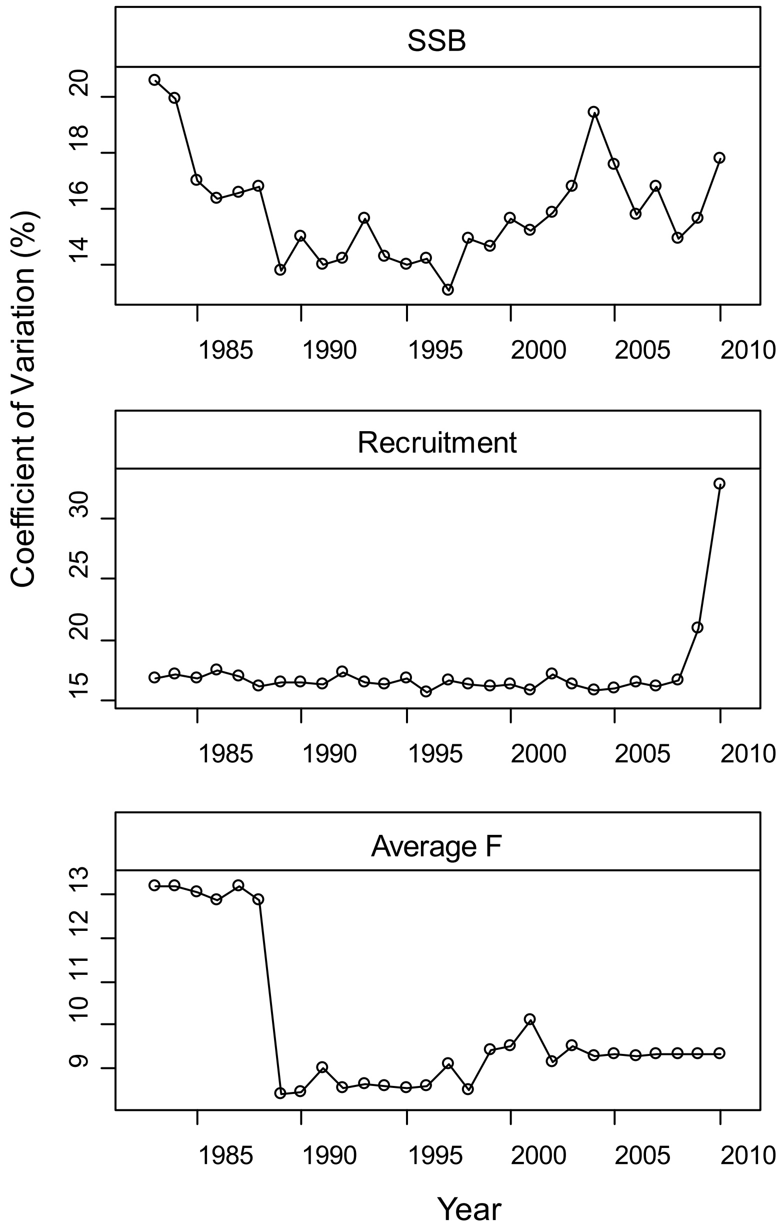


Figure 4.2.9 . Sandeel in Area-1. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

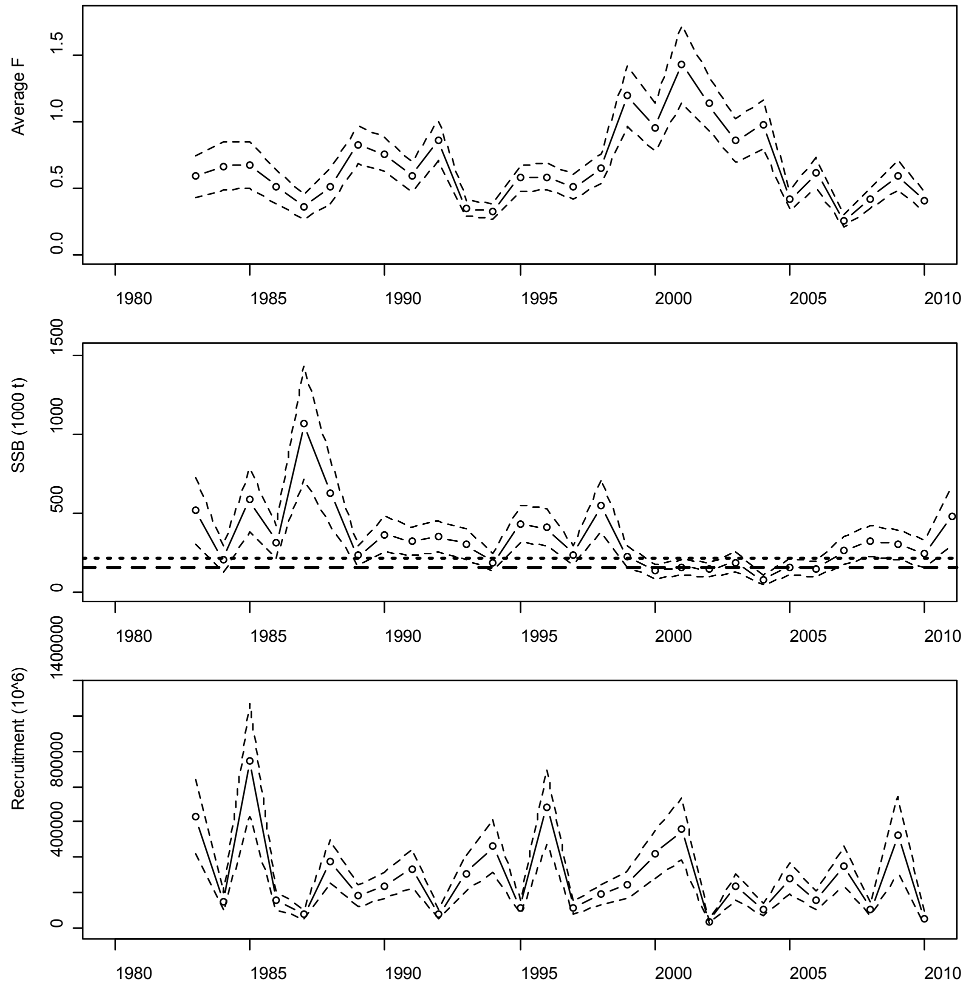


Figure 4.2.10 . Sandeel in Area-1. Model output with mean values and plus/minus 2 * standard deviation.

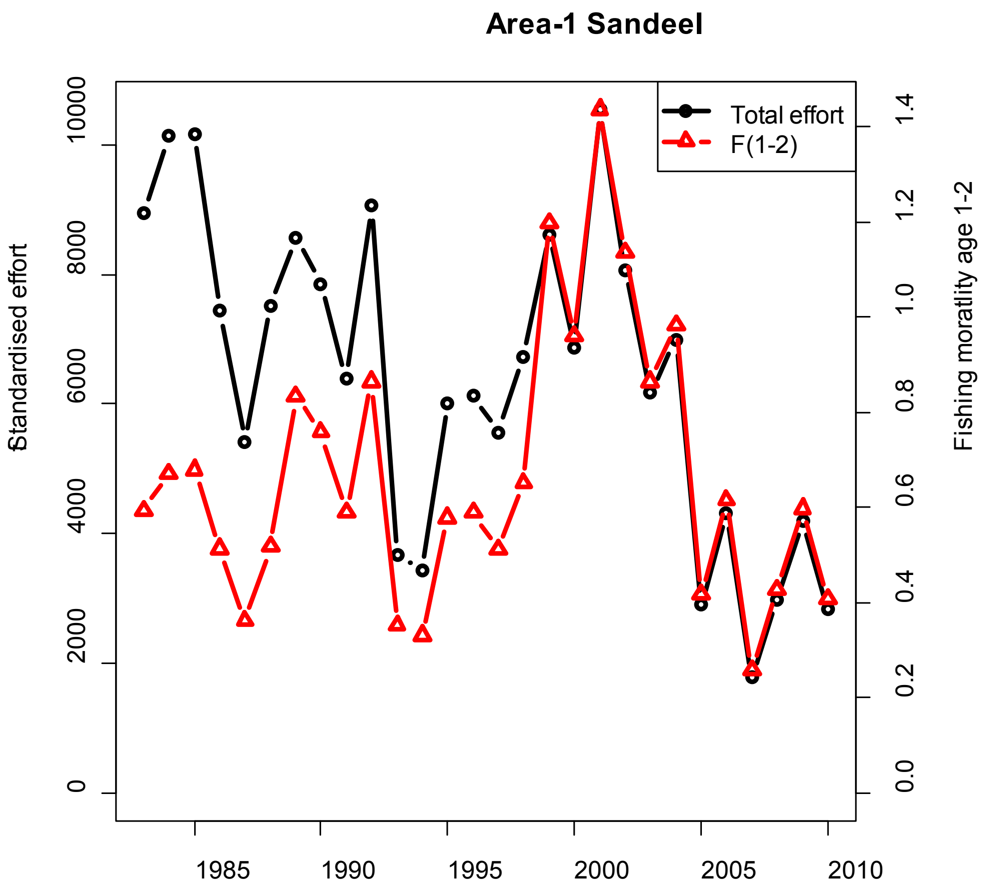


Figure 4.2.11 . Sandeel in Area-1. Total effort (days fishing for a standard 200 GT vessel) and estimated average Fishing mortality.

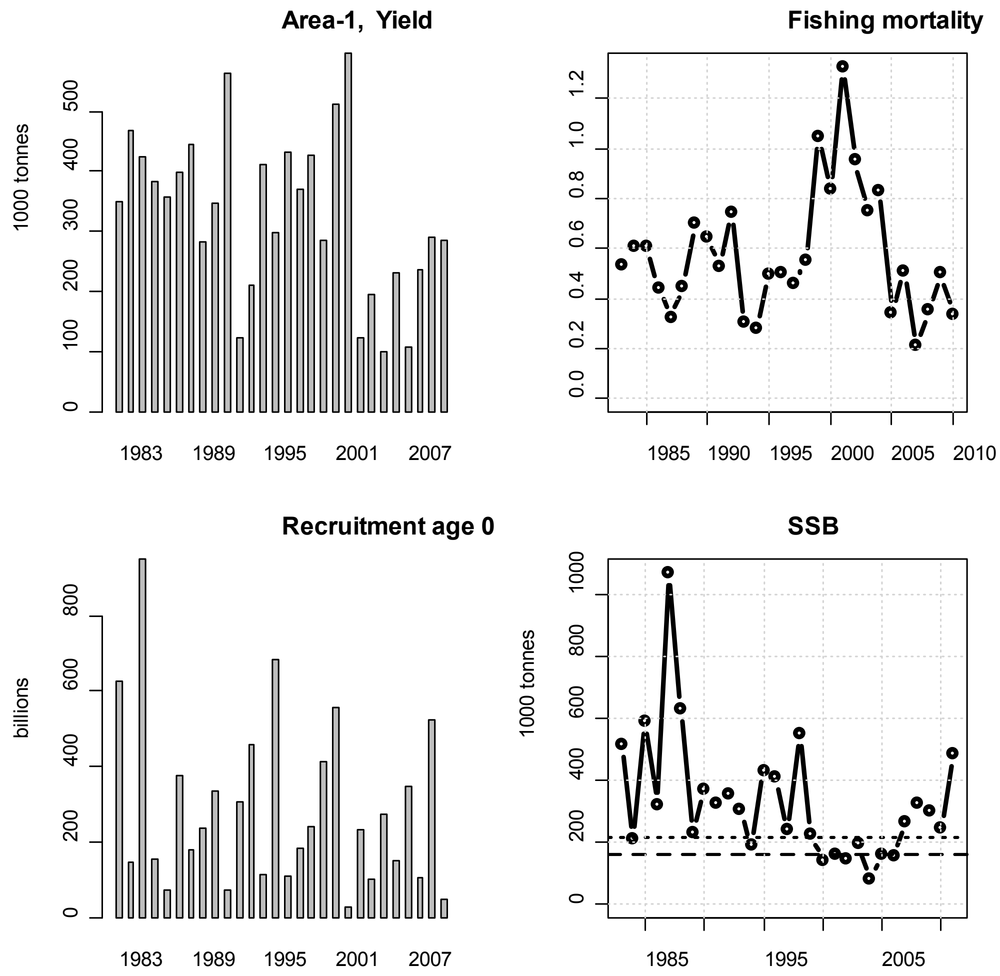


Figure 4.2.12. Sandeel in Area-1. Stock summary.

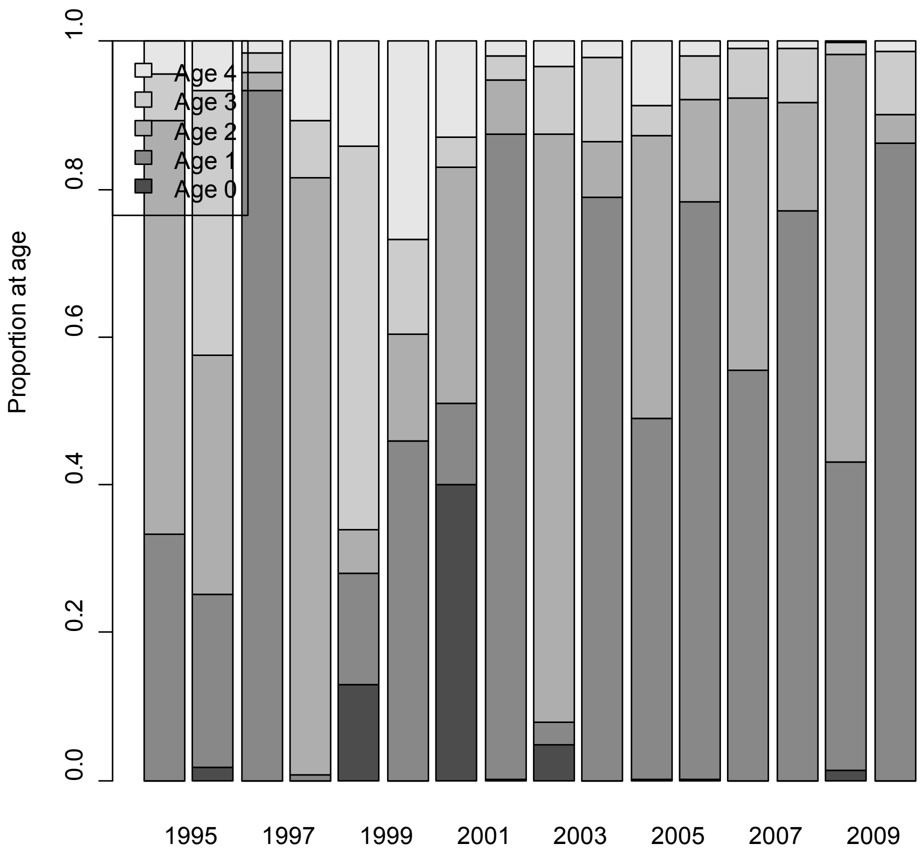


Figure 4.3.1. Sandeel in Area-2. Catch numbers; proportion at age.

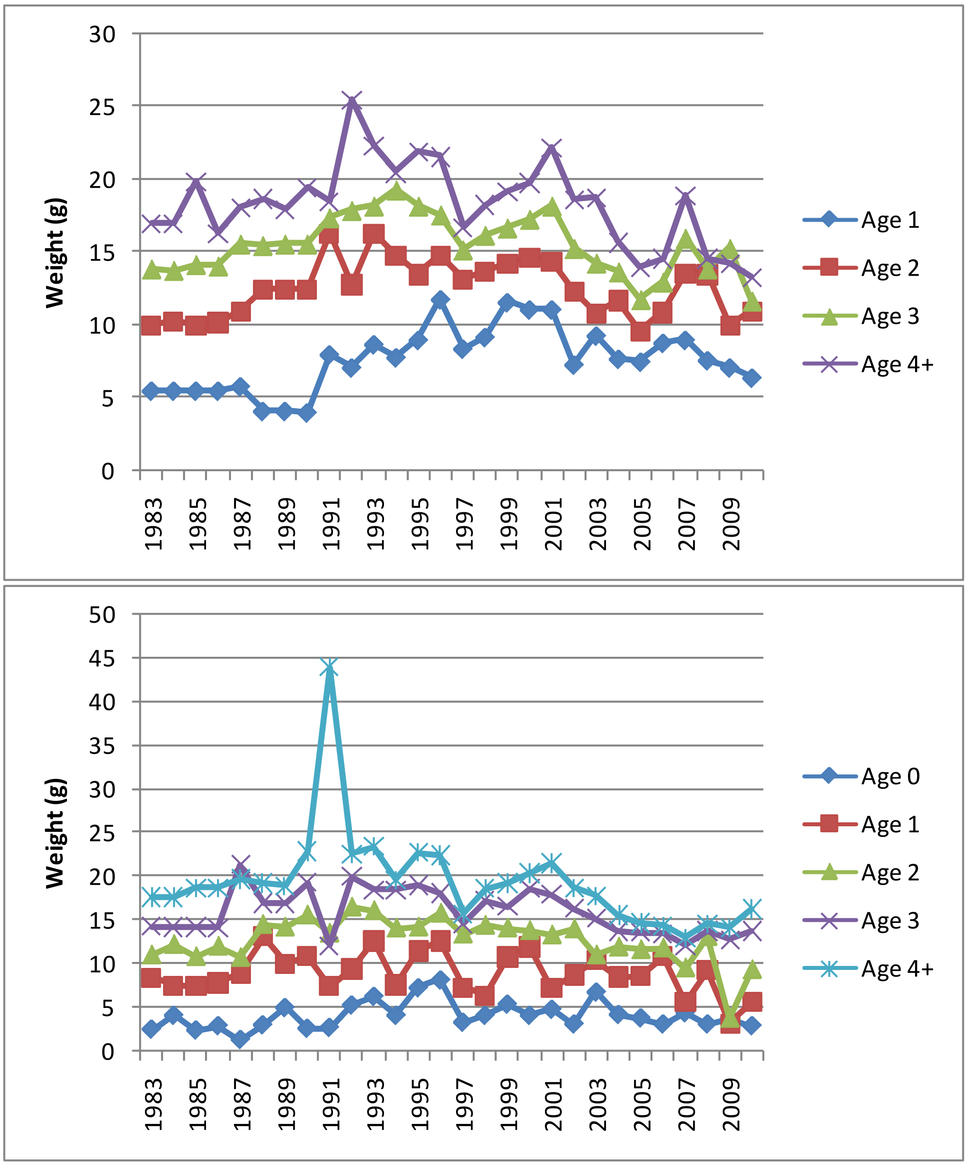


Figure 4.3.2 Sandeel in Area-2. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

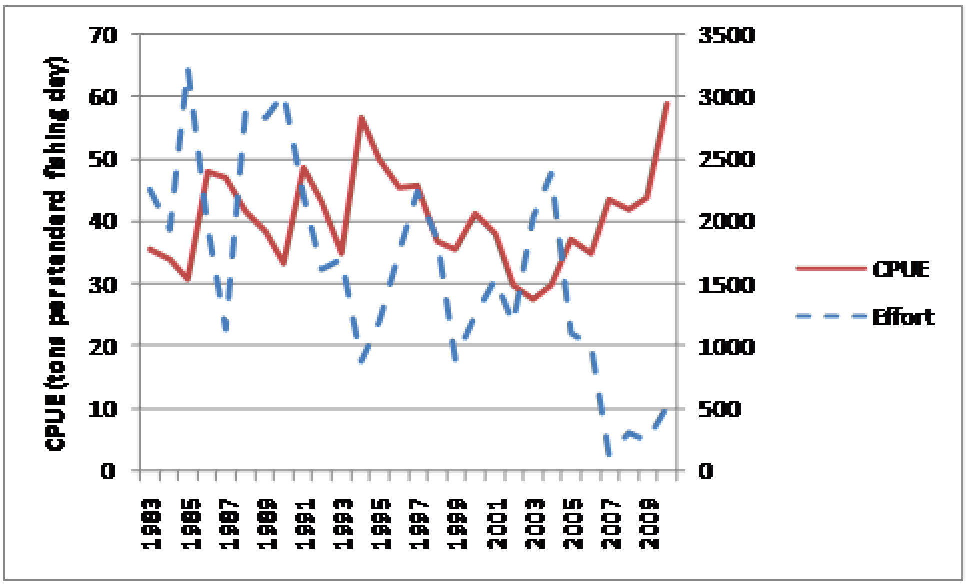


Figure 4.3.3. Sandeel in Area-2. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day)

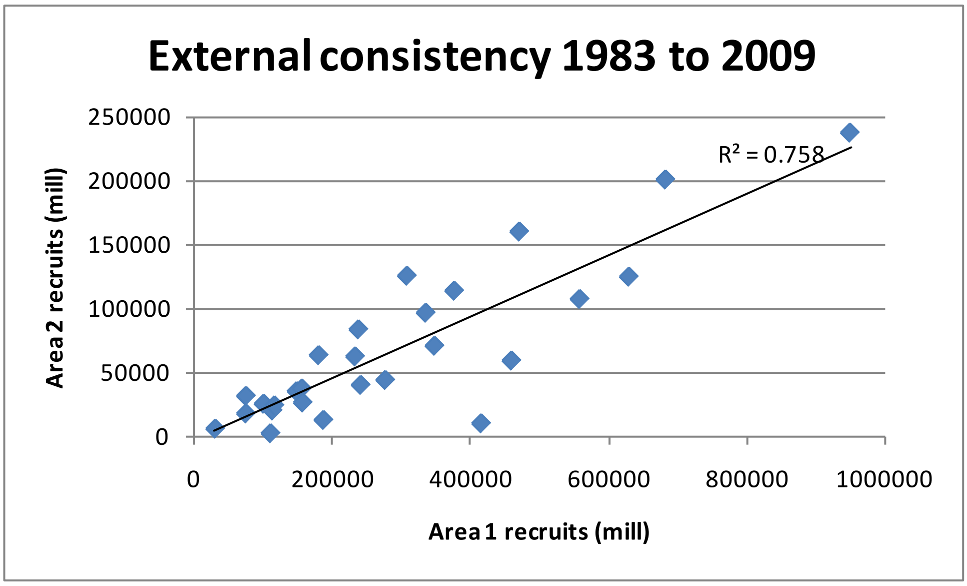


Figure 4.3.4. Sandeel in Area-2. Consistency of recruitments in Area-1 and Area-2

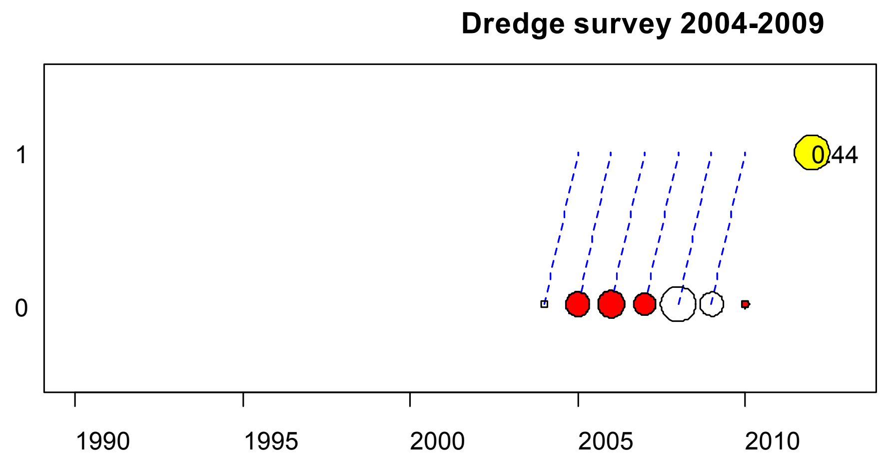


Figure 4.3.5. Sandeel in Area-2. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

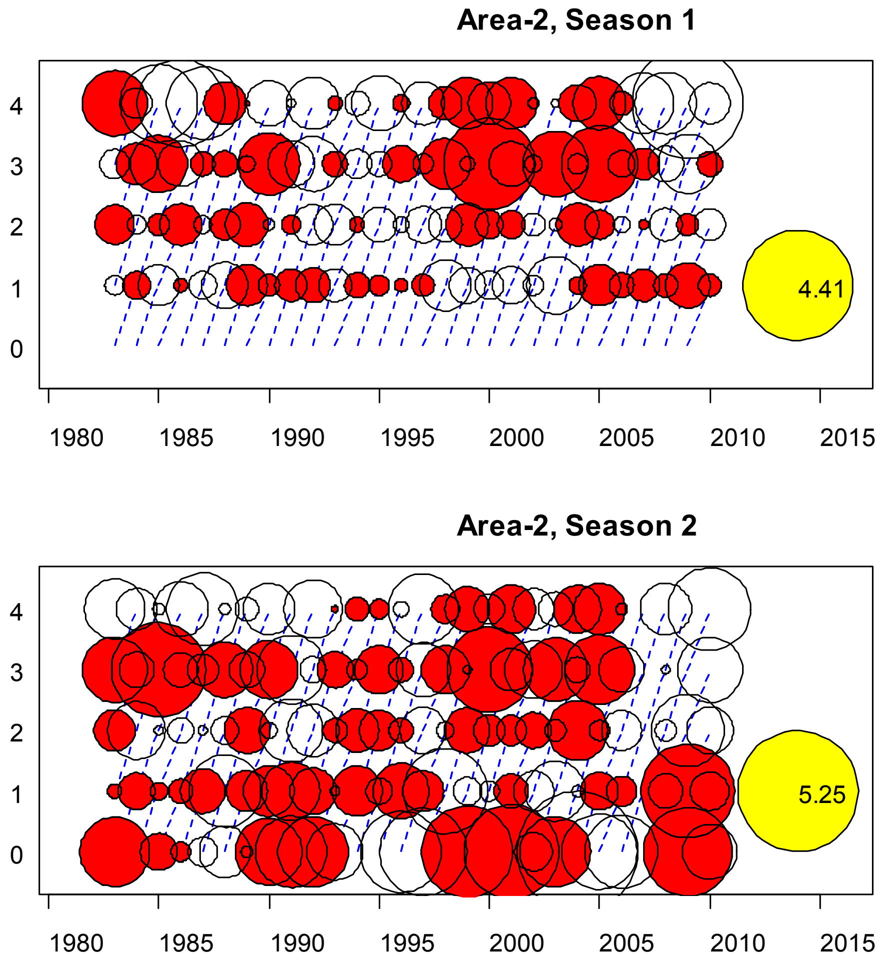


Figure 4.3.6. Sandeel in Area-2. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

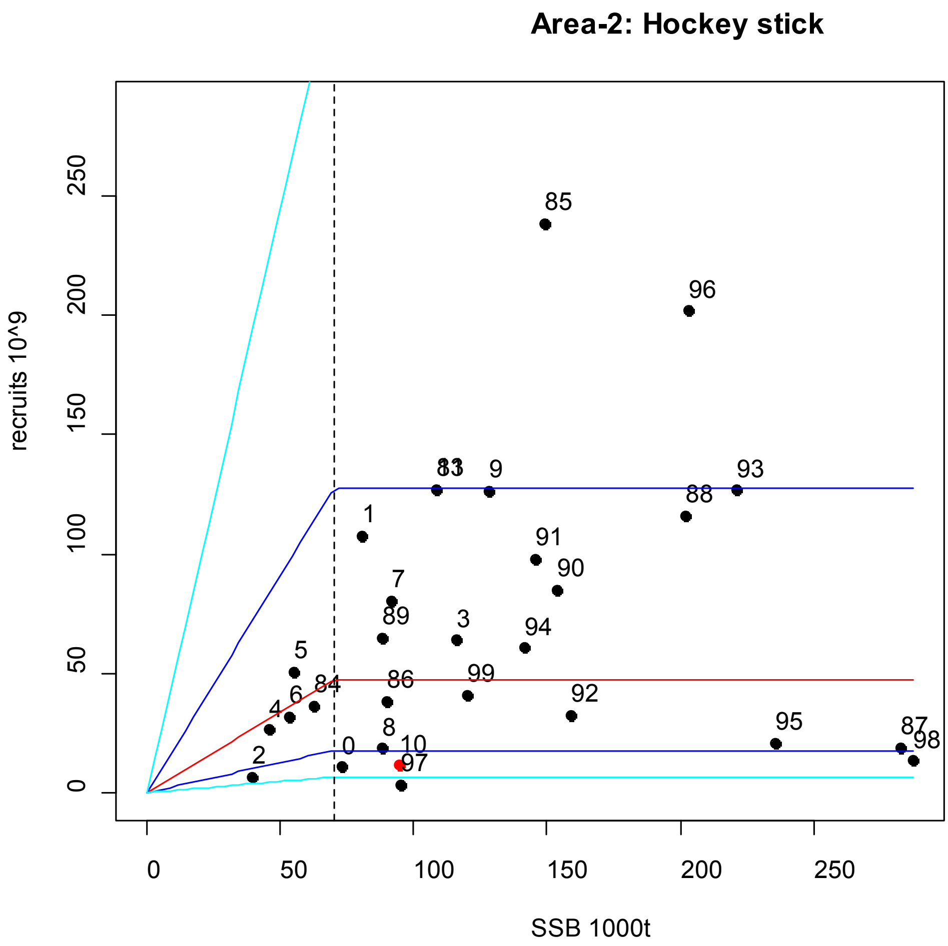


Figure 4.3.7. Sandeel in Area-2. Estimated stock recruitment relation. The 2010 recruitment is highly uncertain and was not used for the estimation.

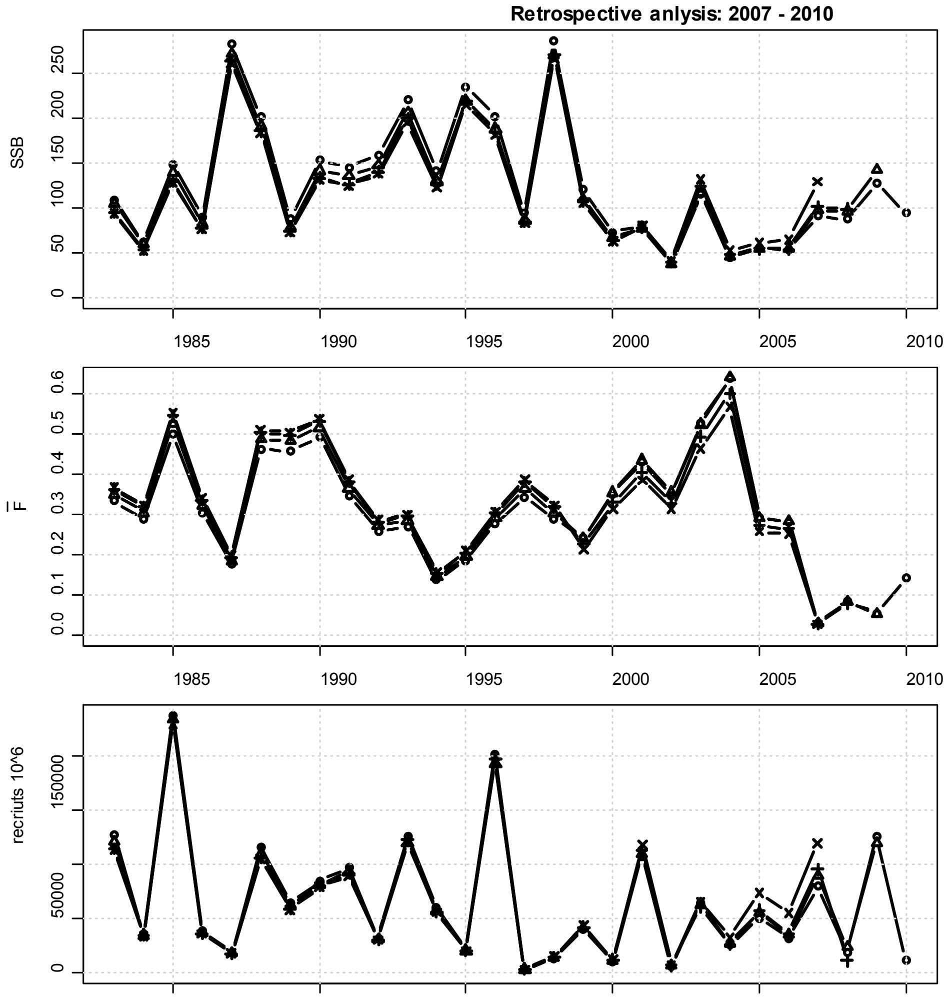


Figure 4.3.8.Sandeel in Area-2. Sandeel retrospective plot. Recruitment in 2010 is a random number and should be disregarded.

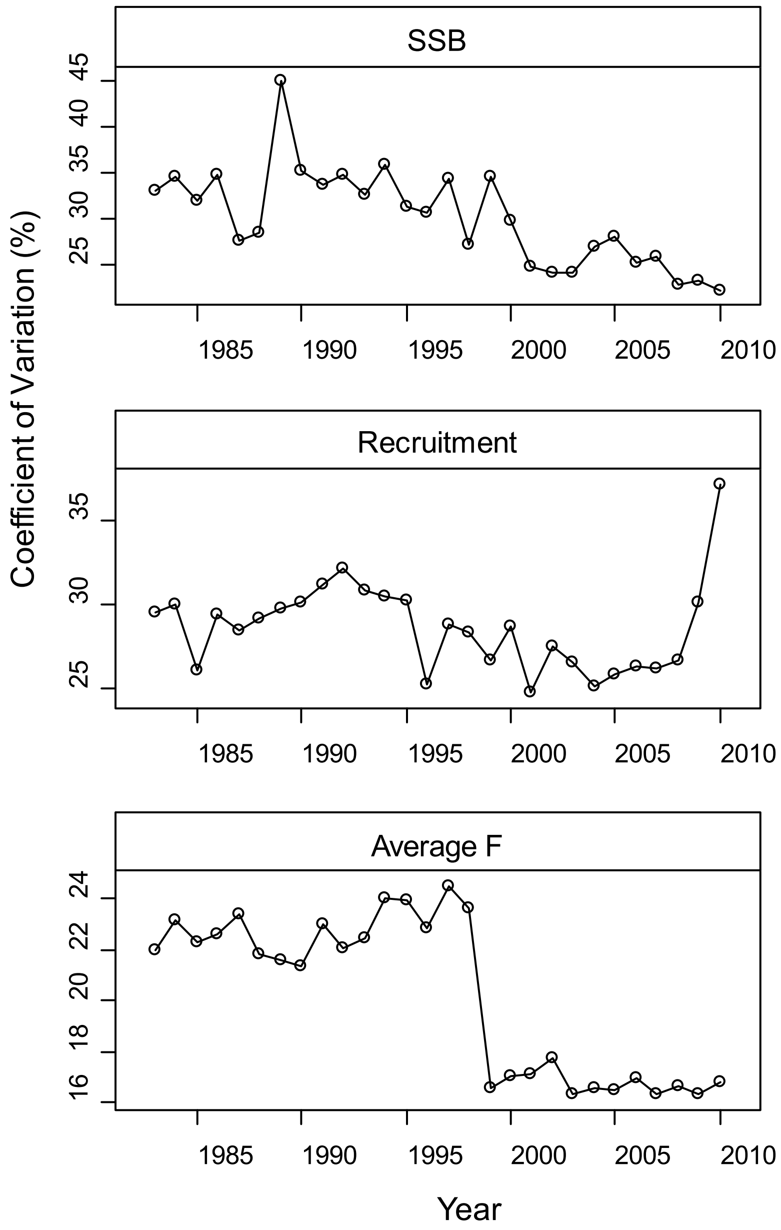


Figure 4.3.9. Sandeel in Area-2. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

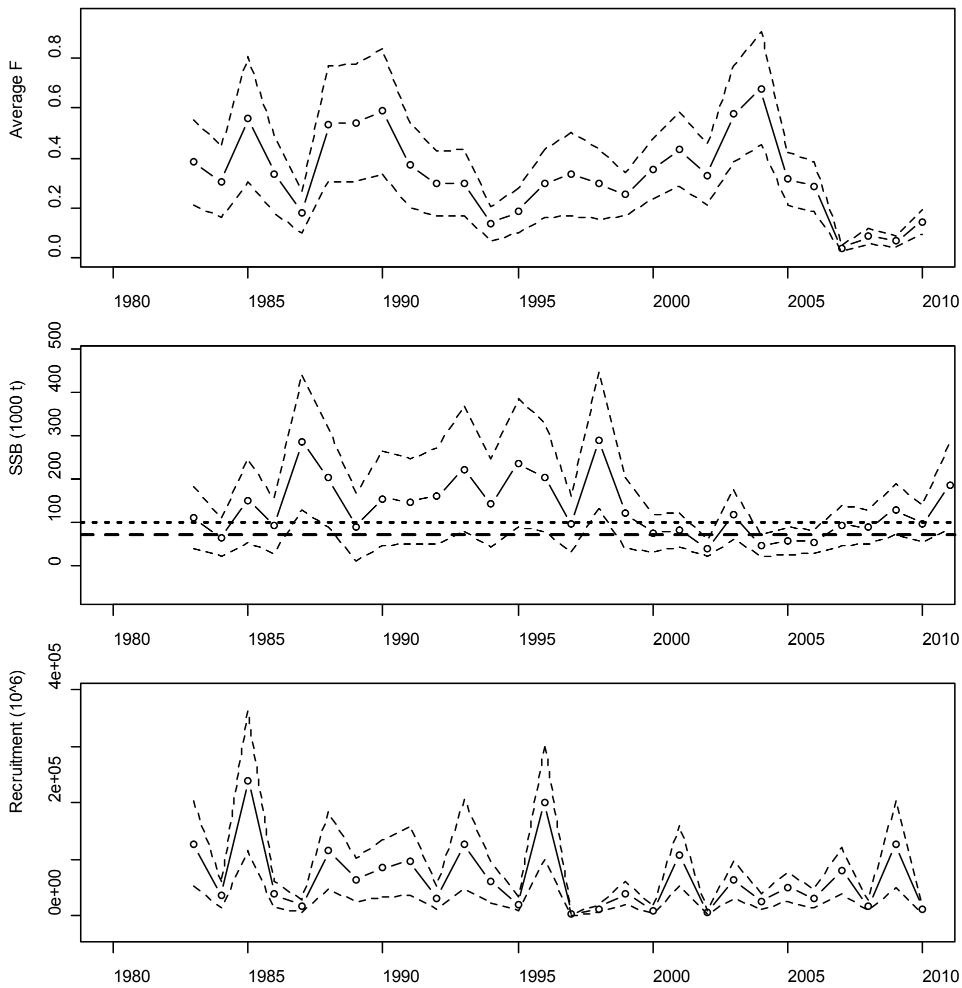


Figure 4.3.10. Sandeel in Area-2. Model output with mean values and plus/minus 2*standard deviation (95% confidence interval).

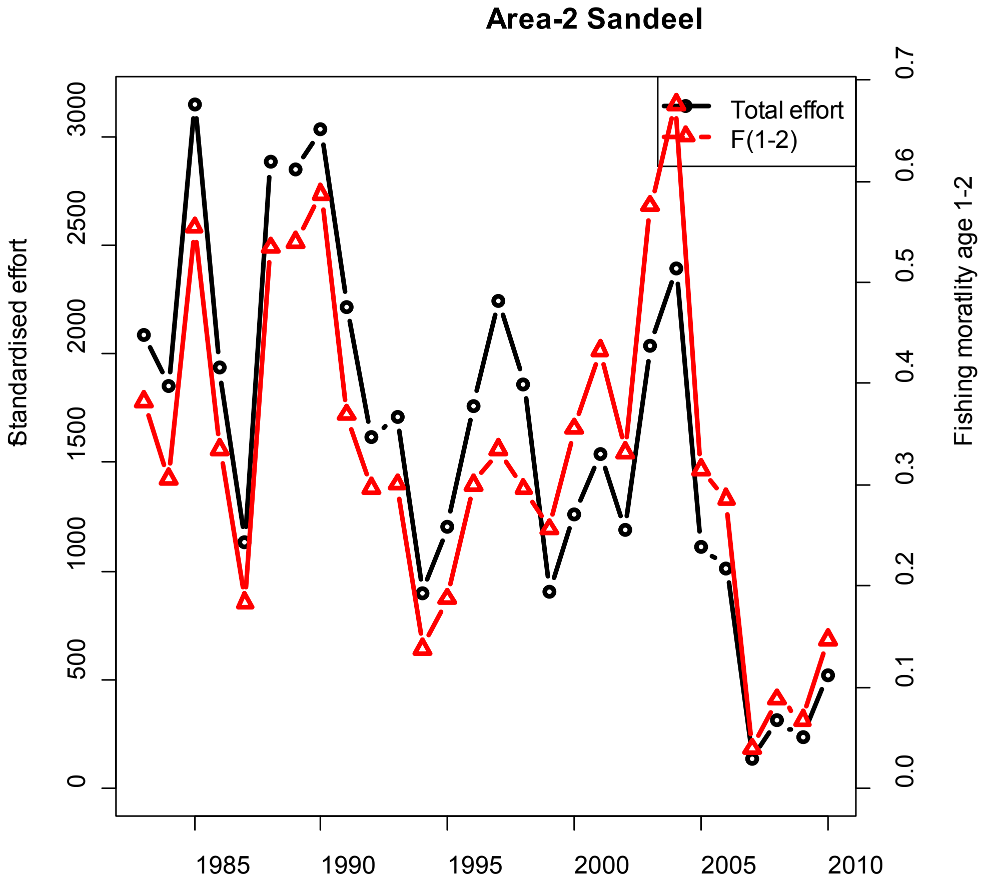


Figure 4.3.11. Sandeel in Area-2. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

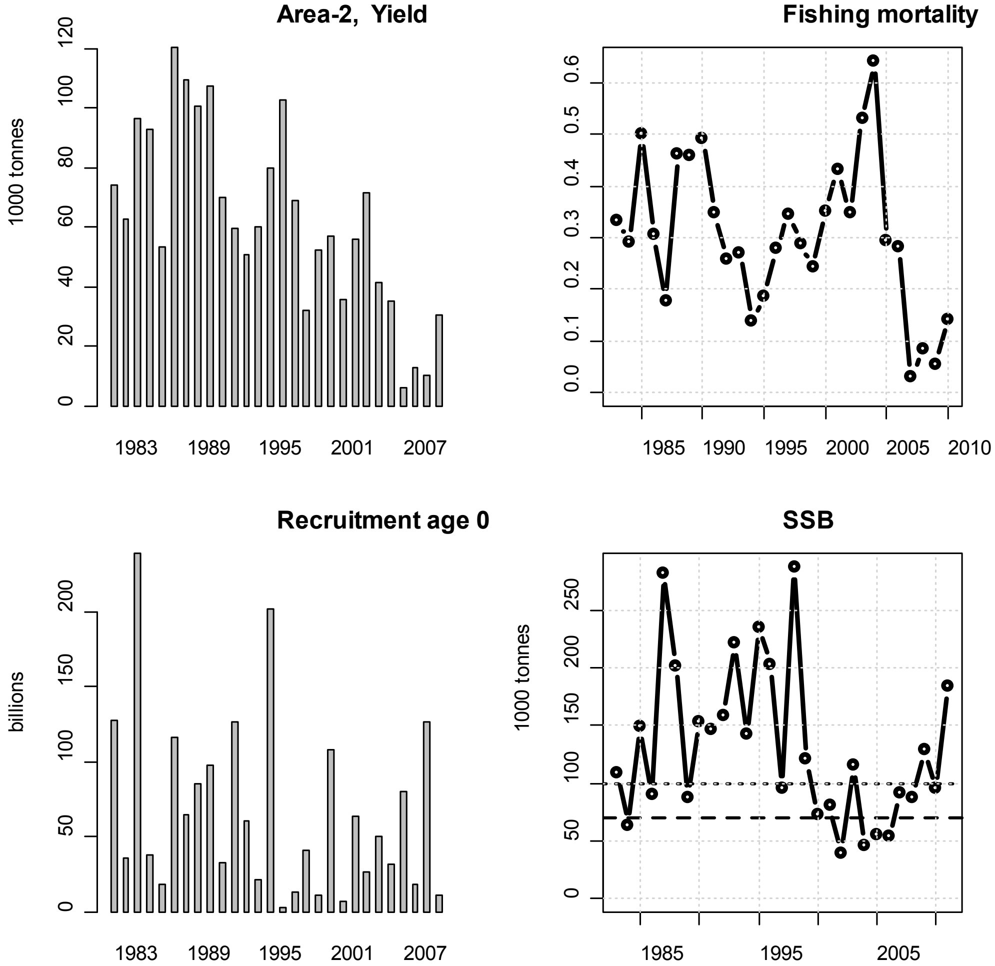


Figure 4.3.12.Sandeel in Area-2. Stock summary.

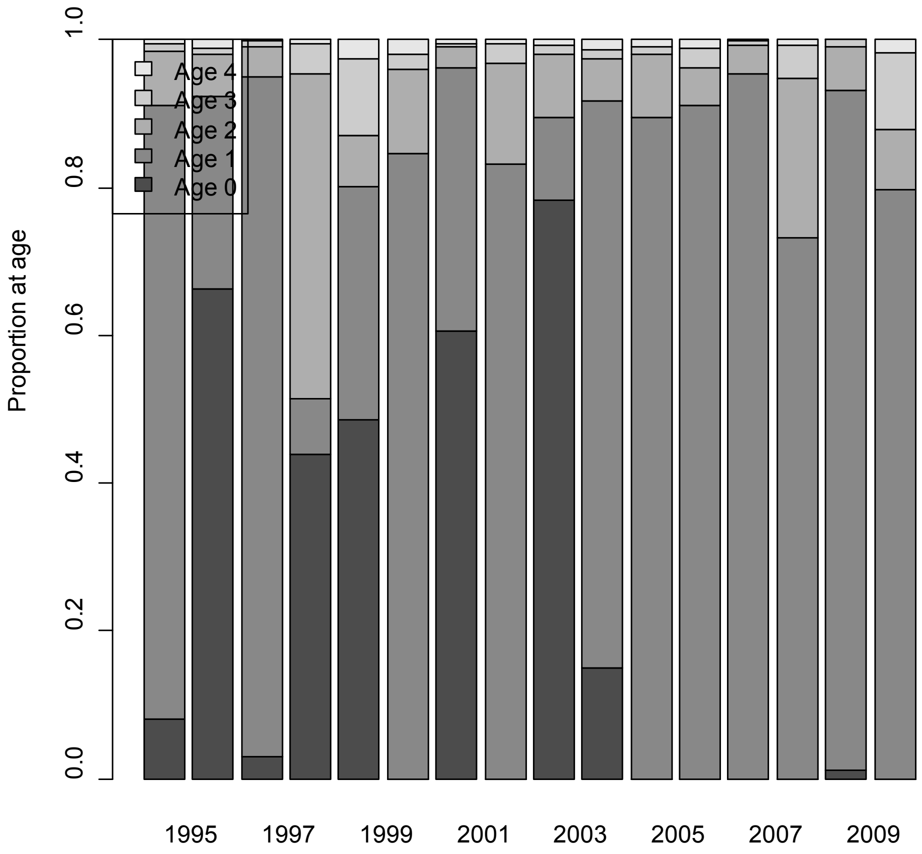


Figure 4.4.1. Sandeel in Area-3. Catch numbers; proportion at age.

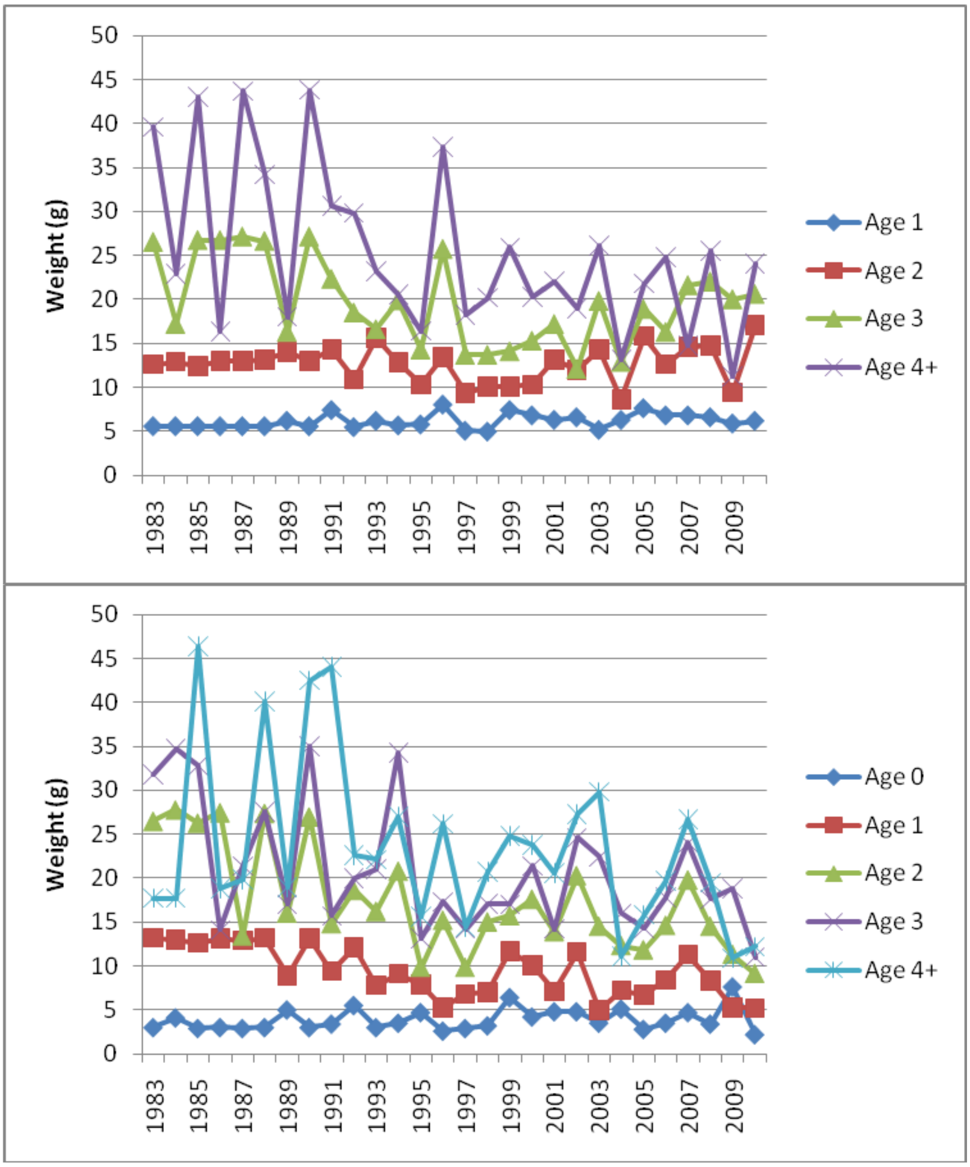


Figure 4.4.2. Sandeel in Area-3. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

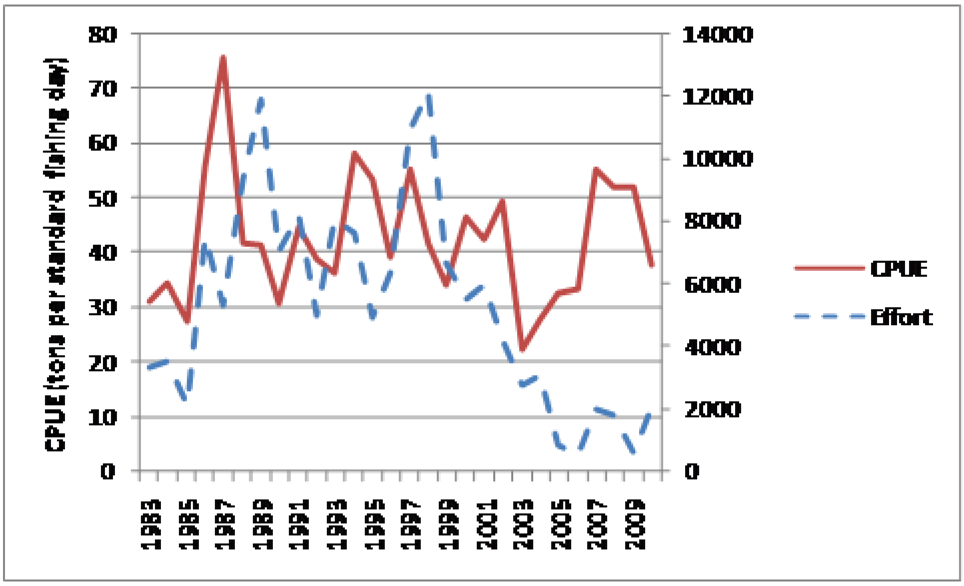


Figure 4.4.3. Sandeel in Area-3. Effort (days fishing for a standard 200 GT vessel) and CPUE (tons per standard fishing day).

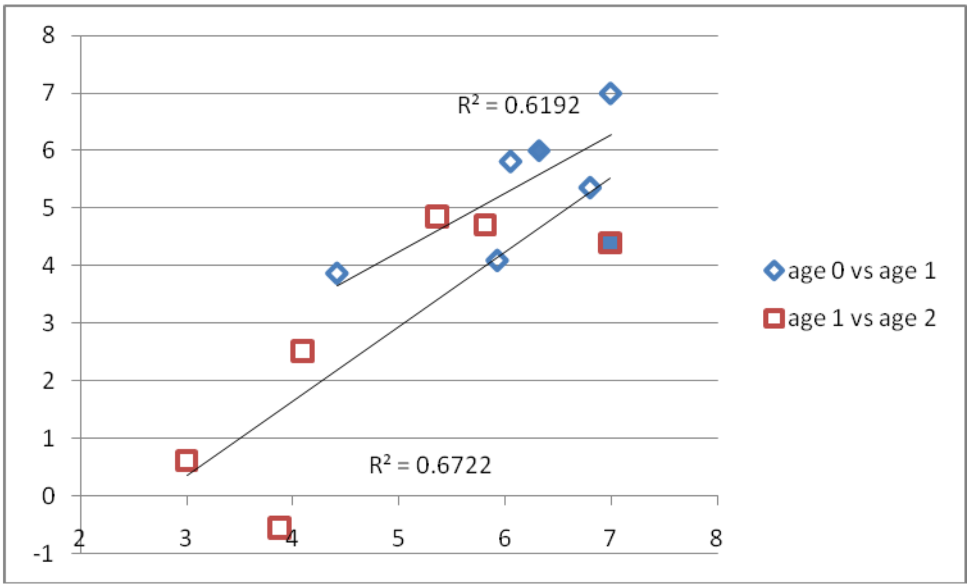


Figure 4.4.4. Sandeel in Area 3. Internal consistency by age of the Danish dredge survey.

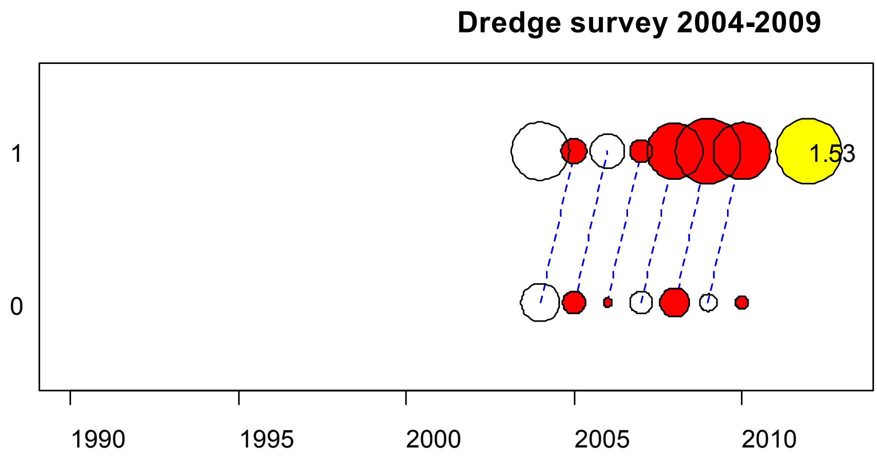


Figure 4.4.5. Sandeel in Area-3. Dredge survey residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

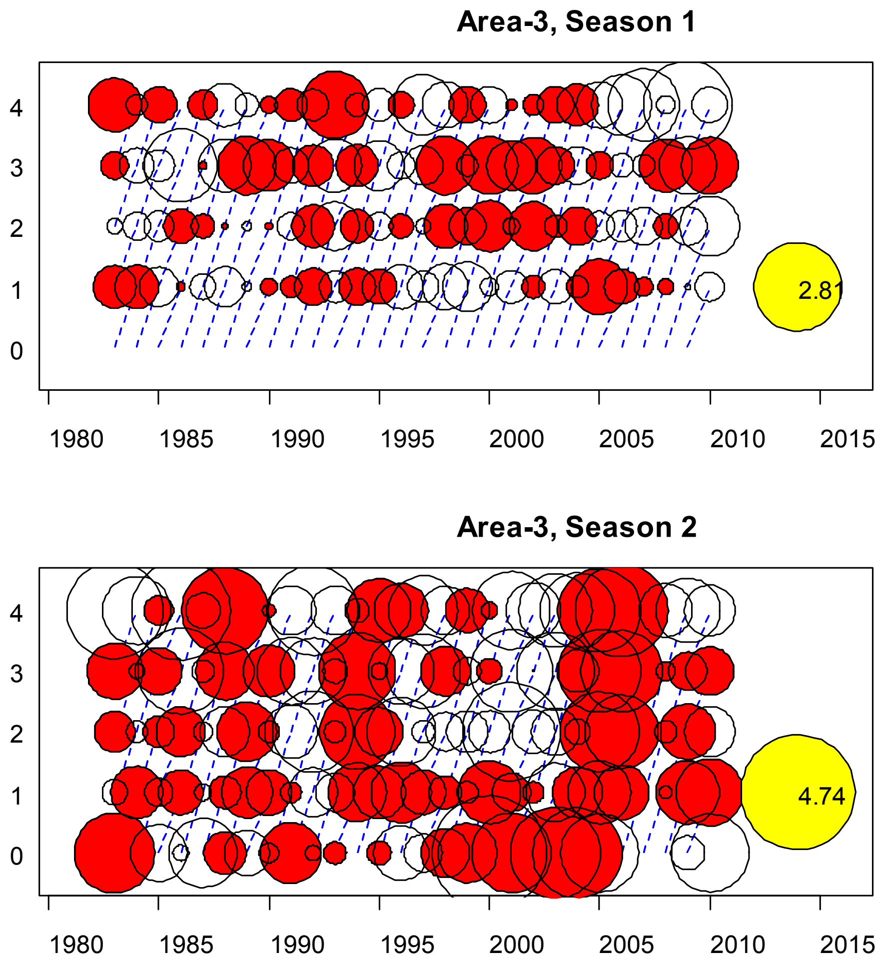


Figure 4.4.6.Sandeel in Area-3. Catch at age residuals (log(observed CPUE) – log(expected CPUE). Red dots show a positive residual.

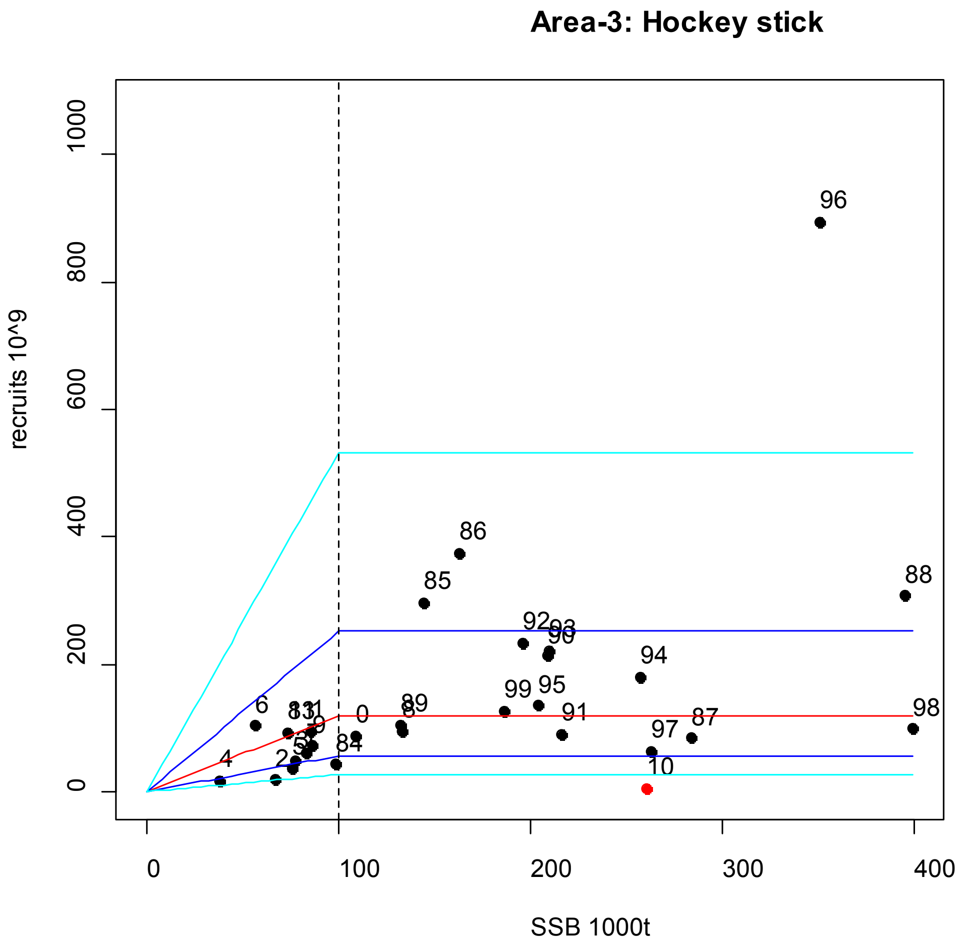


Figure 4.4.7. Sandeel in Area-3. Estimated stock-recruitment relation. The 2010 recruitment is highly uncertain and was not used in the estimation.

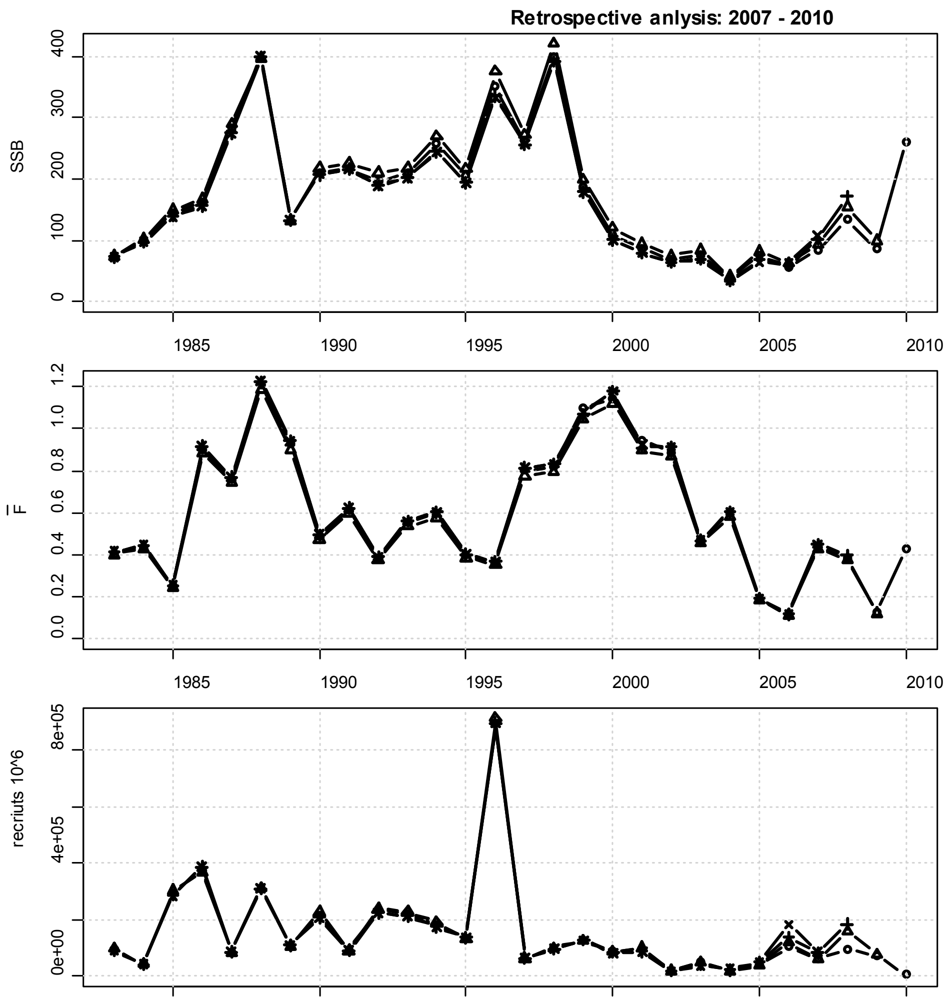


Figure 4.4.8. Sandeel in Area-3. Sandeel retrospective plot.

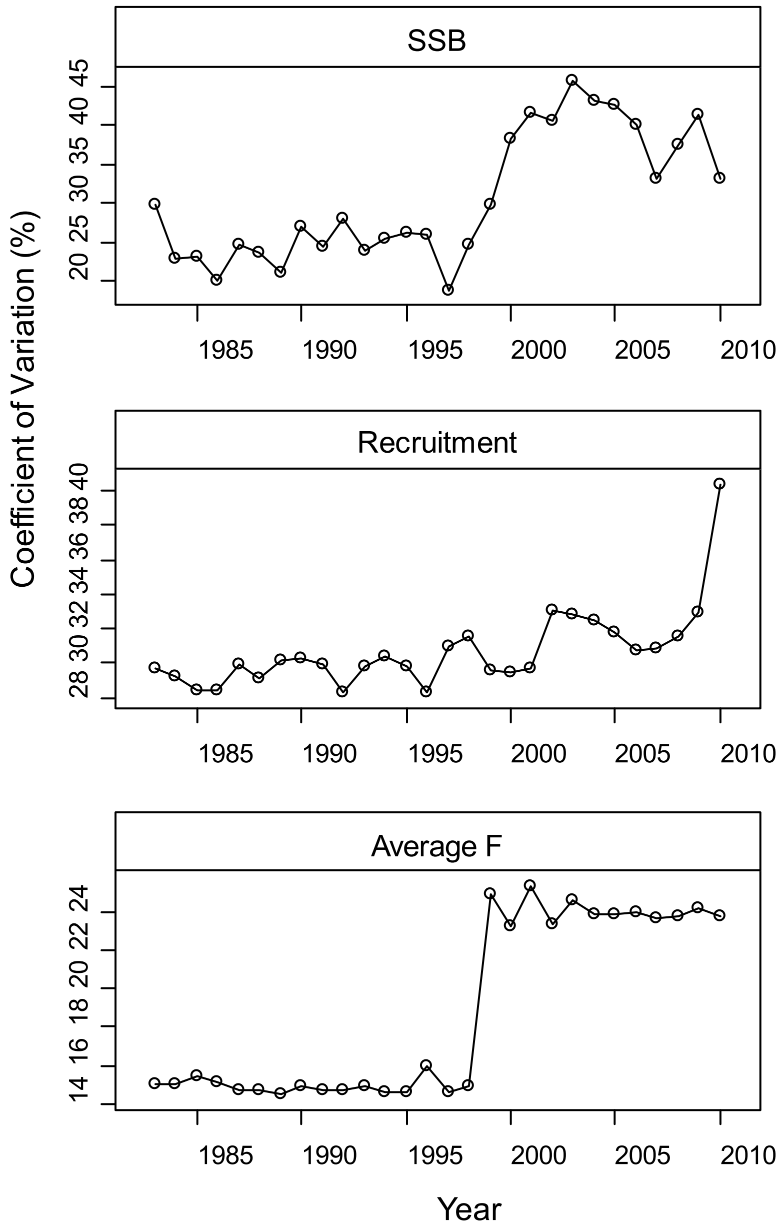


Figure 4.4.9. Sandeel in Area-3. Uncertainties of model output estimated from parameter uncertainties derived from the Hessian matrix and the delta method.

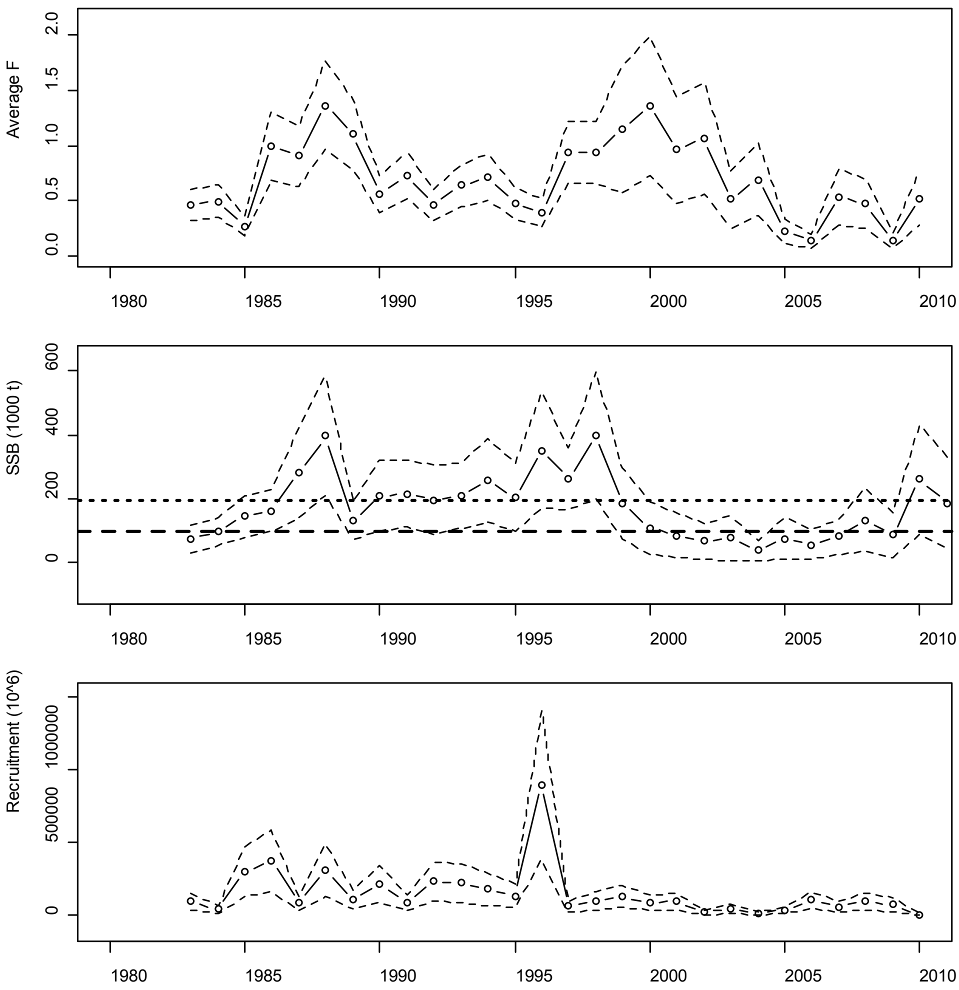


Figure 4.4.10. Sandeel in Area-3. Model output with mean values and plus/minus 2*standard deviation.

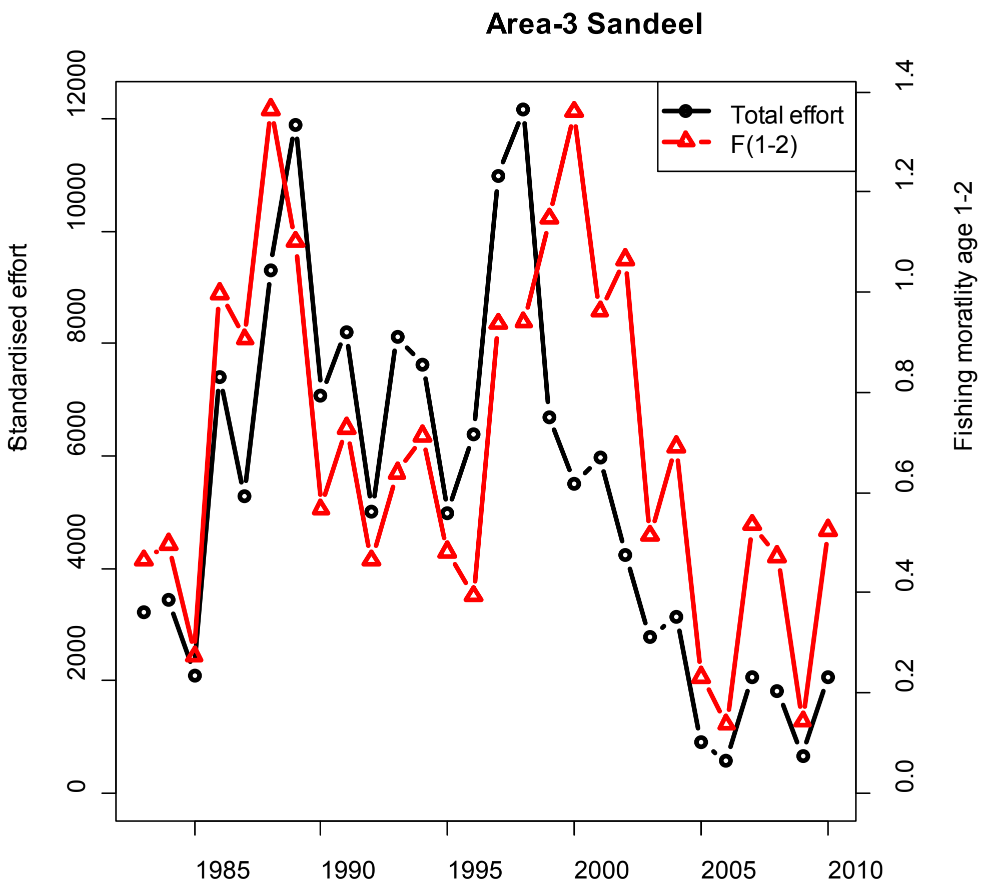


Figure 4.4.11. Sandeel in Area-3. Total effort (days fishing for a standard 200GT vessel) and estimated average Fishing mortality.

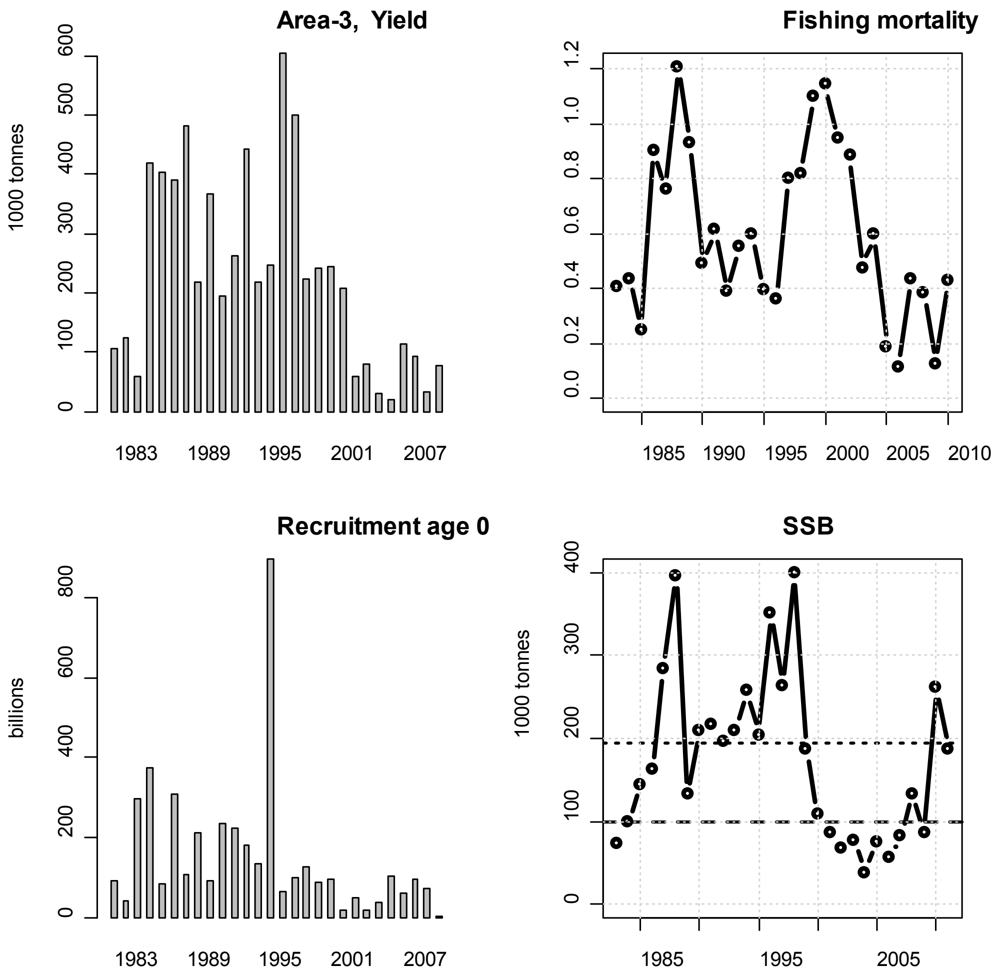


Figure 4.4.12. Sandeel in Arrea-3. Stock summary.

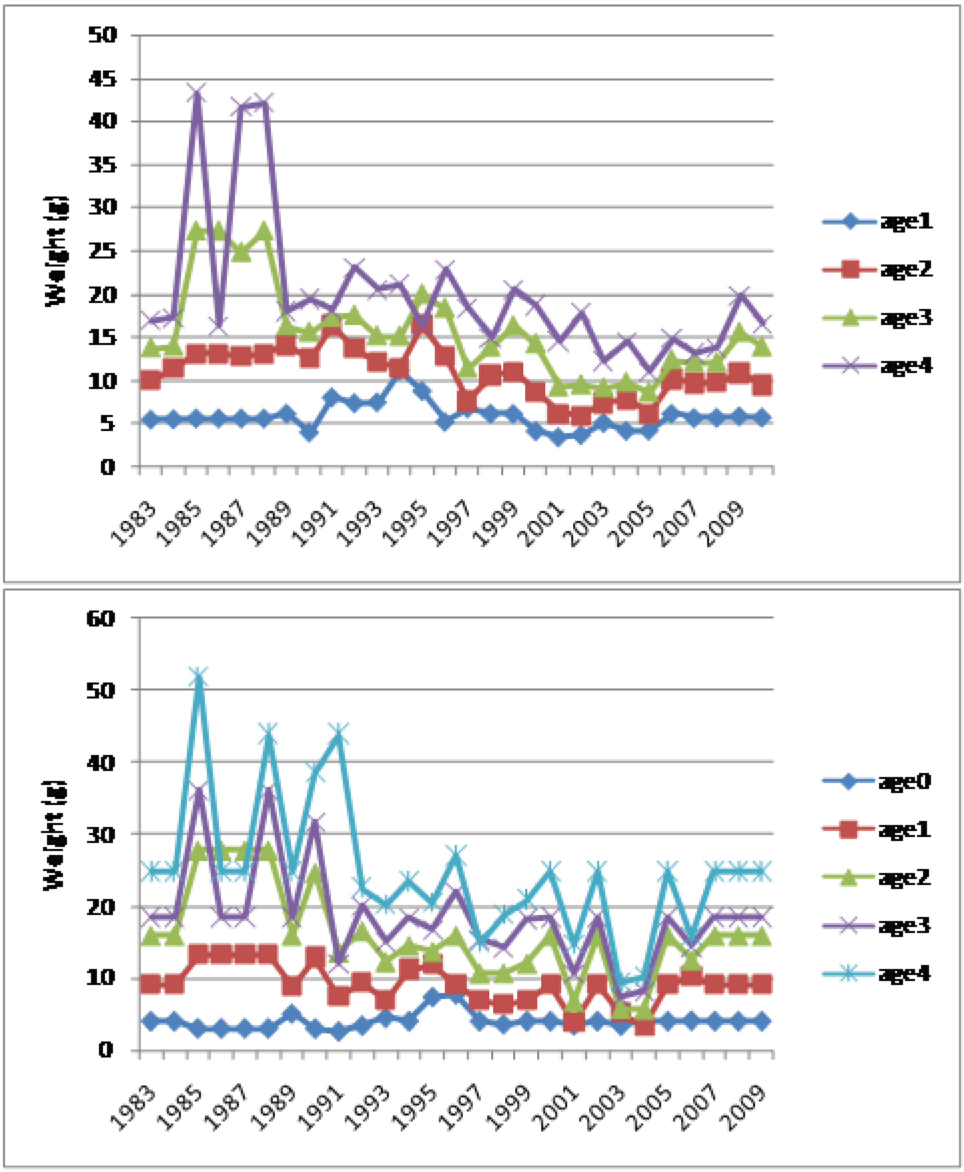


Figure 4.5.1 Sandeel in Area-4. Individual mean weights (g) at age in 1st (upper) and 2nd (lower) half-year.

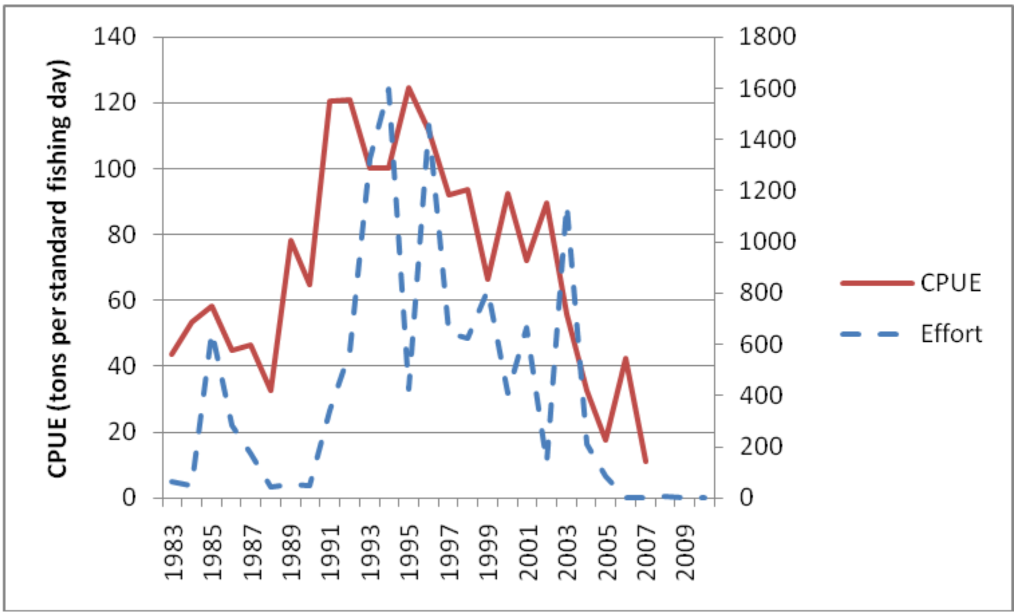


Figure 4.5.2.Sandeel in Area-4. Effort (days fishing for a standard 200GT vessel) and CPUE(tons per standard fishing day).

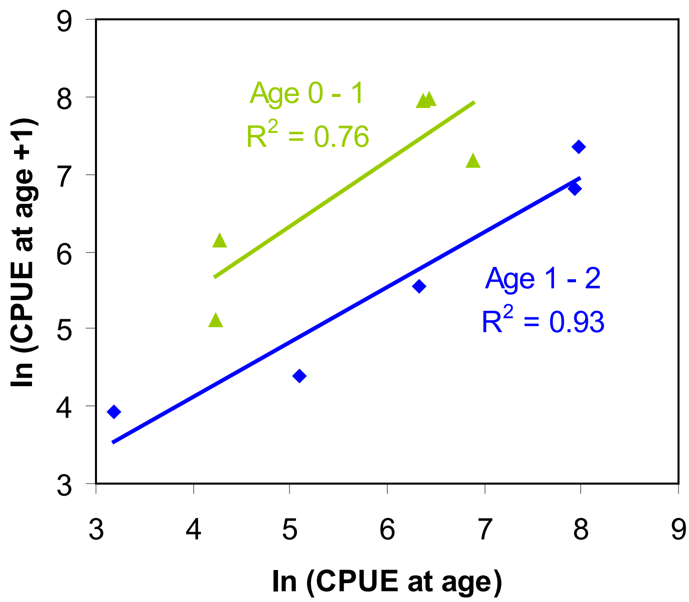


Figure 4.5.3. Internal consistency plot. Average CPUE of consecutive ages from the same year-class for Firth of Forth samples.

5 Norway Pout in ICES Subarea IV and Division IIIa (May 2011)

Introduction: Update assessment

The May 2011 assessment of Norway pout in the North Sea and Skagerrak is an up-date assessment from the May and September 2010 assessments, which basically are up-date assessments of the 2004 and 2006 benchmark assessments using the same tuning fleets and parameter settings. The assessment is a "real time" monitoring (and management) run up to 1st April 2011, but includes new information from second half year 2010 and 1st quarter 2011.

Furthermore, a short term prognosis (Forecast) up to 1st January 2012 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 (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).

So far 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 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 was observed to be only 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 (Sparholt *et al.* 2002a,b; Lambert *et al.* 2009). 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 (ICES WGNSSK Reports). However, 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, haddock, cod and mackerel) (ICES-SGMSNS 2006). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES-SGMSNS 2006).

Natural mortality varies between age groups, and natural mortality at age varies over different time periods. Even though different sources of information (surveys, MSVPA) give slightly different perception of natural mortality at age (see below), the natural mortalities obtained from the most recent run with the North Sea MSVPA model (presented and used in the ICES SGMSNS (2006)) indicate high predation mortality on Norway pout. 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. 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, Nielsen, Larsen and Sparholt, 2009).

In order to protect other species (cod, haddock, 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 Norway Pout fishery is conducted 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 mainly by Denmark and Norway directed towards Norway pout as one of the target species together with Blue Whiting.

Landings have been low since 2001, and the 2003-2004 landings were the lowest on record. Effort in 2003 and 2004 has been 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 at least during the first half year 2011, but in the periods of closure Norway pout were still taken as a by-catch in the Norwegian mixed blue whiting /Norway pout 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 recent strong year classes being on 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 has not been taken in 2008, 2009 and 2010. This is 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 a very low 2010 year class being at the same level as the low 2003-04 year classes the fishery has so far been closed in 2011.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 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. By-catch levels of whiting, haddock and cod in the combined Danish small meshed fishery is shown in section 2 of this report. 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 (Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22). Sorting grids have been used in the Norwegian fishery in 2010. 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 2010 the advice on North Sea Norway pout was updated with the addition of the 3rd quarter 2010 English and Scottish groundfish surveys.

Based on the estimates of SSB in September 2010, ICES classified the stock to show full reproductive capacity (SSB>B_{pa}). Catches and fishing mortality was low in 2008 and 2009, but increased in 2010 based on the relatively strong 2009 year class. 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).

Recruitment reached historical minima in 2003-2004 and was low in 2006, but was about the long term average (at 80 billions, arithmetic mean, age 0 3rd quarter) in 2005, 2007, and 2008. In 2009 recruitment was well above the long term average, while very low in 2010 (showing historical lows together with the 2003-2004 year classes). Based on the real time management and confirmation of recruitment estimates through consecutive surveys, the fishery was open in 2008-2010, but the TAC was not taken in this period.

The 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.

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 2011 will be provided for the stock in autumn 2011 as well.

ICES provides advice according to 3 management strategies for the stock (see below). ICES advised in September 2010 - on the basis of precautionary limits - that in order to maintain the spawning stock biomass above B_{pa} by 1st January 2012 the directed Norway pout fishery should be closed in 2011 (i.e. 0 t in 2011) 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 0.21), and under the long term fixed fishing mortality or fishing effort strategy (TAE) a TAC on 77 000 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.

Biological reference points for the stock have been set by ICES at B_{lim} = 90 000 t as the lowest historical observed biomass (SSB) before 2000 (1986, 1989) and B_{pa} = 150 000 t.

However, in 2005 the SSB was as low as 55 000 t from which the stock has recovered. No F-based reference points are advised for this stock.

5.1.4 Management up to 2011

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. 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. Also in 2011 there is set a small preliminary by-catch quota.

The final TAC for 2008 was 115 kt, 116 kt (EU) for 2009, and 162 kt for 2010, and the respective landings were 36 kt, 55kt and 126kt in 2008, 2009 and 2010, i.e. the TACs were not taken during this period.

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). 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. The most recent catches have been included in the up-date assessment.

5.2.2 Age compositions in Landings

Age compositions were available from Norway and Denmark (except for Norway in 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, and in 2007.

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 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 there has also been used information from other quarters. 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. Mean weight at age in the stock is given in **Table** 5.2.6. The same mean weight at age in the stock is used for all years. The reason for mean weight at age in catch is not used as estimator of weight in the stock is mainly because of the smallest 0-group fish are not fully recruited to the fishery in 3rd quarter of the year because of likely strong effects of selectivity in the fishery. The estimation of mean weights at age in the catches and the used mean weights in the stock in the assessment is described in the **Stock Annex.**

Danish data (in both landings at age and mean weight at age) are in the InterCatch database, but not Norwegian data.

5.2.4 Maturity and natural mortality

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, 10% of the 1-group and 100% of the 2+-group independent of sex. 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 was observed to be only around 90% and 95%, respectively, as compared to 100% used in the assessment.

The natural mortality is set to 0.4 for all age groups in all seasons that result in an annual natural mortality of 1.6 for all age groups.

In response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea a summary of the September 2006 benchmark assessment on this issue is given in the **Stock Annex**. In summary from the exploratory runs using different natural mortalities no conclusions could be reached as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources used (see **Stock Annex**) 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 baseline assessment constant values for natural mortality at age and quarter by year as in previous years assessment. This has been adopted in this year's up-date assessment.

5.2.5 Catch, Effort and Research Vessel Data

Description of catch, effort and research vessel data used in the assessment is given in the **Stock Annex (Q5).** 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 2005-2009 except for second half year 2006. Recent catch information for 2008-2010 is included in this assessment. Catches in all of 2005 as well as in 1st quarter 2009 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 1st quarter 2009.

5.2.5.1 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 2011 assessment. However, no standardized effort data and cpue-indices for the commercial fishery tuning fleet has been included for 2005-2008 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.

5.2.5.1.1 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 2008-2010 has been included.

5.2.5.1.2 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 has not been prepared because of introduction of selective grids in the Norwegian fishery in 2010. Data for 2009 has been included.

5.2.5.1.3 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 2005-2008 except for 2nd half year 2006. Standardized effort data for 2008 and 2010 for the Danish part of the fleet, as well as for both the Danish and Norwegian fleets in 2009, is presented in the table.

5.2.5.1.4 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 2007-2011.

5.2.5.1.5 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 2011 IBTS and the 3rd quarter 2010 IBTS research surveys have been included in this assessment (as well as the 3rd quarter 2010 EGFS and SGFS research survey information which also were included in the September 2010 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.

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 2007-2011 up-date 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 2010 assessments as well as previous up-date assessments (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 2010 assessment were that: a) This section was easy to follow and concise with a good background of the fishery, past management and ecosystem concerns; b) The assessment is consistent with last year and the stock annex, and that the retrospective patterns were seen mostly in recruitment and in general were minor; c) New additions to report are highlighted, this should be removed; and d) The assessment has been performed correctly. The ecosystem considerations were thoughtful and will likely benefit the upcoming benchmark.

In general, the WG note that there is an apparent link between effort and F, this relationship should be presented and explored as part of any future benchmark assessments. This could be part of a wider work item on issues relating to commercial tuning fleets. As noted by the WG, further work is needed on the commercial tuning fleet data. The WG is encouraged to collaborate with SGGEM (Study Group on Gear and Effort Metrics) to investigate possible metrics that could provide more precise estimators of effort. This could also help address the concerns of technological creep associated with the effort control strategy.

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 2011. 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 is presented in **Tables** 5.3.1-2. The SXSA uses the geometric mean for the stock-recruitment relationship (see **Table** 5.3.6).

In contrast to the September 2010 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. All other aspects and settings in the assessment are an up-date of the May 2009 and September 2009 assessments.

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 and in first part of 2011 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.

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 $\mathbf{B_{lim}}$ in 2005 which is the lowest level ever recorded. By 1st January 2007 and 2008 the stock was at $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{trigger}}$) (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 most recent recruitment indices included in the assessment indicates that the 2010 year class to be very low and at the same level as the low 2003 and 2004 year classes where these three year classes are lowest on record since 1983. On this basis the SSB is expected to decrease in 2011 to around $\mathbf{B_{pa}}$ (=MSY $\mathbf{B_{trigger}}$) due to high natural mortality and 10%(-20%) maturation at age 1 (see forecast).

5.3.3 Comparison with 2010 assessment

The final, accepted May 2011 SXSA assessment run was compared to the September 2010 SXSA assessment. The results of the comparative run between the May 2011 and the September 2010 assessments are shown in **Figure** 5.3.5. The retrospective analysis based on the May 2011 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. The difference in recruitment is because of use of different recruitment seasons in the two assessments (as described above).

5.4 Historical stock trends

The assessment and historical stock performance is consistent with previous years assessments.

5.5 Recruitment Estimates

The long-term average recruitment (age 0, 3rd quarter) is 81 billions (arithmetic mean) and 65 billions (geometric mean) for the period 1983-2011 (**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 2006 year class was weak. The 2008 year class was above long term average, and the 2009 year class was very strong. The recruitment indices in autumn 2010 which were confirmed in spring 2011 shows the 2010 year class to be very low and at the same level as in 2003 and 2004 being the lowest on record since 1983.

5.6 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 2012 using full assessment information for 2010 and 1st quarter 2011, 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 2011 which would result in SSB at or above $\mathbf{B_{pa}}$ = MSY $\mathbf{B_{trigger}}$ (=150 000 t) 1st of January 2012. 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 2010 have been used (assessment year). The forecast assumes a 2011 (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). Recruitment in the forecast year is assumed to the 25th percentile = 46 764 millions of the SXSA recruitment estimates (GM = 65 465 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**).

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 (2010) and based on recent running 5 year averages (i.e. for the 5 last years with covering observations) for the forecast year

(2011). The constant weight at age in stock by year and quarter of year used in the SXSA assessment has also been used in the forecast for 2011.

Ten percent of age 1 is mature and is included in SSB. Therefore, the recruitment in 2010 does influence the SSB in 2011.

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 2012 then a catch around 6 000 t can be taken in 2011 corresponding to a F around 0.02 according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 82 000 t can be taken in 2011. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2011 (corresponding to a F around 0.21) 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 2011 as well as under a fixed TAC strategy with a TAC of 50 000 t 2011 the stock will decrease to be under Bpa by 1st of January 2012 according to the long term management strategies.

With a catch scenario where the TAC of 162 kt was taken in 2010, the forecast in autumn 2010 according to the escapement strategy indicated that no catch in 2011 would result in a spawning stock biomass just below MSY $B_{escapement}$. With the objective to maintain the spawning stock biomass above a reference level of MSY $B_{escapement}$ by 1st of January 2012 the autumn 2010 advice was fishery closure (i.e. no catch should be taken) in first part of 2011 in the directed Norway pout fishery. Accordingly, the fishery is closed in the first part of 2011. The most recent forecast in spring 2011 allow for a catch of 6 000 to according to the escapement strategy. The reason for this advice of low directed Norway pout fishery in 2011 is the very low 2010 recruitment and the high natural mortality as well as the short life span of the stock.

5.7 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.

5.8 Biological reference points

	Type	Value	Technical basis
MSY	MSY $B_{escapement}$	150 000 t	= B_{pa}
Approach	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	90 000 t	B_{lim} = B_{loss}, the lowest observed biomass in the 1980s
	B_{pa}	150 000 t	= B_{lim} $e^{0.3*1.65}$
	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

(unchanged since: 2010)

Biomass based reference points have been unchanged since 1997 given MSY $B_{escapement}$ = B_{pa}.

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: Sparholt, Larsen and Nielsen 2002a,b; Lambert, Nielsen, Larsen and Sparholt 2009). Furthermore, 10 % 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 1989 and 2005) 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 B_{lim} and B_{MSY} = B_{pa} (90 000 and 150 000 t) is 0.6.

5.9 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 2010 assessment.

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.

5.10 Status of the stock

Based on the estimates of SSB in September 2010, ICES classified the stock at full reproductive capacity with SSB well above B_{pa} at the start of 2010 (up to 1st July 2011). Also, the most recent estimates of SSB (Q1 2011) show full reproductive capacity of the stock (SSB> MSY $B_{trigger}$ = B_{pa}).

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, and in all of 2007 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. The final TAC for 2008 was 115 kt, 116 kt (EU) for 2009, and 162 kt for 2010, and the respective landings were 36 kt, 55kt and 126kt in 2008, 2009 and 2010, i.e. 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). The 2010 landings was 126 kt based on the strong 2009 year class corresponding to a F=0.42, but based on a very low 2010 year class being at the same level as the low 2003-04 year classes the fishery has so far been closed in 2011.

The 2008 recruitment was above long term average, and the 2009 year class was very strong. The recruitment indices (for 0-group 3rd quarter) in autumn 2010 which were confirmed (for 1-group in 1st quarter) in spring 2011 shows the 2010 year class to be very low and 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).

5.11 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 2012 then a catch around 6 000 t can be taken in 2011 according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 82 000 t can be taken in 2011. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2011 (corresponding to a F around 0.21) 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 2011 as well as under a fixed TAC strategy with a TAC of 50 000 t 2011 the stock will decrease to be under B_{pa} by 1st of January 2012 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 will be provided for the stock in autumn 2011.

Norway pout is a short lived species and most likely a onetime 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: Sparholt, Larsen and Nielsen 2002a,b; Lambert, Nielsen, Larsen and Sparholt 2009). On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$.

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-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). 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 the **Stock Annex.**

5.11.1 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 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 **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.

5.12 Other issues

Recommendations for future assessments:

A benchmark-assessment is planned and organized for the stock in 2012.

The primary aim of the benchmark will be to consider and change the values of a number of biological parameters (maturity, growth, natural mortality) based on new biological information from some work mainly in 2007-2008 and summarized in 2 scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. It will for the benchmarking be relevant to have up-dated natural mortality information from a updated MSVPA model / SMS model run.

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.

Other:

New research findings on developments in by-catch reducing gear devices should be reported and evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Trends and dynamics in landings and other available relevant information of Norway pout in VIa should be evaluated and brought forward to ACOM.

(See also **Stock Annex)**

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 2000-2010, as officially reported to ICES and EU.

By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	14.545	13.619	3.780	4.235	110	-	18	24	156	4 *	51 *
Faroe Islands	-	-	-	50	45	-	-	-	-	-	-
Norway	-	-	96	30	41	-	2	-	-	209	711
Sweden	133	780	-	-	-	-	-	-	-	-	10
Germany	-	-	-	-	54	-	-	-	-	-	-
Total	14.678	14.399	3.876	4.315	250	0	20	24	156	213	772

*Preliminary.

Norway pout ICES area IVa

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	133.149	44.818	68.858	12.223	10.762	941***	39.531	2.032 **	32.158	19.226	71.261 *
Faroe Islands		49	3.367	2.199	1.085	24	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	22	18
Germany	-	-	-	-	27	-	15	-	-	-	-
Norway	48.061	17.158	23.657	11.357	4.953	311	13.618	4.712	6.650	36.961	64.303
Sweden	-	-	-	-	-	-	-	-	10	-	+
UK(Scotland)	-	-	-	-	-	-	-	-	-	-	29
Total	181.210	62.025	95.882	25.779	16.827	1.092	53.164	6.744	38.818	56.209	135.582

*Preliminary.

Norway pout ICES area IVb

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	158	632	556	191	473	-	394	-	244	595	229 *
Faroe Islands	-	-	12	125	29	-	-	-	-	-	-
Germany	2	-	-	-	26	-	19	-	3	75	-
Netherlands	3	-	-	-	-	-	-	-	-	-	-
Norway	34	-	-	-	-	-	2	0	0	82	620
Sweden	-	-	-	-	88	-	-	-	-	-	-
UK (E/W/NI)	+	-	+	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	-	-
Total	197	632	568	316	616	0	415	0	247	752	849

*Preliminary.

Norway pout ICES area IVc

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	182	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	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	147.852	59.069	73.194	16.649	11.345	941***	39.943	2.056	32.558	19.825	71.541
Faroe Islands	0	49	3.379	2.374	1.159	24	0	0	0	0	0
Norway	48.095	17.158	23.753	11.387	4.994	311	13.622	4.712	6.650	37.252	65.634
Sweden	133	780	0	0	88	0	0	0	10	0	10
Netherlands	3	0	0	0	0	0	0	0	0	22	18
Germany	2	0	0	0	107	0	34	0	3	75	0
UK	0	0	0	0	0	0	0	0	0	0	0
Total nominal landings	196.085	77.056	100.326	30.410	17.693	1.252	53.599	6.768	39.221	57.174	137.203
By-catch of other species and other	-11.685	-11.456	-20.326	-3.310	-4.193	-	-6.973	-	-3.083	-2.674	-11.248
WG estimate of total landings (IV+IIIaN)	184.400	65.600	80.000	27.100	13.500	-	46.626	-	36.138	54.500	125.955
Agreed TAC	220.000	211.200	198.000	198.000	198.000	0****	95.000	0****	######	116.279	162.950

* 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 1961-2010 (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

* 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 1996-2010. (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

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											
	Quarter	1	2	3	4								
0		0	0	0	0								
1		6	799	1118	716								
2		1	905	738	331								
3		0	17	15	0								
4+		0	0	0	0								
SOP		198	40322	57487	33071								

In 2007-08: Catch numbers from Norwegian fishery calculated from Norwegian total catch weight divided by mean weight at age from Danish Fishery.

Table 5.2.5 NORWAY POUT in IV and IIIaN (Skagerrak). Mean weights (grams) at age in catch, by quarter 1983-2010, 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. 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											
Quarter of year	1	2	3	4								
Age 0												
1	25,60	15,51	25,37	27,75								
2	37,20	29,99	38,55	39,88								
3		47,00	45,50	62,20								
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 uncertain for 2010, as there are no Danish observations and only few fish caught here.

Table 5.2.6 NORWAY POUT IV & IIIaN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment (as well as revised natural mortality used in previous exploratory assessment runs).

Age	Weight (g)				Proportion mature	M (quarterly)	Revised M vers.1 (quarterly) (Exploratory run)
	Q1	Q2	Q3	Q4			
0	-	-	4	6	0	0.4	0.25
1	7	15	25	23	0.1	0.4	0.25
2	22	34	43	42	1	0.4	0.55
3	40	50	60	58	1	0.4	0.75

Table 5.2.7 NORWAY POUT IV & IIIaN (Skagerrak). Danish CPUE data (tonnes / fishing day) and fishing activities by vessel category for 1988-2010. 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
51-100	-	-	-
101-150	-	-	-
151-200	-	-	-
201-250	-	-	-
251-300	-	-	-
301-	79,13	94,78	106,15

* 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, 1983-2010.

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

* 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 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

* 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 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	.	.	.	.	.	.	.	.	.	.	.	.

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	273	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	2,346	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	5,698	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	762	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	7,876	1,518	65	2,005	6,261	141	2	2,094	6,656	207	23	1,643	7,868	282	11
2001	1,250	2,834	234	3,948	1,013	693	5	759	727	710	26	2,088	1,274	862	27
2002	1,791	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	691	131	37	6,912	803	67	11	3,073	343	132	18	2,614	439	125	17
2006	3,340	146	27	1,680	2,147	151	18	1,127	1,285	69	9	1,349	1,869	150	15
2007	1,286	778	23	3,329		332	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	3,000	1,636	274	58
2009	5,414	1,618	150	6,401	1,371	428	3	5,835	1,750	202	16	5,898	2,562	254	11
2010	4,663	1,448	137	235	5,368	626	31	1,449	5,101	930	29	834	4,744	833	17
2011	550	2.236	276		3,977										

[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 2005-2011 assessments compared to the 2003 assessment.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-11 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	1982-2011
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2010
	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	1998-2010
	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	1991-2010
	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 2011

Run: Baseline May 2011 (Summary from NP511_1)

The following parameters were used:

```
Year range:                                 1983 - 2011
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):                                tun2011.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	*	*	147976.	98826.	*	*	80005.	53628.	*	*	57167.	38316.
1	108865.	69530.	45112.	25471.	64058.	40680.	25425.	12711.	34121.	21018.	13388.	7827.
2	13108.	7724.	4167.	1504.	13556.	7961.	4383.	1561.	5662.	2679.	1677.	475.
3	115.	65.	36.	10.	698.	350.	15.	3.	445.	141.	84.	40.
4+	6.	3.	0.	0.	1.	0.	0.	0.	2.	1.	1.	0.
SSN	24115.				20660.				9521.			
SSB	369522.				371015.				166377.			
TSN	122094.	77321.	197290.	125811.	78312.	48992.	109828.	67904.	40231.	23839.	72317.	46659.
TSB	1055370.	1308946.	1901011.	1242539.	774581.	898429.	1145011.	679867.	381342.	413471.	640501.	432222.

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	106282.	71243.	*	*	31003.	20775.	*	*	85557.	56744.
1	25128.	16520.	10860.	6309.	43194.	26754.	17053.	10099.	13741.	9007.	5960.	3845.
2	2798.	1000.	599.	201.	2763.	1523.	972.	512.	5009.	2784.	1806.	1006.
3	176.	59.	37.	20.	103.	59.	40.	26.	152.	86.	57.	39.
4+	27.	16.	11.	7.	18.	11.	8.	5.	17.	11.	8.	5.
SSN	5514.				7203.				6552.			
SSB	87714.				96154.				126856.			
TSN	28130.	17594.	117789.	77780.	46078.	28348.	49075.	31418.	18919.	11889.	93388.	61639.
TSB	246022.	285621.	724626.	582163.	368276.	456692.	594509.	379958.	213421.	234697.	572328.	473383.

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	91121.	60950.	*	*	85639.	57389.	*	*	162754.	108496.
1	35461.	22349.	14425.	8301.	36882.	23216.	14105.	8660.	37656.	24013.	15576.	9197.
2	2060.	1342.	790.	312.	4139.	2296.	1071.	566.	4838.	2150.	1110.	568.
3	343.	225.	146.	94.	133.	73.	33.	17.	285.	115.	61.	23.
4+	29.	20.	13.	9.	58.	31.	21.	14.	18.	7.	5.	3.
SSN	5978.				8018.				8906.			
SSB	85488.				125452.				145172.			
TSN	37893.	23935.	106495.	69665.	41212.	25616.	100869.	66647.	42797.	26284.	179506.	118287.
TSB	308894.	393183.	767853.	575160.	357811.	431685.	743228.	568311.	382406.	439400.	1091838.	887679.

Year	1992				1993				1994			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	69508.	45872.	*	*	48709.	32572.	*	*	206484.	137881.
1	69873.	43926.	28198.	16071.	29968.	18498.	11734.	6926.	20871.	12374.	7989.	4513.
2	5307.	2668.	1549.	719.	8494.	5122.	3046.	1295.	3783.	2052.	1142.	421.
3	228.	56.	21.	14.	264.	165.	63.	27.	504.	292.	172.	57.
4+	3.	0.	0.	0.	7.	5.	3.	2.	18.	12.	8.	5.
SSN	12525.				11762.				6392.			
SSB	174922.				218802.				118979.			
TSN	75410.	46650.	99275.	62677.	38733.	23789.	63555.	40822.	25176.	14729.	215796.	142878.
TSB	615123.	752411.	1050844.	675875.	407601.	460113.	622932.	410661.	250469.	270628.	1085095.	952085.

Year	1995				1996				1997			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	65163.	43106.	*	*	158806.	105857.	*	*	45016.	30086.
1	88954.	56360.	36219.	22195.	27510.	18003.	11609.	6928.	68898.	45633.	30508.	17920.
2	2085.	1201.	595.	361.	12136.	7503.	4865.	2441.	4111.	2489.	1562.	742.
3	173.	111.	48.	30.	193.	118.	48.	2.	1363.	849.	472.	230.
4+	42.	28.	19.	13.	26.	18.	12.	8.	7.	4.	3.	2.
SSN	11195.				15107.				12371.			
SSB	117389.				295459.				193585.			
TSN	91254.	57700.	102045.	65705.	39866.	25642.	175339.	115236.	74379.	48976.	77560.	48981.
TSB	677802.	893370.	1194644.	786027.	468772.	532039.	1137528.	897140.	627640.	811849.	1038222.	637233.

Table 5.3.3 (Cont´d.). Norway pout IV & IIIaN (Skagerrak).

Year	1998				1999				2000			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	62962.	42128.	*	*	154416.	103475.	*	*	53309.	35674.
1	19887.	13117.	8620.	5442.	27962.	18578.	12193.	7110.	68439.	45341.	30164.	19099.
2	10439.	6432.	4058.	2448.	3213.	2049.	1193.	523.	4294.	2727.	1658.	894.
3	328.	181.	107.	70.	1465.	922.	542.	335.	220.	145.	58.	22.
4+	127.	79.	33.	22.	51.	34.	22.	15.	216.	145.	97.	65.
SSN	12883.				7525.				11574.			
SSB	263826.				151706.				163257.			
TSN	30781.	19809.	75780.	50110.	32691.	21583.	168367.	111458.	73169.	48358.	85286.	55755.
TSB	389114.	428926.	648244.	484812.	327867.	396320.	1006321.	825789.	594422.	788191.	1042099.	692158.

Year	2001				2002				2003			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	47347.	31712.	*	*	32439.	21467.	*	*	14484.	9703.
1	23666.	15684.	10405.	6875.	20956.	13650.	8862.	5432.	14152.	9438.	6274.	4049.
2	9023.	5356.	3389.	2249.	4390.	2821.	1871.	1022.	3254.	2119.	1380.	826.
3	399.	239.	78.	52.	1148.	756.	503.	318.	401.	251.	148.	86.
4+	53.	36.	24.	16.	45.	30.	20.	13.	200.	134.	90.	60.
SSN	11842.				7678.				5271.			
SSB	234024.				159675.				108764.			
TSN	33142.	21315.	61243.	40904.	26538.	17257.	43696.	28252.	18008.	11942.	22376.	14725.
TSB	383122.	431322.	599942.	445860.	291695.	340149.	461955.	315083.	197921.	233683.	283023.	191050.

Year	2004				2005				2006			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	18798.	12589.	*	*	73565.	49312.	*	*	35734.	23945.
1	6503.	4349.	2912.	1910.	8392.	5625.	3771.	2527.	33055.	22133.	14790.	9808.
2	2670.	1744.	1156.	733.	1199.	804.	539.	361.	1694.	1093.	696.	413.
3	422.	276.	180.	115.	428.	287.	192.	129.	242.	155.	84.	51.
4+	71.	48.	32.	21.	90.	60.	40.	27.	104.	70.	47.	31.
SSN	3813.				2556.				5346.			
SSB	84146.				54405.				75927.			
TSN	9666.	6416.	23078.	15369.	10109.	6776.	78107.	52356.	35095.	23451.	51351.	34248.
TSB	125118.	140980.	208517.	156945.	107275.	129415.	423210.	376627.	284173.	380830.	547661.	389536.

Year	2007				2008				2009			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	58558.	39253.	*	*	112529.	75431.	*	*	151852.	101742.
1	15750.	10541.	7032.	4687.	26312.	17633.	11776.	7758.	49597.	33206.	22229.	14392.
2	5685.	3776.	2510.	1670.	3134.	2092.	1369.	823.	4841.	3244.	2136.	930.
3	235.	158.	106.	70.	1114.	747.	500.	335.	526.	353.	232.	148.
4+	55.	37.	25.	16.	57.	38.	26.	17.	236.	158.	106.	71.
SSN	7550.				6936.				10564.			
SSB	148575.				135132.				175524.			
TSN	21725.	14512.	68230.	45696.	30617.	20511.	126200.	84365.	55202.	36961.	176556.	117284.
TSB	247798.	296443.	524305.	417488.	300896.	375125.	833393.	685054.	487988.	634905.	1268935.	989152.

Year	2010				2011
Season	1	2	3	4	1
AGE					
0	*	*	15671.	10505.	*
1	68190.	45705.	29983.	19183.	7041.
2	9509.	6373.	3531.	1763.	12272.
3	602.	403.	256.	160.	911.
4+	147.	98.	66.	44.	136.
SSN	17077.				14024.
SSB	289223.				319002.
TSN	78448.	52579.	49508.	31654.	20361.
TSB	718821.	927927.	979481.	587535.	363364.

Table 5.3.4 Norway pout IV & IIIaN (Skagerrak).

Seasonal extended survivor analysis (SXSA).

Fishing mortalities by quarter of year.

Year	1983				1984				1985			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.004	0.033	*	*	0.000	0.052	*	*	0.000	0.022
1	0.048	0.032	0.169	0.226	0.054	0.069	0.285	0.393	0.084	0.051	0.135	0.587
2	0.127	0.213	0.578	0.355	0.130	0.193	0.590	0.770	0.337	0.068	0.775	0.558
3	0.169	0.195	0.786	1.543	0.281	1.609	0.941	0.000	0.685	0.120	0.321	0.000
4+	0.000	1.807	*	*	0.000	0.000	0.000	0.000	0.441	0.000	0.000	0.000
F (1- 2)	0.087	0.122	0.374	0.290	0.092	0.131	0.438	0.581	0.210	0.059	0.455	0.572

Year	1986				1987				1988			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.000	0.099	*	*	0.000	0.013	*	*	0.011	0.069
1	0.019	0.019	0.141	0.408	0.078	0.050	0.122	0.293	0.022	0.013	0.038	0.219
2	0.587	0.111	0.640	0.263	0.192	0.049	0.236	0.737	0.184	0.033	0.182	0.627
3	0.644	0.061	0.216	0.000	0.152	0.000	0.010	0.258	0.173	0.000	0.000	0.000
4+	0.142	0.000	0.000	0.000	0.070	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.303	0.065	0.390	0.335	0.135	0.049	0.179	0.515	0.103	0.023	0.110	0.423

Year	1989				1990				1991			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.002	0.101	*	*	0.000	0.021	*	*	0.005	0.040
1	0.061	0.037	0.150	0.288	0.062	0.097	0.087	0.179	0.049	0.033	0.125	0.147
2	0.029	0.127	0.502	0.433	0.186	0.350	0.232	0.280	0.395	0.254	0.263	0.487
3	0.021	0.033	0.039	0.182	0.199	0.371	0.244	0.321	0.483	0.221	0.554	1.677
4+	0.000	0.000	0.000	0.000	0.230	0.000	0.000	0.000	0.509	0.000	0.000	0.000
F (1- 2)	0.045	0.082	0.326	0.360	0.124	0.224	0.159	0.229	0.222	0.143	0.194	0.317

Year	1992				1993				1994			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.015	0.026	*	*	0.002	0.045	*	*	0.004	0.038
1	0.064	0.043	0.159	0.232	0.082	0.055	0.125	0.201	0.121	0.037	0.168	0.359
2	0.280	0.142	0.354	0.566	0.105	0.118	0.435	0.514	0.207	0.183	0.560	0.468
3	0.876	0.536	0.058	0.196	0.070	0.530	0.439	0.095	0.144	0.128	0.648	0.000
4+	*	*	*	*	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.172	0.092	0.257	0.399	0.093	0.086	0.280	0.357	0.164	0.110	0.364	0.413

Year	1995				1996				1997			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.013	0.049	*	*	0.006	0.029	*	*	0.003	0.014
1	0.056	0.042	0.089	0.200	0.024	0.038	0.115	0.120	0.012	0.003	0.130	0.138
2	0.149	0.293	0.099	0.219	0.080	0.033	0.282	0.179	0.100	0.066	0.332	0.401
3	0.040	0.412	0.078	0.128	0.091	0.472	1.572	0.159	0.073	0.184	0.307	0.199
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)	0.102	0.168	0.094	0.209	0.052	0.036	0.198	0.150	0.056	0.034	0.231	0.269

Year	1998				1999				2000			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.002	0.010	*	*	0.000	0.013	*	*	0.002	0.010
1	0.016	0.020	0.059	0.125	0.009	0.021	0.137	0.103	0.012	0.008	0.056	0.338
2	0.083	0.060	0.104	0.112	0.050	0.138	0.407	0.445	0.054	0.096	0.213	0.391
3	0.189	0.129	0.018	0.257	0.062	0.130	0.080	0.087	0.015	0.495	0.530	0.383
4+	0.079	0.450	0.000	0.000	0.013	0.006	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.050	0.040	0.082	0.119	0.029	0.080	0.272	0.274	0.033	0.052	0.135	0.365

Year	2001				2002				2003			
Season	1	2	3	4	1	2	3	4	1	2	3	4
AGE												
0	*	*	0.001	0.014	*	*	0.013	0.017	*	*	0.001	0.000
1	0.011	0.010	0.014	0.048	0.028	0.032	0.088	0.111	0.005	0.008	0.038	0.016
2	0.120	0.057	0.010	0.265	0.042	0.010	0.201	0.506	0.029	0.028	0.112	0.265
3	0.112	0.659	0.017	0.021	0.018	0.008	0.059	0.106	0.068	0.126	0.137	0.563
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.026
F (1- 2)	0.066	0.034	0.012	0.157	0.035	0.021	0.145	0.308	0.017	0.018	0.075	0.140

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	*	*	0.001	0.006	*	*	0.000	0.000	*	*	0.000	0.019
1	0.002	0.001	0.021	0.065	0.000	0.000	0.000	0.000	0.001	0.003	0.011	0.143
2	0.025	0.011	0.055	0.137	0.000	0.000	0.000	0.000	0.038	0.052	0.120	0.159
3	0.026	0.025	0.047	0.018	0.000	0.000	0.001	0.001	0.043	0.204	0.107	0.017
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.014	0.006	0.038	0.101	0.000	0.000	0.000	0.000	0.019	0.027	0.065	0.151

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	0.019	*	*	0.000	0.000
1	0.002	0.005	0.006	0.003	0.000	0.004	0.017	0.071	0.001	0.001	0.034	0.014
2	0.009	0.008	0.008	0.004	0.004	0.024	0.107	0.047	0.000	0.018	0.413	0.035
3	0.001	0.001	0.018	0.011	0.000	0.001	0.000	0.000	0.000	0.018	0.048	0.003
4+	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.005	0.007	0.007	0.004	0.002	0.014	0.062	0.059	0.001	0.009	0.224	0.025

Year	2010				2011
Season	1	2	3	4	1
AGE					
0	*	*	0.000	0.000	*
1	0.000	0.021	0.046	0.046	0.000
2	0.000	0.187	0.286	0.254	0.000
3	0.000	0.053	0.073	0.002	0.000
4+	0.000	0.000	0.000	0.000	0.000
F (1- 2)	0.000	0.104	0.166	0.150	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 1983-2011 (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	*	*	*	11.536
1	10.719	*	9.872	9.178
2	9.250	*	8.755	8.426
3	9.250	*	8.755	8.426

Log inverse catchabilities, fleet no: 2 (ibtsq1)

Year 1983-2011 (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	2.468	*	*	*
2	1.492	*	*	*
3	1.492	*	*	*

Log inverse catchabilities, fleet no: 3 (egfsq3)

Year 1992-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	2.904	*
1	*	*	1.638	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 4 (sgfsq3)

Year 1998-2010 (all quarters of year); (The same for all years; estimated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	2.914	*
1	*	*	1.874	*
2	*	*	*	*
3	*	*	*	*

Log inverse catchabilities, fleet no: 5 (ibtsq3)

Year 1991-2010 (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	*	*	1.481	*
3	*	*	1.481	*

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

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

Year 1983-2011 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	1.071
1	1.341	*	3.184	2.066
2	2.157	*	1.694	1.240
3	1.255	*	0.831	0.764

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

Year 1983-2011 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	1.725	*	*	*
2	1.833	*	*	*
3	1.074	*	*	*

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

Year 1992-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	1.263	*
1	*	*	2.342	*
2	*	*	*	*
3	*	*	*	*

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

Year 1998-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	1.651	*
1	*	*	2.479	*
2	*	*	*	*
3	*	*	*	*

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

Year 1991-2010 (all quarters of year); (The same for all years; esti-mated and held constant by year as option in SXSA)

Season	1	2	3	4
AGE				
0	*	*	*	*
1	*	*	*	*
2	*	*	1.487	*
3	*	*	0.854	*

Table 5.3.6 Norway pout IV & IIIaN (Skagerrak). Stock summary table. (SXSA Baseline May 2011).

(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	147976	369,522	1901011	457,6	0,873
1984	80005	371,015	1145011	393,01	1,242
1985	57167	166,377	640501	205,1	1,296
1986	106282	87,714	724626	174,3	1,093
1987	31003	96,154	594509	149,3	0,878
1988	85557	126,856	572328	109,3	0,659
1989	91121	85,488	767853	166,4	0,813
1990	85639	125,452	743228	163,3	0,736
1991	162754	145,172	1091838	186,6	0,876
1992	69508	174,922	1050844	296,8	0,920
1993	48709	218,802	622932	183,1	0,816
1994	206484	118,979	1085095	182,0	1,051
1995	65163	117,389	1194644	236,8	0,573
1996	158806	295,459	1137528	163,8	0,436
1997	45016	193,585	1038222	169,7	0,590
1998	62962	263,826	648244	57,7	0,291
1999	154416	151,706	1006321	94,5	0,655
2000	53309	163,257	1042099	184,4	0,585
2001	47347	234,024	599942	65,6	0,269
2002	32439	159,675	461955	80,0	0,509
2003	14484	108,764	283023	27,1	0,250
2004	18798	84,146	208517	13,5	0,159
2005	73565	54,405	423210	1,9	0,000
2006	35734	75,927	547661	46,6	0,262
2007	58558	148,575	524305	5,7	0,023
2008	112529	135,132	833393	36,1	0,137
2009	151852	175,524	1268935	54,5	0,259
2010	15671	289,223	979481	126,0	0,42
2011		319,002			
Arit mean	**81.173**	**174**	**826.331**		**0,595**
Geomean	**65.465**				

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

Basis: HCR with quarter 1 to 4 2010 (assessment year) and quarter 1 2011

observed exploitation pattern and 2011 (forecast year) quarter 2 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). Recruitment in forecast year

is assumed to the 25% percentile = 46764 millions (of the long term geometric mean

65465 millions) in the 3rd quarter of the year.

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2010	1	0	0	0,000	0,000	0,000	0,4	0
2010	1	1	68190	0,000	0,007	0,001	0,4	0,1
2010	1	2	9509	0,000	0,022	0,037	0,4	1
2010	1	3	602	0,000	0,040	0,039	0,4	1
2010	2	0	0	0,000	0,000	0,000	0,4	0
2010	2	1	45705	0,021	0,015	0,016	0,4	0
2010	2	2	6373	0,187	0,034	0,030	0,4	0
2010	2	3	403	0,053	0,050	0,047	0,4	0
2010	3	0	15671	0,000	0,004	0,009	0,4	0
2010	3	1	29983	0,046	0,025	0,026	0,4	0
2010	3	2	3531	0,286	0,043	0,039	0,4	0
2010	3	3	256	0,073	0,060	0,046	0,4	0
2010	4	0	10505	0	0,006	0,009	0,4	0
2010	4	1	19183	0,046	0,023	0,028	0,4	0
2010	4	2	1763	0,254	0,042	0,040	0,4	0
2010	4	3	160	0,002	0,058	0,062	0,4	0

Year	Season	Age	N	F	WEST	WECA	M	PROPMAT
2011	1	0	0	0,000	0,000	0,000	0,4	0
2011	1	1	7041	0,000	0,007	0,011	0,4	0,1
2011	1	2	12272	0,000	0,022	0,028	0,4	1
2011	1	3	911	0,000	0,040	0,039	0,4	1
2011	2	0	0	0,000	0,000	0,000	0,4	0
2011	2	1	0	0,028	0,015	0,015	0,4	0
2011	2	2	0	0,230	0,034	0,026	0,4	0
2011	2	3	0	0,068	0,050	0,037	0,4	0
2011	3	0	46764	0,001	0,004	0,009	0,4	0
2011	3	1	0	0,122	0,025	0,029	0,4	0
2011	3	2	0	1,019	0,043	0,036	0,4	0
2011	3	3	0	0,120	0,060	0,049	0,4	0
2011	4	0	0	0,046	0,006	0,009	0,4	0
2011	4	1	0	0,227	0,023	0,027	0,4	0
2011	4	2	0	0,361	0,042	0,038	0,4	0
2011	4	3	0	0,005	0,058	0,050	0,4	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..

Basis: HCR with assessment year 2010 (quarter 1-4) observed fishing mortality (F), and 2011 (forecast year) quarter 1 observed fishing mortality (F), as well as forecast year 2011 quarter 2-4 fishing pattern scaled to the average 2008-2010 seasonal exploitation pattern (standardized with the 2008-2010 Fbar to F(1,2)=1). Recruitment in forecast year is assumed to the 25% percentile = 46764 millions (of the long term geometric mean 65465 millions) in the 3rd quarter of the year.

Basis: F (2010)=F(1,2)=0.420; R(2011) = 25 % percentile of long term recruitment (1983-2010) = ~ 47 billion; SSB (2011) = 317 kt;

Rationale	Landings 2011	Basis	F 2011	SSB 2012	%SSB change[1)]
MSY approach	6	MSY $B_{escapement}$	0.02	150	- 53
Precautionary approach	6	B_{pa}	0.02	150	- 53
Zero Catch	0	No fishery	0	154	- 51
Status quo					
	50	Fixed TAC Strat.	0.21	124	-61
	82	Fixed F Strat.	0.35	106	- 67
	101	B_{lim}	0.40	90	- 72

Weights in '000 tonnes.

[1)] SSB 2012 relative to SSB 2011.

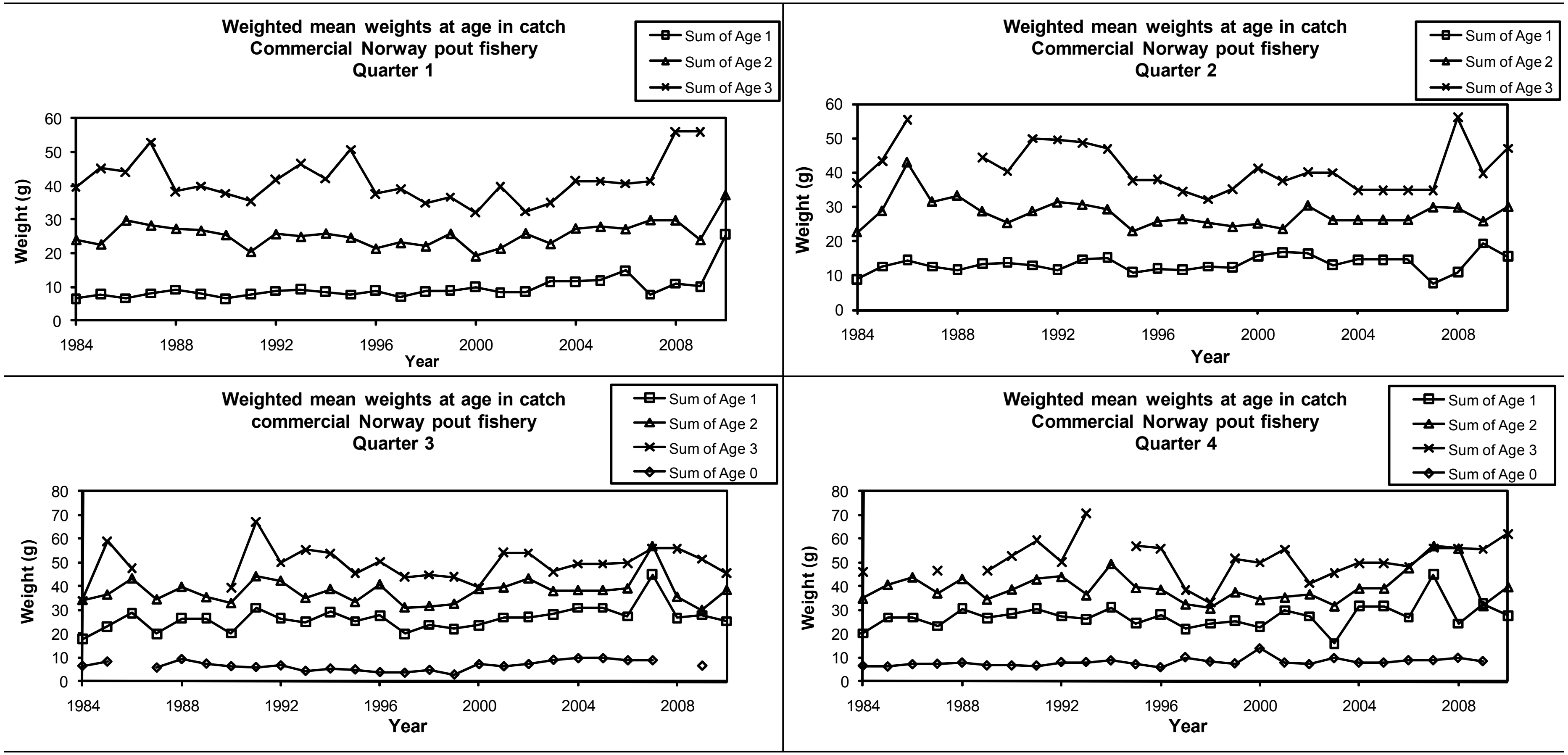


Figure 5.2.1. **NORWAY POUT IV and IIIaN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1982-2011.**

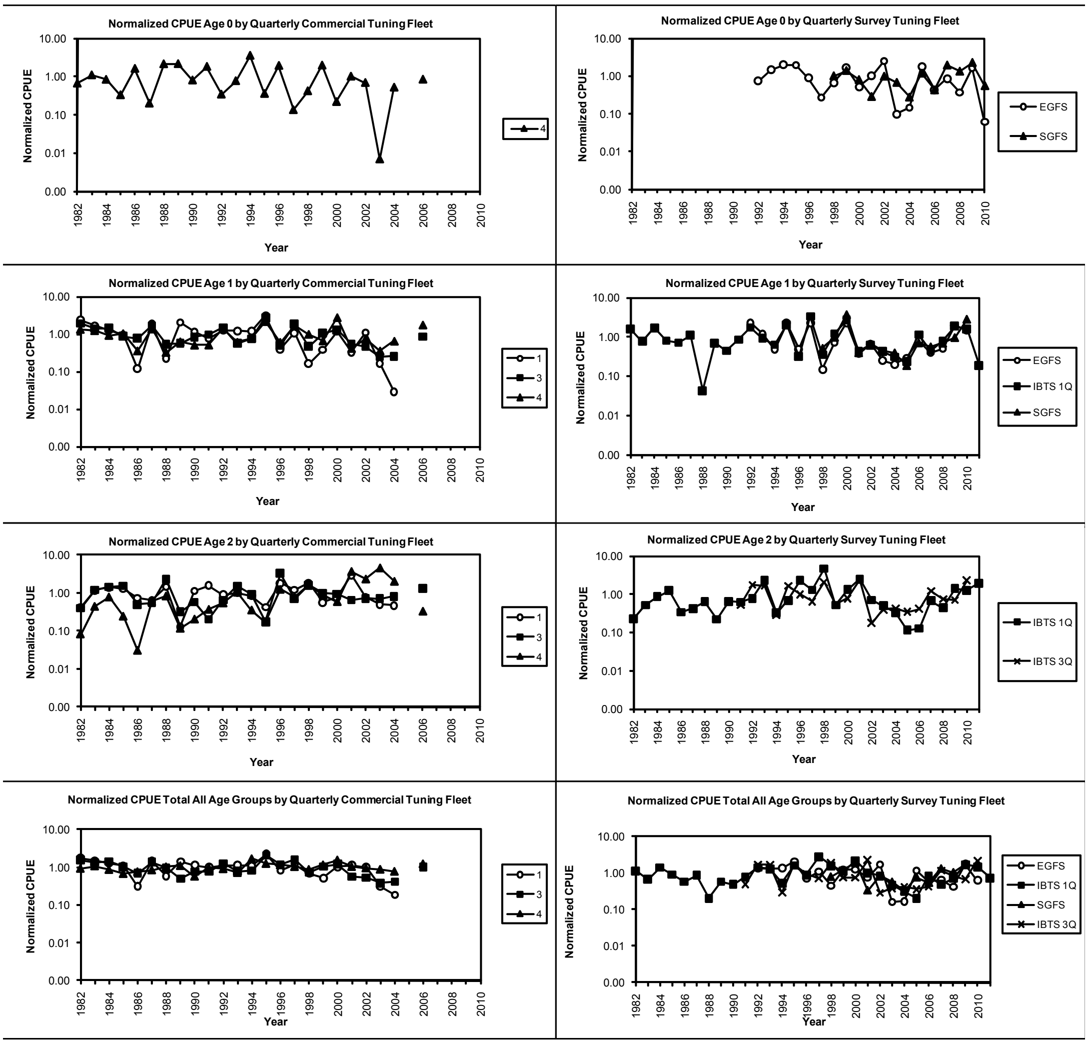


Figure 5.2.2 **NORWAY POUT IV and IIIaN (Skagerak). Trends in CPUE (normalized to unit mean) by quarterly commercial tuning fleet and survey tuning fleet used in the Norway pout SXSA assessment for each age group and all age groups together.**

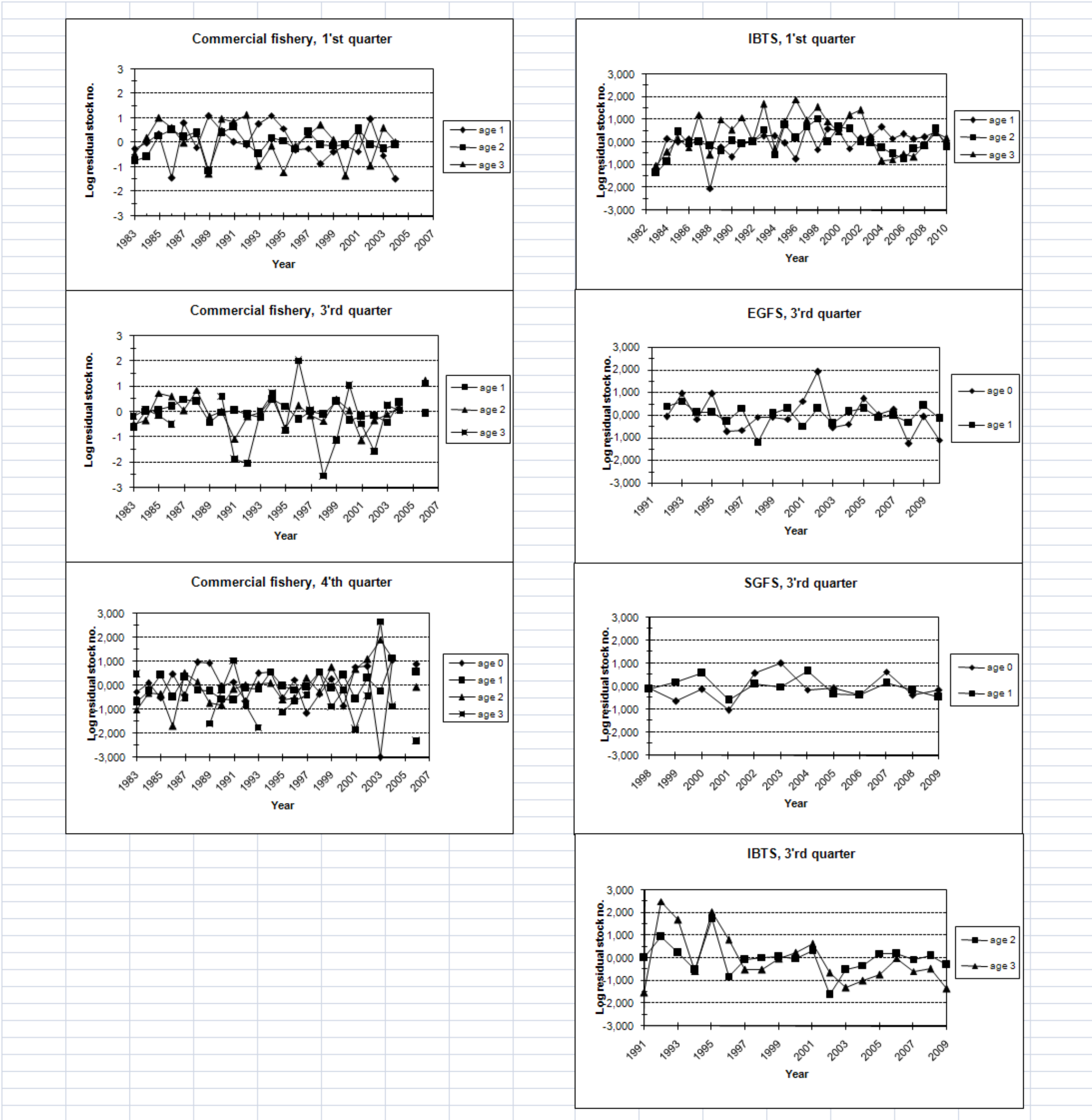


Figure 5.3.1 Norway pout IV & IIIaN (Skagerrak). Log residual stock numbers (log (Nhat/N)) per age group. SXSA divided by fleet and season.

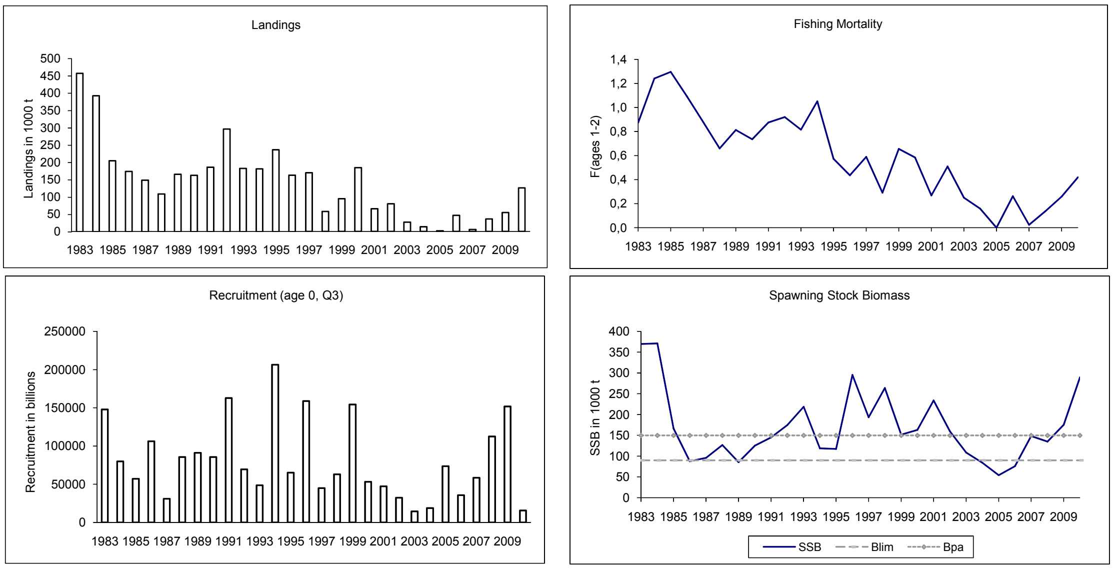


Figure 5.3.2 Norway Pout IV and IIIaN (Skagerrak). Stock Summary Plots. SXSA baseline run May 2011.

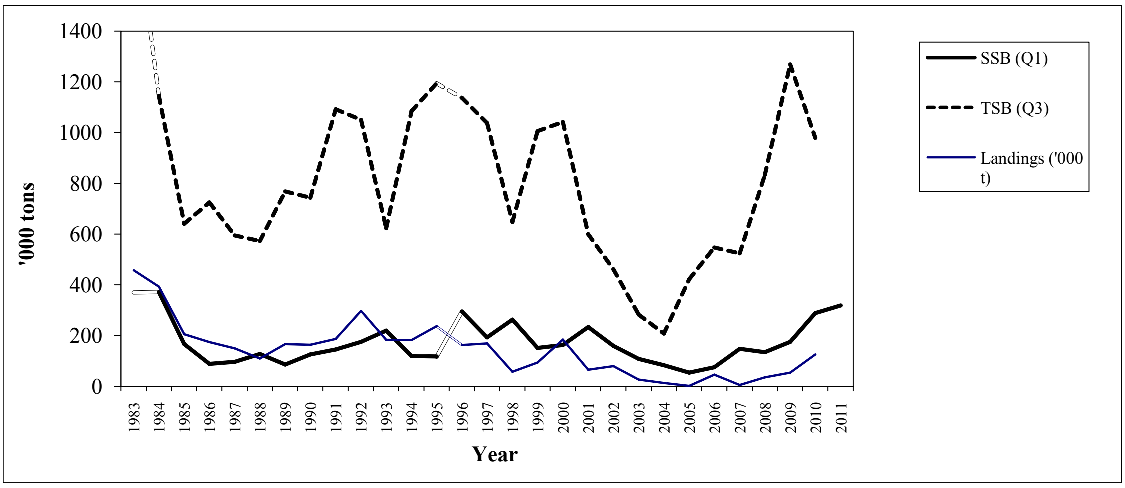


Figure 5.3.3 Norway pout IV & IIIaN (Skagerrak). Trends in yield, SSB and TSB during the period 1983-2011.

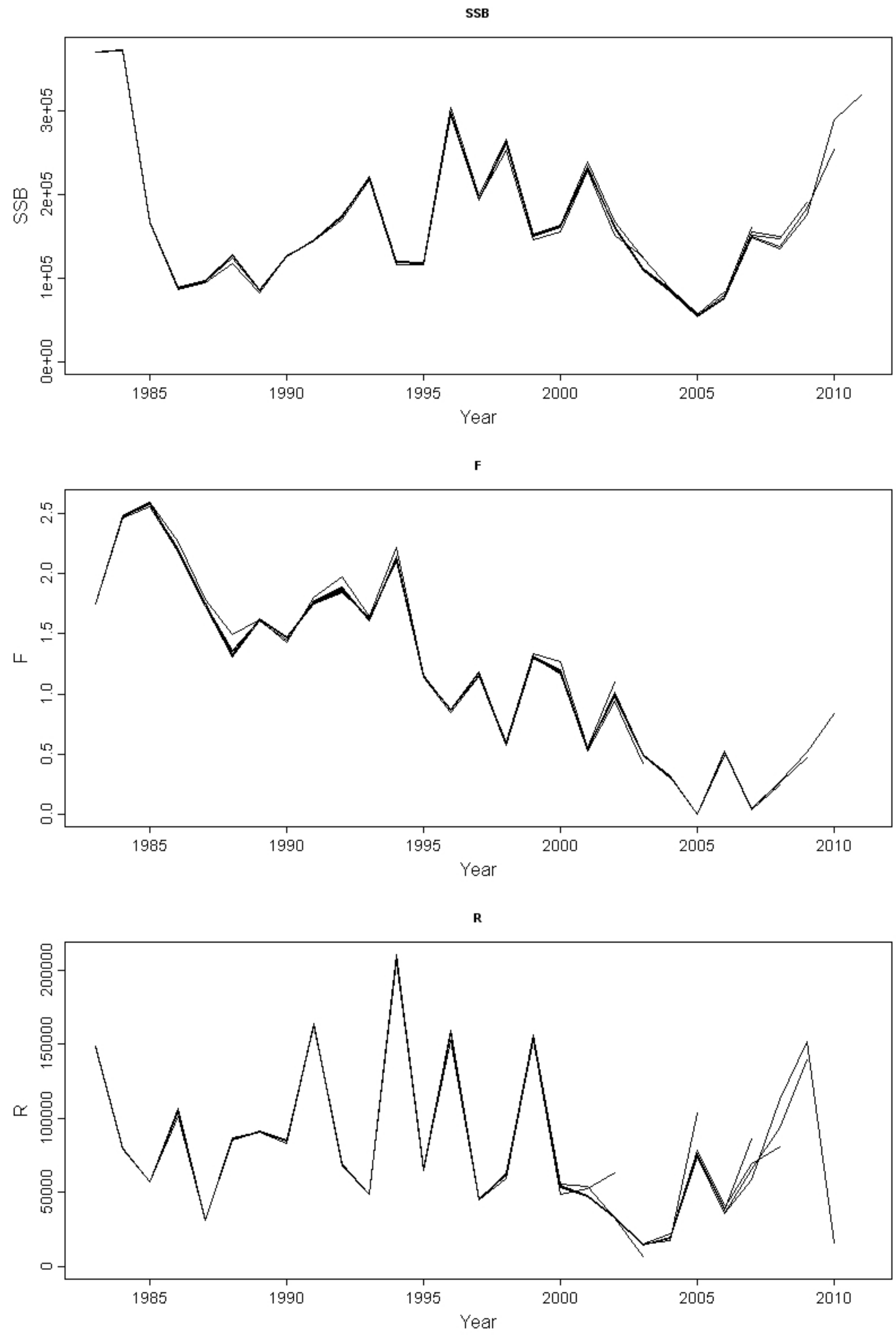


Figure 5.3.4 Norway pout IV & IIIaN (Skagerrak). Retrospective plots of final SXSA assessment May 2011, with terminal assessment year ranging from 2002-2010.

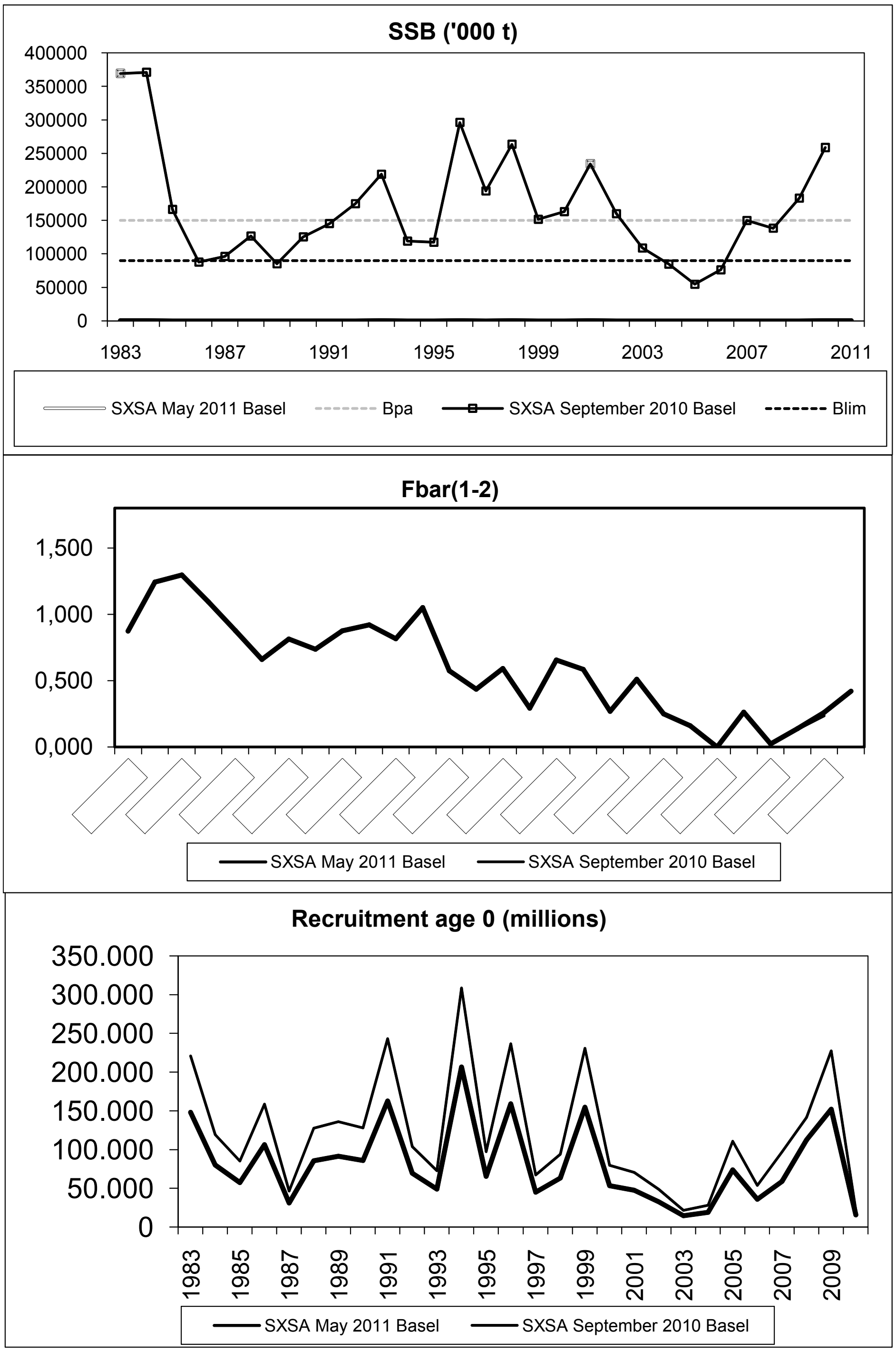


Figure 5.3.5 Norway pout IV and IIIaN (Skagerrak). Comparison of May 2011 SXSA baseline assessment with SXSA September 2010 baseline assessment.OBS: In Sept 2010 recruitment were calculated for 2nd quarter and in May 2011 for 3rd quarter)

6 Plaice in Division VIId

This assessment of plaice in Division VIId is an update assessment. If follows the methodology, described in the Stock Annex revised during ICES WKFLAT 2010.

6.1 General

6.1.1 Ecosystem aspects

No new information on ecosystem aspects was presented at the working group in 2011.

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. 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 all over VIId. The inshore trawlers and netters are mainly vessels <10 m operating on a daily basis within 12 miles of the coast. There are a large number of these vessels (more than 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. However, most of the international catches between 2000-2008 were located straight at the entrance of the Channel (see stock annex).

Due to the minimum mesh size in the mixed beam trawl fishery (80 mm), a large number of undersized plaice are discarded, similarly to what occurs in the North Sea. 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 was historically the most important for the fisheries but the share of the landings for this quarter has been decreasing from the early 1990s to a value around 30 % of the total recently. In 2010, the beginning of the year remains predominant with the first semester corresponding to 53% of the total landings (see text table below).

Quarter	Landings	Cum. Landings	Cum. %
I	993	993	26
II	1045	2038	53
III	736	2774	72
IV	1037	3812	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 studies also showed 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 resident stock biomass**. All the following figures and tables will take into account this Quarter1 removal.**

Age distributions (exploitation pattern) may be quite different between quarters, as shown for 2010 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

2008 advice: The new landings, cpue, and survey data available for this stock do not change the perception of the stock and do not give reason to change the advice from 2007. The advice for the fishery in 2009 is therefore the same as the advice given in 2007 for the 2008 fishery: "In the absence of short-term forecasts, ICES recommends that landings do not increase above the average of landings from the last three years (2004–2006), corresponding to 3500 t."

2009 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 2010 should not increase above the average of landings from the last three years (2006–2008), corresponding to landings less than 3 500 t.

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.

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 effort regulations in VIId are pooled with North Sea and Skagerrak. 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 and 2011, Council Regulation (EC) N°53/2010 and Council Regulation (EC) N°57/2011 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 2010 landings of 3812t (3177t attributed to the resident stock and 635t removed from the first quarter as estimated to be resulting from catches coming from VIIe and IV to spawn) are in the catch level of the past 5 years. As usual, France contributed the largest share (55%) of the total VIId landings in 2010 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 2003-2008 are available from France, Belgium and UK (ICES WGNSSK 2010) although sampling levels are not high. Discards data for the period 2009-2010 are available from France and UK (Figure 6.2.1.1a-c). Discards from the Belgian beam trawler fleet could not be processed in time for the working group due to logistic problems.

Although the series may appear long enough (2003-2010), the low sampling intensity before 2008 (Tables 6.2.1.4a-c) does not allow for adequate estimates of total discards that can be used in the assessment. The sampling intensity for 2009 and 2010 is sufficient, but a long time series of this sampling intensity is required.

The percentage discarded per period, métier and country is highly variable within metier and from year to year. In every case, this percentage is substantial.

An average total fish mortality (Z) of 0.86 is estimated from catch curves slopes (figure 6.2.1.2).

UK, France 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 compositions in the landings per quarter for the year 2010 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 weights at age do not show specific trends. Weight for the oldest ages (after 7 years old) may overlap. This might be due to the low sampling intensity for these ages, which are not frequent in the stock nor in the catches (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 has been 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 2009, RGNSSK stated, as in 2008 that :

- There is a stock definition problems, which is tricky to solve. Mixing stocks during feeding period (North Sea and Channel stocks). Rate of mixing is not known for assessment.
- New discarding information available, however time series considered too short to be taken into account in assessment. Discarding figures in the report are good, showing where Achilles heel is.
- The sampling seems to be adequate, but it seems that discarding estimates and stock identity are major problems for assessment. Discarding in 1-3 quarters high and dependent on gear in use. By omitting young fish dis-

cards, is influencing short term predictions, by boosting SSB somewhat upwards, but perhaps not Fs.

- The assessment has a tendency to overestimate SSB and underestimate F, especially from 2000 when surveys and commercial fleets information began to diverge.
- There is no new elements in the assessment. A conclusion is that the assessment is indicative for trends only

In 2010, RGNSSK stated that:

- RG feels the WG has supported the draft advice based on the assessment results and the RG agrees with the ICES draft advice of "catch not to exceed average recent landings."
- While the assessment is to be used only for current trends, the results indicate that F is being reduced, while SSB seems to be slightly increasing in recent years.
- If the assessment model is not estimating discards The WG states that discard data is a short time series and has relatively low sampling making it unusable in the assessment. The perceived large amount of discards should be looked into further especially if a large portion of those discards are juvenile fish.

WKFLAT 2010 concluded that:

- The discard time series was considered too short and too variable to be used in the assessment, sampling intensity has increased in recent years in order to address this problem.
- 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 FLXSA_2.0 with R 2.8.1.

A preliminary inspection of the quality of international catch-at-age was carried out using separable VPA with a reference age of 3, terminal F=0.8 and terminal S=0.8. The log catch ratio residuals of the separable VPA (Figure 6.3.2.1) showed neither special pattern nor large values for the recent years of data, which suggests a relative consistency of the catch-at-age matrix.

The log catchability residuals from single fleet runs (with settings as in XSA and F shrinkage = 1.0) are shown in Figure 6.3.2.2 for all the fleets. There is a jump in the residuals of the UK BTS 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

The survey-based analysis was carried out with SURBAR software, the results being shown in Figures 6.3.3.1. The parameters used for this exercise are a smoothing coefficient lambda (set to 1.0) and a reference age (set to 4). The age range considered is 1–10+, with the range of F values for calculating the mean being 3 to 6, as in the XSA analysis. The SURBA analysis has been proven to be insensitive to the choice of the initial parameters in the neighbourhood of those chosen here (ICES WGNSSK 2005).

The retrospective analysis (Figure 6.3.3.2) does not show tendencies to under or over estimate Z or SSB but the estimates of mean Z are given with large confidence bounds, questioning the quality of this information. Some extreme values prevent drawing a contrasted picture of the recruitment estimates by SURBA.

6.3.4 Conclusions drawn from exploratory analyses

There is a decreasing trend in the contribution of the first quarter to the whole landings, where a fishery on the spawners takes place, yielding an age distribution different from the rest of the year. It is unknown whether there is major inter-annual variability in the immigration from the North Sea to these spawning grounds, which could distort any catch-based analysis. Any migration events taking place in the first quarter cannot be represented in the surveys in the second semester.

Discarding is shown to take place and is substantial, but is constrained to younger ages. The year range of the data series is too short to make use of it in the analysis.

Both landings-at-age and tuning fleets information are highly dependent on the accuracy of the spatial declaration of the fishing activity as an important component of the fisheries operates on the borderline to ICES subdivision IVc.

Figure 6.3.4.1 compares the single fleet performances to the final assessment. The two main surveys, particularly the UK BTS, keep diverging from the commercial fleet. A map of UK BTS indices per tow locations from 1996 to 2006 (ICES WGNSSK 2010) shows that the catches of plaice by the survey occur mainly inshore, whereas the commercial fisheries spread all over the Channel as plaice is mainly taken as a by-catch. 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.

6.3.5 Final assessment

The settings in the XSA assessment for last year are (parameters were changed in 2010 following Benchmark conclusions):

Year of assessment:		2010	2011
Assessment model:		XSA	XSA
Assessment software		FLR library	FLR library
Fleets:			
BE Beam Trawlers Age range		2–10	2–10
UK Beam Trawl Survey	Age range	4–6	4–6
FR Ground Fish Survey	Age range	**2–3**	**2–3**

Intern'l Young Fish Survey Age range	1	1
Catch/Landings		
Age range:	1–10+	1–10+
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 7
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 6.3.5.5

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 (ICES 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 has been now slightly 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 2009 year class used for predictions was calculated as the geometric mean recruitment over the period 1998-2008, applying the observed fishing mortality of age 1 in 2010 to get the number of age 2 in 2011.

The 2010 and 2011 year classes were estimated using the average recruitment calculated over the period 1998–2008. 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 (98-08)	Accepted estimate
2009	2	12971	**11003**	XSA
2010	1	-	**12162**	GM (1998-08)
2010&2011	0	-	**12162**	GM (1998-08)

6.6 Short-term forecasts

The short term prognosis was carried out with FLSTF (FLR package). The average F for the last three years was used for the forecast. The exploitation pattern used (Figure 6.6.1 an 6.6.2) was the mean F-at-age over the period 2008–2010, scaled by the Fbar(3-6) to the level of last year. The weights used for prediction were the average over the last three years.

Input to the short term predictions are presented in Table 6.6.1 and results in Table 6.6.2.

Assuming status quo F implies a catch in 2011 in VIId of 3007t (the agreed TAC is 4625t for both VIId and VIIe) and a catch of 3166t in 2012. This will result in a spawning biomass resident in VIId in 2012 and 2013 of 4815t and 5143t, respectively.

All the short term forecasts were made following the Benchmark conclusions. The catches do not then take into account catches of fish from VIIe and IV coming in the first quarter to spawn. These levels of catches cannot be compared to the level of catches estimated in the previous assessment, they are given for trends only.

6.7 Medium-term forecasts

No medium-term forecast is available for this stock.

6.8 Biological reference points

Previous Reference Points:

The current assessment is indicative for trends only, therefore the biological reference points are not valid anymore for being used in the advice.

6.9 Quality of the assessment

- The sampling for plaice landings 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 assessment had a tendency to overestimate SSB and underestimate F, especially from 2000 when information from surveys and commercial fleets began to diverge. 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.
- 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 stable for the last five 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 current level of SSB is stable at a low level, and this confirms the fisher's impression assessed by a survey in France in 2006. However, the results of the assessment indicate that F is being reduced, while SSB seems to be slightly increasing in recent years.

6.11 Management considerations

The Spawning Biomass estimated in 2010, 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 slight 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 and estimated from trends in the assessment to be at a very low level.
- 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.

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°57/2011 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 2011 and consequently on plaice that is caught as by catch in this fishery.

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 behaviour of juveniles.

Following the conclusion of the WKFLAT 2010 it is recommended to explore the potential for performing a combined assessment of this continuum of plaice stocks from Kattegat/Baltic to the English Channel. The WGNSSK requests the setup of a Study Group on the identification, assessment and management of plaice stocks, which could convene for the first time during Spring 2012 and address these issues further.

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.

Table 6.1.2.1 - Plaice in VIId. Nominal landings, and Quarter1 removal

Year	TotalLandings	Landings Quarter1	Total Landings	Percentage Removed
1980	2650	908	2060	22
1981	4769	1635	3706	22
1982	4865	1668	3781	22
1983	5043	1729	3919	22
1984	5161	1770	4011	22
1985	6022	2064	4680	22
1986	6834	2343	5311	22
1987	8366	2868	6502	22
1988	10420	3572	8098	22
1989	8758	3002	6807	22
1990	9047	3101	7031	22
1991	7813	2678	6072	22
1992	6337	2173	4925	22
1993	5331	1828	4143	22
1994	6121	2099	4757	22
1995	5130	1758	3987	22
1996	5393	1849	4191	22
1997	6307	2207	4872	23
1998	5762	1993	4467	22
1999	6326	2116	4951	22
2000	6015	2647	4293	29
2001	5266	1820	4083	22
2002	5777	2340	4256	26
2003	4536	1340	3665	19
2004	4007	1268	3183	21
2005	3446	1114	2722	21
2006	3305	1019	2643	20
2007	3674	1207	2889	21
2008	3491	1120	2763	21
2009	3503	945	2889	18
2010	3812	977	3177	17

Table 6.2.1.1 - Plaice in VIId. Nominal landings (tonnes) as officially reported to ICES , 1976-2010.

Table 6.2.1.1 - Plaice in VIId. Nominal landings (tonnes) as officially reported to ICES , 1976-2010											
Year	Belgium	Denmar	France	UK(E+W)	Others	Total reported	Un-allocated	Quarter1 removal	Total as used by WG (7)	Total landings reported in VIIe (8)	Agreed TAC (5)
1976	147	1(1)	1439	376	-	1963	-		1963	640	
1977	149	81(2)	1714	302	-	2246	-		2246	702	
1978	161	156(2)	1810	349	-	2476	-		2476	784	
1979	217	28(2)	2094	278	-	2617	-		2617	977	
1980	435	112(2)	2905	304	-	3756	-1106	590	2060	1215	
1981	815	-	3431	489	-	4735	34	1063	3706	1746	
1982	738	-	3504	541	22	4805	60	1084	3781	1938	
1983	1013	-	3119	548	-	4680	363	1124	3919	1754	
1984	947	-	2844	640	-	4431	730	1151	4011	1813	
1985	1148	-	3943	866	-	5957	65	1342	4680	1751	
1986	1158	-	3288	828	488 (2)	5762	1072	1523	5311	2161	
1987	1807	-	4768	1292	-	7867	499	1864	6502	2388	8300
1988	2165	-	5688 (2)	1250	-	9103	1317	2322	8098	2994	9960
1989	2019	+	3265 (1)	1383	-	6667	2091	1951	6807	2808	11700
1990	2149	-	4170 (1)	1479	-	7798	1249	2016	7031	3058	10700
1991	2265	-	3606 (1)	1566	-	7437	376	1741	6072	2250	10700
1992	1560	1	3099	1553	19	6232	105	1412	4925	1950	9600
1993	877	+(2)	2792	1075	27	4771	560	1188	4143	1691	8500
1994	1418	+	3199	993	23	5633	488	1364	4757	1471	9100
1995	1157	-	2598 (2)	796	18	4569	561	1143	3987	1295	8000
1996	1112	-	2630 (2)	856	+	4598	795	1202	4191	1321	7530
1997	1161	-	3077	1078	+	5316	991	1435	4872	1654	7090
1998	854	-	3276 (23)	700	+	4830	932	1295	4467	1430	5700
1999	1306	-	3388 (23)	743	+	5437	889	1375	4951	1616	7400
2000	1298	-	3183	752	+	5233	781	1721	4293	1678	6500
2001	1346	-	2962	655	+	4963	303	1183	4083	1379	6000
2002	1204		3454	841		5499	278	1521	4256	1608	6700
2003	998	-	2893	756	3	4650	-114	871	3665	1478	6000
2004	954		2766	582	10	4312	-305	824	3183	1402	6060
2005	832		2432	421	21	3706	-260	724	2722	1370	5150
2006	1024		1935	549	17	3525	-220	662	2643	1466	5080
2007	1355		2017	461	12	3845	-171	785	2889	1184	5050
2008	1386		1740	466	17	3609	-118	728	2763	1144	4646
2009	1002		1802	612	16	3432	71	614	2889	1043	4274
2010	1123		2106	515	60	3804	8	635	3177		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	Unavailable										
7	takes into account the removal of 65% of the Quarter 1 catches										
8	Plaice in VIIe. Nominal landings (t) in Division VIIe, as used by Working Group (ICES WGCSE REPORT 2010)										

Table 6.2.1.4.a. Plaice in VIId. Sampling intensity for discard during the period 2003-2010 (France). Number of sampled trips by quarter.

		1	2	3	4
DRB_MOL	2003 -	-	-	-	
DRB_MOL	2004 -	-	-	-	
DRB_MOL	2005 -	-	-	-	
DRB_MOL	2006 -	-	-	-	
DRB_MOL	2007 -	-	-	-	
DRB_MOL	2008 -	-	-	-	
DRB_MOL	2009	1 -	-		1
DRB_MOL	2010 -	-	-		9
GTR_DEF	2003 -		2	6	2
GTR_DEF	2004 -		4	2	1
GTR_DEF	2005 -		4	2 -	
GTR_DEF	2006 -		1	2 -	
GTR_DEF	2007	1 -	-		3
GTR_DEF	2008 -	-	-		3
GTR_DEF	2009	13	14	46	14
GTR_DEF	2010	38	19	20	5
OTB_DEF	2003 -		1	3	3
OTB_DEF	2004 -		2	3	5
OTB_DEF	2005 -		2	8	4
OTB_DEF	2006	1	3	4	1
OTB_DEF	2007	1	5	10	6
OTB_DEF	2008 -		4	1	22
OTB_DEF	2009	20	22	15	13
OTB_DEF	2010	10	13	17	8
TBB_DEF	2003 -	-		1	2
TBB_DEF	2004 -	-		2 -	
TBB_DEF	2005 -	-	-		1
TBB_DEF	2006 -	-	-	-	
TBB_DEF	2007 -	-	-	-	
TBB_DEF	2008 -	-	-	-	
TBB_DEF	2009 -		2	1	2
TBB_DEF	2010	1 -	-		1

Table 6.2.1.4.b. Plaice in VIId. Sampling intensity for discard during the period 2003-2010 (France). Number of sampled hauls by quarter

		1	2	3	4
DRB_MOL	2003 -	-	-	-	
DRB_MOL	2004 -	-	-	-	
DRB_MOL	2005 -	-	-	-	
DRB_MOL	2006 -	-	-	-	
DRB_MOL	2007 -	-	-	-	
DRB_MOL	2008 -	-	-	-	
DRB_MOL	2009	8 -	-		4
DRB_MOL	2010 -	-	-		53
GTR_DEF	2003 -		13	41	13
GTR_DEF	2004 -		27	7	6
GTR_DEF	2005 -		24	9 -	
GTR_DEF	2006 -		12	5 -	
GTR_DEF	2007	5 -	-		20
GTR_DEF	2008 -	-	-		8
GTR_DEF	2009	73	74	216	65
GTR_DEF	2010	129	32	27	5
GTR_DEF	2010	129	32	27	5
OTB_DEF	2003 -		6	11	12
OTB_DEF	2004 -		6	22	37
OTB_DEF	2005 -		8	41	19
OTB_DEF	2006	4	29	11	2
OTB_DEF	2007	3	9	18	8
OTB_DEF	2008 -		31	6	118
OTB_DEF	2009	206	179	44	26
OTB_DEF	2010	30	66	98	88
TBB_DEF	2003 -	-		5	7
TBB_DEF	2004 -	-		6 -	
TBB_DEF	2005 -	-	-		5
TBB_DEF	2006 -	-	-	-	
TBB_DEF	2007 -	-	-	-	
TBB_DEF	2008 -	-	-	-	
TBB_DEF	2009 -		7	3	4
TBB_DEF	2010	2 -	-		1

Table 6.2.1.4.c. Plaice in VIId. Sampling intensity for discard during the period 2003-2010 (France). Number of measured fish by quarter

DIS

		1	2	3	4
DRB_MOL	2003	-	-	-	-
DRB_MOL	2004	-	-	-	-
DRB_MOL	2005	-	-	-	-
DRB_MOL	2006	-	-	-	-
DRB_MOL	2007	-	-	-	-
DRB_MOL	2008	-	-	-	-
DRB_MOL	2009	-	-	-	-
DRB_MOL	2010	-	-	-	3
GTR_DEF	2003	-	180	142	33
GTR_DEF	2004	-	151	125	98
GTR_DEF	2005	-	156	3	-
GTR_DEF	2006	-	-	3	-
GTR_DEF	2007	7	-	-	-
GTR_DEF	2008	-	-	-	5
GTR_DEF	2009	130	175	359	169
GTR_DEF	2010	1169	466	212	33
OTB_DEF	2003	-	2	4	-
OTB_DEF	2004	-	242	110	-
OTB_DEF	2005	-	44	134	145
OTB_DEF	2006	3	95	5	-
OTB_DEF	2007	-	28	9	2
OTB_DEF	2008	-	357	-	1
OTB_DEF	2009	266	587	163	33
OTB_DEF	2010	284	308	175	37
TBB_DEF	2003	-	-	-	-
TBB_DEF	2004	-	-	-	-
TBB_DEF	2005	-	-	-	3
TBB_DEF	2006	-	-	-	-
TBB_DEF	2007	-	-	-	-
TBB_DEF	2008	-	-	-	-
TBB_DEF	2009	-	33	-	-
TBB_DEF	2010	24	-	-	-

LAN

		1	2	3	4
DRB_MOL	2003	-	-	-	-
DRB_MOL	2004	-	-	-	-
DRB_MOL	2005	-	-	-	-
DRB_MOL	2006	-	-	-	-
DRB_MOL	2007	-	-	-	-
DRB_MOL	2008	-	-	-	-
DRB_MOL	2009	40	-	-	3
DRB_MOL	2010	-	-	-	58
GTR_DEF	2003	-	187	254	86
GTR_DEF	2004	-	346	95	253
GTR_DEF	2005	-	93	9	-
GTR_DEF	2006	-	31	42	-
GTR_DEF	2007	13	-	-	132
GTR_DEF	2008	-	-	-	49
GTR_DEF	2009	539	653	2032	441
GTR_DEF	2 010	734	526	297	81
OTB_DEF	2003	-	9	4	65
OTB_DEF	2004	-	316	152	6
OTB_DEF	2005	-	244	121	15
OTB_DEF	2006	52	4	4	11
OTB_DEF	2007	6	70	24	17
OTB_DEF	2008	-	627	12	121
OTB_DEF	2009	184	1193	192	98
OTB_DEF	2010	282	719	184	86
TBB_DEF	2003	-	-	49	68
TBB_DEF	2004	-	-	49	-
TBB_DEF	2005	-	-	-	104
TBB_DEF	2006	-	-	-	-
TBB_DEF	2007	-	-	-	-
TBB_DEF	2008	-	-	-	-
TBB_DEF	2009	-	76	18	23
TBB_DEF	2010	40	-	-	30

Table 6.2.2.1. Plaice in VIId. Landings in numbers (thousands) as used in the assessment, taking into account the first quarter removal.

Table 6.2.2.1 - Plaice VIId. Landings in numbers (thousands)

	1	2	3	4	5	6	7	8	9	10+
1980	53	2336	1077	363	324	50	29	29	3	72
1981	16	2161	5041	1612	192	106	33	28	37	140
1982	265	1231	5125	2219	505	138	62	41	15	61
1983	92	2676	2374	3970	617	151	60	81	3	70
1984	350	1653	5423	1891	1242	356	153	67	23	70
1985	142	5047	4595	3282	274	409	106	66	93	35
1986	679	4315	5219	2462	965	375	165	46	13	24
1987	25	7508	5570	2334	833	287	287	103	69	54
1988	16	4427	13957	3293	741	362	285	85	69	122
1989	826	3214	5362	6353	1770	392	187	119	54	138
1990	1632	2320	6489	4021	2386	535	158	135	118	161
1991	1542	5177	4039	3040	1614	1123	186	80	75	88
1992	1665	5471	3301	1160	786	697	453	132	77	82
1993	740	6719	2832	846	359	313	217	191	68	106
1994	1242	3210	5169	2091	563	280	203	177	183	218
1995	2592	3834	2176	1968	611	152	180	150	82	181
1996	1119	4282	2675	1039	951	326	116	117	110	242
1997	550	3727	5293	2338	724	506	302	135	78	207
1998	464	3888	6436	2290	360	94	79	52	32	126
1999	741	1616	9064	4505	696	121	57	51	28	88
2000	1383	5966	2677	3856	752	150	42	15	23	62
2001	2682	3568	2888	1353	1253	203	63	15	9	59
2002	902	5019	3987	1368	1144	603	162	40	18	68
2003	646	4318	4389	1236	273	264	210	46	32	41
2004	967	4349	3923	620	244	105	88	93	26	32
2005	324	2908	2963	1430	302	129	71	57	49	32
2006	509	2584	2421	1171	603	146	57	63	31	51
2007	790	2740	2132	1146	549	313	82	25	11	37
2008	360	3399	1835	930	439	186	149	26	13	26
2009	472	2760	3250	1067	427	284	134	64	17	70
2010	614	3903	2405	1214	271	228	134	20	97	25

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	8	9	10+
Quarter	1	0	699	1 226	696	183	140	50	20	36	21
	2	0	1 273	984	507	120	91	34	13	12	9
	3	269	990	445	236	27	20	50	1	27	2
	4	346	1 391	534	220	57	65	31	5	31	6

Table 6.2.3.1. Plaice in VIId. Weights in the landings

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1980	0.309	0.312	0.499	0.627	0.787	1.139	1.179	1.293	1.475	1.557
1981	0.239	0.299	0.373	0.464	0.712	0.87	0.863	0.897	0.992	1.174
1982	0.245	0.271	0.353	0.431	0.64	0.795	1.153	1.067	1.504	1.355
1983	0.266	0.296	0.349	0.42	0.542	0.822	0.953	1.144	0.943	1.591
1984	0.233	0.295	0.336	0.402	0.508	0.689	0.703	0.945	1.028	1.427
1985	0.254	0.278	0.301	0.427	0.502	0.57	0.557	1.081	0.849	1.421
1986	0.226	0.306	0.331	0.406	0.546	0.486	0.629	0.871	1.446	1.579
1987	0.251	0.282	0.36	0.477	0.577	0.783	0.735	1.142	1.268	1.515
1988	0.292	0.268	0.321	0.432	0.56	0.657	0.77	0.908	1.218	1.328
1989	0.201	0.268	0.321	0.37	0.473	0.648	0.837	0.907	1.204	1.519
1990	0.201	0.256	0.326	0.378	0.483	0.61	0.781	0.963	1.159	1.31
1991	0.225	0.277	0.311	0.39	0.454	0.556	0.745	1.087	0.924	1.602
1992	0.182	0.277	0.352	0.429	0.509	0.585	0.701	0.837	0.85	1.195
1993	0.22	0.272	0.336	0.432	0.507	0.591	0.741	0.82	0.934	1.156
1994	0.243	0.27	0.288	0.356	0.466	0.576	0.686	0.928	0.969	1.287
1995	0.218	0.271	0.313	0.39	0.485	0.688	0.612	0.806	1.15	1.298
1996	0.221	0.3	0.29	0.396	0.475	0.643	0.764	0.934	1.057	1.312
1997	0.199	0.252	0.298	0.332	0.442	0.577	0.801	0.894	1.055	1.395
1998	0.159	0.244	0.267	0.381	0.502	0.762	0.839	0.981	0.986	1.379
1999	0.197	0.245	0.235	0.306	0.461	0.751	0.768	0.868	0.885	1.508
2000	0.207	0.245	0.261	0.283	0.375	0.576	0.687	0.875	0.926	1.067
2001	0.215	0.252	0.303	0.37	0.447	0.642	0.876	1.008	1.144	1.223
2002	0.254	0.256	0.309	0.376	0.438	0.562	0.627	0.88	0.909	1.33
2003	0.254	0.268	0.271	0.363	0.556	0.643	0.624	0.85	0.583	1.205
2004	0.217	0.243	0.295	0.421	0.493	0.61	0.636	0.933	1.093	1.348
2005	0.21	0.263	0.293	0.36	0.527	0.536	0.753	0.778	0.82	1.014
2006	0.209	0.263	0.318	0.374	0.463	0.611	0.711	0.732	0.858	1.071
2007	0.246	0.293	0.322	0.382	0.473	0.541	0.685	0.793	0.983	1.193
2008	0.244	0.286	0.334	0.404	0.509	0.596	0.727	1.316	0.921	1.254
2009	0.119	0.248	0.301	0.398	0.498	0.626	0.902	0.993	1.057	1.33
2010	0.327	0.298	0.327	0.412	0.453	0.578	0.642	0.777	1.045	1.169

Table 6.2.3.2. Plaice in VIId. Weights in the stock.

	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10+
1980	0.171	0.332	0.482	0.622	0.751	0.87	0.977	1.074	1.161	1.339
1981	0.11	0.216	0.317	0.414	0.506	0.594	0.677	0.756	0.83	1.042
1982	0.105	0.208	0.308	0.406	0.502	0.596	0.687	0.776	0.862	1.118
1983	0.097	0.192	0.286	0.379	0.47	0.56	0.648	0.735	0.821	1.169
1984	0.082	0.164	0.248	0.333	0.42	0.507	0.596	0.686	0.777	1.086
1985	0.084	0.171	0.259	0.348	0.44	0.533	0.628	0.725	0.824	1.206
1986	0.101	0.205	0.311	0.42	0.532	0.646	0.763	0.882	1.004	1.313
1987	0.122	0.242	0.361	0.479	0.596	0.712	0.826	0.939	1.051	1.306
1988	0.084	0.168	0.254	0.34	0.427	0.514	0.603	0.692	0.783	0.952
1989	0.079	0.162	0.25	0.342	0.439	0.541	0.648	0.759	0.874	1.211
1990	0.085	0.23	0.322	0.346	0.465	0.549	0.748	0.899	0.979	1.766
1991	0.143	0.219	0.275	0.335	0.375	0.472	0.633	1.057	1.022	1.502
1992	0.088	0.241	0.336	0.421	0.477	0.521	0.634	0.713	0.741	1.229
1993	0.108	0.258	0.296	0.379	0.493	0.539	0.573	0.699	0.787	1.056
1994	0.165	0.198	0.276	0.331	0.383	0.493	0.603	0.903	0.781	1.15
1995	0.124	0.257	0.286	0.354	0.442	0.707	0.531	0.703	1.092	1.194
1996	0.178	0.229	0.263	0.347	0.354	0.474	0.536	0.907	0.958	1.126
1997	0.059	0.202	0.256	0.266	0.417	0.53	0.665	0.686	0.972	1.364
1998	0.072	0.203	0.273	0.361	0.53	0.67	0.629	0.656	0.915	1.107
1999	0.072	0.172	0.213	0.351	0.429	0.644	0.76	0.782	0.593	1.166
2000	0.068	0.184	0.204	0.246	0.355	0.554	0.693	0.817	0.89	1.131
2001	0.093	0.206	0.274	0.338	0.404	0.624	0.844	0.989	1.153	1.405
2002	0.102	0.206	0.281	0.379	0.467	0.558	0.61	0.759	1.053	1.25
2003	0.103	0.191	0.249	0.33	0.496	0.492	0.548	0.748	0.522	0.982
2004	0.172	0.183	0.268	0.408	0.471	0.521	0.616	0.892	1.102	1.287
2005	0.096	0.201	0.269	0.308	0.47	0.492	0.707	0.629	0.814	0.89
2006	0.106	0.209	0.275	0.336	0.397	0.525	0.636	0.704	0.842	1.09
2007	0.125	0.224	0.265	0.323	0.431	0.463	0.62	0.831	1.04	1.222
2008	0.155	0.253	0.285	0.343	0.41	0.447	0.615	0.755	0.912	1.266
2009	0	0.224	0.279	0.372	0.46	0.494	0.756	0.836	1.259	1.291
2010	0	0.25	0.27	0.347	0.378	0.539	0.588	0.739	0.896	1.149

Table 6.2.5.1. Plaice in VIId. Tuning fleets

BE	CBT								
1 981	2 010								
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

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

UK	BTS		
1 982	2 010		
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

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

FR	GFS		
1 982	2 010		
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	

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

IN	YFS		
1 987	2 006		
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 2011-05-10 13:56:31

CPUE data from xsa.indices

Catch data for 31 years. 1980 to 2010. Ages 1 to 10.

   fleet first age last age first year last year alpha beta
1 BE CBT         2        9       1981      2010     0    1
2 UK BTS         4        6       1988      2010   0.5 0.75
3 FR GFS         2        3       1988      2010  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 >   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   2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  all    1    1    1    1    1    1    1    1    1    1


 Fishing mortalities
    year
age   2001  2002  2003  2004  2005  2006  2007  2008  2009  2010
  1  0.192 0.063 0.054 0.098 0.038 0.062 0.066 0.033 0.021 0.044
  2  0.431 0.575 0.425 0.537 0.421 0.414 0.478 0.390 0.337 0.220
  3  0.829 1.097 1.389 0.758 0.768 0.656 0.631 0.604 0.702 0.489
  4  0.519 1.127 1.151 0.635 0.610 0.702 0.664 0.551 0.763 0.545
  5  0.705 1.010 0.617 0.638 0.650 0.497 0.750 0.510 0.466 0.388
  6  0.473 0.786 0.589 0.451 0.735 0.671 0.461 0.540 0.645 0.433
  7  0.382 0.763 0.618 0.351 0.549 0.752 0.893 0.369 0.849 0.637
  8  0.358 0.394 0.443 0.544 0.356 1.269 0.797 0.710 0.236 0.246
  9  0.300 0.849 0.569 0.437 0.545 0.299 0.641 1.266 1.387 0.597
  10 0.300 0.849 0.569 0.437 0.545 0.299 0.641 1.266 1.387 0.597
```

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

year \ age	1	2	3	4	5	6	7	8	9	10
2001	16160	10704	5388	3514	2603	565	209	52	37	237
2002	15444	12071	6291	2128	1892	1164	319	129	33	124
2003	12833	13117	6148	1901	624	623	480	134	79	98
2004	10855	10997	7761	1387	544	305	313	234	78	96
2005	9195	8902	5814	3291	665	260	176	199	123	79
2006	8912	8012	5289	2442	1618	314	113	92	126	208
2007	13055	7579	4791	2482	1095	890	145	48	23	83
2008	11574	11061	4252	2307	1157	468	508	54	20	38
2009	23432	10130	6775	2102	1203	629	247	318	24	97
2010	14981	20753	6541	3039	887	683	298	96	227	57

Estimated population abundance at 1st Jan 2011

year \ age	1	2	3	4	5	6	7	8	9	10
2011	0	12971	15066	3631	1594	545	401	143	68	113

Fleet: BE CBT

Log catchability residuals.

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
2	-0.062	-0.232	0.408	-1.340	0.369	0.494	0.311	0.068	-2.039	0.260	0.891
3	0.348	-0.304	0.008	0.012	-0.097	0.014	-0.410	-0.139	-0.336	0.457	0.785
4	0.434	0.061	0.370	0.009	0.047	-0.286	-0.391	-0.438	-0.100	0.089	0.142
5	-0.521	0.063	-0.312	0.062	-1.225	-0.326	-0.597	-0.875	0.345	-0.185	0.580
6	-0.675	-0.227	-0.190	0.169	0.322	-0.008	-1.012	-0.909	-0.023	-0.027	0.551
7	-0.318	-0.444	-0.587	0.329	-0.049	-0.160	0.287	-0.253	-0.314	-0.968	0.055
8	0.106	0.470	1.039	-0.042	0.892	-0.856	-0.214	-0.191	0.120	-0.321	-0.401
9	0.023	0.048	0.068	-0.077	-0.690	-0.105	0.084	-0.068	-0.023	-0.429	0.365

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2	1.184	0.397	0.850	-1.748	-0.269	0.000	-0.895	-1.512	-1.473	0.394	0.293
3	0.520	-0.152	0.125	0.096	-0.097	-1.476	-0.244	0.058	-0.925	0.893	0.570
4	-0.256	-0.451	0.638	0.166	0.215	0.534	0.319	0.555	-0.988	0.170	0.381
5	-0.331	-0.229	0.088	0.230	0.431	1.203	0.447	0.857	-0.163	0.194	0.420
6	0.318	-0.291	-0.073	-0.259	-0.027	0.966	0.412	0.868	-0.451	0.080	-0.377
7	-0.273	-0.296	-0.125	0.516	-0.474	0.597	0.415	0.504	-0.395	-0.498	0.086
8	0.587	-0.444	0.348	0.310	0.236	-0.087	0.091	-0.024	-0.436	0.034	-0.850
9	0.486	-0.302	0.121	-0.133	-0.015	0.037	0.249	0.031	-0.082	0.031	-0.047

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
2	0.156	0.157	0.139	0.447	0.949	0.605	0.866	0.333
3	0.604	0.244	-0.169	-0.201	-0.215	0.129	-0.084	-0.013
4	0.434	-0.062	-0.240	-0.091	-0.303	0.049	-0.701	-0.305
5	0.000	0.240	0.363	-0.240	0.240	-0.217	-0.457	-0.084
6	0.431	-0.180	0.398	-0.017	0.282	0.075	-0.137	0.011
7	0.377	0.055	0.066	0.198	0.979	0.210	0.545	-0.066
8	0.114	0.350	-0.071	1.002	0.669	0.096	-1.615	-0.013
9	0.277	-0.069	-0.119	0.131	-0.041	-0.563	-0.627	0.172

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	-7.3425	-5.8271	-5.4772	-5.482	-5.6403	-5.7331	-5.7331	-5.7331
S.E_Logq	0.8474	0.4719	0.3863	0.498	0.4463	0.4283	0.5611	0.2668

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

Fleet: UK BTS

Log catchability residuals.

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
4	-0.234	0.228	-0.379	-0.174	0.130	-0.694	0.147	-0.360	-1.417	-1.421	-0.202
5	0.335	-0.224	-0.154	0.060	0.458	-0.302	-0.091	-0.631	-0.736	-1.228	-1.068
6	-0.275	-0.146	0.080	-0.278	0.779	-0.255	-0.656	-0.702	-0.524	-1.067	-0.639

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
4	-0.596	0.551	0.342	0.513	0.453	0.607	0.836	0.053	0.18	-0.079	0.788	0.729
5	-0.386	0.557	1.014	-0.279	0.469	0.044	1.020	-0.072	0.05	0.148	0.412	0.604
6	-0.537	0.339	0.680	0.764	-0.211	-0.966	1.161	0.525	0.27	0.364	0.828	0.466

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	-6.1603	-5.9883	-6.0187
S.E_Logq	0.6217	0.5830	0.6309

Fleet: FR GFS

Log catchability residuals.

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
2	0.369	-0.380	-1.629	-0.931	-0.588	0.011	-0.630	-0.601	-1.155	-0.332	-0.029
3	0.075	-0.725	-0.388	-0.914	0.107	0.398	-1.325	-0.370	-2.017	0.459	-0.380

age \ year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	-0.292	1.042	-0.440	0.183	0.338	0.602	0.999	0.874	0.844	1.193	0.281	0.270
3	0.418	0.313	-0.263	0.856	0.171	0.632	1.342	0.758	0.780	0.512	-0.197	-0.243

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	-7.1209	-7.3359
S.E_Logq	0.7470	0.7642

Fleet: IN YFS

Log catchability residuals.

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.239	0.292	0.016	0.002	-0.284	0.558	0.493	0.238	0.654	-0.428	-0.472	0.449

age \ year	1999	2000	2001	2002	2003	2004	2005	2006
1	0.151	-0.25	0.149	0.217	-1.129	0.427	-0.969	-0.354

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

	1
Mean_Logq	-9.8438

S.E_Logq 0.4891

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

```
Terminal year survivor and F summaries:

 Age 1 Year class = 2009
source
survivors         N scaledWts
    12971         1         1

 Age 2 Year class = 2008
source
       survivors N scaledWts
BE CBT     21027 1     0.305
FR GFS     19731 1     0.403
fshk        7338 1     0.292

 Age 3 Year class = 2007
source
       survivors N scaledWts
BE CBT      4183 2     0.540
FR GFS      3564 2     0.293
fshk        2373 1     0.167

 Age 4 Year class = 2006
source
       survivors N scaledWts
BE CBT      1294 3     0.619
UK BTS      3306 1     0.169
FR GFS      2329 2     0.095
fshk        1234 1     0.118

 Age 5 Year class = 2005
source
       survivors N scaledWts
BE CBT       422 4     0.550
UK BTS      1050 2     0.266
FR GFS      1036 2     0.046
IN YFS       382 1     0.039
fshk         330 1     0.098

 Age 6 Year class = 2004

source
       survivors N scaledWts
BE CBT       363 5     0.582
UK BTS       569 3     0.277
FR GFS       909 2     0.029
IN YFS       152 1     0.027
fshk         257 1     0.084

 Age 7 Year class = 2003
source
       survivors N scaledWts
BE CBT       126 6     0.684
UK BTS       233 3     0.166
FR GFS       336 2     0.015
IN YFS       219 1     0.013
fshk         129 1     0.123

 Age 8 Year class = 2002
source
       survivors N scaledWts
BE CBT        81 7     0.751
UK BTS        85 3     0.108
FR GFS       195 2     0.007
IN YFS        22 1     0.006
fshk          19 1     0.128

 Age 9 Year class = 2001
source
       survivors N scaledWts
BE CBT       106 8     0.840
UK BTS       145 3     0.072
FR GFS       189 2     0.006
IN YFS       141 1     0.005
fshk         167 1     0.077
```

Table 6.3.5.2. Plaice in VIId. Fishing mortality (F) at age

2011-05-10 13:56:31 units= f

year	age 1	2	3	4	5	6	7	8	9	10
1980	0.003	0.207	0.306	0.397	0.638	0.414	0.348	0.218	0.327	0.327
1981	0.002	0.148	0.795	0.896	0.335	0.391	0.462	0.585	0.421	0.421
1982	0.015	0.168	0.543	0.894	0.696	0.380	0.370	1.620	0.597	0.597
1983	0.007	0.191	0.495	0.960	0.587	0.403	0.252	1.038	0.354	0.354
1984	0.019	0.142	0.636	0.830	0.814	0.713	0.813	0.432	0.845	0.845
1985	0.007	0.375	0.636	0.902	0.232	0.613	0.420	0.911	1.793	1.793
1986	0.016	0.266	0.734	0.746	0.647	0.504	0.473	0.285	0.374	0.374
1987	0.001	0.222	0.571	0.766	0.535	0.355	0.804	0.537	0.804	0.804
1988	0.001	0.257	0.715	0.698	0.517	0.415	0.630	0.516	0.755	0.755
1989	0.073	0.213	0.497	0.746	0.917	0.505	0.347	0.520	0.641	0.641
1990	0.121	0.266	0.754	0.762	0.617	0.696	0.346	0.402	1.377	1.377
1991	0.100	0.597	0.885	0.875	0.706	0.586	0.488	0.262	0.365	0.365
1992	0.084	0.533	0.856	0.601	0.511	0.673	0.439	0.684	0.385	0.385
1993	0.079	0.494	0.515	0.484	0.330	0.347	0.401	0.296	0.805	0.805
1994	0.102	0.497	0.785	0.796	0.612	0.412	0.352	0.589	0.454	0.454
1995	0.151	0.456	0.659	0.696	0.499	0.290	0.448	0.422	0.526	0.526
1996	0.054	0.352	0.590	0.678	0.771	0.481	0.333	0.522	0.555	0.555
1997	0.022	0.230	0.861	1.495	1.373	1.147	1.002	0.714	0.699	0.699
1998	0.047	0.195	0.679	1.057	0.887	0.552	0.467	0.401	0.316	0.316
1999	0.056	0.207	0.808	1.393	0.996	0.756	0.673	0.551	0.339	0.339
2000	0.116	0.719	0.545	0.879	0.817	0.520	0.575	0.320	0.459	0.459
2001	0.192	0.431	0.829	0.519	0.705	0.473	0.382	0.358	0.300	0.300
2002	0.063	0.575	1.097	1.127	1.010	0.786	0.763	0.394	0.849	0.849
2003	0.054	0.425	1.389	1.151	0.617	0.589	0.618	0.443	0.569	0.569
2004	0.098	0.537	0.758	0.635	0.638	0.451	0.351	0.544	0.437	0.437
2005	0.038	0.421	0.768	0.610	0.650	0.735	0.549	0.356	0.545	0.545
2006	0.062	0.414	0.656	0.702	0.497	0.671	0.752	1.269	0.299	0.299
2007	0.066	0.478	0.631	0.664	0.750	0.461	0.893	0.797	0.641	0.641
2008	0.033	0.390	0.604	0.551	0.510	0.540	0.369	0.710	1.266	1.266
2009	0.021	0.337	0.702	0.763	0.466	0.645	0.849	0.236	1.387	1.387
2010	**0.044**	**0.220**	**0.489**	**0.545**	**0.388**	**0.433**	**0.637**	**0.246**	**0.597**	**0.597**

Table 6.3.5.3. Plaice in VIId. Stock number at age

age

year	1	2	3	4	5	6	7	8	9	10
1980	18277	13133	4296	1164	722	156	105	156	10	270
1981	9253	16487	9661	2863	708	345	93	67	114	425
1982	18188	8357	12863	3947	1058	458	211	53	34	143
1983	14563	16205	6390	6763	1460	477	284	132	10	247
1984	19121	13090	12117	3525	2343	734	289	199	42	128
1985	21613	16969	10271	5806	1390	939	326	116	117	44
1986	44504	19421	10553	4923	2131	998	460	194	42	79
1987	22757	39623	13469	4585	2112	1010	545	260	132	101
1988	19480	20568	28711	6889	1928	1119	641	221	137	240
1989	12397	17611	14400	12703	3100	1040	669	309	119	304
1990	15100	10431	12878	7929	5450	1122	568	428	166	224
1991	17016	12111	7232	5479	3350	2662	506	364	259	301
1992	21763	13930	6034	2701	2066	1496	1341	281	253	270
1993	10296	18108	7400	2320	1341	1122	691	782	128	200
1994	13473	8613	9993	4003	1294	872	718	419	526	627
1995	19477	11009	4740	4125	1633	635	523	457	210	462
1996	22274	15158	6314	2219	1861	897	430	302	271	595
1997	26090	19090	9642	3168	1019	779	502	279	162	429
1998	10546	23084	13728	3690	643	234	224	167	123	485
1999	1429	9101	17189	6300	1160	240	122	127	101	319
2000	13284	12226	6698	6931	1415	388	102	56	66	175
2001	16160	10704	5388	3514	2603	565	209	52	37	237
2002	15444	12071	6291	2128	1892	1164	319	129	33	124
2003	12833	13117	6148	1901	624	623	480	134	79	98
2004	10855	10997	7761	1387	544	305	313	234	78	96
2005	9195	8902	5814	3291	665	260	176	199	123	79
2006	8912	8012	5289	2442	1618	314	113	92	126	208
2007	13055	7579	4791	2482	1095	890	145	48	23	83
2008	11574	11061	4252	2307	1157	468	508	54	20	38
2009	23432	10130	6775	2102	1203	629	247	318	24	97
2010	14981	20753	6541	3039	887	683	298	96	227	57

Table 6.3.5.4. Plaice in VIId. Summary table

	recruitment	ssb	catch	landings	tsb	fbar3-6	Y/ssb
1980	18277	3768	2060	2060	11602	0.439	0.55
1981	9253	4510	3706	3706	10042	0.604	0.82
1982	18188	5078	3781	3781	10391	0.628	0.74
1983	14563	5427	3919	3919	10446	0.611	0.72
1984	19121	4879	4010	4010	9731	0.748	0.82
1985	21613	5334	4680	4680	10948	0.596	0.88
1986	44504	6768	5311	5311	16272	0.657	0.78
1987	22757	9067	6502	6502	22367	0.557	0.72
1988	19480	8906	8098	8098	17001	0.587	0.91
1989	12397	9571	6807	6807	14841	0.666	0.71
1990	15100	9710	7031	7031	15092	0.707	0.72
1991	17016	7149	6072	6072	12845	0.763	0.85
1992	21763	6004	4925	4925	11771	0.660	0.82
1993	10296	5226	4143	4143	11374	0.419	0.79
1994	13473	5857	4757	4757	10879	0.651	0.81
1995	19477	5095	3987	3987	10611	0.536	0.78
1996	22274	4657	4191	4191	12384	0.630	0.90
1997	26090	4802	4872	4872	10813	1.219	1.01
1998	10546	5366	4467	4467	11923	0.794	0.83
1999	14291	5574	4951	4951	9743	0.988	0.89
2000	13284	3789	4294	4294	7315	0.691	1.13
2001	16160	4260	4083	4083	8379	0.632	0.96
2002	15444	4099	4256	4256	8651	1.005	1.04
2003	12833	2906	3665	3665	7102	0.936	1.26
2004	10855	2974	3183	3183	7552	0.621	1.07
2005	9195	2931	2722	2722	6110	0.691	0.93
2006	8912	3086	2643	2643	6170	0.632	0.86
2007	13055	2837	2889	2889	6540	0.626	1.02
2008	11574	2924	2763	2763	7698	0.551	0.94
2009	23432	3564	2889	2889	6413	0.644	0.81
2010	14981	3945	3177	3177	9228	0.463	0.81

Table 6.6.1. Plaice in VIId. Input to catch forecast

Age	Stock	Mat	M	F
1	12162	0	0.1	0.03
2	12971	0.15	0.1	0.26
3	15066	0.53	0.1	0.5
4	3631	0.96	0.1	0.51
5	1594	1	0.1	0.38
6	545	1	0.1	0.45
7	401	1	0.1	0.51
8	143	1	0.1	0.38
9	68	1	0.1	0.91
10	113	1	0.1	0.91

Table 6.6.2. Plaice in VIId. Management option table

2011 fmult	f3-6	landings	catch	ssb
1	0.463	3007	3007	4342

2012 fmult	f3-6	landings	catch	ssb 2011	ssb 2012
1	0.532	3166	3166	4815	5143

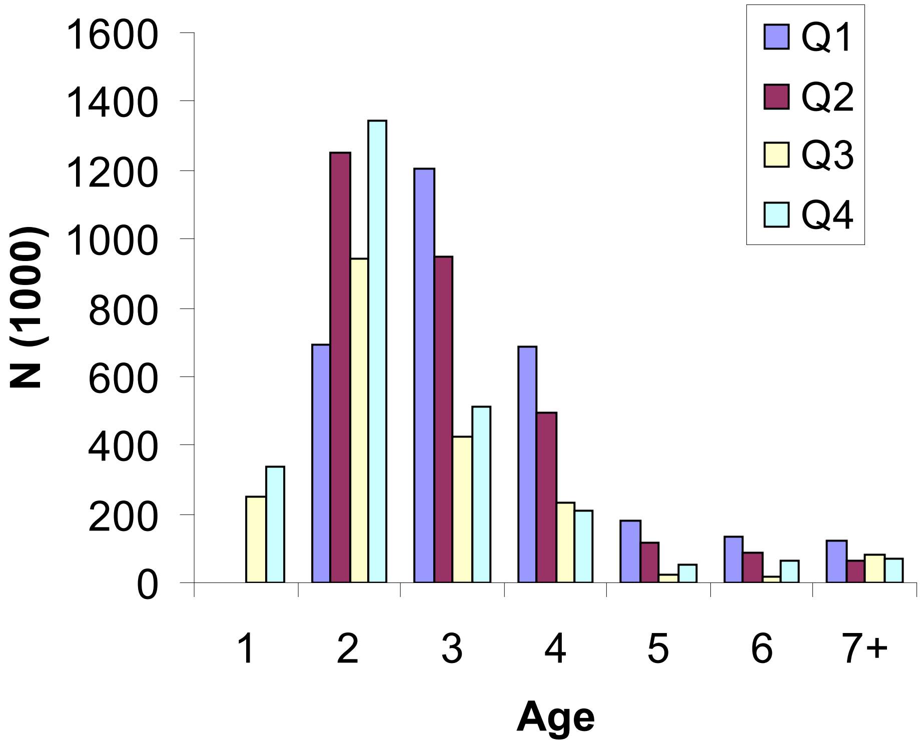


Figure 6.1.2.1. Plaice in VIId. 2010 Age distribution in the landings per quarter.

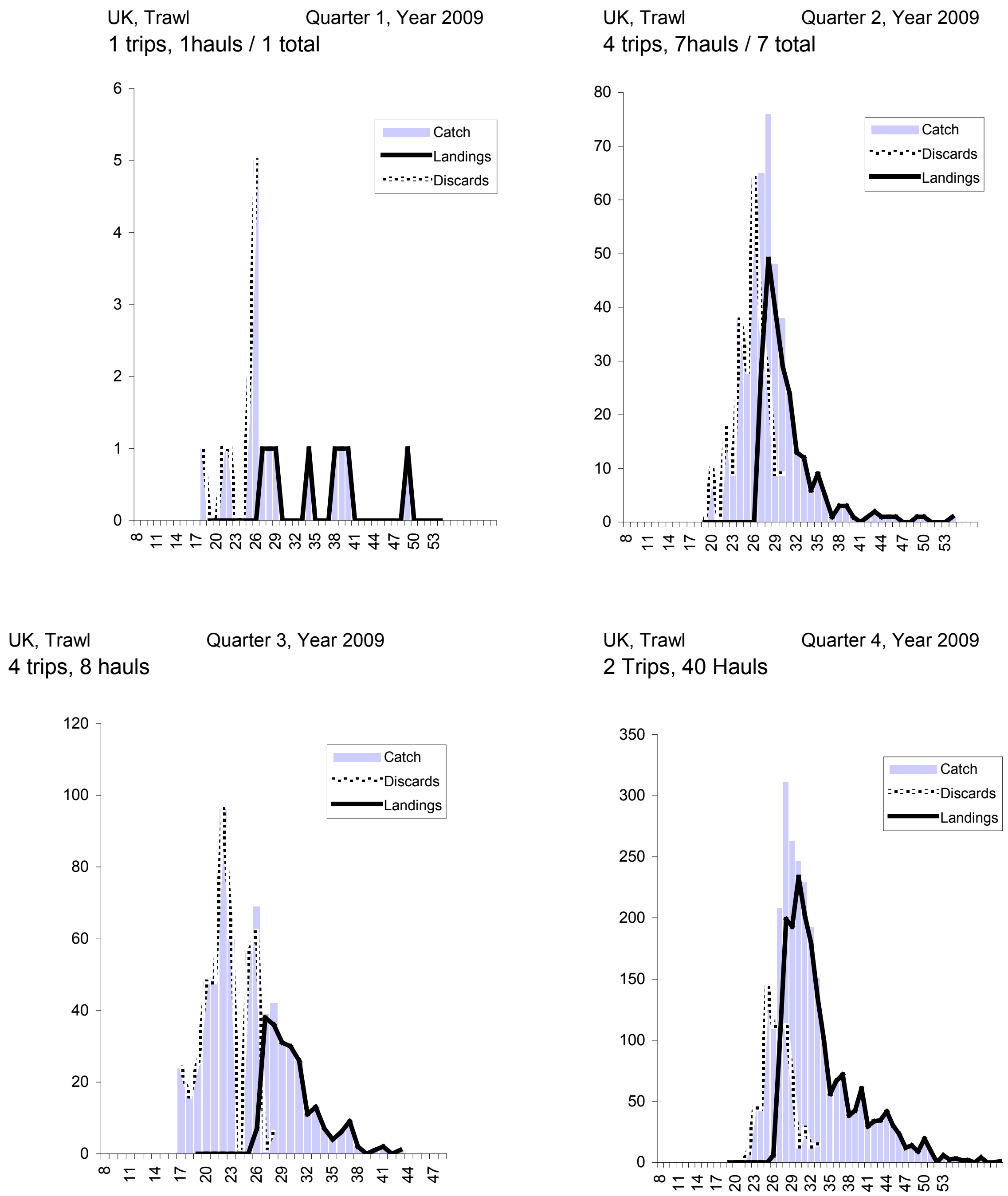


Figure 6.2.1.1a - Plaice VIId - Length structure of discards and landings collected by observations on board

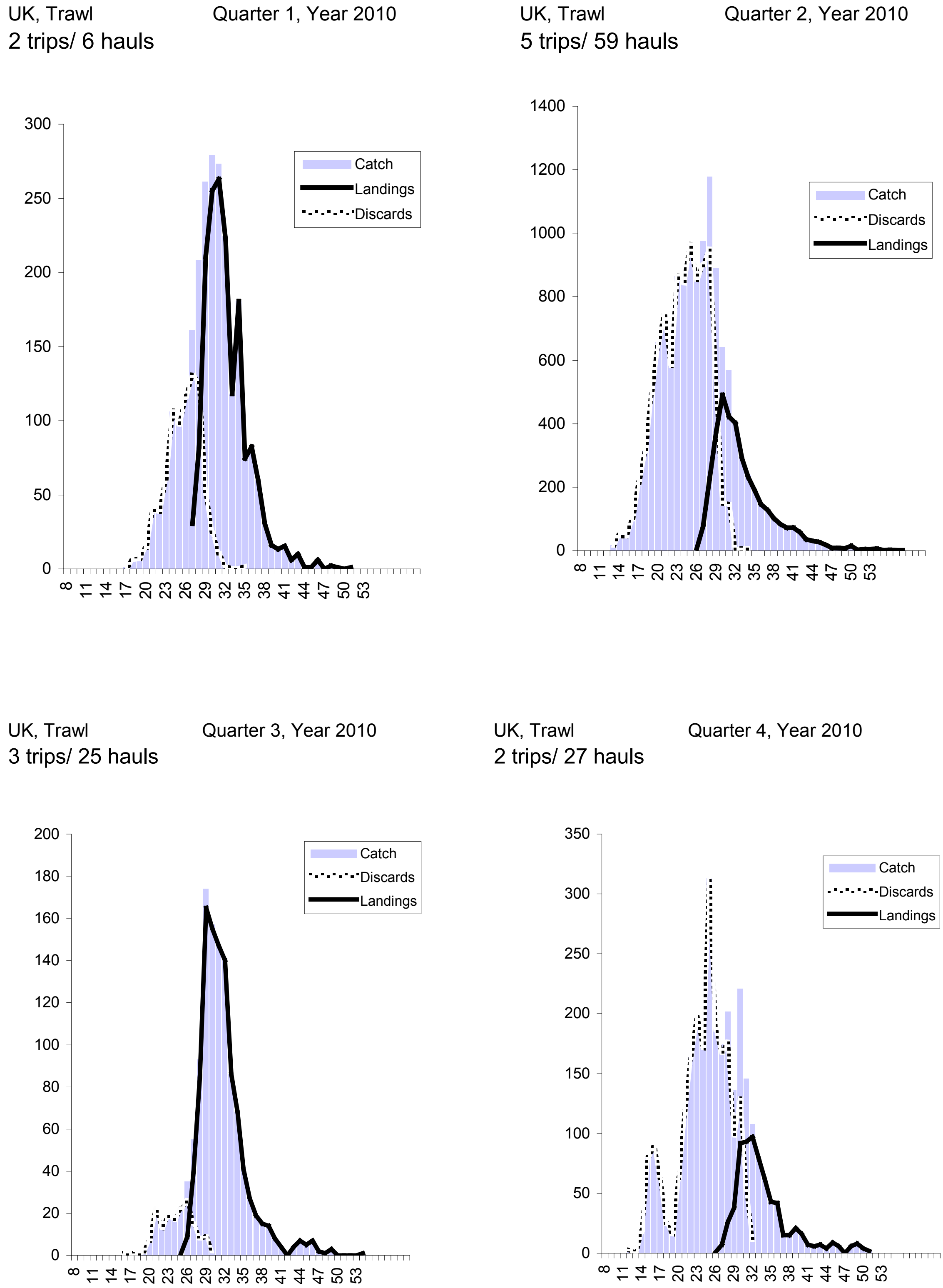


Figure 6.2.1.1a (cont.) - Plaice VIId - Length structure of discards and landings collected by observations on board

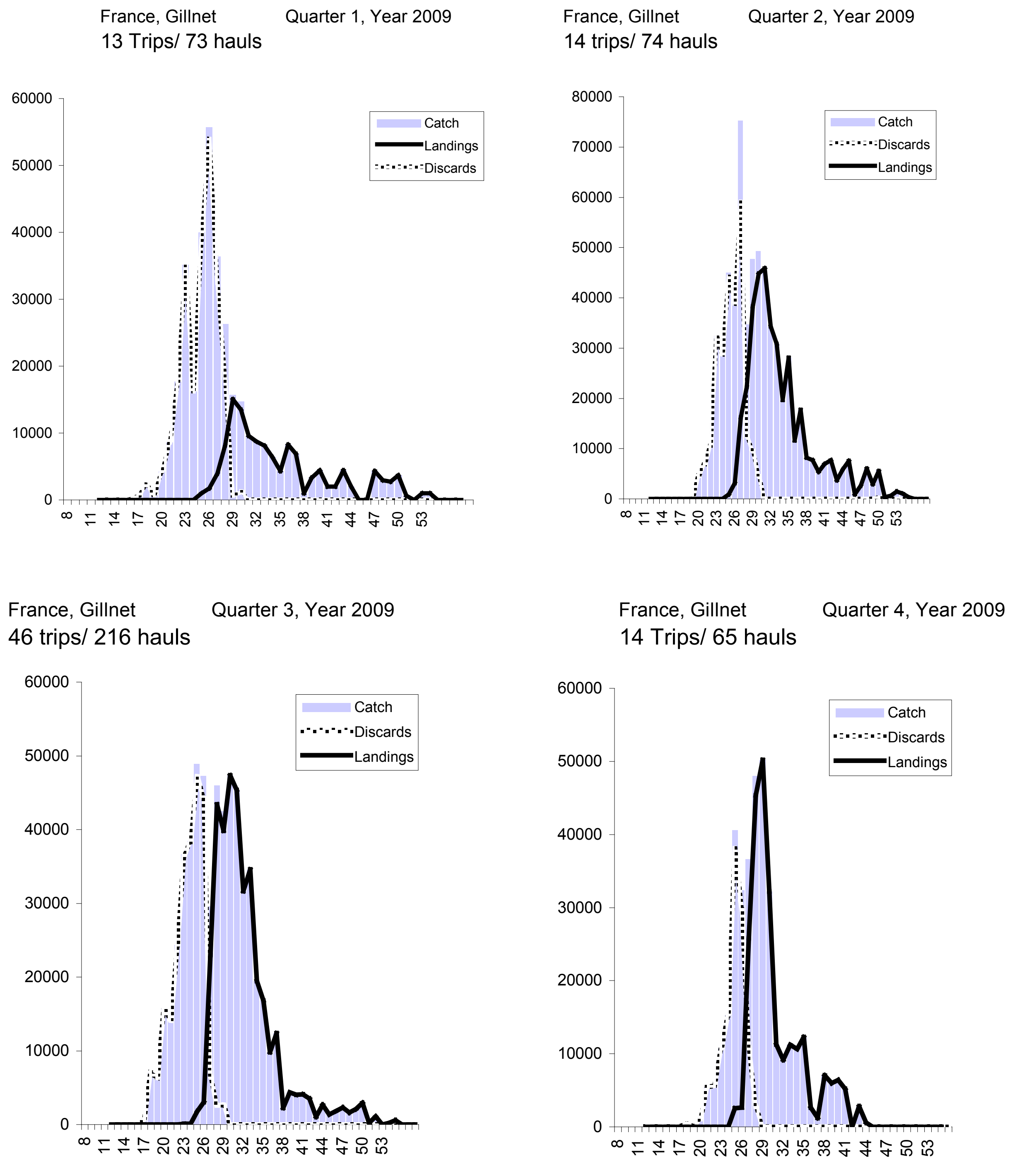


Figure 6.2.1.1b (cont.) - Plaice VIId - Length structure of discards and landings collected by observations on board

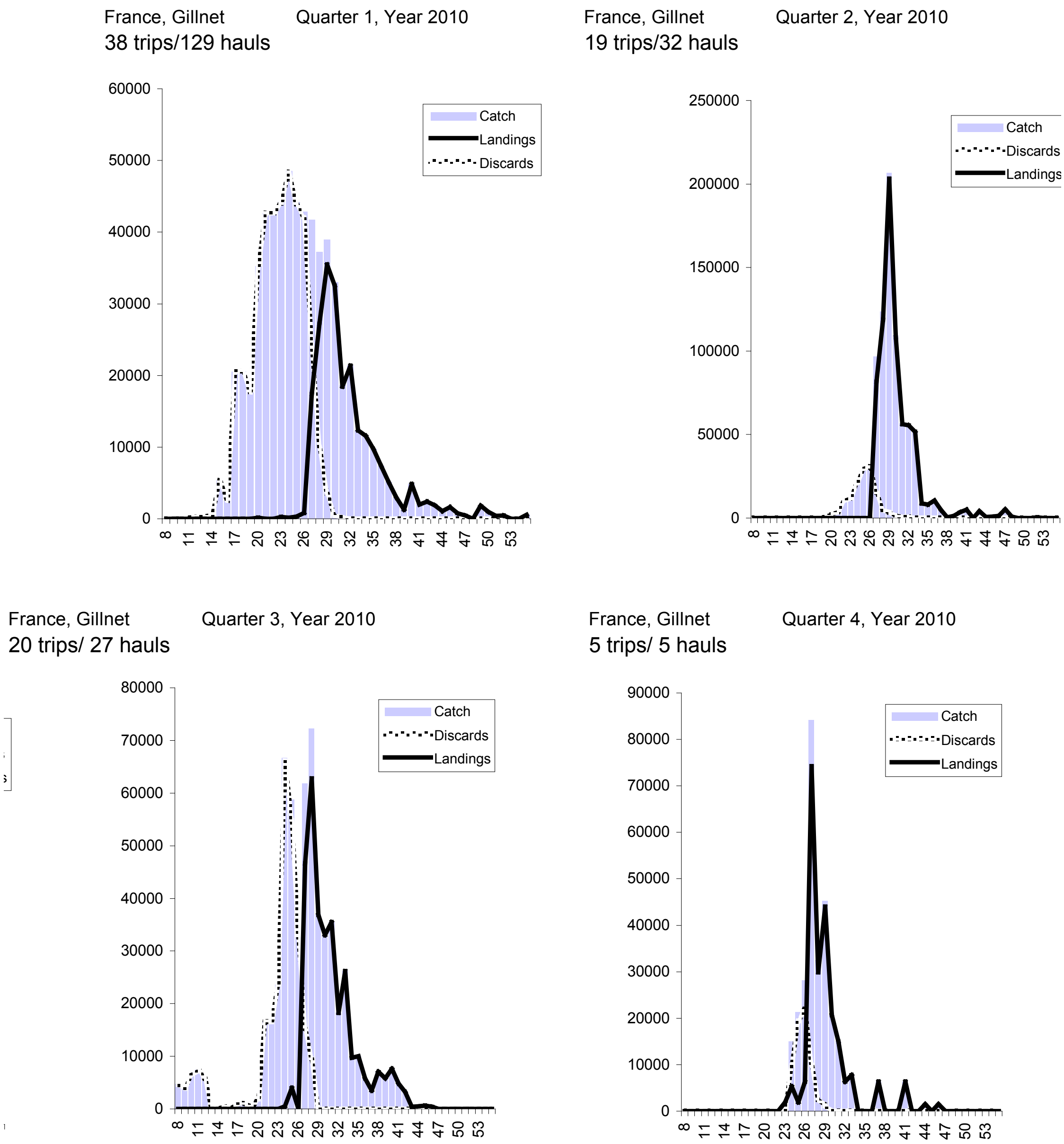


Figure 6.2.1.1b (cont.) - Plaice VIId - Length structure of discards and landings collected by observations on board

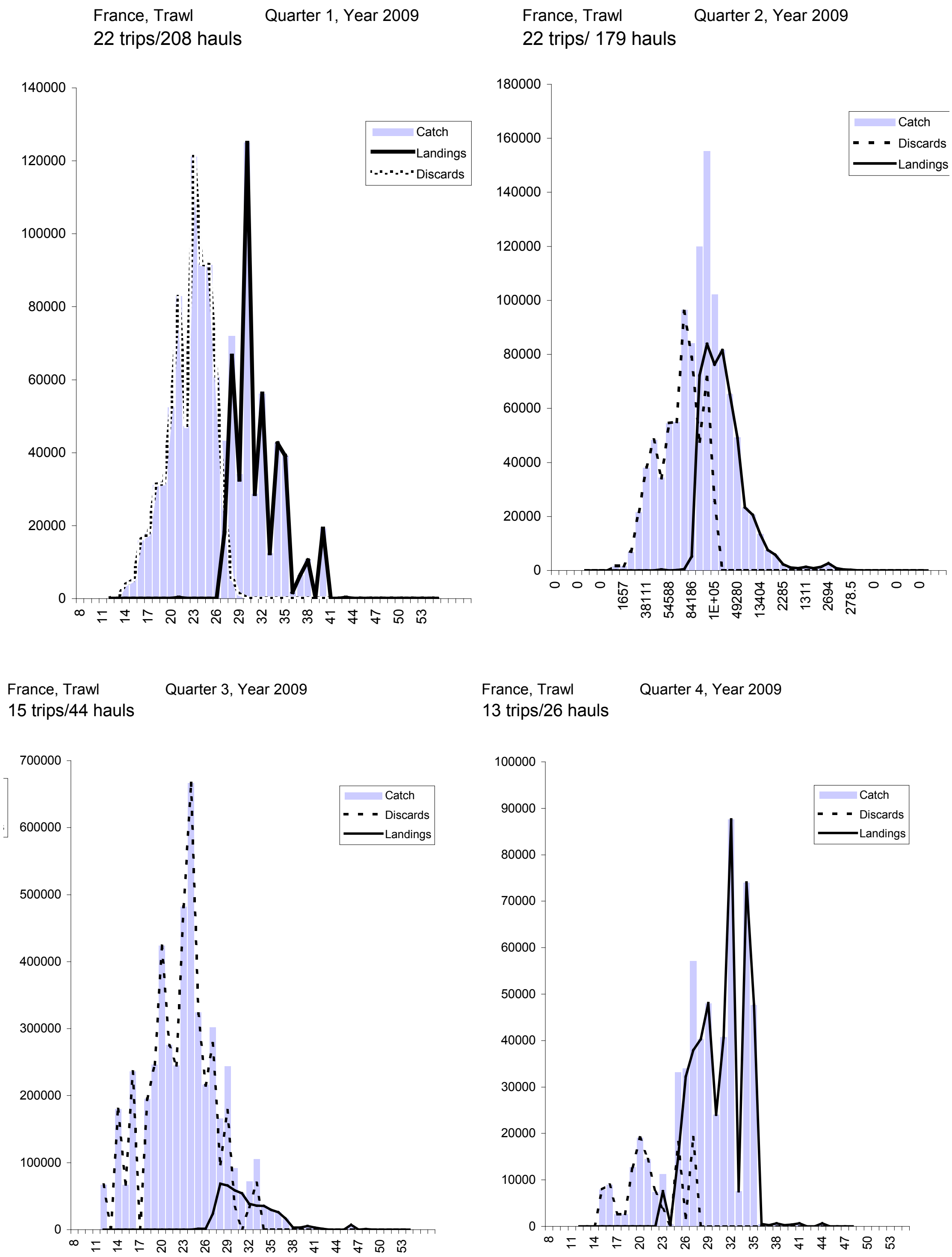


Figure 6.2.1.1c (cont.) - Plaice VIId - Length structure of discards and landings collected by observations on board

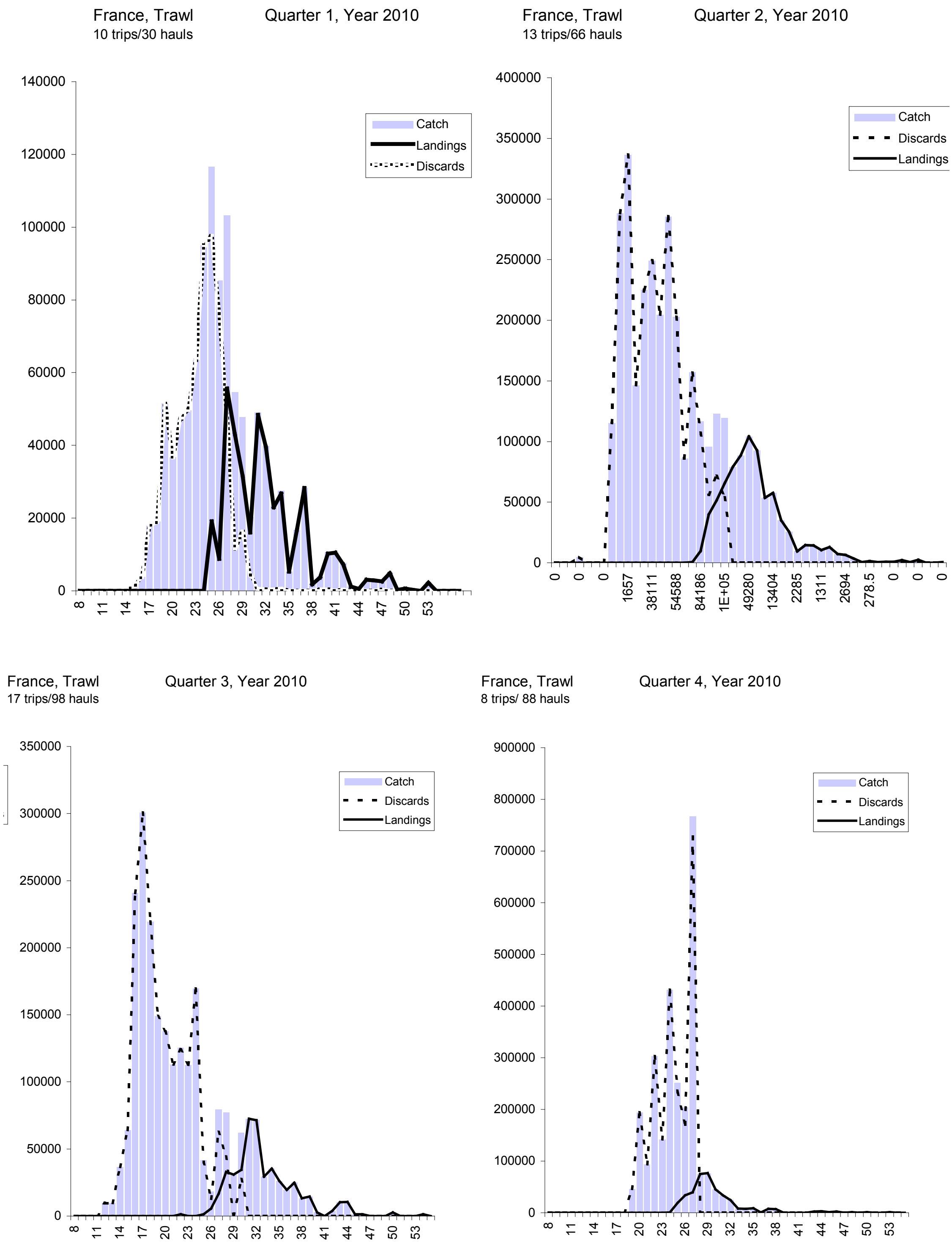


Figure 6.2.1.1c (cont.) - Plaice VIId - Length structure of discards and landings collected by observations on board

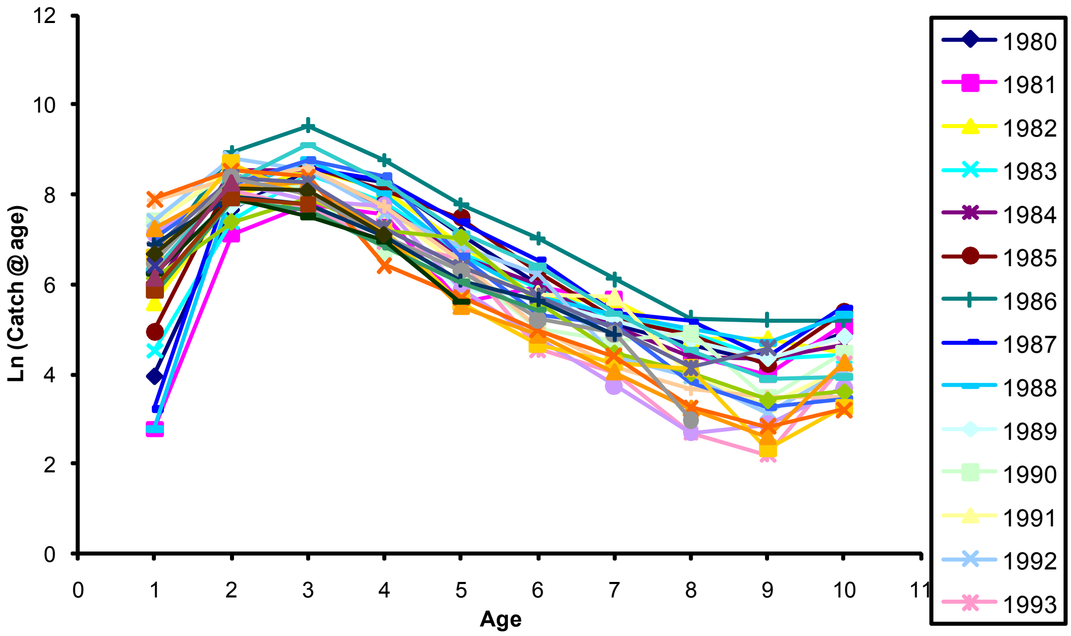


Figure 6.2.1.2a. Plaice in VIId. Catch curves by year class.

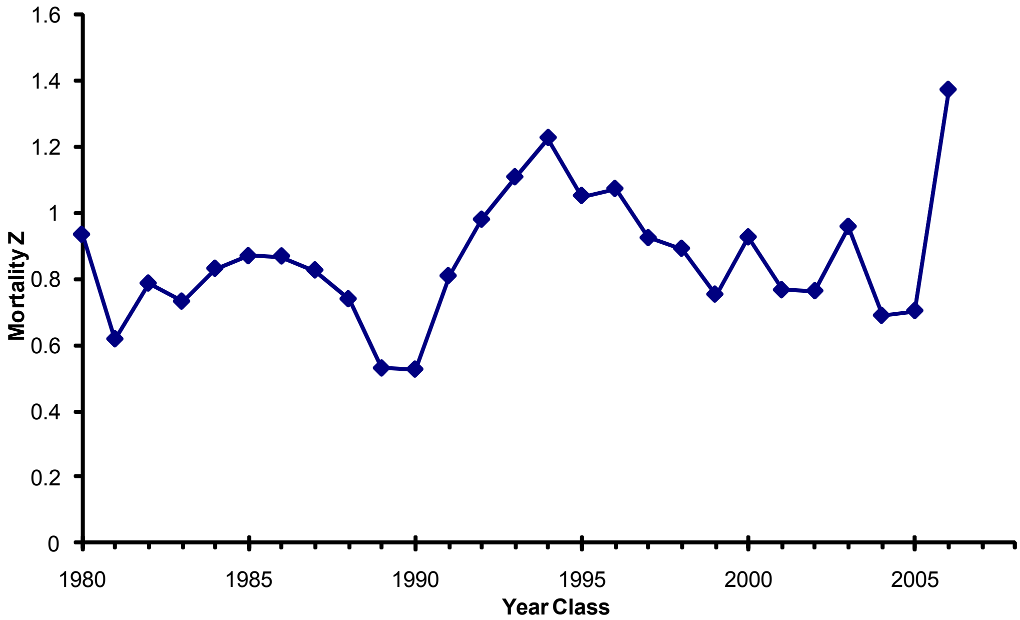


Figure 6.2.1.2b. Plaice in VIId. Evolution of total mortality.

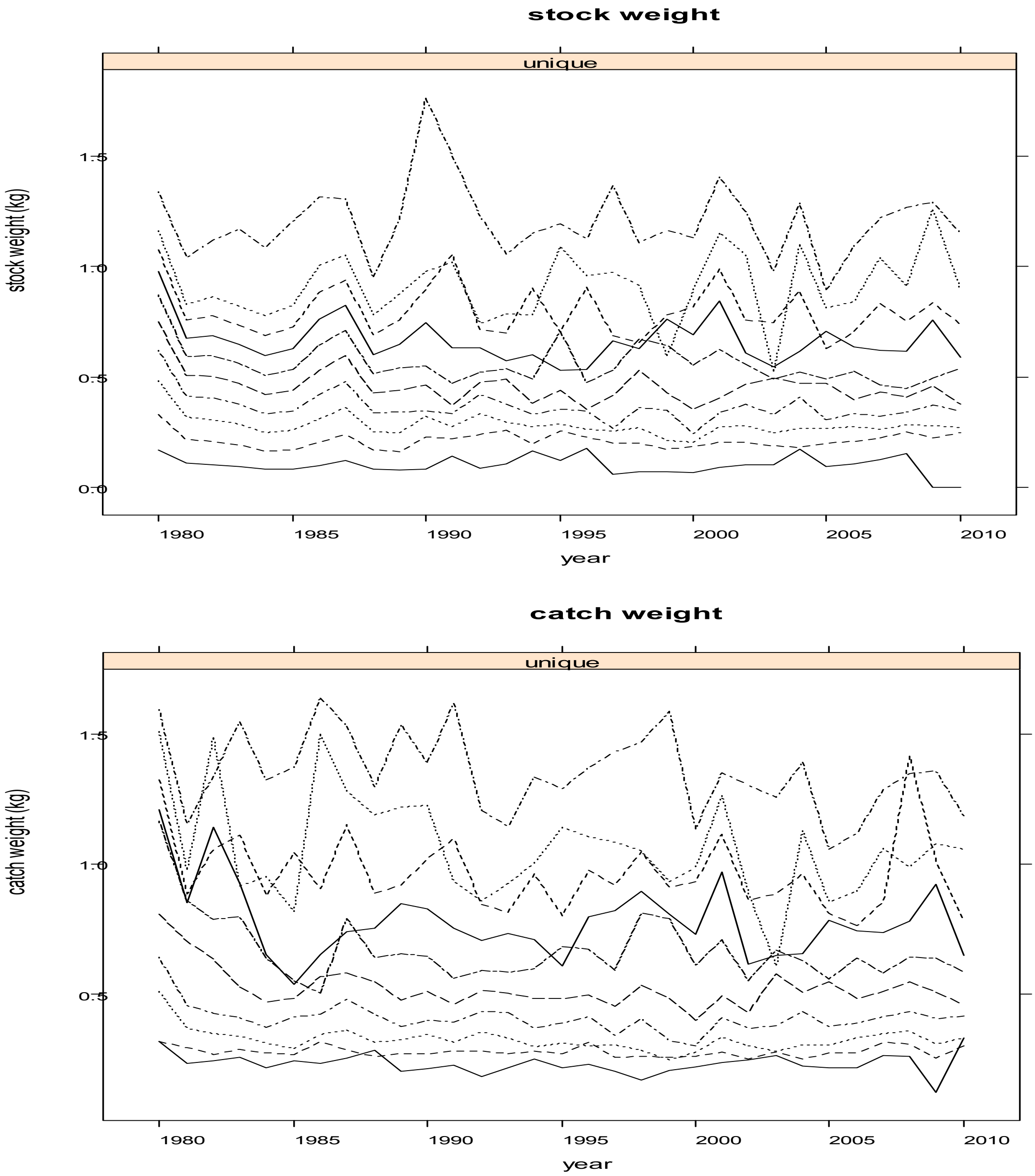
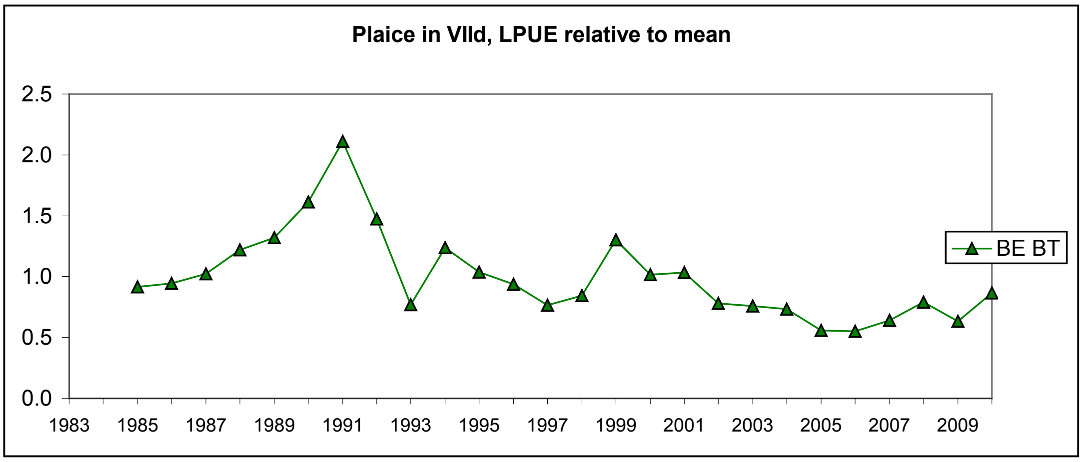


Figure 6.2.3.1. Plaice in VIId. Stock and Catch weight

Figure 6.2.5.1 - Plaice in VIId. LPUE and effort



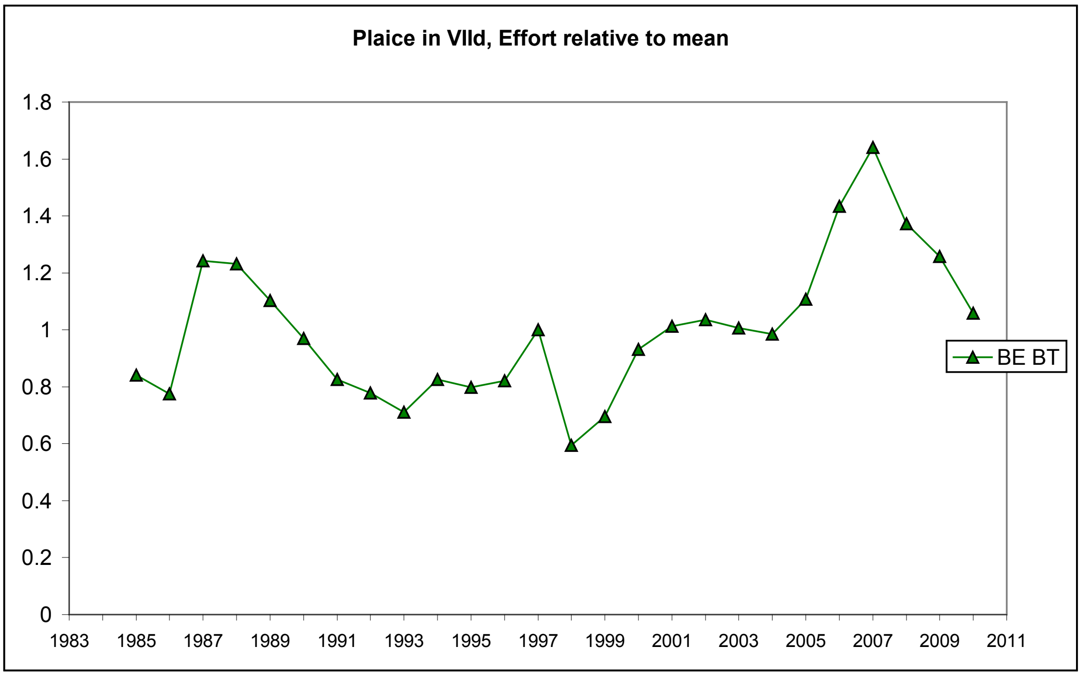


Figure 6.2.5.1 - Plaice in VIId. LPUE and effort

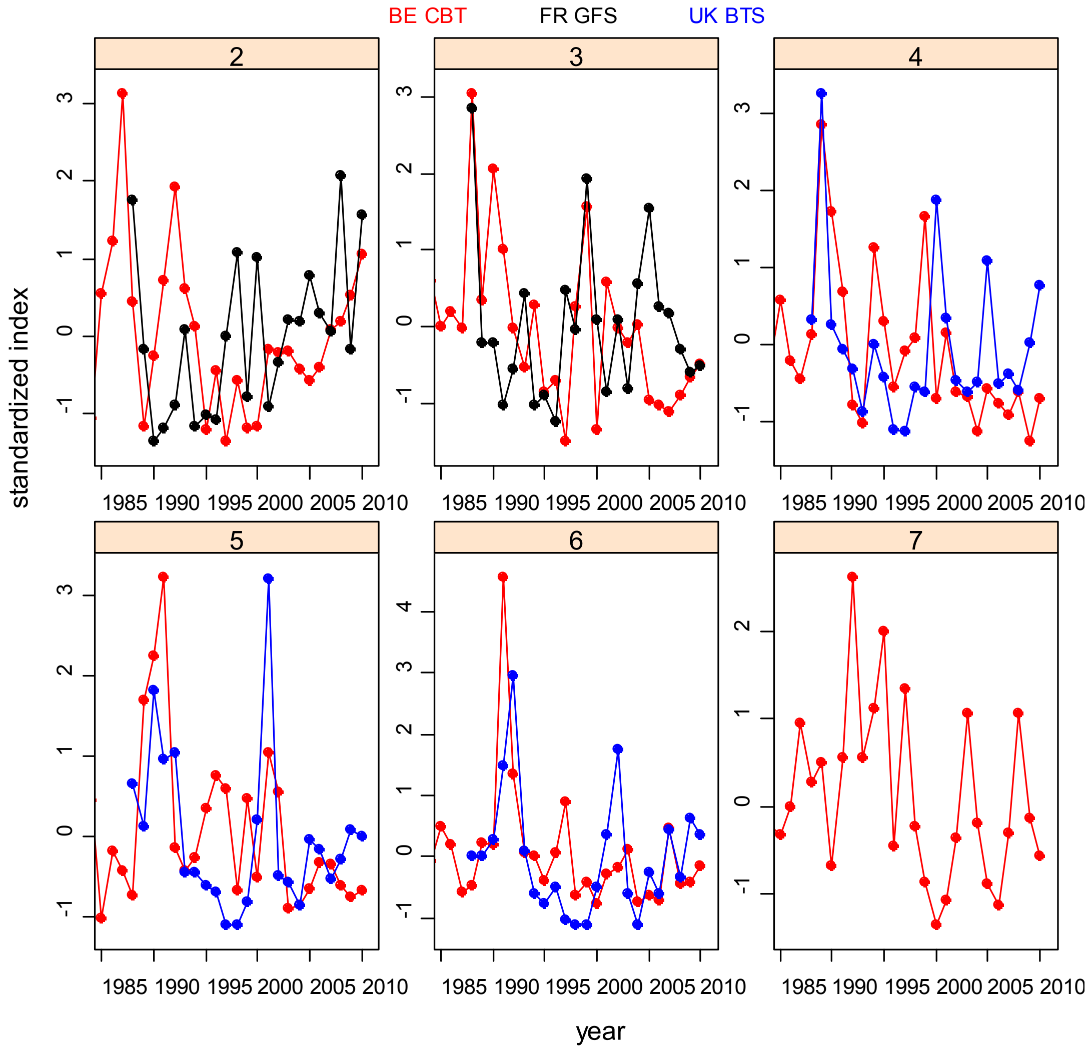
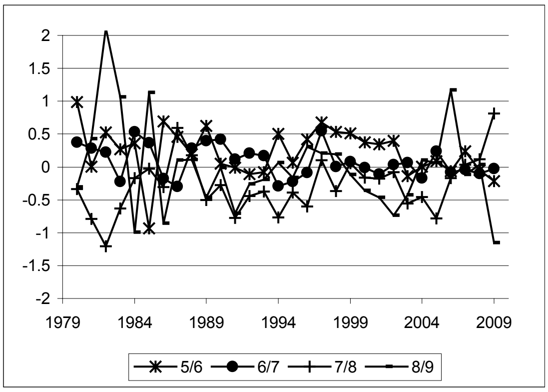
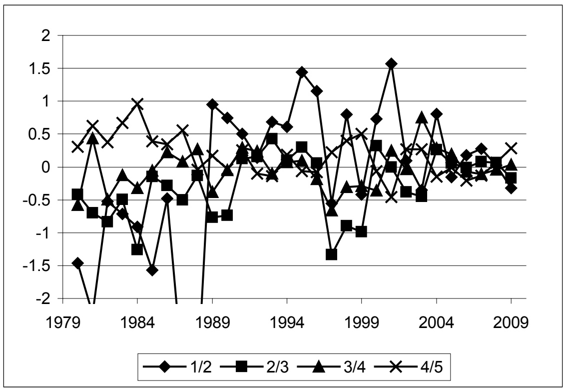


Figure 6.2.5.2. Plaice in VIId. Between survey consistency. Mean standardised indices by surveys for each age





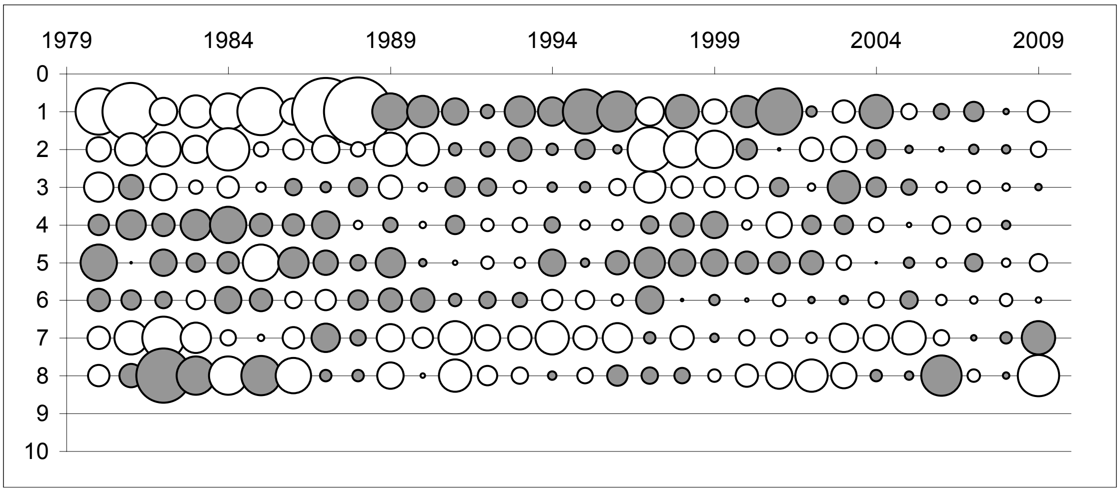


Figure 6.3.2.1 - Plaice in VIId. Separable VPA

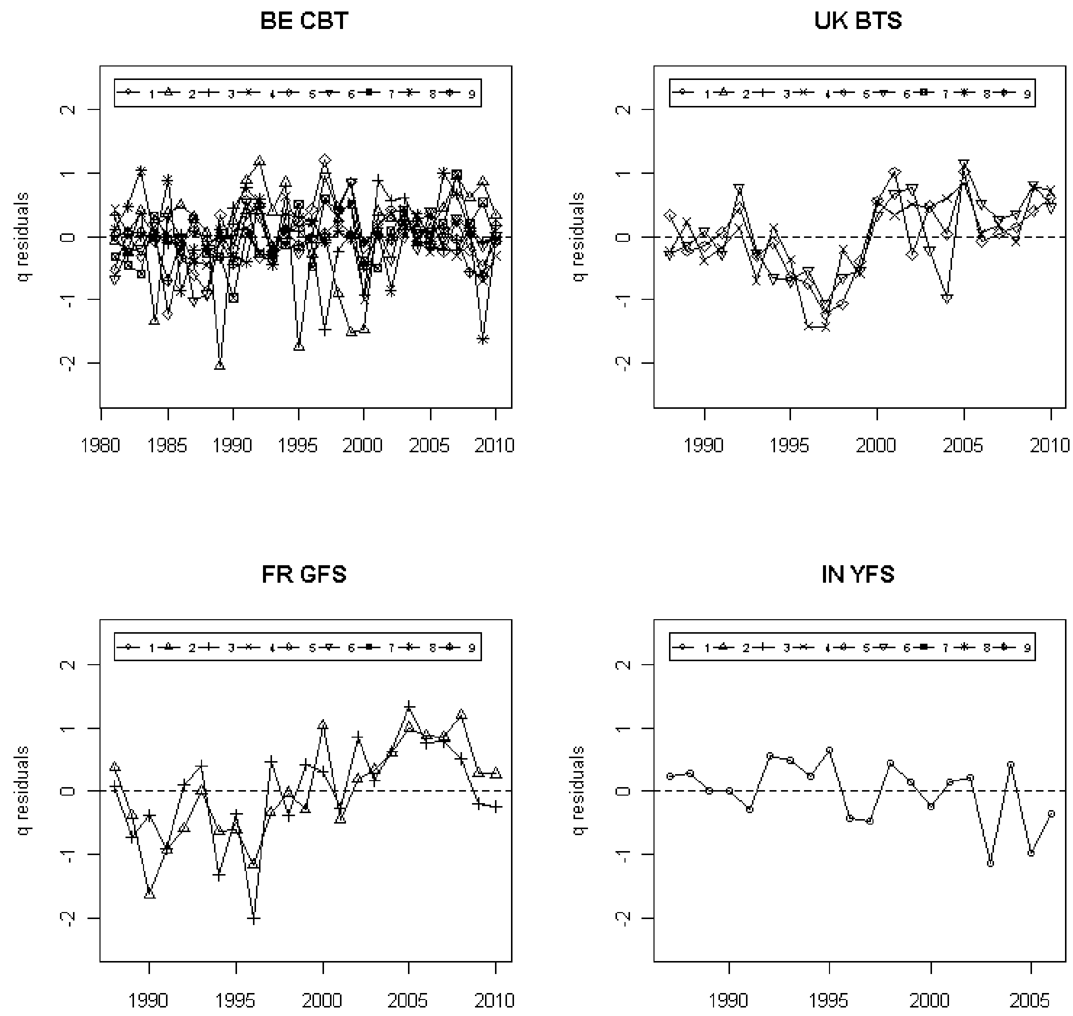


Figure 6.3.2.2. Plaice in VIId. Log q residuals for the single fleet runs (XSA settings and F shrinkage = 1.0)

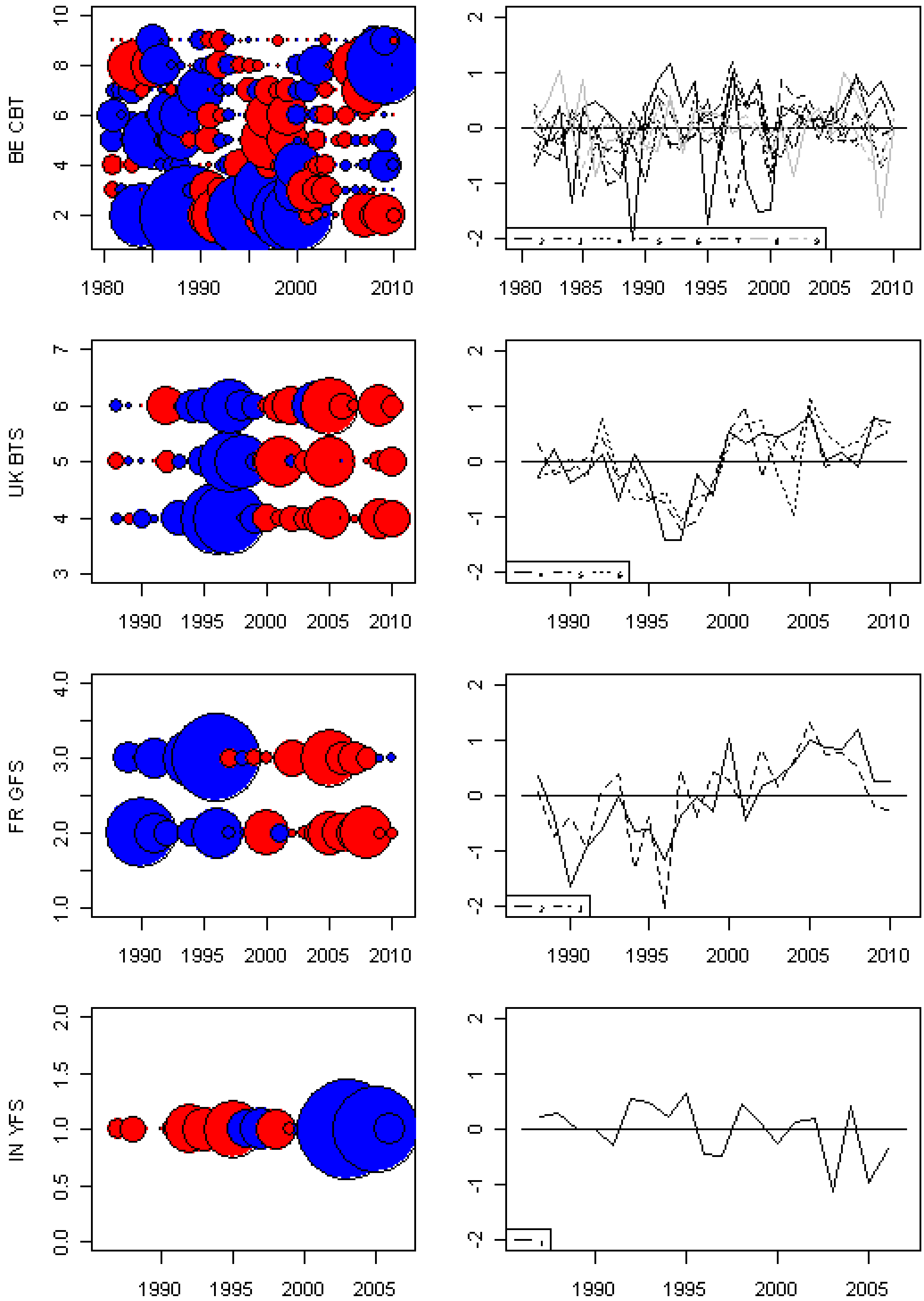


Figure 6.3.2.3. Plaice in VIId. Log q residuals. All fleets combined. Settings as proposed section 6.3.5.

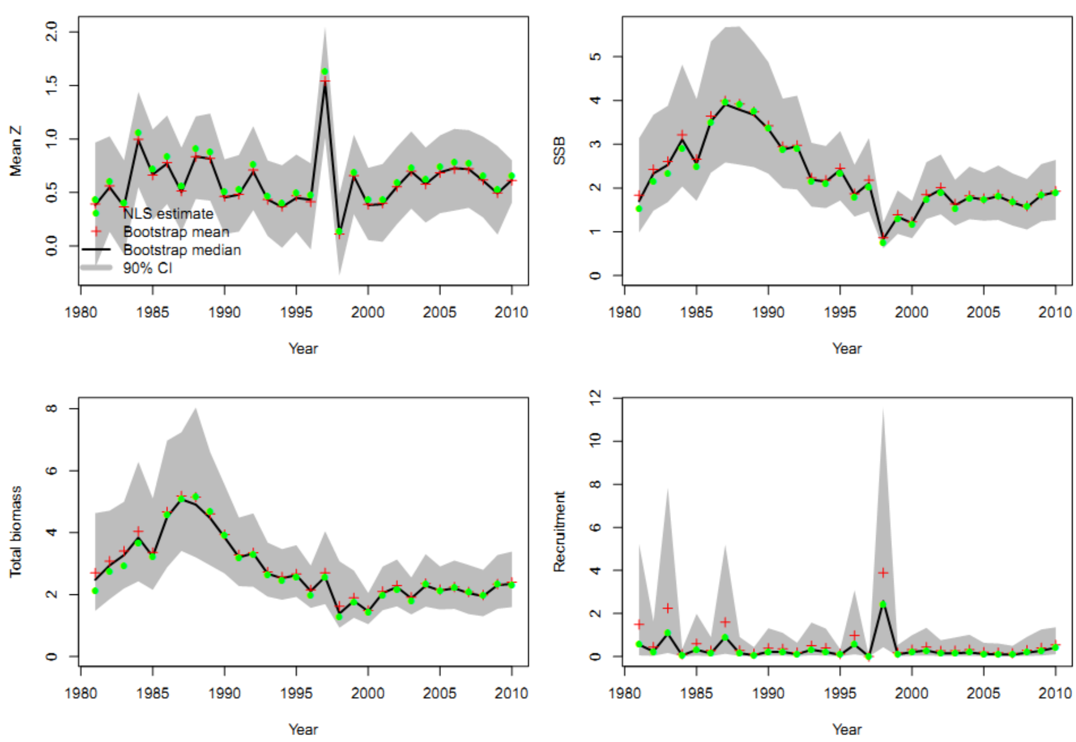


Figure 6.3.3.1. Results of the SURBAR run. Mean mortality Z (ages 3 to 6), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

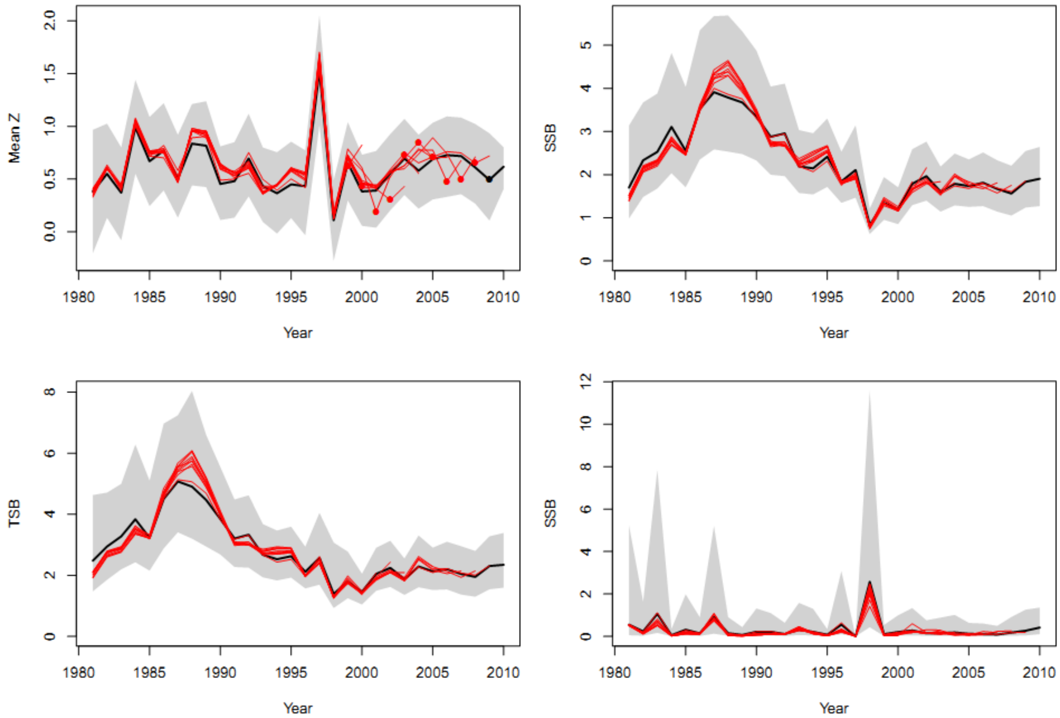


Figure 6.3.3.2. Plaice in VIId. Summary plots of the retrospective analysis from SURBAR. Retrospective analysis plots for mean total mortality Z over ages 3 to 6, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment. The full time-series run is indicated by a black line, the retrospective runs by red lines. Shaded gray areas indicate the 90% CI. For mean Z, the second-last estimate for each analysis is marked with a point (as the last estimate for each analysis is based on a three year mean and is not directly based on data).

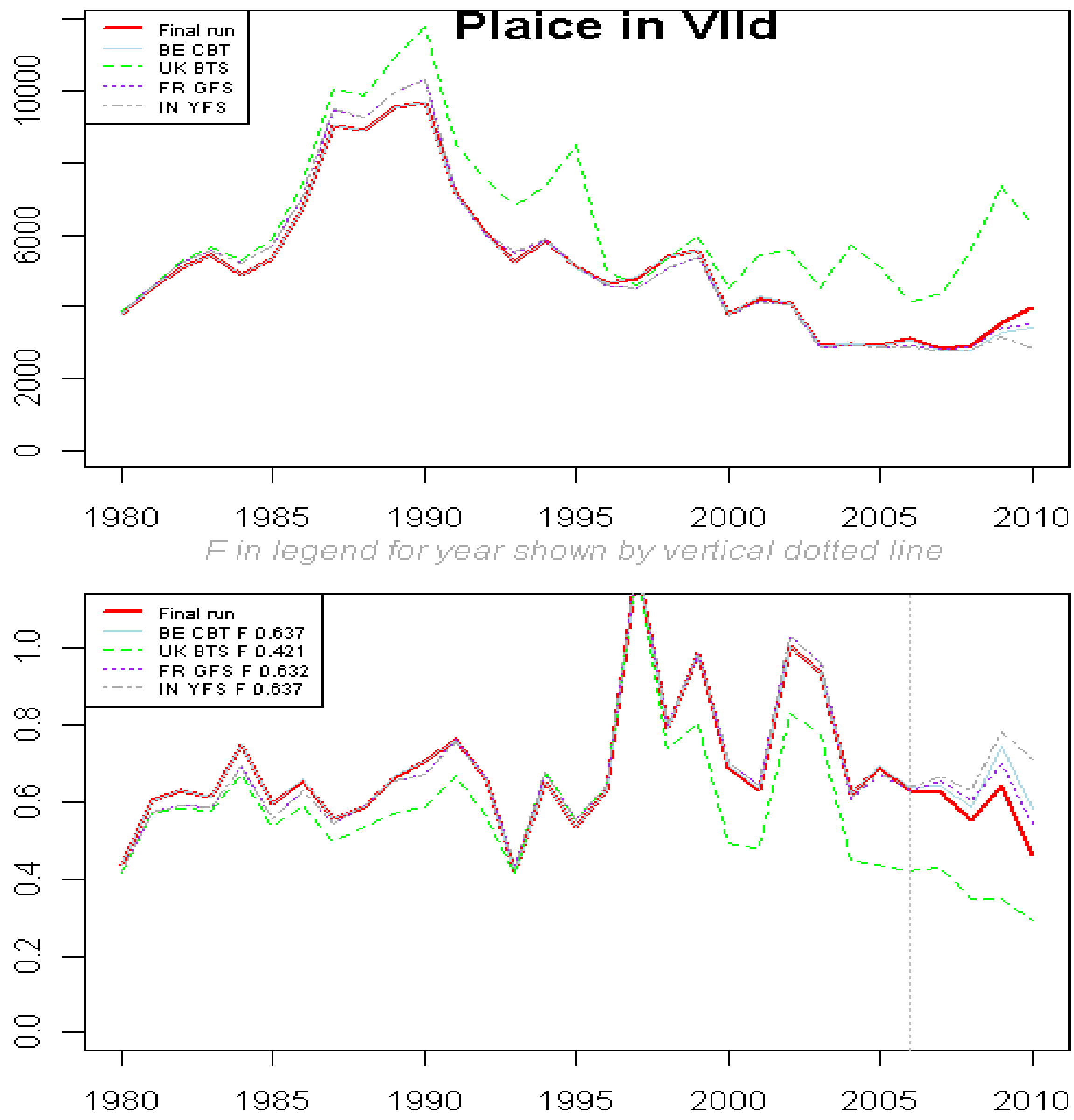


Figure 6.3.4.1. Plaice in VIId. Individual fleet historical performance.

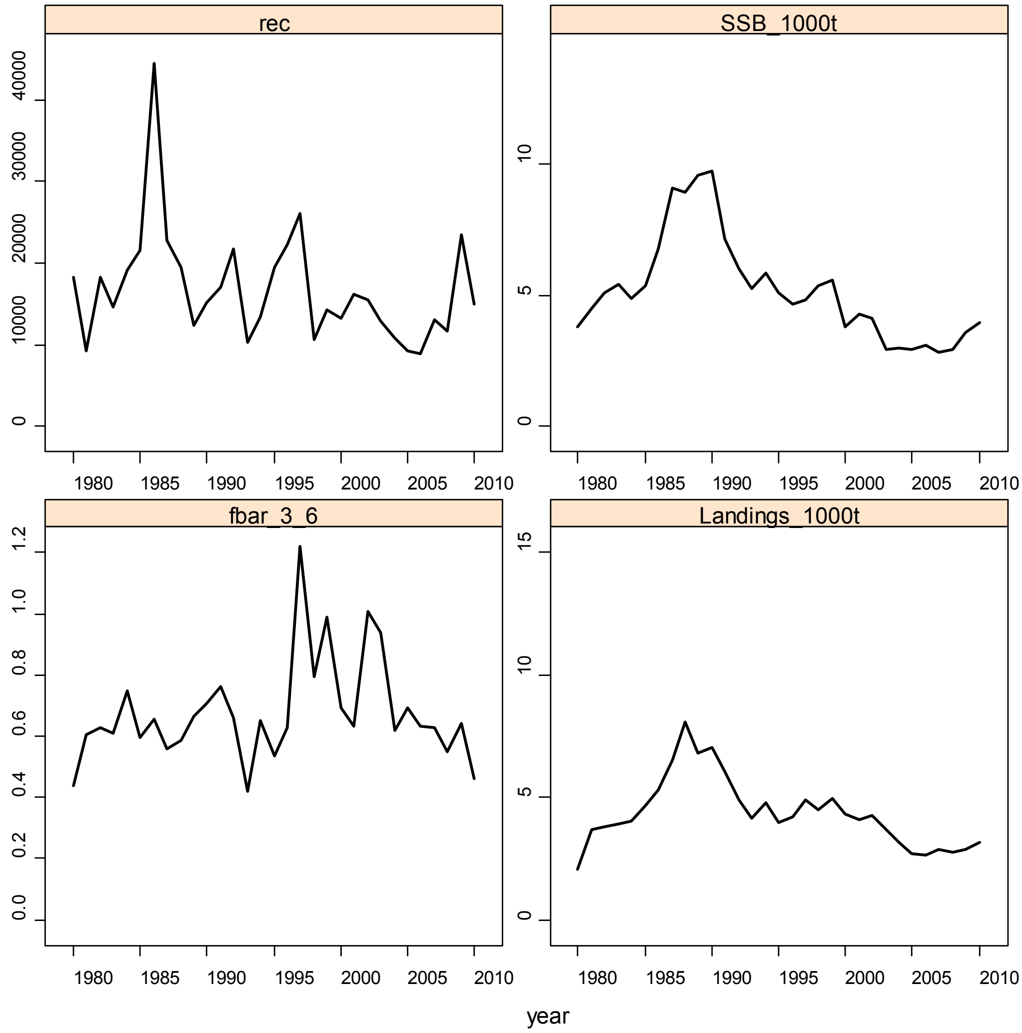


Figure 6.3.5.4. Plaice in VIId. Summary of assessment results

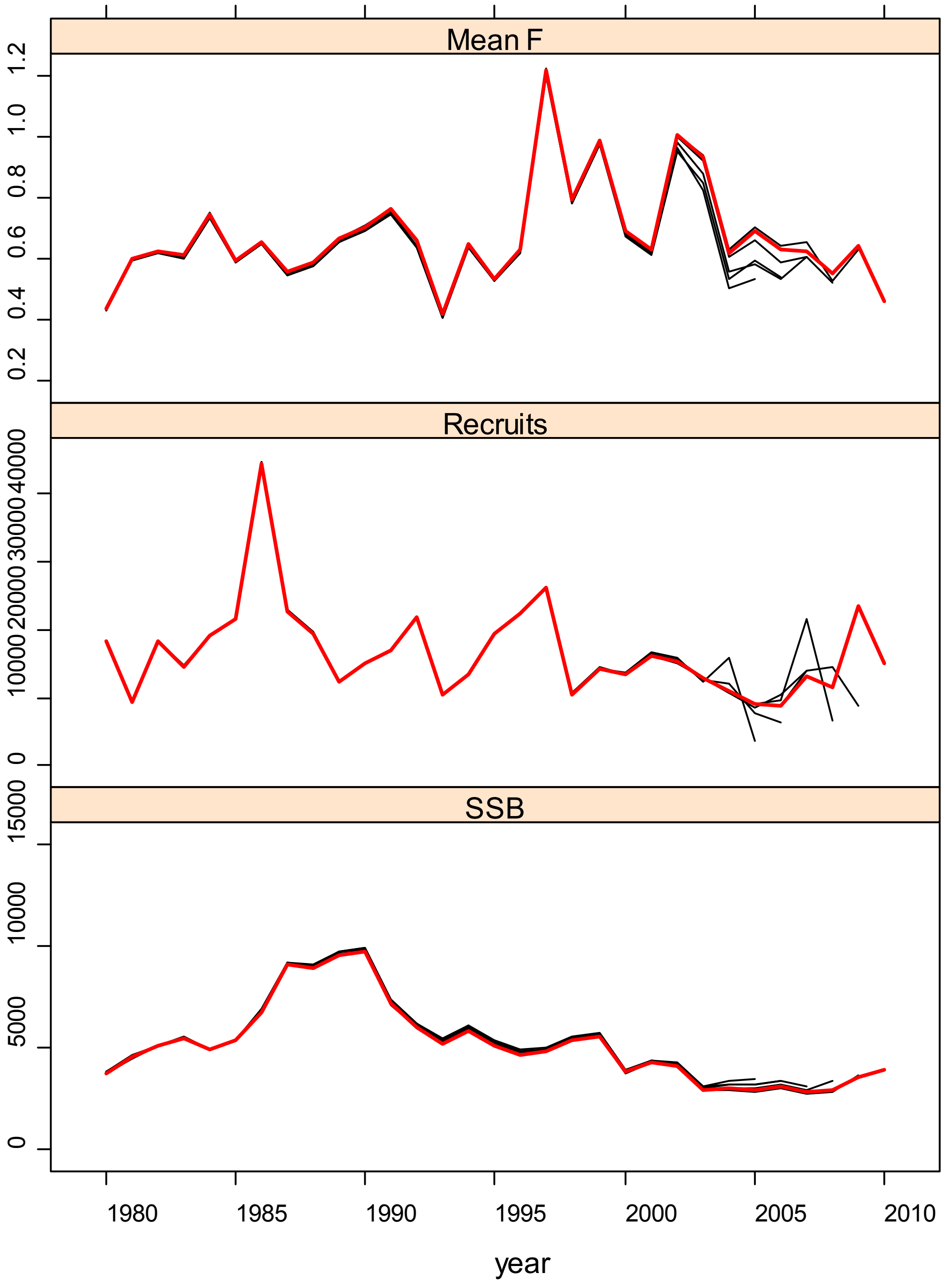


Figure 6.3.5.5. Plaice in VIId. Retrospective patterns for the final run

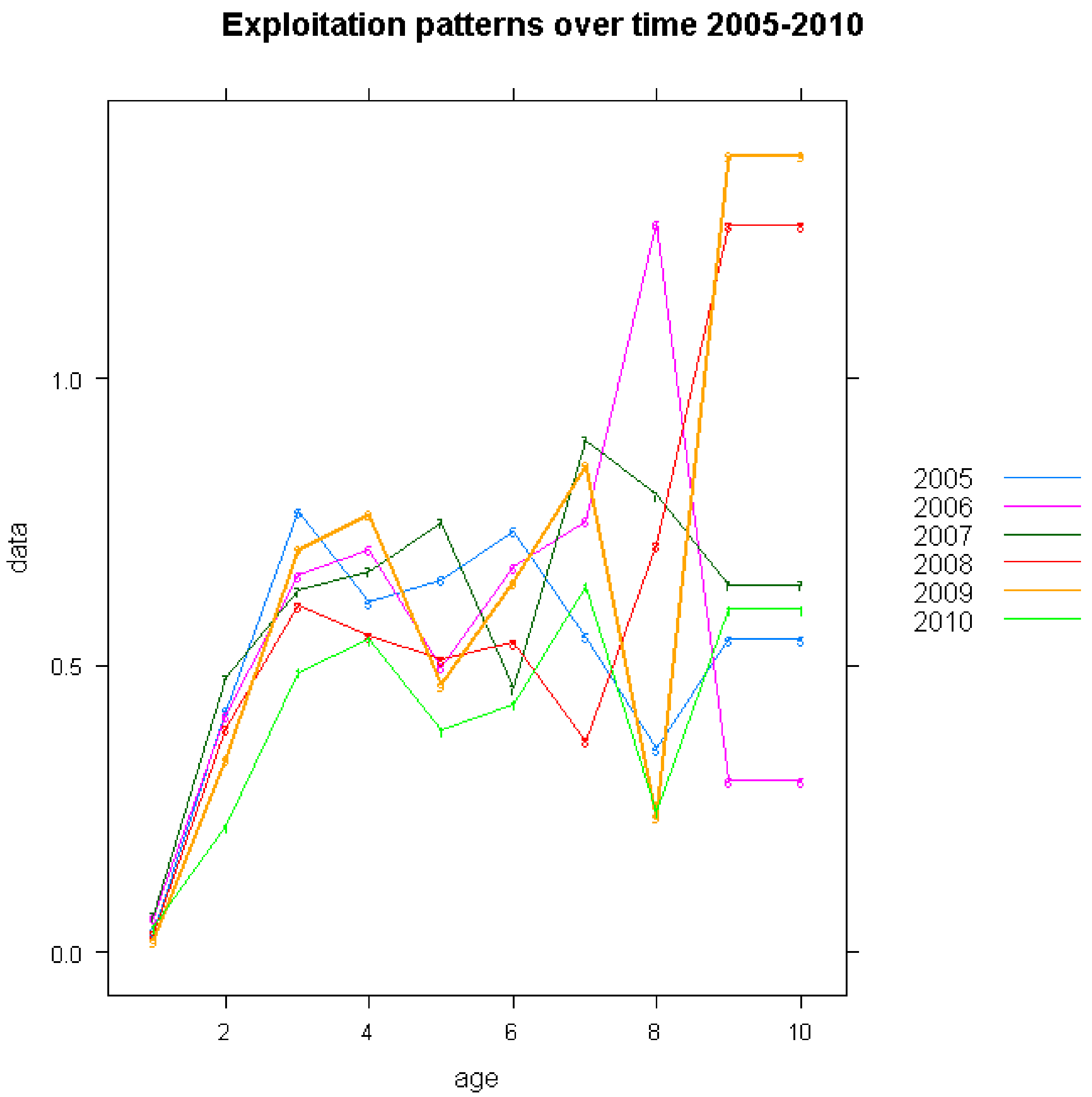


Figure 6.6.1 Plaice in VIId. Trends in F (Age 2 to 6)

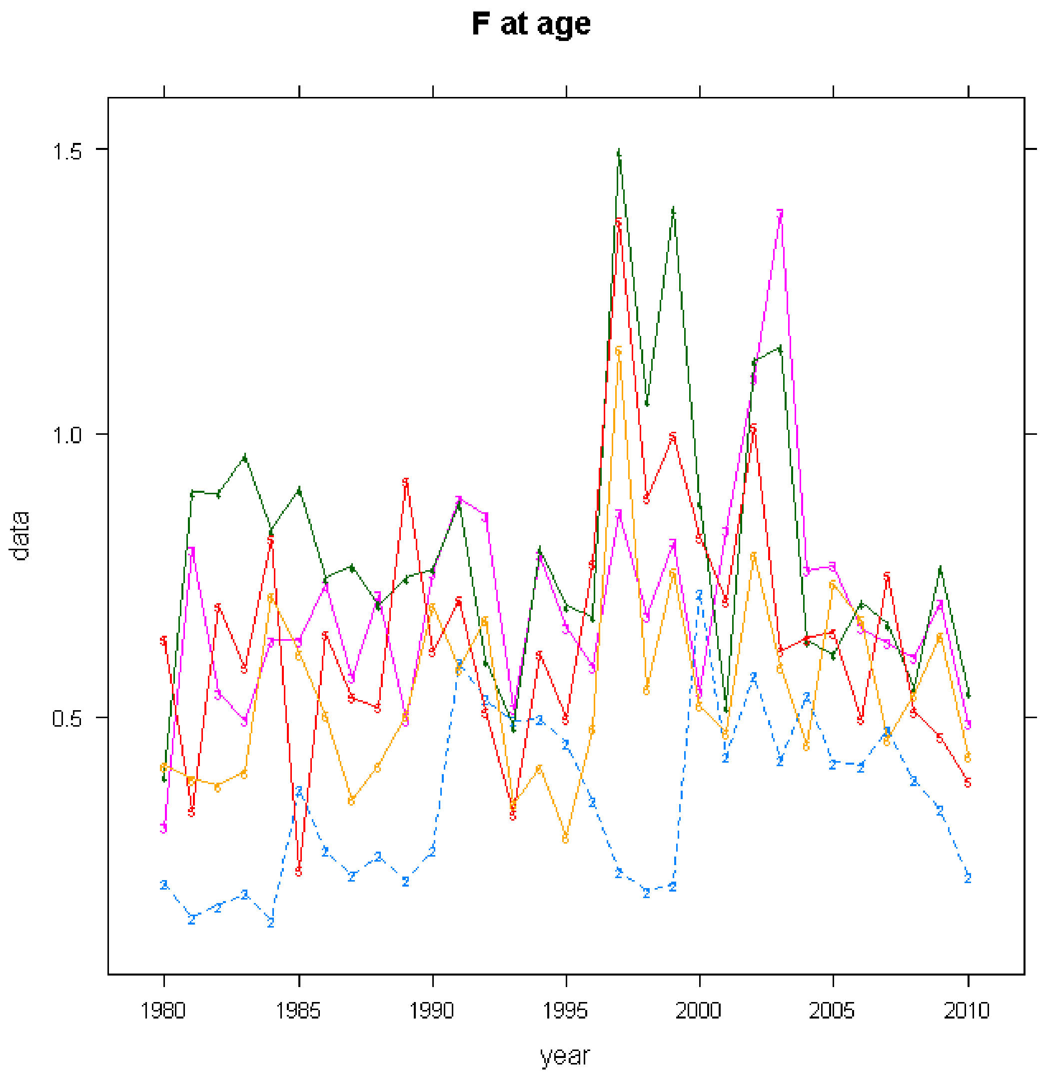


Figure 6.6.2 Plaice in VIId. Exploitation patterns over the last 6 years

7 Plaice in IIIa

No final assessment was produced for this stock.

A large number of issues were investigated during WG sessions in 2006, 2007, and 2009 but the last analytical assessment accepted by the WG was in 2004.

The WG previously 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.

Extensive, in-depth analyses were performed by DTU Aqua in 2010-2011 to investigate these issues related to catch-at-age information, and were presented to the WG during the 2011 meeting. These analyses confirmed previous assumptions that the issues lie beyond what can be addressed through a standard benchmarking procedure. Furthermore, it is considered that enhanced sampling programs would only marginally improve the catch-at-age estimates. A review of the biological knowledge on stock identity points out that the delimitation of a single-stock in area IIIa is questionable, and that the inflow of the North Sea stock in the area blurs the perception of the dynamics of the resident population(s). This issue is to a large extent similar to the stock identity issue hampering the assessment of plaice in area VIId.

The WG considers that an analytical assessment on a single stock in area IIIa is likely not appropriate, and recommends, similarly to WKFLAT 2010, that the continuum of the plaice stocks from the English Channel to the Baltic should be considered in a more integrated way if these issues are to be solved.

This year, exploratory analyses were conducted with XSA and SAM. Reflecting the uncertainty in data the standard trial runs performed by this year's WG showed again large fluctuations in F and SSB and large retrospective patterns.

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.

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

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 though, 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.

7.1.3 Management

There are no explicit management objectives for this stock.

TAC in 2010 was 11 641 t, which is largely similar to the TAC in 2008 and 2009, thus significantly higher than the ICES advice. The TAC was split between Skagerrak and Kattegat, with 9 350 t and 2 291t, respectively. In most

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1 https://stecf.jrc.ec.europa.eu/c/document_library/get_file?p_l_id=53310&folderId=44891&name=DLFE-9402.pdf

years the combined TAC for the area has been largely higher than the actual landings estimates. (Figure 7.1.1). However, while the TAC has been largely unrestrictive in the Kattegat (21% of TAC uptake in 2010), it is better matched to the landings in the Skagerrak (92% of TAC uptake in 2010). (Table 7.1.4).

Based on the EC Policy Paper (COM(2010) 241), The TAC for 2011 was decreased by 15% to 9 938 t (7 950 t in Skagerrak and 1 988 t for Kattegat), which is still above the ICES MSY advice for 2010, but at the level of landings in 2010.

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 long term management plans (EC Council Regulation No. 2056/2001; EC Council Regulation No 676/2007; EC Council Regulation 40/2008).

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, while the KWdays allocations in the Skagerrak are considered within a pool including also North Sea (area IV) and Eastern English Channel (area VIId). 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).

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 2010, 82% of the landings were taken by Denmark. The Swedish landings have declined to very low quantities, and on the contrary landings from the Netherlands have increased in recent years. In 2010, they represented 15% of the landings.

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 (5% of total landings in 2010). This may be largely linked to the general decline in the cod fisheries in the Kattegat and a shift towards mainly *Nephrops* fishery.

According to official national statistics, total landings in 2010 were estimated at 9 183 t, 35% higher than in 2009.

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 (Gatti et al., unpublished; results presented to WGNSSK 2011).

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 7.2.2. There are almost no landings from age 1 plaice, and in consequence the landings-at-age data starts at age 2.

Discards time series from Denmark and Sweden over 2002-2010 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).

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.

Landings and discards at age were raised using ICES InterCatch database.

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.

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.

It is clear that the LPUE from the Danish seiners has continuously increased over the period, potentially indicating significant technical creep which should be further investigated in a future benchmark. (Figure 7.2.6).

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. This issue has not been addressed further.

7.3 Data analyses

7.3.1 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.

7.3.2 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.

7.3.3 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.

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. 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, there are striking differences in the perceptions of stock status in area IIIa compared to the North Sea. While most respondents describe significant increases in stock abundance in the North Sea, there is less optimistic in Skagerrak and even less so in Kattegat, with great proportions of answers indicating "Less" or "Much less" abundance, "Mostly small" fish, and "Low" to "Moderate" recruitment.

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.

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. Furthermore, the FNSSS reported significant perception of negative stock trends in the Kattegat. 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. But these hypotheses cannot be ascertained.

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, as suggested from the increased landings in 2010. 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.

In 2007, WGNSSK identified key issues that would need to be resolved before reaching further improvements in the assessment. In 2011, The WG still considered these issues as outstanding, although sustained scientific effort has tried to address these.

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.

There is however a clear continuum of plaice landings density all along the IIIa area, and no clear alternative stocks boundaries can easily be suggested.

Following the conclusion of the WKFLAT 2010 it is recommended to explore the potential for performing a combined assessment of this continuum of plaice stocks from Kattegat/Baltic to the English Channel. The WGNSSK requests the setup of a Study Group on the identification, assessment and management of plaice stocks, which could convene for the first time during Spring 2012 and address these issues further.

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.

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.

Table 7.1.1 Plaice in IIIa. Official landings in tonnes as reported to ICES and WG estimates, 1972-2010

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		20,599		418		77				3					21,097	
1973		13,892		311		48				6					14,257	
1974		14,830		325		52				5					15,212	
1975		15,046		373		39				6					15,464	
1976		18,738		228		32		717		6					19,721	
1977		24,466		442		32		846		6					25,792	
1978		26,068		405		100		371		9					26,953	
1979		20,766		400		38		763		9					21,976	
1980		15,096		384		40		914		11					16,445	
1981		11,918		366		42		263		13					12,602	
1982		10,506		384		19		127		11					11,047	
1983		10,108		489		36		133		14					10,780	
1984		10,812		699		31		27		22					11,591	
1985		12,625		699		4		136		18					13,482	
1986		13,115		404		2		505		26					14,052	
1987		14,173		548		3		907		27					15,658	19,250
1988		11,602		491		0		716		41					12,850	19,750
1989		7,023		455		0		230		33					7,741	19,000
1990		10,559		981		2		471		69					12,082	13,000
1991		7,546		737		34		315		68					8,700	11,300
1992		10,582		589		117		537		106					11,931	14,000
1993		10,419		462		37		326		79					11,323	14,000
1994		10,330		542		37		325		91					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			181	181			8,514	-1	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			163	163			8,789	127	8,916	14,000
2001	11,114	11,114	385	385	1	0			61	61			11,561	-1	11,560	11,750
2002	8,275	8,276	322	338	29	29			58	58			8,684	17	8,701	12,800
2003	6,884	6884	377	396	14	14			341	341	1494	1584	9,110	109	9,219	16,600
2004	7,135	7,135	317	244	77	77			106	106	1455	1511	9,090	-17	9,073	11,173
2005	5,605	5,619	244	244	21	47			116	116	808	915	6,794	147	6,941	9,500
2006	7,690	7,689	349	350	34	34			142	142	1,167	1,190	9,382	23	9,405	9,600
2007	6,665	6,664	333	331	31	31			99	100		1,659	7,128		8,785	10,625
2008	7,768	7,767	356	355	23	11			79	79	433	403	8,659	-44	8,615	11,688
2009		6,183		176		18				60		255			6,692	11688
2010		7,520		177		17		73		49		1,332			9,168	11641
2011																9938

Table 7.1.2. Plaice in Kattegat. Landings in tonnes Working Group estimates, 1972-2010

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

* years 1972-1990 landings refers to IIIA

Table 7.1.3. Plaice in Skagerrak. Landings in tonnes. Working Group estimates, 1972-2010

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	7,092	111	14		49	1,332	8,598	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

Table 7.2.2. Plaice IIIa. Mean weight at age in catch(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

Table 7.2.3. Plaice IIIa. 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

Table 7.2.4. Plaice IIIa. Discard numbers ('000)

	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

Table 7.2.5. Plaice IIIa. Discard mean weight (kg)

	Age									
Year	0	1	2	3	4	5	6	7	8	9
2002	0.03	0.07	0.12	0.14	0.15	0.17	0.26	0.27	0.32	0.32
2003	0.03	0.06	0.12	0.14	0.15	0.16	0.23	0.27	0.30	0.30
2004	0.03	0.08	0.11	0.14	0.15	0.16	0.18	0.28	0.30	0.30
2005	0.03	0.08	0.11	0.13	0.15	0.16	0.18	0.21	0.16	0.30
2006	0.03	0.08	0.12	0.14	0.15	0.16	0.21	0.25	0.27	0.30
2007	0.03	0.09	0.12	0.14	0.16	0.17	0.18	0.20	0.23	0.24
2008	0.03	0.07	0.09	0.13	0.16	0.18	0.17	0.28	0.21	0.15
2009	0.03	0.07	0.11	0.14	0.16	0.18	0.18	0.33	0.28	0.30
2010	0.00	0.08	0.11	0.14	0.17	0.16	0.22	0.15	0.12	0.00

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

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"

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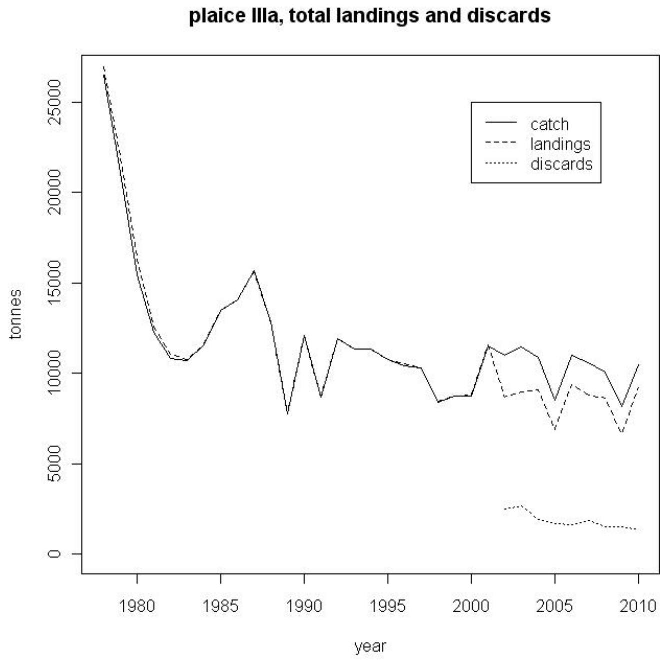
DK Gillnetters

1995	2010								
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

DK Seiners

1995	2010								
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



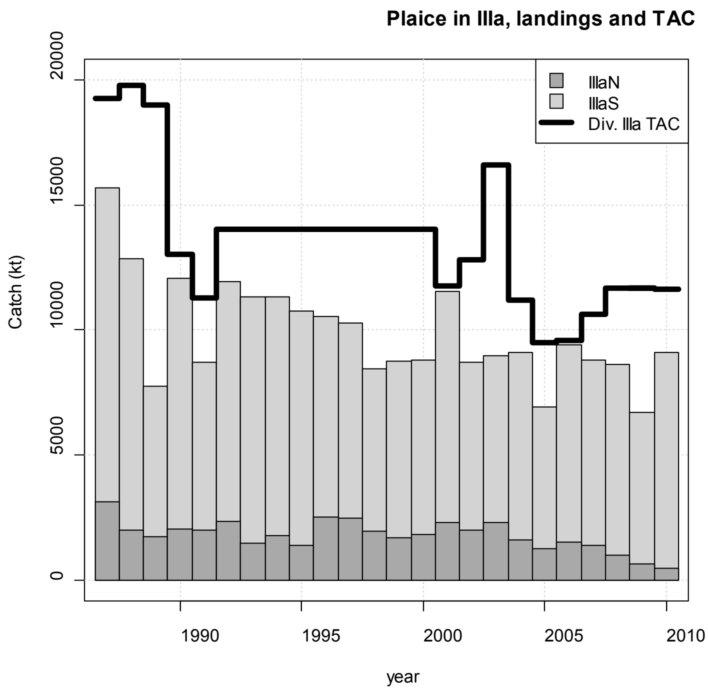


Figure 7.1.1. Plaice IIIa. Upper : Total landings and discards, 1978-2010. Lower : Landings by area and combined TAC

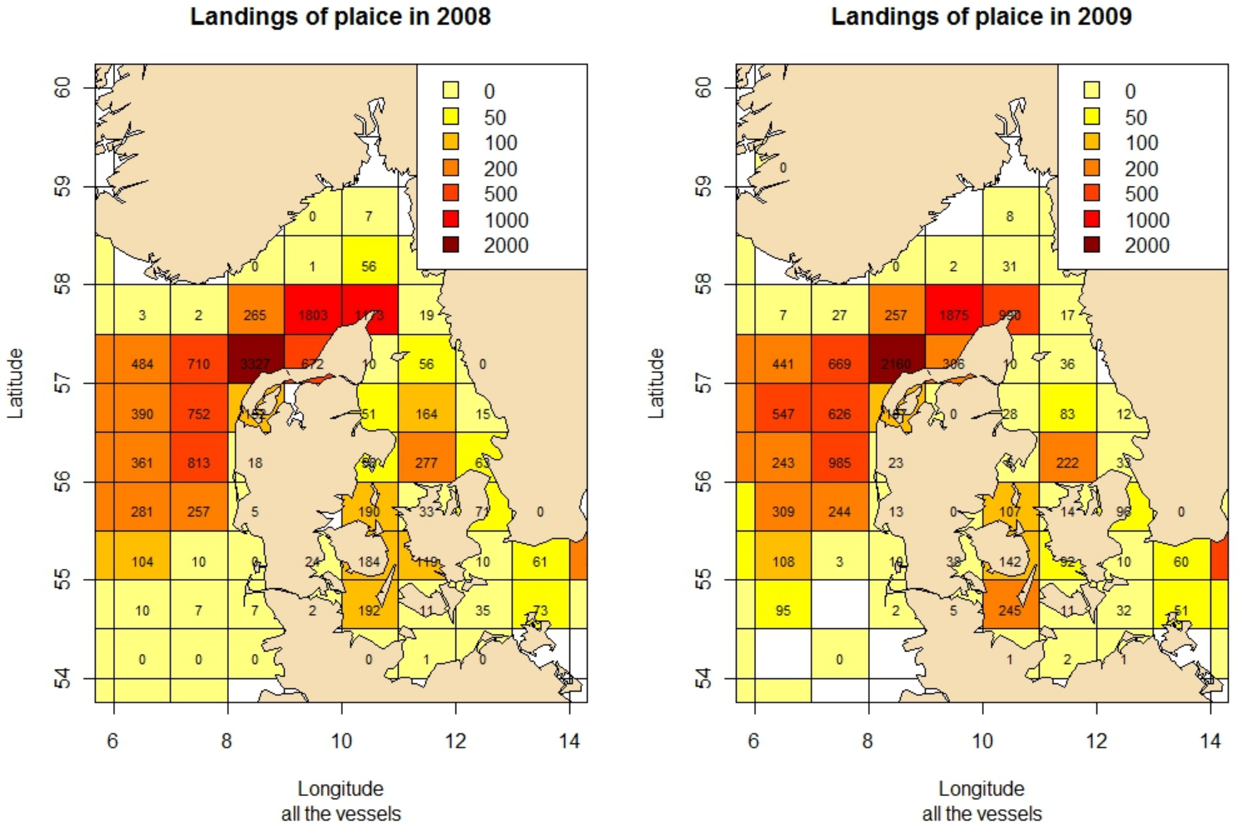


Figure 7.2.1. Annual distribution of Danish plaice landings in 2008 and 2009.

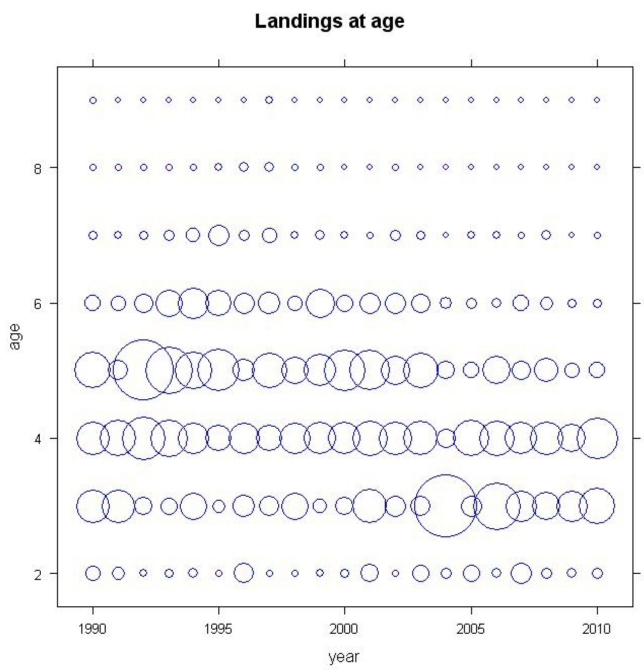


Figure 7.2.2. Plaice IIIa. Relative landings at age.

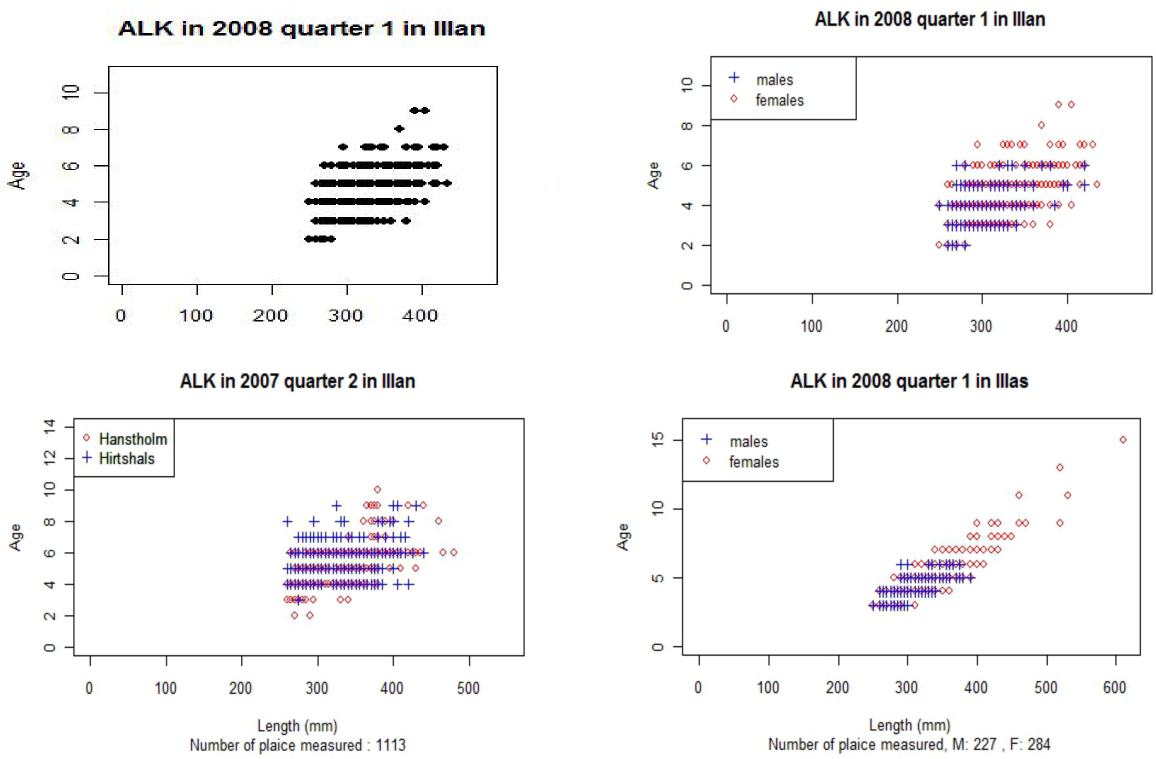


Figure 7.2.3. Example of Age-length key analysis. Ages overlap across length distribution, and there is no strong effect linked to either sex or sampling harbor.

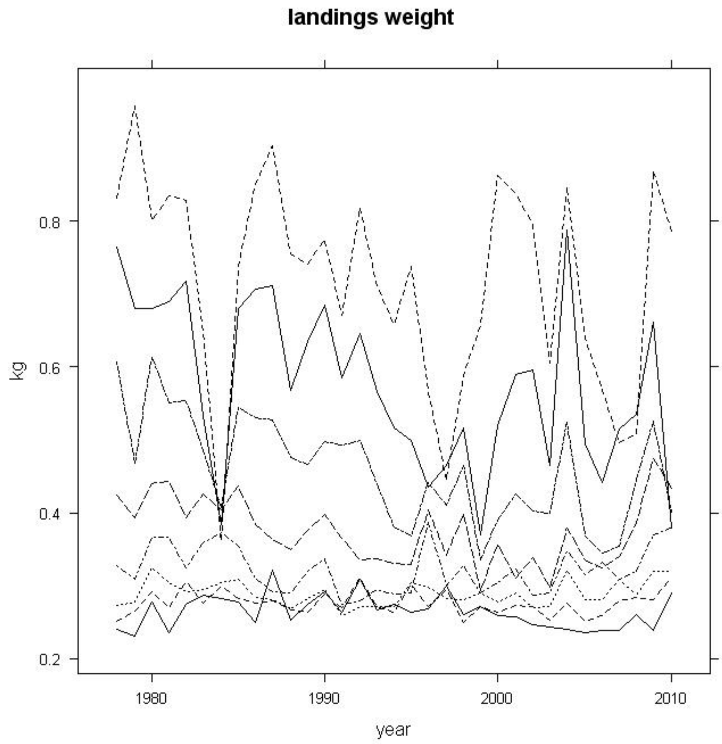


Figure 7.2.4. Landings weight at age

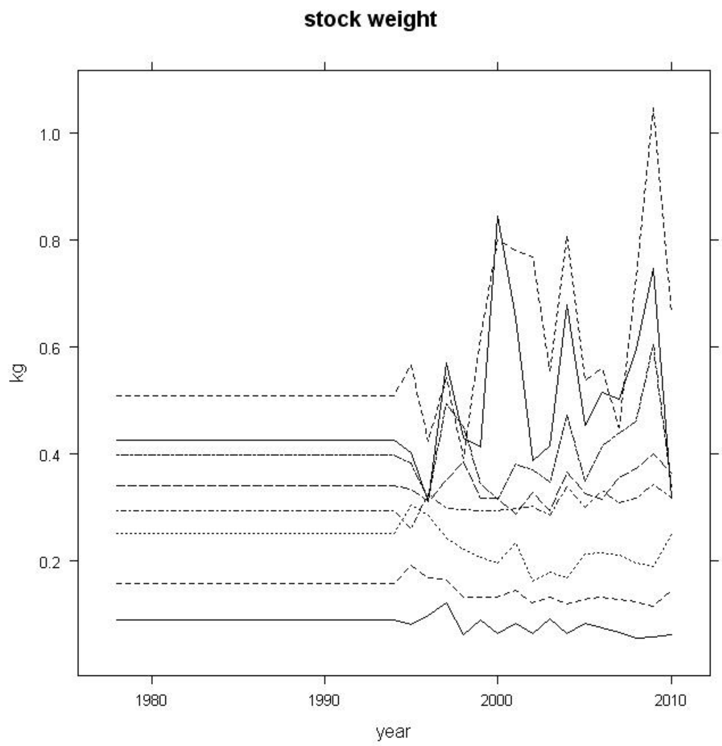


Figure 7.2.5. Stock weight at age

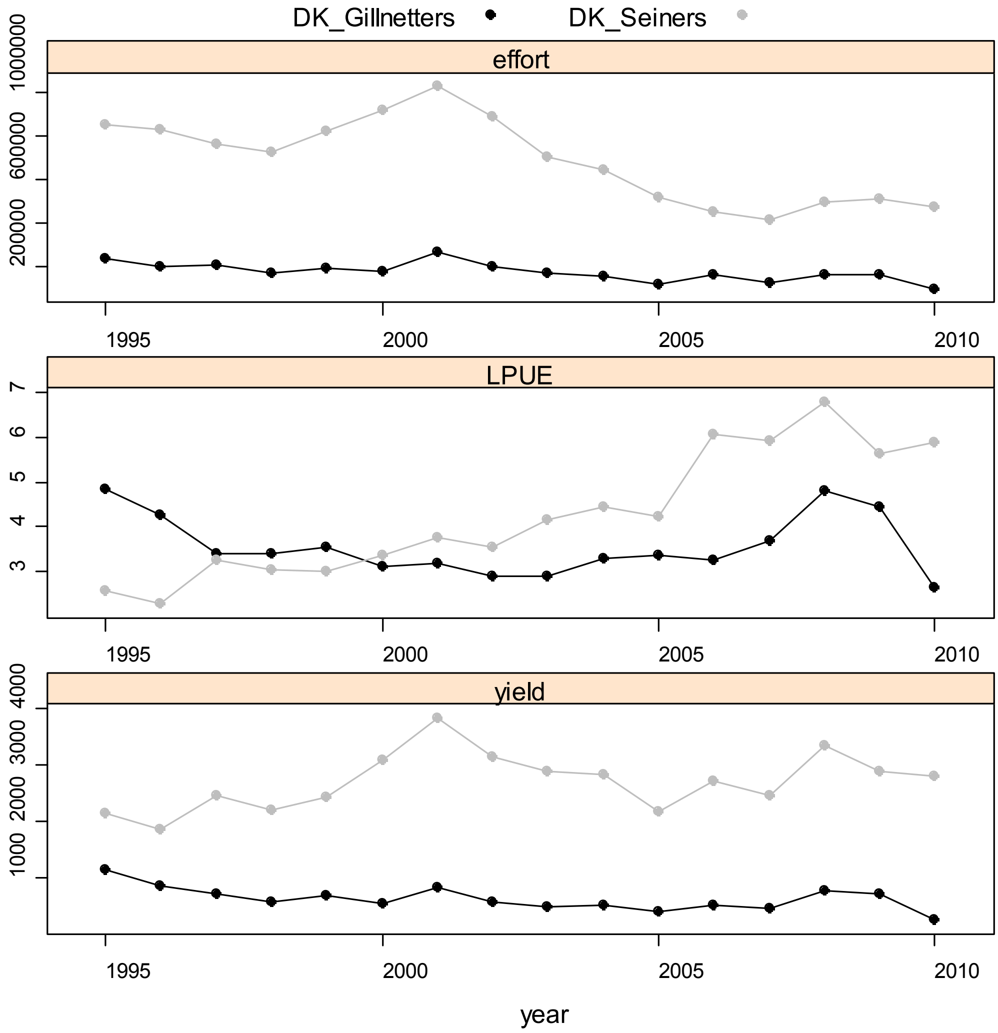


Figure 7.2.6. Plaice IIIa. Effort, landing and LPUE for the Danish commercial tuning fleets.

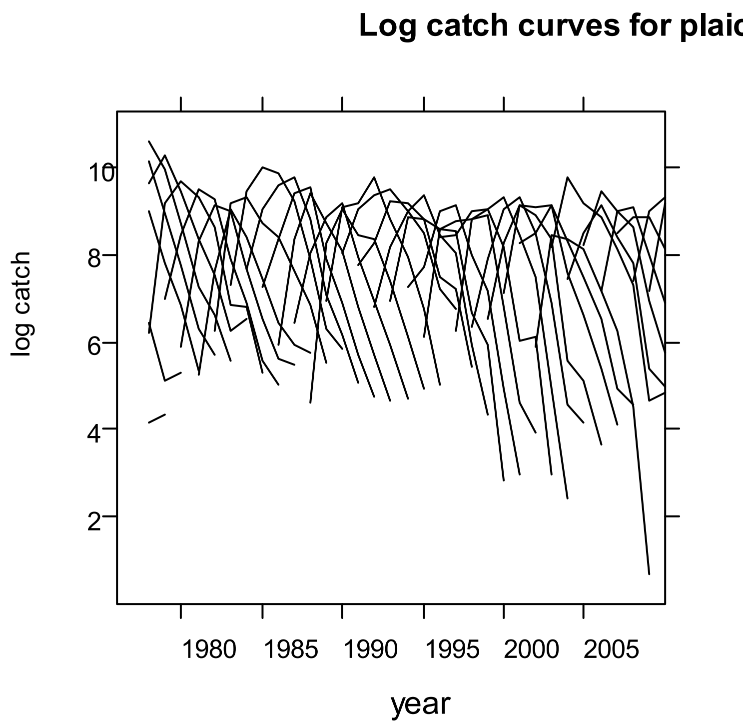
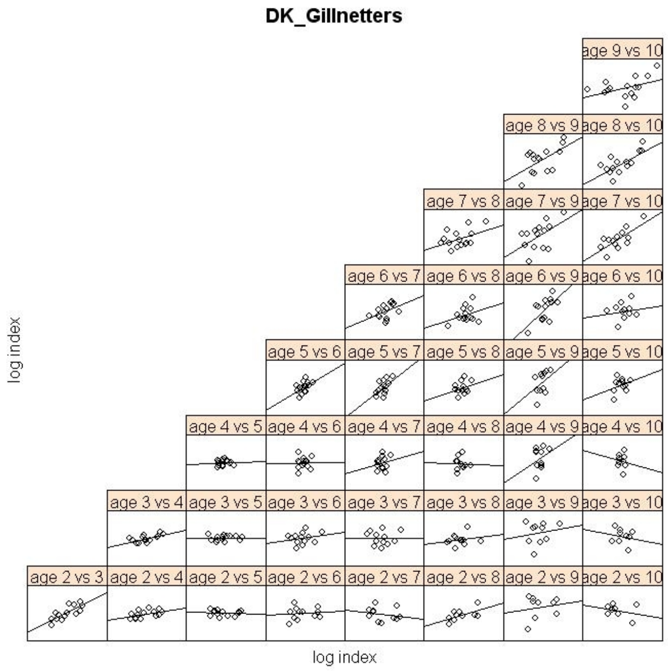


Figure 7.3.1. Plaice IIIa. Log catch curves by cohort in the landings at age



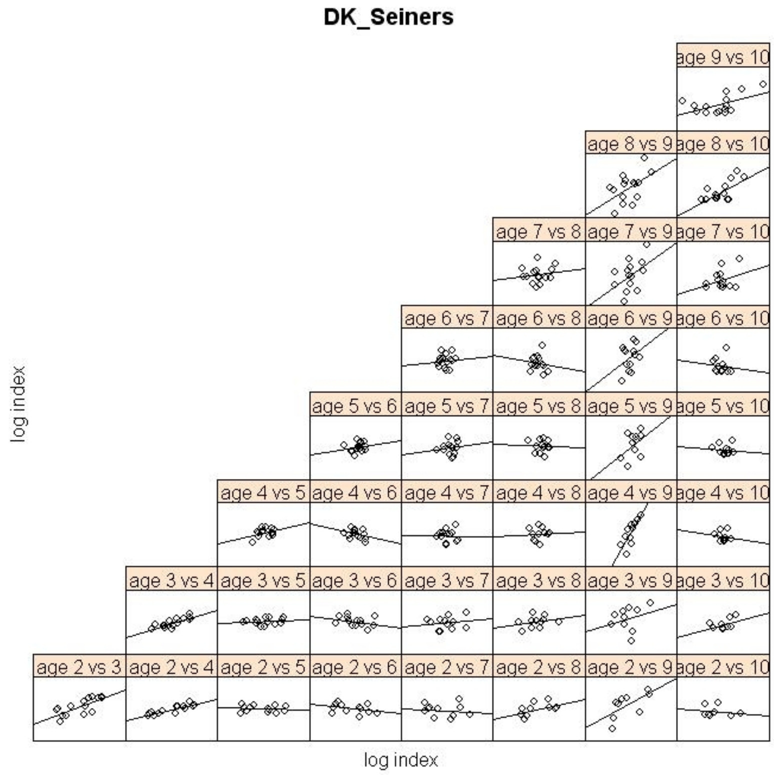


Figure 7.3.2. Plaice IIIa. Internal consistency for the commercial tuning fleets: matrix scatterplots and Log cohort abundance. Up : DK_Gillnetters. Bottom: DK_Seiners.

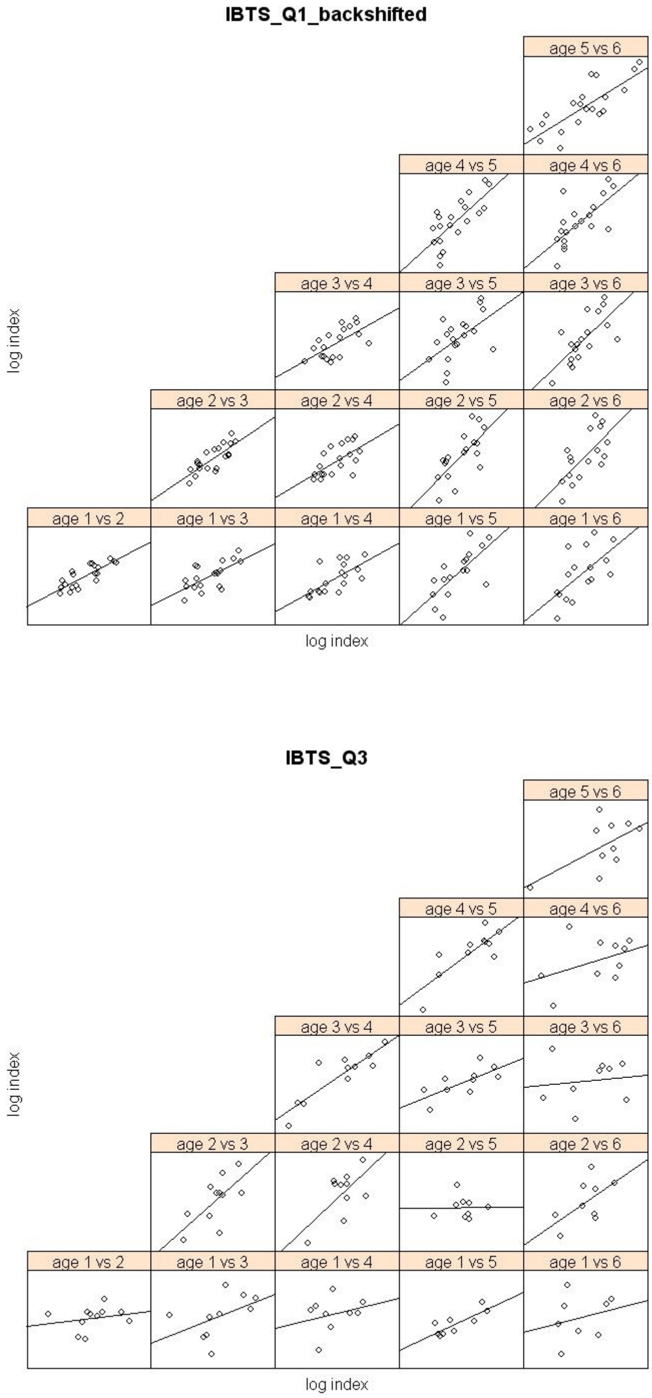


Figure 7.3.3. Plaice IIIa. Internal consistency for the IBTS survey: matrix scatterplots and Log cohort abundance. Top : IBTS Q1 backshifted. Bottom: IBTS Q3.

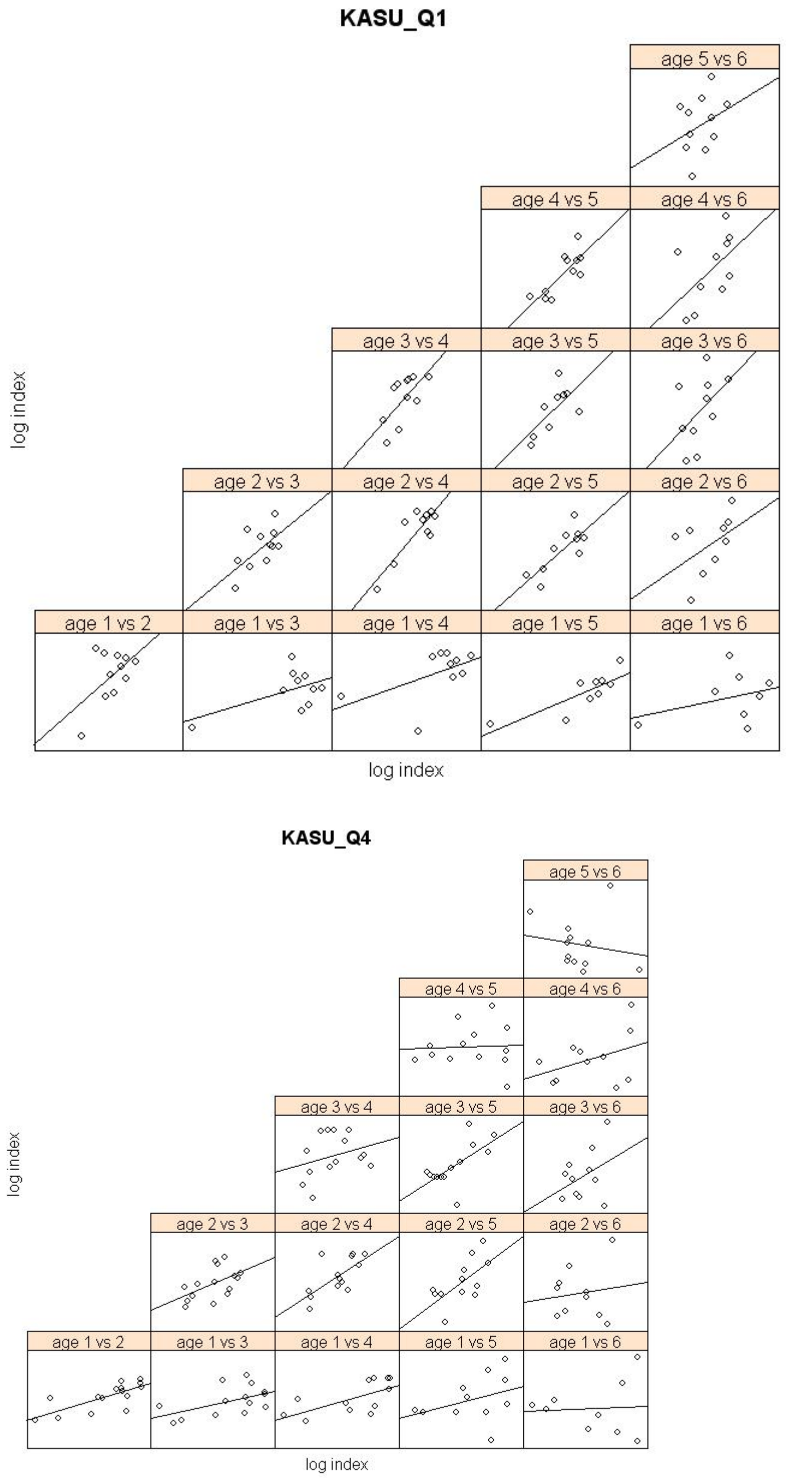


Figure 7.3.4 Internal consistency for the KASU survey: matrix scatterplots and Log cohort abundance. Top : KASU Q1. Bottom: KASU Q4.

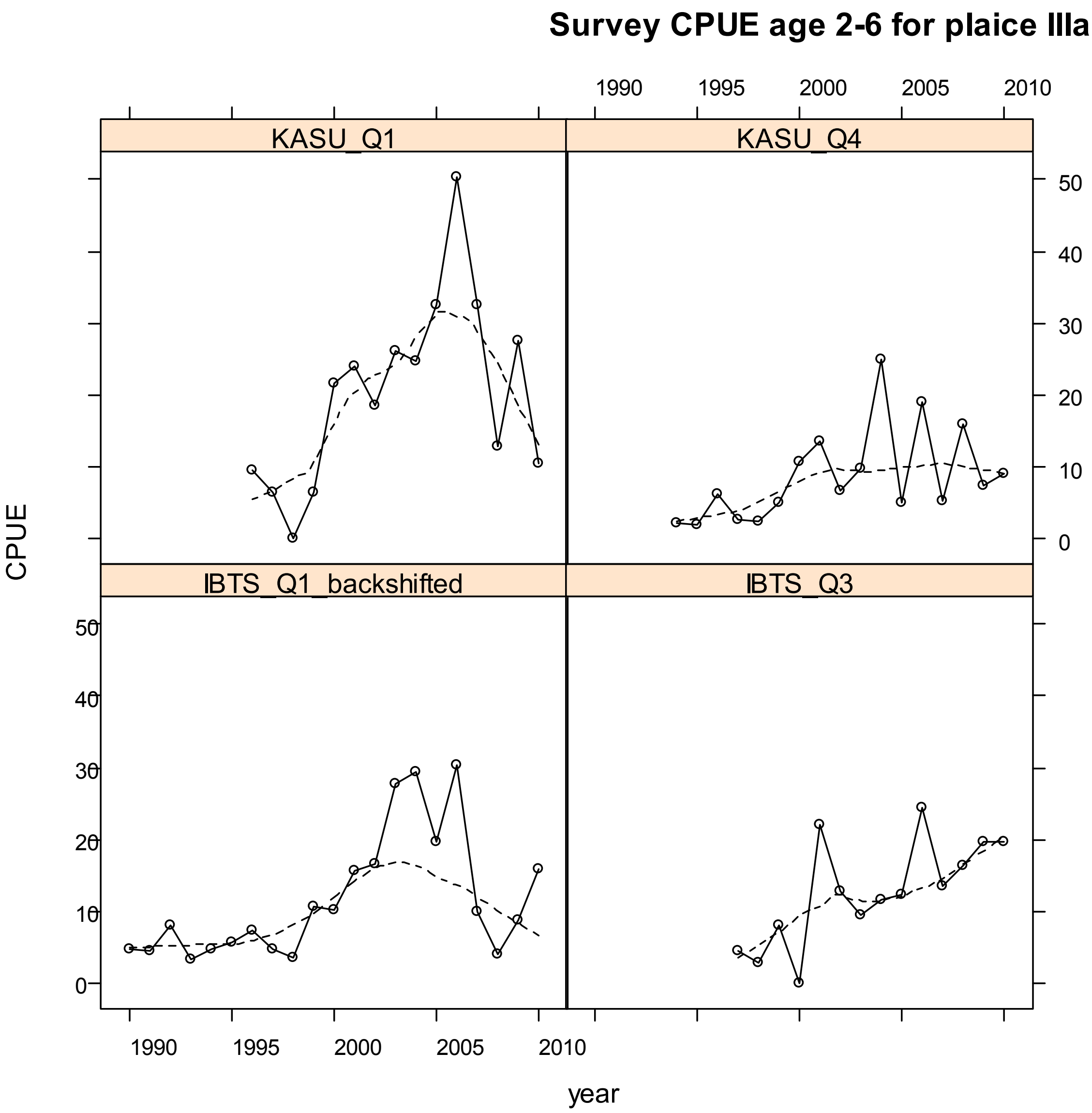


Figure 7.3.5. Plaice IIIa. CPUE (kg/half-hour) for the four surveys

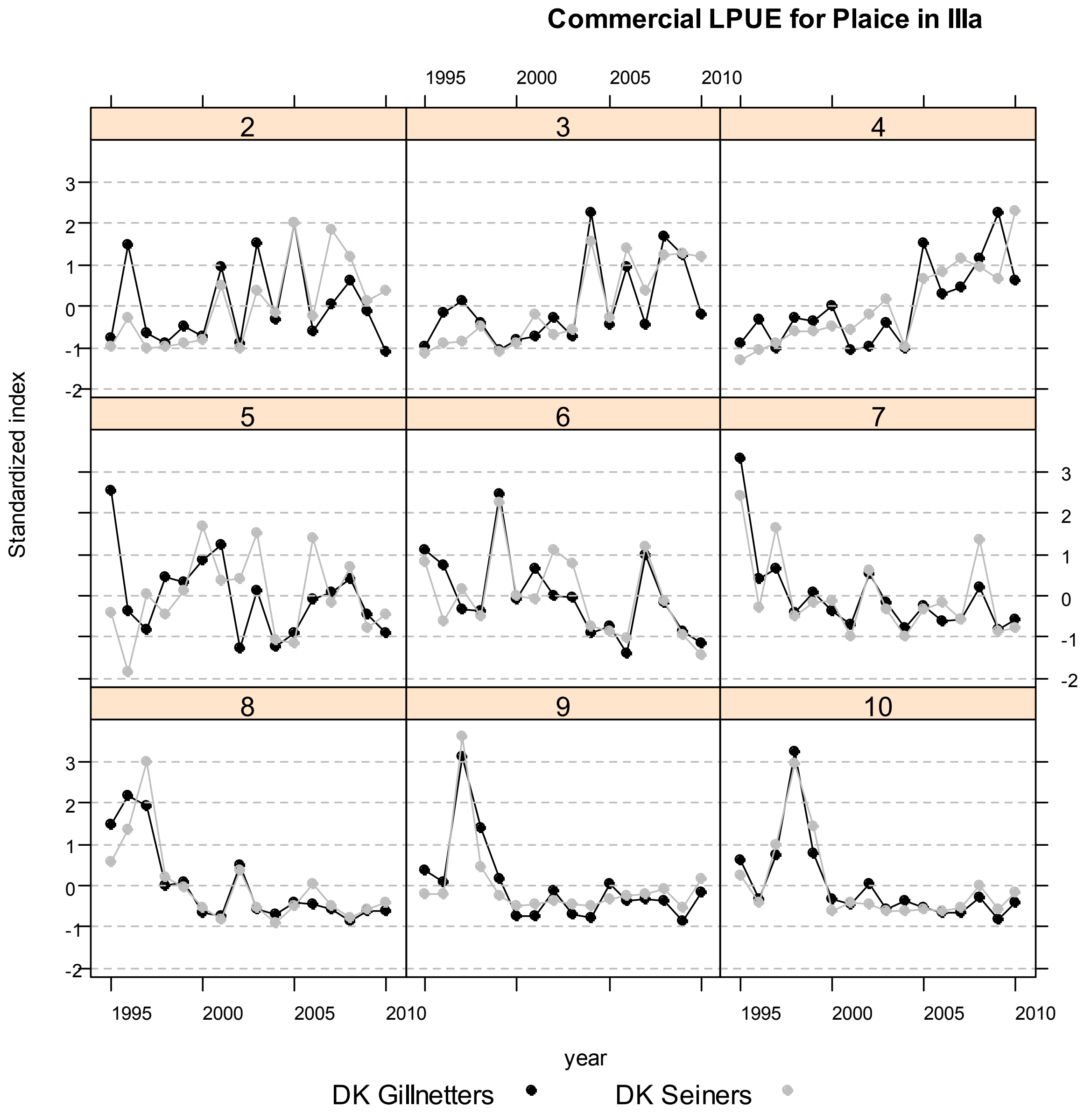


Figure 7.3.6. Plaice IIIa. Standardised Abundance index from commercial tuning series.

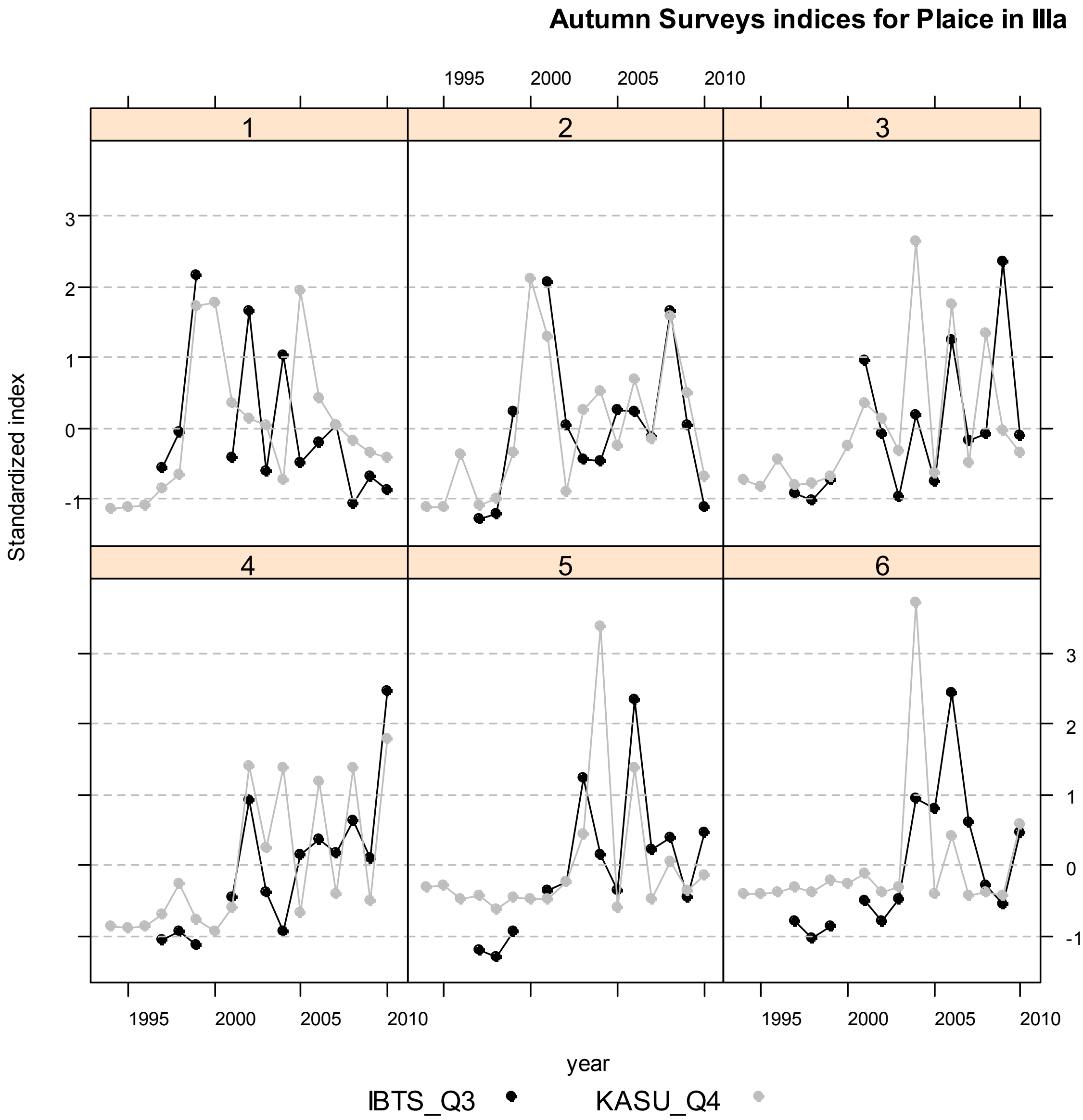


Figure 7.3.7. Plaice IIIa. Standardised Abundance index from Autumn surveys tuning series.

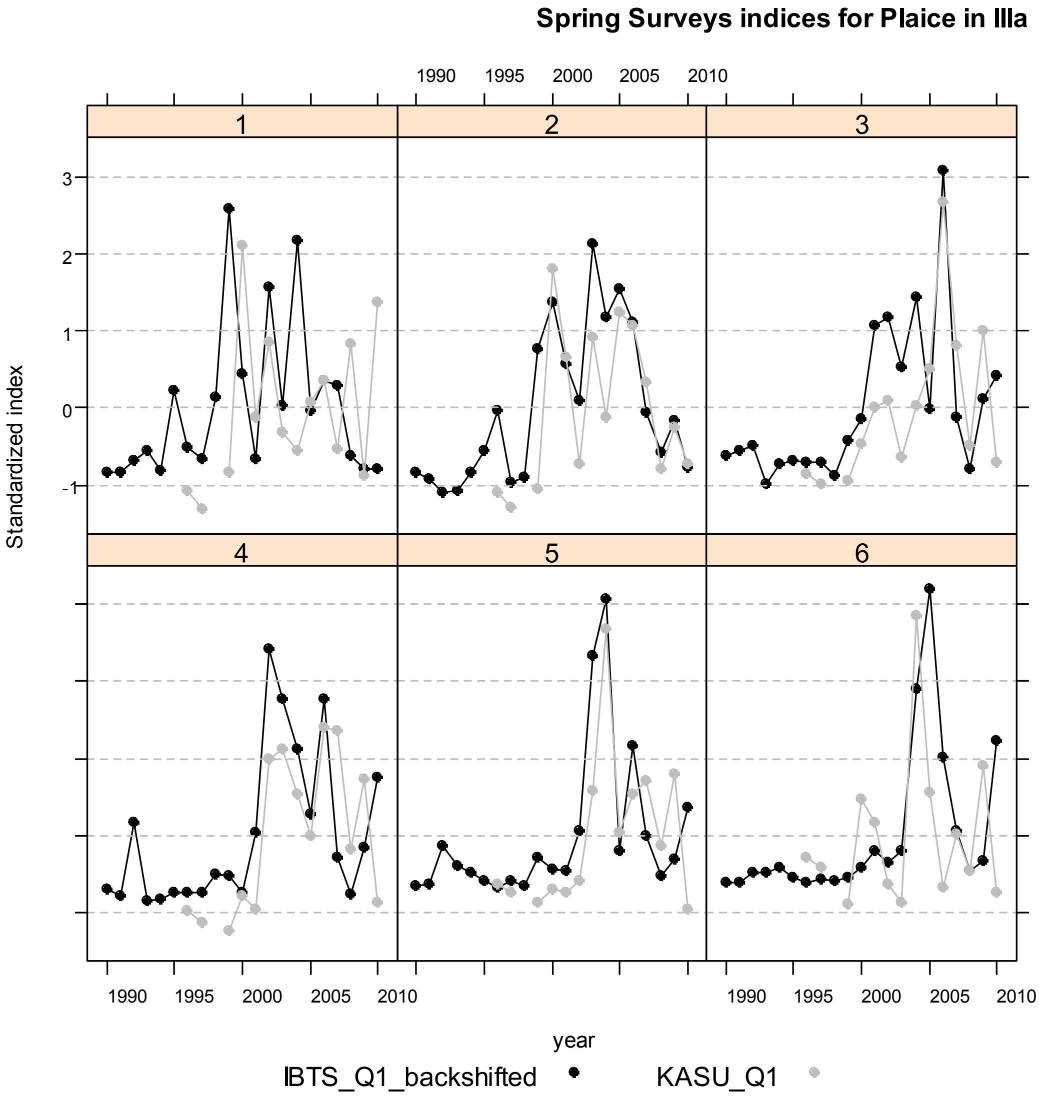


Figure 7.3.8. Plaice IIIa. Standardised Abundance index from Spring surveys tuning series.

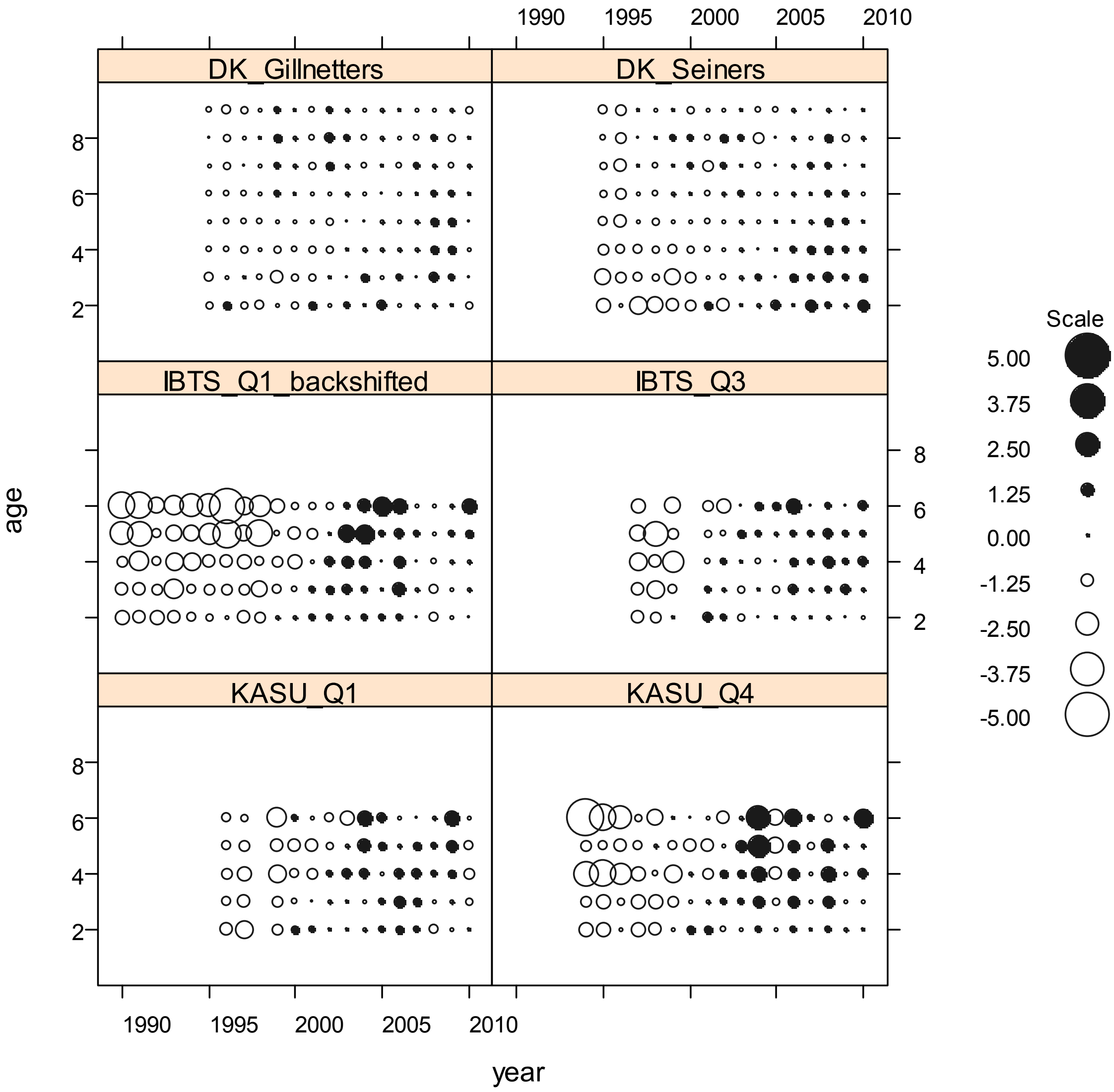


Figure 7.3.9. Plaice IIIa. Log catchability residuals for combined XSA

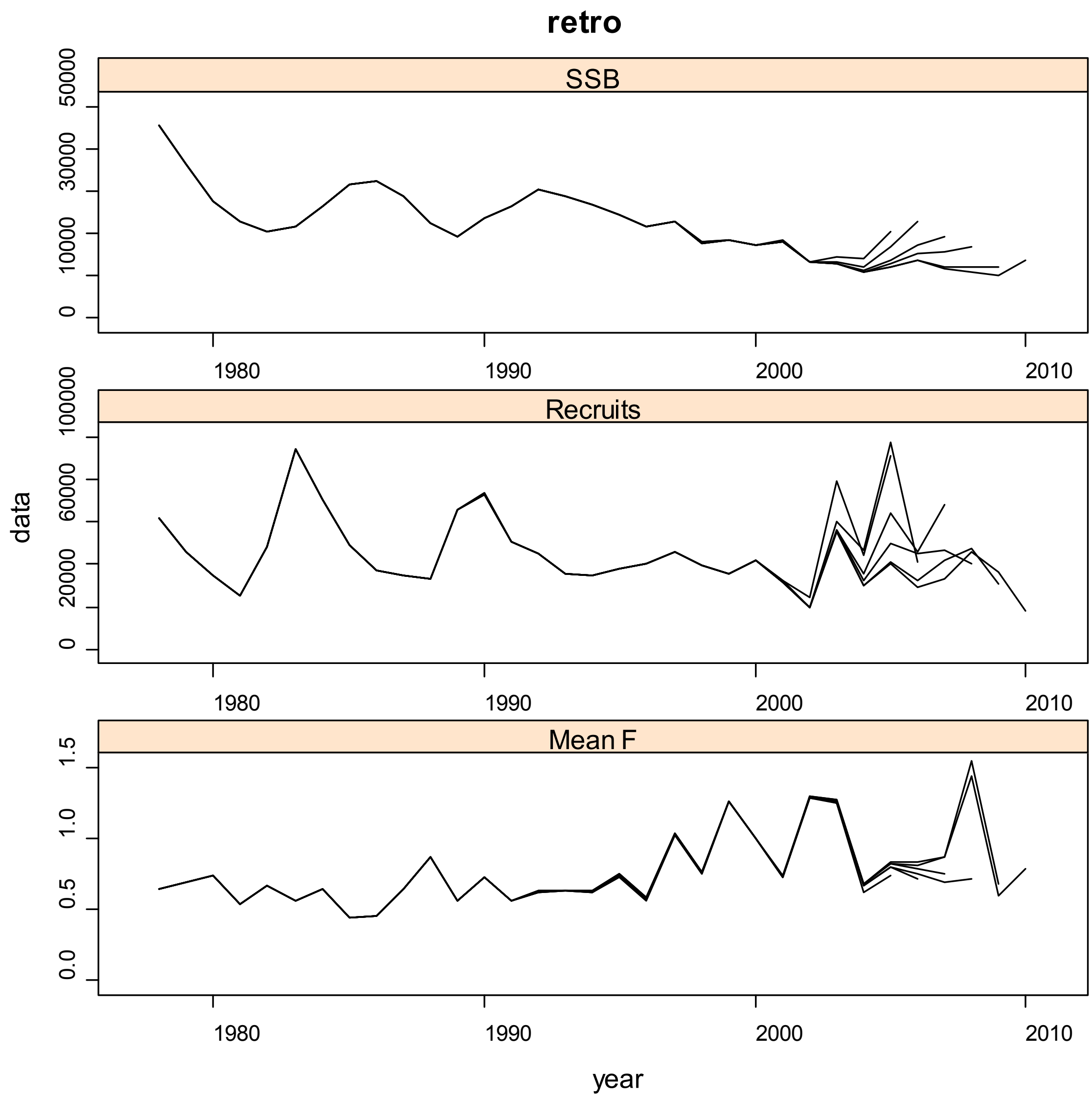


Figure 7.3.8. Plaice IIIa. XSA exploratory run retrospective pattern.

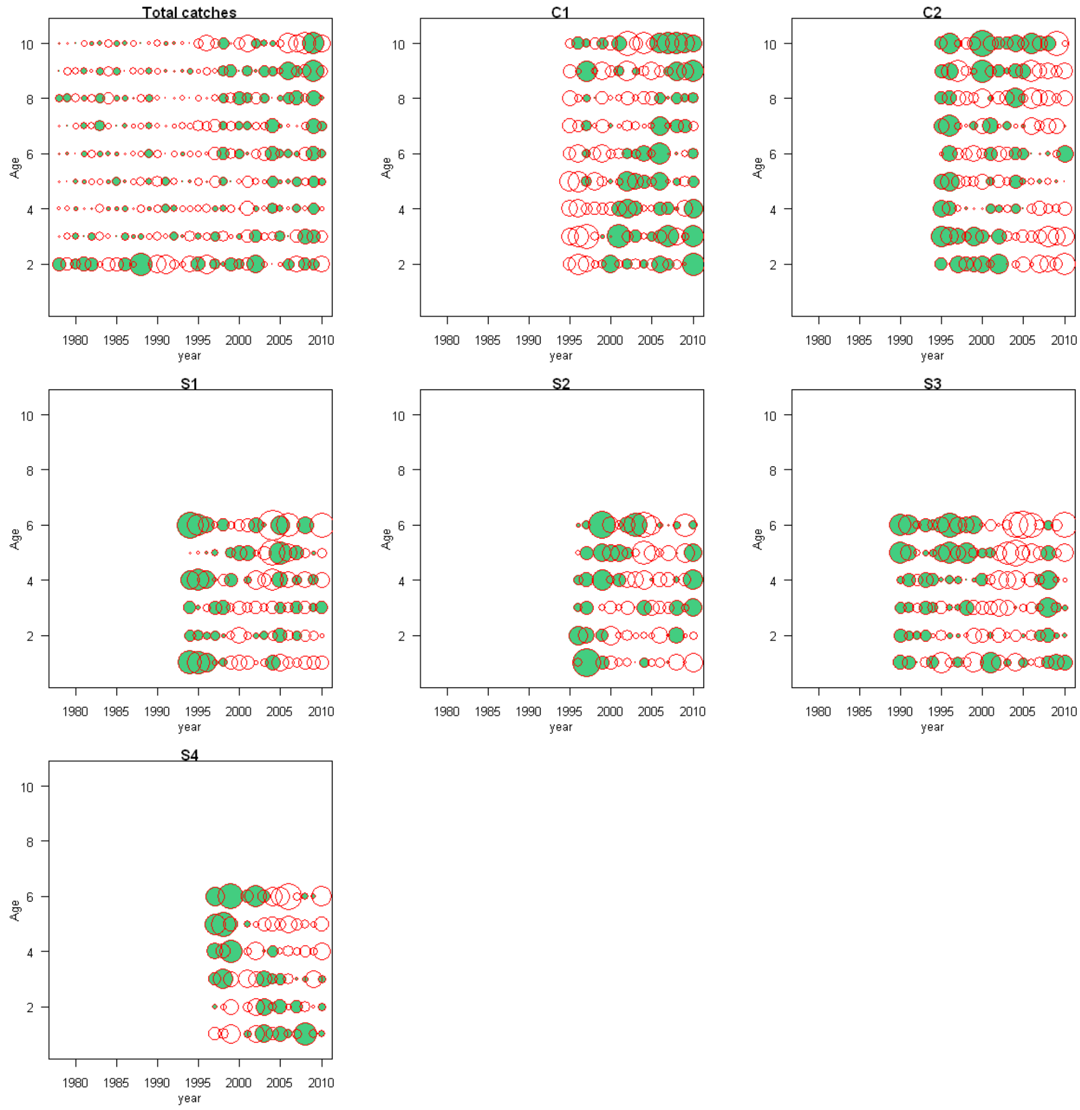


Figure 7.3.9. Plaice IIIa. Normalized residuals for the SAM base run. Red circles indicate a positive residual and filled green circle indicate a negative residual.

Figure 7.3.10. Plaice IIIa. Estimates from SAM with 95% confidence intervals using same inputs as XSA. Upper: Spawning stock biomass. Middle: Average fishing mortalities (ages 4-8). Lower: Number of one year old cods entering the population.

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 2010, section 6.4.7:

Single-stock exploitation boundaries

Exploitation boundaries in relation to existing management plans

"Following EU Council Regulation (EC) No 676/2007 implies increasing F to the target value of 0.3, with a maximum TAC increase of 15%. For 2011 the latter applies, resulting in a TAC of 73 400 t.".

Exploitation boundaries in relation to precautionary limits

"The fishing mortality in 2011 should be no more than F_{pa} (0.6) corresponding to landings of less than 144 400 t in 2011. This is expected to keep SSB above B_{pa} in 2012.

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 combination of days-at-sea regulations, high oil prices, and the constraining TAC for plaice in combination with a relatively stable TAC for sole, led to a more southern fishing pattern in the North Sea. This concentration of fishing effort results in increased discarding of juvenile plaice that are mainly distributed in those areas. This process could be aggravated by movement of juvenile plaice to deeper waters in recent years where they become more available to the fishery. Also the lpue data show a slower recovery of stock size in the southern regions that may be caused by higher fishing effort in the more coastal regions.

The assessment is considered to be highly 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 long term management plan proposed by the Commission of the European Community was adopted by the Council of the European Union in June 2007 and first implemented in 2008 (EC Council Regulation No 676/2007). See Section 16 (Management Plan Evaluations) of this report for further details. The plan consists of two stages. The first phase aims to ensure the return of the stocks of plaice and sole to within safe biological limits for two consecutive years. Once this has been achieved for both stocks, the plan enters into a second phase, in which stocks should be fished at an exploitation level that yields high long term sustainable yields. Following this year's assessments of the two stocks (2011), phase one of the plan has now been completed.

ICES has evaluated the long-term management plan (Council Regulation (EC) No. 676/2007) for plaice and sole (Miller and Poos 2010; Simmonds 2010; see section 8.8.2) and found it to be in agreement with the precautionary approach. It can therefore now be used as the basis for advice for the management of the stock.

The implementation of the management plan resulted in an agreed TAC of 63 825 tonnes in 2010 and 73400 tonnes in 2011.

For 2010 Council Regulation (EC) N°23/2010 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.

8.2 Data available

8.2.1 Catch

Total landings of North Sea plaice in 2010 (Table 8.2.1) were estimated by the WG at 60674 t, an increase of 5701 t from the 2009 landings, but 3126 t less than the 63800 t TAC for 2010. The discards time series used in the assessment was derived from Dutch, Danish, German and UK discards observations for 2000–2010, as is described in the stock annex.

The Dutch discards data for 2009 and 2010 were derived from a combination of the observer programme that has been running since 2000, and a new self-sampling programme. The estimates from both programmes were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet.

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).

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 8.2.5. 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 8.2.6, 8.2.7 and 8.2.8 respectively. Catch weights at age are derived from the discards and landings weights at age according to the relative contributions of each to the overall catch for each age. Figure 8.2.4 presents the stock, discards, landings and catch weights at age.

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 8.2.9) 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 8.2.10 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 8.2.11):

- Demersal Fish Survey (DFS)

At the time of the working group meeting Belgian data for this index was not available for the estimates in 2010

Commercial LPUE series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are (Table 8.2.12 and Figure 8.2.9):

- 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 (Figure 8.2.10). This series has not been updated since 2009 due to discrepancies in the effort data.

Effort of the Dutch beam trawl fleet and of the English beam trawl vessels landing in the Netherlands, by area and fleet component from 1990 up to 2008, are in Figure 8.2.11 and Figure 8.2.12 shows the spatial distribution of effort.

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.

This year, only a very limited number of countries put their landings data in InterCatch before the agreed deadline. After the deadline several, though not all, countries added their landings data to the InterCatch database. Because of time constraints and incomplete data, InterCatch was not used for raising the landings.

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)	Not used	Another tested tool for international raising has been used; We are still getting used to intercatch; not all member states upload their data	Comparison not made	InterCatch has not been properly tested

Estimates of numbers-at-age and weights-at-age in the landings by quarter are given in table 8.2.13.

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

Although the RG believes that the WG followed the stock annex well and provided an excellent assessment given the high uncertainty in discards, the RG agrees that the assessment appears highly uncertain. The stock status appears correctly defined as being fished sustainably and being at full reproductive capacity, but this basis appears to be uncertain due to high uncertainties in discard estimates and estimates of F_{msy}. In addition, the plaice stock appears to be dominated by intermittent, very large year classes which have not been seen for many years. Although recruitment seems fairly steady and at average levels compared to the historic time-series, it is disconcerting that larger year classes have not been observed considering the model predictions of extremely large SSB and historically low F's.

The assessment was very well done. The number and variation of sensitivity runs was both helpful and informative. Also, the model diagnostics were superb. An excellent job was done with highlighting residual patterns and explaining possible reasons that these patterns might arise.

Technical comments

- What is the assumed discard mortality? It is not mentioned in the assessment or annex and plays an important role in determining F levels, etc… (See Plaice division VIId stock annex, section 6.A.3, which sites two studies on plaice discard mortality in the sole fishery. Discard mortality is estimated to be >50% in small otter trawls and between 20% and 40% for large beam trawls).

We have added an additional section on discard mortality (8.2.5) where we summarize the current knowledge on discard mortality.

- It would be beneficial to include more detailed descriptions (probably within the stock annex) of how discards are reconstructed for the time period prior to discard sampling. A few formulas/paragraphs of text would help reviewers to better understand this process and possibly provide insight on how it might be enhanced. Additionally, a brief background description within the stock annex regarding the SCA model would also be helpful.

The following text is presently in the stock annex: "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)."

- No tables of sampling effort are provided in the assessment or annex. Although it is mentioned in the text when sampling is low, it would be useful for reviewers to actually see the data on sampling intensity. It is difficult to make inferences about output results without being able to judge the confidence in the model inputs. This applies not only to discard sampling, but also to length, age, maturity and sex ratios for all fleets involved in the fishery.

We support this comment whole heartedly, but information on sampling intensities is currently not provided by member states.

- Obviously, as mentioned numerous times, sampling of discards is much too low across the fishery. The number one priority for this stock should be to greatly increase sampling effort of all fleets in the sole and plaice fisheries in the North Sea. It is especially disconcerting that the main UK fleets are not sampled especially considering they make up 24% of total catch.

We support this comment whole heartedly. In future, this may be improved by the self-sampling programme which has started in 2009.

- The recent redistribution of fishing effort to plaice nursery grounds may prove to be a large future hindrance to stock rebuilding. In recent years total catch is dominated by age-3 and younger fish, while only 50% of age-3 and age-2 fish are mature while no age-1 fish are assumed mature. If juvenile plaice are being caught and discarded, then large recruitment events may never have the chance to add to the SSB as young fish will not reach maturity. Although this is a difficult issue due to sole/plaice interactions and the fact that larger mesh sizes would lead to escapement of juvenile plaice, but also adult sole, research should be focused towards determining ways to avoid juvenile plaice bycatch.

There has to our knowledge not been a recent distribution of effort to plaice nursery grounds. In fact, the plaice box has been in operation since 1995, excluding large beam trawl vessels from the main nursery areas.

- Continued work should be done regarding reconstructing plaice discard estimates. It might also be helpful to run sensitivity runs to these estimates. This seems especially important considering the large discrepancies between reconstructed discard estimates and those estimated within the SCA model. The SCA model also shows promise and continued work with this model should be carried out and XSA vs. SCA comparisons should continue.

We support this comment whole heartedly. Additional sensitivity runs have been performed in 2011, using discard estimates from the self-sampling program as well as the onboard observer program.

8.3.2 Exploratory catch-at-age-based analyses

The following exploratory analyses have been carried out:

1. Explore sensitivity to the weighting of the discard estimates from the self-sampling program and the observer program
2. explore sensitivity to splitting the tuning indices of the Sole Net Survey and the BTS-Tridens.
3. stock assessment using the statistical catch-at-age model as described in Aarts & Poos (2009).

1. Discard estimates

In the official assessment, discarded numbers-at-age are estimated as a weighted average between the estimates produced by the observer program and the self-sampling program. Discarded numbers-at-age as estimated by the observer program are much higher than those estimated by the self-sampling program. To assess the sensitivity of the assessment to this, we reran the assessment with estimates provided by the self-sampling and observer program separately. Recruitment and mortality was estimated to be higher with the estimates from the observer program (figure 8.3.1), as expected given that the higher estimates of catches of the younger ages. Estimates using the self-sampling program differed little from the final assessment since the weighted average is close to the estimates from the self-sampling program given it has many more trips than the observer program. Estimates of SSB were only slightly affected by the choice of discard estimate as the majority of discards are not part of the spawning stock. The increase in recruitment predicted by the model in the case of higher discarding effectively cancels out the effect of the higher fishing mortality estimated for these younger ages.

2. 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. To investigate the sensitivity of the assessment output to this, we have split the SNS and BTS-Tridens tuning indices at the year 2004, the year where the trend in residuals appears to have started. Assessment runs have been done with these split tuning indices. The results indicate indeed that recruitment is estimated to be higher with the split index, whereas estimates of F and SSB are relatively unaffected (figure 8.3.1). The retrospective pattern of recruitment (not shown) is also reduced.

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). The main difference between the assessment models is in the estimate of the discard levels in recent years (2009 and 2010), 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.

8.3.3 Conclusions drawn from exploratory analyses

Both the XSA trial runs with different discard estimates as the SCA model indicate that estimates of mortality and recruitment are particularly uncertain as a result of the uncertainty in discard estimates. Additionally, recruitment may be underestimated because of the reduced catchability of the SNS over the past years, as evidenced by the catchability residuals estimated by XSA, and the trial run with split tuning indices. This latter issue was discussed in the benchmark in 2009, and given the persistent trends in catchability estimates needs to be addressed again in a future benchmark. All trial runs and both assessment methods agree upon the main stock trends; a large reduction in F and a large increase in SSB since approximately the year 2002.

Final assessment

The settings for the final assessment that is used for the catch option table is given below:

Year	2010
Catch at age	Landings + (reconstructed) discards based on NL, DK + UK + GE fleets
Fleets (years; ages)	BTS-Isis 1985–2008; 1–8 BTS-Tridens 1996–2008; 1–9 SNS 1982–2008 (excl. 2003); 1–3
Plus group	10
First tuning year	1982
Last data year	2009
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 stopped after 41 iterations. The log catchability residuals for the tuning fleets in the final run are dominated by negative values for the SNS tuning index in the most recent period, and positive values for the BTS-Tridens in the younger ages (Figure 8.3.3). 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 2010 was estimated at 461 kt. Mean F(ages 2–6) for 2010 was estimated at 0.24. Recruitment of the 2009 year class, age 1 in 2010, was estimated at 0.873 million in the XSA.

Retrospective analyses of the XSA presented in Figure 8.3.4 indicate that historic estimates for SSB in 2006 and 2007 were much lower compared to the current estimate but values in 2008 and 2009 were more similar. 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.

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, slightly increasing 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 0.24 in 2008 and stable at this level in 2009 and 2010. 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 (2010) estimated at 461 kt, which is 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. The 2009 year class, estimated at 1.3 million individuals at age 1 in 2010 is above the long term geometric mean.

The Fishers' North Sea Stock Survey (FNSSS) again took place in 2010. 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 last year 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 2009 to 2010. Most respondents reported similar or higher abundances of fish, although the proportions reporting higher levels were somewhat less than in 2009.

Overall, about two-thirds of respondents (68%) reported that plaice overall were 'more' or 'much more' abundant in 2010 than in 2009, this was also the case across most individual areas. About one-quarter reported 'no change' in the abundance of plaice, substantially more than in 2009. About three-quarters of respondents overall reported catching 'all sizes' of plaice in 2010, while of the remainder, twice as many reported 'mostly large' plaice as 'mostly small'. Reports of 'mostly large' plaice were most common in the central and southern North Sea (areas 2, 5, 6a & 6b FNSSS). Overall, almost half (45%) 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 2010 than in 2009, while the proportion reporting lower levels of discarding increased by a similar amount. The proportions of respondents reporting higher levels of discards was greatest (>50%) in the north western North Sea (areas 1 & 3) and lowest in the east (areas 7, 8 & 9 in FNSSS). 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 2010 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 2011.

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 2010 (age 1 in 2011) the values predicted by the two surveys (SNS and DFS) in RCT3 differ considerably (several orders of magnitude) and have high prediction standard errors (Table 8.5.2.). Also, the Belgian data for the most recent DFS estimate was not available. Therefore the geometric mean, lower than the RCT3 estimate, was accepted for the short-term forecasts. For year class 2009 (age 2 in 2011), 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. The WG decided to use the RCT3 estimate for the 2009 year class, which was higher than the geometric mean. This choice for the higher recruitment estimate was also 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 2011	XSA Survivors	RCT3	GM 1957–2008	Accepted estimate
2009	2	571477	**830649**		RCT3
2010	1		1319724	**915399**	GM 1957–2008
2011	0			**915399**	GM 1957–2008

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 were computed by the RCT3 program (see table above), and numbers at age 3 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_{2011}	SSB_{2012}	$Landings_{2011}$
A	F_{2011} = F_{2010} (Fsq)	0.240	555666 t	68682 t
B	$Landings_{2011}$ = TAC_{2011}	0.259	547873 t	73400 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 0.2.

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 new analyses revised MSY framework reference points, and ranges, for both sole and plaice in the North Sea are now proposed. A brief description of the technical approach is given in chapter 16 of his report , and detailed results of the various analyses are available in the published reports (ICES 2010, Miller and Poos 2010, and Simmonds et al. 2010). The chosen value for MSY $B_{trigger}$ for plaice is considered to be appropriate (MSY $B_{trigger}$ = B_{pa} = 230 000t SSB). The current management plan target for plaice is 0.3. On the basis of the new analyses presented, 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. This finding is supported by all analyses including simulation tests, uncertainty in input parameters and uncertainty in stock recruit relationships. 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. This range also includes the management plan target value, thereby ensuring that ICES will not provide advice on this basis of the management plan while simultaneously stating that the stock is being unsustainably fished in relation to F_{MSY} at this level.

8.9 Quality of the assessment

Large differences are found in the trends in tuning series over the last seven 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 8.3.3), 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, new a 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. 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.

Technical measures applicable to the mixed flatfish fishery will affect both sole and plaice. The minimum mesh size of 80 mm in the beam trawl fishery selects sole at the minimum landing size. 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.

The combination of days-at-sea regulations, high oil prices, and the constraining TAC for plaice in combination with the relatively stable TAC for sole, have induced a more coastal fishing pattern in the southern North Sea. This concentration of fishing effort results in increased discarding of juvenile plaice that are mainly distributed in those areas. This process could be aggravated by movement of juvenile plaice to deeper waters in recent years where they become more susceptible to the fishery.

The Plaice Box is a partially closed area along the continental coast that was instigated in phases starting in 1989. The area has been closed to most categories of vessels > 300hp all year round since 1995. 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.

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.

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.

The assessment is considered to be highly uncertain most importantly because the different survey tuning series in different areas of the North Sea indicate different trends in the most recent development of the stock. This uncertainty is compounded by a relatively strong retrospective pattern, where this years' assessment result estimates higher SSBs and lower fishing mortalities for the most recent years. However, this retrospective pattern is decreasing in recent years.

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.

Following the conclusion of the WKFLAT 2010 it is recommended to explore the potential for performing a combined assessment of this continuum of plaice stocks from Kattegat/Baltic to the English Channel. The WGNSSK requests the setup of a Study Group on the identification, assessment and management of plaice stocks, which could convene for the first time during Spring 2012 and address these issues further.

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													73400

*** Official estimates not available.**

Table 8.2.2 . North Sea Plaice. landed numbers-at-age

Plaice in IV . landings.

2011-05-07 13:21:06 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

Table 8.2.3 . North Sea Plaice. Discards numbers-at-age

Plaice in IV . discards.n
2011-05-07 13:21:39 units= thousands

year	age 1	2	3	4	5	6	7	8	9	10
1957	32356	45596	9220	909	961	25	0	0	0	0
1958	66199	73552	23655	2572	2137	65	0	0	0	0
1959	116086	127771	46402	11407	4737	106	0	0	0	0
1960	73939	167893	44948	997	1067	519	0	0	0	0
1961	75578	144609	89014	538	1612	130	0	0	0	0
1962	51265	181321	87599	21716	799	186	0	0	0	0
1963	90913	136183	129778	9964	2112	188	0	0	0	0
1964	66035	153274	64156	33825	3011	323	0	0	0	0
1965	43708	426021	59262	3404	923	267	0	0	0	0
1966	38496	163125	349358	14399	1402	125	0	0	0	0
1967	20199	133545	87532	152496	623	260	0	0	0	0
1968	73971	72192	46339	26530	22436	58	0	0	0	0
1969	85192	67378	16747	19334	773	2024	0	0	0	0
1970	123569	152480	27747	1287	5061	161	0	0	0	0
1971	69337	96968	42354	2675	426	81	0	0	0	0
1972	70002	55470	33899	5714	567	73	0	0	0	0
1973	132352	49815	4008	673	1289	67	0	0	0	0
1974	211139	308411	3652	285	611	109	0	0	0	0
1975	244969	280130	190536	4807	253	123	0	0	0	0
1976	183879	140921	71054	18013	174	41	0	0	0	0
1977	256628	103696	79317	33552	9317	129	0	0	0	0
1978	226872	154113	27257	10775	1244	570	0	0	0	0
1979	293166	215084	57578	18382	589	310	0	0	0	0
1980	226371	122561	932	687	193	86	0	0	0	0
1981	134142	193241	1850	373	431	55	0	0	0	0
1982	411307	204572	4624	1109	216	98	0	0	0	0
1983	261400	436331	30716	2235	804	72	0	0	0	0
1984	310675	313490	52651	24529	1492	69	0	0	0	0
1985	405385	229208	35566	2221	200	78	0	0	0	0
1986	1117345	490965	48510	26470	1451	146	0	0	0	0
1987	361519	1374202	180969	1427	1348	248	0	0	0	0
1988	348597	608109	459385	61167	882	177	0	0	0	0
1989	213291	485845	193176	85758	7224	115	0	0	0	0
1990	145314	279298	168674	28102	5011	177	0	0	0	0
1991	183126	301575	141567	40739	5528	939	0	0	0	0
1992	138755	219619	94581	34348	4307	880	0	0	0	0
1993	96371	154083	48088	11966	1635	216	0	0	0	0
1994	62122	95703	35703	1038	822	144	0	0	0	0
1995	118863	82676	15753	860	663	120	0	0	0	0
1996	111250	331065	27606	3930	451	116	0	0	0	0
1997	128653	510918	193828	588	271	108	0	0	0	0
1998	104538	646250	191631	53354	297	33	0	0	0	0
1999	127321	208401	231769	54869	278	58	0	0	0	0
2000	103468	171213	51092	64971	1230	241	263	167	0	0
2001	30346	352452	186900	74744	54276	152	45	1	0	0
2002	309822	177574	76246	12113	1571	661	107	1	0	0
2003	67718	517641	52582	19130	3843	386	5751	1	0	0
2004	232936	179561	115746	6614	1047	232	37	1	0	0
2005	93585	324744	43297	19440	4098	5968	147	1	0	0
2006	220501	223814	107163	9129	2324	249	732	194	0	0
2007	77239	203775	66539	8999	736	6972	170	1644	0	0
2008	135339	251389	34997	4568	1644	328	8845	885	0	0
2009	148639	191957	66063	9165	1973	1106	136	3220	0	0
2010	165914	177912	58279	22582	2672	1726	2073	281	0	0

Table 8.2.4 . North Sea Plaice. Catch numbers-at-age

```
Plaice in IV . catch.n
 2011-05-07 13:22:12  units= thousands
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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

Table 8.2.5. North Sea plaice. Stock weight-at-age

Plaice in IV . stock.wt

2011-05-07 13:22:45 units= kg

year	age 1	2	3	4	5	6	7	8	9	10
1957	0.038	0.102	0.157	0.242	0.325	0.485	0.719	0.682	0.844	1.143
1958	0.041	0.093	0.180	0.272	0.303	0.442	0.577	0.778	0.793	1.112
1959	0.045	0.106	0.173	0.264	0.329	0.470	0.650	0.686	0.908	1.042
1960	0.038	0.111	0.181	0.272	0.364	0.469	0.633	0.726	0.845	1.090
1961	0.037	0.098	0.185	0.306	0.337	0.483	0.579	0.691	0.779	1.067
1962	0.036	0.096	0.173	0.301	0.424	0.573	0.684	0.806	0.873	1.303
1963	0.041	0.103	0.176	0.273	0.378	0.540	0.663	0.788	0.882	1.252
1964	0.024	0.113	0.184	0.296	0.373	0.477	0.645	0.673	0.845	1.232
1965	0.031	0.068	0.198	0.294	0.333	0.430	0.516	0.601	0.722	0.909
1966	0.031	0.099	0.127	0.305	0.403	0.455	0.503	0.565	0.581	0.984
1967	0.029	0.104	0.179	0.205	0.442	0.528	0.585	0.650	0.703	0.985
1968	0.055	0.094	0.175	0.287	0.344	0.532	0.592	0.362	0.667	0.887
1969	0.047	0.158	0.188	0.266	0.344	0.390	0.565	0.621	0.679	0.857
1970	0.043	0.113	0.236	0.274	0.369	0.410	0.468	0.636	0.732	0.896
1971	0.051	0.109	0.251	0.344	0.413	0.489	0.512	0.583	0.696	0.877
1972	0.056	0.158	0.218	0.407	0.473	0.534	0.579	0.606	0.655	0.929
1973	0.037	0.134	0.237	0.308	0.468	0.521	0.566	0.583	0.617	0.804
1974	0.049	0.105	0.217	0.416	0.437	0.524	0.570	0.629	0.652	0.852
1975	0.063	0.141	0.187	0.388	0.483	0.544	0.610	0.668	0.704	0.943
1976	0.082	0.169	0.226	0.308	0.484	0.550	0.593	0.658	0.694	0.931
1977	0.064	0.184	0.265	0.311	0.405	0.551	0.627	0.690	0.667	0.938
1978	0.064	0.151	0.319	0.373	0.411	0.467	0.547	0.630	0.704	0.943
1979	0.062	0.179	0.258	0.365	0.414	0.459	0.543	0.667	0.764	1.004
1980	0.049	0.163	0.289	0.428	0.444	0.524	0.582	0.651	0.778	1.058
1981	0.041	0.140	0.239	0.421	0.473	0.536	0.570	0.624	0.707	1.033
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	1.029
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	0.884
1990	0.043	0.108	0.176	0.261	0.343	0.422	0.555	0.647	0.701	0.972
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	0.834
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	0.798
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	0.852
1998	0.038	0.081	0.207	0.333	0.474	0.577	0.581	0.648	0.656	0.812
1999	0.044	0.091	0.150	0.319	0.437	0.524	0.586	0.644	0.664	0.780
2000	0.051	0.106	0.165	0.219	0.408	0.467	0.649	0.695	0.656	0.787
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	0.873
2003	0.057	0.111	0.227	0.269	0.344	0.391	0.464	0.600	0.714	0.787
2004	0.047	0.116	0.201	0.306	0.384	0.430	0.489	0.495	0.780	0.875
2005	0.053	0.106	0.216	0.237	0.378	0.422	0.434	0.527	0.621	1.010
2006	0.052	0.130	0.190	0.316	0.354	0.424	0.439	0.506	0.583	0.731
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	0.731
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

Table 8.2.6. North Sea plaice. Landings weight-at-age

Plaice in IV . landings.wt

2011-05-07 13:23:18 units= kg

age

year	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	0.406	0.479	0.552	0.596	0.671	0.782	1.027
1981	0.241	0.279	0.335	0.423	0.514	0.568	0.615	0.653	0.738	1.025
1982	0.281	0.264	0.313	0.427	0.517	0.612	0.668	0.716	0.743	0.990
1983	0.199	0.248	0.298	0.381	0.512	0.600	0.673	0.766	0.810	0.978
1984	0.229	0.259	0.279	0.369	0.483	0.603	0.673	0.714	0.824	1.019
1985	0.242	0.259	0.284	0.330	0.453	0.565	0.664	0.714	0.788	1.001
1986	0.218	0.266	0.300	0.343	0.420	0.482	0.667	0.742	0.843	1.001
1987	0.218	0.246	0.296	0.347	0.397	0.498	0.576	0.719	0.819	0.978
1988	0.218	0.250	0.274	0.347	0.446	0.504	0.599	0.688	0.801	0.999
1989	0.233	0.276	0.305	0.327	0.386	0.525	0.594	0.660	0.780	0.929
1990	0.267	0.281	0.293	0.312	0.360	0.440	0.588	0.681	0.749	0.989
1991	0.219	0.276	0.283	0.295	0.352	0.438	0.509	0.646	0.720	0.887
1992	0.246	0.258	0.285	0.312	0.335	0.417	0.521	0.594	0.702	0.875
1993	0.243	0.267	0.282	0.318	0.348	0.413	0.506	0.616	0.704	0.836
1994	0.223	0.256	0.278	0.330	0.387	0.437	0.489	0.595	0.713	0.883
1995	0.270	0.275	0.299	0.336	0.399	0.451	0.525	0.607	0.729	0.902
1996	0.236	0.276	0.302	0.350	0.414	0.479	0.491	0.580	0.709	0.844
1997	0.206	0.269	0.310	0.361	0.453	0.520	0.598	0.611	0.678	0.917
1998	0.150	0.256	0.305	0.388	0.489	0.597	0.623	0.684	0.689	0.900
1999	0.242	0.249	0.276	0.350	0.449	0.539	0.621	0.672	0.742	0.802
2000	0.221	0.259	0.276	0.305	0.420	0.486	0.664	0.690	0.729	0.862
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	0.309	0.341	0.436	0.500	0.678	0.745	0.881
2003	0.227	0.248	0.281	0.319	0.363	0.406	0.477	0.641	0.750	0.837
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	0.888
2006	0.257	0.272	0.289	0.338	0.399	0.409	0.475	0.489	0.533	0.755
2007	0.262	0.267	0.303	0.345	0.378	0.452	0.539	0.481	0.590	0.619
2008	0.247	0.265	0.306	0.343	0.403	0.453	0.538	0.726	0.640	0.637
2009	0.183	0.273	0.326	0.375	0.436	0.501	0.553	0.632	0.695	0.825
2010	0.209	0.266	0.307	0.349	0.418	0.470	0.509	0.619	0.679	0.641

Table 8.2.7. North Sea plaice. Discards weight-at-age

Plaice in IV . discards.wt

2011-05-07 13:23:51 units= kg

year	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

Table 8.2.8. North Sea plaice. Catch weight-at-age

Plaice in IV . catch.wt

2011-05-07 13:24:24 units= kg

year	age 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	0.671	0.782	1.027
1981	0.048	0.184	0.332	0.422	0.510	0.565	0.615	0.653	0.738	1.025
1982	0.056	0.152	0.310	0.423	0.515	0.610	0.668	0.716	0.743	0.990
1983	0.052	0.152	0.273	0.377	0.504	0.598	0.673	0.766	0.810	0.978
1984	0.053	0.149	0.261	0.319	0.473	0.600	0.673	0.714	0.824	1.019
1985	0.054	0.168	0.263	0.329	0.451	0.564	0.664	0.714	0.788	1.001
1986	0.049	0.141	0.273	0.310	0.416	0.481	0.667	0.742	0.843	1.001
1987	0.043	0.113	0.217	0.345	0.393	0.496	0.576	0.719	0.819	0.978
1988	0.043	0.102	0.196	0.274	0.442	0.502	0.599	0.688	0.801	0.999
1989	0.047	0.117	0.213	0.288	0.363	0.522	0.594	0.660	0.780	0.929
1990	0.053	0.129	0.207	0.287	0.356	0.439	0.588	0.681	0.749	0.989
1991	0.056	0.148	0.206	0.266	0.341	0.436	0.509	0.646	0.720	0.887
1992	0.055	0.145	0.223	0.272	0.327	0.412	0.521	0.594	0.702	0.875
1993	0.062	0.159	0.246	0.301	0.343	0.412	0.506	0.616	0.704	0.836
1994	0.064	0.177	0.252	0.328	0.383	0.436	0.489	0.595	0.713	0.883
1995	0.071	0.182	0.281	0.334	0.396	0.450	0.525	0.607	0.729	0.902
1996	0.054	0.139	0.265	0.338	0.411	0.477	0.491	0.580	0.709	0.844
1997	0.045	0.129	0.219	0.359	0.451	0.518	0.598	0.611	0.678	0.917
1998	0.047	0.094	0.206	0.296	0.484	0.594	0.623	0.684	0.689	0.900
1999	0.054	0.103	0.197	0.261	0.446	0.535	0.621	0.672	0.742	0.802
2000	0.063	0.123	0.205	0.268	0.406	0.473	0.614	0.593	0.729	0.862
2001	0.090	0.135	0.194	0.228	0.300	0.472	0.580	0.701	0.787	0.793
2002	0.057	0.130	0.220	0.286	0.335	0.432	0.489	0.677	0.745	0.881
2003	0.066	0.123	0.226	0.282	0.344	0.401	0.413	0.640	0.750	0.837
2004	0.054	0.124	0.220	0.304	0.385	0.428	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	0.888
2006	0.060	0.139	0.212	0.300	0.388	0.401	0.441	0.466	0.533	0.755
2007	0.058	0.112	0.224	0.319	0.370	0.379	0.519	0.349	0.590	0.619
2008	0.057	0.122	0.243	0.326	0.392	0.441	0.358	0.462	0.640	0.637
2009	0.061	0.124	0.234	0.338	0.416	0.483	0.538	0.448	0.695	0.825
2010	0.062	0.131	0.218	0.307	0.393	0.435	0.455	0.566	0.679	0.641

Table 8.2.9. 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 8.2.10 North Sea plaice. Survey tuning indices.

North Sea plaice. Survey tuning indices

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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

BTS-Tridens (all 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

Table 8.2.10 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

Table 8.2.11. North Sea plaice. DFS index catches (numbers per hour), used only for RCT3. Note: a 10 year average has been used as an estimate for the 2010 Belgian data.

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	200.48	NA

Table 8.2.12 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 8.2.13. 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 2011-05-07 13:00:42

CPUE data from xsa.indices

Catch data for 54 years. 1957 to 2010. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-Isis	1	8	1985	2010	0.66	0.75
2	BTS-Tridens	1	9	1996	2010	0.66	0.75
3	SNS	1	3	1982	2010	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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.070	0.210	0.144	0.217	0.141	0.291	0.080	0.169	0.199	0.246
2	0.718	0.588	0.624	0.647	0.495	0.547	0.473	0.365	0.364	0.383
3	0.987	0.514	0.615	0.467	0.458	0.450	0.421	0.265	0.244	0.266
4	0.887	0.635	0.471	0.495	0.366	0.382	0.225	0.271	0.206	0.238
5	0.797	0.671	0.696	0.237	0.444	0.243	0.268	0.168	0.205	0.155
6	0.427	0.446	0.606	0.535	0.238	0.222	0.178	0.140	0.122	0.160
7	0.392	0.511	0.459	0.316	0.464	0.116	0.112	0.150	0.090	0.098
8	0.188	0.239	0.287	0.138	0.252	0.311	0.087	0.094	0.086	0.070
9	0.138	0.163	0.115	0.099	0.083	0.162	0.103	0.020	0.034	0.034
10	0.138	0.163	0.115	0.099	0.083	0.162	0.103	0.020	0.034	0.034

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10
2001	541719	797087	401179	219857	276005	21139	14454	6916	5210	18854
2002	1728682	457012	351836	135297	81951	112549	12480	8833	5185	11063
2003	535123	1268291	229773	190406	64897	37890	65180	6773	6290	8302
2004	1260826	419124	614685	112419	107580	29262	18698	37270	4598	6019
2005	771300	918751	198621	348748	61979	76821	15515	12330	29390	8095
2006	920161	606087	506543	113737	218803	35975	54765	8827	8669	9242
2007	1078318	622512	317450	292228	70207	155320	26079	44133	5849	13545
2008	915240	901007	351167	188458	211100	48585	117601	21097	36604	48704
2009	873354	699043	565701	243684	130060	161409	38228	91574	17380	23834
2010	808130	647434	439723	401050	179519	95860	129253	31619	76023	38876

Table 8.3.1. cont. North Sea plaice. XSA diagnostics from final run.

Estimated population abundance at 1st Jan 2011

age

year	1	2	3	4	5	6	7	8	9	10
2011	0	571489	399531	304834	285928	139141	73937	106036	26669	66485

Fleet: BTS-Isis

Log catchability residuals.

year age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1	-1.23	-0.577	-0.823	0.396	0.407	-0.419	0.213	0.573	0.311	0.474
2	0.325	-0.279	0.575	-0.276	0.6	0.12	0.387	0.643	1.219	0.303
3	-0.06	0.393	-0.255	0.519	-0.29	0.507	-0.01	0.054	0.935	0.41
4	-0.292	-0.14	-0.542	-0.107	0.49	0.572	0.095	-0.389	0.132	0.527
5	-0.541	0.034	-0.338	0.305	0.687	-0.334	0.012	0.254	-0.65	0.32
6	0.319	-0.603	-0.683	-0.002	0.185	-0.308	0.834	0.565	0.238	-0.16
7	0.083	0.117	-0.201	-0.222	-0.249	-0.66	-0.725	-0.045	-0.566	0.842
8	-0.101	-0.041	-0.409	-1.133	0.857	0.541	0.109	0.405	-0.474	0.203

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	-0.203	-0.169	0.512	0.495	0.257	-0.038	0.274	0.134	-0.103	-0.344
2	-0.232	0.45	-0.754	0.405	0.307	-0.394	-0.324	-0.344	-0.065	-0.332
3	-0.138	0.474	-0.501	0.635	0.784	-0.015	-0.221	-0.603	-0.499	0.23
4	0.303	0.175	-0.193	0.492	-0.135	0.004	0.237	-0.063	-0.414	0.233
5	-0.313	0.86	-1.24	0.371	0.493	-0.505	0.477	0.369	0.043	-0.239
6	0.18	0.532	-0.135	0.036	-0.909	-1.015	-0.339	-0.41	0.638	1.121
7	-0.018	-1.921	-0.441	-0.312	-0.463	0.913	-0.707	-0.909	-0.583	0.966
8	1.925	-0.016	-0.284	0.432	-1.437	-1.701	-1.351	-0.345	-0.189	1.243

Age	2005	2006	2007	2008	2009	2010
1	-0.266	-0.574	0.005	-0.11	0.571	0.233
2	-0.71	-0.856	-0.322	-0.181	-0.066	-0.198
3	-0.862	-0.817	-0.286	-0.073	-0.142	-0.169
4	-0.258	-0.583	-0.061	-0.053	0.004	-0.032
5	-0.363	-0.073	0.387	0.112	0.041	-0.171
6	-0.301	0.151	0.606	-0.546	-0.032	0.041
7	0.067	-0.48	0.158	-0.402	-0.415	0.17
8	-0.498	-1.457	-0.191	-0.494	0.019	-1.259

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	-8.0264	-8.4085	-9.0335	-9.6264	-10.2078	-10.5574	-10.5574	-10.5574
S.E_Logq	0.4635	0.4939	0.4755	0.3196	0.4664	0.5321	0.6010	0.8580

Fleet: BTS-Tridens

Log catchability residuals.

year age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	-1.351	-3.893	-2.776	-0.375	-0.001	-0.231	0.861	0.447	0.05	0.627
2	-1.324	-1.109	-0.357	-0.688	-0.27	-0.688	0.182	0.359	0.511	0.012
3	-0.505	-0.538	-0.317	-0.202	-0.242	-0.215	-0.454	0.381	0.149	0.326
4	-0.476	-0.215	-0.259	0.14	-0.491	-0.298	-0.032	-0.143	0.441	-0.154
5	-0.373	0.06	0.154	-0.066	0.312	-0.496	0.065	0.51	-0.482	-0.209
6	-0.142	0.013	0.06	0.511	0.045	-0.276	-0.503	0.245	0.312	0.174
7	-0.425	-0.803	0.218	-0.18	0.233	-0.498	-0.041	-0.067	-0.068	0.453
8	-0.369	0.415	0.407	0.601	0.394	-0.253	0.111	0.357	-0.185	-0.481
9	-0.189	0.174	0.042	0.033	-0.196	0.184	-0.042	0.361	0.07	0.372

age	2006	2007	2008	2009	2010
1	0.534	1.6	1.408	1.11	1.991
2	0.784	0.4	0.71	0.771	0.707
3	0.128	0.301	0.359	0.394	0.436
4	0.537	0.195	0.434	0.171	0.149
5	-0.26	0.094	0.276	0.333	0.082
6	-0.321	-0.182	0.467	-0.112	-0.29
7	-0.141	-0.082	0.304	-0.035	0.132
8	0.316	0.026	0.414	0.278	0.025
9	0.05	-0.404	0.743	0.038	-0.036

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	-12.0847	-10.1715	-9.6284	-9.4077	-9.4042	-9.2575	-9.2575	-9.2575	-9.2575
S.E_Logq	1.6090	0.7034	0.3637	0.3268	0.3076	0.2994	0.3268	0.3305	0.2727

Table 8.3.1. cont. North Sea plaice. XSA diagnostics from final run.

Fleet: SNS

Log catchability residuals.

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.392	0.105	0.468	-0.412	-0.141	-0.334	-0.126	0.193	-0.021	0.985
2	0.618	0.306	0.474	0.806	-0.124	0.443	0.413	0.724	0.161	0.746
3	0.309	-1.164	0.353	0.321	0.116	-0.075	1.387	1.028	0.781	0.379

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.93	0.565	0.564	-0.176	-0.37	0.522	0.56	0.471	-0.098	-0.213
2	1.119	0.853	0.573	0.102	0.457	-0.327	0.827	0.847	-0.707	-0.529
3	0.994	0.298	0.212	-0.188	1.074	-0.547	1.938	1.761	-0.013	-0.6

age	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	-0.29	NA	-0.496	-0.645	-0.532	-0.686	-0.422	-0.344	-0.451
2	-1.031	NA	-0.7	-1.294	-0.988	-0.761	-0.971	-1.009	-1.027
3	-1.136	NA	-0.321	-1.228	-1.172	-1.736	-0.749	-1.182	-0.842

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	-3.5188	-4.5113	-5.6227
S.E_Logq	0.4809	0.7565	0.9664

Terminal year survivor and F summaries:

Terminal year survivor and F summaries:

Age 1 Year class =2009

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	721436	0.472	Inf	Inf	1	0.48	0.2
BTS-Tridens	4186886	1.662	Inf	Inf	1	0.039	0.037
fshk	828283	1.768	Inf	Inf	1	0.034	0.176
SNS	363940	0.489	Inf	Inf	1	0.447	0.364

Age 2 Year class =2008

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	474721	0.346	0.384	1.11	2	0.498	0.331
BTS-Tridens	855286	0.667	0.138	0.207	2	0.143	0.197
fshk	327623	1.652	Inf	Inf	1	0.024	0.45
SNS	226039	0.415	0.321	0.773	2	0.334	0.601

Age 3 Year class =2007

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	269433	0.288	0.031	0.108	3	0.415	0.297
BTS-Tridens	507995	0.331	0.132	0.399	3	0.371	0.168
fshk	208695	1.751	Inf	Inf	1	0.014	0.369
SNS	157041	0.389	0.184	0.473	3	0.2	0.465

Age 4 Year class =2006

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	267303	0.221	0.037	0.167	4	0.466	0.253
BTS-Tridens	382278	0.239	0.125	0.523	4	0.422	0.183
fshk	228108	1.775	Inf	Inf	1	0.009	0.291
SNS	121032	0.387	0.144	0.372	3	0.104	0.492

Age 5 Year class =2005

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated
BTS-Isis	123038	0.207	0.081	0.391	5	0.412	0.173
BTS-Tridens	166219	0.194	0.057	0.294	5	0.522	0.131
fshk	76385	1.851	Inf	Inf	1	0.007	0.266
SNS	72832	0.4	0.079	0.197	3	0.059	0.278

Age 6 Year class =2004

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	67223	0.202	0.097	0.48	6	0.359	0.174
BTS-Tridens	83348	0.17	0.147	0.865	6	0.598	0.143
fshk	64804	1.846	Inf	Inf	1	0.006	0.18
SNS	27166	0.396	0.317	0.801	3	0.037	0.386

Age 7 Year class =2003

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	94963	0.195	0.122	0.626	7	0.333	0.109
BTS-Tridens	117672	0.153	0.059	0.386	7	0.632	0.089
fshk	53230	1.904	Inf	Inf	1	0.005	0.187
SNS	44619	0.397	0.262	0.66	3	0.03	0.219

Age 8 Year class =2002

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	17403	0.202	0.171	0.847	8	0.293	0.106
BTS-Tridens	32629	0.147	0.085	0.578	8	0.692	0.058
fshk	10738	1.931	Inf	Inf	1	0.005	0.166
SNS	9961	0.638	0.263	0.412	2	0.01	0.178

Age 9 Year class =2001

Fleet	Est.Suvivors	Int. s.e.	Ext. s.e.	Var Ratio	N	Scaled Wgts	Estimated F
BTS-Isis	65723	0.203	0.126	0.621	8	0.231	0.035
BTS-Tridens	67663	0.135	0.075	0.556	9	0.752	0.034
fshk	14860	1.966	Inf	Inf	1	0.005	0.145
SNS	49177	0.474	0.015	0.032	2	0.012	0.046

Table 8.3.2. North Sea plaice. Fishing mortality estimates in final XSA run

Plaice in IV . harvest

2011-05-07 12:59:34 units= f

	age									
year	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	0.434	0.518	0.452	0.445	0.445
1977	0.323	0.472	0.495	0.500	0.665	0.420	0.441	0.533	0.514	0.514
1978	0.305	0.429	0.464	0.471	0.461	0.519	0.461	0.427	0.469	0.469
1979	0.427	0.638	0.666	0.675	0.683	0.707	0.704	0.605	0.678	0.678
1980	0.238	0.469	0.667	0.622	0.508	0.517	0.492	0.502	0.530	0.530
1981	0.178	0.485	0.576	0.599	0.582	0.450	0.504	0.533	0.536	0.536
1982	0.242	0.518	0.695	0.674	0.601	0.521	0.481	0.536	0.565	0.565
1983	0.237	0.519	0.569	0.746	0.604	0.527	0.460	0.473	0.564	0.564
1984	0.300	0.552	0.584	0.604	0.637	0.541	0.481	0.573	0.569	0.569
1985	0.262	0.473	0.492	0.699	0.485	0.502	0.505	0.486	0.537	0.537
1986	0.284	0.609	0.633	0.634	0.718	0.713	0.561	0.644	0.730	0.730
1987	0.215	0.640	0.679	0.731	0.771	0.640	0.786	0.491	0.652	0.652
1988	0.232	0.611	0.657	0.673	0.713	0.675	0.644	0.968	0.714	0.714
1989	0.211	0.581	0.591	0.614	0.637	0.618	0.589	0.598	1.239	1.239
1990	0.161	0.473	0.572	0.535	0.667	0.582	0.505	0.437	0.533	0.533
1991	0.238	0.605	0.659	0.698	0.582	0.692	0.660	0.630	0.600	0.600
1992	0.214	0.553	0.652	0.671	0.793	0.480	0.537	0.660	0.900	0.900
1993	0.220	0.486	0.604	0.647	0.745	0.708	0.312	0.356	0.777	0.777
1994	0.163	0.484	0.610	0.712	0.634	0.641	0.908	0.213	0.255	0.255
1995	0.121	0.459	0.645	0.768	0.743	0.596	0.639	0.628	0.101	0.101
1996	0.096	0.546	0.686	0.730	0.745	0.649	0.753	0.613	0.868	0.868
1997	0.065	0.796	0.925	0.742	0.773	0.716	0.581	0.553	0.597	0.597
1998	0.153	0.493	1.000	1.071	0.629	0.455	0.550	0.421	0.504	0.504
1999	0.174	0.477	0.516	1.172	0.637	0.498	0.320	0.455	0.432	0.432
2000	0.119	0.367	0.331	0.582	0.548	0.489	0.285	0.198	0.310	0.310
2001	0.070	0.718	0.987	0.887	0.797	0.427	0.392	0.188	0.138	0.138
2002	0.210	0.588	0.514	0.635	0.671	0.446	0.511	0.239	0.163	0.163
2003	0.144	0.624	0.615	0.471	0.696	0.606	0.459	0.287	0.115	0.115
2004	0.217	0.647	0.467	0.495	0.237	0.535	0.316	0.138	0.099	0.099
2005	0.141	0.495	0.458	0.366	0.444	0.238	0.464	0.252	0.083	0.083
2006	0.291	0.547	0.450	0.382	0.243	0.222	0.116	0.311	0.162	0.162
2007	0.080	0.473	0.421	0.225	0.268	0.178	0.112	0.087	0.103	0.103
2008	0.169	0.365	0.265	0.271	0.168	0.140	0.150	0.094	0.020	0.020
2009	0.199	0.364	0.244	0.206	0.205	0.122	0.090	0.086	0.034	0.034
2010	0.246	0.383	0.266	0.238	0.155	0.160	0.098	0.070	0.034	0.034

Table 8.3.3. North Sea plaice. Stock number estimates in the final XSA runs

Plaice in IV . stock.n

2011-05-07 13:00:07 units= thousands

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	757298	670799	377298	171551	76786	85609	46907	31440	16805	49877
1961	860576	614899	441591	239779	105744	48183	50972	28949	19875	48420
1962	589154	706789	416674	283132	151856	63044	31337	32158	16921	41052
1963	688366	484324	465009	259569	172009	89026	37245	19737	20503	48075
1964	2231500	536380	304564	276885	152215	101919	50127	21480	11359	47991
1965	694573	1956330	325548	176043	156783	80258	56631	30309	13162	54735
1966	586777	586900	1355540	198052	105458	99441	43686	33776	19288	44345
1967	401295	494320	371938	832385	116531	59210	63824	23833	20304	33590
1968	434278	343893	314557	224454	500705	65485	32351	42364	13952	47348
1969	648870	322588	233484	201831	141578	314125	42895	19435	28723	56233
1970	650577	506082	213513	152352	129909	93521	185268	28910	11797	41652
1971	410272	471052	296428	118122	83215	74030	51104	92598	20156	52938
1972	366620	305256	305839	182004	72495	50103	45122	30153	55506	46556
1973	1312021	263019	188696	185323	108923	43137	29096	27150	16912	66364
1974	1132742	1060062	160419	110710	97546	57137	25825	17876	15198	59730
1975	864794	821991	643822	88840	59833	48610	32889	15753	10162	48501
1976	692709	548543	450548	342693	46076	29719	23712	18465	8620	36564
1977	988699	449195	330292	266222	201250	28419	17431	12781	10629	23943
1978	912443	647437	253620	182234	146179	93614	16895	10148	6787	20864
1979	891347	608718	381605	144254	102952	83426	50385	9637	5994	19715
1980	1128540	526403	290996	177455	66467	47044	37208	22544	4762	13671
1981	865978	804883	297987	135199	86172	36202	25380	20577	12353	14888
1982	2030637	655729	448467	151538	67184	43560	20896	13868	10922	20978
1983	1308364	1442978	353287	202578	69910	33327	23411	11689	7345	20099
1984	1259376	934051	776752	181026	86930	34565	17811	13368	6588	15820
1985	1848339	843904	486796	391915	89529	41598	18216	9966	6822	14590
1986	4764511	1286717	475602	269362	176337	49885	22779	9946	5546	14012
1987	1964497	3246664	633398	228466	129324	77817	22123	11766	4729	11956
1988	1770620	1433663	1549550	290684	99553	54135	37141	9124	6517	12765
1989	1187006	1270527	704373	726661	134128	44171	24948	17651	3137	8171
1990	1036812	869960	642994	352826	355806	64164	21550	12522	8779	9640
1991	914859	798445	490549	328359	186935	165161	32437	11767	7320	12960
1992	777188	652215	394440	229679	147870	94485	74776	15168	5669	12179
1993	531145	567997	339430	185967	106191	60544	52879	39554	7094	11372
1994	443366	385636	316059	167809	88127	45632	26990	35032	25068	25307
1995	1164491	340756	214957	155359	74529	42297	21759	9846	25612	41096
1996	1290778	933236	194893	102088	65209	32087	21080	10393	4756	8800
1997	2157357	1061070	489085	88845	44537	28011	15169	8986	5097	9728
1998	775489	1828830	433331	175460	38292	18599	12384	7674	4676	8244
1999	841728	602066	1011143	144250	54429	18467	10679	6463	4560	9235
2000	992460	639993	338269	546091	40417	26049	10159	7016	3711	8255
2001	541719	797087	401179	219857	276005	21139	14454	6916	5210	18854
2002	1728682	457012	351836	135297	81951	112549	12480	8833	5185	11063
2003	535123	1268291	229773	190406	64897	37890	65180	6773	6290	8302
2004	1260826	419124	614685	112419	107580	29262	18698	37270	4598	6019
2005	771300	918751	198621	348748	61979	76821	15515	12330	29390	8095
2006	920161	606087	506543	113737	218803	35975	54765	8827	8669	9242
2007	1078318	622512	317450	292228	70207	155320	26079	44133	5849	13545
2008	915240	901007	351167	188458	211100	48585	117601	21097	36604	48704
2009	873354	699043	565701	243684	130060	161409	38228	91574	17380	23834
2010	-	647434	439723	401050	179519	95860	129253	31619	76023	38876

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	296271	109164	79300	29864	0.37	0.24	0.24	0.27
1960	757298	307214	117334	87541	29793	0.37	0.27	0.23	0.28
1961	860576	319935	118474	85984	32490	0.35	0.24	0.27	0.27
1962	589154	371316	125375	87472	37903	0.39	0.25	0.29	0.24
1963	688366	368352	148376	107118	41258	0.42	0.27	0.36	0.29
1964	2231500	361209	147571	110540	37031	0.47	0.30	0.32	0.31
1965	694573	343910	140223	97143	43080	0.39	0.28	0.25	0.28
1966	586777	359195	166552	101834	64718	0.40	0.24	0.34	0.28
1967	401295	412583	163365	108819	54546	0.43	0.25	0.32	0.26
1968	434278	400992	139521	111534	27987	0.34	0.21	0.22	0.28
1969	648870	376356	142820	121651	21169	0.34	0.25	0.17	0.32
1970	650577	332875	159982	130342	29640	0.48	0.35	0.28	0.39
1971	410272	314678	136939	113944	22995	0.38	0.29	0.22	0.36
1972	366620	316592	142475	122843	19632	0.41	0.33	0.19	0.39
1973	1312021	266572	143783	130429	13354	0.47	0.41	0.13	0.49
1974	1132742	278442	157485	112540	44945	0.49	0.41	0.20	0.40
1975	864794	291432	195235	108536	86699	0.56	0.37	0.43	0.37
1976	692709	307682	166917	113670	53247	0.42	0.30	0.27	0.37
1977	988699	314356	176689	119188	57501	0.51	0.34	0.31	0.38
1978	912443	301196	159639	113984	45655	0.47	0.36	0.22	0.38
1979	891347	295443	213282	145347	67935	0.67	0.49	0.36	0.49
1980	1128540	269567	171031	139951	31080	0.56	0.49	0.16	0.52
1981	865978	260451	172778	139747	33031	0.54	0.47	0.16	0.54
1982	2030637	260900	203674	154547	49127	0.60	0.51	0.22	0.59
1983	1308364	312351	218521	144038	74483	0.59	0.48	0.26	0.46
1984	1259376	321241	226963	156147	70816	0.58	0.43	0.28	0.49
1985	1848339	344322	220387	159838	60549	0.53	0.44	0.23	0.46
1986	4764511	371009	295300	165347	129953	0.66	0.49	0.34	0.45
1987	1964497	448636	344194	153670	190524	0.69	0.48	0.51	0.34
1988	1770620	390442	310898	154475	156423	0.67	0.40	0.51	0.40
1989	1187006	415470	277611	169818	107793	0.61	0.38	0.46	0.41
1990	1036812	380355	227465	156240	71225	0.57	0.38	0.39	0.41
1991	914859	350909	228939	148004	80935	0.65	0.41	0.47	0.42
1992	777188	285921	182239	125190	57049	0.63	0.41	0.40	0.44
1993	531145	249236	152129	117113	35016	0.64	0.50	0.28	0.47
1994	443366	227550	134177	110392	23785	0.62	0.51	0.24	0.49
1995	1164491	219618	120184	98356	21828	0.64	0.55	0.21	0.45
1996	1290778	181093	133722	81673	52049	0.67	0.52	0.34	0.45
1997	2157357	207488	183193	83048	100145	0.79	0.51	0.69	0.40
1998	775489	228153	175285	71534	103751	0.73	0.38	0.60	0.31
1999	841728	203361	151638	80662	70976	0.66	0.37	0.38	0.40
2000	992460	230474	125459	81148	44311	0.46	0.32	0.26	0.35
2001	541719	273609	182272	81963	100309	0.76	0.31	0.71	0.30
2002	1728682	200839	124607	70217	54390	0.57	0.37	0.42	0.35
2003	535123	230158	144294	66502	77792	0.60	0.38	0.45	0.29
2004	1260826	210826	115902	61436	54466	0.48	0.28	0.43	0.29
2005	771300	248307	109576	55700	53876	0.40	0.20	0.38	0.22
2006	920161	256483	119789	57943	61846	0.37	0.19	0.39	0.23
2007	1078318	261286	89179	49744	39435	0.31	0.15	0.35	0.19
2008	915240	360815	94749	48874	45875	0.24	0.14	0.23	0.14
2009	873354	385945	100198	54973	45225	0.23	0.12	0.24	0.14
2010	808130	460708	106491	60674	45817	0.24	0.12	0.25	0.13

Table 8.5.1. North Sea plaice. Input table for RCT3 analysis.

year	XSA1	XSA2	SNS0	SNS1	SNS2	BTS1	BTS2	DFS0
1968	648869	506081	-11	-11	9731.5	-11	-11	-11
1969	650576	471051	-11	9311	28163.5	-11	-11	-11
1970	410270	305254	1200	13539	10779.7	-11	-11	-11
1971	366617	263017	4456	13207	5133.3	-11	-11	-11
1972	1312009	1060052	7758	65643	16508.9	-11	-11	-11
1973	1132726	821976	7183	15366	8168.4	-11	-11	-11
1974	864773	548525	2568	11628	2402.6	-11	-11	-11
1975	692682	449171	1314	8537	3423.8	-11	-11	-11
1976	988665	647406	11166	18537	12678.0	-11	-11	-11
1977	912345	608629	4373	14012	9828.8	-11	-11	-11
1978	891239	526305	3268	21495	12882.3	-11	-11	-11
1979	1128156	804536	29058	59174	18785.3	-11	-11	-11
1980	865944	655698	4210	24756	8642.0	-11	-11	-11
1981	2031170	1443460	35506	69993	13908.6	-11	-11	606.0
1982	1308491	934165	24402	33974	10412.8	-11	-11	433.7
1983	1259358	843888	32942	44965	13847.8	-11	173.9	431.7
1984	1848419	1286790	7918	28101	7580.4	136.8	131.7	261.8
1985	4760609	3243133	47256	93552	32991.1	667.4	764.2	716.3
1986	1962845	1432168	8820	33402	14421.1	225.8	147.0	200.1
1987	1770461	1270384	21335	36609	17810.2	680.2	319.3	516.8
1988	1186811	869783	15670	34276	7496.0	467.9	146.1	318.4
1989	1036516	798177	24585	25037	11247.2	185.3	159.4	435.7
1990	914585	651967	9369	57221	13841.8	291.4	174.5	465.5
1991	776744	567595	17257	46798	9685.6	360.9	283.4	498.5
1992	530684	385219	6473	22098	4976.6	189.0	77.1	351.6
1993	442947	340377	9234	19188	2796.4	193.3	40.6	262.3
1994	1164164	932940	26781	24767	10268.2	265.6	206.9	445.7
1995	1290364	1060695	12541	23015	4472.7	310.3	59.2	184.5
1996	2155842	1827459	84042	95901	30242.2	1046.8	402.7	572.8
1997	774928	601558	17344	33666	10272.1	347.6	121.6	149.2
1998	840878	639225	25522	32951	2493.4	293.3	69.3	-11
1999	991191	795939	39262	22855	2898.5	267.5	72.2	-11
2000	540350	455774	24214	11511	1102.7	206.5	44.5	183.8
2001	1726207	1266052	99628	30809	-11	519.2	159.1	500.4
2002	537804	421550	31202	-11	1349.7	132.8	39.6	210.7
2003	1248173	907301	-11	18202	1818.9	233.7	66.2	359.6
2004	791655	624505	13537	10118	1571.0	163.0	36.4	243.2
2005	922375	624515	27391	12164	2133.9	128.6	67.2	129.3
2006	922375	624515	51124	14175	2700.4	312.0	120.7	232.3
2007	-11	-11	40581	14706	2018.7	221.6	105.2	175.7
2008	-11	-11	50179	14860	1811.5	409.0	84.3	186.9
2009	-11	-11	53259	11947	-11	261.0	-11	235.6
2010	-11	-11	49347	-11	-11	-11	-11	200.5

Table 8.5.2. North Sea plaice. RCT3 results for age 1.

```
Analysis by RCT3 ver3.1 of data from file :

 ple_iv1.txt

 Plaice NorthSea       Age1

 Data for    6 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.


 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

 SNS0       .39  10.58    .53   .482     35  10.81   14.78     .564     .382
DFS0       2.21   1.16    .91   .273     24   5.31   12.87     .996     .123

                                        VPA Mean =   13.86     .495     .495


 Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class     Average      WAP     Std     Std    Ratio             VPA
          Prediction           Error   Error

 2010     1319724     14.09     .35     .44     1.61
```

Table 8.5.3. North Sea plaice. RCT3 results for age 2.

```
Analysis by RCT3 ver3.1 of data from file :


 ple_iv2.txt

 NorthSea      Plaice  Age2

 Data for    6 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.


 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

 SNS0       .39  10.42    .47   .539     35  10.88   14.65     .511     .286
 SNS1      1.20   1.36    .58   .425     35   9.39   12.62     .622     .193
 BTS1      1.54   4.89    .68   .391     23   5.57   13.50     .724     .143
 DFS0      2.21    .87    .93   .254     24   5.47   12.93     .997     .075

                                        VPA Mean =   13.55     .497     .303


 Year     Weighted       Log      Int      Ext     Var      VPA       Log
 Class     Average       WAP      Std      Std    Ratio               VPA
          Prediction             Error    Error

 2009      830649     13.63      .27      .37     1.78
```

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	2011	0.208	0.21	0.00	915399	0.06	0.21	0.06	0.05	0.0	0.1
2	2	2011	0.376	0.35	0.02	830649	0.13	0.27	0.12	0.11	0.5	0.1
3	3	2011	0.263	0.14	0.12	399516	0.23	0.31	0.16	0.19	0.5	0.1
4	4	2011	0.242	0.05	0.19	304815	0.32	0.36	0.20	0.32	1.0	0.1
5	5	2011	0.179	0.01	0.16	285909	0.40	0.42	0.19	0.36	1.0	0.1
6	6	2011	0.143	0.01	0.13	139132	0.45	0.47	0.21	0.41	1.0	0.1
7	7	2011	0.114	0.03	0.08	73930	0.45	0.53	0.21	0.47	1.0	0.1
8	8	2011	0.085	0.03	0.05	106026	0.49	0.66	0.21	0.58	1.0	0.1
9	9	2011	0.030	0.00	0.03	26666	0.67	0.67	0.00	0.58	1.0	0.1
10	10	2011	0.030	0.00	0.03	100473	0.70	0.70	0.00	0.67	1.0	0.1
11	1	2012	0.208	0.21	0.00	915399	0.06	0.21	0.06	0.05	0.0	0.1
12	2	2012	0.376	0.35	0.02	NA	0.13	0.27	0.12	0.11	0.5	0.1
13	3	2012	0.263	0.14	0.12	NA	0.23	0.31	0.16	0.19	0.5	0.1
14	4	2012	0.242	0.05	0.19	NA	0.32	0.36	0.20	0.32	1.0	0.1
15	5	2012	0.179	0.01	0.16	NA	0.40	0.42	0.19	0.36	1.0	0.1
16	6	2012	0.143	0.01	0.13	NA	0.45	0.47	0.21	0.41	1.0	0.1
17	7	2012	0.114	0.03	0.08	NA	0.45	0.53	0.21	0.47	1.0	0.1
18	8	2012	0.085	0.03	0.05	NA	0.49	0.66	0.21	0.58	1.0	0.1
19	9	2012	0.030	0.00	0.03	NA	0.67	0.67	0.00	0.58	1.0	0.1
20	10	2012	0.030	0.00	0.03	NA	0.70	0.70	0.00	0.67	1.0	0.1
21	1	2013	0.208	0.21	0.00	915399	0.06	0.21	0.06	0.05	0.0	0.1
22	2	2013	0.376	0.35	0.02	NA	0.13	0.27	0.12	0.11	0.5	0.1
23	3	2013	0.263	0.14	0.12	NA	0.23	0.31	0.16	0.19	0.5	0.1
24	4	2013	0.242	0.05	0.19	NA	0.32	0.36	0.20	0.32	1.0	0.1
25	5	2013	0.179	0.01	0.16	NA	0.40	0.42	0.19	0.36	1.0	0.1
26	6	2013	0.143	0.01	0.13	NA	0.45	0.47	0.21	0.41	1.0	0.1
27	7	2013	0.114	0.03	0.08	NA	0.45	0.53	0.21	0.47	1.0	0.1
28	8	2013	0.085	0.03	0.05	NA	0.49	0.66	0.21	0.58	1.0	0.1
29	9	2013	0.030	0.00	0.03	NA	0.67	0.67	0.00	0.58	1.0	0.1
30	10	2013	0.030	0.00	0.03	NA	0.70	0.70	0.00	0.67	1.0	0.1

Table 8.6.2A. North Sea plaice. Results from the short term forecast assuming $F_{2011} = F_{2010}$

	year	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb2011
25	2011	0.24	0.25	0.13	68682	48869	117435	522891

	year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb	ssb2013
2	2012	0.2	0.048	0.05	0.03	15439	10237	25656	555666	701643
5	2012	0.3	0.072	0.07	0.04	22931	15132	38033	555666	689082
8	2012	0.4	0.096	0.10	0.05	30275	19886	50120	555666	676811
11	2012	0.5	0.120	0.12	0.06	37476	24501	61926	555666	664823
14	2012	0.6	0.144	0.15	0.08	44535	28983	73458	555666	653109
17	2012	0.7	0.168	0.17	0.09	51456	33335	84723	555666	641664
20	2012	0.8	0.192	0.20	0.10	58243	37562	95728	555666	630479
23	2012	0.9	0.216	0.22	0.11	64899	41668	106480	555666	619549
26	2012	1.0	0.240	0.25	0.13	71425	45656	116985	555666	608867
29	2012	1.1	0.264	0.27	0.14	77826	49529	127252	555666	598426
32	2012	1.2	0.289	0.30	0.15	84104	53293	137284	555666	588221
35	2012	1.3	0.313	0.32	0.16	90262	56949	147090	555666	578245
38	2012	1.4	0.337	0.35	0.18	96302	60501	156674	555666	568492
41	2012	1.5	0.361	0.37	0.19	102227	63953	166043	555666	558957
44	2012	1.6	0.385	0.40	0.20	108040	67307	175202	555666	549634
47	2012	1.7	0.409	0.42	0.22	113743	70567	184157	555666	540518
50	2012	1.8	0.433	0.44	0.23	119338	73735	192913	555666	531603
53	2012	1.9	0.457	0.47	0.24	124828	76814	201475	555666	522886
56	2012	2.0	0.481	0.49	0.25	130215	79807	209848	555666	514360

Table 8.6.2B. North Sea plaice. Results from the short term forecast assuming a F for 2011 such that the landings in 2011 equal the TAC for 2011

	year	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb2011
25	2011	0.259	0.27	0.14	73400	52043	125319	522891

	year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb	ssb2013
2	2012	0.2	0.048	0.05	0.03	15151	10079	25209	547873	691016
5	2012	0.3	0.072	0.07	0.04	22503	14899	37371	547873	678685
8	2012	0.4	0.096	0.10	0.05	29710	19579	49250	547873	666639
11	2012	0.5	0.120	0.12	0.06	36777	24124	60851	547873	654869
14	2012	0.6	0.144	0.15	0.08	43705	28537	72183	547873	643370
17	2012	0.7	0.168	0.17	0.09	50498	32823	83253	547873	632133
20	2012	0.8	0.192	0.20	0.10	57160	36985	94068	547873	621152
23	2012	0.9	0.216	0.22	0.11	63693	41028	104635	547873	610420
26	2012	1.0	0.240	0.25	0.13	70100	44955	114961	547873	599932
29	2012	1.1	0.264	0.27	0.14	76383	48770	125051	547873	589680
32	2012	1.2	0.289	0.30	0.15	82546	52476	134911	547873	579659
35	2012	1.3	0.313	0.32	0.16	88591	56077	144549	547873	569863
38	2012	1.4	0.337	0.35	0.18	94522	59575	153970	547873	560286
41	2012	1.5	0.361	0.37	0.19	100339	62974	163179	547873	550922
44	2012	1.6	0.385	0.40	0.20	106046	66278	172182	547873	541767
47	2012	1.7	0.409	0.42	0.22	111646	69488	180984	547873	532814
50	2012	1.8	0.433	0.44	0.23	117140	72609	189591	547873	524060
53	2012	1.9	0.457	0.47	0.24	122531	75641	198008	547873	515498
56	2012	2.0	0.481	0.49	0.25	127821	78590	206239	547873	507124

Table 8.6.3A. North Sea plaice. Detailed STF table, assuming $F_{2011} = F_{2010}$, rescaled.

	age	f	fdisc	fland	stock	catch	land	disc	stock	catch	catch	land	land	disc	disc	SSB	TSB
					n	wt	wt	wt	wt	n		n		n			
2011																	
1	1	0.208	0.21	0	915399	0.06	0.21	0.06	0.05	164037	9818	1356	289	162680	9544	0	46685
2	2	0.376	0.35	0.02	830649	0.13	0.27	0.12	0.11	248643	31261	15446	4139	233196	27129	47624	95248
3	3	0.263	0.14	0.12	399516	0.23	0.31	0.16	0.19	87982	20376	40700	12732	47283	7676	37887	75775
4	4	0.242	0.05	0.19	304815	0.32	0.36	0.2	0.32	62459	20220	49983	17778	12475	2441	97338	97338
5	5	0.179	0.01	0.16	285909	0.4	0.42	0.19	0.36	44615	17850	40928	17145	3687	713	103785	103785
6	6	0.143	0.01	0.13	139132	0.45	0.47	0.21	0.41	17630	7984	16189	7683	1441	307	57600	57600
7	7	0.114	0.03	0.08	73930	0.45	0.53	0.21	0.47	7612	3428	5605	2989	2007	430	34599	34599
8	8	0.085	0.03	0.05	106026	0.49	0.66	0.21	0.58	8201	4034	5254	3463	2947	631	61460	61460
9	9	0.03	0	0.03	26666	0.67	0.67	0	0.58	744	499	744	499	0	0	15386	15386
10	10	0.03	0	0.03	100473	0.7	0.7	0	0.67	2803	1964	2803	1964	0	0	67211	67211
2012																	
11	1	0.208	0.21	0	915399	0.06	0.21	0.06	0.05	164037	9818	1356	289	162680	9544	0	46685
12	2	0.376	0.35	0.02	672586	0.13	0.27	0.12	0.11	201329	25312	12507	3351	188822	21966	38562	77123
13	3	0.263	0.14	0.12	515922	0.23	0.31	0.16	0.19	113618	26313	52558	16442	61060	9912	48927	97853
14	4	0.242	0.05	0.19	278023	0.32	0.36	0.2	0.32	56969	18443	45590	16215	11379	2226	88782	88782
15	5	0.179	0.01	0.16	216540	0.4	0.42	0.19	0.36	33790	13519	30998	12985	2792	540	78604	78604
16	6	0.143	0.01	0.13	216343	0.45	0.47	0.21	0.41	27414	12415	25173	11947	2241	478	89566	89566
17	7	0.114	0.03	0.08	109148	0.45	0.53	0.21	0.47	11239	5061	8275	4413	2964	634	51081	51081
18	8	0.085	0.03	0.05	59663	0.49	0.66	0.21	0.58	4615	2270	2956	1949	1658	355	34585	34585
19	9	0.03	0	0.03	88145	0.67	0.67	0	0.58	2459	1651	2459	1651	0	0	50859	50859
20	10	0.03	0	0.03	111668	0.7	0.7	0	0.67	3115	2183	3115	2183	0	0	74700	74700
2013																	
21	1	0.208	0.21	0	915399	0.06	0.21	0.06	0.05	164037	9818	1356	289	162680	9544	0	46685
22	2	0.376	0.35	0.02	672586	0.13	0.27	0.12	0.11	201329	25312	12507	3351	188822	21966	38562	77123
23	3	0.263	0.14	0.12	417748	0.23	0.31	0.16	0.19	91998	21306	42557	13313	49441	8026	39616	79233
24	4	0.242	0.05	0.19	359030	0.32	0.36	0.2	0.32	73568	23816	58874	20940	14694	2875	114650	114650
25	5	0.179	0.01	0.16	197507	0.4	0.42	0.19	0.36	30820	12331	28273	11844	2547	492	71695	71695
26	6	0.143	0.01	0.13	163852	0.45	0.47	0.21	0.41	20763	9403	19065	9048	1697	362	67835	67835
27	7	0.114	0.03	0.08	169720	0.45	0.53	0.21	0.47	17476	7870	12867	6863	4608	986	79429	79429
28	8	0.085	0.03	0.05	88085	0.49	0.66	0.21	0.58	6813	3352	4365	2877	2448	524	51060	51060
29	9	0.03	0	0.03	49601	0.67	0.67	0	0.58	1384	929	1384	929	0	0	28620	28620
30	10	0.03	0	0.03	175499	0.7	0.7	0	0.67	4896	3431	4896	3431	0	0	117400	117400

Table 8.6.3B. North Sea plaice. Detailed STF table, forecast assuming a F for 2011 such that the landings in 2011 equal the TAC for 2011

age	f	fdisc	fland	stock	catch	land	disc	stock	catch	catch	land	land	disc	disc	SSB	TSB
				n	wt	wt	wt	wt	n		n		n			
2011																
1	0.224	0.22	0	915399	0.06	0.21	0.06	0.05	175283	10491	1449	309	173834	10198	0	46685
2	0.405	0.38	0.03	830649	0.13	0.27	0.12	0.11	264183	33214	16412	4397	247772	28824	47624	95248
3	0.283	0.15	0.13	399516	0.23	0.31	0.16	0.19	93838	21732	43408	13580	50430	8186	37887	75775
4	0.26	0.05	0.21	304815	0.32	0.36	0.2	0.32	66663	21581	53348	18974	13315	2605	97338	97338
5	0.193	0.02	0.18	285909	0.4	0.42	0.19	0.36	47723	19094	43780	18339	3943	762	103785	103785
6	0.154	0.01	0.14	139132	0.45	0.47	0.21	0.41	18883	8551	17339	8229	1544	329	57600	57600
7	0.123	0.03	0.09	73930	0.45	0.53	0.21	0.47	8161	3675	6009	3205	2152	461	34599	34599
8	0.091	0.03	0.06	106026	0.49	0.66	0.21	0.58	8802	4330	5639	3717	3163	677	61460	61460
9	0.032	0	0.03	26666	0.67	0.67	0	0.58	800	537	800	537	0	0	15386	15386
10	0.032	0	0.03	100473	0.7	0.7	0	0.67	3014	2112	3014	2112	0	0	67211	67211
2012																
1	0.208	0.21	0	915399	0.06	0.21	0.06	0.05	164037	9818	1356	289	162680	9544	0	46685
2	0.376	0.35	0.02	661933	0.13	0.27	0.12	0.11	198140	24911	12309	3298	185831	21618	37951	75902
3	0.263	0.14	0.12	501251	0.23	0.31	0.16	0.19	110387	25565	51064	15975	59323	9630	47535	95071
4	0.242	0.05	0.19	272482	0.32	0.36	0.2	0.32	55833	18075	44682	15892	11152	2182	87013	87013
5	0.179	0.01	0.16	212560	0.4	0.42	0.19	0.36	33169	13271	30428	12746	2741	530	77159	77159
6	0.143	0.01	0.13	213397	0.45	0.47	0.21	0.41	27041	12246	24830	11784	2210	472	88346	88346
7	0.114	0.03	0.08	107960	0.45	0.53	0.21	0.47	11116	5006	8185	4365	2931	627	50525	50525
8	0.085	0.03	0.05	59142	0.49	0.66	0.21	0.58	4574	2250	2931	1932	1644	352	34283	34283
9	0.03	0	0.03	87574	0.67	0.67	0	0.58	2443	1640	2443	1640	0	0	50530	50530
10	0.03	0	0.03	111414	0.7	0.7	0	0.67	3108	2178	3108	2178	0	0	74530	74530
2013																
1	0.208	0.21	0	915399	0.06	0.21	0.06	0.05	164037	9818	1356	289	162680	9544	0	46685
2	0.376	0.35	0.02	672586	0.13	0.27	0.12	0.11	201329	25312	12507	3351	188822	21966	38562	77123
3	0.263	0.14	0.12	411132	0.23	0.31	0.16	0.19	90540	20968	41883	13103	48658	7899	38989	77978
4	0.242	0.05	0.19	348820	0.32	0.36	0.2	0.32	71476	23139	57199	20344	14276	2793	111390	111390
5	0.179	0.01	0.16	193570	0.4	0.42	0.19	0.36	30206	12085	27710	11608	2496	483	70266	70266
6	0.143	0.01	0.13	160841	0.45	0.47	0.21	0.41	20381	9230	18715	8882	1666	355	66588	66588
7	0.114	0.03	0.08	167409	0.45	0.53	0.21	0.47	17238	7763	12692	6769	4546	973	78347	78347
8	0.085	0.03	0.05	87127	0.49	0.66	0.21	0.58	6739	3315	4317	2846	2421	518	50504	50504
9	0.03	0	0.03	49168	0.67	0.67	0	0.58	1372	921	1372	921	0	0	28370	28370
10	0.03	0	0.03	174775	0.7	0.7	0	0.67	4876	3417	4876	3417	0	0	116916	116916

Table 8.6.4. North Sea plaice. Yield and spawning biomass per recruit reference points

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.24	0.08	0.97
Fmax	0.20	0.08	1.22
F0.1	0.15	0.08	1.67
Fmed	0.43	0.06	0.33

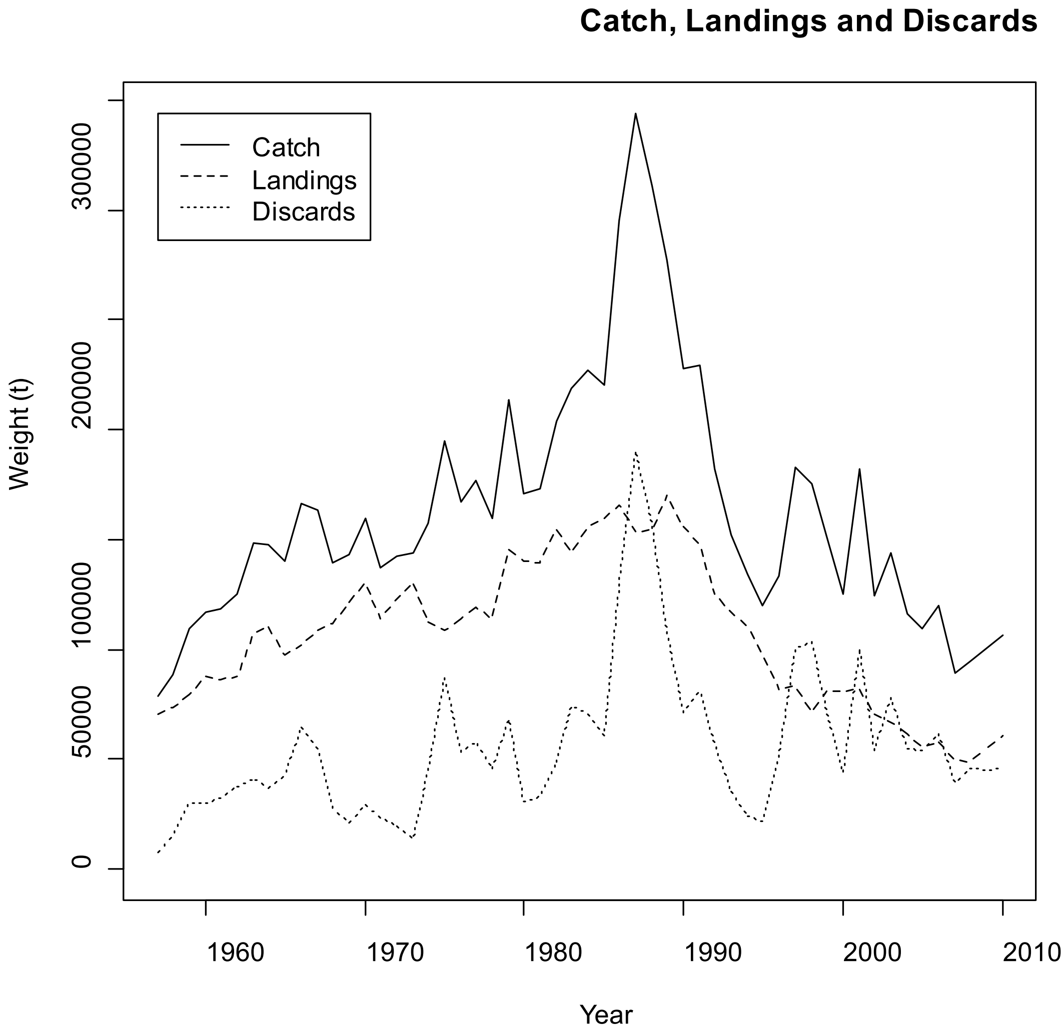


Figure 8.2.1 North Sea plaice. Time series of catch (solid line), landings (dashed line) and discards (dotted line) estimates.

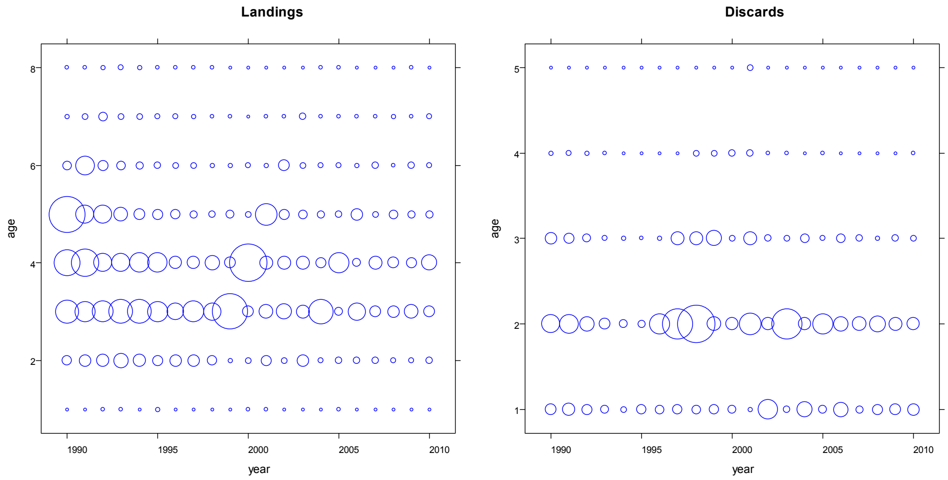


Figure 8.2.2 North Sea plaice. Landing numbers-at-age (left) and discards numbers-at-age (right).

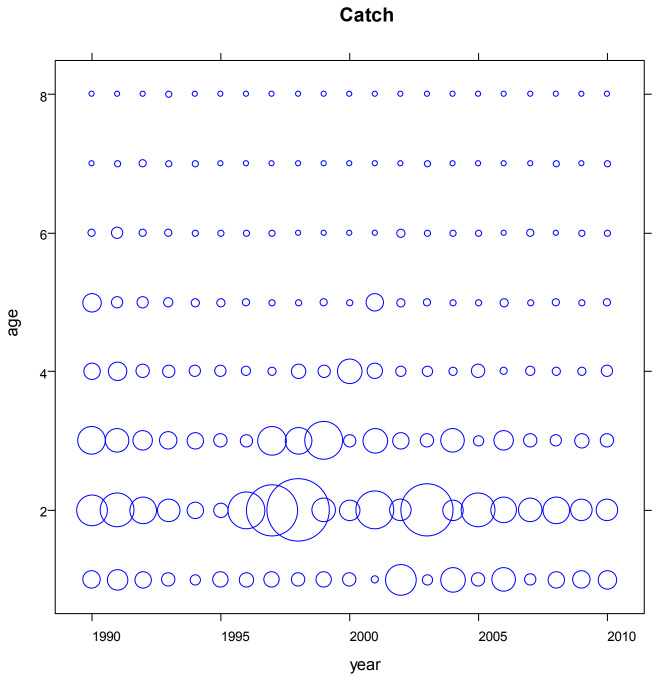


Figure 8.2.3 North Sea plaice. Catch numbers-at-age.

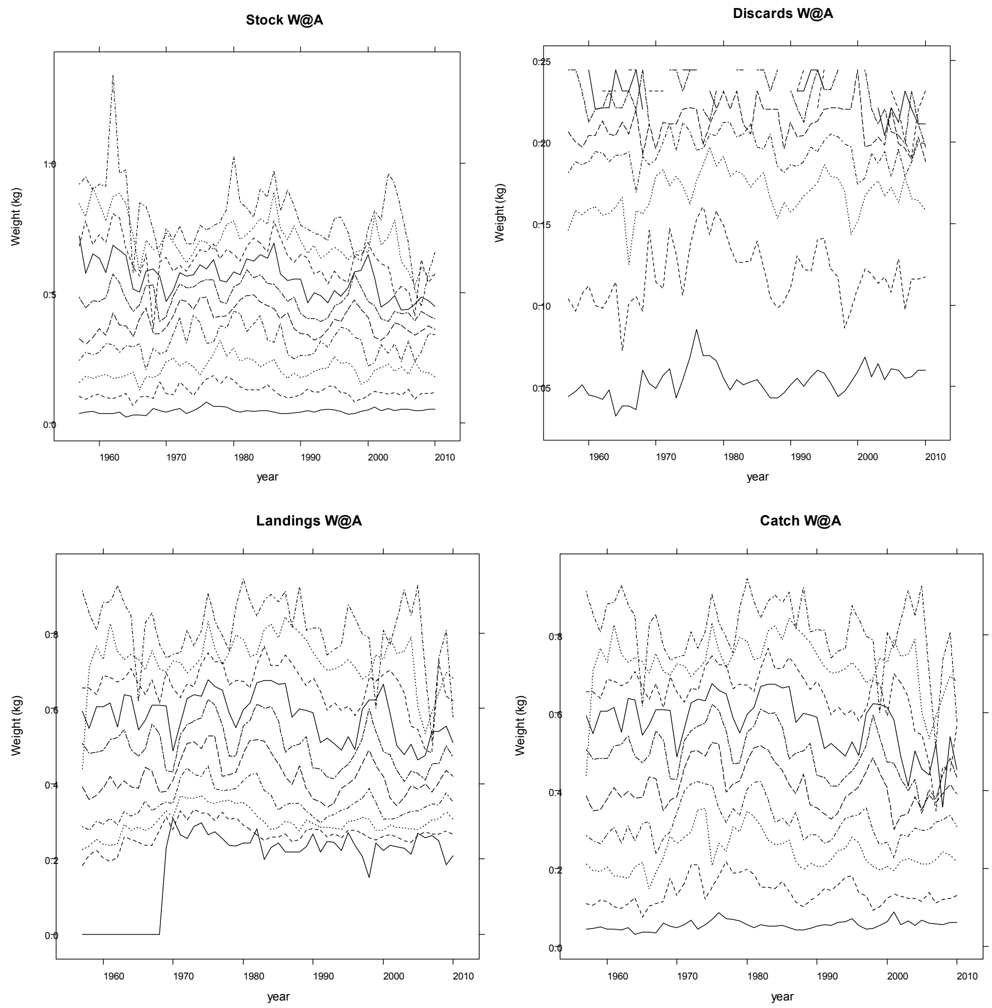


Figure 8.2.4 North Sea plaice. Stock weight-at-age (top left), discards weight-at-age (top right), landings weight-at-age (bottom left) and catch weight-at-age (bottom right)..

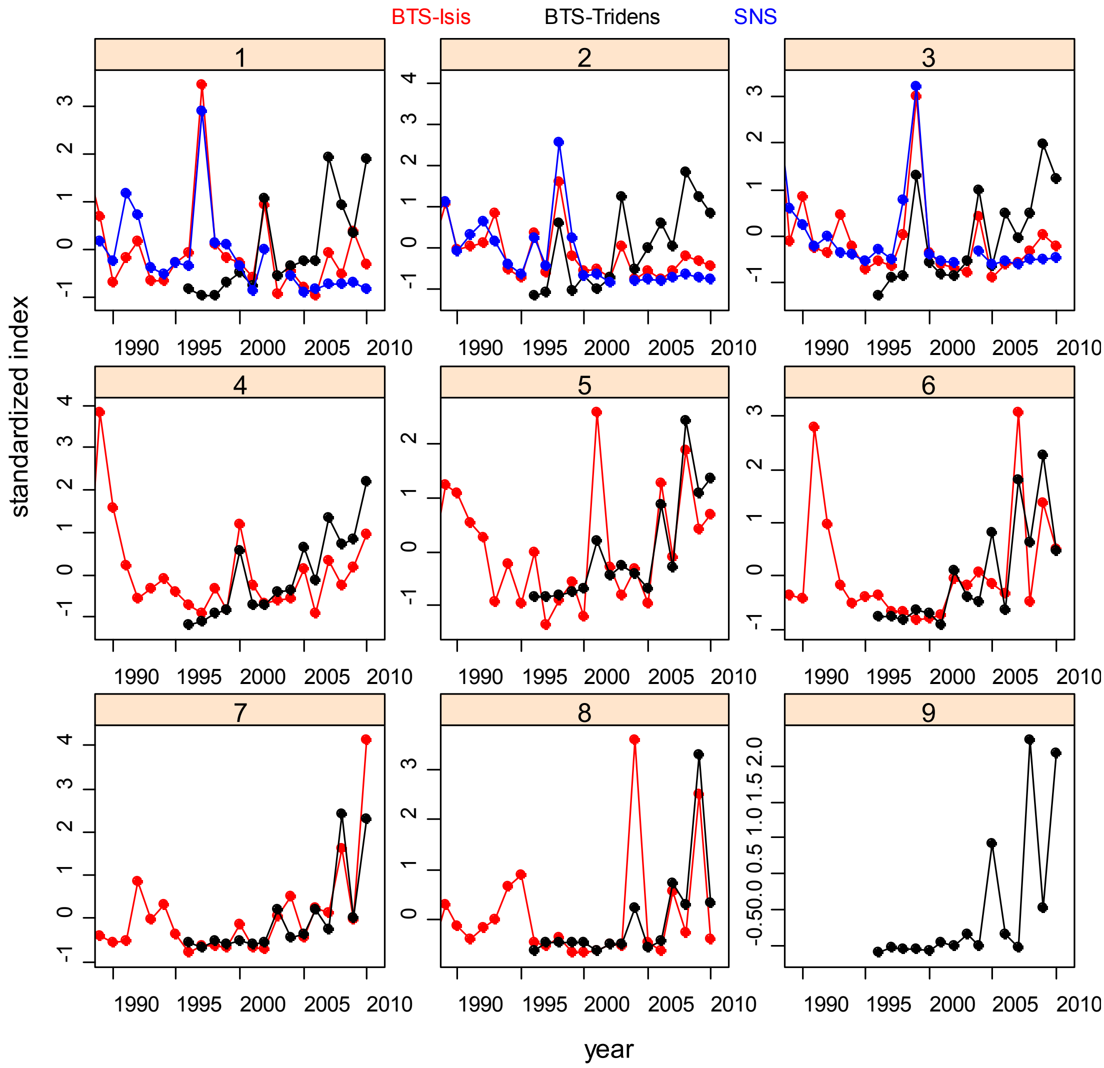


Figure 8.2.5 North Sea plaice. Standardized survey tuning indices used for tuning XSA: BTS-Isis (red), BTS-Tridens (black) and SNS (blue). Note: only ages used in the assessment are presented.

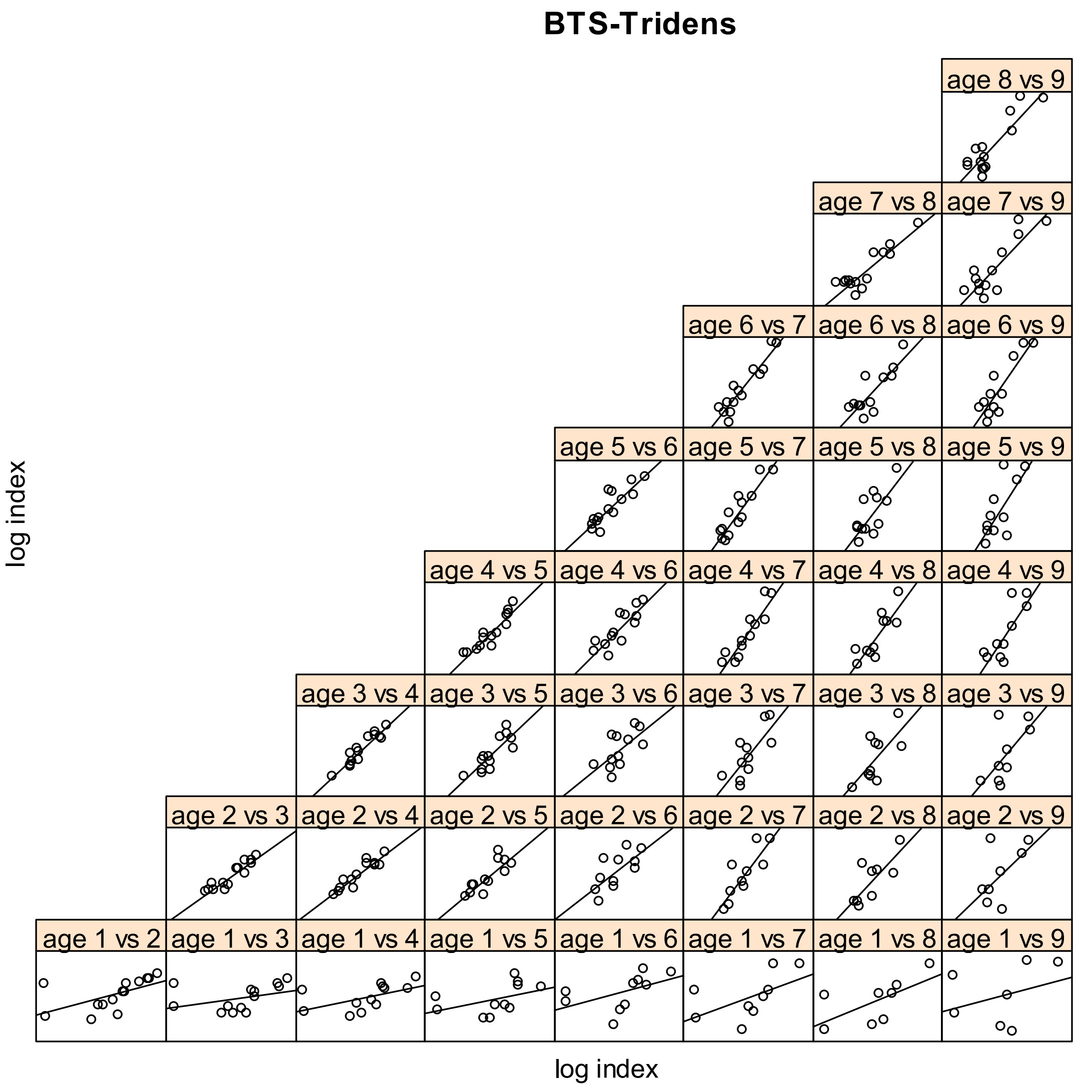


Figure 8.2.6 North Sea plaice. Internal consistency plot for the BTS-Tridens survey.

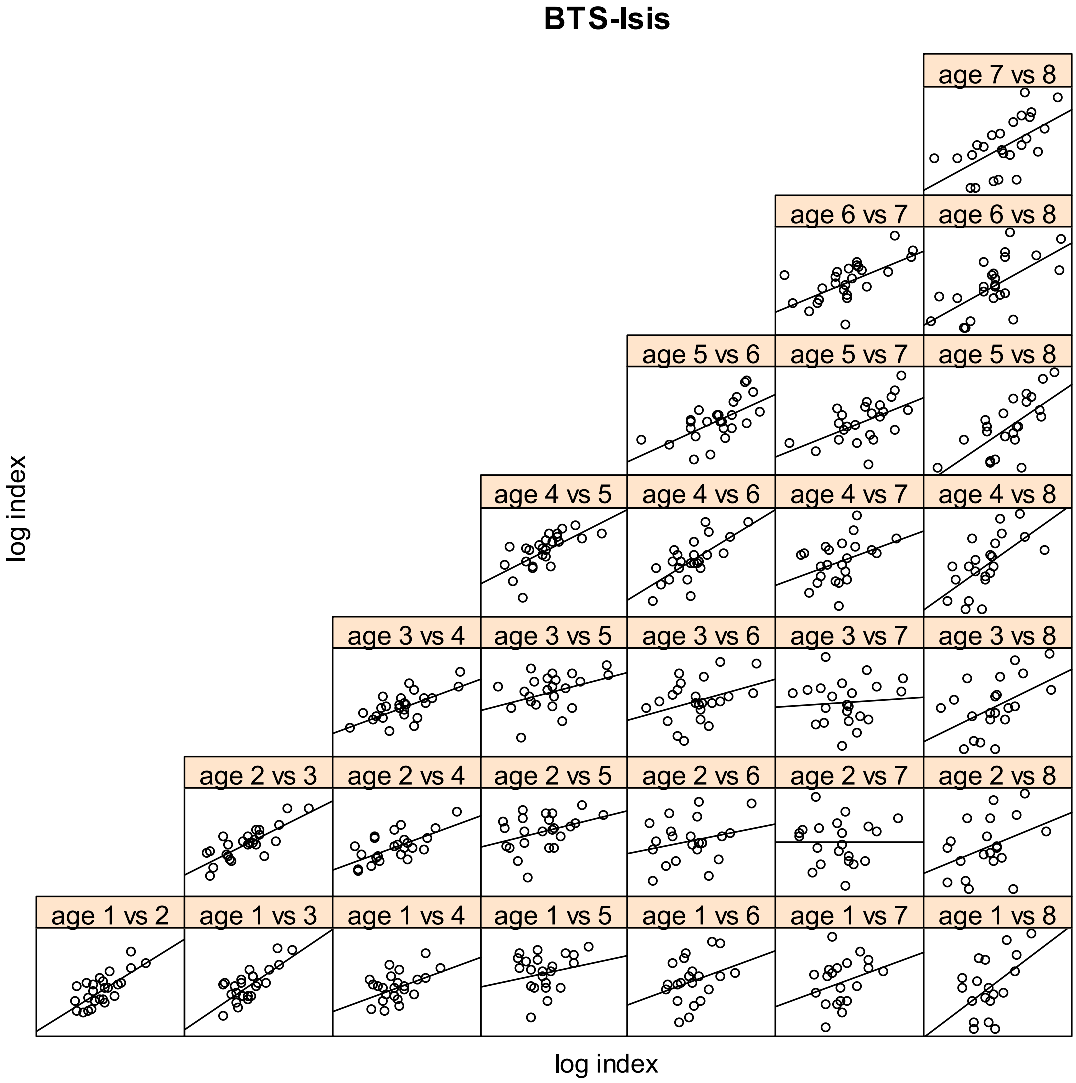


Figure 8.2.7. North Sea plaice. Internal consistency plot for the BTS-Isis survey.

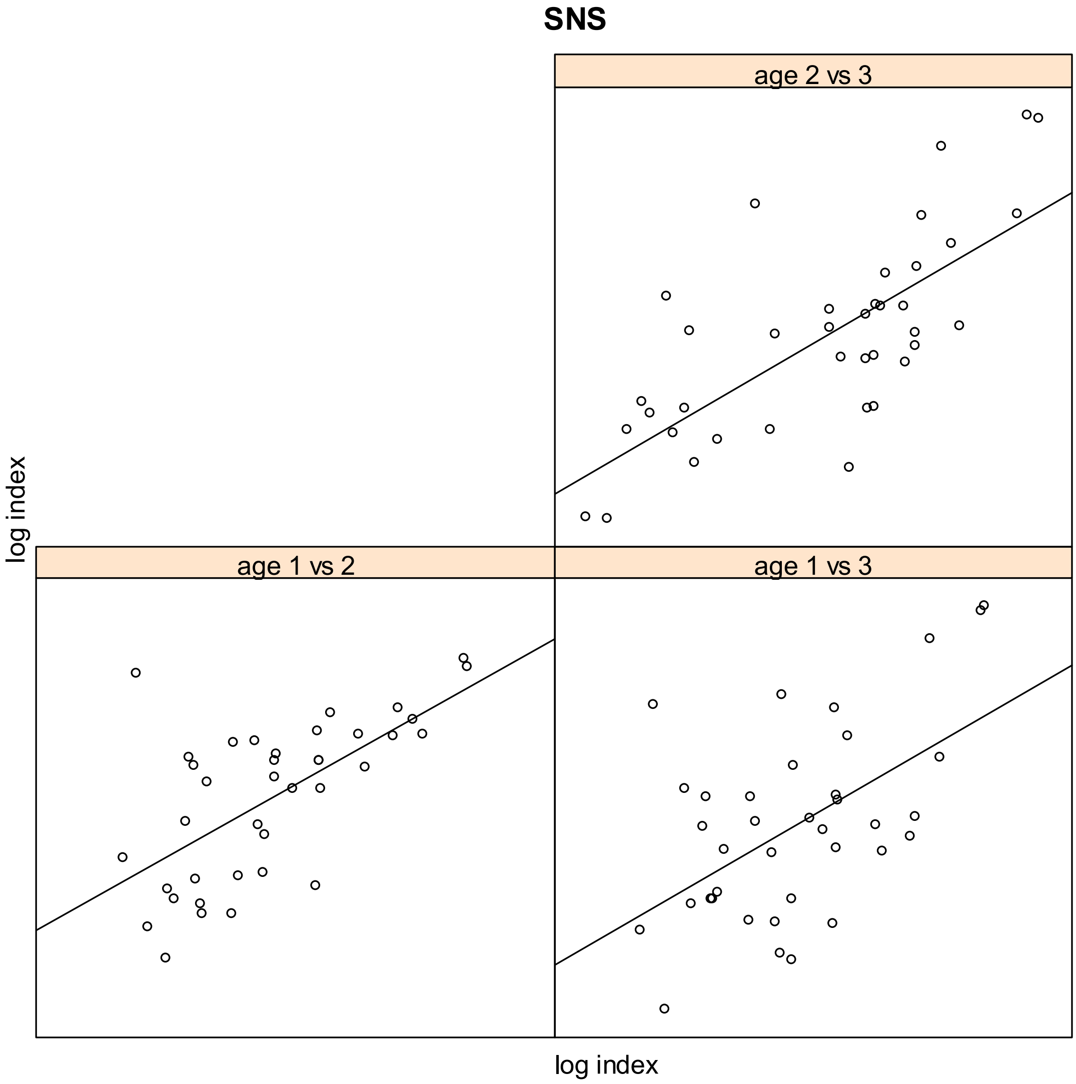


Figure 8.2.8. North Sea plaice. Internal consistency plot for the SNS survey.

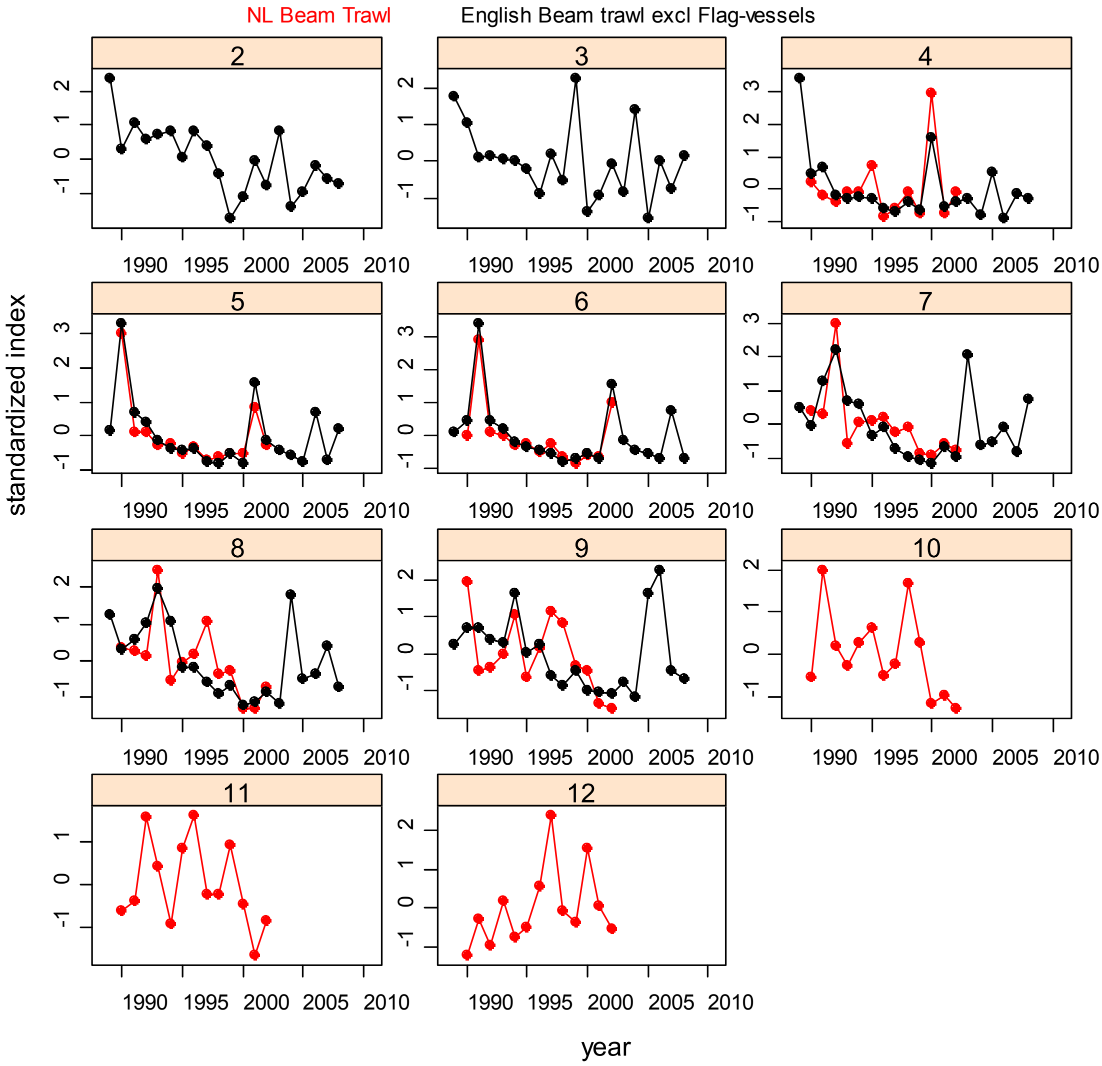


Figure 8.2.9 North Sea plaice. Standardized commercial tuning indices available for tuning: Dutch beam trawl fleet (red) and UK beam trawl fleet excluding all flag vessels (black).

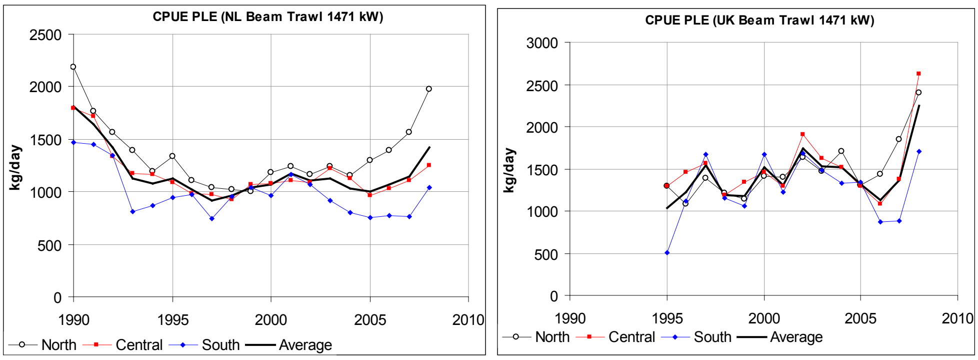
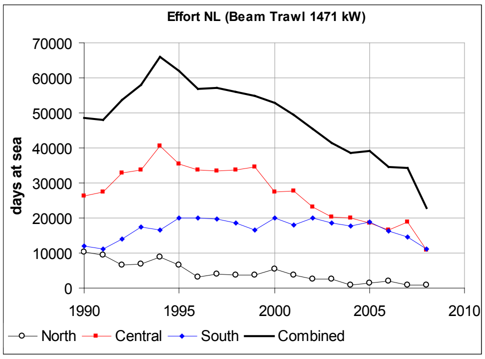


Figure 8.2.10. North Sea plaice. LPUE of the Dutch (left) and UK large trawler fleet (right), in areas north, central and south and the combined North Sea. Source: VIRIS Taken from Quirijns and Poos 2009,Working paper 1 . Note: these series are not used in the XSA assessment and have not been updated since 2008.



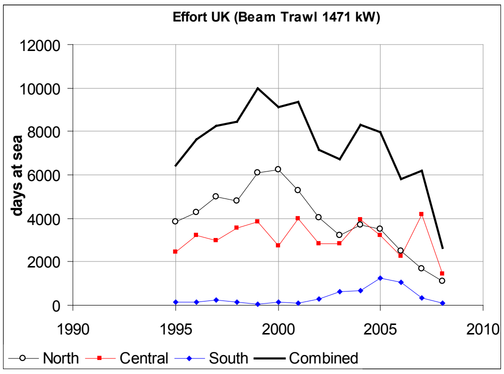


Figure 8.2.11. North Sea plaice. Effort (days at sea per 1471 kW vessel) for the Dutch fleet (left) and UK large trawler fleet (right), in areas north, central and south and the combined North Sea. Source: VIRIS. Taken from Quirijns and Poos 2009, Working paper 1.

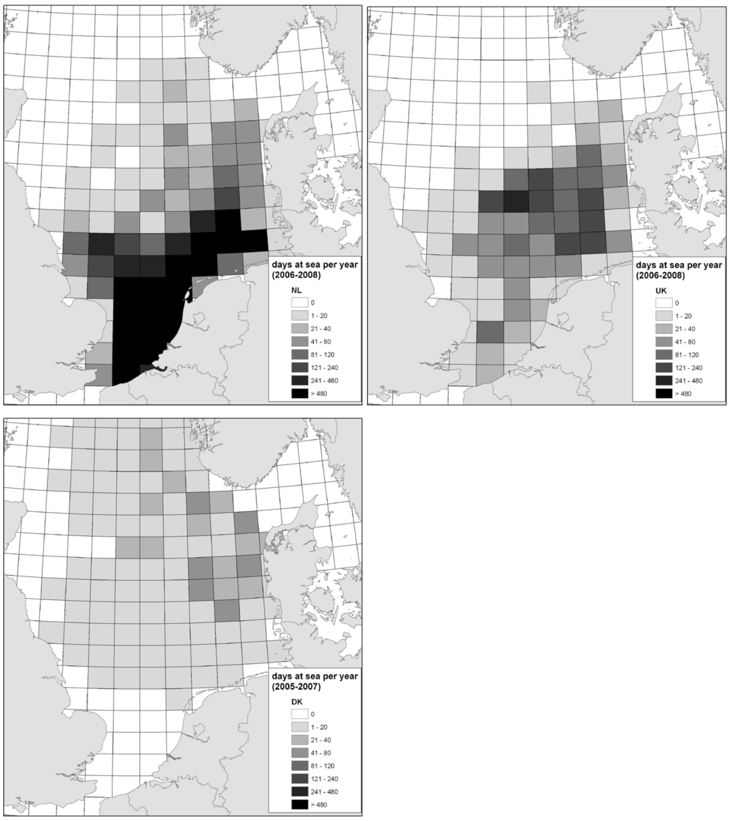


Figure 8.2.12. North Sea plaice. Annual fishing effort by the North Sea trawling fleet: Dutch vessels (left); UK flag vessels (middle); and Danish vessels (right). Expressed in days at sea, averaged over the period 2006-2008 (except for Danish data which cover the period 2005-2007). Source: EC logbook data.

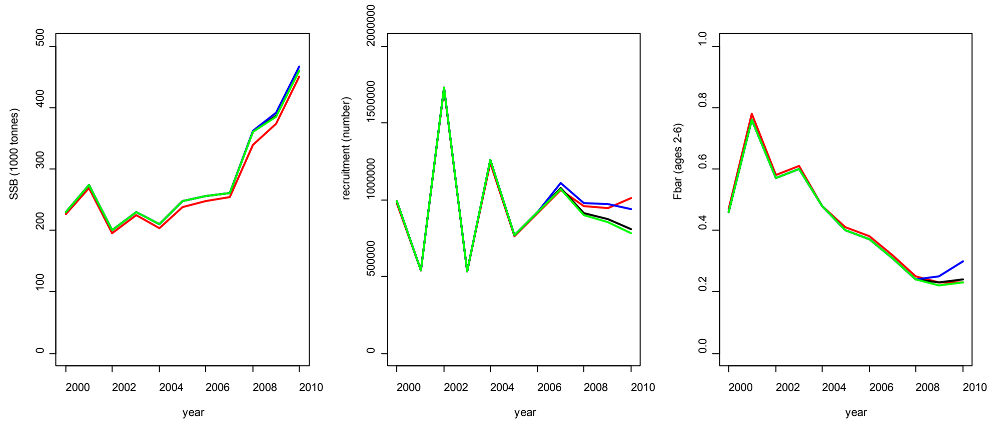


Figure 8.3.1. North Sea plaice. Sensitivity of the assessment with respect to assumptions on discarding and tuning indices (see text). XSA results with respect to SSB (left), recruitment (middle) and F (right) estimates. Black line: the official 2011 assessment made using the final run (discards as weighted average between self sampling and observer programme; no split in tuning indices). Red line: Assessment with the SNS and Tridens tuning indices split at 2002 (weighted average of discards). Green line: assessment done using discard estimates from the self-sampling programme only (no split in tuning indices). Blue line: assessment done using discard estimates from the observer programme only (no split in tuning indices). Note: some lines may be hidden due to near identical outputs.

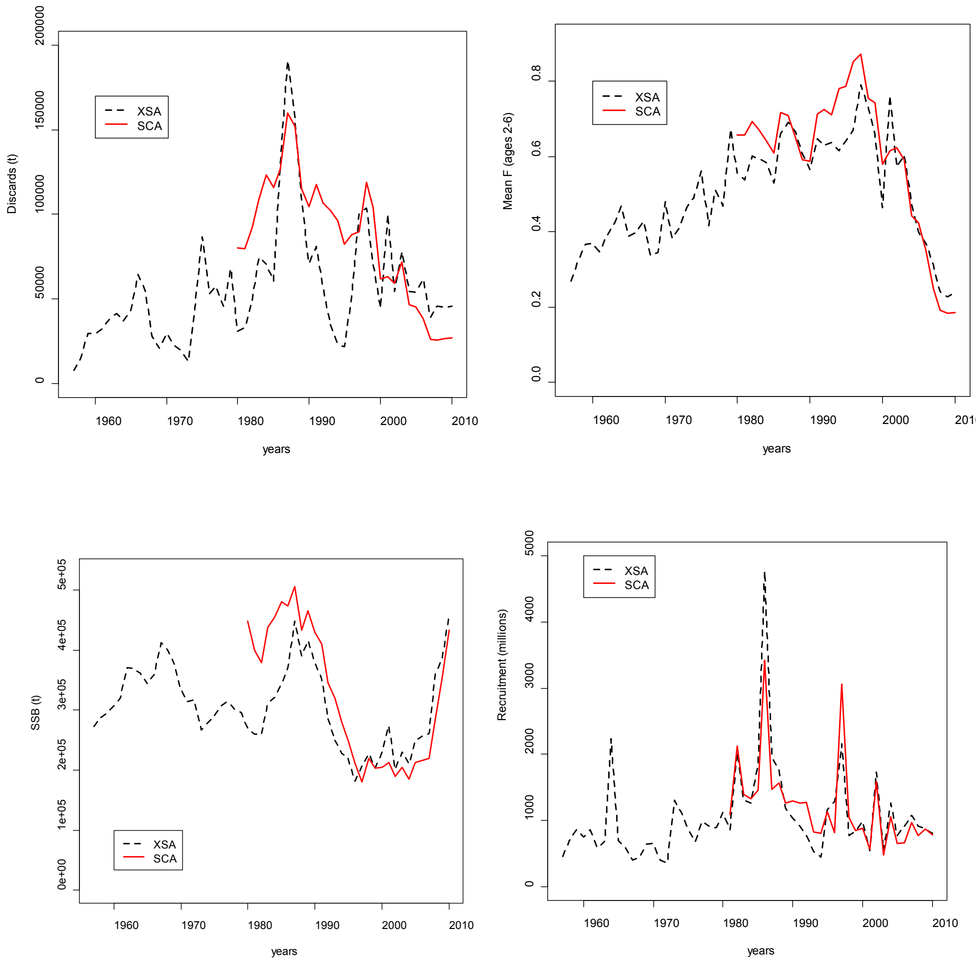


Figure 8.3.2 North Sea plaice. Comparison of XSA and SCA output (see Aarts & Poos 2009). Top left: discard estimates; Top right: mean F (ages 2-6), bottom left: SSB, bottom right: Recruitment. Red line: SCA estimates, Black line: XSA estimates.

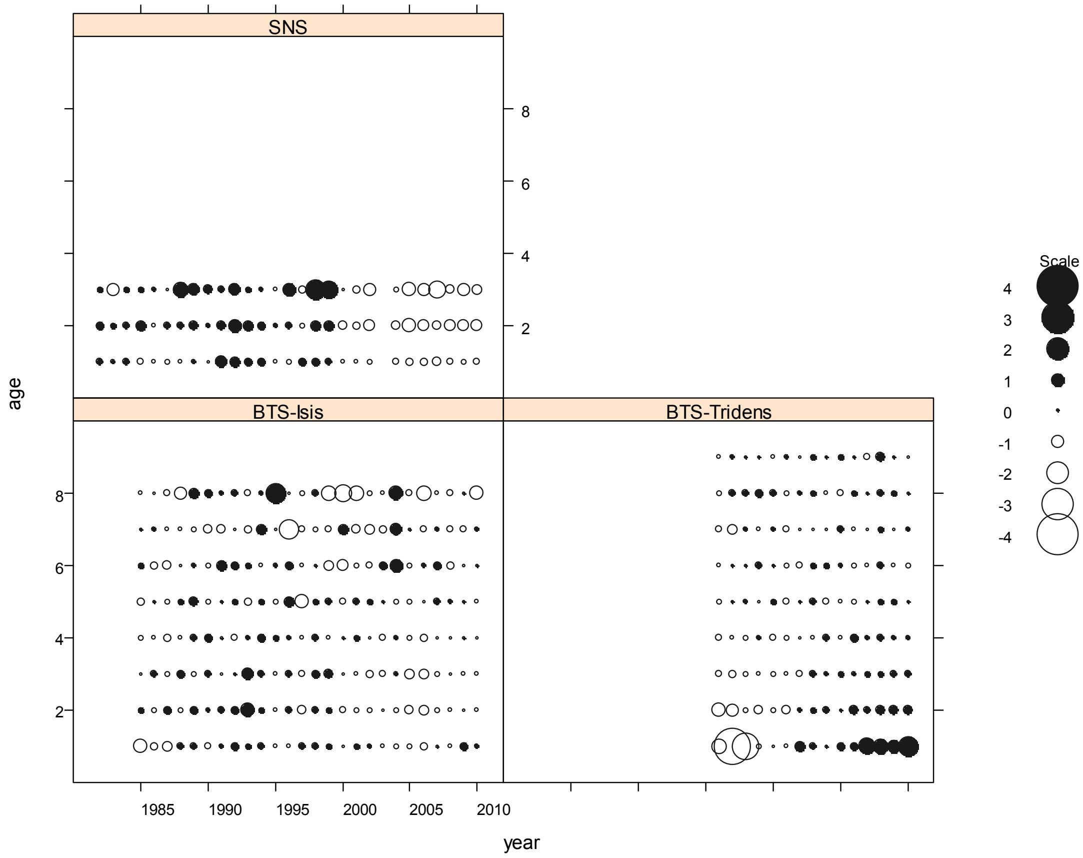


Figure 8.3.3. North Sea plaice. Log catchability residuals for the final XSA run from the three tuning series.

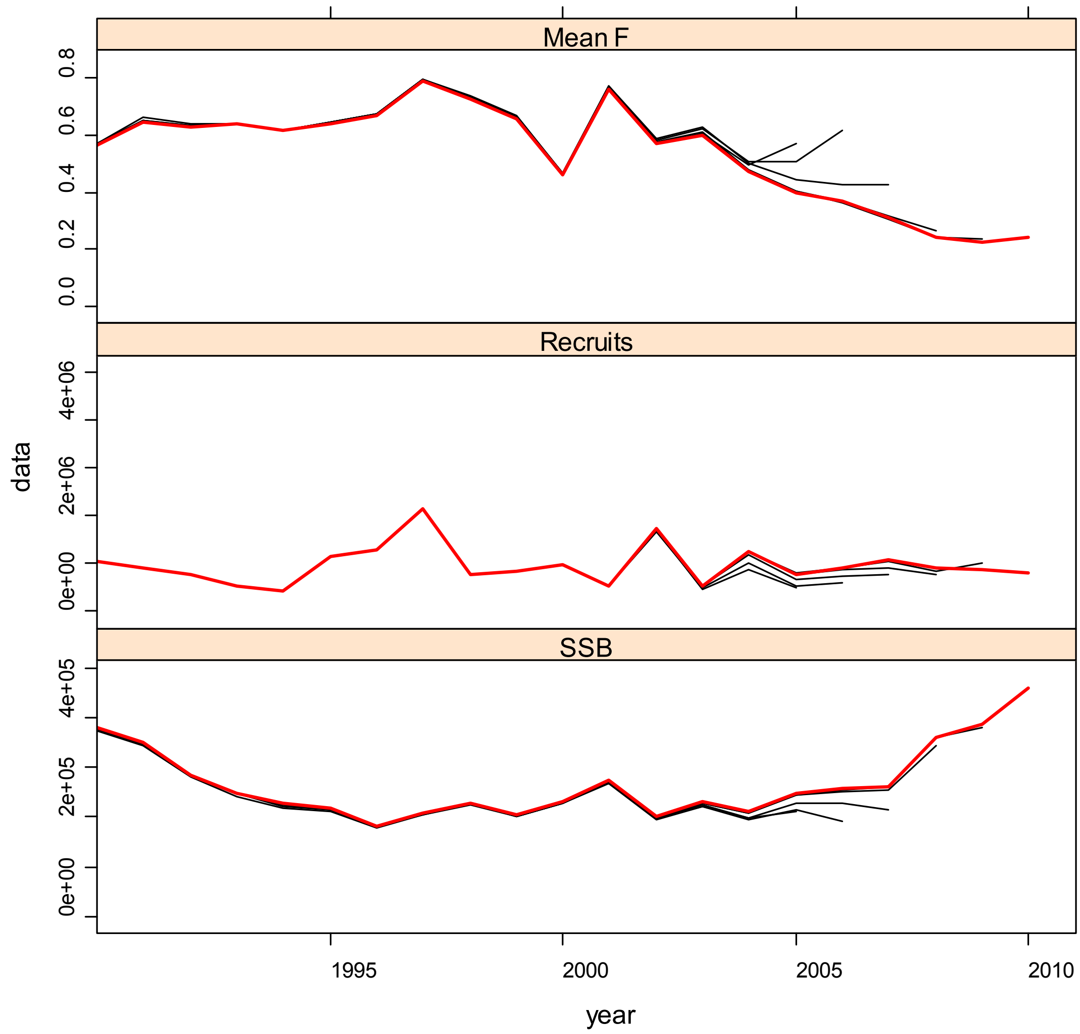


Figure 8.3.4. North Sea plaice. Retrospective pattern of the final XSA run with respect to SSB, recruitment and F.

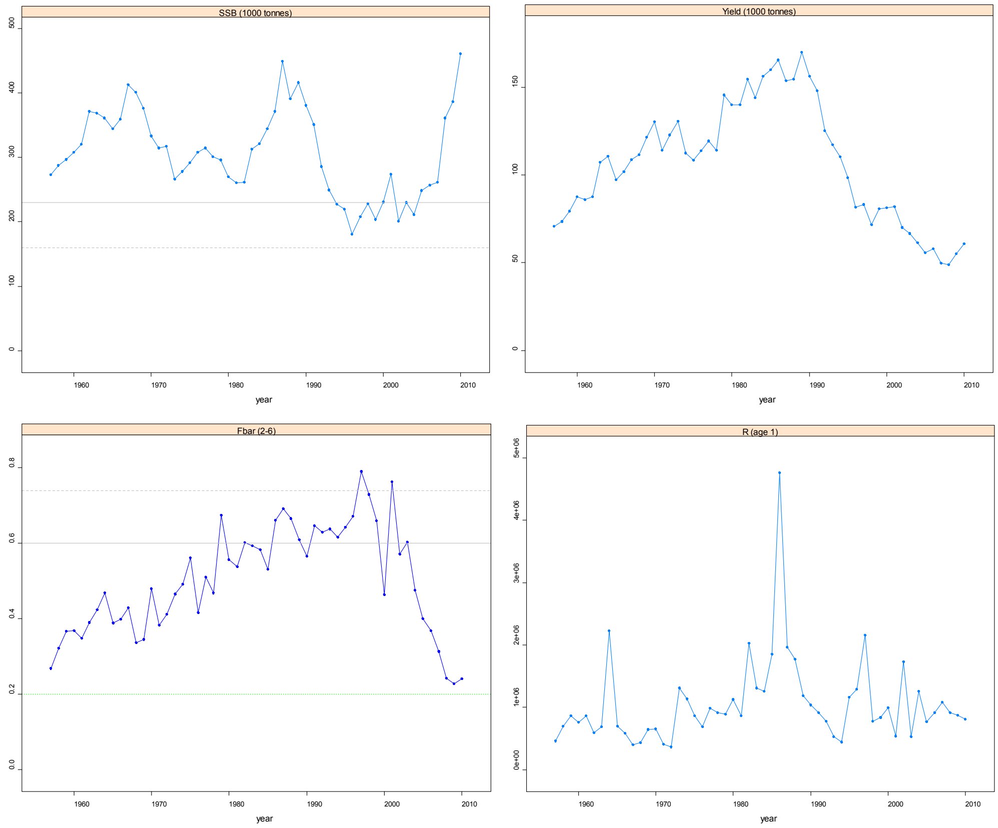


Figure 8.4.1. North Sea plaice. Stock summary figure, time series on SSB (drawn line indicates B_{pa}, dashed line indicates B_{lim}), Yield, Fishing mortality (drawn grey line indicates F_{pa}, dashed grey line indicates F_{lim}, green dashed line indicates MP target F), and recruitment at age 1.

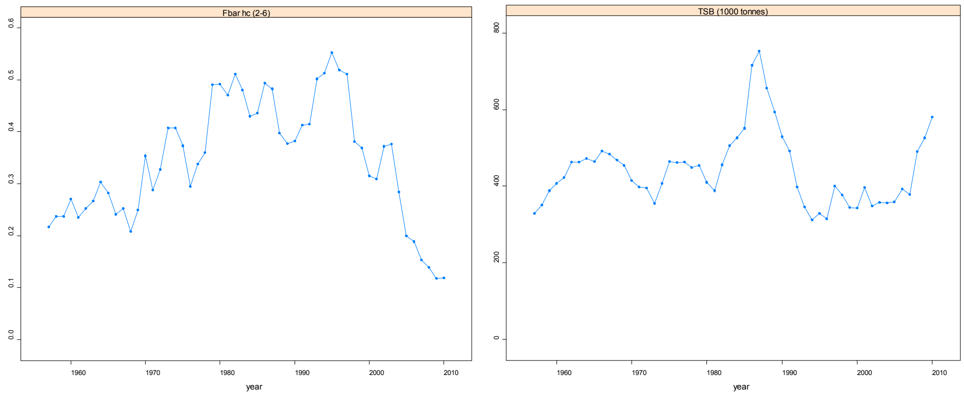


Figure 8.4.2. North Sea plaice. Stock summary figure. Time series on human consumption (left) fishing mortality and total stock biomass (right)

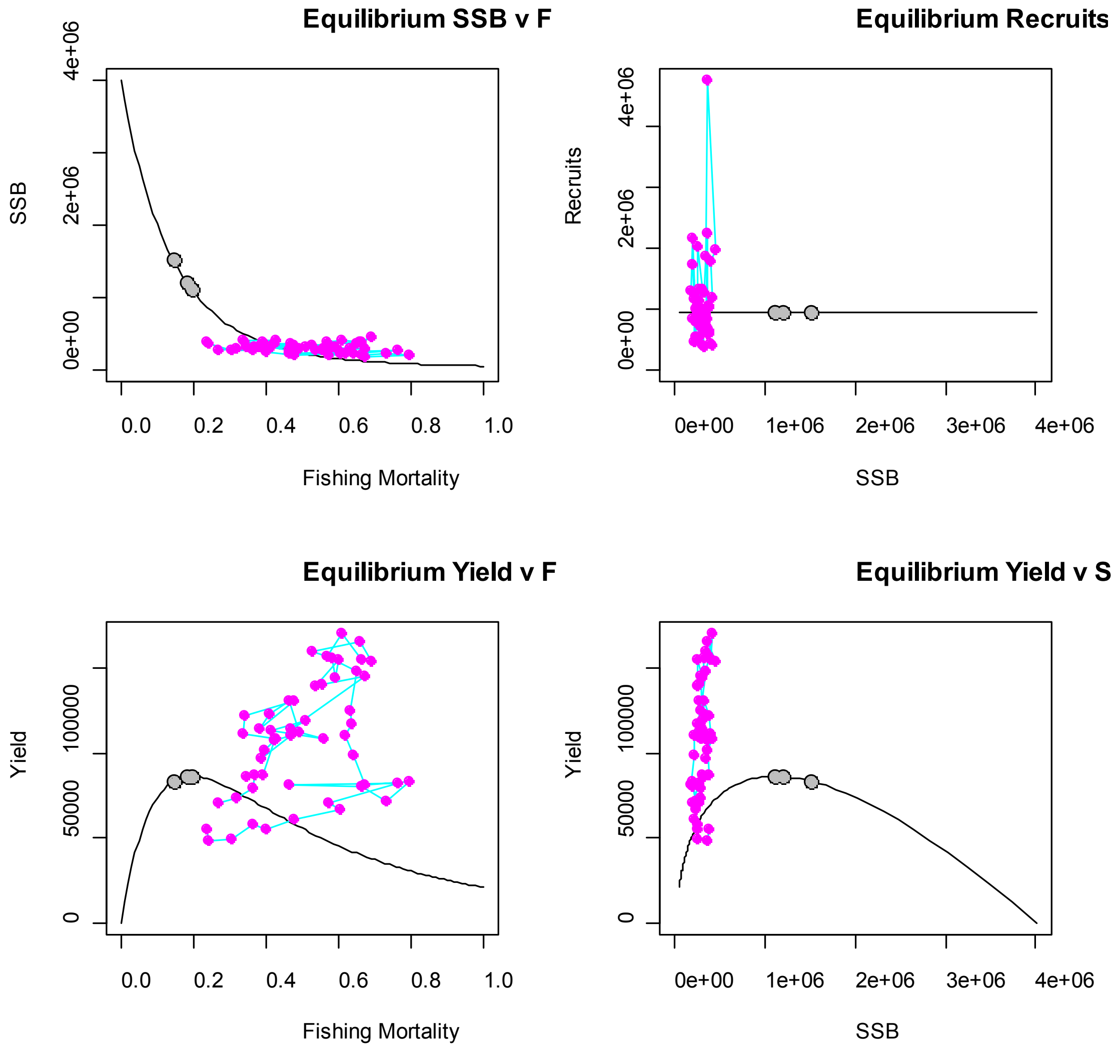


Figure 8.6.1 North Sea plaice. Yield per recruit analysis. Note: These have not been updated in 2010. However, it is unlikely that the latest assessment will have had a large impact on these equilibria.

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 2011.

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.

It is likely that the high oil prices have had some impact on the fishing behaviour of the Belgian and UK beam trawl fleets. For the French and UK inshore fleets however this will probably not be the case since they fish predominantly in the inshore areas.

Apart for the last two years (2009-2010), the TAC was not restrictive for France, Belgium nor UK since 1997.

9.1.3 ICES advice

In 2010 ICES considered the stock as having full reproductive capacity and at risk of being harvested unsustainably.

In 2010 the ICES advice was as follows:

Single-stock exploitation boundaries

ICES advises on the basis of precautionary limits that fishing mortality in 2010 should be no more than Fpa corresponding to landings of less than 3190 t in 2010

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.

Fisheries in Division IIIa (Skagerrak–Kattegat), in Subarea IV (North Sea), and in Division VIId (Eastern Channel) should in 2010 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 skateand undulate ray.*

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.

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 2010 and 2011 are 4219t and 4852t 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 and 2011, Council Regulation (EC) N°53/2010 and Council Regulation (EC) N°57/2011 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

French and UK landings submitted to the Working Group for 2009 were revised upward by 11% to 3045t and downward by 1% to 745t respectively. The 2009 values for the numbers at age were therefore also updated. Total landings for 2009 now amount to 5266t instead of 4969t

The 2010 landings used by the Working Group were 4391t (Table 9.2.1) which is 4% above the agreed TAC of 4219t and 16% above the predicted landings at a status quo fishing mortality in 2010 (5244t). The contribution of France, Belgium and the UK to the landings in 2010 is 55%, 30% and 15% 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 on a quarterly basis (Figure 9.2.1a-e). Numbers are raised to the sampled trips. It should be noted that the number of sampled trips is low.

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 one single UK beam trawl trip in the 4th quarter in 2008 indicates high discard rates of sole. However it should be noted that markets at that time of the year were heavily affecting discards of flatfish, including sole. The information from that single trip is therefore not representative for the UK beam trawl fleet at any time in the year. 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.

UK and FR have provided data this year under the ICES InterCatch format. The Belgian data will be uploaded into the InterCatch database shortly after the working group.

9.2.2 Age compositions

Quarterly data for 2010 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 9.2.2a-c. Revisions have been made to the UK effort and LPUE series for 2009. 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 three 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 2010 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 and LPUE for 2009-2010 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 and 2010, before the next working group.

Belgian and UK beam trawl LPUE have been fluctuating around the mean with no strong trend until recently when 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 level 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 2009 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, the RG did not reported any major deficiencies for the sole assessment in the Eastern English Channel.

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 9.2.3. 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 9.2.4-6. 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 ages 2 and above (Figure 9.3.2), apart from the estimates from the FR-YFS for ages 2, 3, 5, 9 and 10. In this year's assessment the estimates for the recruiting year class 2009 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 45% to the final survivor estimates. F-shrinkage giving 10% of the weighting. It should be noted that both surveys are estimating this year class as above average (UK(E&W)-BTS) and below average (FR-YFS) (see also section 9.4).

At age 2, the 2008 year-class is predominantly estimated by the commercial UK beam trawl fleet and UK beam trawl survey, with a weighting of 40% and 41% respectively. Both tuning fleets divert somewhat in their survivor estimates of that year class (21381 and 49679). The French component of the Young Fish Survey estimates this year class to be very strong (237672), however it only accounts for 7% of the final survivor estimate (see also section 9.4).

Apart from age 1 (10%), 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.

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 3 and above. Although the final XSA estimate for age 2 is coming from a wide 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 2009) is an average value for the time series. (Table 9.3.1 and Table 9.3.4). Although both surveys (UK-BTS and FR-YFS) estimate the 2009 year class as above average and below average respectively, the Working Group decided that the final XSA survivor estimate of 25363 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:

	2011 assessment		
Fleets	Years	Ages	α-β
BE-CBT commercial	86-10	2-10	0-1
UK(E&W)-CBT commercial	86-10	2-10	0-1
UK(E&W)-BTS survey	88-10	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	87-10	1-1	0.5-0.75
-First data year	1982		
-Last data year	2010		
-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) 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 66% downward revision of the 2008 year call (age 1 in 2009). It should be noted that the high XSA estimate (157912) in last year’s 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 52982 fish at age 1.

Fishing mortality for 2009 has been revised downward by 4% SSB upward by 5% 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 F_{pa} (0.4) and F_{lim} (0.57). In the early 90’s it dropped below F_{pa}. Since 1999 it decreased steadily from 0.55 to around 0.4 in 2001 after which it remained stable until 2005. In the last 5 years fishing mortality has increased again above the F_{pa} value.

Recruitment has fluctuated around 25 million recruits with occasional strong year classes. Four of the highest values in the time series have been recorded in the last 9 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 2008 year class in 2009 was estimated in last year's assessment, by XSA to be extremely high with 158 million fish. This value has been replaced in the forecast with an above average year class RCT3 estimate of 47 million fish. This year's assessment (XSA estimate) has revised the 2008 year class to 53 million fish. This strong revision is mainly due to the availability in this year's assessment of survivor estimates from two commercial fleets and the extreme high estimate of the French young fish survey having less weighting in the final survivor estimates (7%).The XSA survivor estimates for this year class were used for further prediction.

The 2009 year class in 2010 was estimated by XSA to be 28 million one year olds which is about average.

Although both surveys (UK-BTS and FR-YFS) estimate the 2009 year class as above average and below average respectively, 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, 1982-2008) was assumed for the 2010 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 2010 year class are not used for prediction, it should be noted that the French Young fish survey (FR-YFS) at age 0 indicates a below 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 2011	**XSA**	**GM 82-08**	**RCT3**	Accepted Estimate
2008	3	<u>38193</u>	15967	-	XSA
2009	2	<u>25363</u>	20854	23547*	XSA
2010	1	-	<u>23535</u>	21308	GM 1982-08
2011 & 2012	recruits	-	<u>23535</u>	-	GM 1982-08

*** 26157 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 2008-2010.

Input to the short term predictions and the sensitivity analysis are presented in Table 9.6.1. Results are presented in Table 9.6.2 (management options) and Table 9.6.3 (detailed output).

Assuming *status quo* F, implies a catch in 2011 of 5840t (the agreed TAC is 4852t) and a catch of 5760t in 2012. Assuming *status quo* F will result in a SSB in 2012 and 2013 of 13900t and 12300t respectively.

Assuming *status quo* F, the proportional contributions of recent year classes to the landings in 2012 and SSB in 2013 are given in Table 9.6.4. The assumed GM recruitment accounts for 9 % of the landings in 2012 and 25 % of the 2013 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 2012 are 3900t and 8100t. There is less then 5% probability that at current fishing mortality SSB will fall below the B_{pa} of 8000t in 2013.

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 *status quo* F in 2011, are given in Table 9.7.1 and Figure 9.7.1. F_{max} is calculated by this year's assessment to be 0.32(0.44 = F_{sq}).

9.8 Biological reference points

		Basis
Flim	0.55	Fishing mortality at or above which the stock has shown continued decline.
Fpa	0.40	F is considered to provide approximately 95% probability of avoiding Flim
Blim	-	Not defined
Bpa	8000	Lowest observed biomass at which there is no indication of impaired recruitment.
Fmax	0.28- 0.30	Using MFDP program Using PLOTMSY program
Fmsy	0.29	PLOTMSY program
F2009	0.51	
Fsq	0.48	

9.9 Quality of the assessment

- Revisions in 2009 landings for France and UK (E&W) together with the income of 2 commercial tuning series to estimate the 2008 year class (see section 9.2.5) resulted in an downward revision of fishing mortality in 2009 by 4% and a upward revision of SSB by 5%. The XSA recruitment estimate in 2009 was revised downward by 66%. However in last year's assessment, this extreme high XSA estimate (157912) was replaced with an RCT3 estimate of 47475 in the forecast. This estimate has been updated (+12%) by this years assessment to 52984.
- The trends and estimates of fishing mortality, SSB and recruitment were consistent with last year's assessment apart from the upward revision of the 2008 year class (see above).

- Except year classes 2002, 2003 and 2006, 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 for 2010 suggest, as in previous years 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 for 2007, 2008, 2009 and 2010, 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.
- The use of a more realistic effort correction for Belgian beam trawl fleet is likely to improve the tuning results for that fleet. These effort corrections should be implemented at the next update assessment.
- 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 F_{msy} (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. last year's adjustment of the XSA recruitment by RCT3 (see section 9.3.5).
- 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. 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 rectangles were removed from the trawl data on a quarterly basis, and the age compositions adjusted to take that into account.
- Sampling for sole landings in division VIId are considered to be at a reasonable level.

9.10 Status of the Stock

Fishing mortality has been stable between 2000 and 2005 around 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 very strong 2008 year class 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 year class.
- EU Council Regulation (EC) N°57/2011 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 2011.
- 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	17	4391	4219

* Unallocated mainly due to misreporting
** Preliminary

Table 9.2.2 - Sole VIId - Landing numbers at age (kg)

Run title : Sole in Division VIId - 2011 WG.

At 30/04/2011 11:34

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE									
1	155	0	24	49	49	9	95	163	1245
2	2625	852	1977	3693	1251	3117	2162	3484	2851
3	5256	3452	3157	5211	5296	3730	7174	3220	5580
4	1727	3930	2610	1646	3195	3271	1602	4399	1151
5	570	897	1900	1027	904	2053	1159	1434	1496
6	653	735	742	1860	768	1042	856	840	301
7	549	627	457	144	1056	1090	388	571	390
8	240	333	317	158	155	784	255	201	260
9	122	108	136	156	190	111	256	166	129
10	83	89	99	69	212	163	83	224	126
+gp	202	193	238	128	372	459	275	282	489
0 TOTALNUM	12182	11216	11657	14141	13448	15829	14305	14984	14018
TONSLAND	3190	3458	3575	3837	3932	4791	3853	3805	3647
SOPCOF %	97	99	99	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	383	105	85	31	838	9	24	33	168	138
2	7166	4046	5028	694	2977	1825	1489	1376	3268	3586
3	4105	8789	6442	6203	4375	7764	6068	5609	8506	4852
4	4160	1888	5444	5902	4765	3035	5008	2704	3307	4395
5	604	1993	1008	3404	2968	3206	2082	1636	1311	1076
6	996	288	563	584	1980	1823	1670	609	869	505
7	257	368	162	567	375	1283	916	558	350	319
8	247	135	188	109	278	271	775	441	672	148
9	258	171	116	147	88	319	239	354	351	328
10	92	95	62	93	106	112	169	239	192	150
+gp	382	231	129	258	241	344	267	301	359	248
0 TOTALNUM	18650	18109	19227	17992	18991	19991	18707	13860	19353	15745
TONSLAND	4351	4072	4299	4383	4420	4797	4764	3363	4135	3476
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 1 Catch numbers at age Numbers*10**-3

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
1	168	707	379	1030	206	608	175	149	231	137
2	6042	7011	10957	4254	3468	7370	6511	2702	3006	5244
3	6194	7513	5086	8623	4034	3753	7316	8516	4418	4432
4	1595	3767	3178	2545	5458	2821	2990	4145	7092	3281
5	2491	1414	1805	2272	1543	3433	1500	1267	2378	3073
6	728	655	671	1108	1143	1103	2038	849	798	1321
7	290	298	588	371	633	796	751	751	615	327
8	128	129	198	448	218	403	467	356	642	266
9	56	97	70	94	283	191	257	164	277	334
10	81	57	88	88	127	208	162	134	251	99
+gp	265	197	245	233	271	307	230	247	451	289
0 TOTALNUM	18038	21845	23265	21066	17384	20993	22397	19280	20159	18803
TONSLAND	4025	4733	5038	4826	4383	4833	5166	4517	5266	4391
SOPCOF %	100	100	100	100	100	100	100	100	100	100

Table 9.2.3 - Sole VIId - Quaterly landings composition for 2010

	Q1		Q2		Q3		Q4	
Age	Numbers	Weights	Numbers	Weights	Numbers	Weights	Numbers	Weights
1	1.0	0.167	16.6	0.143	64.1	0.128	55.1	0.113
2	191.1	0.158	579.5	0.149	2697.0	0.160	1776.2	0.165
3	1576.6	0.191	963.0	0.185	687.6	0.197	1204.8	0.207
4	1157.1	0.261	1327.1	0.210	467.0	0.247	330.1	0.265
5	1252.1	0.303	967.1	0.267	533.9	0.270	320.2	0.313
6	594.4	0.370	475.9	0.316	162.0	0.282	88.5	0.379
7	130.2	0.359	119.3	0.341	57.8	0.308	19.4	0.345
8	88.5	0.360	98.4	0.326	64.4	0.341	14.5	0.585
9	160.3	0.605	116.3	0.440	38.5	0.335	19.1	0.520
10	44.0	0.467	25.9	0.416	20.4	0.367	8.6	0.522
11	59.1	0.434	46.1	0.430	16.9	0.367	5.9	0.609
12	21.2	0.553	16.9	0.330	11.4	0.318	3.5	0.446
13	10.1	0.233	12.4	0.433	9.4	0.451	0.9	0.536
14	0.7	0.721	4.0	0.588	5.3	0.483	0.8	0.779
15+	32.9	0.640	4.9	0.435	2.7	0.445	23.1	0.396

Nominal landings (t)	1491.1	1124.9	958.5	816.3

Table 9.2.4 - Sole VIId - Catch weights at age (kg)

Run title : Sole in Division VIId - 2011 WG

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Table 2 Catch weights at age (kg)

	YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990
	AGE									
	1	0.102	0.000	0.100	0.090	0.135	0.095	0.102	0.106	0.12
	2	0.171	0.173	0.178	0.182	0.180	0.175	0.152	0.154	0.178
	3	0.225	0.230	0.234	0.230	0.212	0.236	0.226	0.192	0.238
	4	0.312	0.302	0.314	0.281	0.306	0.295	0.278	0.271	0.289
	5	0.386	0.404	0.380	0.368	0.363	0.353	0.36	0.293	0.349
	6	0.428	0.436	0.436	0.394	0.387	0.407	0.409	0.358	0.339
	7	0.439	0.435	0.417	0.516	0.437	0.411	0.459	0.388	0.47
	8	0.509	0.524	0.538	0.543	0.520	0.482	0.514	0.472	0.465
	9	0.502	0.537	0.529	0.594	0.502	0.465	0.553	0.515	0.487
	10	0.463	0.583	0.565	0.595	0.523	0.538	0.563	0.547	0.518
	+gp	0.6729	0.6283	0.7135	0.8005	0.6015	0.6176	0.6647	0.7014	0.5621
0	SOPCOFAC	0.9713	0.991	0.9884	0.998	1.0006	1.0004	1.0001	0.9994	0.9995

Table 2 Catch weights at age (kg)

	YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	AGE										
	1	0.114	0.103	0.085	0.099	0.129	0.142	0.139	0.132	0.130	0.145
	2	0.161	0.153	0.147	0.150	0.176	0.165	0.153	0.159	0.151	0.142
	3	0.208	0.203	0.197	0.186	0.179	0.178	0.188	0.172	0.189	0.176
	4	0.266	0.267	0.247	0.235	0.230	0.229	0.233	0.235	0.215	0.223
	5	0.354	0.290	0.335	0.288	0.255	0.269	0.292	0.286	0.260	0.332
	6	0.394	0.403	0.384	0.355	0.333	0.324	0.343	0.343	0.280	0.377
	7	0.421	0.391	0.537	0.381	0.357	0.361	0.390	0.383	0.290	0.424
	8	0.430	0.462	0.553	0.505	0.385	0.405	0.404	0.417	0.341	0.427
	9	0.434	0.459	0.515	0.484	0.490	0.435	0.503	0.484	0.358	0.384
	10	0.478	0.463	0.766	0.496	0.494	0.465	0.474	0.435	0.374	0.459
	+gp	0.5656	0.5661	0.6666	0.6156	0.6536	0.5854	0.6509	0.6162	0.5354	0.68
0	SOPCOFAC	1.0001	1.0001	1.0002	1.0001	0.9997	0.9999	1	1.0013	0.9992	1.0009

Table 2 Catch weights at age (kg)

	YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	AGE										
	1	0.108	0.120	0.114	0.120	0.135	0.139	0.163	0.148	0.143	0.124
	2	0.152	0.162	0.170	0.179	0.172	0.162	0.190	0.164	0.177	0.161
	3	0.211	0.204	0.208	0.205	0.208	0.192	0.202	0.201	0.203	0.195
	4	0.283	0.253	0.257	0.255	0.253	0.249	0.227	0.244	0.260	0.239
	5	0.288	0.316	0.277	0.296	0.303	0.284	0.276	0.262	0.279	0.287
	6	0.334	0.375	0.357	0.304	0.337	0.328	0.294	0.321	0.358	0.340
	7	0.367	0.376	0.381	0.348	0.368	0.353	0.315	0.435	0.321	0.342
	8	0.374	0.393	0.438	0.403	0.433	0.402	0.378	0.411	0.464	0.355
	9	0.493	0.469	0.482	0.492	0.570	0.457	0.441	0.377	0.406	0.512
	10	0.511	0.420	0.494	0.509	0.445	0.450	0.439	0.498	0.476	0.438
	+gp	0.5445	0.5308	0.5274	0.525	0.5369	0.557	0.5206	0.5127	0.6185	0.4505
0	SOPCOFAC	1.0005	0.9995	1.0002	0.9983	0.9989	1	1.0026	0.9991	1.0009	0.9999

Table 9.2.5 - Sole VIId - Stock weights at age (kg)

Run title : Sole in Division VIId - 2011WG

At 30/04/2011 11:34

Table 3 Stock weights at age (kg)

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE									
1	0.059	0.070	0.067	0.065	0.070	0.072	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
3	0.167	0.197	0.192	0.192	0.198	0.203	0.223	0.182	0.232
4	0.217	0.255	0.249	0.254	0.256	0.262	0.268	0.269	0.305
5	0.263	0.309	0.304	0.315	0.309	0.318	0.365	0.323	0.4
6	0.306	0.359	0.355	0.376	0.358	0.370	0.425	0.335	0.361
7	0.347	0.406	0.403	0.436	0.403	0.417	0.477	0.48	0.476
8	0.384	0.448	0.448	0.495	0.443	0.461	0.498	0.504	0.535
9	0.418	0.487	0.490	0.554	0.480	0.500	0.572	0.586	0.571
10	0.4500	0.5220	0.5290	0.6110	0.5120	0.5360	0.636	0.536	0.507
+gp	0.53	0.6008	0.6265	0.7798	0.5761	0.6156	0.7498	0.7135	0.5765

Table 3 Stock weights at age (kg)

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.138	0.144	0.130	0.116	0.126	0.155	0.139	0.140	0.128	0.122
3	0.225	0.199	0.189	0.161	0.129	0.176	0.165	0.158	0.180	0.148
4	0.279	0.277	0.246	0.215	0.220	0.258	0.220	0.233	0.205	0.208
5	0.380	0.305	0.366	0.273	0.234	0.286	0.264	0.299	0.253	0.402
6	0.384	0.454	0.377	0.316	0.333	0.308	0.317	0.374	0.277	0.440
7	0.410	0.405	0.545	0.368	0.357	0.366	0.376	0.363	0.298	0.395
8	0.449	0.459	0.560	0.530	0.330	0.391	0.404	0.357	0.324	0.554
9	0.474	0.430	0.559	0.461	0.614	0.438	0.563	0.450	0.336	0.443
10	0.451	0.528	0.813	0.470	0.382	0.466	0.494	0.372	0.323	0.420
+gp	0.6203	0.5269	0.5664	0.6122	0.6292	0.6304	0.6536	0.5768	0.5118	0.6822

Table 3 Stock weights at age (kg)

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
AGE										
1	0.050	0.050	0.050	0.050	0.144	0.141	0.139	0.131	0.141	0.143
2	0.127	0.136	0.151	0.137	0.157	0.161	0.163	0.158	0.169	0.149
3	0.157	0.179	0.207	0.185	0.203	0.185	0.195	0.191	0.186	0.185
4	0.216	0.209	0.249	0.236	0.241	0.246	0.239	0.250	0.243	0.210
5	0.226	0.258	0.314	0.265	0.267	0.272	0.286	0.294	0.278	0.267
6	0.223	0.254	0.376	0.267	0.309	0.326	0.297	0.368	0.352	0.316
7	0.231	0.301	0.399	0.273	0.349	0.339	0.340	0.401	0.341	0.341
8	0.253	0.234	0.418	0.331	0.401	0.394	0.400	0.476	0.430	0.326
9	0.256	0.326	0.446	0.504	0.608	0.416	0.433	0.463	0.449	0.440
10	0.301	0.404	0.444	0.409	0.425	0.461	0.446	0.402	0.456	0.416
+gp	0.4204	0.4170	0.5032	0.4501	0.5602	0.5553	0.5182	0.5663	0.6598	0.4191

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*	4.35	35.93

[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	31.66	31.23

[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

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BE-CBT

1980	2010													
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

UK(E&W)-CBT

1986	2010													
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

Table 9.2.7 - Sole VIId - tuning files - continued

Bolded numbers = used in XSA

UK(E&W)-BTS-Q3						
1988	**2010**					
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**
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	**2010**					
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**				

Table 9.3.1 - Sole VIId - XSA diagnostics

Lowestoft VPA Version 3.1

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Extended Survivors Analysis

Sole in Division VIId - 2011WG

Catch data for 29 years. 1982 to 2010. Ages 1 to 11.

Fleet	First year	Last year	First age	Last age	Alpha	Beta
BE-CBT	1986	2010	2	10	0	1
UK(E&W)-CBT	1986	2010	2	10	0	1
UK(E&W)-BTS	1988	2010	1	6	0.5	0.75
UK(E&W)-YFS	1987	2010	1	1	0.5	0.75
FR-YFS	1987	2010	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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.007	0.016	0.019	0.057	0.006	0.015	0.011	0.007	0.005	0.005
2	0.255	0.37	0.323	0.275	0.244	0.267	0.201	0.201	0.159	0.123
3	0.45	0.509	0.445	0.402	0.402	0.402	0.409	0.389	0.515	0.329
4	0.335	0.481	0.371	0.371	0.425	0.482	0.572	0.38	0.576	0.805
5	0.568	0.493	0.396	0.439	0.358	0.46	0.453	0.449	0.347	0.467
6	0.433	0.251	0.407	0.4	0.366	0.415	0.483	0.444	0.501	0.294
7	0.349	0.281	0.333	0.366	0.372	0.415	0.489	0.291	0.593	0.349
8	0.229	0.23	0.272	0.405	0.339	0.382	0.406	0.402	0.385	0.489
9	0.219	0.242	0.168	0.179	0.428	0.495	0.397	0.216	0.553	0.315
10	0.124	0.322	0.322	0.294	0.347	0.57	0.918	0.329	0.524	0.345

1

XSA population numbers (Thousands)

YEAR \ AGE	1	2	3	4	5	6	7	8	9	10
2001	2.65E+04	2.82E+04	1.80E+04	5.90E+03	6.04E+03	2.18E+03	1.04E+03	6.58E+02	3.00E+02	7.32E+02
2002	4.69E+04	2.38E+04	1.98E+04	1.04E+04	3.82E+03	3.10E+03	1.28E+03	6.61E+02	4.74E+02	2.18E+02
2003	2.10E+04	4.18E+04	1.49E+04	1.08E+04	5.80E+03	2.11E+03	2.18E+03	8.73E+02	4.75E+02	3.36E+02
2004	1.97E+04	1.86E+04	2.74E+04	8.64E+03	6.72E+03	3.53E+03	1.27E+03	1.41E+03	6.02E+02	3.64E+02
2005	3.68E+04	1.68E+04	1.28E+04	1.66E+04	5.40E+03	3.92E+03	2.14E+03	7.97E+02	8.54E+02	4.55E+02
2006	4.21E+04	3.31E+04	1.19E+04	7.75E+03	9.79E+03	3.41E+03	2.46E+03	1.34E+03	5.14E+02	5.03E+02
2007	1.74E+04	3.75E+04	2.29E+04	7.22E+03	4.33E+03	5.59E+03	2.04E+03	1.47E+03	8.25E+02	2.83E+02
2008	2.40E+04	1.56E+04	2.78E+04	1.38E+04	3.68E+03	2.49E+03	3.12E+03	1.13E+03	8.87E+02	5.02E+02
2009	5.30E+04	2.15E+04	1.15E+04	1.70E+04	8.52E+03	2.13E+03	1.45E+03	2.11E+03	6.85E+02	6.47E+02
2010	2.82E+04	4.77E+04	1.66E+04	6.24E+03	8.65E+03	5.45E+03	1.17E+03	7.23E+02	1.30E+03	3.57E+02

Estimated population abundance at 1st Jan 2011

0.00E+00	2.54E+04	3.82E+04	1.08E+04	2.52E+03	4.91E+03	3.67E+03	7.45E+02	4.02E+02	8.59E+02

Taper weighted geometric mean of the VPA populations:

2.44E+04	2.15E+04	1.58E+04	8.79E+03	4.87E+03	2.79E+03	1.62E+03	9.92E+02	6.33E+02	3.87E+02

Standard error of the weighted Log(VPA populations) :

0.3953	0.3977	0.3561	0.4275	0.4482	0.4674	0.4798	0.49	0.4829	0.5079

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Log catchability residuals.

Fleet : BE-CBT

Age	1986	1987	1988	1989	1990
1	No data for this fleet at this age				
2	0.02	0.56	-0.75	-2.58	1.1
3	0.73	-0.21	-0.43	0	0.09
4	0.19	0.37	-0.72	-0.39	-0.14
5	-0.07	0.6	-0.21	1.03	-0.06
6	-0.11	0.92	-0.21	0.29	-0.16
7	-0.19	0.6	0.05	0.34	0.56
8	0.03	-0.08	-0.76	-0.07	-0.25
9	0.77	0.28	-0.73	-0.35	0.33
10	0.08	2.22	1.32	-2.07	-0.13

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	No data for this fleet at this age									
2	-0.78	-0.05	1.29	-0.31	-0.77	-0.14	-0.75	-0.36	0.36	0.04
3	0.83	0.1	0.25	-0.02	-0.29	-0.05	0.38	-0.21	0.04	0.43
4	0.07	0.41	-0.04	0.57	-0.33	0.28	0.36	0.28	0.53	0.35
5	-0.02	0.26	-0.01	0.29	-0.05	-0.1	0.49	-0.14	0.48	-0.3
6	0.66	-0.47	-0.84	0.42	0.09	0.14	0.16	-0.25	-0.07	0.09
7	0.08	-0.21	0.02	0.04	-0.02	0.26	0.23	-0.21	0	-0.23
8	-0.02	-0.15	-0.24	0.31	-1.09	-0.03	-0.19	0.08	-0.19	0.52
9	-0.66	-0.03	0.7	-0.17	0.2	-0.13	0.07	-0.04	0.01	-0.24
10	0.52	-0.66	-0.56	1.4	-0.74	1.14	-0.94	-0.08	-0.53	-0.33

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	No data for this fleet at this age									
2	0.46	0.83	0.43	0.54	0.96	0.14	0.07	-0.82	0.39	0.1
3	0.04	0.08	0.13	-0.36	0.08	-0.26	-0.49	-0.83	0.02	-0.04
4	-0.34	-0.11	-0.01	-0.22	-0.21	0.04	-0.24	-0.22	-0.35	-0.12
5	0.14	-0.24	-0.1	0.26	-0.63	-0.44	-0.56	-0.19	-0.23	-0.2
6	0.72	-0.81	0.47	-0.09	-0.56	0.06	-0.34	-0.3	0.21	-0.03
7	0.15	-0.23	-0.39	-0.54	-0.27	0.16	-0.37	-0.26	0.19	0.23
8	-0.66	-0.34	-0.17	-0.51	-0.04	-0.16	0.14	-0.05	-0.4	0
9	-0.61	-0.6	-1.49	-0.87	-0.74	0.22	-0.08	-0.49	-0.12	0.07
10	-1.34	0.35	0.09	0.2	-0.99	0.23	0.32	-0.01	-0.12	0.13

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	-7.0541	-5.8189	-5.6887	-5.5835	-5.7643	-5.6968	-5.6968	-5.6968	-5.6968
S.E(Log q)	0.8096	0.3624	0.3298	0.377	0.4401	0.2899	0.3785	0.5432	0.9173

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	0.85	0.417	7.5	0.26	25	0.7	-7.05
3	1.52	-1.73	3.83	0.33	25	0.53	-5.82
4	0.97	0.182	5.79	0.64	25	0.33	-5.69
5	1.19	-0.89	5.04	0.5	25	0.45	-5.58
6	1.1	-0.445	5.55	0.48	25	0.49	-5.76
7	1.02	-0.177	5.66	0.72	25	0.3	-5.7
8	1.26	-1.582	5.6	0.62	25	0.41	-5.87
9	1.28	-1.042	5.72	0.38	25	0.65	-5.89
10	-3.35	-5.609	6.94	0.07	25	2.04	-5.72
1							

Fleet : UK(E&W)-CBT

Age	1986	1987	1988	1989	1990
1	No data for this fleet at this age				
2	-0.36	0.39	0.59	-0.04	-0.2
3	0.5	-0.08	0.34	-0.03	0.08
4	0.52	0.4	-0.05	0.23	-0.12
5	0.29	0.54	0.42	-0.48	0.01
6	0.43	-0.24	0.3	0.16	-0.35
7	0.66	-0.28	-0.14	0.22	-0.27
8	-0.76	0.4	0.28	-0.26	0.02
9	0.11	-0.74	0.09	-0.36	-0.18
10	0.01	-1.28	0.49	0.33	0.5

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	No data for this fleet at this age									
2	-0.07	-0.4	-0.35	-1.2	-0.18	0.26	0.14	0.01	0.36	-0.12
3	-0.29	-0.12	-0.53	-0.12	-0.65	-0.52	0.14	-0.28	0.09	0.24
4	0.04	-0.43	-0.19	-0.32	-0.08	-0.8	-0.24	-0.06	0.12	0.17
5	-1.21	0.49	-0.35	-0.03	-0.14	-0.05	-0.52	0.14	0.18	0.27
6	-0.23	-0.57	0.09	0.03	0.07	-0.22	0.24	-0.06	0.32	0.28
7	-0.94	-0.19	-0.54	0.5	-0.15	-0.1	-0.13	0.2	0.23	0.44
8	-0.59	-0.4	-0.12	-0.16	0.4	-0.19	0.13	0.09	0.17	0.25
9	0.15	0.43	0.02	0.38	0.22	0.22	-0.11	0.21	-0.05	0.52
10	-0.01	-0.26	-0.43	0.45	0.41	0.21	0.23	0.37	-0.27	0.11

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	No data for this fleet at this age									
2	0.06	0.35	0.14	0.01	0.31	0.49	-0.35	0.22	0.52	-0.58
3	-0.15	0.26	-0.03	0.35	0	0.75	0.13	0.42	-0.33	-0.14
4	-0.1	0.16	-0.16	0.01	0.47	0.07	0.36	-0.11	0.16	-0.07
5	0.23	0.18	-0.22	-0.07	0.02	0.48	-0.23	-0.13	-0.13	0.29
6	0.27	0.02	-0.06	-0.08	0.39	-0.26	0.62	-0.23	-0.52	-0.41
7	0.19	0.1	0.09	-0.24	0.34	0	0.23	-0.14	-0.25	0.17
8	0.62	0.53	0.22	0.31	0.6	-0.13	0.51	-0.08	0.04	0.29
9	0.18	-0.26	-0.2	-0.37	0.46	0.47	0.16	-0.97	0	0.21
10	0.18	-0.11	0.25	-0.12	0.73	0.01	-0.5	0.02	0.63	0.46

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	-6.5231	-5.8217	-5.795	-5.9415	-5.952	-6.0072	-6.0072	-6.0072	-6.0072
S.E(Log q)	0.4041	0.3375	0.2915	0.3859	0.3118	0.3437	0.3696	0.366	0.4419

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	1.22	-0.865	5.76	0.41	25	0.49	-6.52
3	0.93	0.386	6.09	0.57	25	0.32	-5.82
4	0.91	0.669	6.08	0.72	25	0.27	-5.8
5	0.73	2.213	6.63	0.75	25	0.26	-5.94
6	0.82	1.657	6.31	0.78	25	0.25	-5.95
7	0.78	2.011	6.32	0.79	25	0.25	-6.01
8	0.83	1.474	6.09	0.76	25	0.29	-5.92
9	0.85	1.21	6.06	0.73	25	0.31	-5.98
10	0.88	0.82	5.92	0.67	25	0.38	-5.91
1							

Fleet : UK(E&W)-BTS

Age	1986	1987	1988	1989	1990
1	99.99	99.99	0.25	-0.46	0.12
2	99.99	99.99	1.02	0.19	-0.77
3	99.99	99.99	0.64	0.61	-0.5
4	99.99	99.99	-0.31	-0.07	0.01
5	99.99	99.99	0.45	0.18	-0.13
6	99.99	99.99	0.09	-0.81	-0.28
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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.04	-1.78	-2.11	-0.31	-0.29	-0.29	1.02	-0.8	1.47	0.31
2	0.1	-0.37	0.07	-1.02	-0.23	-0.26	-0.29	0.36	0.1	0.53
3	-0.38	0.11	0.04	0.11	-0.98	-0.35	-0.13	-0.48	0.76	0.24
4	0.02	-0.65	0.58	-0.03	-0.35	-0.81	-0.29	-0.26	0.55	0.58
5	-0.22	-0.07	0.02	0.41	-0.42	-0.29	-1.2	0.15	1.01	0.31
6	0.07	0.34	0.31	-0.86	0.21	-0.06	-0.6	-1.1	1.27	0.57
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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.33	1.02	0.23	0.45	1.02	-0.49	-0.71	-0.71	0.85	0.83
2	0.36	-0.01	0.32	-0.12	-0.56	0.54	0.08	-0.25	0.11	0.11
3	0.42	-0.07	-0.1	-0.11	-0.34	-0.29	0.59	-0.2	0.47	-0.03
4	-0.15	0.44	-0.01	-0.24	-0.06	0.18	-0.2	0.42	0.22	0.44
5	0.51	-1.04	0.25	0.04	0.33	-0.05	-0.1	-1.33	0.71	0.47
6	0.26	0.07	-0.31	0.37	0.27	-0.78	0.15	0.06	0.03	0.75
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	-8.2444	-7.3419	-7.7506	-8.0818	-8.1506	-8.2339
S.E(Log q)	0.8844	0.449	0.4359	0.3817	0.5768	0.5579

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	0.48	2.178	9.27	0.45	23	0.39	-8.24
2	0.79	1.093	7.91	0.57	23	0.35	-7.34
3	0.92	0.328	7.91	0.44	23	0.41	-7.75
4	0.79	1.479	8.3	0.7	23	0.29	-8.08
5	0.81	0.88	8.22	0.49	23	0.47	-8.15
6	0.89	0.477	8.2	0.48	23	0.51	-8.23
1							

Fleet : UK(E&W)-YFS

Age	1986	1987	1988	1989	1990
1	99.99	0.65	0.1	-0.57	-0.41
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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	0.48	-0.39	0.19	0.43	0.85	-0.78	-0.49	-0.05	-0.16	0.19
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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	-1.52	0.31	0.06	0.78	0.53	-0.21	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	1.24	-0.547	9.43	0.22	20	0.74	-9.57

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Fleet : FR-YFS

Age		1986	1987	1988	1989	1990
	1	99.99	-0.28	-0.25	-0.01	0.38
	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		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	1	0.26	-0.26	-1.55	1.14	0.56	-0.06	-2.06	-0.42	0.46	0.16
	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		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	1	1.69	-1.27	0.6	-0.07	0.97	0.86	-0.6	-1.21	1.83	-0.86
	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	-11.6182
S.E(Log q)	0.9676

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	0.57	1.472	10.99	0.35	24	0.54	-11.62

Terminal year survivor and F summaries :

Age 1 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	1	0	0	0	0	0	0
UK(E&W)-CBT	1	0	0	0	0	0	0
UK(E&W)-BTS	58181	0.903	0	0	1	0.49	0.002
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	10680	0.988	0	0	1	0.41	0.012
F shrinkage mean	15090	2				0.1	0.009

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
25363	0.63	0.58	3	0.918	0.005

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 2 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	42336	0.826	0	0	1	0.1	0.111
UK(E&W)-CBT	21381	0.412	0	0	1	0.402	0.21
UK(E&W)-BTS	49679	0.409	0.297	0.73	2	0.408	0.096
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	237672	0.988	0	0	1	0.07	0.021
F shrinkage mean	20806	2				0.019	0.215

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
38193	0.26	0.3	6	1.135	0.123

Age 3 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	11041	0.338	0.153	0.45	2	0.257	0.323
UK(E&W)-CBT	12041	0.265	0.316	1.19	2	0.403	0.3
UK(E&W)-BTS	10368	0.302	0.166	0.55	3	0.304	0.341
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	3220	0.988	0	0	1	0.026	0.837
F shrinkage mean	7964	2				0.01	0.425

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
10827	0.17	0.12	9	0.687	0.329

Age 4 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	2258	0.247	0.125	0.51	3	0.299	0.868
UK(E&W)-CBT	2297	0.207	0.123	0.59	3	0.409	0.858
UK(E&W)-BTS	3280	0.25	0.2	0.8	4	0.269	0.669
UK(E&W)-YFS	1	0	0	0	0	0	0
FR-YFS	1380	0.988	0	0	1	0.011	1.182
F shrinkage mean	4948	2				0.012	0.489

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
2524	0.13	0.09	12	0.674	0.805

Age 5 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	3420	0.219	0.138	0.63	4	0.335	0.618
UK(E&W)-CBT	5994	0.193	0.12	0.62	4	0.398	0.397
UK(E&W)-BTS	5791	0.242	0.131	0.54	5	0.232	0.409
UK(E&W)-YFS	3962	0.599	0	0	1	0.019	0.553
FR-YFS	11548	0.988	0	0	1	0.007	0.226
F shrinkage mean	5691	2				0.009	0.415

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
4907	0.12	0.09	16	0.745	0.467

Table 9.3.1 - Sole VIId - XSA diagnostics - continued

Age 6 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	3014	0.201	0.077	0.38	5	0.314	0.348
UK(E&W)-CBT	3092	0.172	0.123	0.72	5	0.449	0.341
UK(E&W)-BTS	6786	0.231	0.067	0.29	6	0.213	0.17
UK(E&W)-YFS	6218	0.599	0	0	1	0.013	0.184
FR-YFS	9722	0.988	0	0	1	0.005	0.122
F shrinkage me	2254	2				0.006	0.443

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
3672	0.11	0.09	19	0.827	0.294

Age 7 Catchability constant w.r.t. time and dependent on age

Year class = 2003

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	828	0.192	0.097	0.5	6	0.419	0.319
UK(E&W)-CBT	742	0.175	0.169	0.96	6	0.442	0.35
UK(E&W)-BTS	513	0.246	0.225	0.91	6	0.123	0.474
UK(E&W)-YFS	1626	0.599	0	0	1	0.006	0.175
FR-YFS	696	0.988	0	0	1	0.002	0.369
F shrinkage mean	573	2				0.007	0.434

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
745	0.12	0.08	21	0.716	0.349

Age 8 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	401	0.185	0.09	0.49	7	0.436	0.489
UK(E&W)-CBT	399	0.175	0.099	0.56	7	0.462	0.491
UK(E&W)-BTS	400	0.242	0.077	0.32	6	0.085	0.49
UK(E&W)-YFS	425	0.599	0	0	1	0.005	0.467
FR-YFS	733	0.988	0	0	1	0.002	0.297
F shrinkage mean	541	2				0.01	0.384

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
402	0.12	0.05	23	0.413	0.489

Age 9 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	666	0.175	0.066	0.38	8	0.405	0.39
UK(E&W)-CBT	1049	0.163	0.093	0.57	8	0.511	0.264
UK(E&W)-BTS	911	0.24	0.09	0.37	6	0.071	0.299
UK(E&W)-YFS	1170	0.599	0	0	1	0.004	0.24
FR-YFS	241	0.988	0	0	1	0.001	0.842
F shrinkage mean	610	2				0.008	0.419

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
859	0.11	0.06	25	0.568	0.315

Age 10 Catchability constant w.r.t. time and age (fixed at the value for age) 7

Year class = 2000

Fleet	Estimated Survivors	Int s.e	Ext s.e	Var Ratio	N	Scaled Weights	Estimated F
BE-CBT	196	0.188	0.078	0.41	9	0.356	0.392
UK(E&W)-CBT	259	0.175	0.086	0.49	9	0.572	0.31
UK(E&W)-BTS	181	0.234	0.177	0.76	6	0.057	0.419
UK(E&W)-YFS	50	0.599	0	0	1	0.003	1.058
FR-YFS	1238	0.988	0	0	1	0.001	0.073
F shrinkage mean	201	2				0.012	0.384

Weighted prediction :

Survivors at end of year	Int s.e	Ext s.e	N	Var Ratio	F
229	0.12	0.06	27	0.48	0.345

Table 9.3.2 - Sole VIId - Fishing mortality (F) at age

Run title : Sole in Division VIId - 2011WG

At 30/04/2011 11:34

Table 8 Fishing mortality (F) at age

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE									
1	0.0129	0	0.0012	0.004	0.002	0.0009	0.0039	0.0102	0.03
2	0.1860	0.0820	0.1138	0.2224	0.1199	0.152	0.2599	0.1711	0.222
3	0.3105	0.3526	0.4306	0.4324	0.5021	0.5443	0.5404	0.6706	0.4009
4	0.4847	0.3580	0.4358	0.3712	0.4566	0.5891	0.4207	0.665	0.4738
5	0.2300	0.4432	0.2613	0.2712	0.3186	0.5292	0.3771	0.7285	0.4384
6	0.2261	0.4597	0.713	0.3902	0.2977	0.6501	0.3878	0.4572	0.2859
7	0.4663	0.3137	0.5125	0.2524	0.356	0.7851	0.4729	0.4296	0.353
8	0.4091	0.5079	0.2305	0.2954	0.4179	0.432	0.3687	0.4249	0.3147
9	0.3452	0.2895	0.3548	0.152	0.6102	0.5285	0.2169	0.3867	0.4709
10	0.3362	0.4040	0.4157	0.2729	0.283	1.5958	0.8569	0.2669	0.5043
+gp	0.3362	0.4040	0.4157	0.2729	0.283	1.5958	0.8569	0.2669	0.5043
0 FBAR 3- 8	0.3544	0.4058	0.4306	0.3355	0.3915	0.5883	0.4279	0.5626	0.3778

Table 8 Fishing mortality (F) at age

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	0.0116	0.0033	0.0053	0.0012	0.0464	0.0005	0.0009	0.0019	0.0067	0.0046
2	0.2152	0.1465	0.1913	0.0495	0.1396	0.1213	0.0960	0.0593	0.2371	0.1738
3	0.5034	0.3937	0.3253	0.3389	0.4360	0.5654	0.6420	0.5436	0.5400	0.5781
4	0.5215	0.4043	0.4008	0.4931	0.4193	0.5431	0.7806	0.5858	0.6361	0.5257
5	0.4332	0.4502	0.3482	0.4166	0.4374	0.4899	0.7915	0.5569	0.5564	0.3852
6	0.5190	0.3364	0.1954	0.3101	0.4038	0.4659	0.4524	0.4945	0.5754	0.3811
7	0.3745	0.3255	0.2858	0.2747	0.2985	0.4405	0.3998	0.2373	0.5213	0.3792
8	0.3514	0.3061	0.2449	0.2824	0.1879	0.3254	0.4612	0.3032	0.4407	0.3853
9	0.5203	0.3889	0.4156	0.2742	0.3441	0.3040	0.4698	0.3507	0.3733	0.3549
10	0.6425	0.3254	0.2113	0.6099	0.2895	0.8623	0.2332	1.0869	0.2901	0.2404
+gp	0.6425	0.3254	0.2113	0.6099	0.2895	0.8623	0.2332	1.0869	0.2901	0.2404
0 FBAR 3- 8	0.4505	0.3694	0.3001	0.3527	0.3638	0.4717	0.5879	0.4536	0.5450	0.4391

Table 8 Fishing mortality (F) at age

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	FBAR 08-10
AGE											
1	0.0067	0.0160	0.0192	0.0566	0.0059	0.0153	0.0106	0.0066	0.0046	0.0051	0.0054
2	0.2548	0.3700	0.3227	0.2746	0.2443	0.2669	0.2014	0.2011	0.1587	0.1228	0.1609
3	0.4499	0.5089	0.4447	0.4023	0.4022	0.4020	0.4090	0.3893	0.5150	0.3289	0.4111
4	0.3346	0.4811	0.3712	0.3707	0.4254	0.4823	0.5721	0.3803	0.5764	0.8049	0.5872
5	0.5679	0.4931	0.3963	0.4388	0.3576	0.4597	0.4529	0.4486	0.3473	0.4673	0.4211
6	0.4329	0.2512	0.4069	0.4003	0.3657	0.4149	0.4828	0.4437	0.5010	0.2943	0.4130
7	0.3487	0.2811	0.3332	0.3665	0.3722	0.4152	0.4894	0.2913	0.5926	0.3489	0.4109
8	0.2288	0.2296	0.2723	0.4049	0.3389	0.3817	0.4060	0.4015	0.3850	0.4886	0.4250
9	0.2189	0.2424	0.1681	0.1794	0.4284	0.4953	0.3968	0.2161	0.5532	0.3147	0.3613
10	0.1236	0.3219	0.3216	0.2936	0.3473	0.5699	0.9185	0.3295	0.5243	0.3451	0.3996
+gp	0.1236	0.3219	0.3216	0.2936	0.3473	0.5699	0.9185	0.3295	0.5243	0.3451	
0 FBAR 3- 8	0.3938	0.3742	0.3708	0.3972	0.3770	0.4260	0.4687	0.3925	0.4862	0.4555	

Table 9.3.3 - Sole VIId - Stock numbers at age

Run title : Sole in Division VIId - 2011WG

At 30/04/2011 11:34

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1982	1983	1984	1985	1986	1987	1988	1989	1990
AGE									
1	12738	21358	21543	12915	25737	10984	25839	16811	44314
2	16257	11379	19325	19470	11639	23241	9930	23290	15056
3	20700	12213	9486	15606	14105	9341	18064	6929	17759
4	4727	13731	7767	5580	9164	7725	4904	9521	3206
5	2917	2634	8686	4545	3483	5252	3878	2914	4431
6	3392	2097	1530	6052	3136	2292	2800	2407	1272
7	1549	2448	1198	679	3707	2107	1082	1719	1378
8	752	879	1619	649	477	2349	869	610	1012
9	439	452	479	1163	437	284	1380	544	361
10	306	281	306	304	904	215	152	1005	334
+gp	741	608	733	562	1582	597	499	1262	1292
0 TOTAL	64517	68079	72671	67524	74370	64388	69398	67011	90416

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
AGE										
1	34889	33662	16791	26575	19448	18913	27800	18022	26294	31354
2	38912	31205	30358	15112	24017	16800	17105	25131	16275	23632
3	10911	28393	24386	22687	13014	18900	13465	14060	21431	11618
4	10761	5968	17331	15938	14627	7614	9716	6412	7387	11300
5	1806	5780	3604	10503	8807	8703	4003	4027	3230	3538
6	2586	1060	3334	2302	6265	5146	4825	1641	2088	1675
7	865	1392	685	2481	1528	3786	2922	2777	906	1063
8	876	538	910	466	1706	1026	2205	1773	1982	487
9	669	558	359	644	318	1279	670	1258	1184	1154
10	204	360	342	214	443	204	854	379	802	738
+gp	842	872	710	591	1005	621	1346	473	1494	1217
0 TOTAL	103323	109787	98811	97514	91179	82991	84910	75954	83074	87776

Table 10 Stock number at age (start of year) Numbers*10**-3

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	GMST 82-08	AMST 82-08
AGE													
1	26513	46899	20983	19671	36766	42112	17418	23954	52984	28175	0	23535	25196
2	28239	23831	41764	18625	16819	33071	37527	15594	21533	47723	25363	20854	22356
3	17972	19804	14894	27367	12807	11920	22913	27762	11540	16625	38193	15967	16982
4	5897	10370	10773	8638	16560	7751	7215	13774	17019	6239	10827	8685	9421
5	6044	3819	5800	6725	5395	9792	4330	3685	8520	8654	2524	4670	5123
6	2178	3100	2110	3531	3924	3414	5595	2491	2129	5447	4907	2748	3046
7	1035	1278	2182	1271	2141	2463	2040	3124	1446	1167	3672	1647	1845
8	658	661	873	1415	797	1335	1471	1132	2112	723	745	976	1094
9	300	474	475	602	854	514	825	887	685	1300	402	615	688
10	732	218	336	364	455	503	283	502	647	357	859	381	435
+gp	2393	750	934	960	968	739	399	922	1156	1038	893		
0 TOTAL	91962	111203	101123	89168	97485	113615	100016	93826	119772	117447	88386		

* Replaced with GM (23535) in prediction

Table 9.3.4 - Sole VIId - Summary

Run title : Sole in Division VIId - 2011WG

At 30/04/2011 11:34

Table 16 Summary (without SOP correction)

	RECRUITS Age 1	TOTALBIO	TOTSPBIO	LANDINGS	YIELD/SSB	FBAR 3- 8
1982	12738	10433	7828	3190	0.4075	0.3544
1983	21358	12625	9594	3458	0.3604	0.4058
1984	21543	12977	9002	3575	0.3971	0.4306
1985	12915	13357	10006	3837	0.3835	0.3355
1986	25737	14011	10627	3932	0.3700	0.3915
1987	10984	13046	9025	4791	0.5309	0.5883
1988	25839	12889	10157	3853	0.3793	0.4279
1989	16811	11933	8461	3805	0.4497	0.5626
1990	44314	13941	9648	3647	0.3780	0.3778
1991	34889	15931	8816	4351	0.4935	0.4505
1992	33662	17424	11247	4072	0.3620	0.3694
1993	16791	17999	13212	4299	0.3254	0.3001
1994	26575	15675	12593	4383	0.3480	0.3527
1995	19448	15148	11149	4420	0.3964	0.3638
1996	18913	15748	12198	4797	0.3933	0.4717
1997	27800	14381	10614	4764	0.4488	0.5879
1998	18022	12574	8154	3363	0.4124	0.4536
1999	26294	12499	9101	4135	0.4543	0.5450
2000	31354	13021	8570	3476	0.4056	0.4391
2001	26513	12568	7656	4025	0.5258	0.3938
2002	46899	14165	8579	4733	0.5517	0.3742
2003	20983	17802	10447	5038	0.4823	0.3708
2004	19671	15061	11526	4826	0.4187	0.3972
2005	36766	19500	11565	4383	0.3790	0.3770
2006	42112	21368	10106	4833	0.4782	0.4260
2007	17418	19603	11065	5166	0.4669	0.4687
2008	23954	19274	13672	4517	0.3304	0.3925
2009	52984	23277	12167	5266	0.4328	0.4862
2010	28175	21347	10207	4391	0.4302	0.4555
2011	23535[1]	22040[2]	14760[2]			0.4447[3]
Arith. Mean	26257	15503	10241	4253	0.4204	0.4259
0 Units	(Thousands)	(Tonnes)	(Tonnes)	(Tonnes)		

[1] Geometric mean 1982-2008

[2] From forecast

[3] $F_{(08\text{-}10)}$ NOT rescaled to F_{2010}

Table 9.5.1 - Sole VIId – RCT3 input

Yearclass	XSA (Age 1)	XSA (Age 2)	FR-YF0	FR-YF1	BTS1	BTS2
1981	12738	11379	3.33	0.07	-11	-11
1982	21358	19325	1.04	0.02	-11	-11
1983	21543	19470	0.79	-11	-11	-11
1984	12915	11639	-11	-11	-11	-11
1985	25737	23241	-11	-11	-11	-11
1986	10984	9930	-11	0.07	-11	14.20
1987	25839	23290	0.75	0.17	8.20	15.40
1988	16811	15056	0.04	0.14	2.60	3.70
1989	44314	38912	17.43	0.54	12.10	22.80
1990	34889	31205	0.57	0.38	8.90	12.00
1991	33662	30358	1.04	0.22	1.40	17.50
1992	16791	15112	0.48	0.03	0.50	3.20
1993	26575	24017	0.27	0.70	4.80	10.60
1994	19448	16800	4.04	0.28	3.50	7.30
1995	18913	17105	3.50	0.15	3.50	7.30
1996	27800	25131	0.28	0.03	19.00	21.20
1997	18022	16275	0.07	0.10	2.00	9.44
1998	26294	23632	10.52	0.35	28.14	22.03
1999	31354	28239	2.84	0.31	10.49	21.01
2000	26513	23831	2.41	1.21	9.09	11.42
2001	46899	41764	4.32	0.11	31.76	28.48
2002	20983	18625	0.94	0.32	6.47	8.49
2003	19671	16819	0.21	0.15	7.35	5.04
2004	36766	33071	7.29	0.82	25.00	29.20
2005	42112	37527	0.05	0.83	6.30	21.86
2006	17418	15594	1.04	0.08	2.14	6.50
2007	-11	-11	0.03	0.06	2.90	13.3
2008	-11	-11	6.58	2.78	30.5	30.1
2009	-11	-11	2.47	0.1	15.9	-11
2010	-11	-11	0.20	-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   30 years :  1981 - 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.

Yearclass =   2008

          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    1.36   8.82   1.07   .102     23   2.03   11.58    1.182     .038
 FR-YF1    3.41   9.26    .63   .286     23   1.39   13.98    1.008     .052
 BTS1       .61   8.92    .41   .414     20   3.47   11.05     .476     .235
 BTS2       .88   7.86    .36   .534     21   3.44   10.89     .411     .316

                                        VPA Mean =   10.07     .386     .358

 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    1.36   8.82   1.07   .102     23   1.24   10.52    1.142     .053
 FR-YF1    3.41   9.26    .63   .286     23    .00    9.26     .692     .145
 BTS1       .61   8.92    .41   .414     20   2.83   10.66     .455     .335
 BTS2

                                        VPA Mean =   10.07     .386     .467

 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    1.36   8.82   1.07   .102     23    .18    9.07(8691)    1.161
.099
 FR-YF1
 BTS1
 BTS2

                                        VPA Mean =   10.07(23623)    .386
.901


 Year     Weighted      Log      Int      Ext      Var      VPA       Log
 Class     Average      WAP      Std      Std     Ratio               VPA
          Prediction             Error    Error

 2008       50051     10.82      .23      .44      3.58
 2009       26157     10.17      .26      .27      1.02
 2010       21308      9.97      .37      .30       .66
```

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   30 years :  1981 - 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.

 Yearclass =   2008

          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    1.39   8.68   1.09   .098     23   2.03   11.50(98716)      1.212    .036
 FR-YF1    3.41   9.14    .63   .284     23   1.39   13.88(1066614)    1.011    .052
 BTS1       .62   8.79    .42   .408     20   3.47   10.95(56954)       .484    .225
 BTS2       .87   7.78    .35   .548     21   3.44   10.77(47572)       .399    .331

                                      VPA Mean =    9.95(20952)     .385
.356

 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    1.39   8.68   1.09   .098     23   1.24   10.41(33190)    1.172    .051
 FR-YF1    3.41   9.14    .63   .284     23    .10    9.47(12965)     .682    .150
 BTS1       .62   8.79    .42   .408     20   2.83   10.55(38177)     .462    .327
 BTS2

                                      VPA Mean =    9.95(20952)     .385
.472

 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    1.39   8.68   1.09   .098     23    .18    8.94    1.191     .095
 FR-YF1
 BTS1
 BTS2

                                      VPA Mean =    9.95     .385     .905


 Year     Weighted     Log      Int      Ext     Var     VPA      Log
 Class     Average     WAP      Std      Std    Ratio             VPA
          Prediction           Error    Error

 2008       44599     10.71      .23      .43     3.58
 2009       24342     10.10      .26      .22      .67
 2010       19121      9.86      .37      .30      .66
```

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	23535	0.39	WS1	0.138	0.05
N2	25363	0.63	WS2	0.159	0.06
N3	38193	0.30	WS3	0.187	0.02
N4	10827	0.17	WS4	0.234	0.09
N5	2524	0.13	WS5	0.280	0.05
N6	4907	0.12	WS6	0.345	0.08
N7	3672	0.11	WS7	0.361	0.10
N8	745	0.12	WS8	0.411	0.19
N9	402	0.12	WS9	0.451	0.03
N10	859	0.11	WS10	0.425	0.07
N11	893	0.12	WS11	0.548	0.22
H.cons selectivity			Weight in the HC catch		
sH1	0.0054	0.19	WH1	0.138	0.09
sH2	0.1609	0.24	WH2	0.167	0.05
sH3	0.4111	0.23	WH3	0.200	0.02
sH4	0.5872	0.36	WH4	0.248	0.04
sH5	0.4211	0.15	WH5	0.276	0.05
sH6	0.4130	0.26	WH6	0.340	0.05
sH7	0.4109	0.39	WH7	0.366	0.17
sH8	0.4250	0.13	WH8	0.410	0.13
sH9	0.3613	0.48	WH9	0.432	0.16
sH10	0.3996	0.27	WH10	0.471	0.06
sH11	0.3996	0.27	WH11	0.527	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		
HF11	1	0.09	K11	1	0.1
HF12	1	0.09	K12	1	0.1
HF13	1	0.09	K13	1	0.1
Recruitment in 2007 and 2008					
R12	23535	0.39			
R13	23535	0.39			

Table 9.6.2 Sole in VIId - Management option table

MFDP version 1a
Run: S7d_fin
Sole in VIId
Time and date: 20:23 30/04/2011
Fbar age range: 3-8

2011				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
22040	14760	1.0000	0.4447	5837

2012					2013	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
20540	13924	0.0000	0.0000	0	25169	18534
.	13924	0.1000	0.0445	701	24410	17777
.	13924	0.2000	0.0889	1370	23685	17054
.	13924	0.3000	0.1334	2009	22993	16364
.	13924	0.4000	0.1779	2619	22333	15705
.	13924	0.5000	0.2224	3202	21702	15077
.	13924	0.6000	0.2668	3760	21100	14477
.	13924	0.7000	0.3113	4293	20525	13904
.	13924	0.8000	0.3558	4802	19976	13356
.	13924	0.9000	0.4002	5289	19451	12833
.	13924	1.0000	0.4447	5755	18950	12334
.	13924	1.1000	0.4892	6201	18471	11857
.	13924	1.2000	0.5337	6627	18013	11401
.	13924	1.3000	0.5781	7035	17575	10965
.	13924	1.4000	0.6226	7426	17157	10548
.	13924	1.5000	0.6671	7800	16756	10149
.	13924	1.6000	0.7115	8158	16373	9768
.	13924	1.7000	0.7560	8500	16007	9404
.	13924	1.8000	0.8005	8829	15657	9055
.	13924	1.9000	0.8450	9143	15321	8721
.	13924	2.0000	0.8894	9445	15000	8402

Input units are thousands and kg - output in tonnes

Fmult corresponding to Fpa = 0.9

.	13924	0.9	0.4002	5289	19451	12833

Fmult corresponding to Fmsy = 0.65

.	13924	0.652	0.2900	4040	20798	14175

Fmult corresponding to Fmsy transition = 0.88

.	13924	0.877	0.39	5179	19570	12952

Bpa/Btrigger = 8 000 t

Table 9.6.3 Sole in VIId. Detailed results

MFDP version 1a
Run: S7d_fin
Time and date: 20:23 30/04/2011
Fbar age range: 3-8

Year: 2011 F multiplier: 1 Fbar: 0.4447

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0054	121	17	23535	3256	0	0	0	0
2	0.1609	3591	601	25363	4024	0	0	0	0
3	0.4111	12292	2454	38193	7155	38193	7155	38193	7155
4	0.5872	4598	1139	10827	2537	10827	2537	10827	2537
5	0.4211	828	229	2524	706	2524	706	2524	706
6	0.4130	1585	538	4907	1695	4907	1695	4907	1695
7	0.4109	1182	432	3672	1326	3672	1326	3672	1326
8	0.4250	246	101	745	306	745	306	745	306
9	0.3613	116	50	402	181	402	181	402	181
10	0.3996	270	127	859	365	859	365	859	365
11	0.3996	281	148	893	490	893	490	893	490
Total		25112	5837	111920	22040	63022	14760	63022	14760

Year: 2012 F multiplier: 1 Fbar: 0.4447

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0054	121	17	23535	3256	0	0	0	0
2	0.1609	2999	502	21180	3361	0	0	0	0
3	0.4111	6289	1256	19539	3660	19539	3660	19539	3660
4	0.5872	9730	2410	22910	5369	22910	5369	22910	5369
5	0.4211	1787	493	5446	1523	5446	1523	5446	1523
6	0.4130	484	164	1499	518	1499	518	1499	518
7	0.4109	945	346	2938	1061	2938	1061	2938	1061
8	0.4250	728	299	2203	905	2203	905	2203	905
9	0.3613	128	55	441	199	441	199	441	199
10	0.3996	80	38	253	108	253	108	253	108
11	0.3996	334	176	1063	583	1063	583	1063	583
Total		23626	5755	101007	20540	56292	13924	56292	13924

Year: 2013 F multiplier: 1 Fbar: 0.4447

Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0054	121	17	23535	3256	0	0	0	0
2	0.1609	2999	502	21180	3361	0	0	0	0
3	0.4111	5252	1049	16317	3057	16317	3057	16317	3057
4	0.5872	4978	1233	11721	2747	11721	2747	11721	2747
5	0.4211	3782	1044	11523	3223	11523	3223	11523	3223
6	0.4130	1045	355	3234	1117	3234	1117	3234	1117
7	0.4109	289	106	897	324	897	324	897	324
8	0.4250	583	239	1762	724	1762	724	1762	724
9	0.3613	377	163	1303	587	1303	587	1303	587
10	0.3996	87	41	278	118	278	118	278	118
11	0.3996	251	132	799	438	799	438	799	438
Total		19764	4880	92550	18950	47835	12334	47835	12334

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	2007	2008	2009	2010	2011
Stock No. (thousands) of 1 year-olds	23954	52984	28175	23535	23535
Source	XSA	XSA	XSA	GM82-08	GM82-08
Status Quo F:					
% in 2011 landings	19.5	42.0	10.3	0.3	-
% in 2012 landings	8.6	41.9	21.8	8.7	0.3
% in 2011 SSB	17.2	48.5	0.0	0.0	-
% in 2012 SSB	10.9	38.6	26.3	0.0	0.0
% in 2013 SSB	9.1	26.1	22.3	24.8	0.0

GM : geometric mean recruitment

Sole VIId : Year-class % contribution to

a) 2012 landings **b) 2013 SSB**

Table 9.7.1 - Sole in VIId Yield per recruit summary table

MFYPR version 2a
Run: S7d_Yield_fin
Time and date: 20:34 30/04/2011
Yield per results

FMult	Fbar	CatchNos	Yield	StockNos	Biomass	SpwnNosJan	SSBJan	SpwnNosSpwn	SSBSpwn
0.0000	0.0000	0.0000	0.0000	10.5083	3.9030	8.6035	3.6211	8.6035	3.6211
0.1000	0.0445	0.2549	0.0926	7.9624	2.6207	6.0581	2.3389	6.0581	2.3389
0.2000	0.0889	0.3953	0.1330	6.5611	1.9475	4.6572	1.6657	4.6572	1.6657
0.3000	0.1334	0.4839	0.1523	5.6788	1.5439	3.7754	1.2623	3.7754	1.2623
0.4000	0.1779	0.5446	0.1619	5.0749	1.2810	3.1720	0.9994	3.1720	0.9994
0.5000	0.2224	0.5886	0.1665	4.6371	1.0993	2.7347	0.8178	2.7347	0.8178
0.6000	0.2668	0.6220	0.1685	4.3062	0.9682	2.4043	0.6868	2.4043	0.6868
0.7000	0.3113	0.6482	0.1692	4.0478	0.8702	2.1464	0.5889	2.1464	0.5889
0.8000	0.3558	0.6692	0.1690	3.8408	0.7949	1.9398	0.5136	1.9398	0.5136
0.9000	0.4002	0.6864	0.1685	3.6713	0.7357	1.7709	0.4545	1.7709	0.4545
1.0000	0.4447	0.7008	0.1677	3.5302	0.6881	1.6303	0.4069	1.6303	0.4069
1.1000	0.4892	0.7130	0.1669	3.4109	0.6492	1.5114	0.3681	1.5114	0.3681
1.2000	0.5337	0.7234	0.1660	3.3086	0.6169	1.4097	0.3360	1.4097	0.3360
1.3000	0.5781	0.7325	0.1651	3.2200	0.5898	1.3216	0.3089	1.3216	0.3089
1.4000	0.6226	0.7405	0.1643	3.1425	0.5667	1.2445	0.2859	1.2445	0.2859
1.5000	0.6671	0.7476	0.1635	3.0740	0.5469	1.1765	0.2661	1.1765	0.2661
1.6000	0.7115	0.7540	0.1627	3.0130	0.5296	1.1160	0.2490	1.1160	0.2490
1.7000	0.7560	0.7596	0.1620	2.9583	0.5145	1.0618	0.2339	1.0618	0.2339
1.8000	0.8005	0.7648	0.1613	2.9089	0.5011	1.0129	0.2206	1.0129	0.2206
1.9000	0.8450	0.7695	0.1607	2.8641	0.4893	0.9685	0.2088	0.9685	0.2088
2.0000	0.8894	0.7738	0.1601	2.8231	0.4786	0.9280	0.1983	0.9280	0.1983

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4447
FMax	0.7252	0.3225
F0.1	0.2905	0.1292
F35%SPR	0.2984	0.1327

Figure 9.2.1a - Sole VIId - UK Length distributions of discarded and retained fish from discard sampling studies for static gear (2005 - 2006 - 2007 - 2008 - 2009 - 2010) and one beam trawl trip in 2008

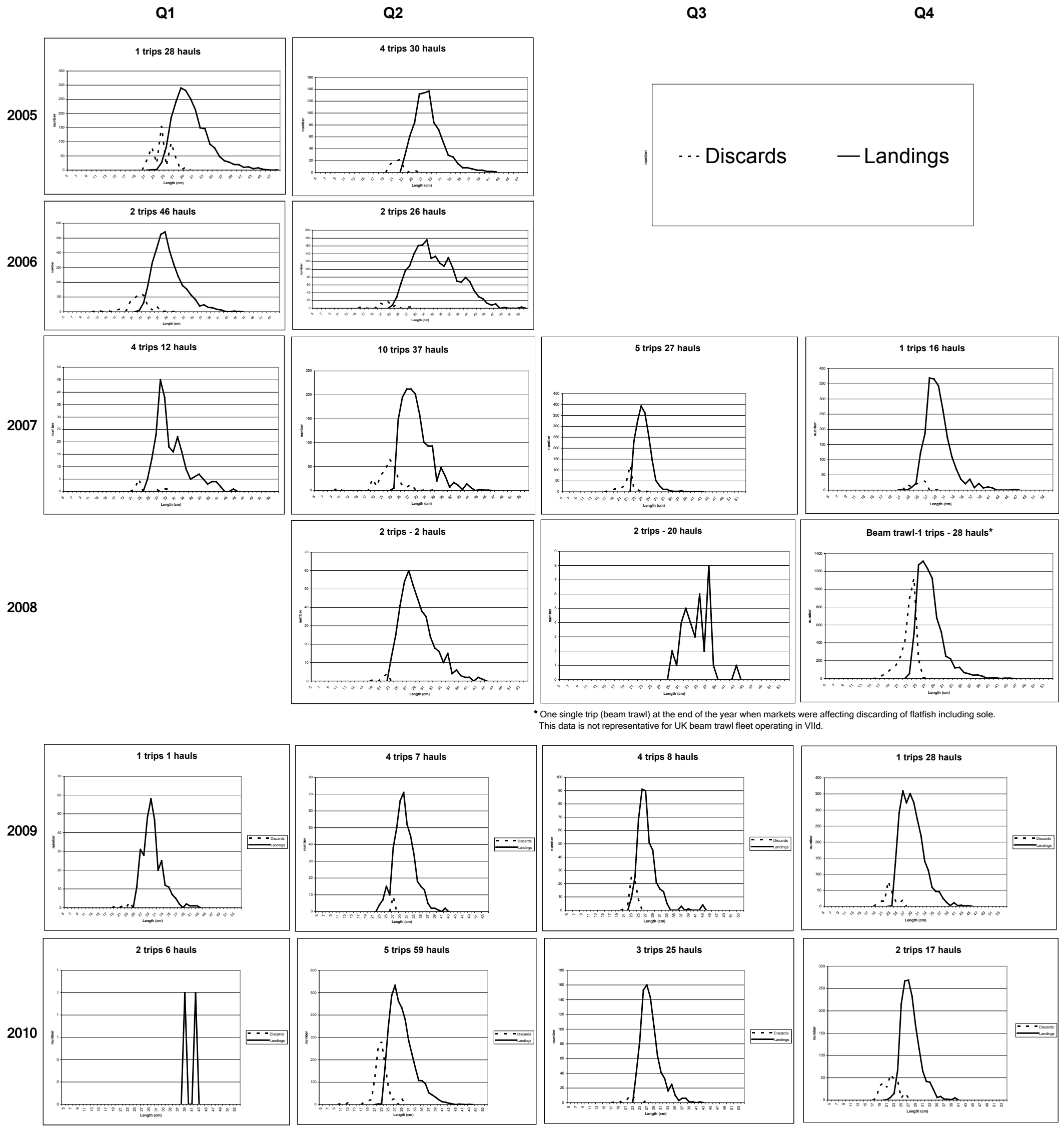
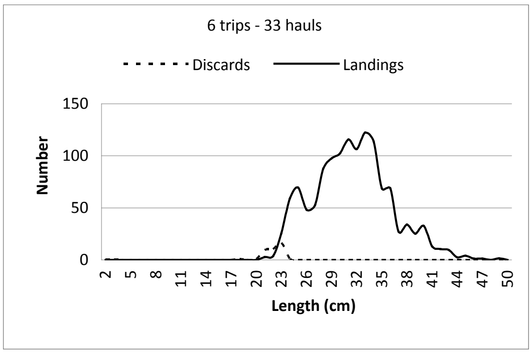
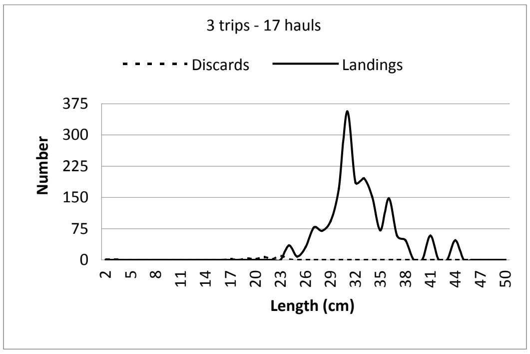


Figure 9.2.1b - French length distributions of discarded and retained fish from discard sampling studies of Gillnets (2005-2010)

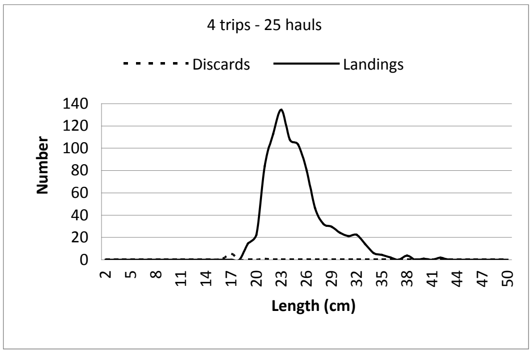
2005



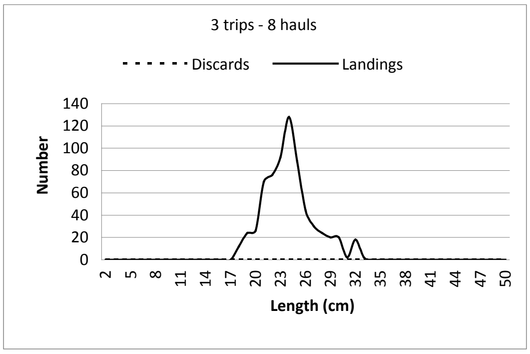
2006



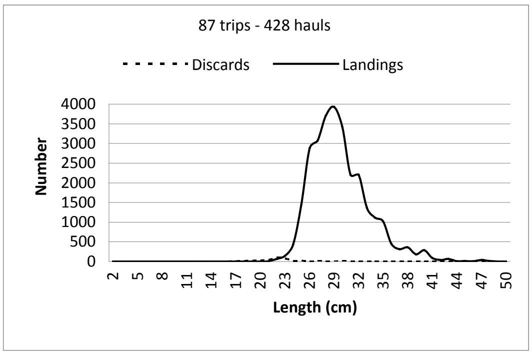
2007



2008



2009



2010

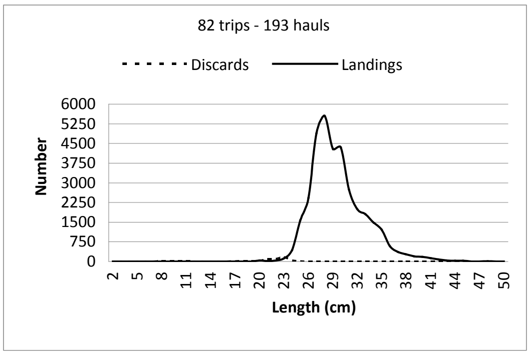
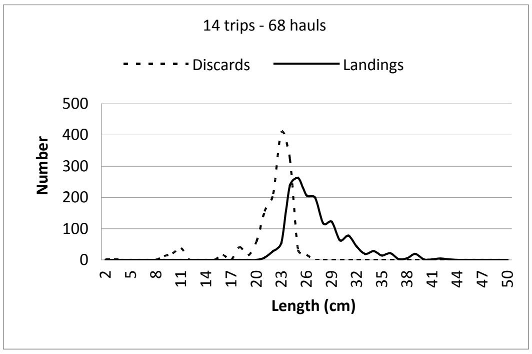
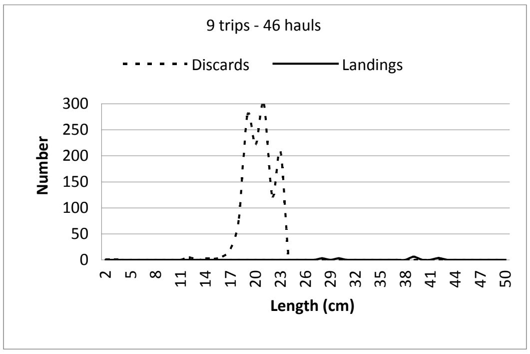


Figure 9.2.1c - French length distributions of discarded and retained fish from discard sampling studies for Otter Trawl (2005-2010)

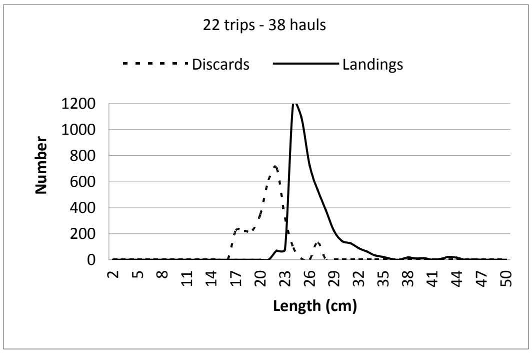
2005



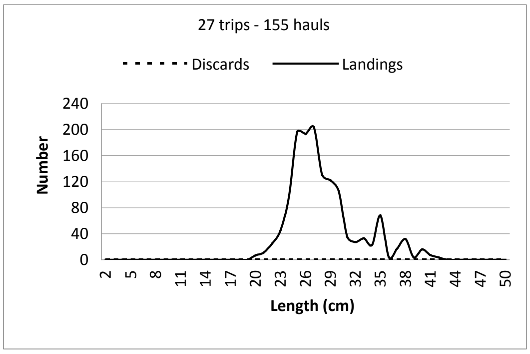
2006



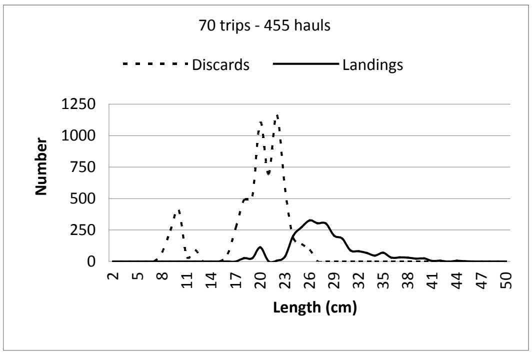
2007



2008



2009



2010

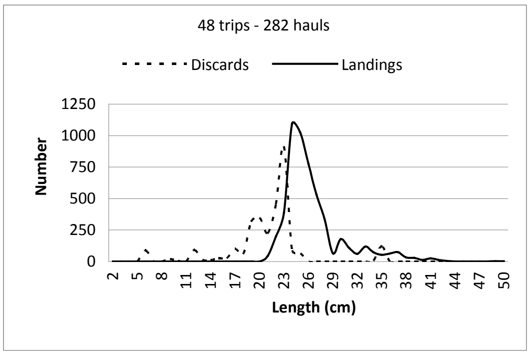
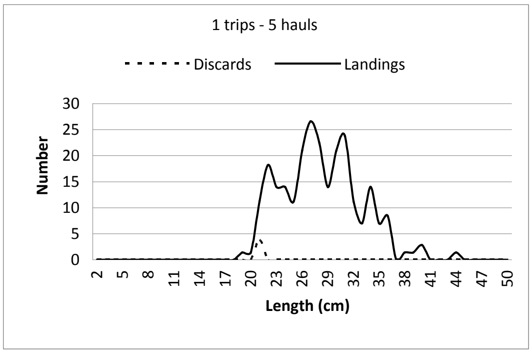
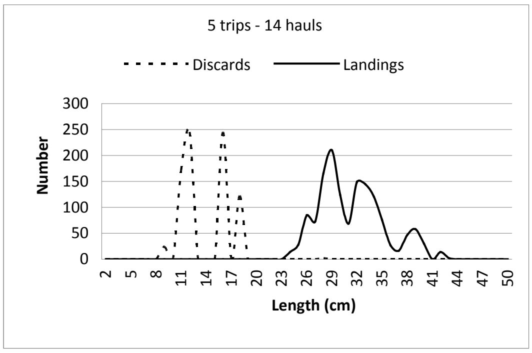


Figure 9.2.1d - French length distributions of discarded and retained fish from discard sampling studies for Beam Trawl (2005, 2009-2010)

2005



2009



2010

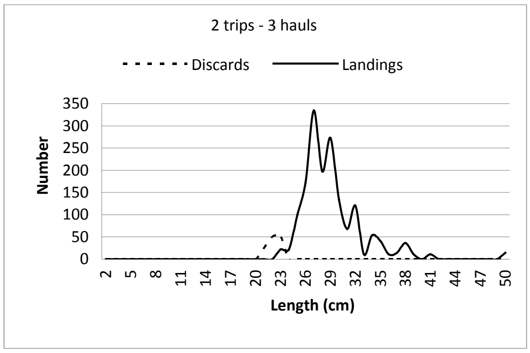


Figure 9.2.1e - Sole VIId - BE Length distributions of discarded and retained fish from discard sampling studies of beam trawls in 2010

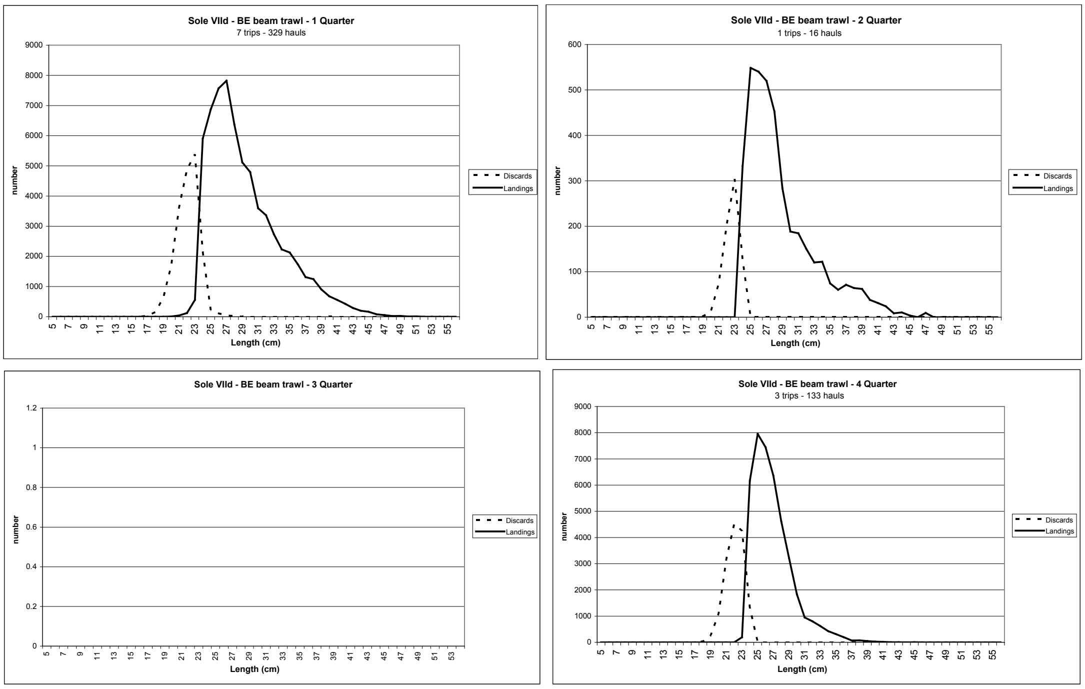


Figure 9.2.2a

Sole VIId - Effort series

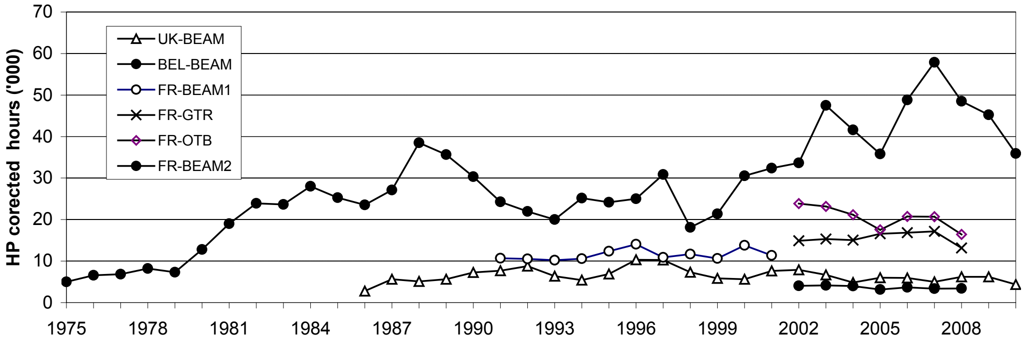


Figure 9.2.2b

Sole VIId - Relative Effort series

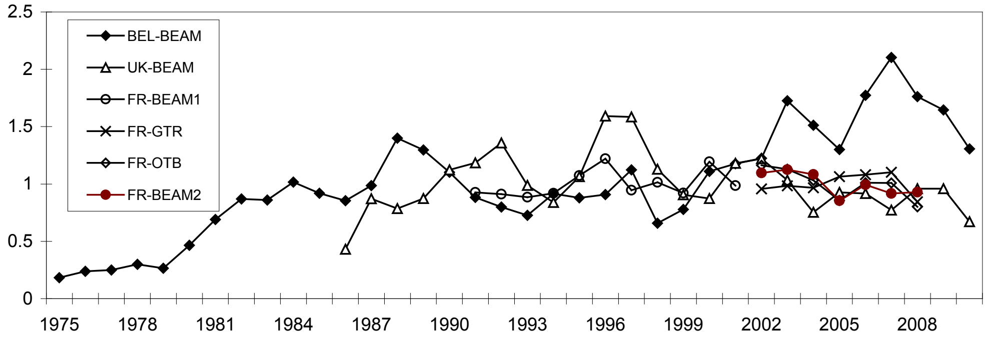
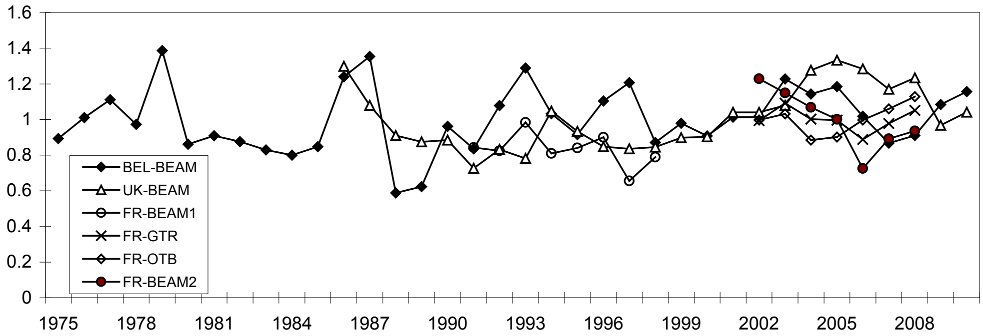


Figure 9.2.2c

Sole VIId - Relative LPUE series



BE-CBT (blue), UK(E&W)-CBT (pink), UK-BTS (green) UK(E&W)YFS (red) and FR-YFS (orange).

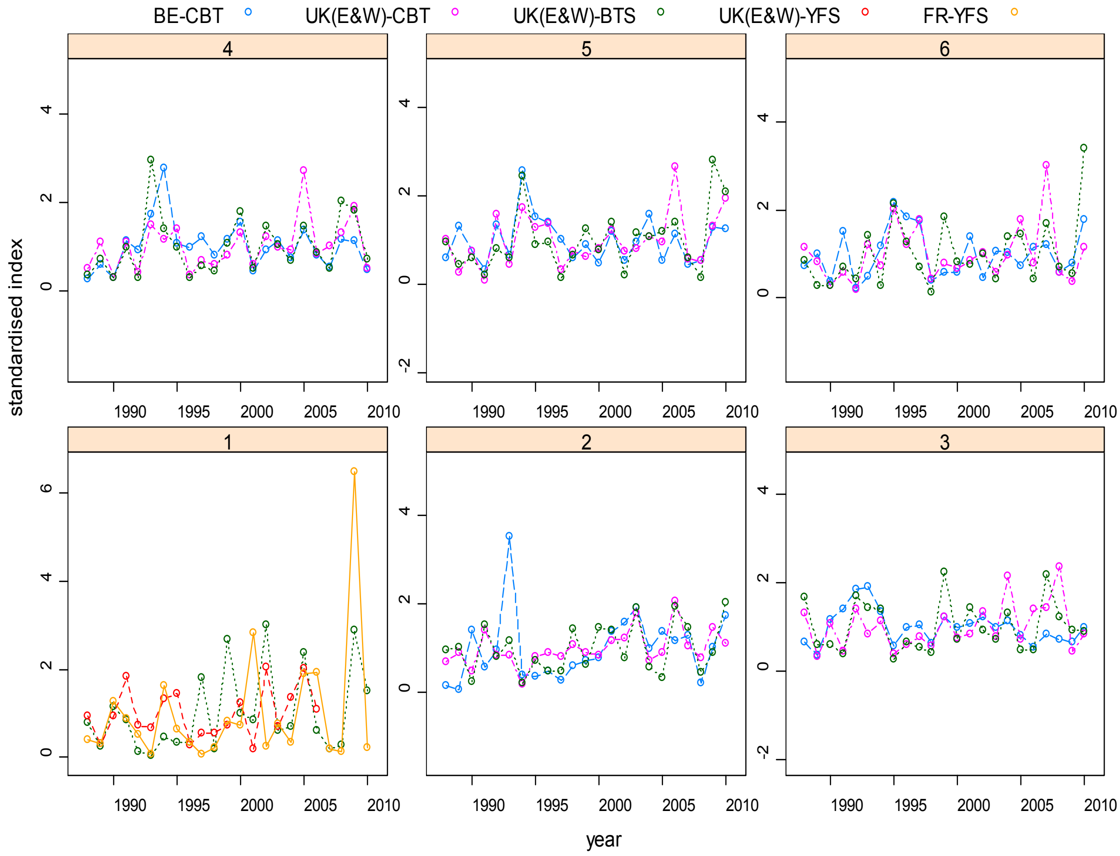


Figure 9.2.3 Sole in VIId. Standardized tuning indices used for tuning XSA:

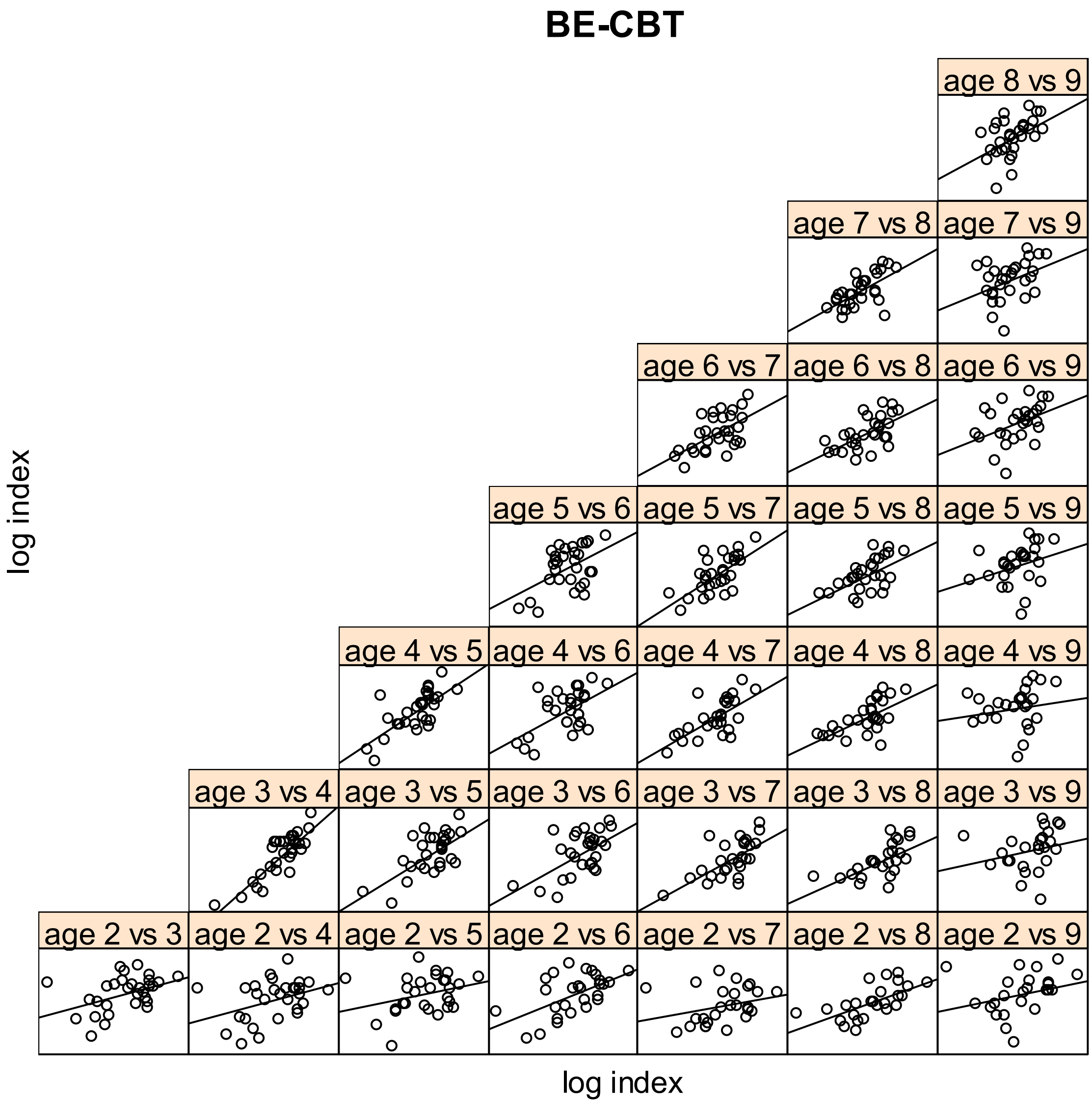


Figure 9.2.4 Sole in VIId. Internal concistency plot for the Belgian commercial fleet (BE-CBT).

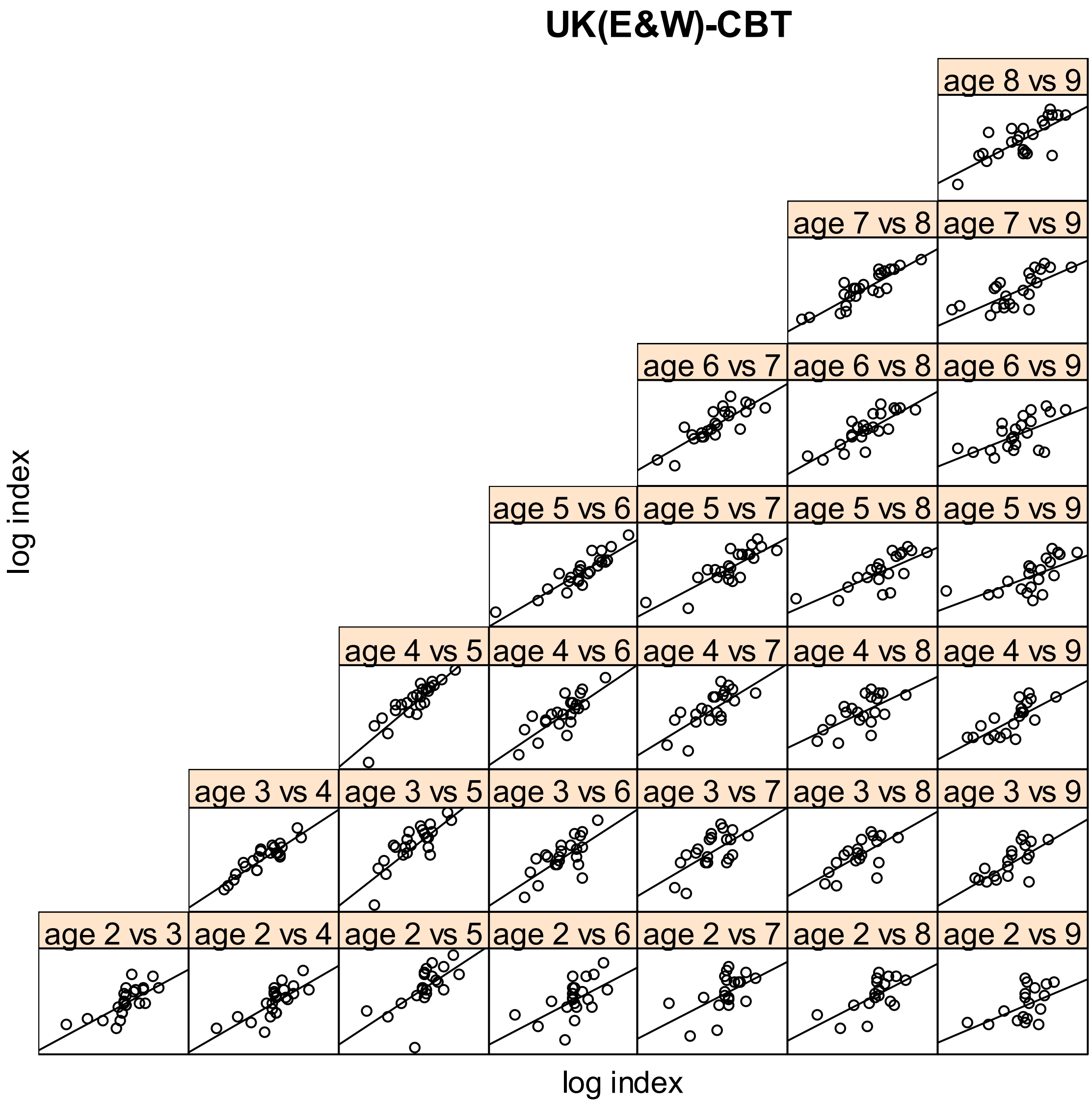


Figure 9.2.5 Sole in VIId. Internal concistency plot for the UK commercial fleet (UK(E&W)-CBT).

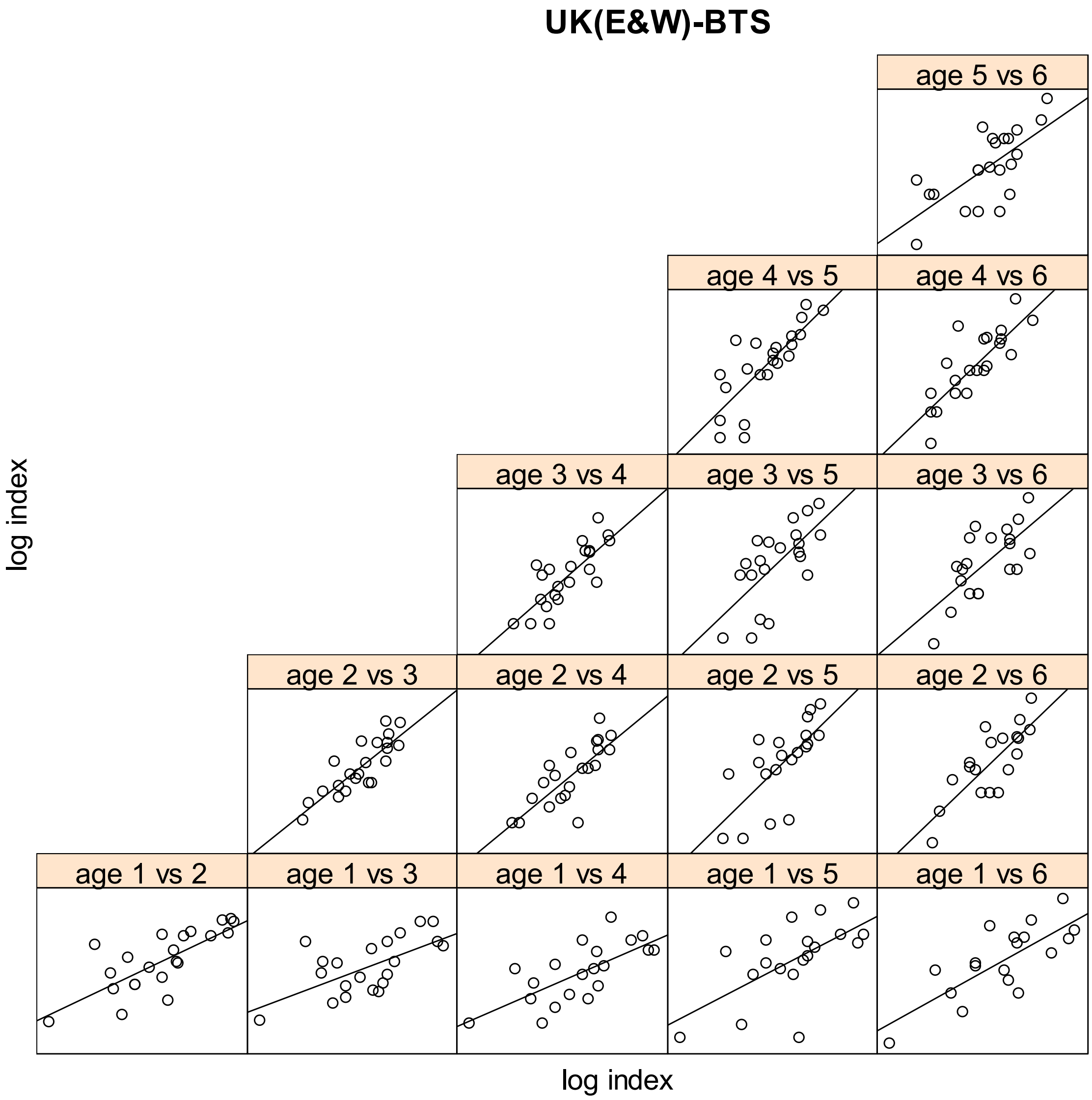


Figure 9.2.6 Sole in VIId. Internal consistency plot for the UK beam trawl survey (UK(E&W)-BTS).

Figure 9.3.1a - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

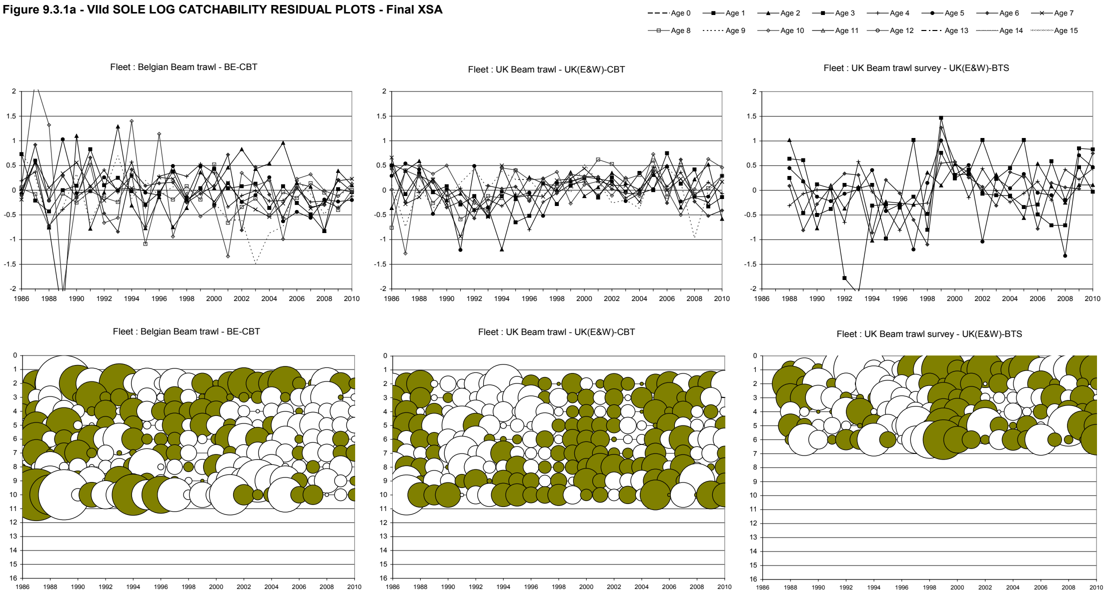


Figure 9.3.1b - VIId SOLE LOG CATCHABILITY RESIDUAL PLOTS - Final XSA

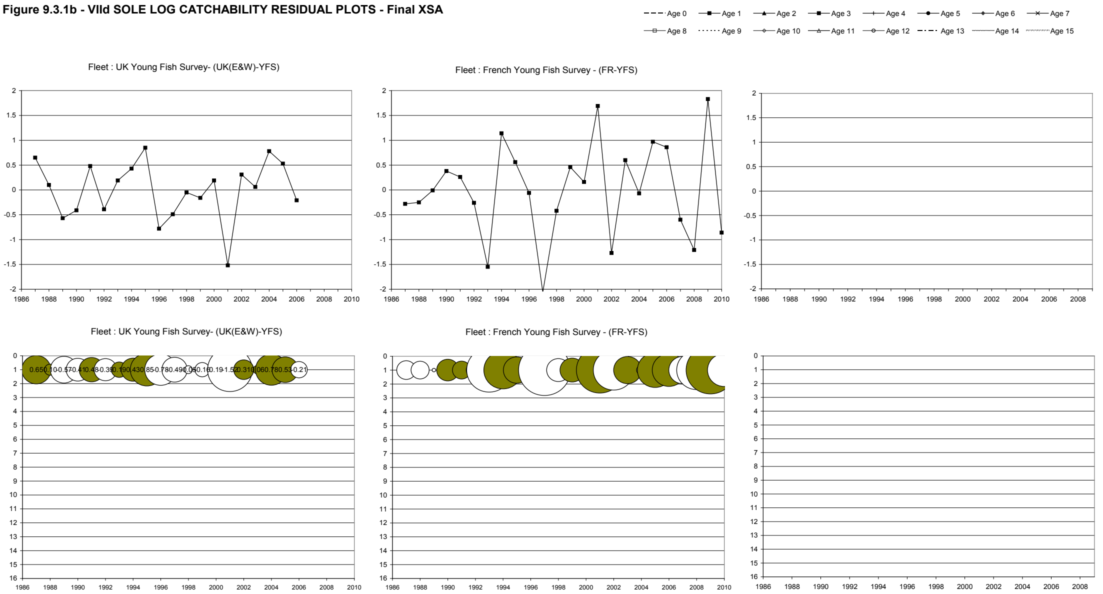
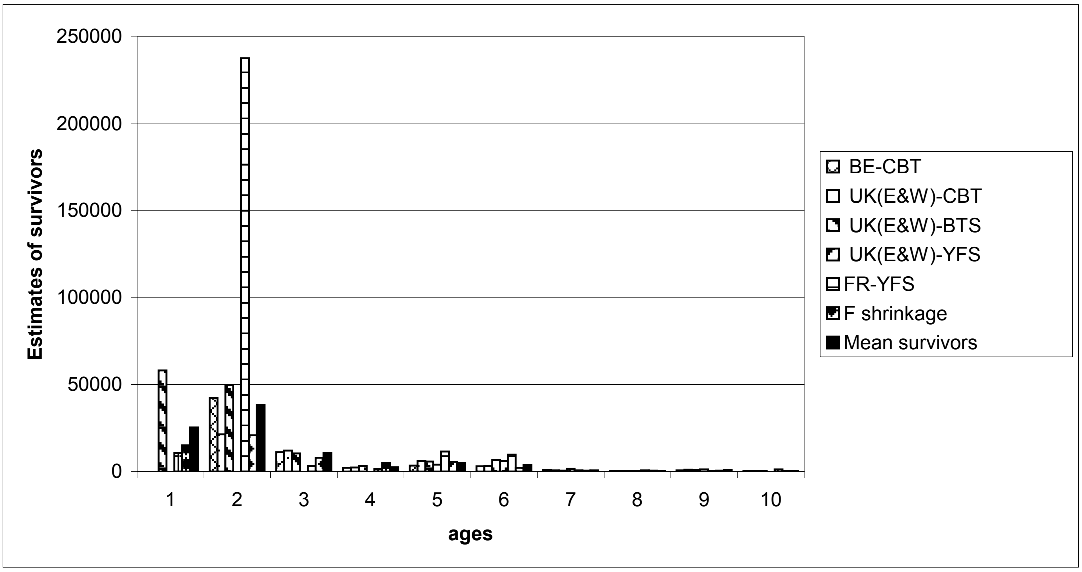


Figure 9.3.2 Sole in VIId. Estimates of survivors from different fleets and shrinkage, as well as their different weighting in the final XSA-run



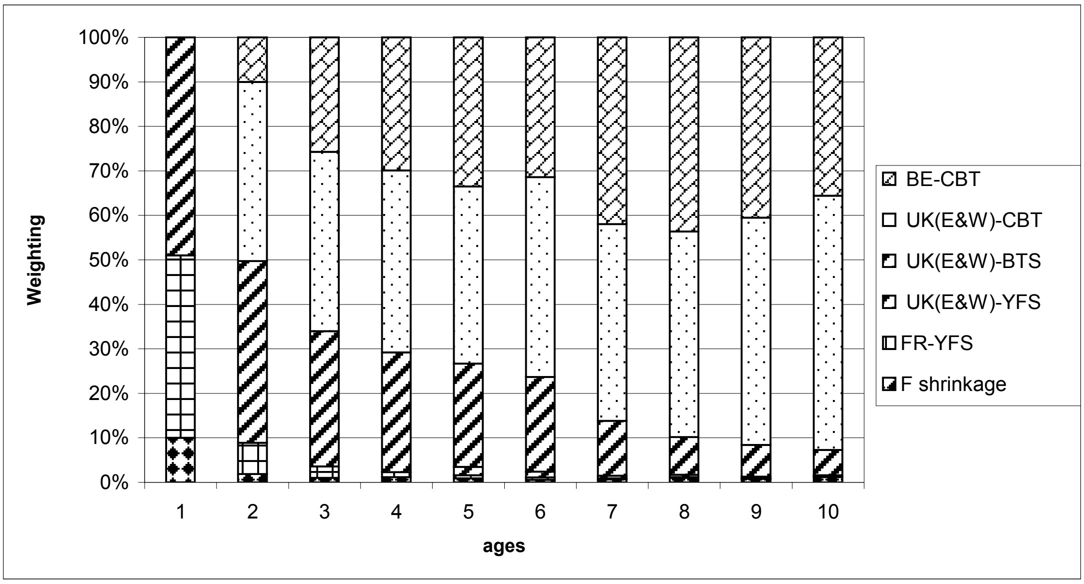


Figure 9.3.3 Sole in VIId. Summary plots

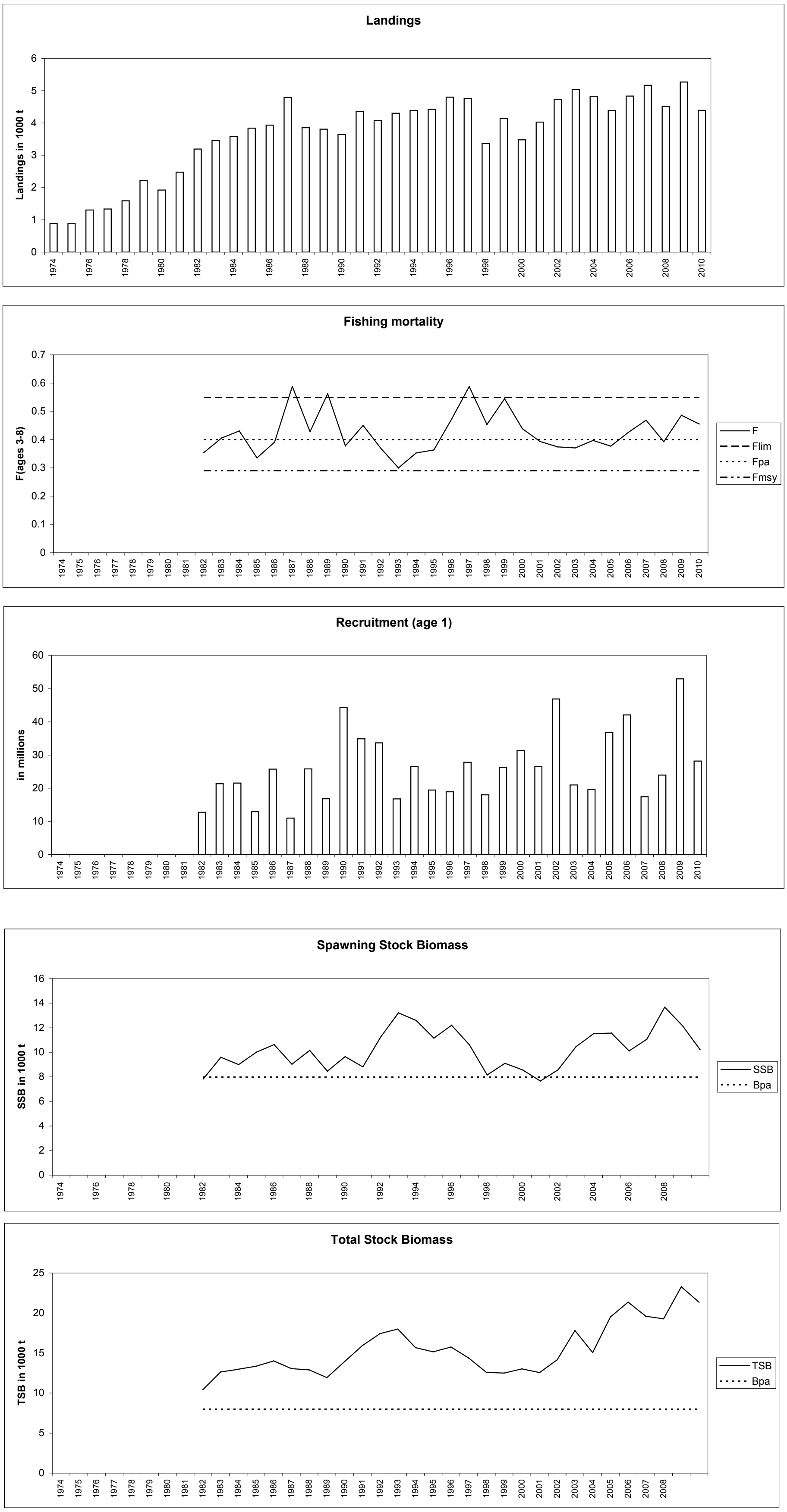


Figure 9.3.4 - Sole VIId retrospective XSA analysys (shinkage SE=2.0)

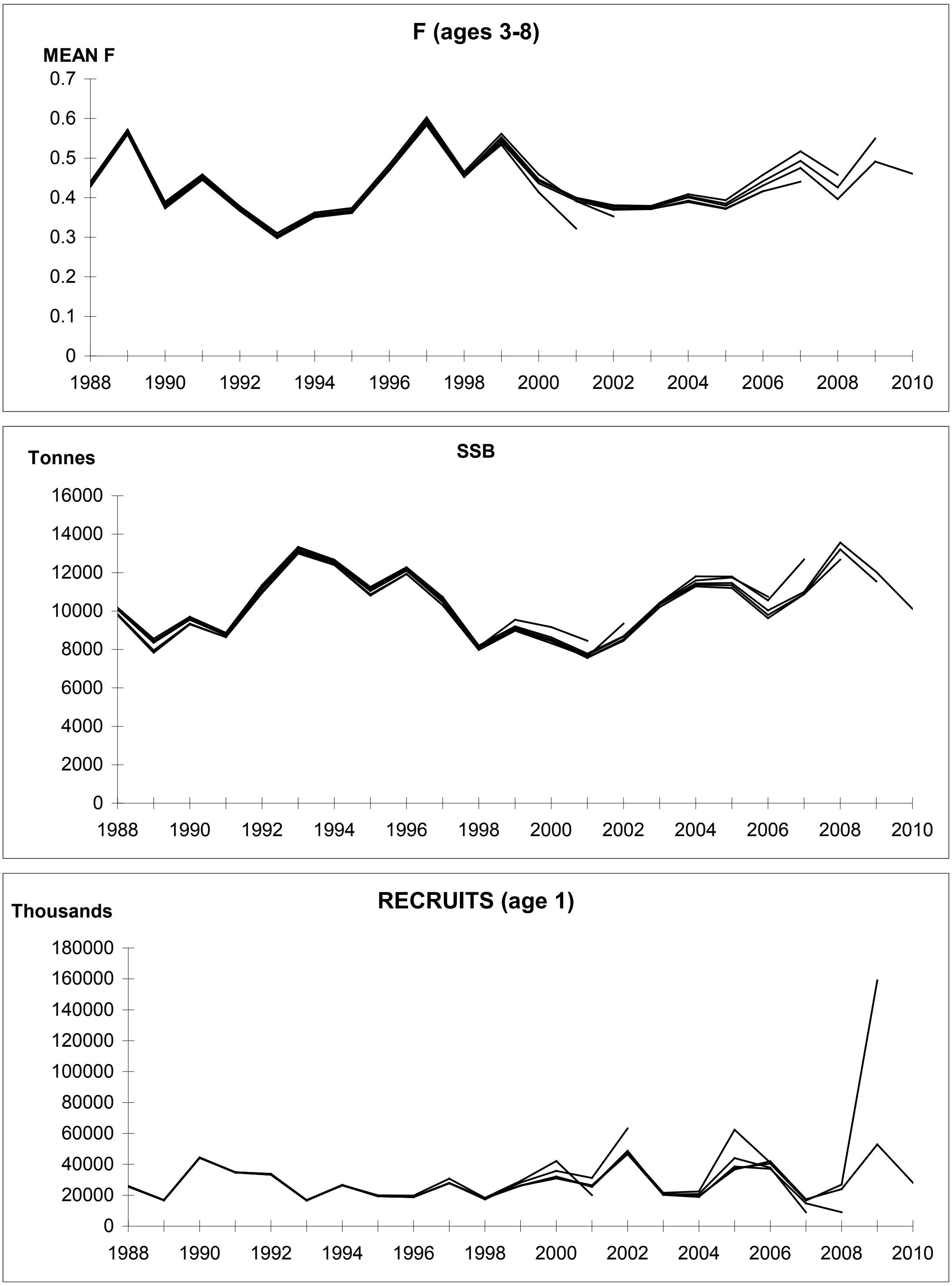
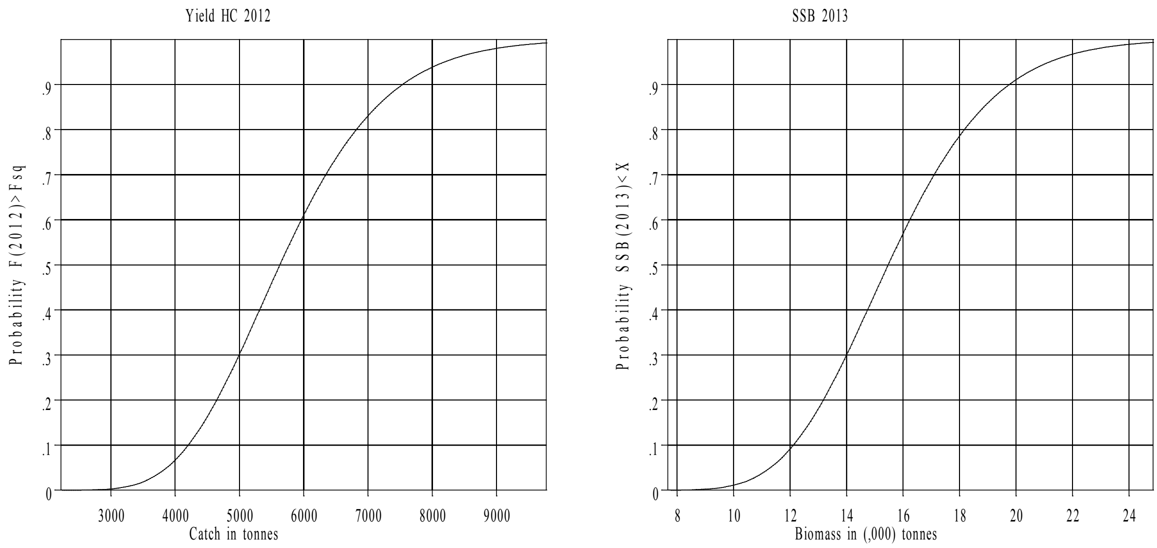
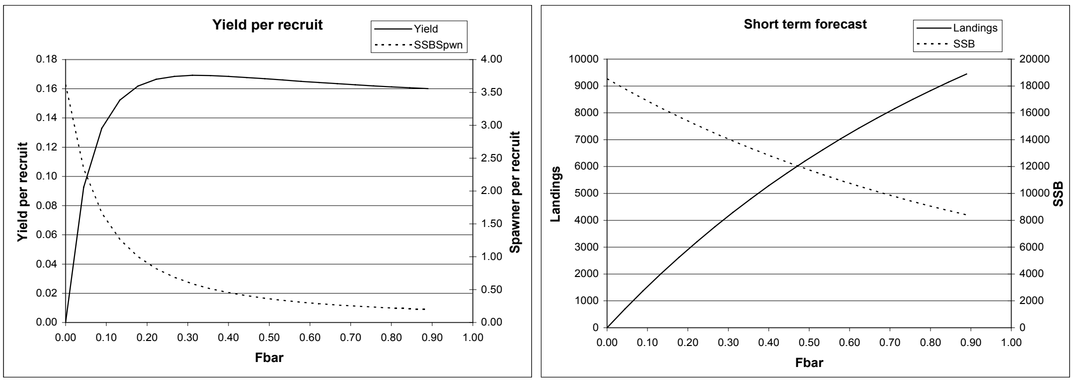


Figure 9.6.1 - Sole VIId - Probability profiles for short term forecast.



Data from file:D:\Pie & profile\sol-eche_2011WG.SEN on 07/05/2011 at 17:05:58

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: 20:34 30/04/2011

Reference point	F multiplier	Absolute F
Fbar(3-8)	1.0000	0.4447
FMax	0.7252	0.3225
F0.1	0.2905	0.1292
F35%SPR	0.2984	0.1327

MFDP version 1a
Run: S7d_fin
Sole in VIId
Time and date: 20:23 30/04/2011
Fbar age range: 3-8

Input units are thousands and kg - output in tonnes

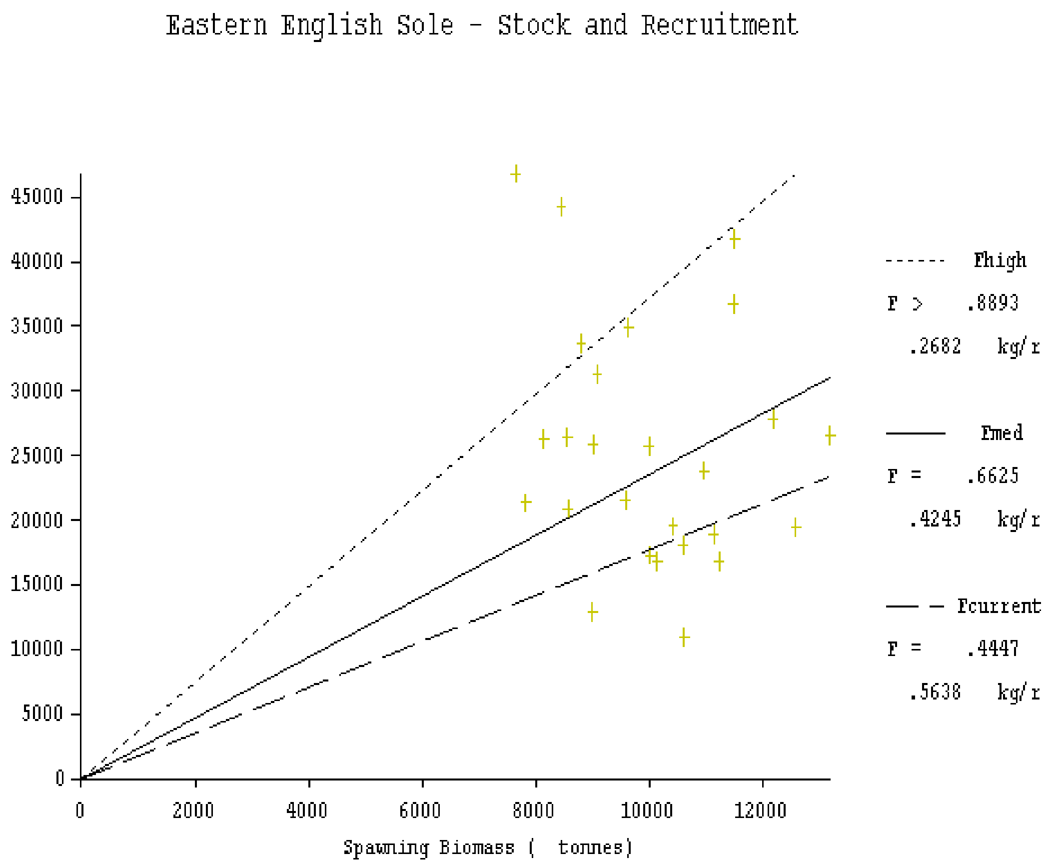
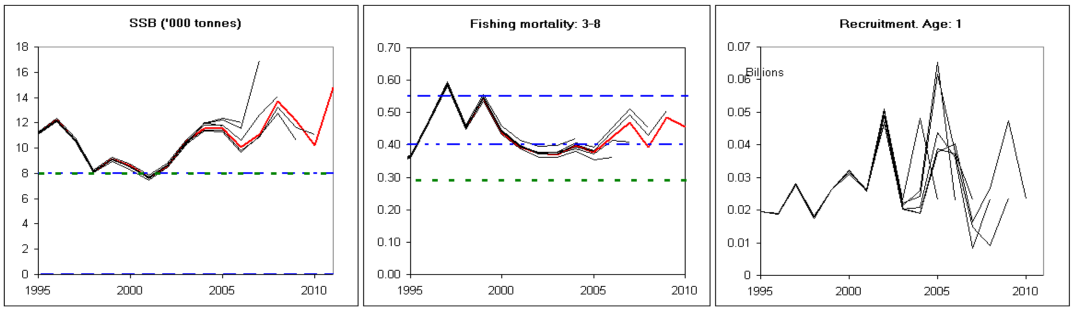


Figure 9.9.1 - Sole VIId Stock/recruitment plot

Figure 9.9.2 Sole in VIId. Historical Performance of assessment of successive WG assessment and forecast

Sole in Division VIId (Eastern Channel)



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.

10.1.3 ICES Advice

Based on the most recent estimate of SSB (start of 2011) and fishing mortality (in 2010), ICES classifies the stock as having full reproductive capacity and as being harvested sustainably. SSB has fluctuated around the precautionary reference points for the last decade, but has increased slightly since 2008 owing to a large incoming 2005 year class and reduced fishing mortality. Fishing mortality declined between 1995 and 2007, has been rather stable between 2008 and 2010, and is currently (Fbar 2010 = 0.34) estimated to be below F_{pa} (0.4). The current (2011) assessment suggests that the 2009 year class was average, while 2010 year classes was above average.

Single-stock exploitation boundaries

ICES advises on the basis of the EU management plan that landings in 2012 should be no more than 15 700 t.

Exploitation boundaries in relation to the agreed management plan

Following the EU management plan implies a 10% reduction of F to 0.31 (TAC of 15 700 t in 2012, implying a 10% reduction in fishing effort), this is expected to lead to an SSB of 45 600 t in 2013. This leads to a TAC increase of 11%, being within the 15% bounds of the management plan TAC change constraints.

Exploitation boundaries in relation to high long-term yield, low risk of depletion of production potential and considering ecosystem effects

The current fishing mortality is above the range that is expected to lead to high long-term yields and low risk to stock depletion.

Exploitation boundaries in relation to precautionary limits

The precautionary F_{pa} for North Sea sole is 0.4. This would lead to landings of 19 700t in 2012 (a 40% increase in TAC) and an SSB of 41 700 to in 2013

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 and 2010.

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.

10.1.4 Management

The TAC for 2011 was set at 14 100 tones. The TAC for 2010 was also 14 100 tonnes, which is more than the landings (12 600t) estimated by the working group (Table 10.2.1).

A long term management plan proposed by the Commission of the European Community was adopted by the Council of the European Union in June 2007 and first implemented in 2008 (EC Council Regulation No 676/2007). See Section 16 (Management Plan Evaluations) of this report for further details. The plan consists of two stages. The first phase aims to ensure the return of the stocks of plaice and sole to within safe biological limits for two consecutive years. Once this has been achieved for both stocks, the plan enters into a second phase, in which stocks should be fished at an exploitation level that yields high long term sustainable yields. Following this year's assessments of the two stocks (2011), phase one of the plan has now been completed.

ICES has evaluated the long-term management plan (Council Regulation (EC) No. 676/2007) for plaice and sole (Miller and Poos 2010; Simmonds 2010; see section 8.8.2) and found it to be in agreement with the precautionary approach. It can therefore now be used as the basis for advice for the management of the stock.

The minimum landing size of North Sea sole is 24 cm. 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.

Effort has been restricted because of implementation of a days-at-sea regulation for the cod recovery plan and fishing effort limitation of the long term management plan (EC Council Regulation No. 2056/2001; EC Council Regulation No 676/2007; EC Council Regulation 40/2008).

For 2008 Council Regulation N°40/2008, annex II[a] allocates different days at sea depending on gear, mesh size and catch composition. (see section 2for a complete list). The days at sea limitations for the major fleets operating in ICES sub-area IV can be summarised as follows: Beam trawlers can fish between 119–143 days per year. Trawls or Danish seines can fish between 103 and 280 days per year. Gillnets are allowed to fish between 140 and 162 days per year and Trammel nets between 140 and 205 days.

For 2009 and 2010, Council Regulation (EC) N°43/2009 and Council Regulation (EC) N°23/2010 allocate different amounts of Kw*days by Member State and area to different effort groups of vessels depending on gear and mesh size. (see section 2). 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.

Technical measures applicable to the flatfish beam trawl fishery before 2000 were an exemption to use 80 mm mesh cod-end when fishing south of 55°North. From January 2000, the exemption area extends from 55°North to 56°North, east of 5°East latitude. Fishing with 80 mm mesh cod-end is permitted within that area provided that the landings comprise at least 70% of a mix of species, which are defined in the technical measures of the European Community (EC Council Regulation 1543/2000).

10.2 Data available

10.2.1 Catch

Annual landings data by country and TACs are presented in Table 10.2.1 and total landings are presented in Figure 10.2.1A. In 2010 approximately 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.

10.2.2 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). Recently the sole population (Figure 10.2.1) has been dominated by the strong 2005 year class which were age 5 in 2010 (~13 million). Log catch ratios and catch curves for sole ages 2 to 9 are summarised in Figures 10.2.2 A and B (1957 to 2010).

InterCatch

Because of time constraints, and a need to train staff in its use, InterCatch was not used for raising the landings (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 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.**
Sol-nsea (sole in area IV)	Not used	Another tested tool for international raising has been used; We are still getting used to intercatch; not all member states upload their data	Comparison not made	InterCatch have not been properly tested

Estimates of numbers-at-age and weights-at-age in the landings by quarter are given in table 10.2.4.

10.2.3 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 (Figs 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.

10.2.4 Maturity and natural mortality

As in previous North Sea sole assessments, a knife-edged maturity-ogive was used, assuming full maturation at age 3.

Natural mortality in the period 1957–2010 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 last two winters (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 WGNSSK.

10.2.5 Catch, effort and research vessel data

One commercial and two survey series were used to tune the assessment. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days and was revised in 2009 due to a database change. 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 increase in fishing effort (< 1%) was recorded between 2009 and 2010.

The LPUE estimated for 2010 (367 kg hpday^{-1}) was substantially above the 1997-2009 mean (253 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).

10.3 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 2010 by the RGNSSK (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 report is clearly written easy to follow and interpret. Ecosystem aspects are well described in the annex.

Since the maturity ogive for sole is based on market sampling from the 1960's and 1970's, the RG concurs with the WG that more work needs to be done to update the age at maturity data to improve the models in use.

Consistent slight bias in the recent retrospective pattern, particularly on F was explored exhaustively during the Benchmark Assessment (WKFLAT 2010)".

Technical comments

"The assessment has been done as outlined in the Stock Annex. Adding a detailed map of the stock areas and fishing banks would be helpful in the Annex. Section 10.1.3 ICES Advice. A codend configuration change to a square mesh would likely not reduce discards of plaice. In general a square mesh retains more flatfish while roundfish such as cod haddock and saithe escape more readily from square panels. Conversely, a diamond mesh releases greater numbers of flatfish compared with roundfish. Section 10.2.1 states the MLS for sole is 23 cm, but it's listed as 24 cm elsewhere in the document. Figure 10.4.1. The figure legend is incorrect. It states the top left graph is SSB when it should be recruitment".

WGNSSK 2011 reply: a map of fishing activity by Dutch vessels targeting sole has been added to the Stock Annex. The MLS of sole is 24 cm and this has now been made consistent across stock annex and report. Axes labeling problems have been addressed.

Conclusions of the review group

"The assessment has been performed correctly. The RG agrees with all eight recommendations put forth by the WG following the Benchmark Assessment (WKFLAT 2010). The RG concurs that the XSA model continue to be used and that the SAM model be run alongside XSA to compare model results. The confidence bounds produced by SAM will be useful for informing management and the WG should consider switching to SAM in the future.

WGNSSK 2011 reply: both XSA and SAM were run by WGNSSK in 2011 and the output of both methods was rather similar.

10.3.1 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 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 10.3.5a,b,c). The model gives similar outputs and time trends to the XSA. SSB, for example, estimated by SAM was 34 100t in 2010 versus 35 200t in 2010 for the Final XSA run (see Table 10.4.1).

10.3.2 Exploratory survey-based analyses

No survey-based analysis was carried out in this year's WG.

10.3.3 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.

10.3.4 Final assessment

Catch at age analysis was carried out with XSA using the settings given below.

Year	2009	2010	2011
Catch at age	Landings	Landings	Landings
Fleets	BTS-Isis 1985–2008 SNS 1970–2008 Nl-BT 1990–2008	BTS-Isis 1985–2009 SNS 1970–2009 Nl-BT 1997–2009	BTS-Isis 1985–2010 SNS 1970–2010 Nl-BT 1997–2010
Plus group	10	10	10
First tuning year	1970	1970	1970
Last data year	2008	2009	2010
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 2009 was estimated at around 34 700 t (Table 10.4.1) which has increased slightly to around 35 200 t in 2010. Mean F(2–6) was estimated at 0.34 which and has been stable since 2008 (see Table 10.4.1). Recruitment of the 2009 year class, age 1 in 2010, was estimated by the XSA at 153 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 2010.

10.4 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 2010 landings were estimated to be around 12 600 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 2010 is estimated at around 35 200 t. Recruitment in 2010 of the 2009 year class at the age of 1 was estimated at 153 million, higher 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 0.34 (see Table 10.4.1).

10.5 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 2010 (age 1 in 2011) the value predicted by the RCT3 (89 205) was very similar to 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 2009 (age 2 in 2011), 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
2009	2	138 158	135 764	83 039
2010	1		89 205	94 000
2011	Recruit			94 000

10.6 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 2008 year-class are taken from the long-term geometric mean (1957–2008: 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 2010; A) F2011 is assumed to be equal to Fsq, F in 2010 rescaled to the average selection pattern from 2008 to 2010; B) F2011 is 0.9 times Fsq, rescaled; and C) F2011 is set such that the landings in 2011 equal the TAC of that same year. 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 different scenarios.

Scenario	Assumption	F_{2011}	SSB_{2012}	$Landings_{2011}$
A	$F_{2011} = F_{sq}$	0.34	45 544	15 831
B	$F_{2011} = 0.9F_{sq}$	0.305	46 851	14 470
C	F~$Landings_{2011} = TAC_{2011}$	0.296	47 207	14 100

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 2011 and 2012, SSB is expected to increase to 45 500 t in 2012. The landings at Fsq are expected to be around 15 800 t in 2011 which is above the 2011 TAC (14 100t). The landings in 2012 are predicted to be around 17 800 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 2013, when fishing at Fsq. The landings in 2013 will consist for a large part of uncertain year classes (2009–2010). The contribution of year classes 2010 and 2011 to SSB forecast in 2013 is approximately 40%. These forecasts are subject to revision by ACOM in October 2010 when new survey information becomes available.

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 as no difference was apparent, see also Table 10.6.4 which was updated). Fmax is poorly defined at 0.55.

10.7 Medium-term forecasts

No medium term projections were done this year.

10.8 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 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 FMSY, taking into account uncertainty in stock recruitment relationships.

In light of these new analyses revised MSY framework reference points, and ranges, for both sole and plaice in the North Sea are now proposed. A brief description of the technical approach is given in chapter 16 of his report , and detailed results of the various analyses are available in the published reports (ICES 2010, Miller and Poos 2010, and Simmonds et al. 2010). The chosen value for MSY $B_{trigger}$ for sole is considered to be appropriate (MSY $B_{trigger}$ = B_{pa} = 35 000t SSB). Further discussion focuses on the appropriate exploitation rate for this stock. The current management plan target for plaice is 0.2, and, given the new hierarchy of advice following WKFRAME2 (ICES 2011), this is the value that will be used to provide advice (given other constraints included within the management plan. On the basis of the CEFAS ADMB analyses, an F target of 0.22, within the range 0.13-0.39, was considered appropriate as a basis for F_{MSY}. The MSE simulations conducted by IMARES indicated that alternative F target values in the range 0.15 to 0.35 result in both short term and long term differences in TAC. An F target of 0.15 produces lower TAC in both the short and long term, while a F target of 0.3 provides higher short term TACs, slowly becoming more similar to the long term TACs from F targets in the 0.2-0.25 range. There is a short term difference between 0.2 and 0.25, though in the long term this is less substantial. 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. The equilibrium analyses taking into account uncertainty in stock recruitment relationships using 2010 assessment values gives an F_{MSY} value for North Sea sole of F=0.32. However, it is considered that it is important to take the risk into account when setting the target F for sole. An increase in F target might lead to higher catches, but the risks associated with increase in target F above 0.3 are considered to be not precautionary.

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. This finding is supported by all analyses including simulation tests, uncertainty in input parameters and uncertainty in stock recruit relationships. 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%

10.9 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 2010 (35 200t) compared to 2009 (35 000t) due in part the rather stable trend in fishing effort between 2008 and 2010 (see Table 10.2.7).

The historic performance of the assessment is summarized in Figure 10.4.2 which shows that the stable SSB, the falling and Fbar and the recruitment have been reliably estimated over the last 5 years.

10.10 Status of the Stock

Fishing mortality was estimated at 0.34 in 2010 which is below F_{pa} (=0.4). The SSB in 2010 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 2012 at Fsq are 17 181t, higher than projected landings for 2011 (15 831).

10.11 Management Considerations

Sole is mainly taken by beam trawlers in a mixed fishery with plaice in the southern and central part of the North Sea. Fishing effort (kWdays) has been substantially reduced since 1995. The fall reversed between 2008 and 2009 (see Table. 10.2.7). Technical measures applicable to the mixed flatfish fishery will affect both sole and plaice. The minimum mesh size of 80 mm in the beam trawl fishery selects sole at the minimum landing size. However, this mesh size generates high discards of plaice. Mesh enlargement would reduce the catch of undersized plaice, but would also result in loss of marketable sole catches. The combination of days-at-sea regulations, higher oil prices, and constraining TAC for plaice and relatively stable TAC for sole, appear to have induced a shift in fishing effort towards the southern North Sea. This concentration of fishing effort result in higher plaice discards because juveniles are mainly distributed in this area.

The sole stock dynamics are heavily dependent on the occasional occurrence of strong year classes.

The mean age in the landings is estimated at 3.7 in 2009, but used to be 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 could enhance the stability in the catches.

The 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. The fishery opportunities and SSB are now dependent on incoming year classes and can therefore fluctuate considerably between years. The SSB and landings in recent years have been dominated by the 2001 and 2005 year classes.

For sole there will be new recruitment information 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.

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											14100

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

Table 10.2.4 North Sea Sole. 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	0.000	0.0	0.000	8.7	0.132	339.9	0.168
2	1321.8	0.154	1173.0	0.149	3608.4	0.168	5512.7	0.204
3	3393.8	0.231	3660.8	0.200	3374.2	0.205	3116.4	0.250
4	2659.5	0.253	2145.1	0.230	1858.3	0.214	1277.6	0.279
5	4560.3	0.309	4200.6	0.272	3635.3	0.229	1510.1	0.314
6	544.7	0.365	529.2	0.307	268.1	0.298	211.0	0.305
7	344.3	0.280	278.7	0.336	174.3	0.255	100.9	0.305
8	121.1	0.468	300.8	0.336	178.3	0.258	89.6	0.295
9	384.6	0.524	399.3	0.361	215.1	0.279	109.6	0.291
10	7.4	0.993	36.8	0.507	6.8	0.482	23.7	0.335
11	7.4	0.695	80.3	0.364	23.2	0.290	13.9	0.466
12	34.5	0.601	42.3	0.281	12.1	0.257	27.8	0.315
13	47.9	0.450	12.9	0.568	2.9	0.643	0.0	0.000
14	28.4	0.869	8.6	0.708	11.3	0.716	1.9	1.021
15	32.9	0.349	19.1	0.392	3.3	0.799	0.0	0.000

Table 10.2.5 Sole in sub-area IV: Landing weights at age (kg)

2011-05-06 11:42:06 units= kg

year \ age	1	2	3	4	5	6	7	8	9	10
1957	0.000	0.154	0.177	0.204	0.248	0.279	0.290	0.335	0.436	0.408
1958	0.000	0.145	0.178	0.220	0.254	0.273	0.314	0.323	0.388	0.413
1959	0.000	0.162	0.188	0.228	0.261	0.301	0.328	0.321	0.373	0.426
1960	0.000	0.153	0.185	0.235	0.254	0.277	0.301	0.309	0.381	0.418
1961	0.000	0.146	0.174	0.211	0.255	0.288	0.319	0.304	0.346	0.419
1962	0.000	0.155	0.165	0.208	0.241	0.295	0.320	0.321	0.334	0.412
1963	0.000	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	0.480
1965	0.000	0.169	0.209	0.246	0.286	0.282	0.345	0.378	0.404	0.480
1966	0.000	0.177	0.190	0.180	0.301	0.332	0.429	0.399	0.449	0.501
1967	0.000	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	0.350	0.404	0.441	0.463	0.443	0.533
1971	0.145	0.193	0.237	0.322	0.358	0.425	0.420	0.490	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	0.520	0.559	0.609	0.653
1975	0.129	0.182	0.225	0.320	0.406	0.456	0.529	0.595	0.629	0.669
1976	0.143	0.190	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	0.430	0.520	0.562	0.619
1978	0.152	0.196	0.231	0.314	0.370	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	0.550	0.598	0.684
1981	0.143	0.187	0.226	0.324	0.378	0.424	0.442	0.516	0.542	0.630
1982	0.141	0.188	0.216	0.307	0.371	0.409	0.437	0.491	0.580	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	0.610
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	0.270	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	0.470	0.611
1990	0.124	0.183	0.227	0.292	0.371	0.413	0.415	0.514	0.476	0.620
1991	0.127	0.186	0.210	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	0.380	0.409	0.460	0.487	0.556
1993	0.097	0.167	0.196	0.239	0.264	0.300	0.338	0.441	0.496	0.603
1994	0.143	0.180	0.202	0.228	0.257	0.300	0.317	0.432	0.409	0.510
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	0.370	0.390	0.594
1997	0.151	0.180	0.206	0.236	0.267	0.296	0.323	0.306	0.384	0.440
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	0.170	0.200	0.248	0.290	0.299	0.323	0.368	0.402	0.427
2001	0.143	0.185	0.202	0.270	0.275	0.333	0.391	0.414	0.433	0.493
2002	0.140	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	0.340	0.344	0.503	0.431
2004	0.127	0.180	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	0.190	0.220	0.263	0.291	0.322	0.293	0.358	0.397	0.397
2007	0.154	0.180	0.205	0.237	0.253	0.273	0.295	0.299	0.281	0.326
2008	0.150	0.181	0.223	0.240	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**	**0.220**	**0.236**	**0.273**	**0.308**	**0.283**	**0.311**	**0.361**	**0.381**

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

Table 10.2.7 Sole in subarea IV: Effort and CpUE series. Note: see Table 10.2.1 for (Netherlands) for source of landings estimates.

year	landings (tons)	Effort(new) HP days ($\cdot 10^6$)	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

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	0.000	0.000	0.000
1986	1	7.168	5.183	1.596	0.987	0.623	0.171	0.158	0.000	0.018
1987	1	6.973	12.548	1.834	0.563	0.583	0.222	0.228	0.058	0.000
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	0.000	0.051
1990	1	37.839	24.487	21.789	0.778	1.081	0.770	0.120	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	0.090	0.162	0.078	0.020
1993	1	6.350	42.345	1.338	5.516	3.371	6.199	0.023	0.084	0.053
1994	1	7.660	7.121	19.743	0.124	1.636	0.088	0.983	0.009	0.000
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	0.710	0.380	0.096	0.035	0.042
1998	1	17.108	27.422	1.862	1.242	0.073	0.015	0.391	0.000	0.000
1999	1	11.960	18.363	15.783	0.584	1.920	0.310	0.218	0.604	0.003
2000	1	14.594	6.144	4.045	1.483	0.263	0.141	0.060	0.007	0.150
2001	1	7.998	9.963	2.156	1.564	0.684	0.074	0.037	0.028	0.000
2002	1	20.989	4.182	3.428	0.886	0.363	0.361	0.032	0.069	0.000
2003	1	10.507	9.947	2.459	1.670	0.360	0.187	0.319	0.000	0.020
2004	1	4.192	4.354	3.553	0.644	0.626	0.118	0.070	0.073	0.000
2005	1	5.534	3.395	2.377	1.303	0.167	0.171	0.077	0.047	0.000
2006	1	17.089	2.332	0.278	0.709	0.479	0.151	0.088	0.000	0.007
2007	1	7.498	19.504	1.464	0.565	0.315	0.537	0.031	0.009	0.000
2008	1	15.247	9.062	12.298	1.313	0.222	0.279	0.202	0.028	0.047
2009	1	15.950	4.999	2.858	4.791	0.252	0.124	0.272	0.079	0.000
2010	1	54.81	10.71	2.027	0.774	1.252	0.143	0.122	0.005	0.027

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

Table 10.2.8 cont.

2011-05-06 12:17:21[1] NL Beam Trawl units= NA

	E	2	3	4	5	6	7	8	9
1997	72.0	62.6	256	62.6	46.2	135.7	6.90	25.00	1.319
1998	70.2	720.4	129	158.4	26.0	16.3	48.36	3.01	4.801
1999	67.3	175.6	820	61.7	66.3	10.8	4.99	22.69	1.976
2000	68.4	180.0	432	317.9	29.9	23.1	6.65	4.71	9.371
2001	64.8	289.0	211	231.0	201.9	11.1	7.81	2.10	1.435
2002	59.1	152.4	420	134.3	102.1	86.0	7.17	6.50	0.914
2003	55.7	465.8	207	223.4	61.0	50.7	35.22	4.04	1.113
2004	51.5	217.3	723	109.4	98.2	23.1	12.43	10.52	2.621
2005	52.4	96.6	312	401.3	72.4	38.2	17.58	5.52	11.813
2006	46.9	144.8	166	143.0	175.4	20.3	20.15	11.13	5.736
2007	45.1	737.8	170	99.4	81.1	82.0	7.43	7.23	2.816
2008	32.5	145.1	885	100.2	57.4	39.0	44.15	6.09	5.446
2009	34.0	254.6	227	562.9	59.2	32.4	27.56	23.38	1.824
2010	34.3	258.2	295	151.9	299.9	30.4	19.74	13.29	21.662

Table 10.3.1. Sole in sub area IV: XSA diagnostics

FLR XSA Diagnostics 2011-05-06 11:47:46

CPUE data from xsa.indices

Catch data for 54 years. 1957 to 2010. Ages 1 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	BTS-ISIS	1	9	1985	2010	0.66	0.75
2	SNS	1	4	1970	2010	0.66	0.75
3	NL Beam Trawl	2	9	1997	2010	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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	1	1	1	1	1	1	1	1	1	1

Fishing mortalities

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.015	0.006	0.013	0.012	0.025	0.034	0.006	0.028	0.018	0.003
2	0.286	0.232	0.229	0.237	0.214	0.268	0.255	0.140	0.188	0.158
3	0.562	0.625	0.611	0.547	0.612	0.446	0.480	0.350	0.335	0.351
4	0.755	0.644	0.635	0.706	0.683	0.473	0.504	0.459	0.404	0.433
5	0.749	0.725	0.641	0.606	0.707	0.494	0.528	0.390	0.439	0.335
6	0.537	0.644	0.819	0.461	0.668	0.543	0.456	0.377	0.358	0.416
7	0.585	0.462	0.472	0.391	0.607	0.524	0.541	0.352	0.417	0.305
8	0.761	0.991	0.488	0.306	0.448	0.556	0.450	0.550	0.324	0.347
9	0.679	0.527	0.513	1.127	0.390	0.459	0.878	0.535	0.845	0.404
10	0.679	0.527	0.513	1.127	0.390	0.459	0.878	0.535	0.845	0.404

XSA population number (Thousand)

year \ age	1	2	3	4	5	6	7	8	9	10
2001	62938	109284	52779	39408	33374	3612	1980	541	358	1536
2002	184939	56108	74299	27215	16751	14284	1911	998	229	930
2003	83375	166336	40255	35978	12934	7343	6791	1089	335	1175
2004	45234	74444	119754	19779	17249	6167	2929	3833	605	599
2005	49131	40438	53139	62727	8838	8514	3521	1793	2554	1300
2006	213023	43356	29535	26070	28675	3943	3949	1736	1036	1529
2007	55653	186269	30013	17108	14704	15825	2072	2115	901	971
2008	71878	50055	130601	16801	9348	7844	9075	1091	1220	1136
2009	94210	63211	39394	83272	9611	5728	4866	5774	570	1568
2010	153078	83708	47373	25488	50312	5605	3625	2903	3780	2174

Estimated population abundance at 1st Jan 2011

year \ age	1	2	3	4	5	6	7	8	9	10
2011	3344	138158	64657	30168	14952	32572	3344	2417	1857	2284

Fleet: BTS-ISIS

Log catchability residuals.

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	-0.192	-0.671	-0.111	-0.128	-0.265	0.145	-0.381	0.052	-0.125	0.122	0.453	-0.129	0.638	0.042	0.088	-0.095	0.073	-0.202	0.013	-0.033	0.061
2	0.056	-0.528	-0.245	0.535	0.312	0.738	0.379	1.062	0.137	-0.047	0.448	-0.157	-0.068	0.039	0.428	-0.296	-0.168	-0.407	-0.630	-0.646	-0.301
3	-0.021	-0.231	-0.486	-0.573	0.561	0.173	0.485	0.376	-0.739	0.445	0.858	0.242	0.071	0.119	0.677	0.055	-0.198	-0.032	0.239	-0.529	-0.072
4	0.257	-0.250	-0.280	-0.026	0.909	-0.217	-0.172	0.319	0.640	-2.164	0.161	0.806	0.349	0.303	0.025	-0.567	0.188	-0.088	0.260	-0.045	-0.510
5	0.008	0.254	0.066	-0.927	0.331	0.456	-1.011	-0.175	1.592	0.332	-0.207	0.469	1.013	-0.953	1.796	0.141	-0.315	-0.276	-0.085	0.156	-0.425
6	0.168	-0.382	0.117	-0.420	-0.112	1.275	-0.856	-0.483	1.366	-0.895	0.498	0.755	-0.402	-1.784	1.422	0.260	-0.276	0.009	0.141	-0.398	-0.203
7	NA	0.215	0.360	0.074	0.463	0.204	-0.741	-0.144	-1.172	-0.052	1.125	0.383	0.135	0.237	1.421	0.490	-0.518	-0.715	0.324	-0.409	-0.346
8	NA	NA	0.002	0.101	NA	0.422	-0.094	0.063	-0.104	-1.361	0.224	0.378	-1.076	NA	1.363	-1.213	0.625	1.076	NA	-0.696	-0.276
9	NA	-0.115	NA	-0.465	-0.114	-0.328	-0.717	-0.080	0.267	NA	0.937	-0.253	1.408	NA	-0.933	0.586	NA	NA	0.592	NA	NA

age	2006	2007	2008	2009	2010
1	-0.405	0.125	0.327	0.149	0.450
2	-0.708	-0.051	0.415	-0.378	0.081
3	-1.748	-0.078	0.488	0.217	-0.300
4	-0.389	-0.172	0.657	0.312	-0.306
5	-0.698	-0.426	-0.420	-0.286	-0.412
6	0.354	0.172	0.163	-0.347	-0.141
7	-0.385	-0.772	-0.508	0.459	-0.127
8	NA	-2.093	-0.226	-1.014	-3.070
9	-1.625	NA	0.170	NA	-1.608

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	-8.8632	-9.4409	-9.7198	-9.8826	-10.0709	-9.8864	-9.8864	-9.8864
S.E_Logq	0.4467	0.5358	0.5897	0.6891	0.7073	0.5961	1.0591	0.8309

Regression statistics
Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7325008	9.567114

Fleet: SNS

Log catchability residuals.

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	0.289	0.166	-0.014	0.511	-0.018	-0.120	-0.331	0.068	0.384	-0.154	0.087	0.018	0.262	-0.145	0.348	0.453	-0.038	0.188	-0.202	0.101	-0.264	-0.037
2	0.813	0.860	0.072	0.684	-0.598	0.288	-1.294	0.148	0.476	0.346	0.152	0.445	0.236	0.263	0.288	0.569	-0.143	-0.021	0.299	0.512	0.464	0.756
3	0.559	0.238	-0.228	0.313	-0.645	-0.009	0.297	0.326	0.517	0.364	0.343	0.841	0.045	-0.664	0.460	-0.127	-0.381	-0.834	0.165	0.549	-0.007	0.884
4	0.143	-2.514	0.000	-0.363	0.000	-0.647	-0.731	-0.138	0.192	0.441	0.016	-0.128	0.065	-0.341	0.140	-0.013	-0.461	-0.320	0.691	-0.189	0.981	0.742

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	-0.013	-0.008	-0.245	-0.203	-0.763	0.143	0.273	0.001	-0.300	-0.094	0.256	NA	0.350	-0.207	-0.418	-0.080	-0.040	-0.005	-0.200
2	-1.169	0.431	0.103	-0.373	-0.432	-0.721	0.678	0.300	-1.372	-0.079	0.003	NA	0.222	-0.526	-0.889	-0.304	-0.329	-0.244	-0.919
3	0.000	0.090	0.385	0.069	-0.943	0.308	0.537	0.124	-0.147	-0.210	0.093	NA	0.261	-0.034	-1.165	-0.879	-0.154	-0.623	-0.719
4	1.006	0.635	-1.433	0.887	0.152	0.289	1.024	-0.793	0.152	-0.334	0.000	NA	0.971	0.000	-0.302	0.429	0.000	-0.278	0.029

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	-4.7664	-5.5245	-6.0615
S.E_Logq	0.5848	0.4968	0.6726

Regression statistics
Ages with q dependent on year class strength

	slope	intercept
Age 1	0.7534686	5.68294

Fleet: NL Beam Trawl

Log catchability residuals.

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	-0.759	-0.084	-0.642	-0.061	0.047	0.048	0.077	0.123	-0.089	0.272	0.436	0.069	0.422	0.141
3	-0.208	-0.515	-0.201	0.107	-0.229	0.145	0.046	0.176	0.179	0.062	0.081	0.203	0.034	0.120
4	-0.303	-0.091	-0.498	-0.204	0.190	-0.031	0.195	0.110	0.246	-0.001	0.071	0.076	0.176	0.064
5	-0.127	-0.509	-0.063	-0.277	0.187	0.184	-0.110	0.064	0.473	0.086	-0.002	0.041	0.067	-0.013
6	0.134	-0.255	-0.403	0.127	-0.429	0.288	0.501	-0.267	0.005	0.090	0.054	-0.022	0.096	0.081
7	-0.564	-0.059	-0.495	0.264	-0.020	-0.124	0.203	-0.034	0.226	0.211	-0.135	0.085	0.266	0.175
8	0.442	-0.650	-0.060	0.395	0.041	0.655	-0.125	-0.509	-0.330	0.453	-0.224	0.312	-0.112	0.022
9	-0.284	-0.177	0.242	-0.110	0.036	-0.032	-0.224	0.303	0.051	0.263	-0.126	0.082	-0.116	0.272

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	-5.7955	-4.9807	-4.9317	-4.9000	-5.0522	-5.1927	-5.1927	-5.1927
S.E_Logq	0.3396	0.2086	0.2119	0.2284	0.2600	0.2655	0.3873	0.1973

Terminal year survivor and F summaries:

Age 1 Year class =2009

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.366	255345	2009
SNS	0.513	105898	2009
fshk	0.016	15578	2009
nshk	0.105	82633	2009

Age 2 Year class =2008

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.300	70117	2008
SNS	0.178	25804	2008
NL Beam Trawl	0.504	74413	2008
fshk	0.018	46596	2008

Age 3 Year class =2007

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.179	22344	2007
SNS	0.211	14706	2007
NL Beam Trawl	0.592	34002	2007
fshk	0.019	22576	2007

Age 4 Year class =2006

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.172	11006	2006
SNS	0.116	15395	2006
NL Beam Trawl	0.688	15937	2006
fshk	0.024	12305	2006

Age 5 Year class =2005

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.150	21568	2005
NL Beam Trawl	0.824	32146	2005
fshk	0.026	19291	2005

Age 6 Year class =2004

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.143	2903	2004
NL Beam Trawl	0.828	3625	2004
fshk	0.028	2788	2004

Age 7 Year class =2003

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.191	2128	2003
NL Beam Trawl	0.785	2881	2003
fshk	0.024	1364	2003

Age 8 Year class =2002

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.104	86	2002
NL Beam Trawl	0.847	1898	2002
fshk	0.048	1293	2002

Age 9 Year class =2001

source

	scaledWts	survivors	yrcls
BTS-ISIS	0.103	457	2001
NL Beam Trawl	0.868	2998	2001
fshk	0.029	2552	2001

Table 10.3.2. Sole in sub area IV: fishing mortality at age

2011-05-06 11:44:10 units= f

age

year	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	0.114	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	0.320	0.331	0.381	0.367	0.390	0.390
1971	0.011	0.334	0.557	0.672	0.577	0.410	0.374	0.370	0.482	0.482
1972	0.005	0.238	0.659	0.518	0.532	0.358	0.227	0.309	0.390	0.390
1973	0.007	0.207	0.692	0.605	0.557	0.451	0.360	0.531	0.503	0.503
1974	0.001	0.188	0.593	0.640	0.512	0.500	0.562	0.381	0.521	0.521
1975	0.007	0.278	0.551	0.667	0.474	0.512	0.349	0.648	0.504	0.504
1976	0.010	0.107	0.565	0.508	0.563	0.371	0.459	0.387	0.639	0.639
1977	0.013	0.263	0.554	0.614	0.492	0.369	0.179	0.471	0.278	0.278
1978	0.001	0.236	0.573	0.536	0.522	0.514	0.658	0.536	0.487	0.487
1979	0.001	0.225	0.660	0.632	0.484	0.459	0.364	0.660	0.370	0.370
1980	0.004	0.128	0.557	0.591	0.584	0.404	0.577	0.496	0.624	0.624
1981	0.003	0.255	0.525	0.601	0.530	0.579	0.447	0.428	0.488	0.488
1982	0.019	0.232	0.697	0.564	0.633	0.598	0.507	0.517	0.516	0.516
1983	0.003	0.311	0.600	0.725	0.333	0.478	0.459	0.554	0.634	0.634
1984	0.003	0.292	0.722	0.683	0.670	0.732	0.545	0.422	0.576	0.576
1985	0.002	0.319	0.747	0.776	0.600	0.556	0.410	0.439	0.437	0.437
1986	0.002	0.143	0.620	0.698	0.684	0.762	0.745	0.350	0.607	0.607
1987	0.001	0.239	0.512	0.611	0.529	0.574	0.444	0.666	0.417	0.417
1988	0.000	0.238	0.661	0.716	0.613	0.615	0.556	0.433	0.934	0.934
1989	0.001	0.126	0.527	0.688	0.432	0.434	0.428	0.419	0.368	0.368
1990	0.005	0.137	0.405	0.528	0.587	0.567	0.477	0.676	0.679	0.679
1991	0.002	0.091	0.425	0.531	0.753	0.435	0.574	0.627	1.053	1.053
1992	0.003	0.120	0.437	0.467	0.479	0.611	0.690	0.455	0.766	0.766
1993	0.001	0.182	0.424	0.559	0.829	0.555	0.821	0.557	0.505	0.505
1994	0.013	0.141	0.482	0.637	0.682	0.887	0.488	0.577	1.016	1.016
1995	0.054	0.306	0.446	0.771	0.614	0.546	0.801	0.461	0.796	0.796
1996	0.004	0.275	0.698	0.984	0.713	0.850	0.746	1.024	0.439	0.439
1997	0.006	0.154	0.580	0.702	0.816	0.776	0.618	0.907	1.193	1.193
1998	0.002	0.280	0.618	0.794	0.770	0.754	0.660	0.982	1.284	1.284
1999	0.004	0.176	0.611	0.716	0.794	0.587	0.554	0.562	1.467	1.467
2000	0.020	0.240	0.582	0.797	0.624	0.784	0.882	0.767	0.497	0.497
2001	0.015	0.286	0.562	0.755	0.749	0.537	0.585	0.761	0.679	0.679
2002	0.006	0.232	0.625	0.644	0.725	0.644	0.462	0.991	0.527	0.527
2003	0.013	0.229	0.611	0.635	0.641	0.819	0.472	0.488	0.513	0.513
2004	0.012	0.237	0.547	0.706	0.606	0.461	0.391	0.306	1.127	1.127
2005	0.025	0.214	0.612	0.683	0.707	0.668	0.607	0.448	0.390	0.390
2006	0.034	0.268	0.446	0.473	0.494	0.543	0.524	0.556	0.459	0.459
2007	0.006	0.255	0.480	0.504	0.528	0.456	0.541	0.450	0.878	0.878
2008	0.028	0.140	0.350	0.459	0.390	0.377	0.352	0.550	0.535	0.535
2009	0.018	0.188	0.335	0.404	0.439	0.358	0.417	0.324	0.845	0.845
2010	0.003	0.158	0.351	0.433	0.335	0.416	0.305	0.347	0.404	0.404

Table 10.3.3 Sole in sub area IV: stock numbers at age

2011-05-06 11:44:52 units= NA

year	age 1	2	3	4	5	6	7	8	9	10
1957	128913	72456	89309	59107	17319	15058	27046	11837	2500	30811
1958	128647	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	99501	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	539177	8304	7993	27187	10397	59623	8154	6857	2666	9789
1965	121989	487815	7366	5223	19167	5784	37458	4405	4483	9392
1966	39913	110380	396590	5629	3205	12585	2873	22003	2505	8712
1967	75201	36115	88197	231749	4152	1776	7878	1891	13894	7984
1968	99240	68044	29172	55373	128720	1898	1097	5303	989	19824
1969	50897	88810	45257	13177	26349	70269	1278	760	3235	14266
1970	137946	45677	57603	20546	6857	12058	39669	842	455	16963
1971	42142	123583	35490	27396	10757	4507	7837	24517	527	12565
1972	76415	37732	80081	18391	12654	5467	2707	4878	15322	9086
1973	105141	68803	26918	37494	9911	6727	3458	1952	3241	15338
1974	109999	94467	50624	12197	18529	5139	3876	2184	1038	12407
1975	40846	99435	70847	25317	5817	10049	2822	2000	1350	9113
1976	113310	36708	68138	36962	11762	3277	5449	1802	947	5898
1977	140363	101537	29845	35052	20115	6059	2046	3115	1107	9122
1978	47164	125343	70636	15521	17157	11124	3790	1548	1761	4347
1979	11666	42650	89605	36050	8214	9209	6022	1776	820	5175
1980	151653	10548	30811	41916	17343	4582	5268	3788	831	2708
1981	148978	136616	8394	15978	21013	8751	2767	2676	2087	2463
1982	152495	134398	95823	4495	7927	11192	4436	1602	1579	3320
1983	141577	135453	96463	43189	2314	3810	5571	2418	864	2619
1984	70888	127735	89833	47915	18924	1500	2136	3186	1257	2134
1985	81645	63961	86344	39495	21902	8760	653	1121	1891	2883
1986	159358	73718	42066	37022	16440	10873	4544	392	654	3863
1987	72698	143837	57796	20468	16660	7507	4592	1953	250	2133
1988	456494	65690	102513	31326	10056	8880	3825	2665	908	545
1989	108214	413043	46865	47877	13855	4931	4342	1986	1564	1592
1990	177225	97805	329612	25033	21772	8138	2890	2562	1182	1791
1991	70390	159539	77141	198886	13360	10954	4178	1623	1179	1744
1992	352998	63578	131836	45620	105846	5693	6416	2129	784	2304
1993	69162	318474	51029	77076	25865	59323	2795	2913	1222	2221
1994	56983	62529	240176	30222	39864	10211	30815	1112	1509	1483
1995	95963	50878	49156	134180	14457	18246	3807	17124	565	1271
1996	49378	82264	33892	28476	56185	7081	9559	1547	9773	2910
1997	271069	44516	56530	15266	9630	24910	2737	4102	503	2522
1998	113801	243761	34527	28653	6845	3854	10371	1334	1499	1217
1999	82278	102739	166679	16839	11720	2869	1641	4848	452	1096
2000	123249	74176	77969	81881	7449	4792	1443	853	2500	1908
2001	62938	109284	52779	39408	33374	3612	1980	541	358	1536
2002	184939	56108	74299	27215	16751	14284	1911	998	229	930
2003	83375	166336	40255	35978	12934	7343	6791	1089	335	1175
2004	45234	74444	119754	19779	17249	6167	2929	3833	605	599
2005	49131	40438	53139	62727	8838	8514	3521	1793	2554	1300
2006	213023	43356	29535	26070	28675	3943	3949	1736	1036	1529
2007	55653	186269	30013	17108	14704	15825	2072	2115	901	971
2008	71878	50055	130601	16801	9348	7844	9075	1091	1220	1136
2009	94210	63211	39394	83272	9611	5728	4866	5774	570	1568
2010	153078	83708	47373	25488	50312	5605	3625	2903	3780	2174
2011	NA	138158	64656	30168	14952	32571	3344	2417	1857	3597

Table 10.4.1. Sole in sub area IV: XSA summary

year	recruits	ssb	catch	landings	fbar2-6	Y/ssb
1957	128913	55108	12067	12067	0.18	0.22
1958	128647	60920	14287	14287	0.21	0.23
1959	488783	65582	13832	13832	0.17	0.21
1960	61717	73401	18620	18620	0.20	0.25
1961	99501	117104	23566	23566	0.19	0.20
1962	22899	116836	26877	26877	0.21	0.23
1963	20424	113637	26164	26164	0.31	0.23
1964	539177	37132	11342	11342	0.29	0.31
1965	121989	30035	17043	17043	0.32	0.57
1966	39913	84262	33340	33340	0.32	0.40
1967	75201	82985	33439	33439	0.41	0.40
1968	99240	72342	33179	33179	0.49	0.46
1969	50897	55316	27559	27559	0.55	0.50
1970	137946	50739	19685	19685	0.40	0.39
1971	42142	43818	23652	23652	0.51	0.54
1972	76415	47550	21086	21086	0.46	0.44
1973	105141	36891	19309	19309	0.50	0.52
1974	109999	36212	17989	17989	0.49	0.50
1975	40846	38599	20773	20773	0.50	0.54
1976	113310	39011	17326	17326	0.42	0.44
1977	140363	35009	18003	18003	0.46	0.51
1978	47164	36409	20280	20280	0.48	0.56
1979	11666	45012	22598	22598	0.49	0.50
1980	151653	33531	15807	15807	0.45	0.47
1981	148978	23075	15403	15403	0.50	0.67
1982	152495	32871	21579	21579	0.54	0.66
1983	141577	39880	24927	24927	0.49	0.63
1984	70888	43297	26839	26839	0.62	0.62
1985	81645	40801	24248	24248	0.60	0.59
1986	159358	34073	18201	18201	0.58	0.53
1987	72698	29365	17368	17368	0.49	0.59
1988	456494	38586	21590	21590	0.57	0.56
1989	108214	33879	21805	21805	0.44	0.64
1990	177225	89838	35120	35120	0.44	0.39
1991	70390	77617	33513	33513	0.45	0.43
1992	352998	77307	29341	29341	0.42	0.38
1993	69162	55471	31491	31491	0.51	0.57
1994	56983	74309	33002	33002	0.57	0.44
1995	95963	59020	30467	30467	0.54	0.52
1996	49378	38415	22651	22651	0.70	0.59
1997	271069	27606	14901	14901	0.61	0.54
1998	113801	20412	20868	20868	0.64	1.02
1999	82278	41485	23475	23475	0.58	0.57
2000	123249	38611	22641	22641	0.61	0.59
2001	62938	30318	19944	19944	0.58	0.66
2002	184939	30974	16945	16945	0.57	0.55
2003	83375	25174	17920	17920	0.59	0.71
2004	45234	37425	18757	18757	0.51	0.50
2005	49131	32194	16355	16355	0.58	0.51
2006	213023	24178	12594	12594	0.44	0.52
2007	55653	18191	14635	14635	0.44	0.80
2008	71878	37624	14071	14071	0.34	0.37
2009	94210	34740	13952	13952	0.34	0.40
2010	153078	35192	12603	12603	0.34	0.36

Table 10.5.1. Sole in sub area IV: RCT3 input table

Year Class	age 1	age 2	DFS 0	SNS 1	SNS 2	BTS 1
1971	76415	68803	NA	1455	935	NA
1972	105141	94467	NA	5587	361	NA
1973	109999	99435	NA	2348	864	NA
1974	40846	36708	NA	525	74	NA
1975	113310	101537	168.84	1399	776	NA
1976	140363	125343	82.28	3743	1355	NA
1977	47164	42650	33.8	1548	408	NA
1978	11666	10548	96.87	94	89	NA
1979	151653	136616	392.08	4313	1413	NA
1980	148978	134398	404	3737	1146	NA
1981	152495	135453	293.93	5856	1123	NA
1982	141577	127735	328.52	2621	1100	NA
1983	70888	63961	104.38	2493	716	NA
1984	81645	73718	186.53	3619	458	7.03
1985	159358	143837	315.03	3705	944	7.17
1986	72698	65690	73.22	1948	594	6.97
1987	456494	413043	523.86	1122	5005	83.11
1988	108214	97805	50.07	2831	1120	9.01
1989	177225	159539	77.8	2856	2529	37.84
1990	70390	63578	21.09	1254	144	4.03
1991	352998	318474	391.93	11114	3420	81.63
1992	69162	62529	25.3	1291	498	6.35
1993	56983	50878	25.13	652	224	7.66
1994	95963	82264	69.11	1362	349	28.13
1995	49378	44516	19.07	218	154	3.98
1996	271069	243761	59.62	10279	3126	169.34
1997	113801	102739	44.08	4095	972	17.11
1998	82278	74176	NA	1649	126	11.96
1999	123249	109284	NA	1639	655	14.59
2000	62938	56108	15.51	970	379	8
2001	184939	166336	85.31	7547	NA	20.99
2002	83375	74444	64.97	NA	624	10.51
2003	45234	40438	16.82	1370	163	4.19
2004	49131	43356	40.1	568	117	5.53
2005	213023	186269	46.81	2726	911	17.09
2006	55653	50055	14.69	849	259	7.5
2007	NA	NA	23.51	1259	344	15.25
2008	NA	NA	26.74	1932	237	15.95
2009	NA	NA	39.59	2637	NA	54.81
2010	NA	NA	58.4	NA	NA	NA

Table 10.5.2. Sole in sub area IV: RCT3 analysis – age 1

```
Analysis by RCT3 ver3.1 of data from file : altin_1.txt, Sole North Sea Age 1

 Data for    4 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.
 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

 DFS0    1.18   6.34   1.07   .326     30   4.08   11.17    1.123     .270

                                        VPA Mean =   11.48     .683     .730

 Year     Weighted      Log     Int     Ext     Var
 Class     Average      WAP     Std     Std    Ratio
          Prediction           Error   Error

 2010       89205     11.40     .58     .14     .06
```

Table 10.5.3. Sole in sub area IV: Output RCT3 – age 2

```
Analysis by RCT3 ver3.1 of data from file : altin_2.txt, Sole North Sea Age 2


 Data for    4 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.

 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

 DFS0      1.18   6.26   1.06   .329     30   3.70   10.62    1.187     .051
 SNS1       .75   5.70    .35   .797     35   7.88   11.57     .380     .469
 BTS1       .79   9.35    .39   .748     23   4.02   11.58     .422     .342

                                        VPA Mean =   11.37     .683     .138

 Year     Weighted      Log     Int     Ext     Var
 Class     Average      WAP     Std     Std    Ratio
          Prediction           Error   Error

 2009      135764     11.82     .25     .31      1.53
```

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
1	2011	0.016	0	0.02	93627	0.15	0.15	0.05	0	0.1
2	2011	0.160	0	0.16	138158	0.18	0.18	0.15	0	0.1
3	2011	0.342	0	0.34	64656	0.22	0.22	0.19	1	0.1
4	2011	0.428	0	0.43	30168	0.25	0.25	0.22	1	0.1
5	2011	0.384	0	0.38	14952	0.27	0.27	0.26	1	0.1
6	2011	0.380	0	0.38	32571	0.31	0.31	0.30	1	0.1
7	2011	0.354	0	0.35	3344	0.31	0.31	0.30	1	0.1
8	2011	0.403	0	0.40	2417	0.32	0.32	0.30	1	0.1
9	2011	0.589	0	0.59	1857	0.33	0.33	0.31	1	0.1
10	2011	0.589	0	0.59	3597	0.40	0.40	0.40	1	0.1
1	2012	0.016	0	0.02	93627	0.15	0.15	0.05	0	0.1
2	2012	0.160	0	0.16	NA	0.18	0.18	0.15	0	0.1
3	2012	0.342	0	0.34	NA	0.22	0.22	0.19	1	0.1
4	2012	0.428	0	0.43	NA	0.25	0.25	0.22	1	0.1
5	2012	0.384	0	0.38	NA	0.27	0.27	0.26	1	0.1
6	2012	0.380	0	0.38	NA	0.31	0.31	0.30	1	0.1
7	2012	0.354	0	0.35	NA	0.31	0.31	0.30	1	0.1
8	2012	0.403	0	0.40	NA	0.32	0.32	0.30	1	0.1
9	2012	0.589	0	0.59	NA	0.33	0.33	0.31	1	0.1
10	2012	0.589	0	0.59	NA	0.40	0.40	0.40	1	0.1
1	2013	0.016	0	0.02	93627	0.15	0.15	0.05	0	0.1
2	2013	0.160	0	0.16	NA	0.18	0.18	0.15	0	0.1
3	2013	0.342	0	0.34	NA	0.22	0.22	0.19	1	0.1
4	2013	0.428	0	0.43	NA	0.25	0.25	0.22	1	0.1
5	2013	0.384	0	0.38	NA	0.27	0.27	0.26	1	0.1
6	2013	0.380	0	0.38	NA	0.31	0.31	0.30	1	0.1
7	2013	0.354	0	0.35	NA	0.31	0.31	0.30	1	0.1
8	2013	0.403	0	0.40	NA	0.32	0.32	0.30	1	0.1
9	2013	0.589	0	0.59	NA	0.33	0.33	0.31	1	0.1
10	2013	0.589	0	0.59	NA	0.40	0.40	0.40	1	0.1

Table 10.6.2. (A) Sole in sub area IV: STF option table, assuming F(2011) = F(sq)

year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb2011**	
2011	**1**	**0.339**	**0**	**0.34**	**15831**	**0**	**15831**	**36550**	
year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb**	**ssb2013**
2012	0.2	0.068	0	0.07	3924	0	3924	45544	56960
2012	0.3	0.102	0	0.10	5786	0	5786	45544	55156
2012	0.4	0.136	0	0.14	7586	0	7586	45544	53415
2012	0.5	0.169	0	0.17	9325	0	9325	45544	51734
2012	0.6	0.203	0	0.20	11005	0	11005	45544	50112
2012	0.7	0.237	0	0.24	12628	0	12628	45544	48545
2012	0.8	0.271	0	0.27	14198	0	14198	45544	47033
2012	0.9	0.305	0	0.30	15715	0	15715	45544	45573
2012	1.0	0.339	0	0.34	17181	0	17181	45544	44163
2012	1.1	0.373	0	0.37	18599	0	18599	45544	42801
2012	1.2	0.407	0	0.41	19970	0	19970	45544	41486
2012	1.3	0.440	0	0.44	21296	0	21296	45544	40215
2012	1.4	0.474	0	0.47	22578	0	22578	45544	38988
2012	1.5	0.508	0	0.51	23818	0	23818	45544	37803
2012	1.6	0.542	0	0.54	25018	0	25018	45544	36657
2012	1.7	0.576	0	0.58	26179	0	26179	45544	35551
2012	1.8	0.610	0	0.61	27302	0	27302	45544	34481
2012	1.9	0.644	0	0.64	28389	0	28389	45544	33448
2012	2.0	0.678	0	0.68	29441	0	29441	45544	32449

Table 10.6.2. (B) Sole in sub area IV: STF option table, assuming F(2011) = 0.9*F(sq)

year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb2011**	
2011	**1**	**0.305**	**0**	**0.3**	**14470**	**0**	**14470**	**36550**	
year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb**	**ssb2013**
2012	0.2	0.068	0	0.07	4025	0	4025	46851	58191
2012	0.3	0.102	0	0.10	5936	0	5936	46851	56340
2012	0.4	0.136	0	0.14	7781	0	7781	46851	54554
2012	0.5	0.169	0	0.17	9564	0	9564	46851	52830
2012	0.6	0.203	0	0.20	11287	0	11287	46851	51166
2012	0.7	0.237	0	0.24	12951	0	12951	46851	49560
2012	0.8	0.271	0	0.27	14560	0	14560	46851	48009
2012	0.9	0.305	0	0.30	16115	0	16115	46851	46512
2012	1.0	0.339	0	0.34	17618	0	17618	46851	45067
2012	1.1	0.373	0	0.37	19071	0	19071	46851	43671
2012	1.2	0.407	0	0.41	20476	0	20476	46851	42323
2012	1.3	0.440	0	0.44	21834	0	21834	46851	41022
2012	1.4	0.474	0	0.47	23148	0	23148	46851	39764
2012	1.5	0.508	0	0.51	24418	0	24418	46851	38550
2012	1.6	0.542	0	0.54	25647	0	25647	46851	37376
2012	1.7	0.576	0	0.58	26835	0	26835	46851	36243
2012	1.8	0.610	0	0.61	27986	0	27986	46851	35148
2012	1.9	0.644	0	0.64	29098	0	29098	46851	34089
2012	2.0	0.678	0	0.68	30175	0	30175	46851	33067

Table 10.6.2. (C) Sole in sub area IV: STF option table, assuming F(2011)~Landings for 2011=TAC for 2011

year	fmult	f2-6	f_dis2-3	f_hc2-6	landings	discards	catch	ssb2011	
2011	1	0.296	0	0.3	14100	0	14100	36550	
year	**fmult**	**f2-6**	**f_dis2-3**	**f_hc2-6**	**landings**	**discards**	**catch**	**ssb**	**ssb2013**
2012	0.2	0.068	0	0.07	4053	0	4053	47207	58526
2012	0.3	0.102	0	0.10	5977	0	5977	47207	56662
2012	0.4	0.136	0	0.14	7834	0	7834	47207	54864
2012	0.5	0.169	0	0.17	9629	0	9629	47207	53128
2012	0.6	0.203	0	0.20	11364	0	11364	47207	51453
2012	0.7	0.237	0	0.24	13039	0	13039	47207	49836
2012	0.8	0.271	0	0.27	14659	0	14659	47207	48275
2012	0.9	0.305	0	0.30	16224	0	16224	47207	46768
2012	1.0	0.339	0	0.34	17737	0	17737	47207	45313
2012	1.1	0.373	0	0.37	19200	0	19200	47207	43908
2012	1.2	0.407	0	0.41	20613	0	20613	47207	42551
2012	1.3	0.440	0	0.44	21981	0	21981	47207	41241
2012	1.4	0.474	0	0.47	23303	0	23303	47207	39975
2012	1.5	0.508	0	0.51	24581	0	24581	47207	38753
2012	1.6	0.542	0	0.54	25818	0	25818	47207	37572
2012	1.7	0.576	0	0.58	27014	0	27014	47207	36431
2012	1.8	0.610	0	0.61	28172	0	28172	47207	35329
2012	1.9	0.644	0	0.64	29291	0	29291	47207	34264
2012	2.0	0.678	0	0.68	30375	0	30375	47207	33234

Table 10.6.3. (A) Sole in sub area IV: STF detailed, assuming F(2011) = F(sq).

age	year	f	f.land	stock.n	catch.wt	lands.wt	stock.wt	mat	M	catch.n	catch	lands.n	landings	SSB	TSB
1	2011	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2011	0.16	0.16	138158	0.18	0.18	0.15	0	0.1	19514	3593	19514	3593	0	20493
3	2011	0.342	0.34	64656	0.22	0.22	0.19	1	0.1	17877	3881	17877	3881	12565	12565
4	2011	0.428	0.43	30168	0.25	0.25	0.22	1	0.1	10024	2470	10024	2470	6778	6778
5	2011	0.384	0.38	14952	0.27	0.27	0.26	1	0.1	4552	1246	4552	1246	3818	3818
6	2011	0.38	0.38	32571	0.31	0.31	0.3	1	0.1	9830	3011	9830	3011	9641	9641
7	2011	0.354	0.35	3344	0.31	0.31	0.3	1	0.1	952	296	952	296	1004	1004
8	2011	0.403	0.4	2417	0.32	0.32	0.3	1	0.1	765	243	765	243	725	725
9	2011	0.589	0.59	1857	0.33	0.33	0.31	1	0.1	790	258	790	258	580	580
10	2011	0.589	0.59	3597	0.4	0.4	0.4	1	0.1	1530	616	1530	616	1440	1440
1	2012	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2012	0.16	0.16	83352	0.18	0.18	0.15	0	0.1	11773	2168	11773	2168	0	12364
3	2012	0.342	0.34	106480	0.22	0.22	0.19	1	0.1	29441	6392	29441	6392	20693	20693
4	2012	0.428	0.43	41554	0.25	0.25	0.22	1	0.1	13807	3402	13807	3402	9336	9336
5	2012	0.384	0.38	17800	0.27	0.27	0.26	1	0.1	5419	1483	5419	1483	4545	4545
6	2012	0.38	0.38	9215	0.31	0.31	0.3	1	0.1	2781	852	2781	852	2728	2728
7	2012	0.354	0.35	20155	0.31	0.31	0.3	1	0.1	5740	1782	5740	1782	6053	6053
8	2012	0.403	0.4	2123	0.32	0.32	0.3	1	0.1	672	213	672	213	637	637
9	2012	0.589	0.59	1462	0.33	0.33	0.31	1	0.1	622	203	622	203	457	457
10	2012	0.589	0.59	2739	0.4	0.4	0.4	1	0.1	1165	469	1165	469	1096	1096
1	2013	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2013	0.16	0.16	83352	0.18	0.18	0.15	0	0.1	11773	2168	11773	2168	0	12364
3	2013	0.342	0.34	64240	0.22	0.22	0.19	1	0.1	17762	3856	17762	3856	12484	12484
4	2013	0.428	0.43	68433	0.25	0.25	0.22	1	0.1	22738	5602	22738	5602	15375	15375
5	2013	0.384	0.38	24518	0.27	0.27	0.26	1	0.1	7464	2042	7464	2042	6260	6260
6	2013	0.38	0.38	10970	0.31	0.31	0.3	1	0.1	3311	1014	3311	1014	3247	3247
7	2013	0.354	0.35	5702	0.31	0.31	0.3	1	0.1	1624	504	1624	504	1713	1713
8	2013	0.403	0.4	12795	0.32	0.32	0.3	1	0.1	4050	1284	4050	1284	3839	3839
9	2013	0.589	0.59	1284	0.33	0.33	0.31	1	0.1	546	178	546	178	401	401
10	2013	0.589	0.59	2110	0.4	0.4	0.4	1	0.1	898	362	898	362	845	845

Table 10.6.3. (B) Sole in sub area IV: STF detailed, assuming F(2011) = 0.9*F(sq).

age	year	f	f.land	stock.n	catch.wt	lands.wt	stock.wt	mat	M	catch.n	catch	lands.n	landings	SSB	TSB
1	2011	0.015	0.01	93627	0.15	0.15	0.05	0	0.1	1293	196	1293	196	0	4681
2	2011	0.144	0.14	138158	0.18	0.18	0.15	0	0.1	17698	3258	17698	3258	0	20493
3	2011	0.308	0.31	64656	0.22	0.22	0.19	1	0.1	16347	3549	16347	3549	12565	12565
4	2011	0.385	0.38	30168	0.25	0.25	0.22	1	0.1	9200	2267	9200	2267	6778	6778
5	2011	0.346	0.35	14952	0.27	0.27	0.26	1	0.1	4170	1141	4170	1141	3818	3818
6	2011	0.342	0.34	32571	0.31	0.31	0.3	1	0.1	9003	2758	9003	2758	9641	9641
7	2011	0.319	0.32	3344	0.31	0.31	0.3	1	0.1	871	270	871	270	1004	1004
8	2011	0.362	0.36	2417	0.32	0.32	0.3	1	0.1	701	222	701	222	725	725
9	2011	0.53	0.53	1857	0.33	0.33	0.31	1	0.1	730	238	730	238	580	580
10	2011	0.53	0.53	3597	0.4	0.4	0.4	1	0.1	1414	569	1414	569	1440	1440
1	2012	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2012	0.16	0.16	83487	0.18	0.18	0.15	0	0.1	11792	2171	11792	2171	0	12384
3	2012	0.342	0.34	108203	0.22	0.22	0.19	1	0.1	29917	6495	29917	6495	21027	21027
4	2012	0.428	0.43	43000	0.25	0.25	0.22	1	0.1	14287	3520	14287	3520	9661	9661
5	2012	0.384	0.38	18577	0.27	0.27	0.26	1	0.1	5656	1547	5656	1547	4743	4743
6	2012	0.38	0.38	9576	0.31	0.31	0.3	1	0.1	2890	885	2890	885	2834	2834
7	2012	0.354	0.35	20935	0.31	0.31	0.3	1	0.1	5962	1851	5962	1851	6288	6288
8	2012	0.403	0.4	2199	0.32	0.32	0.3	1	0.1	696	221	696	221	660	660
9	2012	0.589	0.59	1522	0.33	0.33	0.31	1	0.1	648	212	648	212	475	475
10	2012	0.589	0.59	2905	0.4	0.4	0.4	1	0.1	1236	498	1236	498	1163	1163
1	2013	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2013	0.16	0.16	83352	0.18	0.18	0.15	0	0.1	11773	2168	11773	2168	0	12364
3	2013	0.342	0.34	64345	0.22	0.22	0.19	1	0.1	17791	3863	17791	3863	12504	12504
4	2013	0.428	0.43	69540	0.25	0.25	0.22	1	0.1	23105	5693	23105	5693	15623	15623
5	2013	0.384	0.38	25371	0.27	0.27	0.26	1	0.1	7724	2113	7724	2113	6478	6478
6	2013	0.38	0.38	11449	0.31	0.31	0.3	1	0.1	3455	1058	3455	1058	3389	3389
7	2013	0.354	0.35	5925	0.31	0.31	0.3	1	0.1	1687	524	1687	524	1780	1780
8	2013	0.403	0.4	13291	0.32	0.32	0.3	1	0.1	4207	1333	4207	1333	3987	3987
9	2013	0.589	0.59	1330	0.33	0.33	0.31	1	0.1	566	185	566	185	416	416
10	2013	0.589	0.59	2224	0.4	0.4	0.4	1	0.1	946	381	946	381	890	890

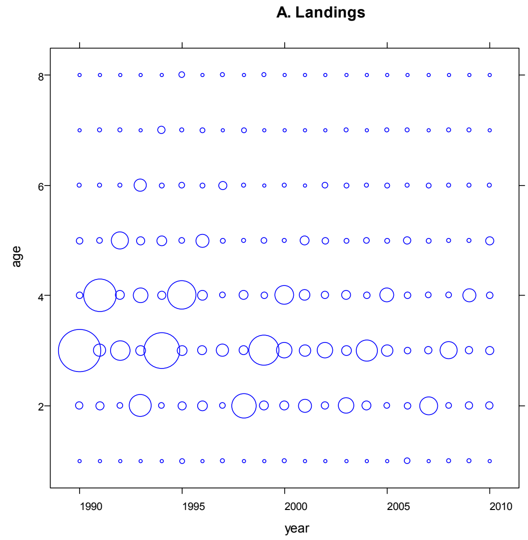
Table 10.6.3. (C) Sole in sub area IV: STF detailed, assuming F(2011) = TAC

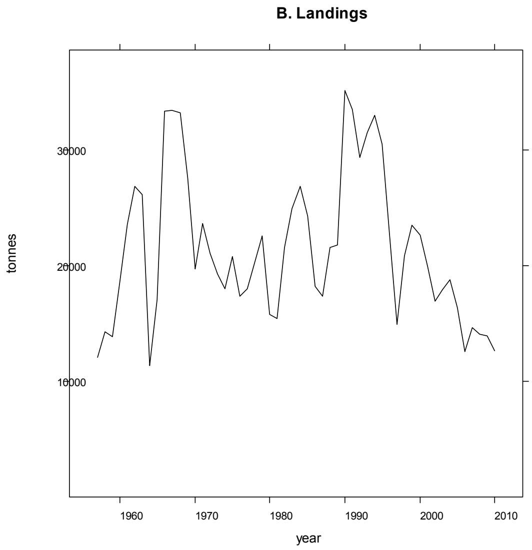
age	year	f	f.land	stock.n	catch.wt	landings.v	stock.wt	mat	M	catch.n	catch	landings.r	landings	SSB	TSB
1	2011	0.014	0.01	93627	0.15	0.15	0.05	0	0.1	1255	191	1255	191	0	4681
2	2011	0.14	0.14	138158	0.18	0.18	0.15	0	0.1	17209	3168	17209	3168	0	20493
3	2011	0.299	0.3	64656	0.22	0.22	0.19	1	0.1	15930	3459	15930	3459	12565	12565
4	2011	0.373	0.37	30168	0.25	0.25	0.22	1	0.1	8974	2211	8974	2211	6778	6778
5	2011	0.335	0.34	14952	0.27	0.27	0.26	1	0.1	4066	1112	4066	1112	3818	3818
6	2011	0.332	0.33	32571	0.31	0.31	0.3	1	0.1	8778	2689	8778	2689	9641	9641
7	2011	0.309	0.31	3344	0.31	0.31	0.3	1	0.1	849	264	849	264	1004	1004
8	2011	0.352	0.35	2417	0.32	0.32	0.3	1	0.1	684	217	684	217	725	725
9	2011	0.514	0.51	1857	0.33	0.33	0.31	1	0.1	713	233	713	233	580	580
10	2011	0.514	0.51	3597	0.4	0.4	0.4	1	0.1	1382	557	1382	557	1440	1440
1	2012	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2012	0.16	0.16	83523	0.18	0.18	0.15	0	0.1	11797	2172	11797	2172	0	12389
3	2012	0.342	0.34	108666	0.22	0.22	0.19	1	0.1	30045	6523	30045	6523	21117	21117
4	2012	0.428	0.43	43394	0.25	0.25	0.22	1	0.1	14418	3552	14418	3552	9749	9749
5	2012	0.384	0.38	18790	0.27	0.27	0.26	1	0.1	5721	1565	5721	1565	4798	4798
6	2012	0.38	0.38	9674	0.31	0.31	0.3	1	0.1	2920	894	2920	894	2864	2864
7	2012	0.354	0.35	21149	0.31	0.31	0.3	1	0.1	6023	1870	6023	1870	6352	6352
8	2012	0.403	0.4	2220	0.32	0.32	0.3	1	0.1	703	223	703	223	666	666
9	2012	0.589	0.59	1539	0.33	0.33	0.31	1	0.1	655	214	655	214	481	481
10	2012	0.589	0.59	2951	0.4	0.4	0.4	1	0.1	1256	506	1256	506	1181	1181
1	2013	0.016	0.02	93627	0.15	0.15	0.05	0	0.1	1436	218	1436	218	0	4681
2	2013	0.16	0.16	83352	0.18	0.18	0.15	0	0.1	11773	2168	11773	2168	0	12364
3	2013	0.342	0.34	64373	0.22	0.22	0.19	1	0.1	17799	3864	17799	3864	12510	12510
4	2013	0.428	0.43	69838	0.25	0.25	0.22	1	0.1	23205	5717	23205	5717	15690	15690
5	2013	0.384	0.38	25604	0.27	0.27	0.26	1	0.1	7795	2133	7795	2133	6537	6537
6	2013	0.38	0.38	11580	0.31	0.31	0.3	1	0.1	3495	1071	3495	1071	3428	3428
7	2013	0.354	0.35	5986	0.31	0.31	0.3	1	0.1	1705	529	1705	529	1798	1798
8	2013	0.403	0.4	13426	0.32	0.32	0.3	1	0.1	4249	1347	4249	1347	4028	4028
9	2013	0.589	0.59	1343	0.33	0.33	0.31	1	0.1	571	187	571	187	419	419
10	2013	0.589	0.59	2255	0.4	0.4	0.4	1	0.1	959	386	959	386	903	903

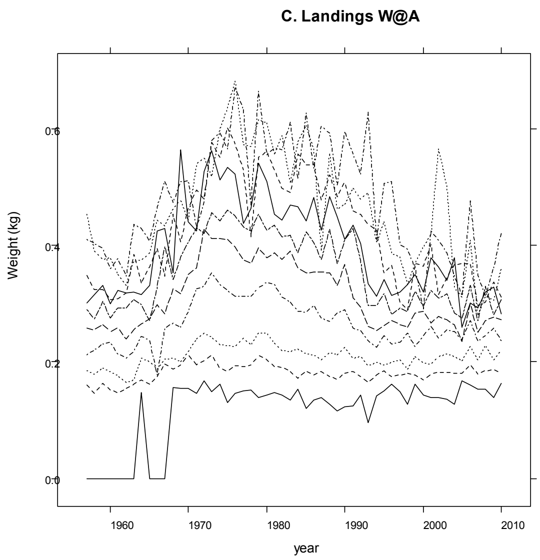
Table 10.6.4 Yield and spawning biomass per Recruit F-reference points (2011).

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.34	0.17	0.42
Fmax*	0.55	0.17	0.27
F0.1	0.09	0.14	1.11
Fmed	0.33	0.17	0.43

*Poorly defined


A. Landings
age
year
8
6
4
2
1990
1995
2000
2005
2010


B. Landings
tonnes
year
30000
20000
10000
1960
1970
1980
1990
2000
2010


C. Landings W@A
Weight (kg)
year
0.6
0.4
0.2
0.0
1960
1970
1980
1990
2000
2010

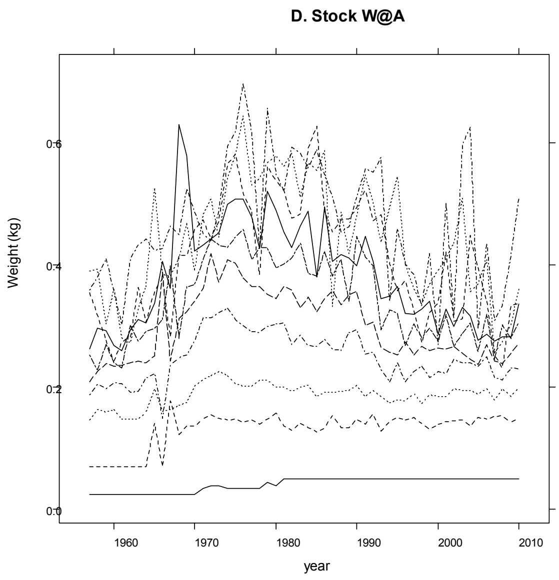
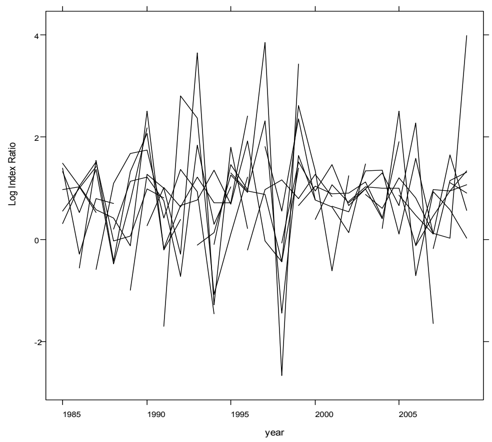


Figure 10.2.1. Sole in SubArea IV. A: bubble plot of landings (n) by age and year; B: time series of landings (total tonnages) 1957-2010; C: time-series of stock-weights by age 1957-2010; D: time-series of landing-weights by age 1957-2010.



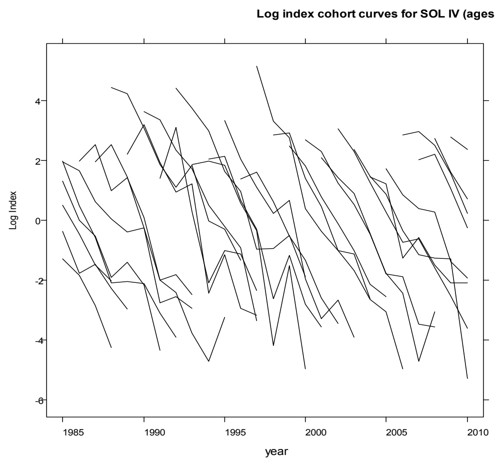


Figure 10.2.2. Sole in Sub-Area IV: Log catch ratios (left) and catch curves (right) from 1957 to 2010.

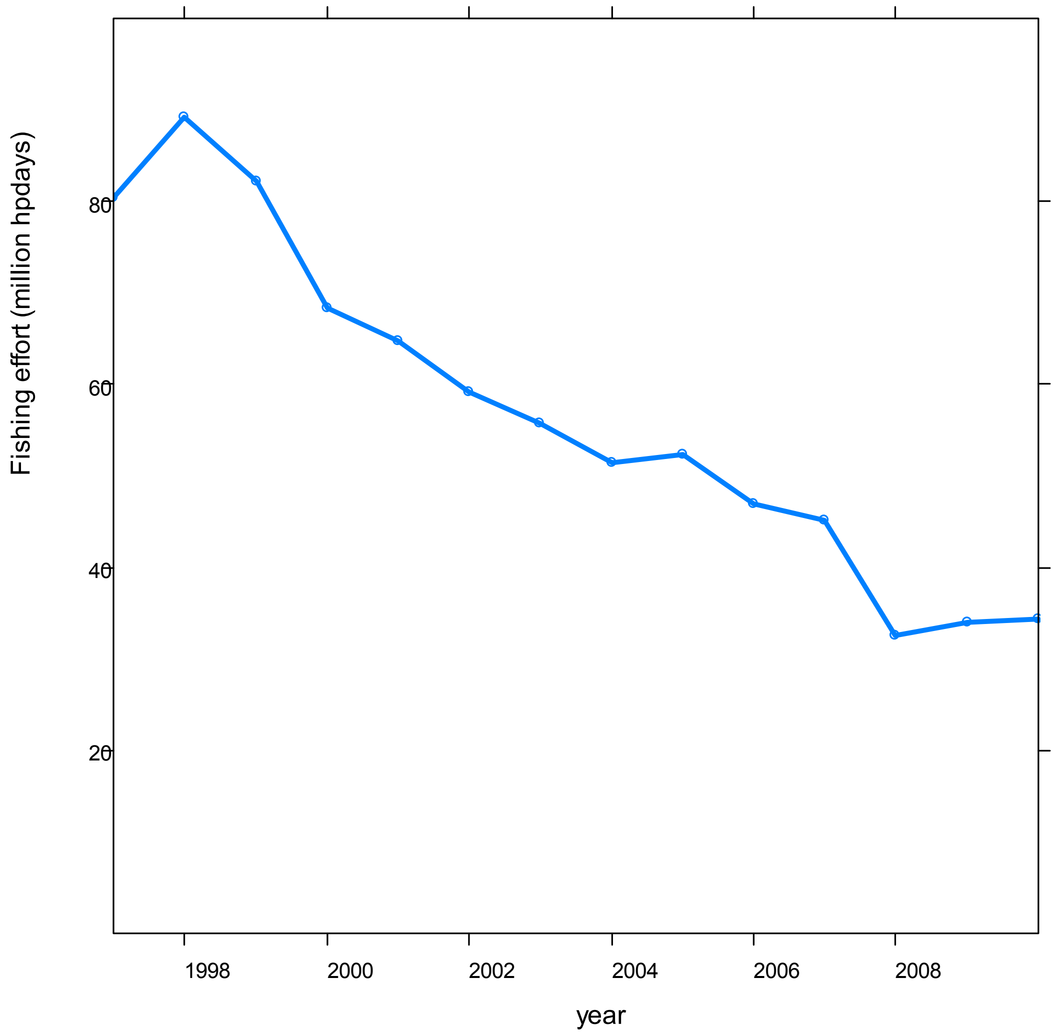


Figure 10.2.3. Sole in Sub-Area IV: Trends in the Dutch beam trawl fleet fishing effort based on days at sea records in the Dutch logbook database from vessels landings into the Netherlands.

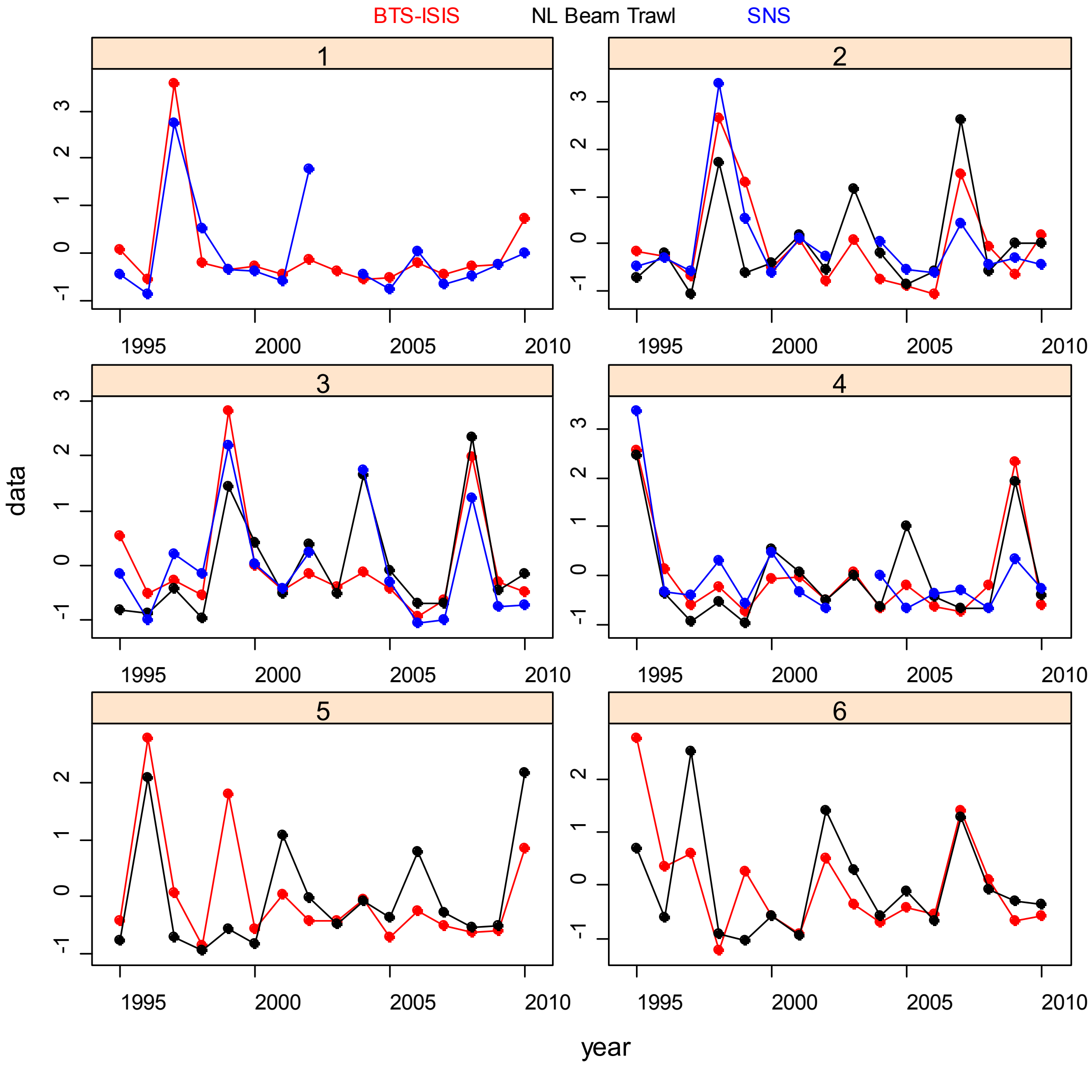


Figure 10.2.4 Sole in sub-area IV. Time series of the standardized indices age 1 to 6 from the three tuning fleets used in the final XSA assessment (BTS-ISIS, SNS and NL beam trawl).

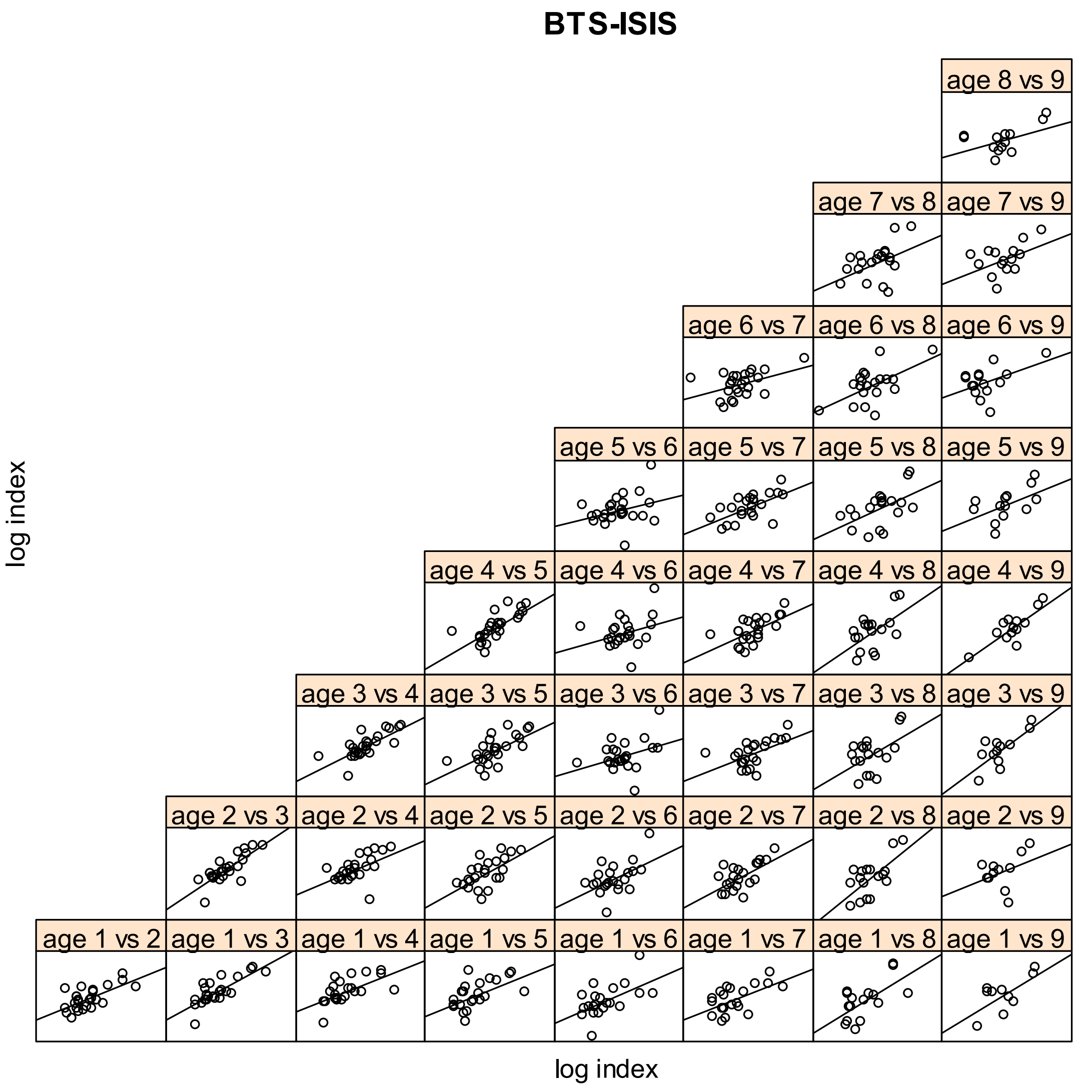


Figure 10.2.5 Sole in sub-area IV. Internal consistency in BTS-ISIS survey tuning index.

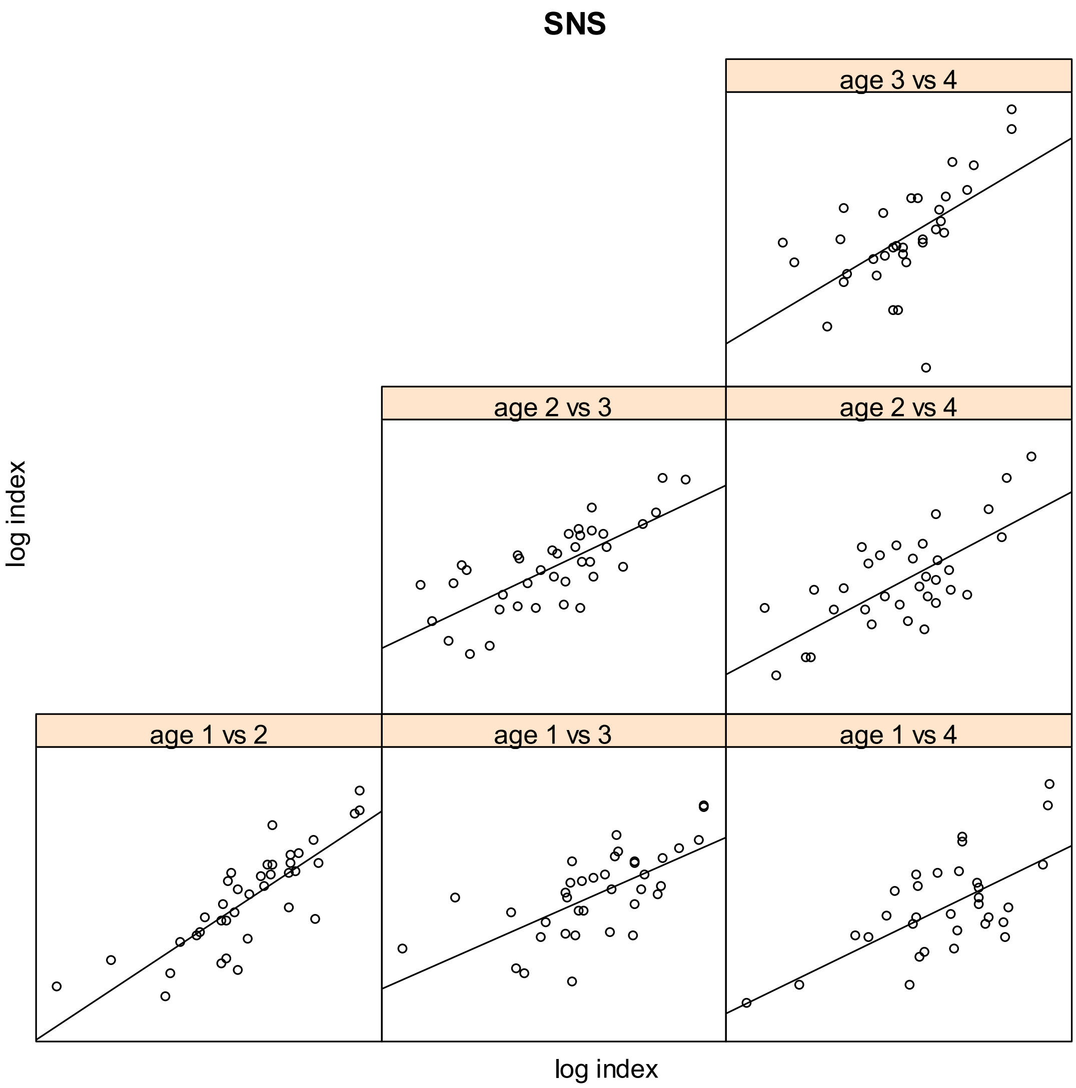


Figure 10.2.6 Sole in sub-area IV. Internal consistency in SNS survey tuning index.

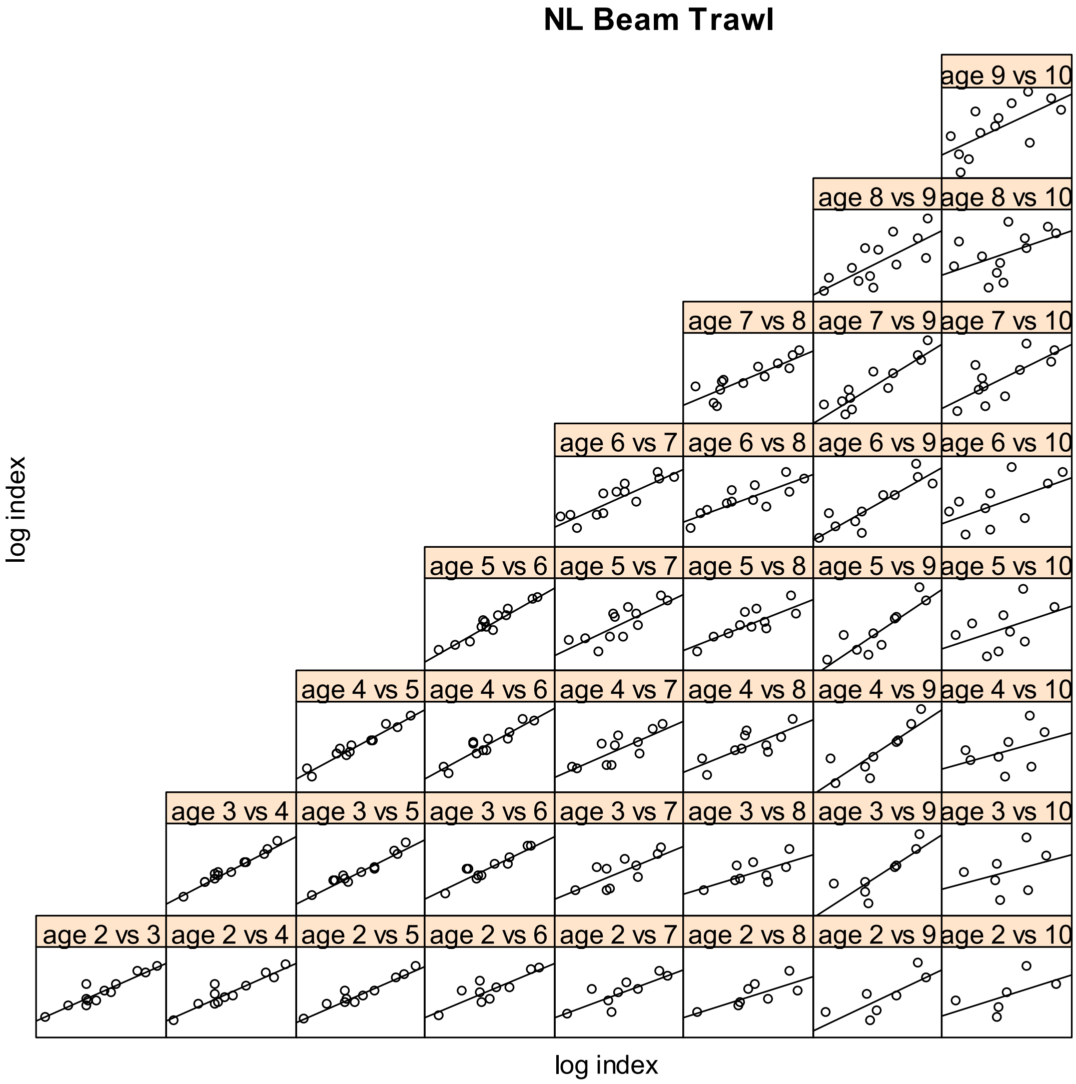


Figure 10.2.7 Sole in sub-area IV. Internal consistency in NL Beam trawl commercial tuning index.

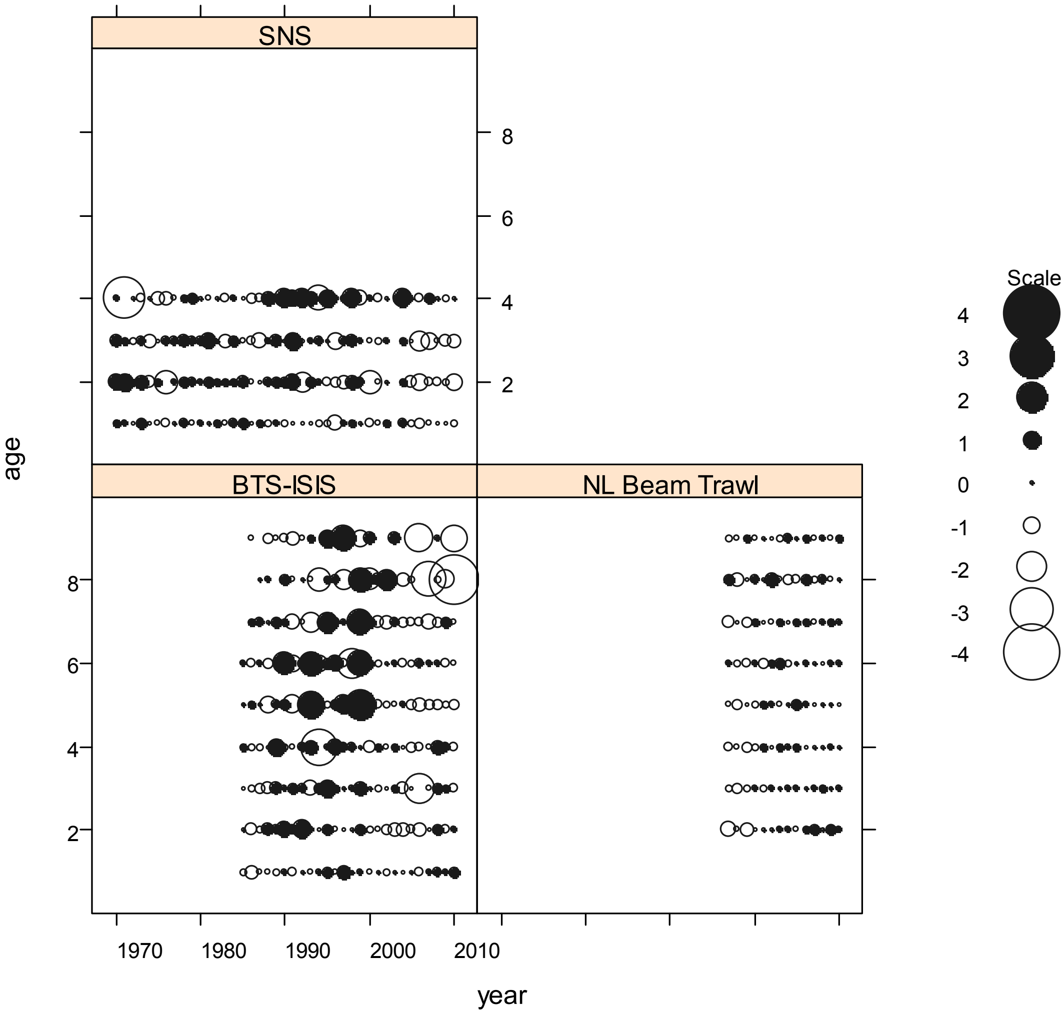


Figure 10.3.1. Sole in sub-area IV. log catchability residuals for the tuning fleets, BTS, SNS and NL beam trawl, in the final run. Closed and dark- circles indicate positive residuals, Open circles indicate negative residuals

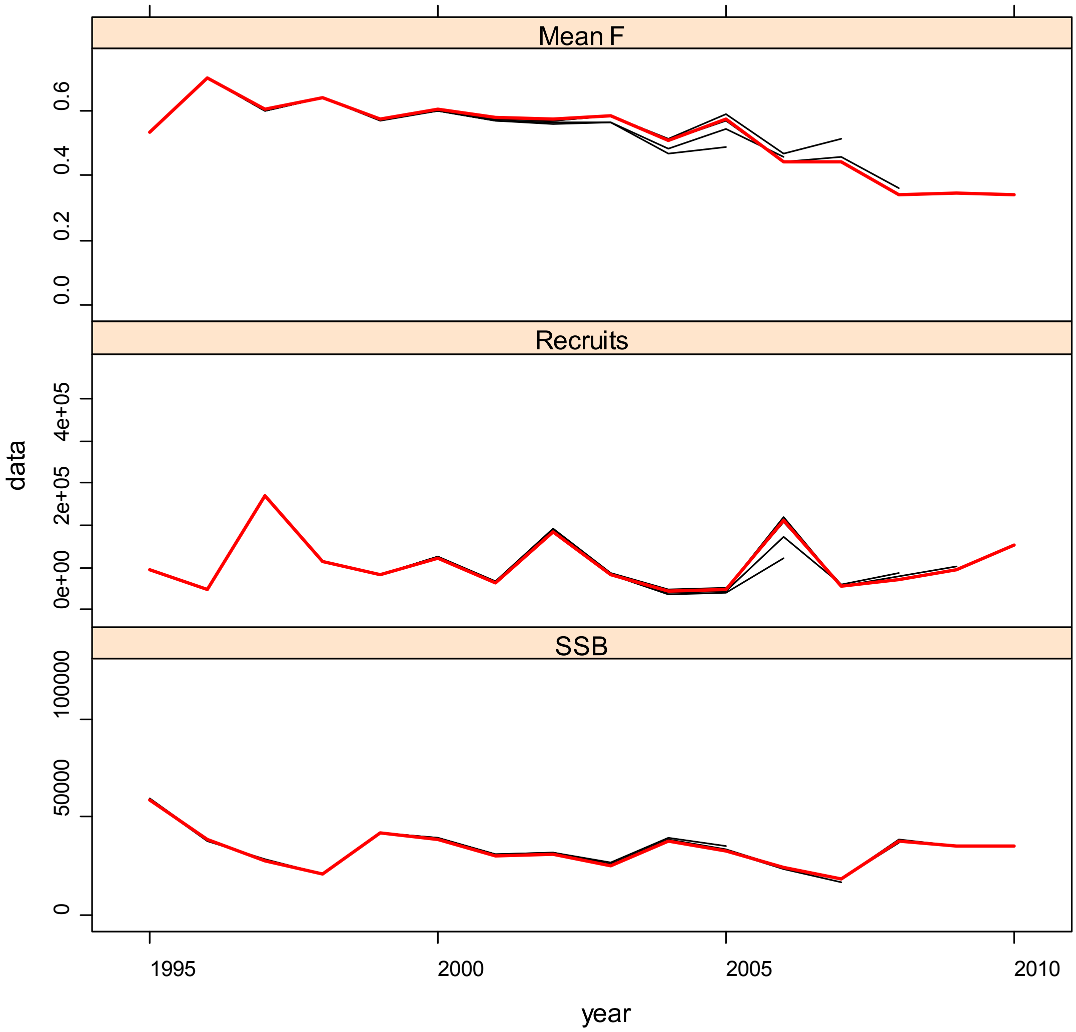


Figure 10.3.2 Sole in sub-area IV. Retrospective analysis of F, SSB and recruitment for 1995–2010 for the final XSA run.

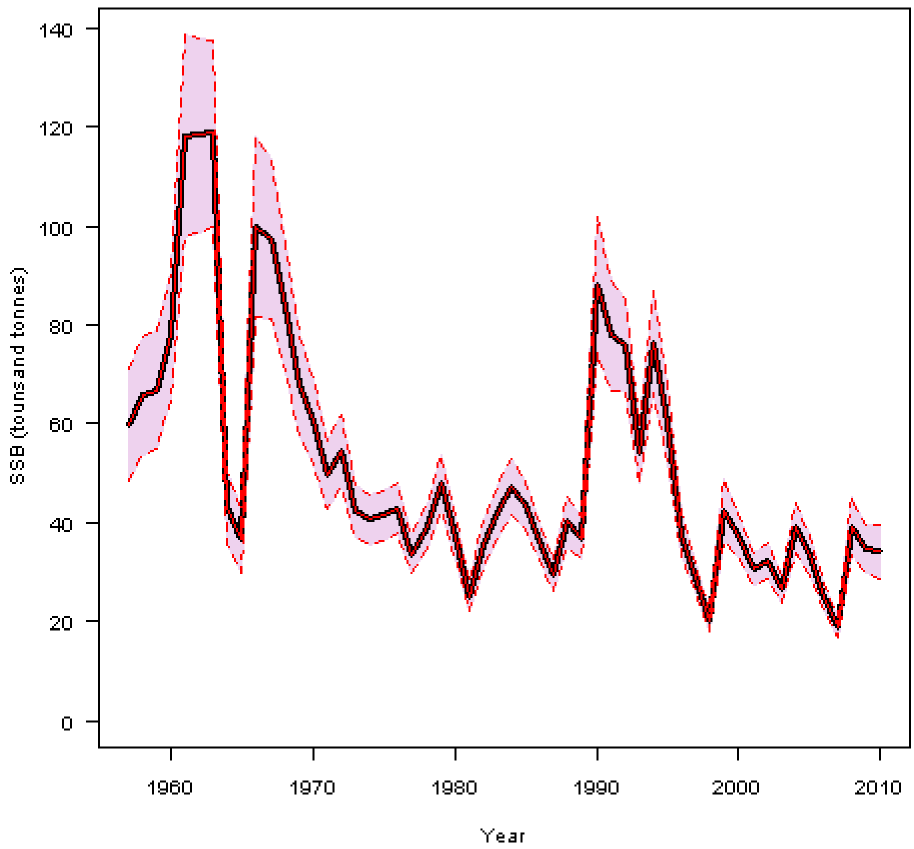


Figure 10.3.3a Sole in sub-area IV: SSB 1957–2010 output by SAM model.

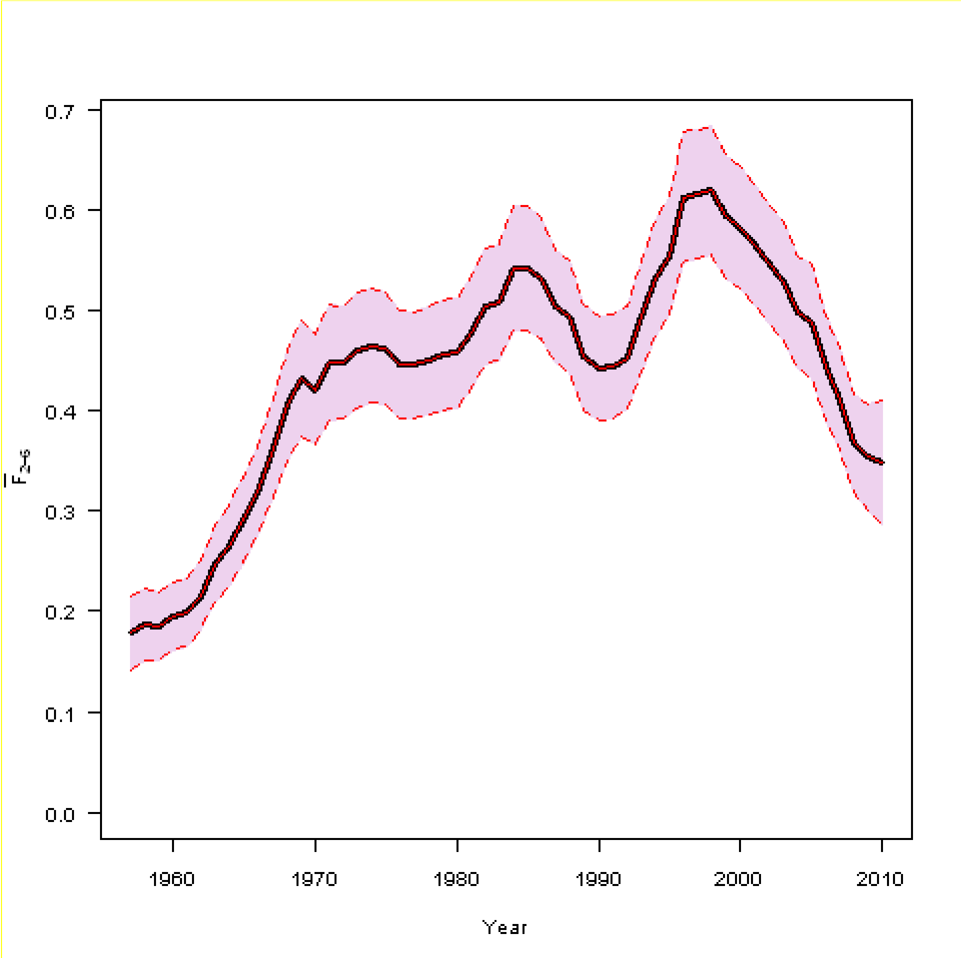


Figure 10.3.3b Sole in sub-area IV: Fishing mortality on ages 2-6 1957–2010 output by SAM model.

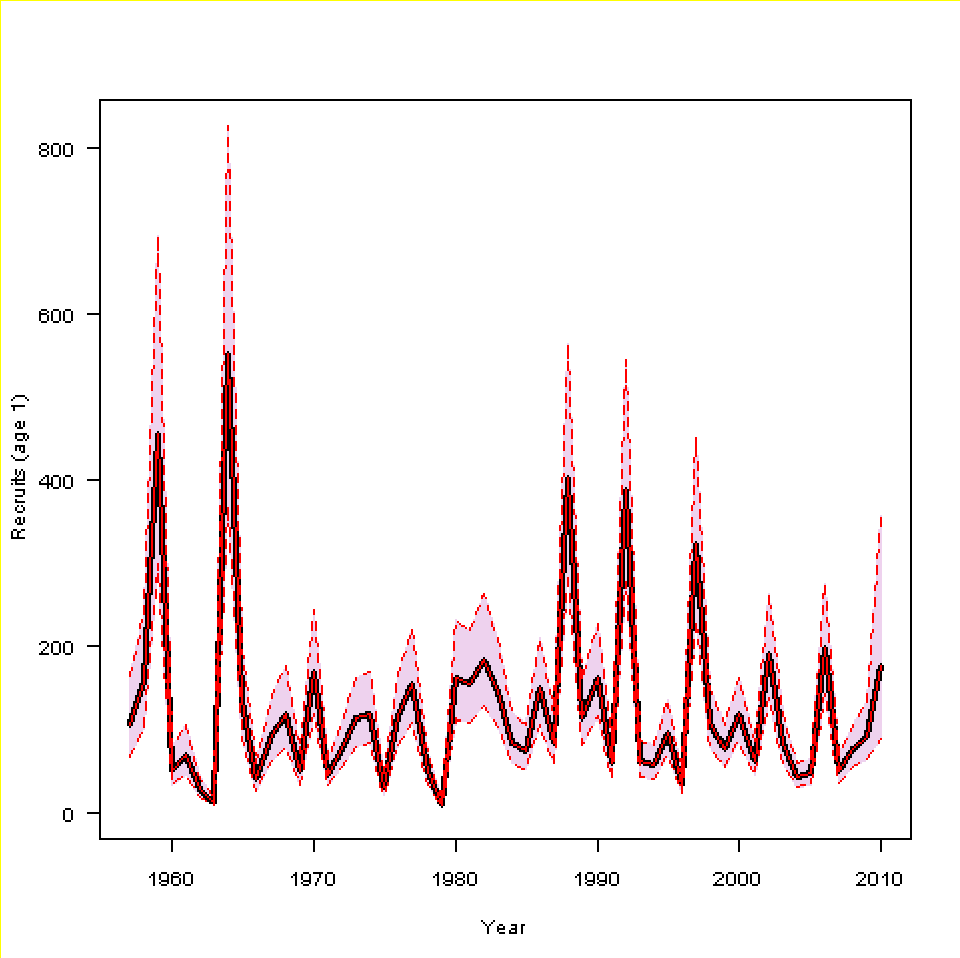


Figure 10.3.3c Sole in sub-area IV: Recruitment 1957–2010 output by SAM model.

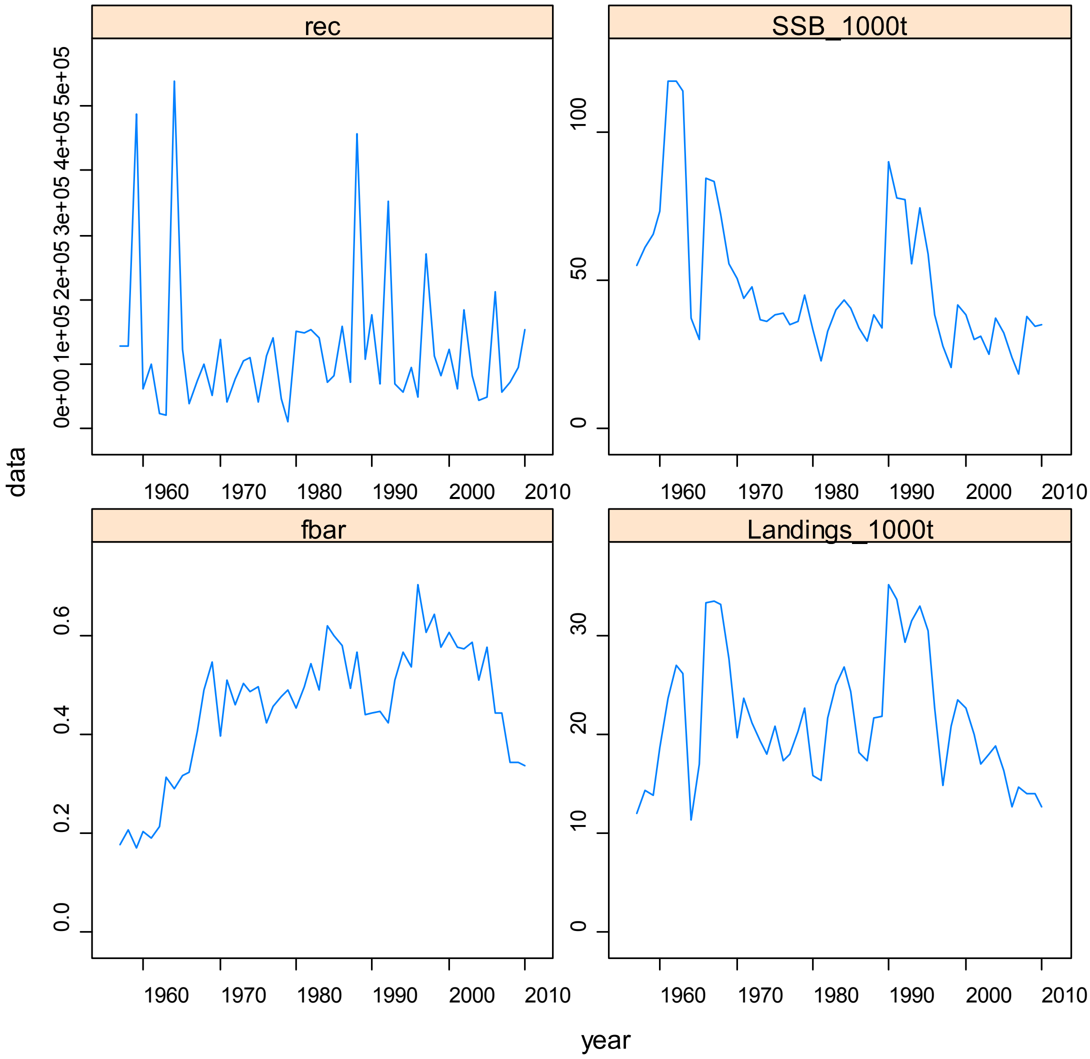


Figure 10.4.1 Sole in sub-area IV 1957-2010. XSA summary plots. Time series of recruitment (top left), SSB (top right), mean fishing mortality one ages 2-6 (bottom left) and landings (bottom right).

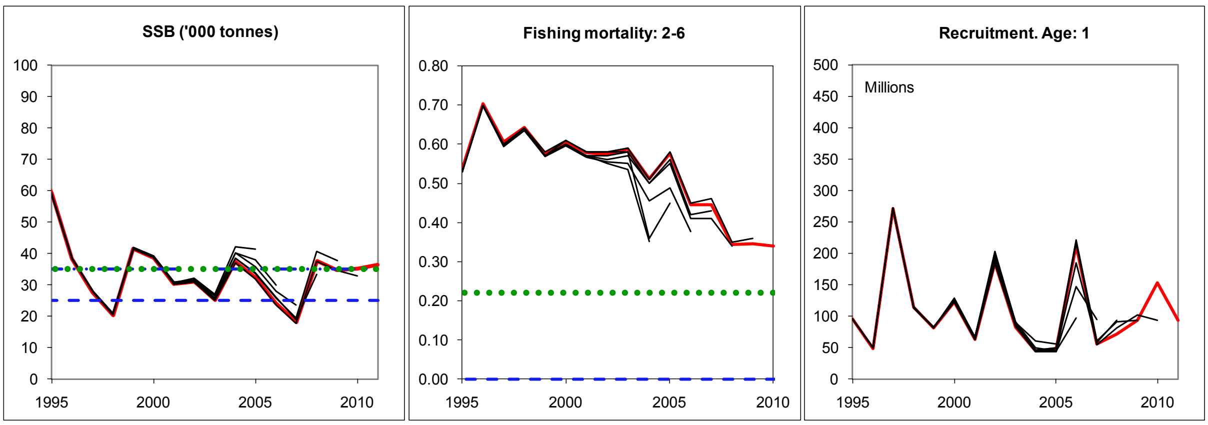


Figure 10.4.2 Sole in Subarea IV (North Sea). Historical assessment results (final year recruitment estimates included).

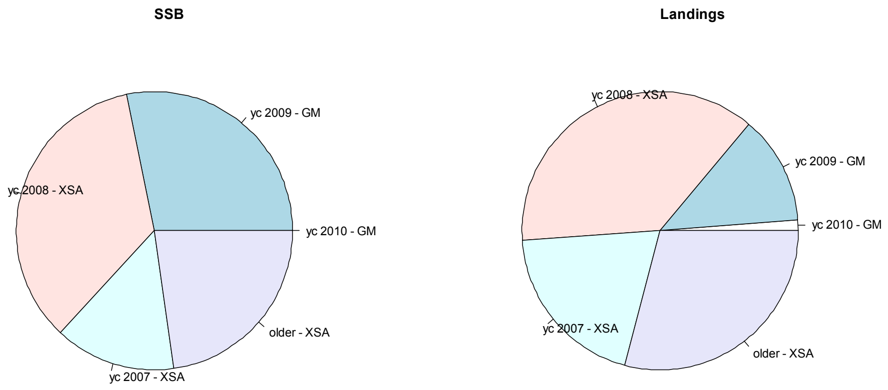
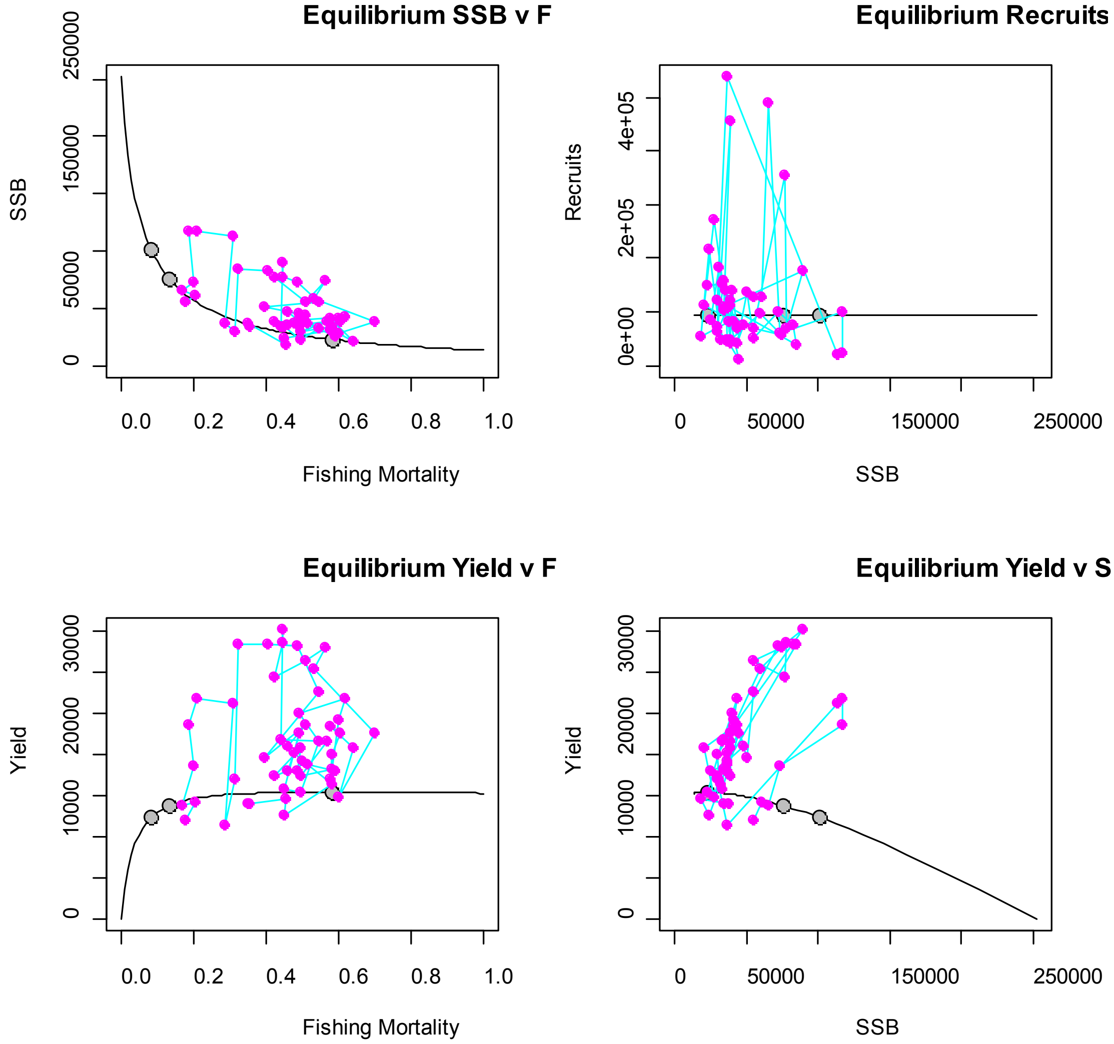


Figure 10.5.1 Sole in sub-area IV. Relative year class contribution to 2013 predicted SSB (left) and 2013 landings (right). Stock numbers of 1 year olds: (2007/XSA) 55 600 (2008/XSA) 71 878, (2009/XSA) 94 210 & (2010/XSA) 153 078 and (2011/GM) 94 000.



Yield and spawning biomass per Recruit

F-reference points:

	Fish Mort Ages 2-6	Yield/R	SSB/R
Average last 3 years	0.34	0.17	0.42
Fmax	0.55	0.17	0.27
F0.1	0.09	0.14	1.11
Fmed	0.33	0.17	0.43

Figure 10.5.2 Sole in sub-area IV. YPR results.

11 Saithe in Subareas IV, VI and Division IIIa

The June 2011 assessment of saithe (Pollachius virens) in Subareas IV and VI and Division IIIa has been run as agreed during the benchmark WKBENCH 2011 as described below.

In October the AGCREFA 2008 protocol showed that new survey data information in Q3 made reopening of the advice necessary. Section 11 describes the June assessment, the autumn assessment (using different model settings) is described in Annex 2 of the report.

For the June advice, the changes compared to earlier assessments are the exclusion of the younger ages from the commercial cpue indices and the inclusion of a Norwegian Acoustic young fish survey (NORASS) and re-inclusion of the Norwegian CPUE index (NORTRL). The XSA model settings have not been changed apart from the inclusion of SOP corrections of catches.

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 and thereby a change in fishing pattern for at least the German fleet. A shift in geographical distribution of the catches has also been shown for the Norwegian trawling fleet, even without such restrictions (Figure 11.2.3).

French and German trawlers are targeting saithe and have large quotas. The Norwegian trawlers have a total ban for discarding, and restricted bycatch allowances. They have 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 2010 the landings were estimated to be around 95 655 t in Subarea IV and Division IIIa, and 6 888 t in Subarea VI, which both are below the TACs for both area IV and Division IIIa and for Subarea VI (107 000 and 11 000 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 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.

ICES advice for 2011

In 2010, no assessment was performed due to missing and incomplete indices for 2009. The 2009 advice was taken as the basis for a 4 year forecast and in light of MSY considerations.

Exploitation boundaries in relation to existing management plans

"The EU Norway agreement management plan as updated in December 2008 results in a TAC of 103 000 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 103 000 t in 2011. This is expected to lead to an SSB of 219 000 in 2012. "

Exploitation boundaries in relation to precautionary limits

"Fishing mortality would have to be increased by 27% to reduce SSB to B_{pa} in 2012. This corresponds to landings of less than 125 000 t in 2011."

ICES conclusion on exploitation boundaries

"An update assessment could not be run in 2010 due to missing and incomplete indices for 2009. The assessment of the 2009 working group meeting has been used as a basis for the forecast run that has been extended to 4 years. SSB is estimated to have been above B_{pa} from 2001 2008. From 2001 2008, F has been at or below the fishing mortality target of the management plan (0.3)."

11.1.2 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 2010 were 107 044 t, and 13 066 t for Subarea VI. The agreed TAC in 2011 were 93 318 tons for Subarea IV and Division IIIa and 9 682 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."*

11.1.3 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. Minor revisions were applied to the 2009 landings. 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 (95655 t) are considerably higher than officially reported landings (83447) in 2010. In especially official landings from France and Denmark show a large break in the time series pointing towards problems in officially reported landings.

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, UK (England), Denmark and UK (Scotland) for Area IV and IIIa and only UK (Scotland) for Area VI. The differences between the sum-of-products (SOP) and the working group estimate was less than 3 % in 2010 but considerably lower in previous years. Therefore, SOP correction was used. The 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.

11.2.3 Weight at age

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 a increase in weight at age are now observed for all ages over 3 years.

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. A change in methodology was not concluded during the WKBENCH.

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: 6-9, year range 1990-2010 ("FRATRB")
- German bottom trawl, age range: 6-9, year range 1995-2010 ("GEROTB")
- Norwegian bottom trawl, age range: 6-9, year range 1980-2010 ("NORTRL")

  (Part 2 : 1993-2010)

NORTRL 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 11.3.11) does not indicate large problems any more, and the spatial changes in particular in the German fisheries, made WKBENCH include the index again.

Analysis done during the Benchmark 2011 showed both a change in spatial and temporal pattern of the commercial fishing fleets used as a basis for GEROTB and NORTRL (Figure 11.2.3). The Norwegian commercial fleet has been fishing more at the edge of the Norwegian trench, and has shifted more of the catches 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 for at least the German fleet (where data has been available) which may shift the distribution of the catches. The last years this fleet have changed their geographical distribution to the banks outside Egersund, and in the same period, the number of statistical squares representing 90 % of the catches has gone down from 18 to 11, which reflects a concentration of the effort. Data from the French fleet has not yet been analysed.

The Surveys are:

- Norwegian acoustic survey, age range 3-6, year range 1995-2008 ("NORACU")
- IBTS quarter 3, age range: 3-5, year range 1991-2010 ("IBTSq3")
- Norwegian Acoustic saithe survey, age range 2-4, year range 2005-2010: "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. The NORACU and IBTS Q3 indexes both show a declining trend the last few years (Figure 11.2.4) while the trend in the NORASS index is positive, for the last observations of 2 year old (Figure 11.2.5).

The data available for the working group for the tuning in 2011 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

The Review Group in ACOM had these technical comments:

None of the available documents indicate how the maturity ogive was derived. Depending on when it was derived, and given observed declines in weight at age, it may need to be recalculated.

This was analysed during WKBENCH. The analysis suggested that the existing ogive could not be rejected, and the assessment could also have advantages from a yearly updated ogive.

Changes in exploitation rates of age-3 fish over time seem to indicate that age-4 indices are a better indicator of year class strength – this may be worth exploring in the upcoming benchmark.

Including the NORASS index should strengthen the reliability of the age 3 indices.

No description of the FLSTF tool (FLR) is given in any of the available documents.

The tables and figures were well-prepared and matched text references well, although some figures would benefit from more detailed labeling (e.g. ages).

This will be done from the 2012 report.

11.3.2 Exploratory survey-based analyses

Log-abundance indices by cohort for the tuning series are shown in Figure 11.3.1. The pattern is similar to the pattern in the catch data curves (Figure 11.3.9), with partial recruitment of age 3 for recent cohorts. The curves for the most recent cohorts of the NORTRL time series show a pattern that differs from earlier cohorts in the NORTRL series and from the curves of the other tuning series (Figure 11.3.1), 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 11.3.11) and the fact that other indices might have been more variable or biased in recent years.

Within-survey correlations for the available tuning series are shown in Figures 11.3.2 – 11.3.7. For all the commercial tuning series the relationship between older ages are strong (Figures 11.3.2 – 11.3.7). There is some discrepancy for age 8 between FRATRB and the two other indices, but the FRATRB 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.

The survey-based indexes have a better consistency for younger age groups than the commercial indexes.

The three survey time series are relatively consistent (Figure 11.3.8). 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 11.3.3).

The youngfish survey for saithe, NORASS, is the only survey giving index values for 2 year old, and the information may be significant for the RCT3 analysis later in 2011. The relative CPUEs in the commercial tuning series are compared in Figure 11.3.9. For age 8 and 9 the consistency between the series is poor, but the overall trend for the two ages are consistent.

In the 2011 assessment, the time series of the “GEROTB” and “NORTRL” indicated a very strong 2007 cohort, while in the “FRATRL” series and in the surveys it appeared medium strong at best (Figure 11.3.8), which gave rise to some uncertainty. During the benchmark 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 is 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.

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 11.3.10. 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 purse seine decreased significantly in the early 1990s, and purse seiners mainly target young saithe. 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

Due to discussions about the quality of the IBTS Q3 index in 2009, a testrun without the use of this index was done. However, no important change was found.

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 index in the assessment, and to reduce the ages used from the commercial indexes (NORTRL, FRATRL, GEROTB) from 3-9 to 6-9. Also, the new acoustic index of young saithe (NORASS) was included for ages 3-4. It was agreed that XSA still should be the model used.

As a sensitivity analysis during the WKBENCH 2011, the 2009 assessment was run with both the former used settings and the settings agreed during the benchmark to analyse the retrospective pattern and the retrospective analysis shows the large certainty of recruitment estimation (Figure 11.3.10).

In this 2011 assessment, for comparison, also a full assessment was run with the settings as used before the benchmark (Figure 11.3.11). For the total assessment this trial showed hardly any change in SSB and a slightly lower F compared to the total assessment with the new settings.

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
Assessment model:	XSA	No assessment	XSA
Fleets:	FRAtrb (age range: 3-9, 1990 onwards)	No assessment	FRATRB (age 6-9, 1990 onwards)
	GERotb (age range: 3-9, 1995 onwards)	No assessment	GEROTB (age: 6-9, 1995 onwards)
	NORacu (age range: 3-6, 1996 onwards)	No assessment	NORACU (age 3-6, 1996 onwards)
	IBTSq3 (age range: 3-5, 1992 onwards)	No assessment	IBTSq3 (age 3-5, 1992 onwards)
			NORTRL (age 6-9, 1993 onwards
			NORASS (age 2-4, 2005 onwards)
Age range:	3-10+	No assessment	3-10+
Catch data:	1967-2008	No assessment	1967-2010
Fbar:	3-6	No assessment	3-6
Time series weights:	Tricubic over 20 years	No assessment	Tricubic over 20 years
Power model for ages:	No	No assessment	No
Catchability plateau:	Age 7	No assessment	Age 7
Survivor est. shrunk towards the mean F:	5 years / 3 ages	No assessment	5 years/ 3 ages
S.e. of mean (F-shrinkage):	1.0	No assessment	1.0
Min. s.e. of population estimates:	0.3	No assessment	0.3
Prior weighting:	No	No assessment	No
Number of iterations before convergence:	47	No assessment	53

Outputs from the final run are given in Table 11.3.1 (diagnostics), Table 11.3.2 (fishing mortality at age), and Table 11.3.3 (population numbers at age).

The log catchability residuals from the final XSA-run are shown in Figure 11.3.12, and a retrospective analysis in Figure 11.3.13.

11.4 Historic Stock Trends

The historic stock and fishery trends 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 (2002-2010), TAC levels have been higher than the reported landings. Estimated landings for area IV in 2010 (not shown in figure) were 96 thousand tons while TAC was 107 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 2009, dropping below F_{lim} in 1993 and below F_{pa} in 1997. In the last two years, at relatively stable landings, fishing mortality has increased sharply and is currently above F_{lim}. The most important explanation is that four out of the five last year classes are well below average, and the 2006 is the lowest observed. Also a change in spatial pattern of the fishing activities that shows a concentration of fishing activities (reduced area from 18 to 11 squares as in one of the fleets) may give hyperstability in the CPUE index if the fish are aggregating, while the actual CPUE, if still fished in the original area, could be decreasing.

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 below 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. The 2007 year class seems to be below average strength in the assessment.

11.5 Recruitment estimates

There are indications of the 2007 year class to be below or at average in the assessment, even if it appeared strong in the commercial indexes. This is because only survey indexes are used for this age in the assessment, because the survey indexes were considered by the benchmark as less biased. For the 2008 year class there is one observation from the NORASS index which suggest this year class is stronger, but not far from the level of the former four year classes. It was therefore decided to use the geometric mean of recruits (age 3 from the final assessment) from the period 1988-2008 as the estimated recruitment for these year classes. 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 2011. TAC uptake has been increasing in recent years and as the landings in 2010 are close to the TAC for 2011it was decided to use a TAC constraint for the intermediate year (i.e. the fishing mortality for 2011 was determined such that the landings in 2011 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 – 2008.

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 2011 and 2012 is expected to lead to landings of about 103 000 tonnes in 2011 and a drop to 106 000 t in the expected spawning stock biomass in the beginning of 2012. A fishing mortality in 2012 according to the EU-Norway management plan that has a TAC restrain to maximum 15 % corresponds to F=0.48, and is expected to lead to landings of 87 600 t in 2012 and an SSB of 110 500 t in 2013. 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 two years however, the exploitation pattern may have changed again due to effort regulations in the Cod management plan.

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.

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 2011 survey (conducted in the last part of May) will give input for RTC3 analysis in October.

Another problem with the assessment is the necessity to use commercial CPUE for tuning, as the survey series that are used only contain usable information for ages 3-6, and the stability of the indexes may be a result of hyperstability. This is a serious problem; that is commercial catch rates remain high while population abundance drops, which may occur when vessels are able to locate high fish concentrations independently of population size. Hyperstability may be demonstrated if the degree of the fleet's spatial concentration is monitored. Analyses showed significant changes in exploitation pattern both in location (Figure 11.2.3) and in total area fished (11 vs 18 squares).

11.11 Status of the Stock

The general perception of the status of the saithe stock is less positive than in many years. The fishing mortality in 2010 at above F_{lim} is a 15 year high, and the spawning stock is the lowest in more than 15 years. This has occurred in spite of almost constant catches due to the historically low recruitment in the last 5 years. Not even zero catches will give a SSB at MSY $B_{trigger}$ level in 2012.

11.12 Management Considerations

The ICES advice applies to the combined areas IIIa, IV, and VI.

The total landings in 2010 in areas IIIa and IV are still lower than the TAC, as was also the case in the 7 previous years although the uptake has increased in 2009 and 2010. Effort regulations may play a role in the priorities of the fishermen in EU, and combined with fuel prices this may be 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.

By-catch of other demersal fish species occurs in the trawl fishery for saithe(WGMIXFISH, 2010). This should be considered especially for the cod management plan, and the effort regulations that might have shifted the exploitation pattern of the stock. Saithe is also taken as unintentional by-catch in other fisheries, and discards may occur if the vessels do not have a saithe quota.

Since recruitment at age 3 tends to be poorly estimated in the XSA, the size of the 2006 and 2007 year classes is uncertain, but since the year classes are expected to be rather poor, only very large relative errors will make a large impact on the forecast. The Norwegian acoustic survey will be conducted also in May-June 2011, and significant new information on both year classes can be expected this year. A new forecast will be done in October 2011 following the AGCREFA protocol.

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 less 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.

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, 2001-2010, as officially reported to ICES, and WG estimates

SAITHE IV and IIIa

Country	2001	2002	2003	2004*	2005*	2006	2007*	2008*	2009*	2010*
Belgium	24	107	45	22	28	16	18	7	27	15
Denmark	3575	5668	6954	7991	7498	7471	5458	8069	8802	392
Faroe Isl.	289	872	495	558	184	62	15	108	-	146
France	20472	25441	18001	13628	10768	15739	13043	15302	5445*	4582*
Germany	9479	10999	8956	9589	12401	14390	12790	14141	13689	11192
Greenland	15262*	62	1616	403	-	-	-	-	-	-
Ireland	-	-	-	1	-	0	-	81	81	-
Netherlands	20	6	11*	3	40	28	5	3	17	3
Norway	44397	60013	61735	62783	67365	61268	45395	62055	57708	53031
Poland	727	752	734*	0	1100	-	-	1407	988	654
Russia	-	-	-	-	35	2	5	5	13	-
Sweden	1627	1863	1876	2249	2114	1695	1380	1639	1363	1545
UK (E/W/NI)	1186	2521	1215	457	1190	9129**	9628**	11701**	12545**	11887'*
UK (Scotland)	5219	6596	5829	5924	7703					
Total reported	88541	114900	107467	103608	110575	109800	87377	114517	100678	83447
Unallocated	1030	1291	-5809	-3646	968	7312	6241	-3084	4851	12208
WG estimate	89571	116191	101658	99962	111543	117112	93618	111433	105529	95655
TAC	87000	135000	165000	190000	145000	123250	135900	135900	125934	107000

*Preliminary, 2Preliminary data reported in Iva, **Scotland+E/W/NI combined

SAITHE VI

Country	2001	2002	2003	2004*	2005*	2006	2007*	2008*	2009*	2010*
Faroe Islands	-	-	2	34	21	76	32	23	-	24
France	5157	3062	3499	3053	3452	5782	3956	2617	2093*	2003
Germany	466	467	54	4	373	532	580	147	298	257
Ireland	399	91	170	95	168	243	322	208	208	519
Netherlands	-	-	-	-	-	-	-	1	-	-
Norway	31	12	28	16	20	28	377	78	68	249
Russia	1	1	6	6	25	7	2	50	4	2
Spain	15	4	6	2	3	-	-	-	-	-
UK (E/W/NI)	273	307	263	37	203	2748**	1419**	2887'*	3501**	3168**
UK (Scotland)	2246	1567	1189	1563	4433					
Total reported	8588	5513	5215	4810	8699	9416	6688	6011	6172	6222
Unallocated	-1770	-327	35	-296	-2960	848	98	1223	791	666
WG estimate	6818	5186	5250	4514	5739	8568	6786	7234	6963	6888
TAC	9000	14000	17119	20000	15044	12787	14100	14100	13066	11000

*Preliminary **Scotland+E/W/NI combined

SAITHE IV, IIIa and VI

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010*
WG estimate	96389	121377	106908	104476	117282	125680	100404	118667	112492	102543
TAC	96000	149000	182119	210000	160044	136037	150000	150000	139000	118000

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	23319	12286	10381	6662	1930	3058	1315	2421

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	0.741	1.325	1.858	2.527	3.205	3.281	3.778	4.823

Table 11.2.5 Saithe in Sub-Areas IV,VI and Division IIIa. Tuning data, effort and index values.

FRATRB_IV
1990 2010
1 1 0 1
3 9

21758	3380	2472	1406	304	290	33	15
15248	1381	2539	731	372	131	68	12
7902	717	1481	499	74	24	7	6
13527	3918	2253	1162	104	8	9	6
14417	1771	3653	1381	434	39	5	3
14632	3152	1683	922	226	70	24	13
16241	895	4286	1053	536	108	25	15
12903	1087	1915	3175	190	84	17	14
13559	800	2538	1870	1481	52	23	10
14588	852	1234	2667	620	400	24	14
8695	889	1993	1039	1195	215	181	32
6366	724	1339	2373	270	145	26	29
11022	3276	7577	1220	1242	175	151	41
10536	1517	3236	2355	264	325	81	113
5234	447	978	1021	495	93	36	20
3015	407	661	643	428	210	16	14
5710	1682	3142	551	145	199	40	13
8255	4201	1041	2807	241	100	3	1
7016	879	1523	245	950	165	34	33
7093	408	1194	1134	540	127	96	38
6035	661	672	565	184	28	83	28

NORTRL_IV1
1980 1992
1 1 0 1
3 9

18317	186	1290	658	980	797	261	60
28229	88	844	1345	492	670	699	119
47412	6624	12016	2737	2112	341	234	19
43099	4401	4963	8176	1950	2367	481	357
47803	20576	7328	2207	3358	433	444	106
66607	27088	21401	5307	1569	637	56	46
57468	5297	29612	3589	818	393	122	25
30008	2645	18454	2217	290	235	201	198
18402	3132	2042	2214	141	157	74	134
17781	649	2126	835	694	309	154	65
10249	804	781	924	519	203	63	12
28768	14348	4968	1194	518	203	51	56
35621	3447	9532	4031	1087	465	165	109

NORTRL_IV2
1993 2010
1 1 0 1
3 9

24572	7635	4028	2878	1018	526	365	252
30628	3939	16098	4276	926	251	72	203
32489	4347	9366	5412	833	1644	273	203
40400	3790	14429	4414	2765	1144	189	16
36026	2894	5266	9837	1419	892	299	72
24510	1376	8279	5454	5662	977	489	243
21513	813	2595	6869	2368	3602	1168	346
15520	284	1628	2054	4261	1066	1203	221
23106	4808	5228	6513	935	1235	509	390
38114	4015	12063	3474	3775	981	1632	1050
41645	1630	5451	10452	3602	4432	792	1004
32726	663	2677	5709	6578	2256	2640	656
34964	1202	3080	5177	9204	6954	1728	1434
30190	797	4116	3842	4611	7310	3974	811
26354	1563	1442	4684	3506	2655	3121	887
32550	2308	10354	3664	8357	2155	1619	1234
34360	1071	3257	5936	1254	5334	1636	933
24101	9219	3850	3756	2764	728	1052	416

GER_OTB_IV
1995 2010
1 1 0 1

```
3       9
21167   1158    2359    1350    589     152     30      16
19064   510     3167    1081    517     257     148     41
21707   816     2475    3636    292     163     70      24
20153   591     2744    1395    1776    238     100     39
18596   284     1065    2264    943     1015    77      36
12223   542     2185    823     1216    242     325     38
11008   892     1329    2317    372     532     249     155
12789   650     3658    1230    1100    99      140     69
14560   500     1399    2630    438     392     58      72
13708   334     2040    1928    1079    200     235     47
11700   434     510     1623    1543    787     205     119
10815   374     1575    690     668     685     350     147
12606   937     713     2813    607     405     417     175
12871   477     3151    627     1662    354     220     223
16692   359     759     1263    316     708     314     271
16046   1046    1115    721     441     100     242     161
NORACU
1995    2010
1       1       0.5     0.75
3       6
1       56244   4756    1214    174
1       21480   29698   6125    4593
1       22585   16188   24939   3002
1       15180   48295   13540   11194
1       16933   21109   27036   4399
1       34551   82338   14213   13842
1       72108   28764   17405   3870
1       82501   163524  17479   4475
1       67774   107730  41675   4581
1       34153   43811   31636   6413
1       48446   36560   27859   10174
1       18909   58132   11378   7922
1       77958   12070   32445   2384
1       7122    18989   4180    10262
1       NA      NA      NA      NA
1       2490    5225    4891    2899
IBTSq3
1991    2010
1       1       0.5     0.75
3       5
1       1.946   0.402   0.064
1       1.077   2.760   0.516
1       7.965   2.781   1.129
1       1.117   1.615   0.893
1            13.959   2.501   1.559
1       3.825   6.533   1.112
1       3.756   3.351   7.461
1       1.181   4.134   1.351
1       2.086   1.907   3.155
1       3.479   8.836   1.081
1            21.614   6.206   3.959
1            10.748     18.974        1.327
1            19.272     23.802     13.402
1       4.979   6.896   3.158
1       8.893   6.870   4.994
1            10.636     29.820        2.934
1            34.017   5.593     11.763
1       3.438   5.827   0.952
1       1.346   1.703   0.568
1        1.365  0.962   0.465
NORASS
2005    2010
1       1       0       1
2       5
NA      NA      NA      NA      NA
1       15.63   7.66    17.89   1.86
1       9.83    55.47   6.28    20.01
1       5.10    30.89   23.42   2.40
1       7.96    27.68   11.83   4.35
1       18.29   30.79   5.07    1.35
```

Table 11.3.1. FLR XSA Diagnostics.

```
CPUE data from xsa.indices
Catch data for 44 years. 1967 to 2010. Ages 3 to 10.
            fleet first age last age first year last year alpha beta
1       FRATRB_IV            6         9       1990      2010     0    1
2      NORTRL_IV2            6         9       1993      2010     0    1
3      GER_OTB_IV            6         9       1995      2010     0    1
4          NORACU            3         6       1996      2010   0.5 0.75
5          IBTSq3            3         5       1992      2010   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 ages >   3
    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     2001 2002  2003  2004  2005  2006 2007  2008 2009 2010
  all   0.751 0.82 0.877 0.921 0.954 0.976 0.99 0.997    1    1

 Fishing mortalities
    year
age   2001  2002  2003  2004  2005  2006  2007  2008  2009  2010
  3  0.082 0.120 0.108 0.063 0.087 0.213 0.182 0.196 0.286 0.383
  4  0.328 0.321 0.173 0.196 0.207 0.256 0.268 0.422 0.441 0.760
  5  0.427 0.272 0.330 0.225 0.354 0.326 0.316 0.480 0.565 0.773
  6  0.303 0.299 0.315 0.286 0.371 0.340 0.329 0.449 0.618 0.464
  7  0.265 0.378 0.411 0.322 0.429 0.431 0.353 0.349 0.561 0.521
  8  0.276 0.367 0.428 0.448 0.423 0.411 0.361 0.377 0.516 0.308
  9  0.248 0.526 0.447 0.657 0.475 0.431 0.208 0.280 0.452 0.359
  10 0.248 0.526 0.447 0.657 0.475 0.431 0.208 0.280 0.452 0.359

 XSA population number ( NA )
      age
year        3      4      5     6     7     8     9   10
  2001 225967  69741  71308 14158 17032  8112  8131 1229
  2002 194161 170481  41133 38095  8561 10700  5038 4338
  2003 126370 140947 101275 25650 23138  4804  6068 3156
  2004  96016  92912  97112 59609 15327 12555  2565 1827
  2005 184032  73802  62509 63497 36668  9093  6566 1331
  2006  56778 138065  49107 35922 35885 19539  4876 4482
  2007 116407  37555  87512 29026 20937 19087 10606 5712
  2008  60102  79484  23525 52246 17098 12040 10894 7810
  2009  41462  40437  42667 11914 27291  9872  6764 9612
  2010  81056  25508  21303 19845  5257 12749  4825 8816

 Estimated population abundance at 1st Jan  2011
      age
year   3     4    5    6     7    8    9   10
  2011 0 45263 9768 8048 10219 2558 7672 2760

 Fleet:  FRATRB_IV
 Log catchability residuals.
   year
age   1990   1991   1992   1993   1994   1995   1996   1997   1998   1999  2000
  6 -0.390  0.220 -0.413 -0.399  0.288 -0.442  0.117 -0.673  0.124 -0.111 0.792
  7  0.696  0.408 -0.671 -1.759 -0.073 -0.087  0.015 -0.135 -0.916 -0.024 0.500
  8 -0.441  0.309 -1.285 -1.485 -1.596  0.217 -0.226 -0.815 -0.788 -1.062 0.321
  9 -0.125 -0.415 -0.864 -1.248 -1.847  0.069  0.496  0.167 -0.589 -0.589 0.506
   year
age   2001   2002   2003   2004   2005   2006   2007   2008   2009   2010
  6  0.414  0.400 -0.699 -0.230  0.154 -1.016 -0.666  0.336  1.313 -0.179
  7  0.161  0.542  0.226  0.041  0.586 -0.081 -0.638  0.228 -0.416 -0.155
  8 -0.827  0.168  0.409 -0.658 -0.615 -1.097 -4.023 -0.979  0.304 -0.038
  9 -0.707 -0.316  0.522  0.433 -0.362 -0.797     NA -0.952 -0.269 -0.124
```

```
 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 -12.8920 -13.4632 -13.4632 -13.4632
S.E_Logq    0.5531   0.5735   0.9957   0.6280

 Fleet:  NORTRL_IV2
 Log catchability residuals.

   year
age  1993   1994   1995   1996   1997   1998  1999  2000   2001   2002   2003
  6 0.553 -0.444 -0.670  0.110 -0.426  0.137 0.104 0.748 -0.369 -0.465 -0.198
  7 0.297 -0.458  0.769 -0.029 -0.294 -0.075 0.290 0.026 -0.482 -0.473 -0.033
  8 0.165 -1.240  0.351 -0.596 -0.443  0.180 0.930 0.142 -0.621 -0.192 -0.175
  9 0.367  0.219  0.499 -1.858 -0.700  0.475 0.756 0.371 -0.903  0.192 -0.163
   year
age   2004  2005  2006   2007   2008   2009   2010
  6 -0.211 0.034 0.045  0.116  0.240 -0.159  0.408
  7 -0.095 0.141 0.360 -0.014 -0.233  0.246  0.239
  8  0.318 0.140 0.349  0.244 -0.156  0.061 -0.375
  9  0.606 0.302 0.157 -0.497 -0.371 -0.150 -0.308

 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 -12.1558 -11.9669 -11.9669 -11.9669
S.E_Logq    0.3776   0.3301   0.4871   0.6469

 Fleet:  GER_OTB_IV
 Log catchability residuals.

   year
age   1995   1996   1997   1998   1999   2000  2001   2002   2003   2004  2005
  6  0.220 -0.008 -0.692 -0.019  0.137  0.540 0.259  0.201 -0.446 -0.341 0.151
  7 -0.004  0.407 -0.308 -0.113  0.348 -0.039 0.597 -0.496 -0.228 -0.469 0.235
  8 -0.250  1.089 -0.210 -0.033 -0.465  0.251 0.584 -0.377 -0.560 -0.052 0.281
  9 -0.434  1.013 -0.113  0.020 -0.182  0.028 0.095 -0.260 -0.568  0.018 0.087
   year
age   2006   2007   2008   2009   2010
  6 -0.052 -0.093  0.360 -0.008 -0.213
  7  0.197  0.022  0.068  0.128 -0.161
  8  0.125  0.147 -0.045  0.312 -0.259
  9  0.654 -0.204  0.024  0.514  0.329

 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 -12.9633 -13.1456 -13.1456 -13.1456
S.E_Logq    0.3131   0.3066   0.4193   0.4039

 Fleet:  NORACU
 Log catchability residuals.
   year
age   1996   1997   1998   1999  2000   2001   2002  2003   2004   2005   2006
  3 -0.110 -0.347  0.058 -0.371 0.210 -0.057  0.111 0.305  0.177 -0.093  0.308
  4 -0.808 -0.744 -0.032  0.090 0.555  0.004  0.844 0.524  0.056  0.112 -0.020
  5 -0.365 -0.168 -0.093  0.275 0.551 -0.227  0.231 0.235 -0.064  0.330 -0.342
  6  0.614  0.143  0.270  0.049 0.935  0.424 -0.423 0.006 -0.519 -0.068  0.232
   year
age   2007   2008 2009   2010
  3  0.440 -0.157   NA -0.759
  4 -0.283 -0.483   NA -0.427
  5  0.122 -0.511   NA -0.073
  6 -0.762  0.185   NA -0.103

 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 -0.5606 -0.7924 -1.4073
S.E_Logq   0.4800  0.3064  0.4464
 Regression statistics
 Ages with q dependent on year class strength
          slope intercept
```

```
Age 3 0.6579258  4.765762

 Fleet:  IBTSq3
 Log catchability residuals.
   year
age   1992   1993   1994   1995   1996   1997   1998   1999   2000  2001   2002
  3 -1.213  0.003 -1.282  0.013 -0.419 -0.788 -1.040 -1.126 -0.342 0.332 -0.074
  4 -0.453 -0.411 -1.258 -0.583 -0.660 -0.657 -0.881 -0.595 -0.015 0.127  0.352
  5 -0.349 -0.017 -0.288 -0.018 -0.176  0.521 -0.516 -0.045 -0.130 0.182 -0.451
   year
age  2003   2004   2005  2006  2007  2008   2009   2010
  3 0.780 -0.093 -0.196 1.071 1.352 0.103 -0.285 -0.828
  4 0.676 -0.131  0.102 0.974 0.610 0.003 -0.545 -0.458
  5 0.996 -0.473  0.506 0.198 1.003 0.069 -1.154 -0.531

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

               4       5
Mean_Logq -9.1303 -9.5957
S.E_Logq   0.5768  0.5344

 Regression statistics
 Ages with q dependent on year class strength
         slope intercept
Age 3 0.9003995  9.775909

 Fleet:  NORASS
 Log catchability residuals.
   year
age 2005   2006   2007  2008  2009  2010
  3   NA -1.149  0.210 0.275 0.586 0.054
  4   NA -0.544 -0.284 0.353 0.354 0.106

 Mean log catchability and standard error of ages with catchability
 independent of year class strength and constant w.r.t. time

Mean_Logq  S.E_Logq
  -8.1877    0.3994

 Regression statistics
 Ages with q dependent on year class strength
        slope intercept
Age 3 1.034338  7.523317

 Terminal year survivor and F summaries:
 Age 3 Year class = 2007
source
                              survivors N scaledWts
NORACU                        14287 1     0.200
IBTSq3                        18043 1     0.105
NORASS                        47680 1     0.142
fshk                          98710 1     0.142
nshk                          75456 1     0.411

 Age 4 Year class = 2006
source
                    survivors N  scaledWts
NORACU                 6371   1       0.271
IBTSq3                 6372   2       0.223
NORASS                11783   2       0.379
fshk                   29400   1       0.127

 Age 5 Year class = 2005
source
                   survivors   N   scaledWts
NORACU                7327     2     0.493
IBTSq3                5120     3     0.220
NORASS                11279    2     0.189
fshk                  18472    1     0.099
```

Age 6 Year class = 2004
source

	survivors	N	scaledWts
FRATRB_IV	8547	1	0.062
NORTRL_IV2	15368	1	0.244
GER_OTB_IV	8259	1	0.298
NORACU	9202	3	0.204
IBTSq3	6924	3	0.078
NORASS	14192	2	0.067
fshk	11402	1	0.046

Age 7 Year class = 2003
source

	survivors	N	scaledWts
FRATRB_IV	2893	2	0.130
NORTRL_IV2	2893	2	0.333
GER_OTB_IV	2301	2	0.328
NORACU	1819	3	0.104
IBTSq3	4016	3	0.037
NORASS	1737	2	0.032
fshk	3270	1	0.036

Age 8 Year class = 2002
source

	survivors	N	scaledWts
FRATRB_IV	6105	3	0.091
NORTRL_IV2	7703	3	0.341
GER_OTB_IV	7811	3	0.360
NORACU	8419	4	0.124
IBTSq3	17153	3	0.031
NORASS	4452	1	0.023
fshk	5295	1	0.030

Age 9 Year class = 2001
source

	survivors	N	scaledWts
FRATRB_IV	2672	4	0.124
NORTRL_IV2	2474	4	0.310
GER_OTB_IV	3341	4	0.403
NORACU	1982	4	0.104
IBTSq3	3081	3	0.027
fshk	2191	1	0.032

Table 11.3.2 Fishing mortality at age

year	age 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	0.769	0.609	0.609
1982	0.387	0.479	0.534	0.475	0.563	0.525	0.525	0.525
1983	0.307	0.466	0.656	0.763	0.937	1.030	0.920	0.920
1984	0.572	0.691	0.608	0.837	0.524	0.663	0.681	0.681
1985	0.644	1.045	0.698	0.471	0.461	0.424	0.456	0.456
1986	0.239	1.395	0.954	0.692	0.514	0.425	0.548	0.548
1987	0.363	0.867	0.840	0.519	0.528	0.496	0.519	0.519
1988	0.373	0.601	0.943	0.580	0.698	0.729	0.675	0.675
1989	0.377	0.737	0.698	0.900	0.494	0.650	0.688	0.688
1990	0.477	0.683	0.674	0.581	0.601	0.468	0.555	0.555
1991	0.459	0.789	0.610	0.465	0.432	0.424	0.444	0.444
1992	0.247	0.732	0.986	0.578	0.368	0.311	0.431	0.431
1993	0.321	0.489	0.624	0.699	0.634	0.773	0.738	0.738
1994	0.240	0.676	0.658	0.484	0.469	0.272	0.515	0.515
1995	0.140	0.565	0.569	0.399	0.963	0.734	0.940	0.940
1996	0.116	0.311	0.545	0.672	0.698	0.611	0.530	0.530
1997	0.106	0.303	0.425	0.323	0.510	0.502	0.464	0.464
1998	0.177	0.331	0.456	0.423	0.332	0.464	0.591	0.591
1999	0.077	0.380	0.531	0.449	0.516	0.705	0.760	0.760
2000	0.088	0.198	0.452	0.504	0.302	0.307	0.418	0.418
2001	0.082	0.328	0.427	0.303	0.265	0.276	0.248	0.248
2002	0.120	0.321	0.272	0.299	0.378	0.367	0.526	0.526
2003	0.108	0.173	0.330	0.315	0.411	0.428	0.447	0.447
2004	0.063	0.196	0.225	0.286	0.322	0.448	0.657	0.657
2005	0.087	0.207	0.354	0.371	0.429	0.423	0.475	0.475
2006	0.213	0.256	0.326	0.340	0.431	0.411	0.431	0.431
2007	0.182	0.268	0.316	0.329	0.353	0.361	0.208	0.208
2008	0.196	0.422	0.480	0.449	0.349	0.377	0.280	0.280
2009	0.286	0.441	0.565	0.618	0.561	0.516	0.452	0.452
2010	0.383	0.760	0.773	0.464	0.521	0.308	0.359	0.359

11.3.3. Population numbers at age

Year	3	4	5	6	7	8	9	10
1967	127456	77470	54512	6638	5177	1407	680	621
1968	114114	88671	48750	30578	3351	2796	888	1041
1969	300689	72416	53388	27984	19585	2356	2070	490
1970	291836	218825	43291	33705	16026	10843	1213	1008
1971	327932	205231	109793	21871	16622	9597	7256	2974
1972	171373	205322	115736	60269	13622	9765	5286	5132
1973	152852	96808	108298	71849	30155	7830	5330	9288
1974	148740	75983	45149	64373	44292	17063	4601	6037
1975	181239	61210	31681	24186	33985	22993	9266	7036
1976	384112	96822	26712	16601	12956	15467	10359	9984
1977	118017	126439	31260	11287	7934	7009	7811	9495
1978	92454	71776	53783	12243	4273	3078	2620	11785
1979	77651	43972	34091	27690	7027	2469	1586	6075
1980	67144	48798	23138	17793	14800	3215	1358	6076
1981	172824	39144	28786	10787	8489	6997	1592	6076
1982	109952	117810	24503	17470	5506	3932	2657	3357
1983	118231	61161	59730	11760	8894	2567	1904	2399
1984	205238	71245	31432	25365	4491	2854	750	1427
1985	311848	94803	29220	14010	8995	2178	1204	2220
1986	288242	134050	27305	11906	7159	4645	1166	2331
1987	113420	185833	27209	8614	4879	3505	2486	1891
1988	115581	64612	63953	9618	4196	2356	1748	1511
1989	77848	65152	29005	20398	4411	1708	931	1070
1990	118968	43714	25517	11816	6792	2203	730	935
1991	138422	60478	18071	10646	5409	3049	1130	1398
1992	93025	71602	22486	8039	5474	2875	1634	1319
1993	152278	59510	28208	6870	3693	3103	1725	2143
1994	103458	90451	29877	12377	2797	1605	1173	2159
1995	225510	66645	37687	12668	6245	1433	1001	1426
1996	111978	160506	31008	17466	6957	1952	563	1304
1997	165232	81667	96248	14723	7305	2834	867	851
1998	70716	121676	49401	51496	8728	3592	1404	678
1999	140145	48521	71555	25637	27614	5127	1849	1345
2000	92990	106210	27173	34440	13399	13497	2075	1416
2001	225967	69741	71308	14158	17032	8112	8131	1229
2002	194161	170481	41133	38095	8561	10700	5038	4338
2003	126370	140947	101275	25650	23138	4804	6068	3156
2004	96016	92912	97112	59609	15327	12555	2565	1827
2005	184032	73802	62509	63497	36668	9093	6566	1331
2006	56778	138065	49107	35922	35885	19539	4876	4482
2007	116407	37555	87512	29026	20937	19087	10606	5712
2008	60102	79484	23525	52246	17098	12040	10894	7810
2009	41462	40437	42667	11914	27291	9872	6764	9612
2010	81056	25508	21303	19845	5257	12749	4825	8816
2011	**118030**	**45262**	**9768**	**8048**	**10219**	**2558**	**7671**	**7803**

Table 11.4.1. Saithe in Sub-Areas IV,VI and Division IIIa. Historic stock and fishery trends

	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	890440	0.408	0.75
1971	327932	429605	265381	265381	1018390	0.329	0.62
1972	171373	474021	261877	261877	903521	0.395	0.55
1973	152852	534465	242499	242499	847458	0.416	0.45
1974	148740	554915	298351	298351	833754	0.556	0.54
1975	181239	472028	271584	271584	743380	0.482	0.58
1976	384112	351614	343967	343967	752445	0.760	0.98
1977	118017	263126	216395	216395	509441	0.615	0.82
1978	92454	268127	155141	155141	463889	0.477	0.58
1979	77651	241075	128360	128360	419175	0.396	0.53
1980	67144	235181	131908	131908	396815	0.443	0.56
1981	172824	241235	132278	132278	495217	0.306	0.55
1982	109952	210482	174351	174351	511781	0.469	0.83
1983	118231	214310	180044	180044	467317	0.548	0.84
1984	205238	176714	200834	200834	466042	0.677	1.14
1985	311848	160973	220869	220869	490737	0.715	1.37
1986	288242	152033	198596	198596	487708	0.820	1.31
1987	113420	153738	167514	167514	386140	0.647	1.09
1988	115581	149082	135172	135172	322229	0.624	0.91
1989	77848	116463	108877	108877	259963	0.678	0.93
1990	118968	105174	103800	103800	264748	0.604	0.99
1991	138422	103602	108048	108048	284638	0.581	1.04
1992	93025	104937	99742	99742	279641	0.635	0.95
1993	152278	109823	111491	111491	327171	0.533	1.02
1994	103458	119232	109622	109622	320267	0.514	0.92
1995	225510	135623	121810	121810	458728	0.418	0.90
1996	111978	149142	114997	114997	440403	0.411	0.77
1997	165232	197779	107327	107327	472418	0.289	0.54
1998	70716	198204	106123	106123	390781	0.347	0.54
1999	140145	209687	110716	110716	407698	0.359	0.53
2000	92990	208957	91322	91322	438476	0.311	0.44
2001	225967	224081	95042	95042	509890	0.285	0.42
2002	194161	223402	115395	115395	548239	0.253	0.52
2003	126370	256194	105569	105569	514928	0.231	0.41
2004	96016	310654	104237	104237	542014	0.193	0.34
2005	184032	314923	124532	124532	556827	0.255	0.40
2006	56778	298294	125681	125681	497478	0.284	0.42
2007	116407	294913	101202	101202	462647	0.274	0.34
2008	60102	276108	119305	119305	432867	0.387	0.43
2009	41462	233917	115747	115747	328723	0.478	0.49
2010	**81056**	**197327**	**102543**	**102543**	**302985**	**0.595**	**0.52**

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	2011	0.364	118030	0.81	0.81	0.00	0.2
4	2011	0.683	45262	1.24	1.24	0.15	0.2
5	2011	0.765	9768	1.64	1.64	0.70	0.2
6	2011	0.644	8048	2.12	2.12	0.90	0.2
7	2011	0.602	10219	2.66	2.66	1.00	0.2
8	2011	0.505	2558	3.09	3.09	1.00	0.2
9	2011	0.459	7671	3.63	3.63	1.00	0.2
10	2011	0.459	7803	4.62	4.62	1.00	0.2

Table 11.6.2 Saithe in Sub-Areas IV, VI and Division IIIa. Management option table.

Basis: Projection based on 2010 assessment. F(2011) = estimated from landings constraint 2011 = 0.61; R11–13 = GM88–08 =118; SSB(2012) =106.0; landings (2011) = 103

Rationale	landings 2012	landings IIIa&IV 2012[1)]	landings VI 2012[1)]	Basis	F 2012	SSB 2013	%SSB change [2)]	% TAC change [3)]
MSY framework	33.4	30.3	3.1	F_{MSY}*SSB2012/B trigger [4]	0.16	150.5	42	-68
FMSY	58.9	53.4	5.5	F_{MSY}	0.3	131.4	24	-43
MSY transition	75.3	68.3	7.1	Fpa	0.4	119.4	13	-27
Management plan	87.6	79.3	8.2	15 % TAC constraint	0.48	110.5	4	-15
Zero catch	0	0	0	F=0	0	175.8	66	-100
Management plan 5)	21.5	19.4	2.0	SSB = Blim in 2012	0.1	159.5	50	-79

Weights in '000 t.

1) Landings split according to the average in 1993–1998, i.e. 90.6% in Subarea IV and Division IIIa and 9.4% in Subarea VI.

2) SSB 2013 relative to SSB 2012.

3) Landings 2012 relative to TAC 2011.

4) equals MP rule without TAC constraints

5) MP when determining the stock status in 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	2005	2006	2007	2008	2009
Stock no. (thousands) of 3 years old	60102	41462	81056	118030	118030
Source	XSA	XSA	XSA	GM88-08	GM88-08
Status Quo F:					
% in 2011 landings	7.27	7.77	25.07	25.41	-
% in 2012 landings	3.82	3.54	15.40	36.03	22.82
% in 2011 SSB	11.35	8.36	6.3	0	-
% in 2012 SSB	8.87	6.93	20.80	11.35	0.00
% in 2013 SSB	5.18	4.74	15.11	32.87	11.21

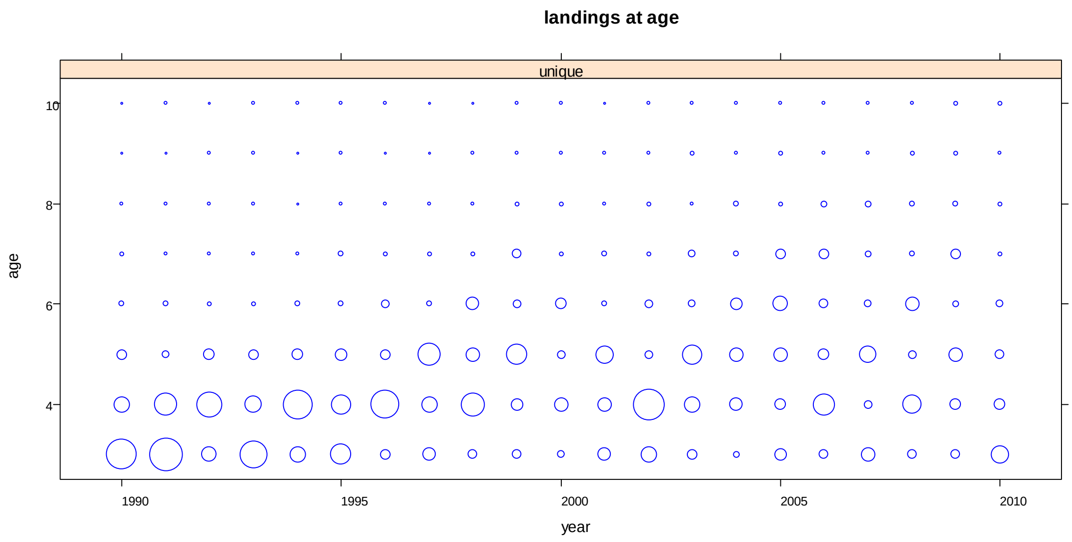


Figure 11.2.1. Saithe in Sub-Area IV, VI and Division IIIa, landings at age.

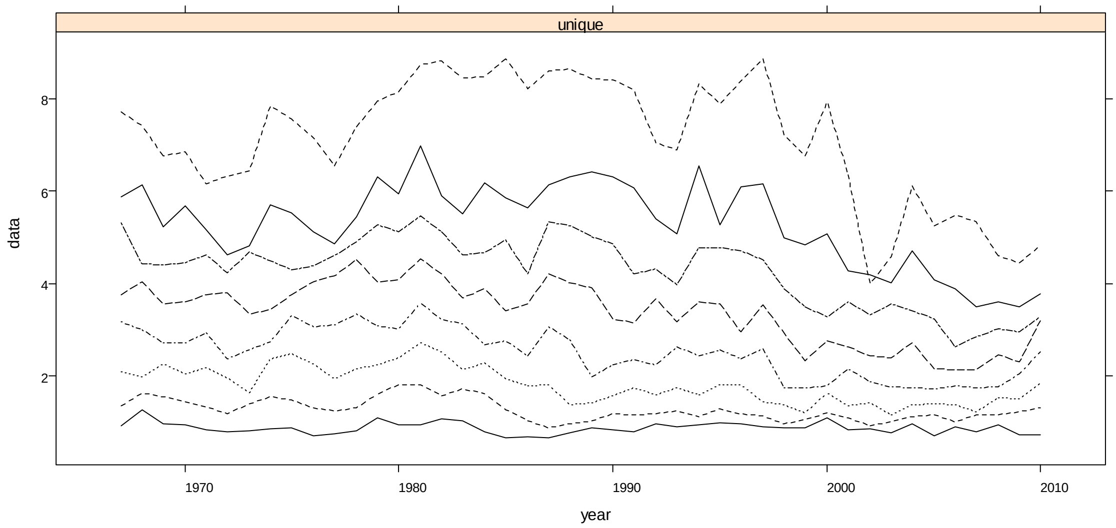


Figure 11.2.2. Weight at age in the landings for age 3-10+. These weights are also used as weight at age in the stock.

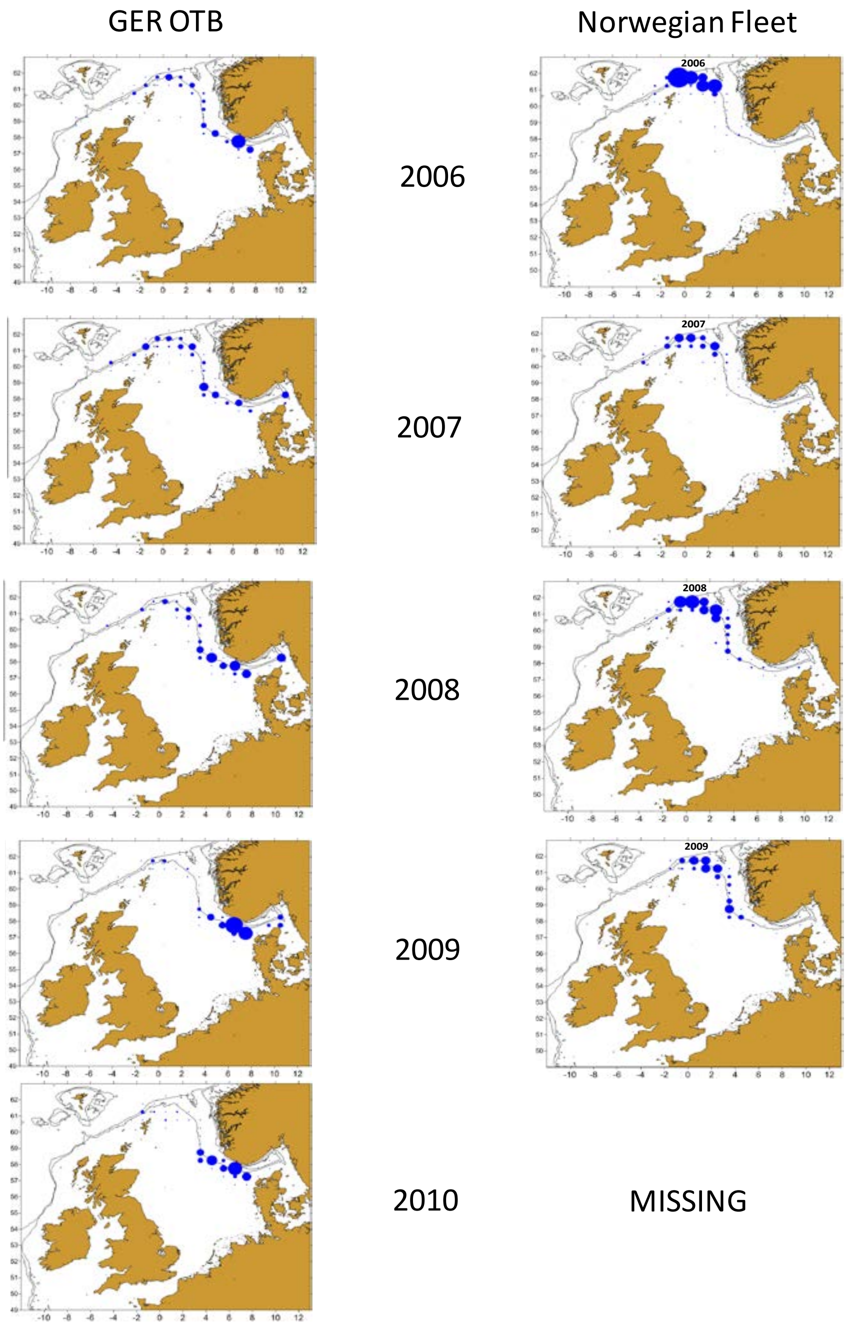


Figure 11.2.3. Spatial distribution of the German and Norwegian trawl catches 2006-2010.

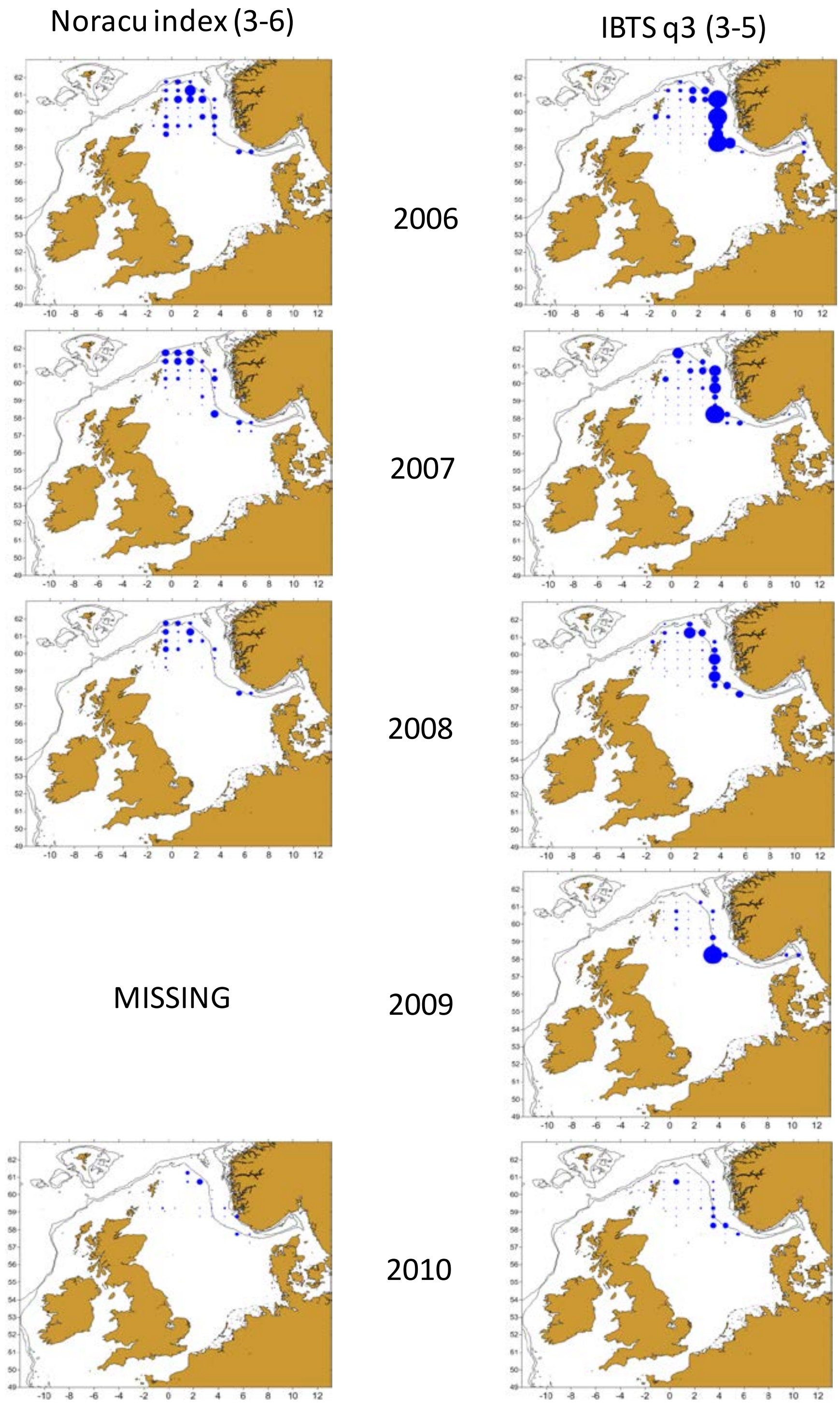


Figure 11.2.4. NORACU and IBTS Q3 indexes in the period 2006-2010.

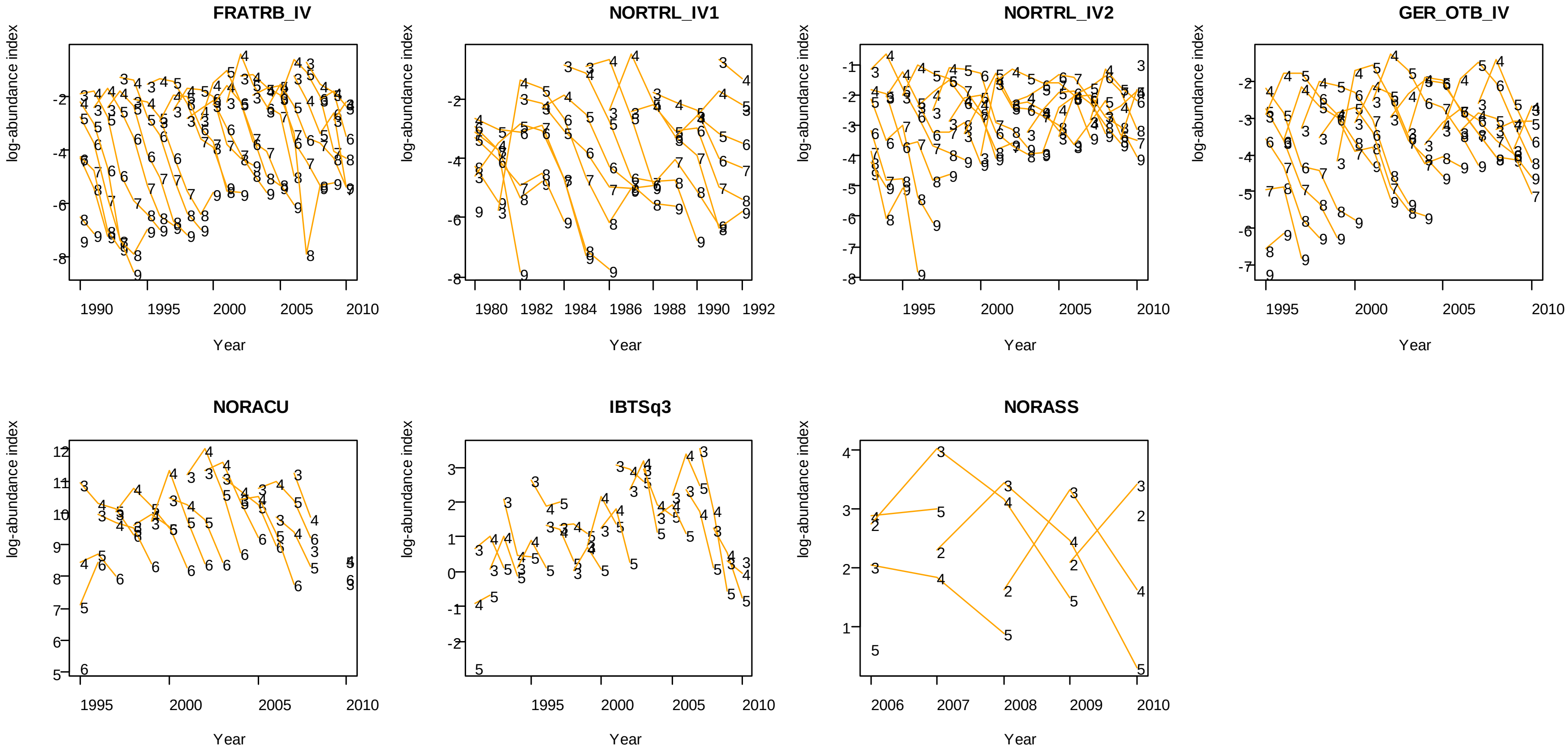


Figure 11.3.1 Saithe in Sub-Area IV, VI and Division IIIa. Log-abundance indices by cohort for each of the available tuning series.

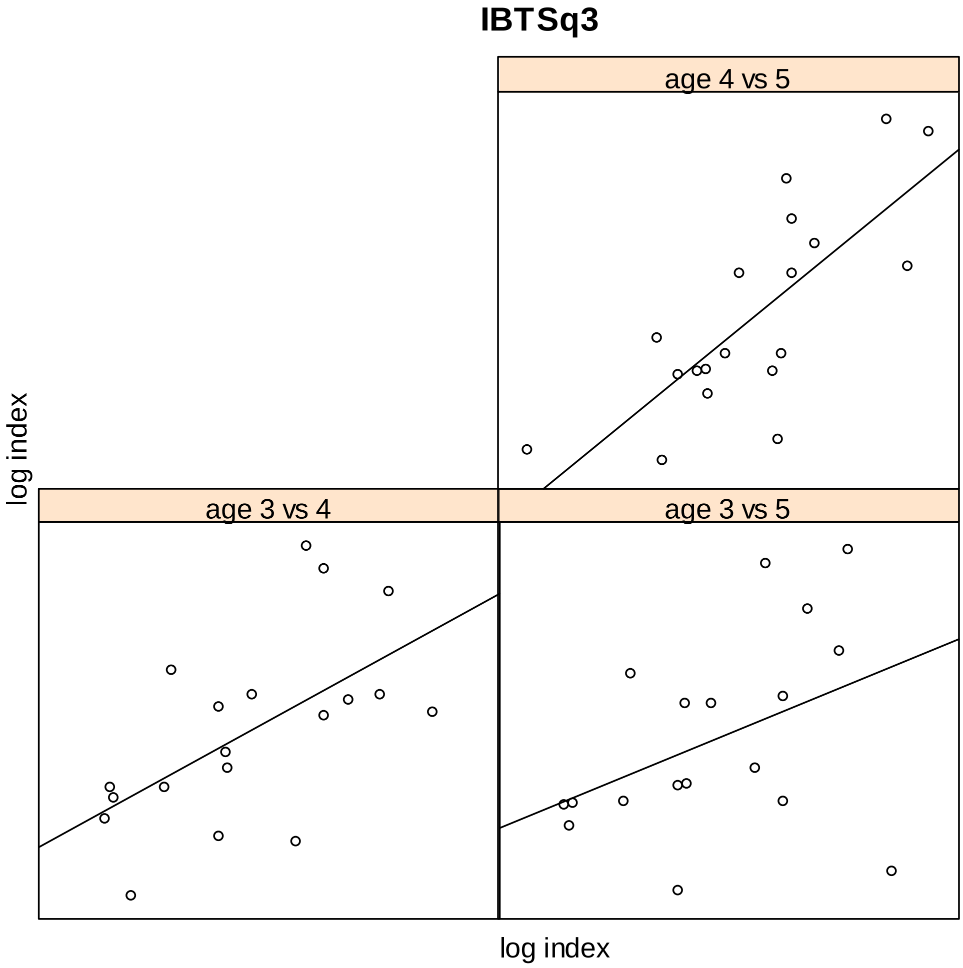


Figure 11.3.2. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for IBTSq3 for the period 1991-2010

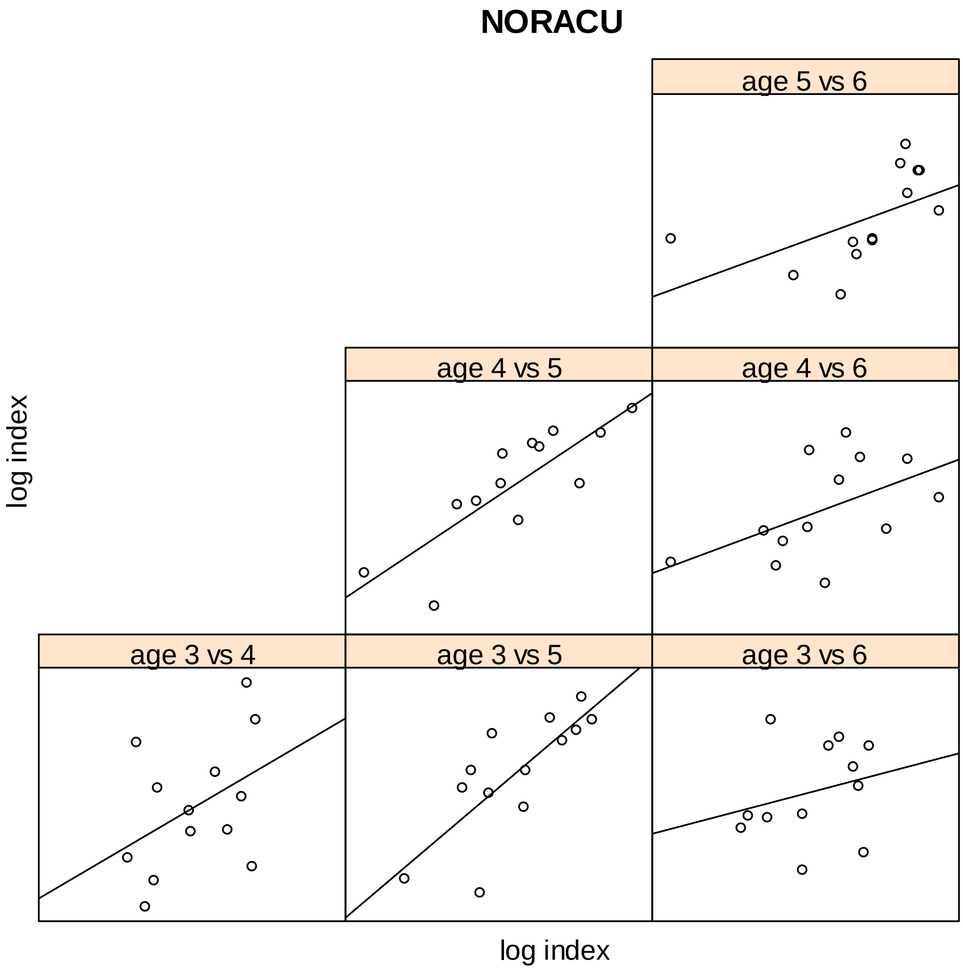


Figure 11.3.3. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NORACU for the period 1991-2010 (survey not conducted 2009).

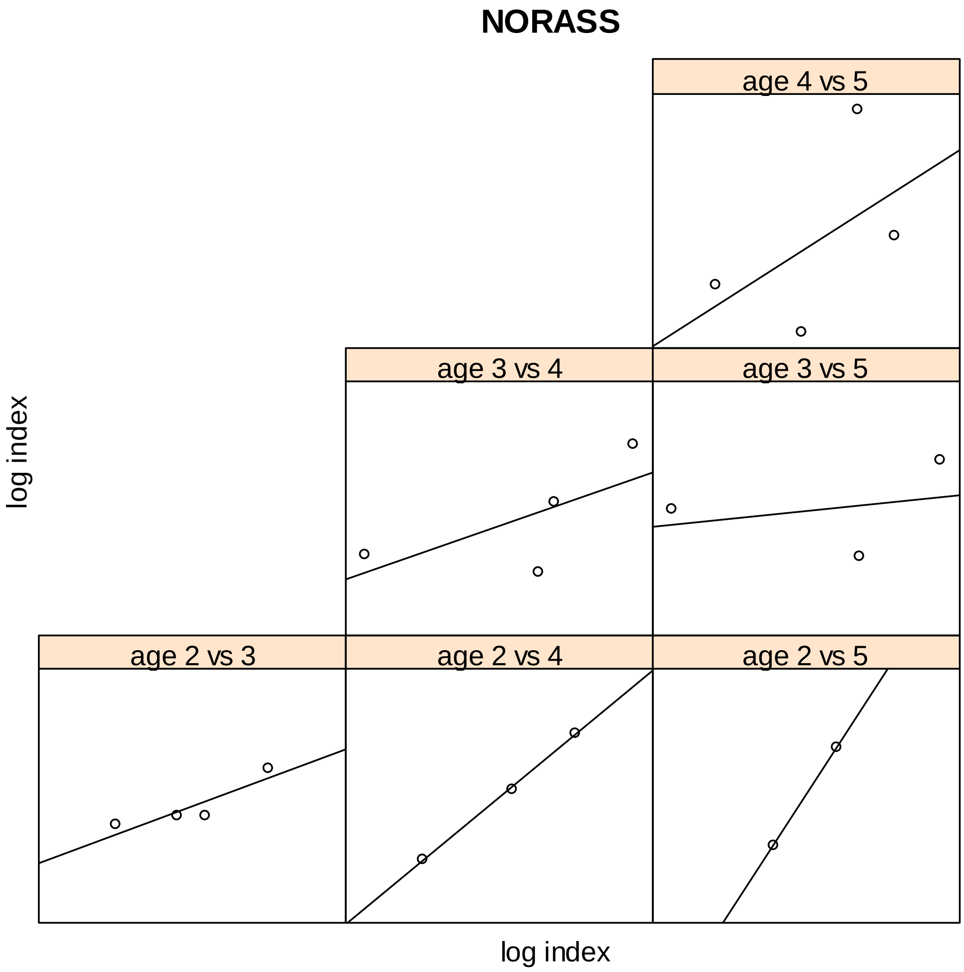


Figure 11.3.4. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NORASS for the period 2006-2010.

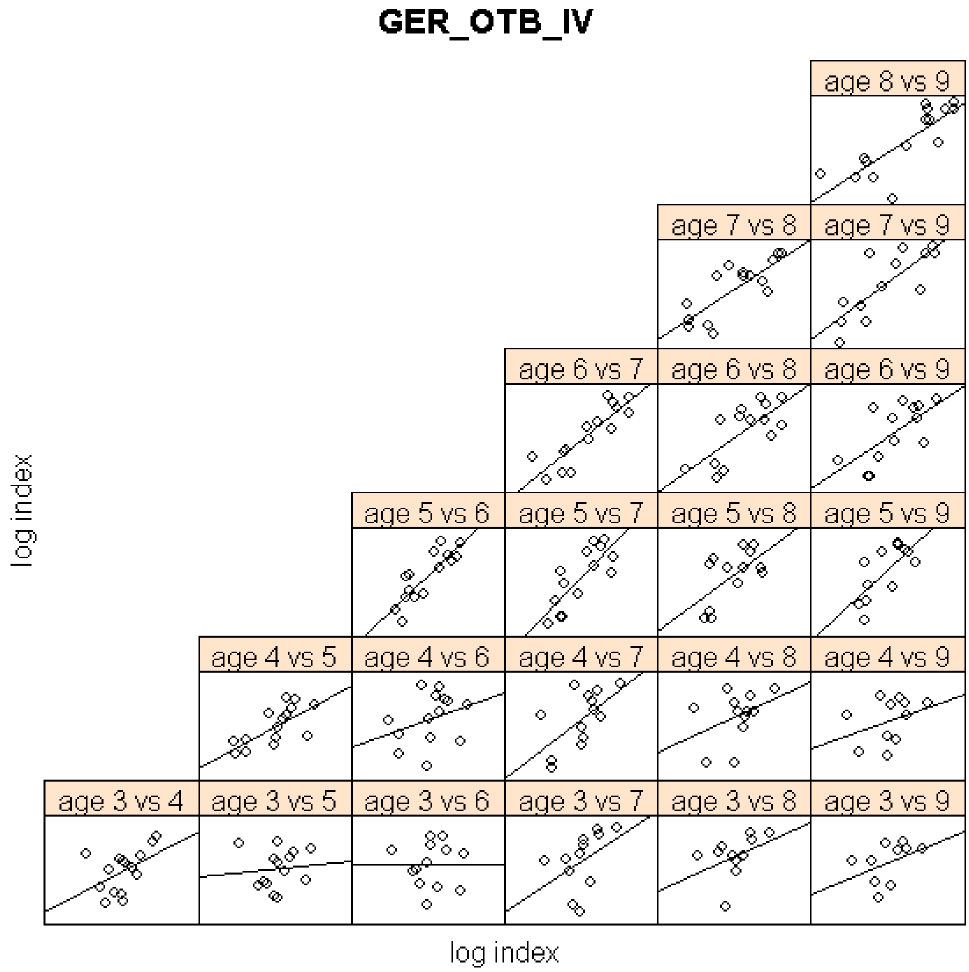


Figure 11.3.5. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for GEROTB.

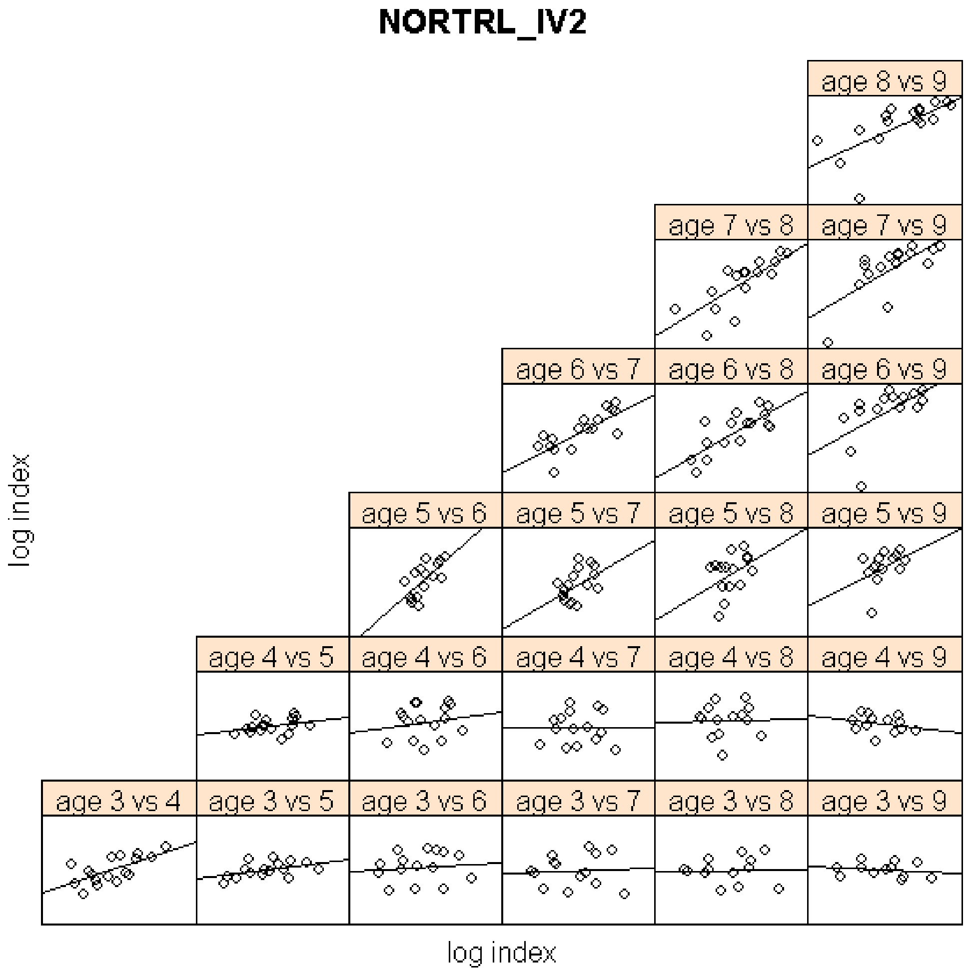


Figure 11.3.6. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for NORTRL.

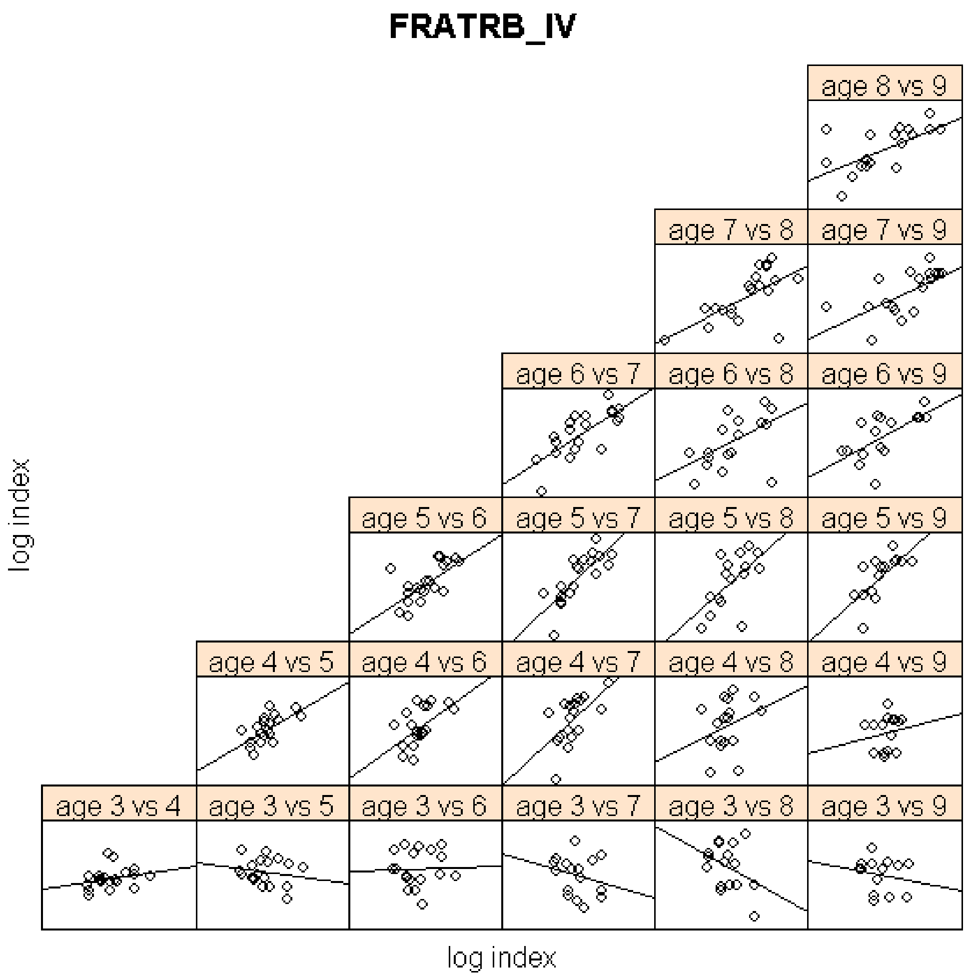


Figure 11.3.7. Saithe in Sub-Area IV, VI and Division IIIa Within-survey correlations for FRATRB.

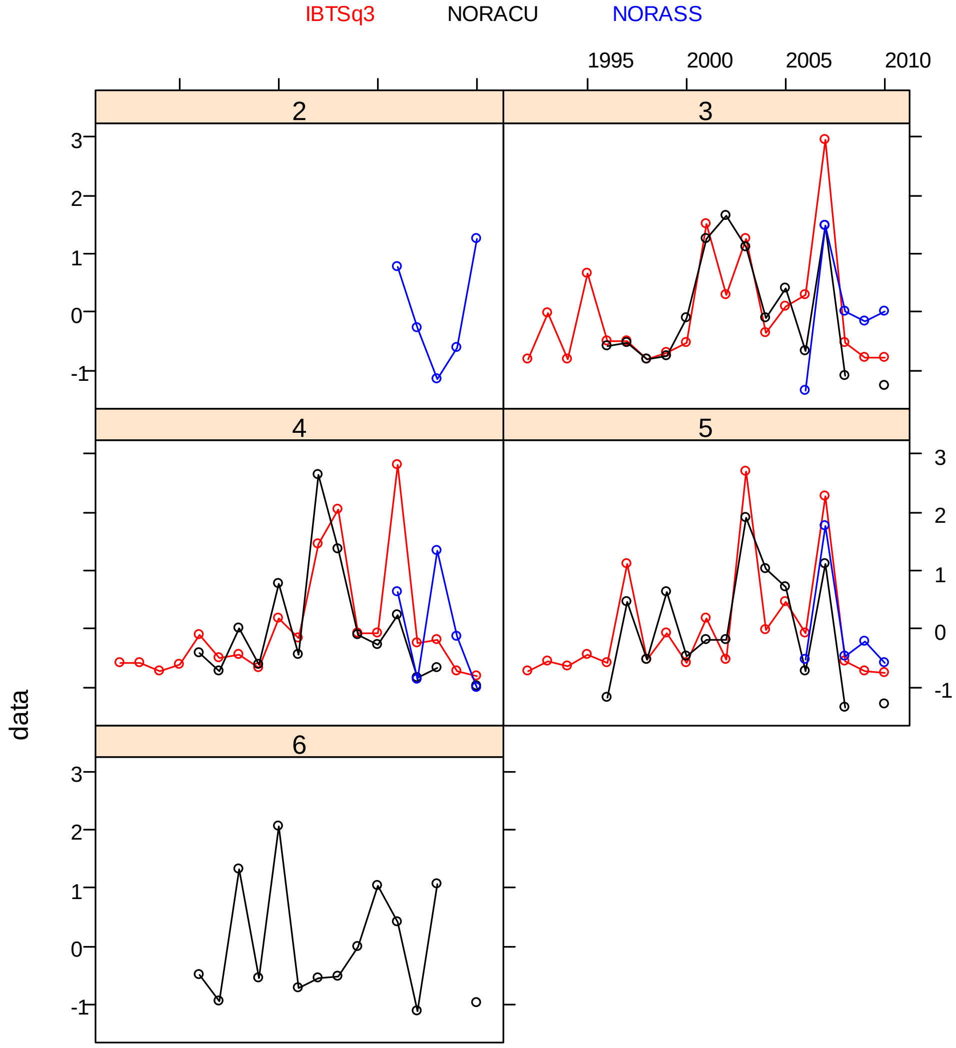


Figure 11.3.8. Saithe in Sub-Area IV, VI and Division IIIa. Standardised indices from the three survey time series.

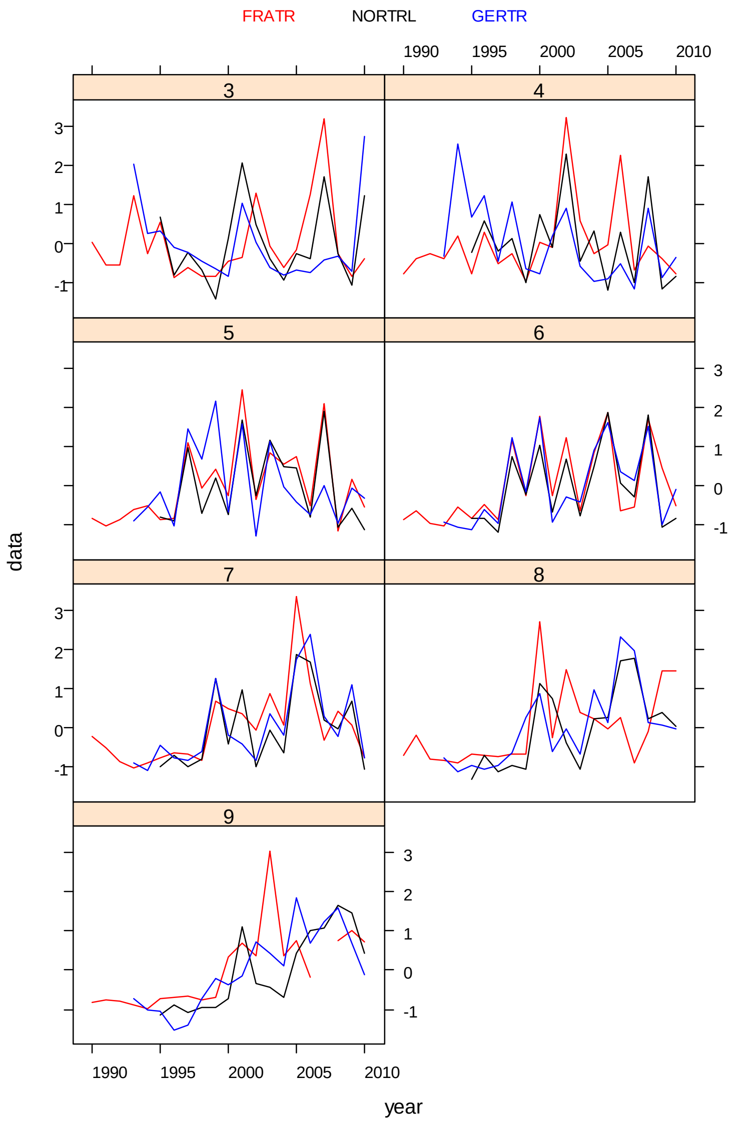


Figure 11.3.9. Saithe in Sub-Area IV, VI and Division IIIa. Standardised indices from the three commercial tuning series. Only ages 6-9 are used in the assessment.

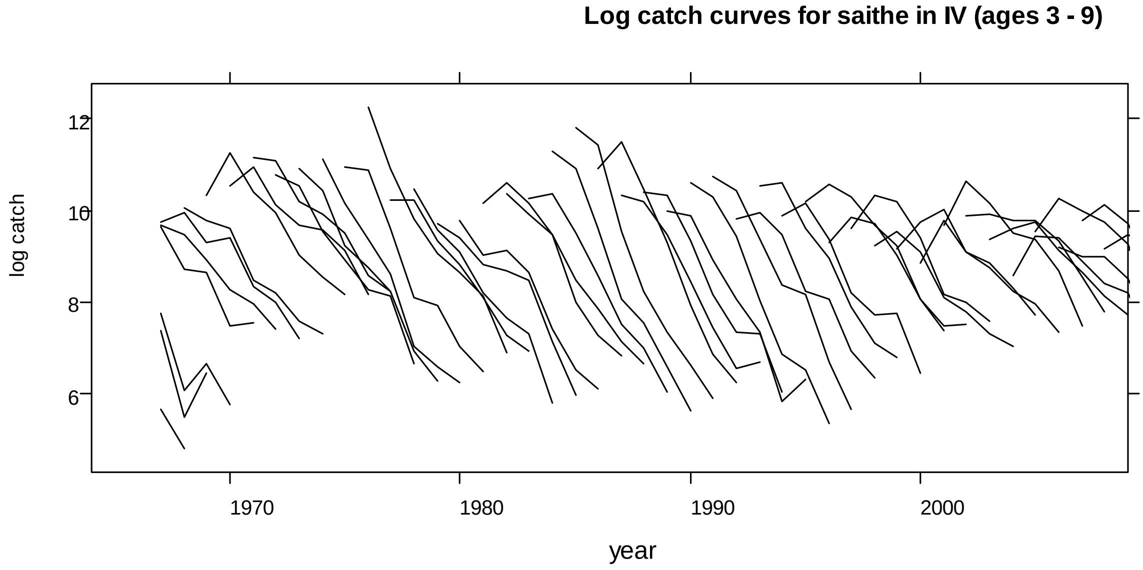


Figure 11.3.10. Saithe in Sub-Area IV, VI and Division IIIa. Log of catch curves for saithe.

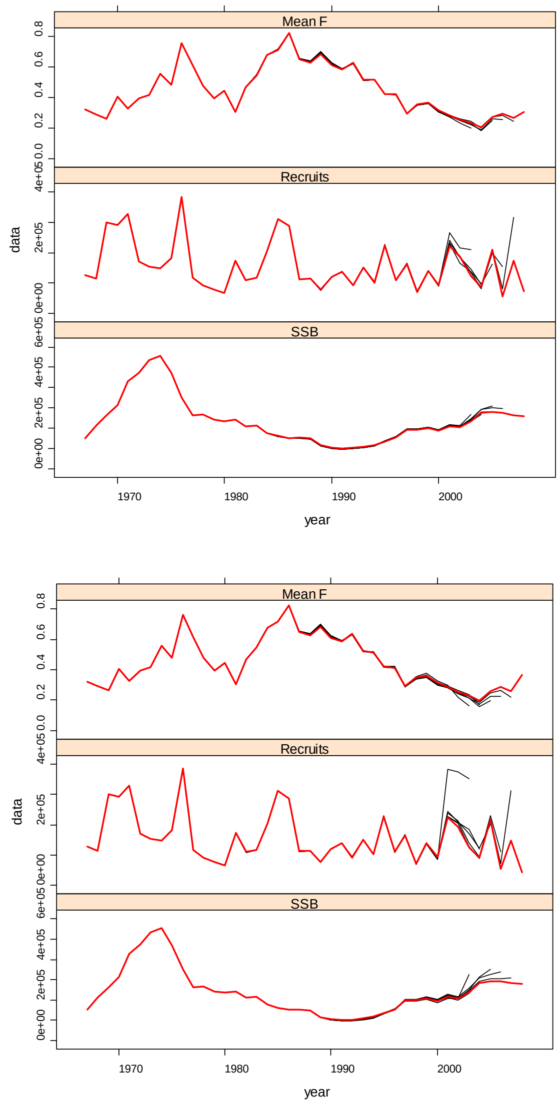


Figure 11.3.10 Sensitivity analysis, 2009 assessment: Retrospective plot for the previously accepted assessment (left), and the benchmark assessment 2011 for the same data (right), showing the retrospective pattern in F_{3-6}, R3 and SSB.

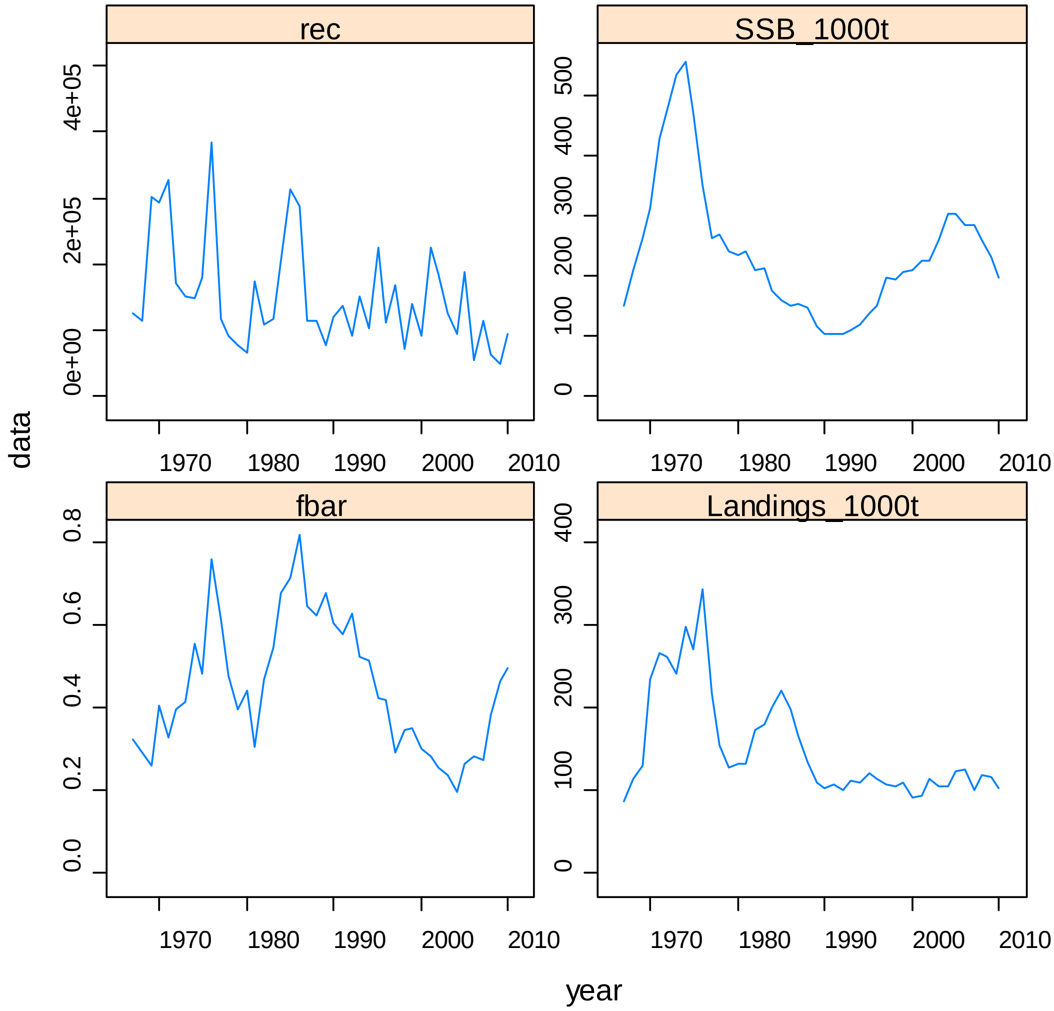


Figure 11.3.11 Sensitivity analysis: The assessment ran with settings as before WKBENCH, without NORASS and with full agespan for commercial indexes. Stock summary, historical trends in recruitment, SSB, $F_{3\text{-}6}$ and landings.

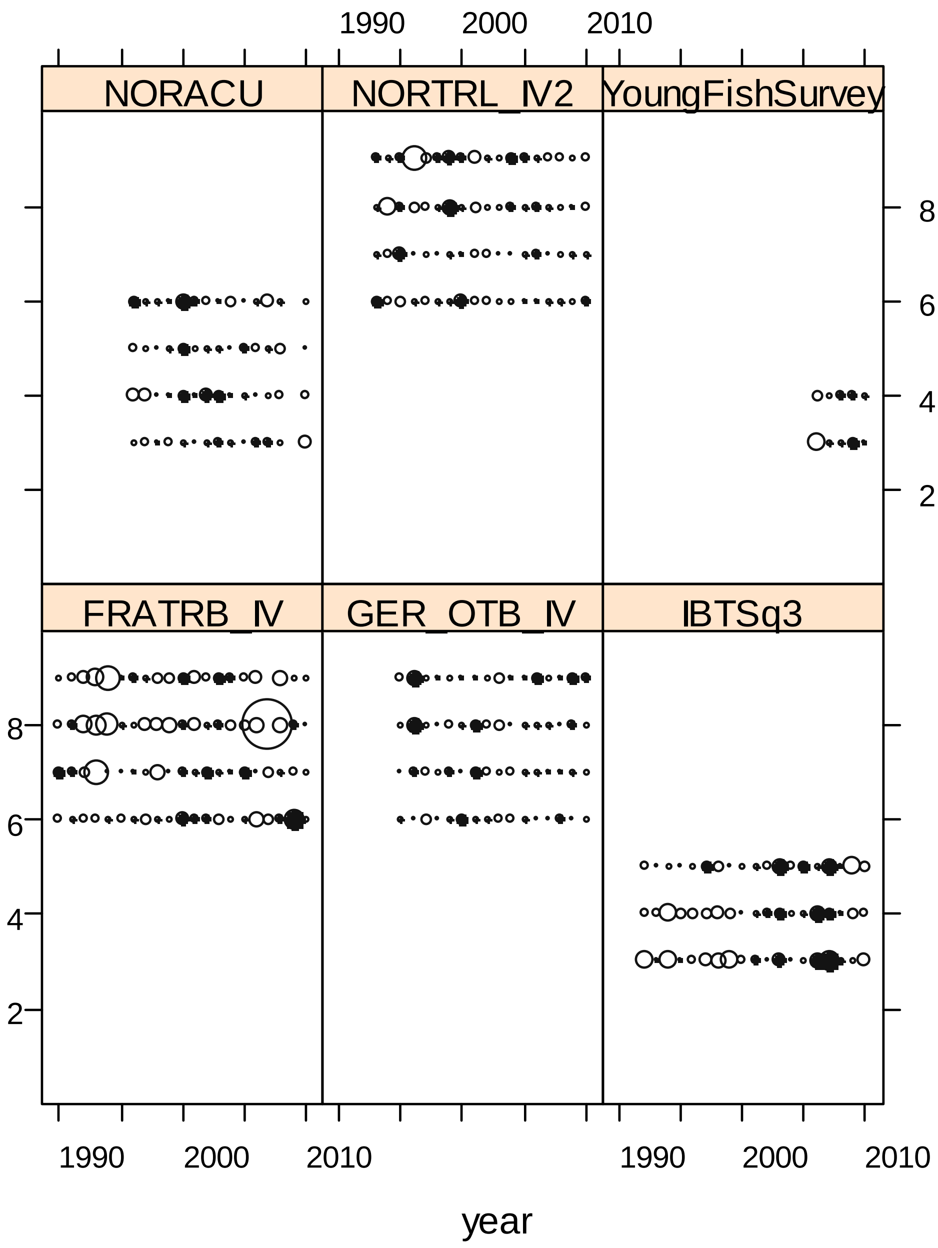


Figure 11.3.12. Log catchability residuals from the final XSA shown for each tuning fleet.

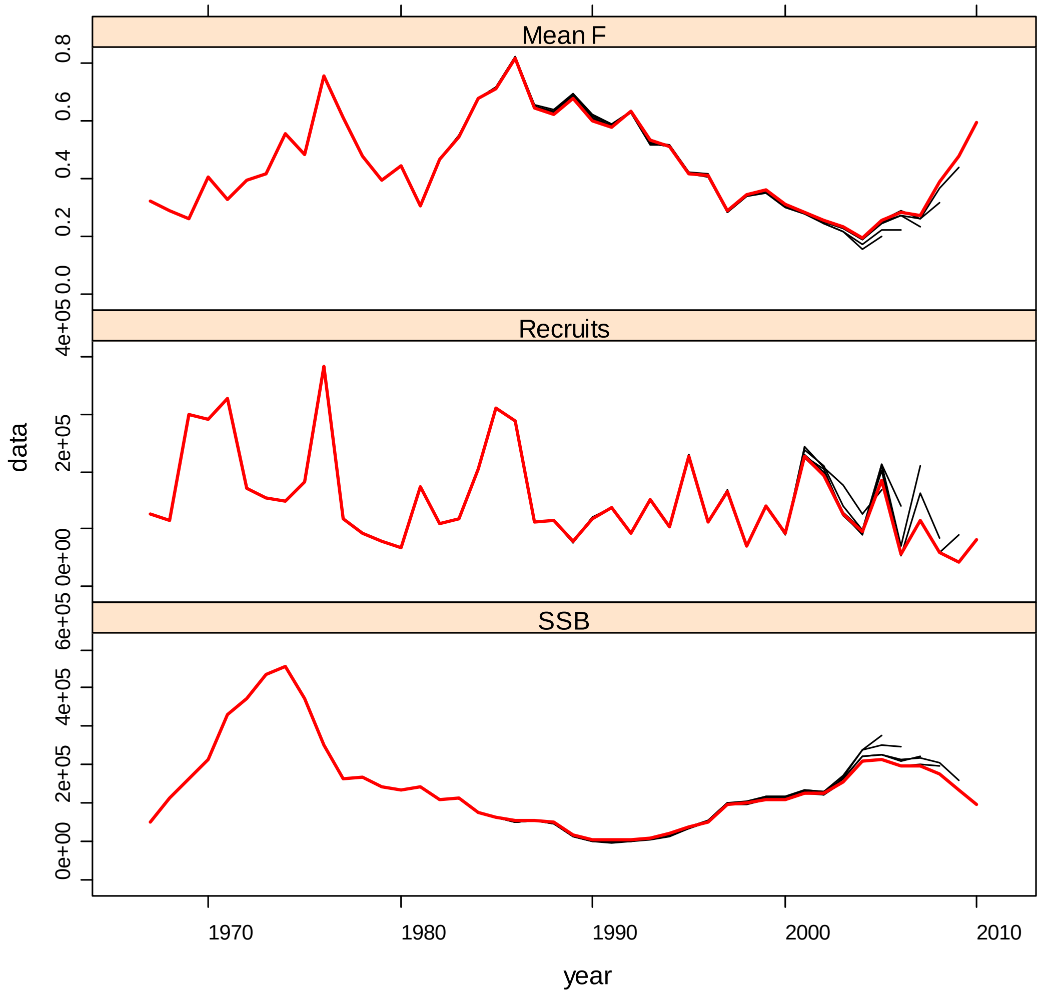


Figure 11.3.13. Retrospective plot for the final assessment, showing the retrospective pattern in $F_{3\text{-}6}$, R3 and SSB.

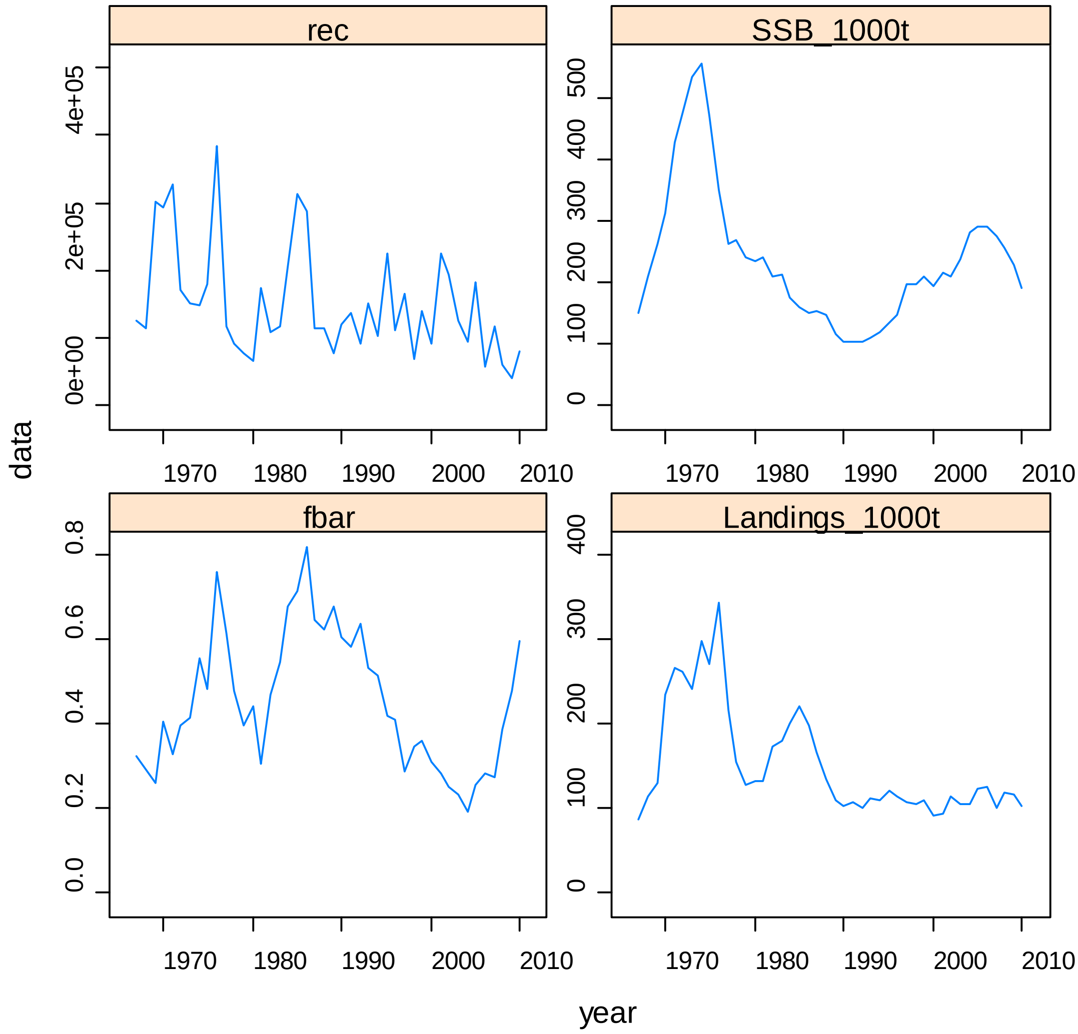


Figure 11.4.1 Stock summary, historical trends in recruitment, SSB, F_{3-6} and landings.

12 Whiting in Subarea IV and Divisions VIId and IIIa

Sections 12.1 to 12.11 contain 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. A benchmark was held for this stock in January 2009. The conclusions from the benchmark were that the assessment was consistent since 1995 and offers a reliable basis for determining stock status, including estimation of current stock size and fishing mortality. Available information on whiting from Division IIIa are presented in section 12.12

12.1 General

12.1.1 Stock Definition

No new information was presented at the working group. A summary of available information on stock-definition can be found in the Stock Annex prepared at WKROUND (2009)

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 WKROUND (2009).

12.1.3 Fisheries

Information on the fishery (and its historical development) is contained in the Stock Annex prepared at WKROUND (2009).

The recent low TACs combined with local aggregations of whiting on the East English Coast and East of Shetland has resulted in a rapid uptake of the whiting quota in recent years. In the first five months of 2009 52% of the UK North Sea quota was taken. In 2010, in the first five months 55% of the UK North Sea quota was taken. A similar picture is emerging for 2011.

Industry Contributed Reports

The Fisheries Science Partnership's North East Cod survey has been running since 2003, and covers a small but commercially important area of the North Sea on the north east coast of England. The survey does not only measure cod, but also give an index of whiting abundance for ages 0 to 7+. The final report (De Oliviera *et al.*, 2009) documents the spatial distribution and abundance of whiting from 2003 to 2008. This publication shows that the local abundance of whiting has increased in this area, particularly over the years 2005 to 2008; this is also noted in the North Sea Stock survey (Napier, 2011). The survey also notes a particularly large amount of age 1 whiting in the study area in 2008.

A new Fisheries Science partnership survey was launched in 2009 and continued in 2010. This survey targets 6 representative fishing areas covering IVa and IVb and uses commercial gears and commercial vessels to compare catch rates by age across substrate and also attempts a comparison with IBTS catch rates.

12.1.4 ICES Advice

12.1.4.1 ICES advice for 2010:

In the absence of defined reference points, the state of the stock cannot be evaluated. An analytical assessment estimates SSB in 2009 as being near the lowest level since the beginning of the time-series in 1990. Fishing mortality has declined from 2000-2004, but increased in recent years. Recruitment has been very low since 2002, with an indication of a modest improvement in the 2007 year class.

12.1.4.2 ICES advice for 2011:

To cautiously avoid impaired recruitment human consumption landings should be less than 12 700 t.

12.1.5 Management

Management of whiting is by TAC and technical measures. 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 12 900 t in 2010 and 14 832 t in 2011. There is no separate TAC for Division VIId; landings from this Division are counted against the TAC for Divisions VIIb-k combined (14 410 t in 2010 and 16 568 t in 2011). There is no way of controlling how much of the VIIb-k TAC is taken from VIId. By comparison, a specific TAC for area VIId was established for cod in 2009, and it would be recommended to follow the same procedure for whiting.

The human consumption landings in Divisions IV and 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 for the past three years.

The minimum landing size for whiting in the North Sea 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 including whiting. Regulations also apply to the area of the Norway pout box, preventing industrial fishing with small meshes in an area where the by-catch limits are likely to be exceeded.

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). In 2011, 59 closures have been implemented by 16th May. The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it 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 whiting 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).

Data available

12.1.5.1 Whiting discards in VIId

In 2009 France provided discards data including numbers at age and mean weights at age for the years 2003 to 2007 for ICES Subarea IV and Division VIId separately. In 2010 France provided discard age compositions for VIId and IV but no mean weights. France is the main prosecutor of the VIId whiting fishery and takes around 15 % of the IV landings and 90% of VIId landings. The French IV discard age compositions have been included and the North Sea data worked up resulting in a minor change to the age compositions of filled in fleets in 2003 to 2007. To include the VIId discard estimates, discards from missing years were estimated. This was done by fitting a logistic mixed model to estimate the average probability of discarding at age given total catch. Age was treated as continuous and there was a random intercept and slope co-varying for each year. The discard numbers were estimated from the mean intercept and slope (b_0 and b_1) by

$$\hat{p}_a = \frac{e^{b_0 + b_1 \text{age}}}{1 + e^{b_0 + b_1 \text{age}}}$$

and

$$\hat{d}_{ay} = \frac{\hat{p}_a}{1 - \hat{p}_a} l_{ay}$$

Where l_{ay} are the estimated numbers landed in year y at age a, and $\hat{d}_{ay}$ are the estimates of numbers discarded in year y at age a. The fitted ogive is presented in Figure 12.2.1.

The sensitivity of including extra discards in the assessment was conducted last year and very little change to the perception of the stock was seen.

12.1.6 Catch

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.

In the 2009 roundfish benchmark workshop (WKROUND, 2009) it was decided to truncate the catch data from 1990. This is due to unresolved discrepancies between survey and catch data prior to 1990.

Working group estimates of weights of the catch components for the North Sea and Eastern Channel are given in Table 12.2.2, the table covers the period 1990 to 2010. Total catch increased slightly on last year due largely to an increase in North Sea discards. The reported tonnages of the North Sea catch components remain among the lowest in the series due to a restrictive TAC, and whiting industrial by-catch remains low even following the reopening of the fishery for Norway pout in 2008. For the Eastern Channel, the total catch in 2010 is an increase on the last two years and is the third highest in the series, whereas the total catch from the North Sea is one of the lowest in the series.

Figure 12.2.3 plots the trends in the commercial catch for each component along with the IV and IIa TAC. Each component shows a general decline with recent landings stable while discards decline. Figure 12.2.4 plots trends in the commercial catch components as they contribute to the total. Industrial by-catch can be seen to be removing proportionately less through time. Human consumption landings have fluctuated around 45% of the total catch during the period 1990–2004, rising to 60% in the recent years. The proportion of discards has increased over the last ten years, but has been decreasing in the most recent period.

12.1.7 Age compositions

Age compositions in the landings were supplied by Scotland, England and France. Age compositions in the discards were supplied by Scotland, England, France and Denmark. 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 have been 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).

Proportion in number at ages 1 to 8+ in the catch of human consumption landings, discards and industrial by-catch are plotted in Figure 12.2.4. This shows a general decline in discards and industrial bycatch for ages 1 to 4, stable proportions for ages 5 to 7 and increasing discards at age 8+.

Total international catch numbers at age (IV and VIId combined) are presented in Table 12.2.3. Total catch comprises human consumption landings, discards and industrial by-catch for reduction purposes. Discards are for the North Sea (IV) and Eastern Channel (VIId). Total international human consumption landings are given in Table 12.2.4. Discard numbers at age are presented in Table 12.2.5. Industrial by-catch numbers at age for the North Sea are presented in Table 12.2.6.

12.1.8 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. These are shown graphically in Figure 12.2.5, which indicates a recent increase in mean weight at age in the landings, discards and catch for all ages except age 1. This trend in mean weights is present in all samples provided, but the sharp increase in ages 4 and 5 in the last two years largely driven by Scottish sampling data. These recent high weights are more similar to landings and industrial bycatch weights and reflect discarding of marketable fish due to the restrictive TAC. From 1992 ages 6 and above in the catch and landings have shown a periodic increase and decrease in mean weight.

Unrepresentative sampling of industrial bycatch in 2006 to 2008 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).

Mean weight at age in the catch by cohort is plotted in Figure 12.2.6. This figure shows declining mean weights in early cohorts at older ages, slow growth for the 1999 to 2002 cohorts, and steeper growth for the most recent cohorts.

12.1.9 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.

Values of Natural mortality are taken from WGSAM (2008), and are smoothed estimates of annual natural mortality estimated from the key SMS for the North Sea and are given in table 12.2.11. Values for 2008, 2009 and 2010 are those estimated for 2007.

12.1.10 Catch, effort and research vessel data

Survey distributions at age for recent years are given in Figure 12.2.7 for the IBTS Q1 (2006 – 2011, ages 1 to 4+) and in Figure 12.2.8 for the IBTS Q3 survey (2005 – 2010, ages 1 to 4+). The IBTS Q1 plots show

- Improved year class strength for the last four cohorts.
- The 2006 and 2007 year classes are concentrated to the East of England.
- In 2008, the numbers of age 2 whiting exceeded that observed at age 1 in 2007
- The 2007 cohort does not change in abundance from 2008 to 2009 and becomes more concentrated in distribution by 2010.
- The 2008 cohort does not appear to decline from 2009 to 2010 and is still prevalent in 2011.
- Recruitment in 2011 looks to be widespread
- The survey does not see many whiting to the east of Shetland.

The IBTS Q3 plots show:

- Increased recruitment in 2008 to 2010
- The numbers of age 1 whiting in 2008 do not change much in abundance from 2008 to 2009, but their distribution seems to contract.
- The survey does not see many whiting to the east of Shetland.

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) provides 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 the WKROUND (2009).

12.2 Data analyses

Reviews of last year's assessment

The review group generally agreed with the assessment, recommendations and future work, and made the following thoughtful suggestions:

- Applicable biological reference points should be sought.
- An effort should be made to address the effectiveness of recent conservation measures to reduce fishing mortality
- It might be worth looking at ecosystem aspects, particularly predation on young fish, due to evidence for variability in spatiotemporal patterns of recruitment observed in surveys
- Weight at age decreases in at older ages for some cohorts, perhaps a model with 6+ would be appropriate to explore the effects of this.
- The maturity ogive is based on IBTS data from 1981-1985. Perhaps this should be updated.

Presently there is work underway to define a long term management plan for whiting. This involves defining a suitable F and a limit below which recruitment is considered to be impaired; this in part addresses the first suggestion. There was not time in the WG to assess the effectiveness of recent conservation measures on whiting, but an effort will be made in future assessments to summaries work relating to these issues. The remaining suggestions will be revisited at the next benchmark.

12.2.1 Exploratory survey-based analyses

Catch curve analyses are shown in Figures 12.3.4 to 12.3.5. These show consistent tracking of year classes (since catch curves are mostly smooth) and consistent selection with some recent exceptions. Evident are the low 2002 – 2006 year classes. Most unusual is the lack of decline from 2009 to 2011 for the 2005 to 2009 year classes. The catchability of the IBTS Q1 seems to have changed since 2009, vastly 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 and also at age 2 for the 2007 year class. 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 year class.

The explanation of the retrospective pattern seen in the last two assessments of this stock follows from the fact that the surveys see very slow rates of decline in the recent cohorts but the catch data and the values of natural mortality set against the size of the stock say that there must be a decline through cohort, so to balance this the model says there are more recruits than we thought year on year. This pattern seems set to continue into 2011 (Figure 12.3.4).

The consistency within surveys is assessed using correlation plots. Only survey indices used in the final assessment are presented as this is an update assessment. The IBTS Q1 and Q3 surveys both show good internal consistency across all ages (Figure 12.3.6 and 12.3.7).

12.2.2 Exploratory catch-at-age-based analyses

Catch curves for the catch data are plotted in Figure 12.3.8 and shows numbers-at-age on the log scale linked by cohort. This shows partial recruitment to the fishery up to age 3. Also evident is the persistence of the 1999 to 2001 year classes in the catch and the recent low catches of the 2002 – 2007 year classes.

Within cohort correlations between ages are presented in Figure 12.3.9. In general catch numbers correlate well between cohorts with the relationship breaking down as you compare cohorts across increasing years.

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 12.3.10. The population trends from each survey are consistent; however, the absolute levels of the F and SSB estimates differ over the last 10 years. The IBTS Q1 gives a higher F, lower SSB and lower recruitment than the IBTS Q3. Residual patterns (Figure 12.3.11) show that both the 2007 and 2008 year classes have large negative residuals at age 1 for both surveys.

12.2.3 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. This has had big implications for the estimation of recruitment at age 1 in 2007 resulting in a large retrospective pattern. Catch curves analysis of survey indices suggest this is likely to continue.

12.2.4 Final assessment

The final assessment was an XSA fitted to the combined landings, discard and industrial by-catch data for the period 1990–2010. This is the same procedure as last year and that agreed at WKROUND (2009). The settings are contained 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 12.3.12. These show contrasting trends between the IBTS Q1 and Q3 surveys in the recent years: IBTS Q1 has negative residuals at ages 3-5 for 2005 to 2008, while the IBTS Q3 survey has all positive residuals. The IBTS Q3 survey also has positive residuals for ages 1 and 2 in 2009 while the IBTS Q1 has negative residuals. Both surveys indicate that the survey catchability of age 1 whiting was reduced during 2005 to 2008. Recruitment in 2009 is not consistently estimated by both surveys, the 2009 estimate being a balance of the two. The estimate of recruitment in 2010 seems more consistent between surveys. The contribution of each tuning fleet to the estimation of survivors in the most recent year is given in Figure 12.3.13.

Fishing mortality estimates are presented in Table 12.3.2, the stock numbers in Table 12.3.3 and the assessment summary in Table 12.3.4 and Figure 12.3.14. Fishing mortality at age is plotted in Figure 12.3.15. Fishing mortality can be seen to have decreased at ages 3 - 4, with a slow increase on ages 5 to 7. Fishing mortality on age 7 is very noisy at the beginning of the series.

A retrospective analysis is shown in Figures 12.3.16 and 12.3.17. This shows a consistent bias in recruitment since 2006. 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.

Comparing directly to last years' assessment, Figures 12.3.18 and 12.3.19 show the proportional change in stock number estimates and F estimates at age (as a proportion of the final assessment estimates). It can be seen that 2006 year class is still being revised upwards and there was a general downwards revision of F across all ages with a slight increase on age 1.

12.3 Historic Stock Trends

A plot of estimated F-at-age over the years 2008 to 2010 is presented in Figure 12.4.1. This figure shows the decline in F at ages 3 and 4.

Contribution of age classes to TSB and SSB is shown in Figure 12.4.2 and as proportions in Figure 12.4.3. This shows the important contribution of ages 1 and 2 to the TSB. These figures also show that in 2010, 90% of the TSB is ages 1 to 3.

Historic trends for F, SSB and recruitment are presented in Figure 12.3.14.

12.4 Recruitment estimates

The RCT3 estimate of recruitment in 2011 was 1 562 million. The geometric mean of the recruitment for 2003 to 2007 is 1 126 million and the geometric mean of all recruitments excluding the most recent two years is 2 043 million. RCT input tables are presented in Table 12.5.1, and RCT3 output is presented in Table 12.5.2.

It was agreed to use the RCT3 estimates for recruitment in 2011, however the geometric mean of the 5 recent low recruitments (2003 to 2007) was not considered sensible for recruitment in 2012 and 2013. The high recruitments in 2008 and 2009 have been verified in this years' assessment and it is the opinion of the WG that this stock is no longer in a regime of critically low recruitment. It was agreed by the WG to revert to the standard approach of estimating forecast year recruitment. The estimates of recruitment for 2012 and 2013 were taken as 2 043 million: the geometric mean of all recruitments, excluding the two most recent estimates.

12.5 Short-term forecasts

A short-term forecast was carried out based on the final XSA assessment. XSA survivors from 2010 were used as input population numbers for ages 2 and older in 2011. Recruitment assumptions are detailed in section 12.5.

The exploitation pattern was chosen as the mean exploitation pattern over the years 2008–2010. Given the recent changes in F(2–6) this exploitation pattern was scaled to the mean F(2–6) in 2010 for forecasts (Figure 12.4.1).

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 2008 – 2010 (Figure 12.2.5).

Mean weights at age are generally consistent over the recent period but there are trends at several ages (Figure 12.2.6), notably ages 4 and over in the discards. This is thought to reflect recent trends in discarding. The 2010 estimates were used for the purposes of forecasting.

Results of the short term forecast are presented in Table 12.6.1.

No TAC constraint was applied in the intermediate year since it is not considered that fishing will stop when the TAC is reached.

Estimated landings in 2011 were 24 920 t; based on 2010 TAC uptake the landings for 2011 for area IV and VIId combined will be 20 590 t. This is calculated as 88% of the TAC for Subarea IV and Division IIa (14 830 t) and 45% of the TAC for Divisions VIIb-k combined (16 570 t). However, the proportion of the VIIb-k TAC that is being removed from VIId has increased steadily from 22% in 2008 to 45% in 2010 leaving room for a further increase in 2011.

Assuming $F_{2011}=F_{2010}$ and unconstrained landings results in human consumption landings in 2011 of 24 920 t from a total catch of 37 060 t, giving an SSB in 2012 of 201 980 t - a reduction from the 2011 value of 208 690 t. For the same fishing mortality in 2012, human consumption landings are predicted to be 25 470 t from a total catch of 37 290 t resulting in an SSB in 2013 of 207 040 t. Under the assumptions of the prediction, SSB in 2013 will have increased by 14% (as compared to that estimated for 2011) in the absence of fishing in 2012.

To maintain a stable SSB landings should not exceed 24 150 t, which can be split into 16 900 t for IV and 7 250 t for VIId based on the landings statistics from the last three years (a 70-30 split respectively).

The intermediate year forecast predicts that at status quo fishing mortality, human consumption landings will exceed the TAC for 2011 by 4 330 t, this excess could be accommodated in the remaining TAC in VIIb-k and also though increased discarding of marketable fish.

12.6 MSY estimation and medium-term forecasts

Medium term projections were carried out to assess the provisional long term management plan agreed at the EU Norway negotiations in 2010. This analysis is presented in section 16.

For the first time the basis for ICES advice will be to aim for maximum sustainable yield or MSY using the reference points Fmsy and Btrigger.

There are two methods presently available to estimate Fmsy incorporating uncertainty in input parameters and allowing recruitment model selection based on AIC, unfortunately neither method is set up to deal with an industrial bycatch fleet. It is hoped this will be remedied later in the year using a spreadsheet implementation developed for haddock but in the meantime no Fmsy reference points are presented for this stock. However, from preliminary analyses (not presented) ignoring industrial bycatch Fmsy appears to be well defined in conjunction with the Ricker, Shepherd and Beverton and Holt recruitment models. Fmsy is undefined using the hockey stick model. The ranges of Fmsy for these preliminary runs were 0.33 using the Ricker model and 0.45 when using the Shepherd or Beverton and Holt models. In these fits the Shepherd model had reduced to the Beverton and Holt model. The model with the lowest AIC was the Beverton and Holt, however the Ricker was a competing model.

12.7 Biological reference points

The precautionary fishing mortality and biomass reference points agreed by the EU and Norway, (unchanged since 1999), are as follows:

B_{lim} = 225,000 t; B_{pa} = 315,000 t; F_{lim} = 0.90; F_{pa} = 0.65.

The WG considers that these reference points are not applicable to the current assessment (see discussion in 12.9)

F0.1 and Fmax were estimated based on the F at age from the final XSA assessment in each year back to 1993. F0.1 has been stable historically at around 0.4 but has been very variable in the last 5 years. Due to the shape of the yield per recruit curve, a maximum is often not reached, thus Fmax is not defined for several years. The WG considers that yield per recruit F reference points are not applicable to this stock since Fmax is undefined in most years, and the estimate of F0.1 is very variable in recent years (see WGNSSK, 2009 section 12.8). A long term average selection pattern could be used to stabilise F0.1 or a long term average of F0.1 could be interpreted as a sensible reference point.

12.8 Quality of the assessment

Previous meetings of this WG and the benchmark workshop (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 the 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 working group 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 at a time when the commercial catch-at-age data and the survey data conflict.

The low size of the age 4 + stock makes the forecast sensitive to recruitment assumptions. Recruitment in 2007 – 2008 was underestimated by the age 1 survey indices of the IBTS Q1 and Q3. It follows that the RCT3 estimate may well be an underestimate, and from the IBTS Q1 survey indices it looks as though recruitment in 2010 will be revised upwards next year. 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.

Survey information for VIId was not available in a form that could be used by the working group. 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 VIId showed it did not track cohorts well (WKROUND, 2009).

Age distributions and mean weights at age have been estimated for the industrial bycatch since 2006. This is 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 no cohort information is coming from the industrial component of the catch and this potentially reduces our ability to estimate the recruitment of the recent year classes.

The historic performance of the assessment is summarised in Figure 12.9.1.

12.9 Status of the Stock

The working group considers the status of the stock unknown with respect to biological reference points and MSY reference points for the reasons given in section 12.9 and 12.7. Nevertheless all indications are that the stock, at the level of the entire North Sea and Eastern Channel, has been at a historical low level relative to the period since 1990 and the recent increase is in large part due to an improved perception of recruitment in 2008. Fishing mortality, previously estimated to be low relative to the period since 1990, increased to a moderate level since 2005.

The recent high estimates of older whiting (ages 8 and above) is unprecedented in the assessment period. These fish have come from a period of moderate recruitment

(1999 to 2002) implying that further moderate recruitments may be sufficient to allow an improvement in the stock.

12.10 Management Considerations

Discard age compositions are available from France for 2003 to 2007 and 2009 to 2010 for Division VIId. To include these data, discards from Division VIId were estimated for 1990 to 2002 and 2008 using an estimated ogive based on the 2003 to 2007 data. This resulted in a minor increase in the whole stock through a minor increase in recruitment estimates.

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. Recruitment in 2008 and 2009 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 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 has increased on younger ages due to increased discarding in the recent year 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. The ICES WGMIXFISH Group 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 a 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 2011 if this is the case.

12.11 Whiting in Division IIIa

12.11.1 General

12.11.1.1 Stock Definition

No new information was presented at the working group.

12.11.1.2 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 WGNSSK (2011)

12.11.1.3 Fisheries

Information on the fisheries was provided by Sweden in terms of the spatial distribution of the Swedish landings in 2010 using logbooks information. The plot is reported in Figure 12.12.1 and showed that higher landings occurred along the Swedish coastline in comparison with off shore location in the central Skagerrak. A summary of available information on fisheries is presented in the Stock Annex prepared at WGNSSK (2011)

12.11.2 Data available

The new data available for this stock are too sparse to revise the advice from last year and therefore no assessment of this stock was undertaken. Total landings are shown in Table 12.12.1.

The WGNSSK requested ICES to produce IBTS indices and the plots for the age distribution for IBTS Q1 and IBTS Q3 are presented in Figure 12.12.2 and indicate the presence of high interannual variability.

Plots of the IBTS Q1 and IBTS Q3 are shown in Figures 12.12.1 and 12.12.2.

12.11.3 Data analyses

12.11.3.1 Exploratory survey-based analysis

Based on the information provided by the IBTS indices for Q1 and Q3 a SURBAR analysis was performed. The summary plot from this run is given is Figure 12.12.3 and indicate the presence of no trends in the mean mortality (Z), the relative spawning stock biomass (SSB), relative total biomass and recruitment.

The parameter estimates for the age-effect in Z (*s*), the year-effect in Z (*f*) and the cohort effect (*r*) are presented in Figure 12.12.4 and indicate a separate cohort-effect estimates for older fish from age-1 fish. The plots of the log residual estimates per age class for IBTS Q1 and IBTS Q3 in Figure 12.12.5 showed the presence of no trends.

The retrospective analysis plots for mean total mortality (Z) over ages 2 and 4, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment reported in Figure 12.12.5, provided further evidence that no trends were observed.

12.11.3.2 Conclusions drawn from exploratory analysis

The SURBAR analysis provided useful information based on the available IBTS indices for Q1 and Q3, however the estimates were uncertain based on the 90% CI and no further considerations for this stock can be provided.

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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	529	536	454	270	248	144	105	93	45	115	162	147
Denmark	58	105	105	96	89	62	57	251	78.5	42	80	158
France	0	2527	3455	3314	2675	1721	1261	2711	3312	3051	2304	2631
Germany	176	424	402	354	334	296	149	252	76	76	125	156
Netherlands	1795	1884	2478	2425	1442	977	805	702	618	656	718	615
Norway	68	33	44	47	38.5	23	16	17	11	92	73	118
Sweden	9	4	6	7	10	2	0	1	1	1	4	8
UK (E.&W)	2268	1782	1301	1322	680	1209	2560	3539	3048	1541	1397	
UK (Scotland)	17206	17158	10589	7756	5734	5057	3441	8093	9063	8850	7456	
UK (Total)												7841
Total	**22109**	**24453**	**18834**	**15591**	**11251**	**9491**	**8394**	**15659**	**16253**	**14424**	**12319**	**11674**
Unallocated landings	3591	-173	426	-721	-800.5	-541	2286	-562	-587	-945	-545	607
WG estimate of H.Cons. landings	25700	24280	19260	14870	10450	8950	10680	15097	15666	13479	11774	12281
WG estimate of discards	22109	21931	16130	17144	26135	18142	10300	14018	5206	8356	5223	7853
WG estimate of Ind. By-catch	5040	9160	940	7270	2730	1210	890	2190	1240	1020	1350	1750
WG estimate of total catch	**52849**	**55371**	**36330**	**39284**	**39315**	**28302**	**21870**	**31305**	**22112**	**22855**	**18347**	**21884**

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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	48	65	75	58	67	46	45	73	75	69	71	88
France		5875	6338	5172	6654	5006	4638	3487	3135	2875	6266	5436
Nether-lands	6	14	67	19	175	132	128	117	118	162	112	270
UK (E.&W)	135	118	134	112	109	99	90	53	50	54	86	253
Total	**189**	**6072**	**6614**	**5361**	**7005**	**5283**	**4901**	**3730**	**3378**	**3160**	**6535**	**6074**
Unallo-cated	4241	-1772	-814	439	-1295	-933	-111	-287	-124	1311	111	-135
W.G Esti-mate of H.Cons. landings	4430	4300	5800	5800	5710	4350	4790	3443	3254	4471	6646	5939
WG esti-mate of discards	3571	4129	3109	1356	604	907	2219	2291	1763	1943	2477	3727
W.G. esti-mate Catch	**8001**	**8429**	**8910**	**7156**	**6315**	**5258**	**7010**	**5735**	**5018**	**6415**	**9123**	**9666**

Estimated Catch Subarea IV and Division VIId

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
W.G. estimate	60850	63800	45240	46440	45630	33560	28880	37040	27130	29270	27470	31550

Annual TAC for Subarea IV and Division IIa

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
44,000	30,000	29,700	41,000	16,000	16,000	28,500	23,800	23,800	17,850	15,173	12,897	14,832

Annual TAC for Divisions VIIb-k combined

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
25,000	22,000	21,000	31,700	31,700	27,000	21,600	19,940	19,940	19,940	16,949	14,407	16,568

Table 12.2.2 Whiting in IV and VIId. WG estimates of catch components by weight ('000s tonnes).

	Sub Area IV (North Sea)				VIId (Eastern Channel)			Total	VIId HC as a proportion of total HC
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	152.60	7.6%
1991	46.21	30.84	39.76	116.81	5.72	4.22	9.94	126.75	11.0%
1992	45.21	28.47	25.04	98.72	5.74	4.09	9.83	108.55	11.3%
1993	46.61	41.40	20.72	108.73	5.21	2.97	8.18	116.91	10.1%
1994	41.87	31.84	17.47	91.18	6.62	3.85	10.47	101.65	13.7%
1995	40.55	28.94	27.38	96.87	5.39	3.24	8.63	105.50	11.7%
1996	35.55	27.13	5.12	67.80	4.95	3.37	8.32	76.12	12.2%
1997	30.94	16.66	6.21	53.81	4.62	3.00	7.62	61.43	13.0%
1998	23.69	12.48	3.49	39.66	4.60	3.21	7.81	47.47	16.3%
1999	25.70	22.11	5.04	52.85	4.43	3.57	8.00	60.85	14.7%
2000	24.28	21.93	9.16	55.37	4.30	4.13	8.43	63.80	15.0%
2001	19.26	16.13	0.94	36.33	5.80	3.11	8.91	45.24	23.1%
2002	14.87	17.14	7.27	39.28	5.80	1.36	7.16	46.44	28.1%
2003	10.45	26.14	2.73	39.32	5.71	0.60	6.31	45.63	35.3%
2004	8.95	18.14	1.21	28.30	4.35	0.91	5.26	33.56	32.7%
2005	10.68	10.30	0.89	21.87	4.79	2.22	7.01	28.88	31.0%
2006	15.10	14.02	2.19	31.31	3.44	2.29	5.73	37.04	18.6%
2007	15.67	5.21	1.24	22.11	3.25	1.76	5.02	27.13	17.2%
2008	13.48	8.36	1.02	22.86	4.47	1.94	6.41	29.27	24.9%
2009	11.77	5.22	1.35	18.35	6.65	2.48	9.12	27.47	36.1%
2010	12.28	7.85	1.75	21.88	5.94	3.73	9.67	31.55	32.6%
min.	8.95	5.21	0.89	18.35	3.25	0.60	5.02	27.13	7.6%
mean	25.49	21.07	11.02	57.58	5.01	2.83	7.84	65.42	19.8%
max.	46.61	52.27	51.34	145.79	6.65	4.22	10.47	152.60	36.1%

Table 12.2.3 Whiting in IV and VIId. Total catch numbers at age (thousands).

year	1	2	3	4	5	6	7	8+
1990	258102	501372	127966	84147	31102	1934	719	109
1991	135797	194921	184960	36290	25554	5339	526	268
1992	230301	167478	87819	91081	11654	6634	2546	112
1993	223424	172048	125599	46181	45300	3899	1501	754
1994	191544	158369	97559	51040	18683	17905	1258	514
1995	148170	144023	112416	35649	15062	5117	4472	470
1996	86318	118910	99644	48303	14088	4638	1281	1095
1997	60945	80471	84336	41975	18304	3333	1012	456
1998	92556	50361	43423	36295	17627	6343	1416	405
1999	189162	95416	45920	33921	18271	7443	2021	672
2000	82544	129582	63706	23913	16198	8758	4309	1264
2001	52566	83086	52076	20799	9256	4826	2233	1268
2002	51338	62462	84600	34659	8098	2048	1461	755
2003	83680	111144	55866	41840	14218	2358	473	397
2004	47967	23009	32557	30401	21755	8342	1351	307
2005	47805	34627	12204	18146	14931	8979	3041	654
2006	73908	42198	21652	8642	15076	11822	4618	1458
2007	39041	34000	24900	9905	4009	7656	5267	3117
2008	67209	30743	23770	13945	4408	1877	3957	2952
2009	21558	57094	15256	11726	5364	1419	614	2836
2010	28289	61405	25239	8166	5435	2879	519	1510

Table 12.2.4 Whiting in IV and 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	268
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	1157
2001	12260	28476	27293	17491	8633	4503	2091	1249
2002	2610	10346	30890	22353	6712	1710	1330	639
2003	403	11613	13990	18974	9513	1861	443	396
2004	3973	2812	9629	13302	11846	4409	747	274
2005	11009	10414	5669	10926	10283	5933	2343	429
2006	11055	11023	8494	5362	12259	10161	4118	1192
2007	10378	14740	16491	7666	3310	6681	4227	2638
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

Table 12.2.5 Whiting in IV and VIId. Discard numbers at age (thousands). , representing North Sea and Eastern Channel discards.

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	105837	63829	27659	23115	1231	355	1064	2
1993	128248	104844	51054	9205	10727	521	131	0
1994	96889	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	50702	24200	17053	11076	2987	936	213	106
1999	96412	56365	15228	9016	3104	862	167	85
2000	48161	81085	24082	3075	2311	1560	478	107
2001	39825	52156	23055	2795	471	283	142	19
2002	10597	33371	45124	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	265
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	30045	8121	2637	1194	1082	151	344

Table 12.2.6 Whiting in IV and VIId. Industrial bycatch numbers at age (thousands). Representing the industrial fishery in the North Sea.

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	5046	2441	1030	374	103	29	3	1
2009	6685	3234	1364	495	137	39	4	1
2010	8708	4213	1777	645	178	50	6	1

Table 12.2.7 Whiting in IV and VIId. Total catch mean weights at age (kg).

year	1	2	3	4	5	6	7	8+
1990	0.084	0.137	0.210	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	0.401
1992	0.085	0.185	0.257	0.277	0.331	0.346	0.313	0.506
1993	0.073	0.174	0.250	0.316	0.328	0.346	0.400	0.379
1994	0.084	0.167	0.255	0.328	0.382	0.376	0.419	0.431
1995	0.089	0.180	0.257	0.340	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	0.387	0.422
1998	0.090	0.179	0.236	0.281	0.314	0.340	0.333	0.369
1999	0.078	0.174	0.232	0.256	0.289	0.305	0.311	0.291
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	0.350	0.343	0.336
2003	0.057	0.118	0.193	0.259	0.299	0.354	0.385	0.368
2004	0.111	0.150	0.213	0.253	0.286	0.285	0.286	0.351
2005	0.124	0.199	0.239	0.250	0.282	0.305	0.298	0.287
2006	0.131	0.180	0.231	0.274	0.288	0.360	0.345	0.316
2007	0.098	0.206	0.257	0.325	0.345	0.309	0.309	0.319
2008	0.100	0.210	0.279	0.314	0.401	0.407	0.317	0.354
2009	0.089	0.218	0.287	0.380	0.401	0.464	0.393	0.328
2010	0.085	0.224	0.303	0.374	0.448	0.422	0.458	0.373

Table 12.2.8 Whiting in IV and 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	0.401
1992	0.194	0.246	0.289	0.306	0.340	0.356	0.383	0.501
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	0.410
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	0.260	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	0.320	0.301
2000	0.166	0.227	0.272	0.299	0.292	0.313	0.276	0.269
2001	0.160	0.216	0.268	0.285	0.267	0.301	0.288	0.293
2002	0.183	0.214	0.260	0.293	0.313	0.364	0.350	0.333
2003	0.208	0.228	0.258	0.308	0.311	0.374	0.391	0.369
2004	0.210	0.216	0.242	0.290	0.326	0.330	0.334	0.363
2005	0.205	0.253	0.277	0.270	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	0.280	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	0.470	0.479	0.541	0.388

Table 12.2.9 Whiting in IV and 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	0.130	0.183	0.186	0.196	0.249	0.302	0.000
1991	0.089	0.154	0.177	0.213	0.230	0.253	0.268	0.000
1992	0.093	0.173	0.210	0.215	0.241	0.245	0.220	1.183
1993	0.087	0.160	0.205	0.237	0.235	0.225	0.213	0.000
1994	0.090	0.151	0.203	0.230	0.244	0.254	0.332	0.000
1995	0.102	0.163	0.204	0.233	0.247	0.247	0.332	0.290
1996	0.094	0.151	0.198	0.225	0.281	0.265	0.304	0.000
1997	0.125	0.181	0.213	0.225	0.233	0.256	0.617	0.352
1998	0.086	0.173	0.204	0.228	0.234	0.224	0.247	0.206
1999	0.100	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	0.240	0.225	0.243
2002	0.130	0.167	0.196	0.224	0.224	0.225	0.272	0.352
2003	0.062	0.105	0.170	0.214	0.262	0.257	0.293	0.055
2004	0.131	0.158	0.203	0.223	0.239	0.235	0.227	0.245
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	0.170	0.214	0.225	0.247	0.237	0.215	0.217
2008	0.072	0.181	0.213	0.230	0.265	0.328	0.244	0.293
2009	0.089	0.193	0.243	0.376	0.393	0.484	0.286	0.319
2010	0.075	0.211	0.272	0.319	0.384	0.330	0.254	0.323

Table 12.2.10 Whiting in IV and 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	0.280	0.355	0.335	0.472
1991	0.105	0.136	0.215	0.272	0.265	0.279	0.322	0.000
1992	0.068	0.151	0.235	0.244	0.364	0.219	0.256	0.282
1993	0.045	0.156	0.260	0.264	0.307	0.235	0.392	0.000
1994	0.055	0.131	0.259	0.388	0.521	0.555	0.440	0.555
1995	0.072	0.160	0.312	0.373	0.511	0.000	0.000	0.000
1996	0.064	0.151	0.239	0.233	0.347	0.250	0.000	0.000
1997	0.051	0.145	0.252	0.321	0.348	0.588	0.000	0.000
1998	0.049	0.115	0.220	0.304	0.286	0.000	0.000	0.000
1999	0.027	0.077	0.144	0.194	0.286	0.000	0.000	0.000
2000	0.051	0.166	0.242	0.289	0.339	0.000	0.588	0.000
2001	0.055	0.118	0.225	0.320	0.351	0.386	0.000	0.000
2002	0.044	0.101	0.185	0.294	0.415	0.380	0.000	0.000
2003	0.035	0.102	0.189	0.302	0.418	0.462	0.000	0.000
2004	0.032	0.083	0.143	0.264	0.362	0.380	0.000	0.000
2005	0.043	0.133	0.196	0.205	0.366	0.438	0.541	0.530
2006	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530
2007	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530
2008	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530
2009	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530
2010	0.046	0.119	0.208	0.277	0.362	0.401	0.564	0.530

Table 12.2.11 Whiting in IV and VIId. Natural mortality at age. These data come from the key run of the multispecies working group (WGSAM, 2008), data is available up to 2007. Natural mortality for 2008 , 2009 and 2010 is assumed equal to that in 2007.

year	1	2	3	4	5	6	7	8+
1990	1.312	0.495	0.381	0.373	0.362	0.345	0.334	0.306
1991	1.321	0.485	0.374	0.367	0.358	0.341	0.332	0.308
1992	1.332	0.479	0.368	0.361	0.354	0.339	0.330	0.310
1993	1.347	0.475	0.363	0.357	0.352	0.336	0.329	0.312
1994	1.364	0.473	0.359	0.353	0.350	0.335	0.328	0.314
1995	1.383	0.472	0.356	0.350	0.348	0.333	0.328	0.315
1996	1.405	0.471	0.354	0.347	0.347	0.332	0.328	0.316
1997	1.429	0.470	0.351	0.344	0.345	0.331	0.328	0.317
1998	1.455	0.470	0.349	0.341	0.343	0.330	0.328	0.317
1999	1.483	0.471	0.346	0.337	0.342	0.330	0.328	0.317
2000	1.514	0.474	0.344	0.334	0.340	0.331	0.329	0.317
2001	1.548	0.480	0.344	0.331	0.340	0.333	0.332	0.318
2002	1.584	0.490	0.344	0.329	0.341	0.336	0.336	0.321
2003	1.619	0.502	0.345	0.329	0.342	0.340	0.340	0.324
2004	1.651	0.516	0.348	0.329	0.344	0.345	0.345	0.327
2005	1.679	0.531	0.350	0.329	0.347	0.350	0.350	0.331
2006	1.705	0.546	0.353	0.329	0.350	0.355	0.356	0.335
2007	1.731	0.562	0.356	0.330	0.353	0.360	0.361	0.339
2008	1.731	0.562	0.356	0.330	0.353	0.360	0.361	0.339
2009	1.731	0.562	0.356	0.330	0.353	0.360	0.361	0.339
2010	1.731	0.562	0.356	0.330	0.353	0.360	0.361	0.339

Table 12.2.12 Whiting in IV and VIId. Tuning series used in the assessment and forecast. Data used in the assessment is in bold.

International bottom trawl survey (IBTS) quarter 1

year	effort	1	2	3	4	5	6+
1990	100	519	862	198	92	17	4
1991	100	1008	686	480	71	38	8
1992	100	907	666	240	151	13	14
1993	100	1076	523	245	65	59	11
1994	100	722	627	181	68	12	9
1995	100	679	448	239	58	12	6
1996	100	502	486	245	70	23	10
1997	100	288	342	163	60	18	9
1998	100	543	161	125	54	15	9
1999	100	676	305	95	57	26	11
2000	100	757	538	182	53	20	15
2001	100	649	598	299	98	26	26
2002	100	671	417	275	67	22	10
2003	100	132	299	237	133	48	13
2004	100	185	90	173	100	49	22
2005	100	168	56	31	56	38	29
2006	100	223	92	33	17	28	27
2007	100	64	150	66	18	8	27
2008	100	268	206	66	22	8	15
2009	100	210	294	93	27	12	13
2010	100	326	228	243	95	29	28
2011	100	233	304	137	115	23	26

International bottom trawl survey (IBTS) quarter 3

year	effort	0	1	2	3	4	5	6+
1991	100	537	703	159	79	15	5	1
1992	100	1379	601	296	72	57	10	6
1993	100	919	639	177	66	15	16	3
1994	100	611	678	220	75	20	5	3
1995	100	729	620	291	107	22	6	3
1996	100	317	546	278	129	34	7	4
1997	100	2063	333	181	109	28	11	4
1998	100	2632	331	150	53	31	11	5
1999	100	2499	1204	191	54	24	10	4
2000	100	1968	942	327	64	14	7	5
2001	100	3031	645	282	95	19	4	8
2002	100	264	732	237	125	34	5	3
2003	100	363	246	302	135	66	16	5
2004	100	711	162	48	64	45	31	12
2005	100	163	180	71	28	45	29	34
2006	100	203	173	85	32	13	23	25
2007	100	822	96	64	38	12	8	21
2008	100	758	357	66	31	14	4	15
2009	100	811	767	530	53	13	9	8
2010	100	722	354	184	75	14	5	10

Table 12.3.1 Whiting in IV and VIId. XSA tuning diagnostics.

Fleet = IBTS_Q1

Catchability residuals:

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	-0.14	0.55	0.50	0.56	0.23	0.30	0.36	0.08	0.35	0.16	0.13	0.21	0.34
2	-0.26	0.38	0.29	0.19	0.25	-0.02	0.20	0.21	-0.27	0.06	0.27	0.16	0.05
3	-0.04	0.06	0.20	0.08	-0.02	0.04	0.12	-0.18	-0.11	-0.15	0.30	0.39	-0.05
4	-0.14	0.27	-0.07	-0.02	0.05	0.02	-0.08	-0.22	-0.26	-0.01	0.29	0.73	-0.32
5	-0.68	0.26	-0.38	-0.04	-0.59	-0.45	0.12	-0.41	-0.67	-0.13	-0.10	0.51	-0.02

	2003	2004	2005	2006	2007	2008	2009	2010
1	-0.24	0.00	-0.39	-0.11	-1.39	-0.75	-0.71	-0.03
2	-0.12	-0.08	-0.72	-0.52	0.03	0.26	-0.19	-0.18
3	0.05	0.08	-0.46	-0.48	-0.10	-0.07	0.12	0.24
4	0.05	-0.04	-0.32	-0.31	-0.11	-0.29	-0.06	0.85
5	0.03	-0.32	-0.42	-0.46	-0.41	-0.13	-0.13	0.71

Mean log catchability and standard error of ages with
independant of year class strength and constant w.r.t time:

	1	2	3	4	5
Mean log q	-12.9390	-11.7473	-11.6670	-11.8305	-11.8305
S.E. log q	0.4853	0.2831	0.2142	0.3136	0.4088

Regression Statistics:

	Model used?	slope	Intercept	RSquare	Num Pts	Reg s.e	Mean Q
1	No	0.7	13.42	0.63	21	0.32	-12.94
2	No	0.84	11.95	0.88	21	0.22	-11.75
3	No	0.83	11.76	0.94	21	0.15	-11.67
4	No	1.08	11.86	0.74	21	0.34	-11.83
5	No	1.21	12.31	0.63	21	0.44	-12.01

Fleet = IBTS_Q3

Catchability residuals:

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	0.00	-0.06	-0.12	0.01	0.06	0.29	0.08	-0.27	0.64	0.23	0.09	0.34	0.42
2	-0.50	0.02	-0.32	-0.28	0.07	0.14	0.07	0.13	0.11	0.28	-0.16	-0.08	0.43
3	-0.89	-0.13	-0.27	0.03	0.13	0.35	0.27	-0.21	0.13	0.13	-0.03	-0.08	0.21
4	-0.28	-0.08	-0.47	-0.09	0.02	0.20	-0.05	0.10	0.09	-0.11	-0.04	-0.17	0.15
5	-0.53	0.41	-0.29	-0.34	0.00	-0.06	0.09	-0.04	-0.15	-0.17	-0.30	-0.63	-0.25

	2004	2005	2006	2007	2008	2009	2010
1	-0.15	-0.34	-0.34	-1.00	-0.47	0.56	0.03
2	-0.21	0.05	-0.07	-0.30	-0.38	0.88	0.12
3	-0.21	0.14	0.33	0.13	-0.03	0.27	-0.27
4	-0.05	0.22	0.29	0.38	0.11	0.06	-0.29
5	0.04	0.10	0.15	0.53	0.18	0.48	-0.19

Mean log catchability and standard error of ages with
independant of year class strength and constant w.r.t time:

	1	2	3	4	5
Mean log q	-12.0348	-11.8577	-12.0895	-12.3188	-12.3188
S.E. log q	0.3795	0.3128	0.2866	0.2076	0.3143

Regression Statistics:

	Model used?	slope	Intercept	RSquare	Num Pts	Reg s.e	Mean Q
1	No	0.83	12.45	0.65	20	0.32	-12.03
2	No	0.93	11.93	0.77	20	0.3	-11.86
3	No	1.34	12.06	0.76	20	0.34	-12.09
4	No	1.13	12.44	0.86	20	0.23	-12.32
5	No	1.19	12.72	0.72	20	0.36	-12.37

Table 12.3.2 Whiting in IV and VIId. Final XSA fishing mortality.

year	1	2	3	4	5	6	7	8+	Fbar(2-6)
1990	0.183	0.512	0.808	0.909	1.129	0.870	0.947	0.947	0.846
1991	0.096	0.467	0.480	0.718	1.045	0.715	0.753	0.753	0.685
1992	0.178	0.365	0.529	0.576	0.662	1.134	1.193	1.193	0.653
1993	0.154	0.444	0.700	0.747	0.806	0.586	1.096	1.096	0.657
1994	0.142	0.346	0.655	0.891	1.022	1.173	0.444	0.444	0.817
1995	0.125	0.337	0.587	0.658	0.921	1.156	1.496	1.496	0.732
1996	0.105	0.316	0.544	0.670	0.736	1.063	1.422	1.422	0.666
1997	0.098	0.305	0.506	0.565	0.716	0.449	0.856	0.856	0.508
1998	0.105	0.248	0.343	0.512	0.597	0.710	0.407	0.407	0.482
1999	0.145	0.355	0.488	0.598	0.642	0.659	0.612	0.612	0.548
2000	0.054	0.336	0.559	0.616	0.795	0.926	1.393	1.393	0.646
2001	0.044	0.164	0.276	0.420	0.619	0.707	0.779	0.779	0.437
2002	0.048	0.159	0.321	0.352	0.334	0.309	0.570	0.570	0.295
2003	0.244	0.359	0.266	0.304	0.277	0.177	0.125	0.125	0.277
2004	0.122	0.250	0.215	0.265	0.299	0.307	0.170	0.170	0.267
2005	0.091	0.329	0.264	0.208	0.234	0.227	0.205	0.205	0.252
2006	0.145	0.295	0.475	0.358	0.314	0.352	0.207	0.207	0.359
2007	0.072	0.251	0.383	0.497	0.330	0.310	0.313	0.313	0.354
2008	0.056	0.204	0.380	0.459	0.517	0.303	0.314	0.314	0.373
2009	0.024	0.168	0.195	0.387	0.379	0.372	0.181	0.181	0.300
2010	0.040	0.241	0.137	0.178	0.369	0.435	0.270	0.270	0.272

Table 12.3.3 Whiting in IV and VIId. Final XSA stock numbers.

year	1	2	3	4	5	6	7	8+	total
1990	2970904	1601990	279284	169870	55087	3954	1387	204	5082680
1991	2868490	665921	584887	85064	47135	12397	1173	582	4265649
1992	2755293	695426	256973	249114	28747	11586	4310	184	4001633
1993	3074780	608775	299044	104857	97591	10406	2657	1290	4199400
1994	2869508	685851	242938	103282	34770	30655	4139	1664	3972807
1995	2513003	636830	302392	88095	29779	8820	6790	683	3586392
1996	1751124	555861	283546	117659	32149	8365	1989	1631	2752324
1997	1335092	386836	253125	115546	42535	10881	2073	908	2146996
1998	1920820	290020	178119	107377	46559	14715	4991	1407	2564008
1999	2932565	403657	141471	89190	45757	18179	5200	1692	3637711
2000	3343417	575468	176696	61433	35001	17111	6760	1903	4217789
2001	2665782	697209	256062	71579	23762	11242	4871	2695	3733202
2002	2420530	542919	366064	137746	33779	9106	3975	2014	3516133
2003	867538	473563	283852	188279	69689	17200	4778	3974	1908873
2004	949861	134651	200221	153941	100040	37517	10254	2306	1588791
2005	1274131	161258	62601	114077	85040	52586	19560	4158	1773411
2006	1288486	217029	68274	33864	66716	47557	29532	9216	1760674
2007	1340114	202670	93571	29815	17031	34363	23451	13673	1754688
2008	2926562	220938	89895	44691	13035	8605	17574	12917	3334217
2009	2197572	490084	102772	43063	20304	5463	4435	20272	2883965
2010	1729781	380174	236350	59206	21014	9769	2626	7534	2446454
2011	0	294485	170422	144399	35637	10209	4410	5491	665052

Note that stock numbers in 2011 are estimates of survivors from 2010.

Table 12.3.4 Whiting in IV and VIId. Final XSA summary table. Units are in millions of individuals and tonnes where appropriate

	recruitment (age 1)	tsb	ssb	catch	landings	discards	industrial bycatch	Y/ssb	fbar(2-6)
1990	2971	588292	348629	152600	48993	52267	51340	0.14	0.85
1991	2868	580989	306532	126750	56154	30836	39760	0.18	0.69
1992	2755	512867	294136	108550	55041	28469	25040	0.19	0.65
1993	3075	475444	267201	116910	54794	41396	20720	0.21	0.66
1994	2870	478661	254974	101650	52340	31840	17470	0.21	0.82
1995	2513	464406	256180	105500	49182	28938	27380	0.19	0.73
1996	1751	377041	223116	76120	43869	27131	5120	0.20	0.67
1997	1335	311938	192360	61430	38558	16662	6210	0.20	0.51
1998	1921	318800	160789	47470	31505	12475	3490	0.20	0.48
1999	2933	375508	166311	60850	33701	22109	5040	0.20	0.55
2000	3343	572702	216173	63800	32709	21931	9160	0.15	0.65
2001	2666	497637	247301	45240	28170	16130	940	0.11	0.44
2002	2421	384038	228661	46440	22026	17144	7270	0.10	0.30
2003	868	239106	190625	45630	16765	26135	2730	0.09	0.28
2004	950	250272	154820	33560	14208	18142	1210	0.09	0.27
2005	1274	280606	137425	28880	17690	10300	890	0.13	0.25
2006	1288	282342	128993	37040	20832	14018	2190	0.16	0.36
2007	1340	234921	114696	27130	20684	5206	1240	0.18	0.35
2008	2927	397040	132864	29270	19894	8356	1020	0.15	0.37
2009	2198	367351	184734	27470	20801	5319	1350	0.11	0.30
2010	1730	343497	205826	31550	20601	9199	1750	0.10	0.27
min	868	234921	114696	27130	14208	5206	890	0.09	0.25
mean	2190	396831	210112	65421	33263	21143	11015	0.16	0.50
max	3343	588292	348629	152600	56154	52267	51340	0.21	0.85

Table 12.5.1 Whiting in IV and VIId. RCT3 input table

Whi4&7d (age 1)

4	22	2			
1989	2971	518.94	686.45	-11	-11.00
1990	2868	1007.62	665.71	-11	703.37
1991	2755	907.30	522.81	536.99	600.87
1992	3075	1075.62	627.41	1379.46	638.72
1993	2870	721.71	448.48	919.19	677.65
1994	2513	678.59	485.97	610.74	619.79
1995	1751	502.36	342.21	729.25	545.71
1996	1335	287.73	160.70	316.50	332.97
1997	1921	543.12	305.45	2062.67	330.60
1998	2933	676.27	537.86	2631.69	1203.50
1999	3343	756.87	598.39	2498.55	941.66
2000	2666	648.65	416.82	1968.07	645.00
2001	2421	670.59	298.87	3031.44	732.14
2002	868	131.60	89.73	264.06	246.16
2003	950	184.61	55.97	363.41	161.56
2004	1274	167.63	92.38	711.28	179.50
2005	1288	223.01	149.87	162.59	172.79
2006	1340	64.28	205.53	202.83	95.65
2007	2927	267.72	294.36	821.74	356.90
2008	2198	209.79	227.95	757.81	767.24
2009	1730	326.10	304.45	810.69	353.62
2010	-11	232.56	-11.00	721.79	-11.00
ibtsq1age1					
ibtsq1age2					
ibtsq3age0					
ibtsq3age1					

Table 12.5.2 Whiting in IV and VIId. RCT3 output table.

```
Analysis by RCT3
Data for 4 surveys over 23 year classes : 1988 - 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    .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
ibtsq1age1	0.6873	6.663	0.3244	0.6329	21	0.844	7.243	0.3534	0.6113
ibtsq1age2	0.6278	6.943	0.1768	0.8530	21				
ibtsq3age0	0.6569	6.231	0.4085	0.5268	19	1.977	7.529	0.4431	0.3887
ibtsq3age1	0.7486	6.511	0.2960	0.6764	20				
VPA Mean					21		7.618	0.4151	0.0000

	WAP	logWAP	int.se
yearclass:2010	1563	7.354	0.23

Table 12.5.2 Whiting in IV and VIId. Short term forecast inputs.

Fbar age range (Total) : 2-6
Fbar age range Fleet 1 : 2-6
Fbar age range Fleet 2 : 2-6

2011

Age	N	M	Mat	PF	PM	SWt
1	1562674	1.731	0.11	0	0	0.085
2	294485	0.562	0.92	0	0	0.224
3	170421.6	0.356	1	0	0	0.303
4	144399	0.330	1	0	0	0.374
5	35637.37	0.353	1	0	0	0.448
6	10208.69	0.360	1	0	0	0.422
7	4409.701	0.361	1	0	0	0.458
8	14623.06	0.339	1	0	0	0.373

Catch

Age	Sel	CWt	DSel	DCWt
1	0.006	0.221	0.022	0.075
2	0.086	0.255	0.082	0.211
3	0.120	0.331	0.064	0.272
4	0.200	0.416	0.075	0.319
5	0.285	0.470	0.068	0.384
6	0.242	0.479	0.082	0.330
7	0.149	0.541	0.072	0.254
8	0.175	0.388	0.046	0.323

Industrial

Age	Sel	CWt
1	0.006	0.046
2	0.012	0.119
3	0.013	0.208
4	0.013	0.277
5	0.010	0.362
6	0.006	0.401
7	0.001	0.564
8	0.000	0.530

2012

Age	N	M	Mat	PF	PM	SWt
1	2042915	1.731	0.11	0	0	0.085
2	.	0.562	0.92	0	0	0.224
3	.	0.356	1	0	0	0.303
4	.	0.330	1	0	0	0.374
5	.	0.353	1	0	0	0.448
6	.	0.360	1	0	0	0.422
7	.	0.361	1	0	0	0.458
8	.	0.339	1	0	0	0.373

Catch

Age	Sel	CWt	DSel	DCWt
1	0.006	0.221	0.022	0.075
2	0.086	0.255	0.082	0.211
3	0.120	0.331	0.064	0.272
4	0.200	0.416	0.075	0.319
5	0.285	0.470	0.068	0.384
6	0.242	0.479	0.082	0.330
7	0.149	0.541	0.072	0.254
8	0.175	0.388	0.046	0.323

Industrial

Age	Sel	CWt
1	0.006	0.046
2	0.012	0.119
3	0.013	0.208
4	0.013	0.277
5	0.010	0.362
6	0.006	0.401
7	0.001	0.564
8	0.000	0.530

2013

Age	N	M	Mat	PF	PM	SWt
1	2042915	1.731	0.11	0	0	0.085
2	.	0.562	0.92	0	0	0.224
3	.	0.356	1	0	0	0.303
4	.	0.330	1	0	0	0.374
5	.	0.353	1	0	0	0.448
6	.	0.360	1	0	0	0.422
7	.	0.361	1	0	0	0.458
8	.	0.339	1	0	0	0.373

Catch

Age	Sel	CWt	DSel	DCWt
1	0.006	0.221	0.022	0.075
2	0.086	0.255	0.082	0.211
3	0.120	0.331	0.064	0.272
4	0.200	0.416	0.075	0.319
5	0.285	0.470	0.068	0.384
6	0.242	0.479	0.082	0.330
7	0.149	0.541	0.072	0.254
8	0.175	0.388	0.046	0.323

Industrial

Age	Sel	CWt
1	0.006	0.046
2	0.012	0.119
3	0.013	0.208
4	0.013	0.277
5	0.010	0.362
6	0.006	0.401
7	0.001	0.564
8	0.000	0.530

Input units are thousands and kg - output in tonnes

Table 12.6.1 Whiting in IV and VIId. Short term forecast table.

Biomass 2011	SSB 2011	Estimated IV landings	Catch F Multiplier	Catch Fbar	Catch Yeild	Landings Fbar	Landings Yeild	Discards Fbar	Discards Yeild	Industrial Fbar	Industrial Yeild	Biomass 2012	SSB 2012
328776	205282	17110	1.00	0.27	36476	0.19	24443	0.07	10694	0.01	1339	359381	200040

	Biomass 2012	SSB 2012	Estimated IV landings	Catch F Multiplier	Catch Fbar	Catch Yeild	Landings Fbar	Landings Yeild	Discards Fbar	Discards Yeild	Industrial Fbar	Industrial Yeild	Biomass 2012	SSB 2012	% TAC change	% SSB change
No directed fishery	359381	200040	0	0.00	0.01	1436	0.00	0	0.00	0	0.01	1436	398522	237529	-100	16
15% TAC reduction			12611	0.69	0.19	26774	0.13	18016	0.05	7411	0.01	1348	375811	214942	-15	5
no change TAC			14764	0.82	0.23	31130	0.15	21092	0.06	8706	0.01	1332	371928	211082	0	3
15% TAC increase			17011	0.96	0.26	35684	0.18	24302	0.07	10066	0.01	1316	367876	207055	15	1
F = 0.3 EU/Norway LTMP target			19491	1.12	0.30	40722	0.21	27844	0.08	11580	0.01	1298	363402	202609	31	-1
Stable SSB			18030	1.02	0.28	37751	0.19	25757	0.08	10686	0.01	1308	366039	205229	22	0
			4811	0.25	0.08	11071	0.05	6873	0.02	2795	0.01	1403	389863	228915	-68	12
			9343	0.50	0.14	20181	0.09	13347	0.04	5463	0.01	1371	381701	220799	-37	8
			16057	0.90	0.25	33749	0.17	22939	0.07	9487	0.01	1323	369597	208765	8	2
status quo F			17640	1.00	0.27	36959	0.19	25200	0.07	10449	0.01	1311	366742	205928	19	0
			19186	1.10	0.30	40101	0.21	27408	0.08	11393	0.01	1300	363952	203155	29	-1
			21439	1.25	0.34	44689	0.23	30627	0.09	12779	0.01	1283	359886	199115	45	-3
			25026	1.50	0.40	52016	0.28	35751	0.11	15009	0.01	1256	353410	192683	69	-6
			28414	1.75	0.47	58966	0.33	40591	0.13	17145	0.01	1230	347289	186606	92	-9
			31616	2.00	0.53	65563	0.37	45165	0.15	19192	0.01	1205	341502	180861	113	-12

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 estimates of discards.

Year	Denmark (1)			Norway	Sweden	Others	Total	WG estimate
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	Total	Total					
1981	1,027	23,915	24,942	70	1,054	7	26,073	
1982	1,183	39,758	40,941	40	670	13	41,664	
1983	1,311	23,505	24,816	48	1,061	8	25,933	
1984	1,036	12,102	13,138	51	1,168	60	14,417	
1985	557	11,967	12,524	45	654	2	13,225	
1986	484	11,979	12,463	64	477	1	13,005	
1987	443	15,880	16,323	29	262	43	16,657	
1988	391	10,872	11,263	42	435	24	11,764	
1989	917	11,662	12,579	29	675	-	13,283	
1990	1,016	17,829	18,845	49	456	73	19,423	
1991	871	12,463	13,334	56	527	97	14,041	
1992	555	3,340	3,895	66	959	1	4,921	
1993	261	1,987	2,248	42	756	1	3,047	
1994	174	1,900	2,074	21	440	1	2,536	
1995	85	2,549	2,634	24	431	1	3,090	
1996	55	1,235	1,290	21	182	-	1,493	
1997	38	264	302	18	94	-	414	
1998	35	354	389	16	81	-	486	
1999	37	695	732	15	111	-	858	
2000	59	777	836	17	138	1	992	
2001	61	970[1]	1,031[1]	27	126	+	1,184[1]	
2002	101	975[1]	1,076[1]	23	127	1	1,227[1]	
2003	93	654[1]	747[1]	20	71.9	2	840.9[1]	429
2004	93	1,120[1]	1,213[1]	17	74	1	1,305[1]	909
2005	49	907[1]	956[1]	13	73	0	1,042[1]	299
2006	59[1]	290[1]	349[1]	n/a	85.9[2]	n/a	434.9[2]	331
2007	53[2]	278[2]	331[2]	14	82	1	428[2]	561
2008	52[2]	288[2]	340[2]	14	52	n/a	406[2]	241
2009	71[2]	173[2]	244[2]	10.3	33.8[2]	-	288.1[2]	128
2010	41	165	206	9.7	29.7	-	245.4	291

[1] Values from 1992 updated by WGNSSK (2007).

[2] Values updated by WGNSSK (2011).

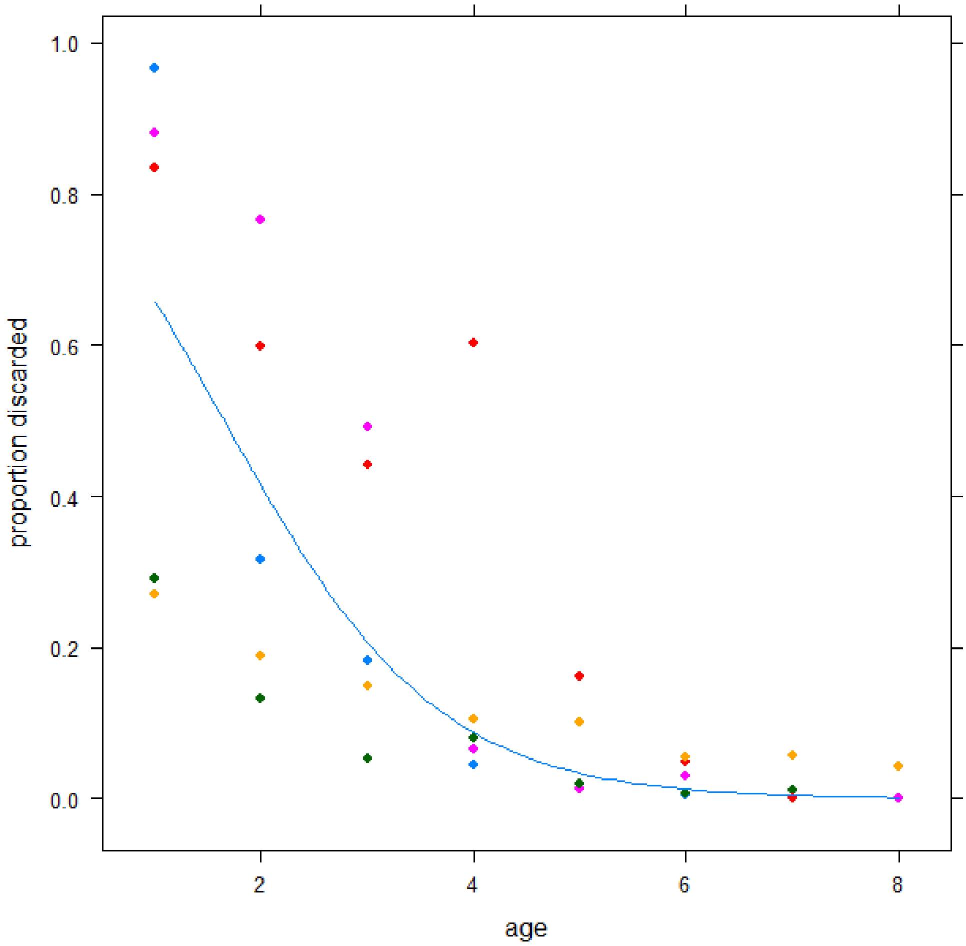


Figure 12.2.1 Whiting in IV and VIId. GLMM fit to VIId discard data. The dots represent the proportion of the total catch discarded at age coloured by year. The blue line is the fixed effect population mean and is the ogive applied to all unsampled years.

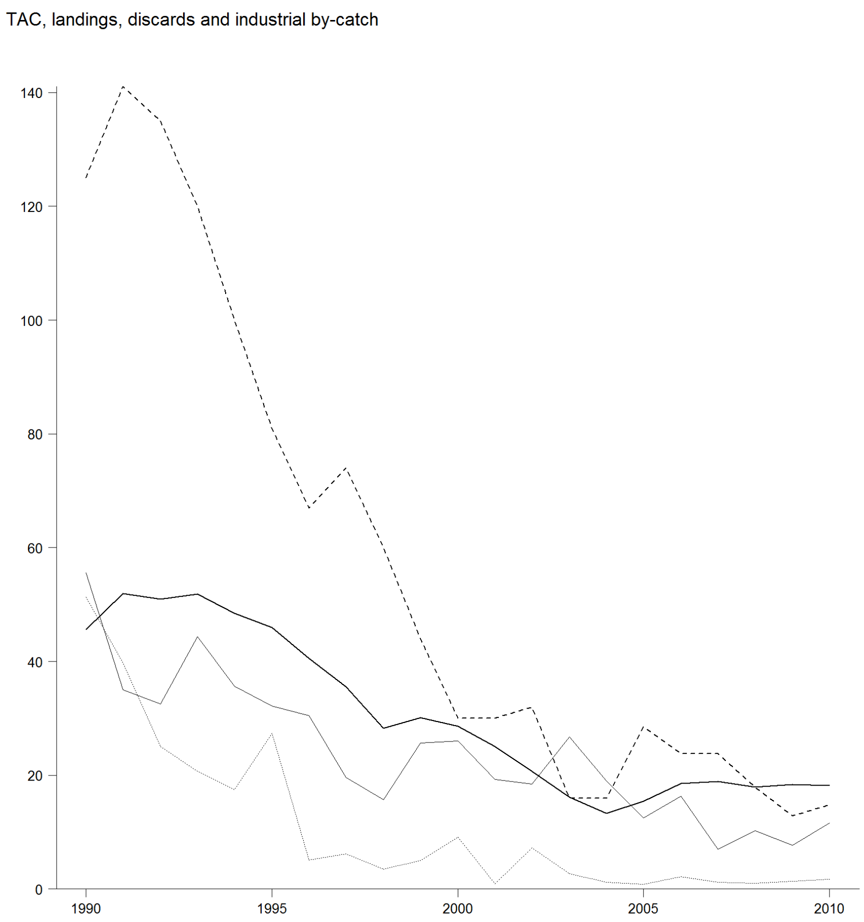


Figure 12.2.2 Whiting in IV and VIId. Time series of each catch component. Human consumption landings (black line) , followed by discards (dark grey line) and lastly industrial bycatch (light grey line). Also shown as a dashed line is the TAC for Subarea IV and Division IIa.

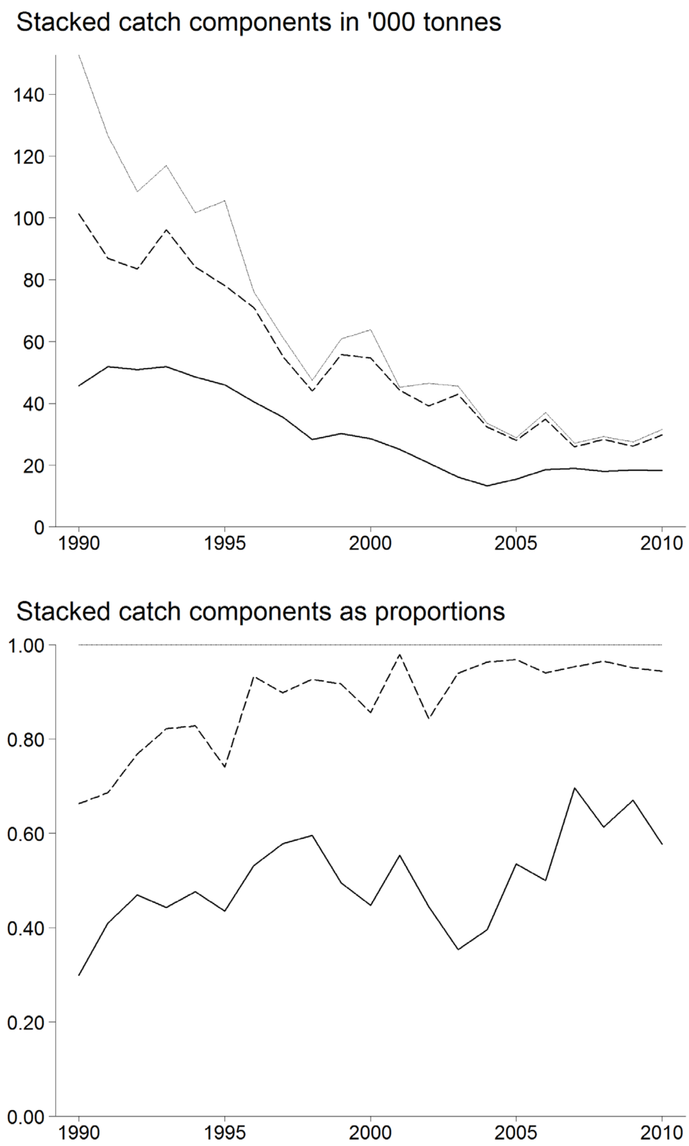


Figure 12.2.3 Whiting in IV and VIId. Time series of catch components as they contribute to total catch. Human consumption landings (black line) , followed by discards (dashed line) and lastly industrial bycatch (grey line).

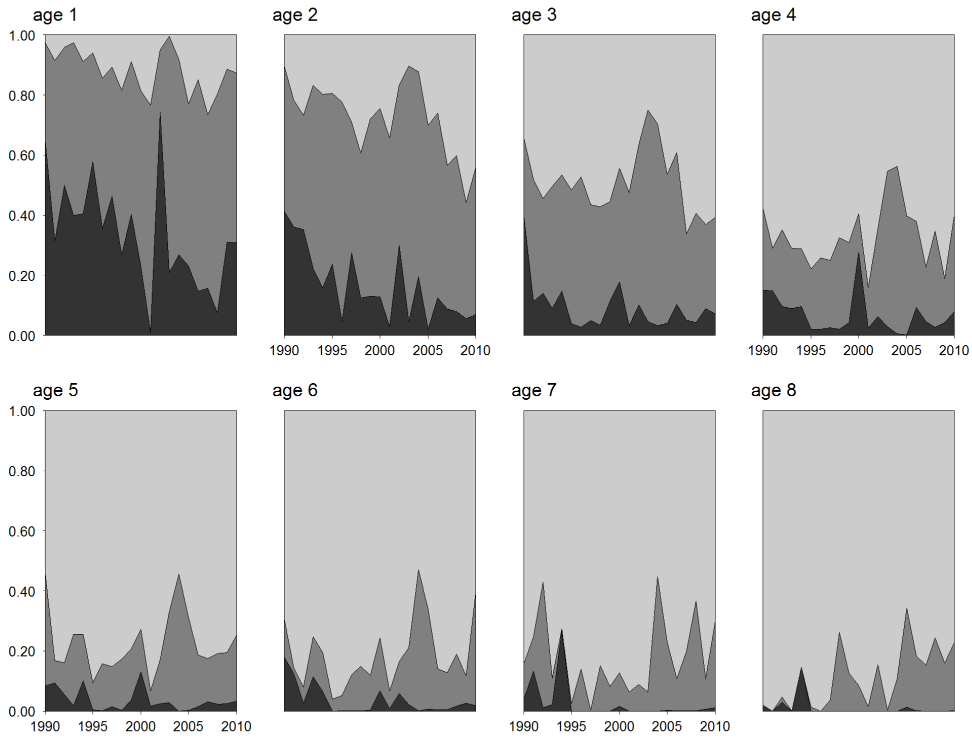


Figure 12.2.4 Whiting in IV and VIId. Proportion by number for each catch component. Landings are light grey; discards are medium grey and industrial by-catch are dark grey.

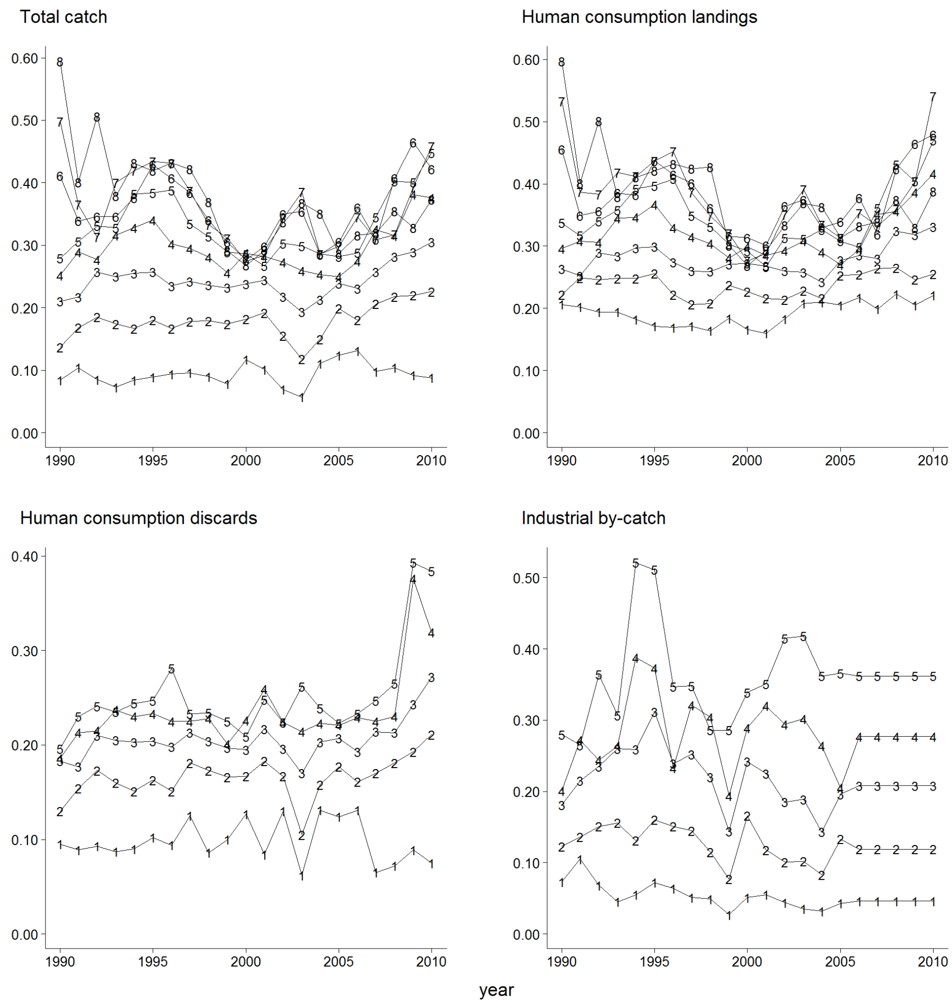


Figure 12.2.5 Whiting in IV and VIId. Mean weights at age (kg) by catch component. Catch mean weights are also used as stock mean weights.

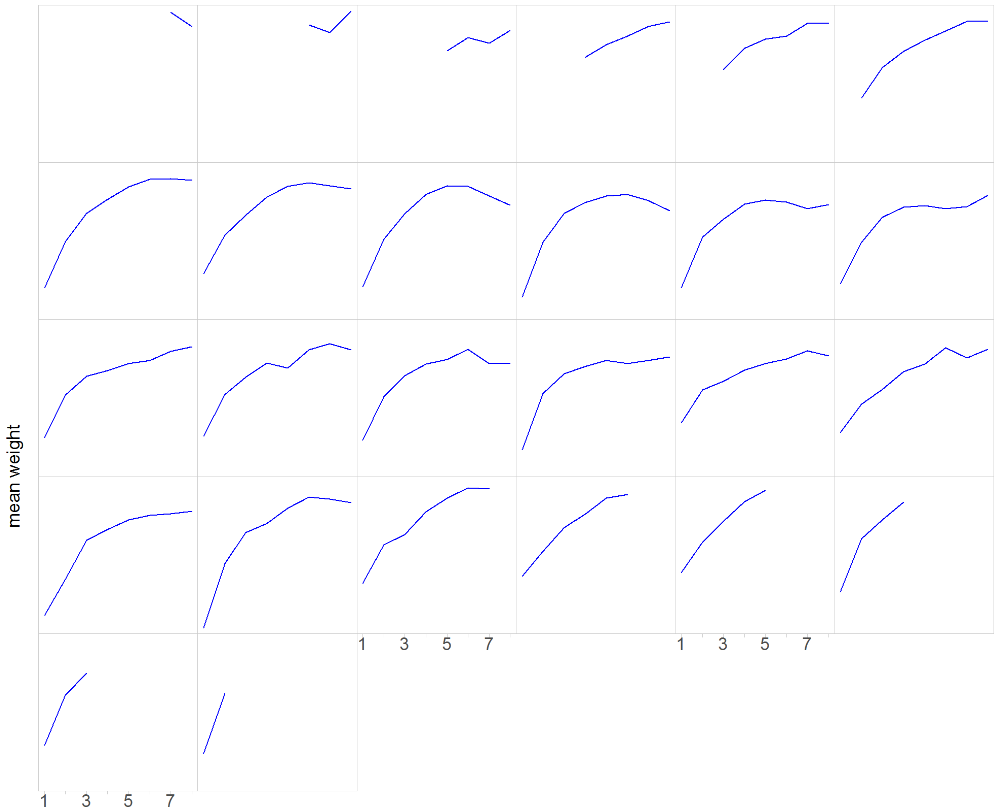


Figure 12.2.6 **Whiting in IV and VIId. Mean weights in the catch for ages 1 to 7. Catch mean weights are also used as stock mean weights. The final panel (bottom right) is the 2008 year class.**

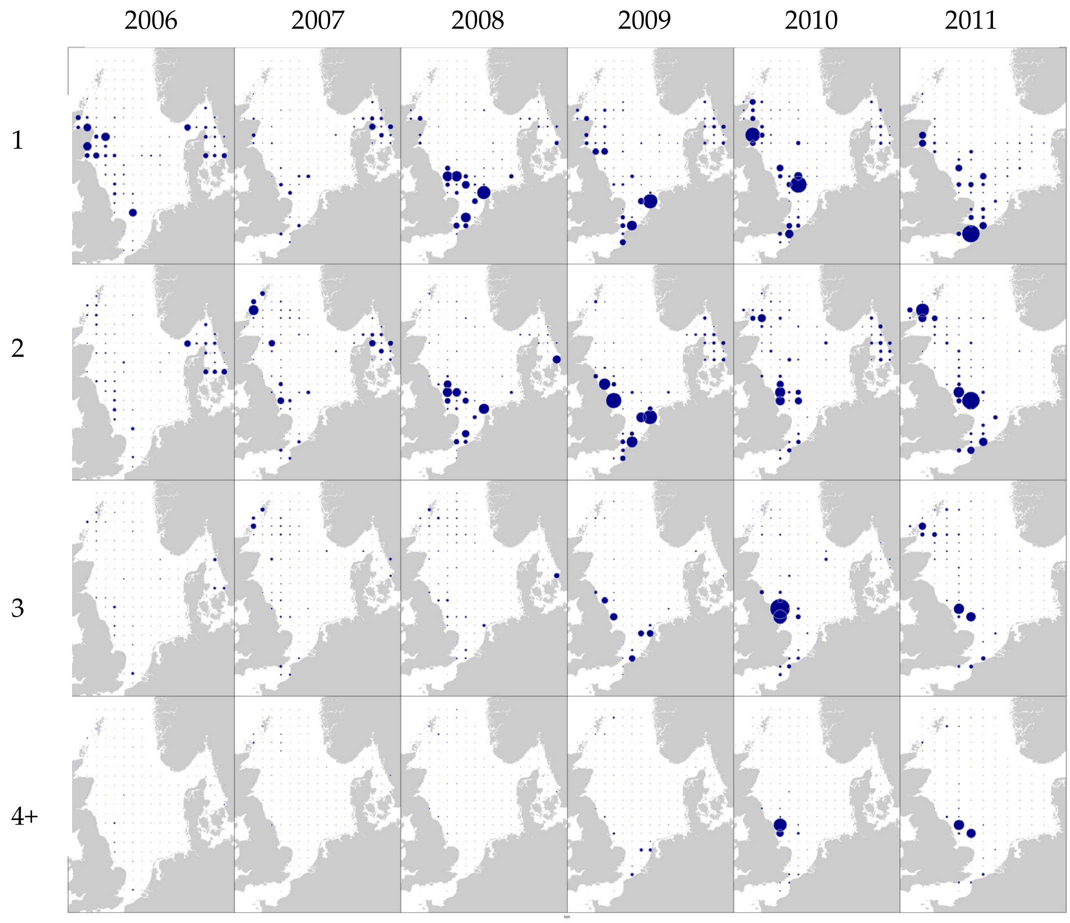


Figure 12.2.7 Whiting in IV and VIId. Distribution plot of the IBTS quarter 1 Survey age 1 to 4+. Ages are on rows, years on columns from left to right 2006 to 2011.

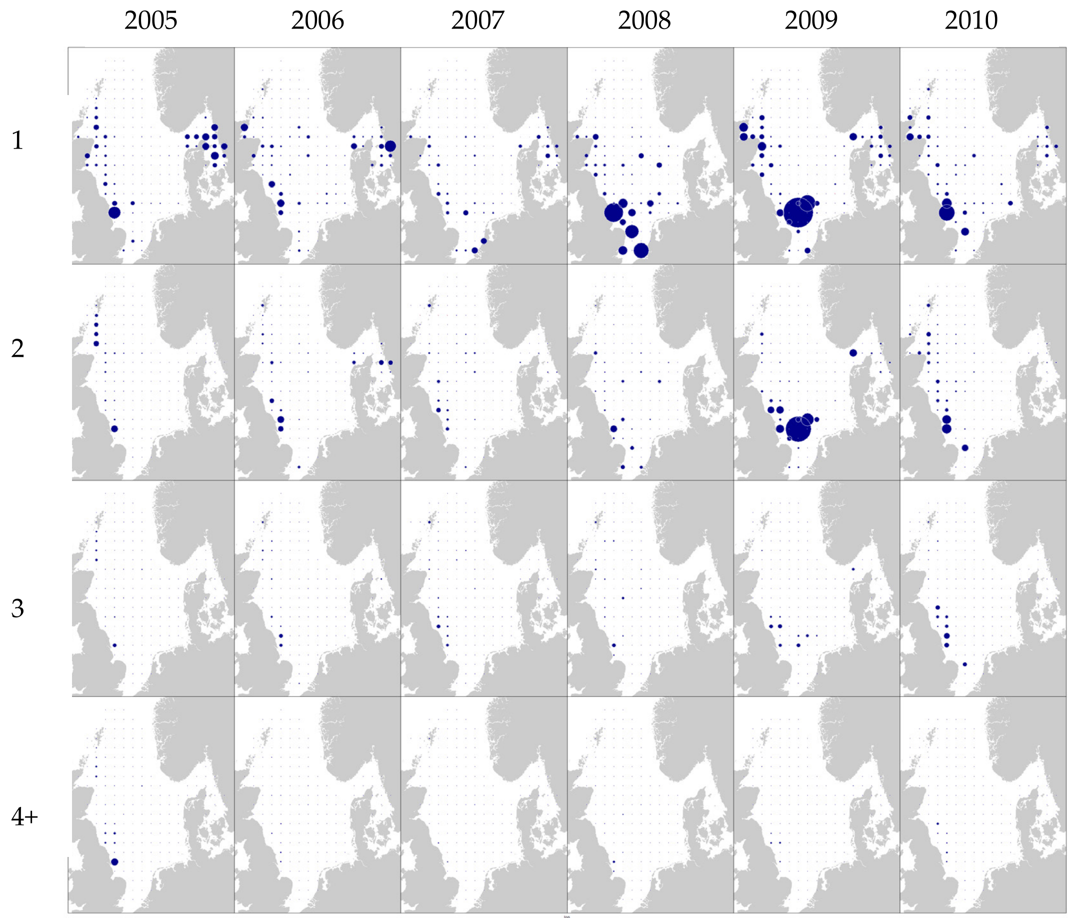


Figure 12.2.8 Whiting in IV and VIId. Distribution plot of the IBTS quarter 3 Survey age 1 to 4+. Ages are on rows, years on columns from left to right 2005 to 2010.

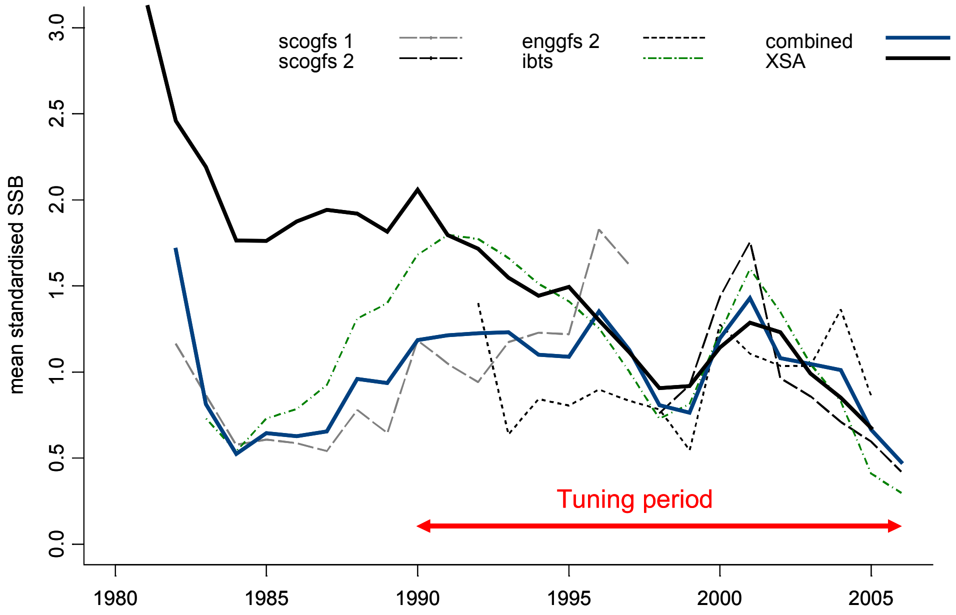


Figure 12.3.1 Whiting in IV and VIId. Analysis conducted in WGNSSK (2007) showing catch based estimates of spawning stock biomass (black line) along side survey based estimates of spawning stock biomass (blue, and dashed lines), the blue line showing an estimate based on all the surveys. These are scaled so that the mean of each line over the years 1996 – 2006 is one.

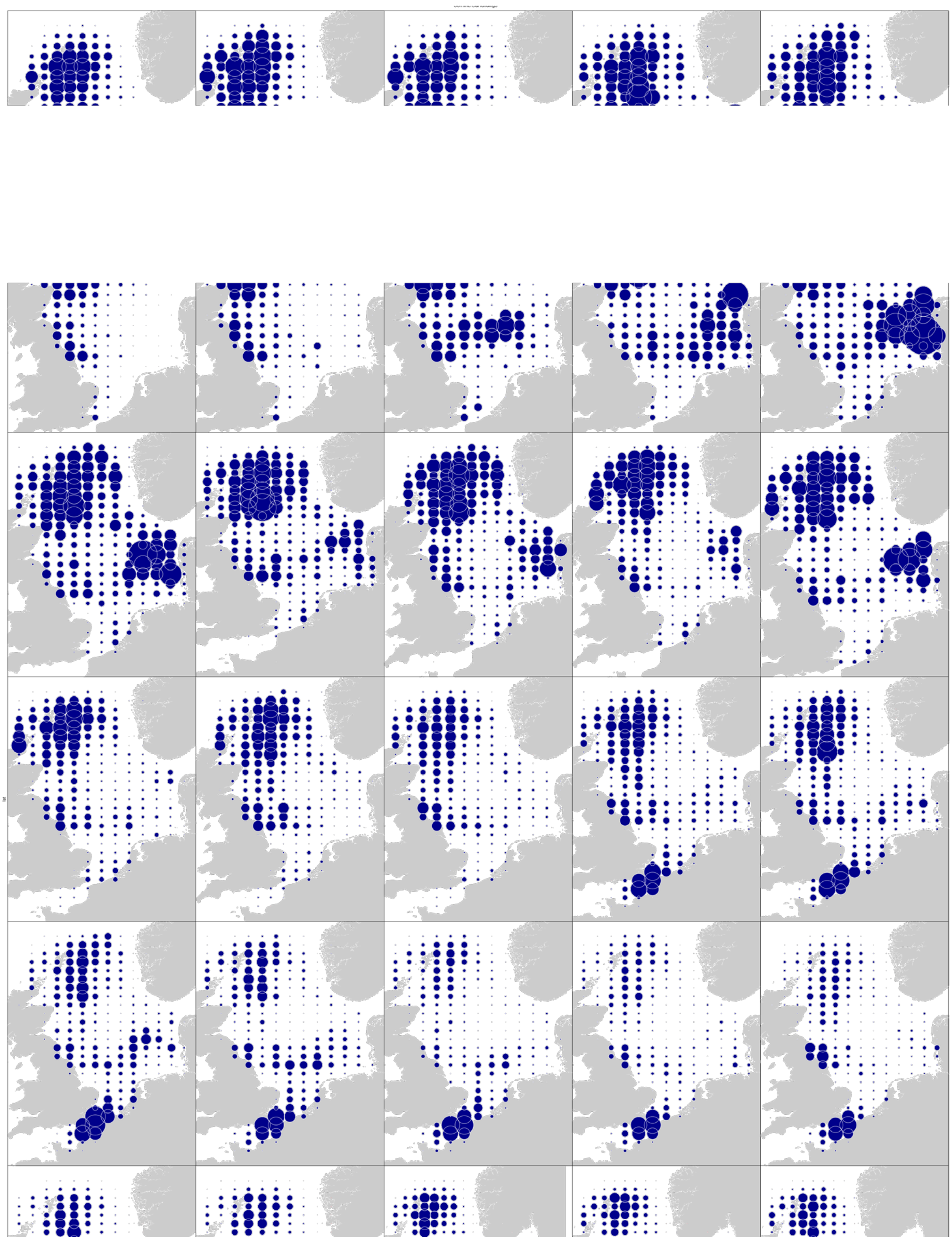


Figure 12.3.2 Whiting in Subarea IV and Division VIId. Commercial landings (human consumption and industrial fisheries) by ICES statistical rectangle over the years 1986 to 2010. The same scaling is used in each map. Danish industrial bycatch was available from 1988. French human consumption landings were available from 1999.

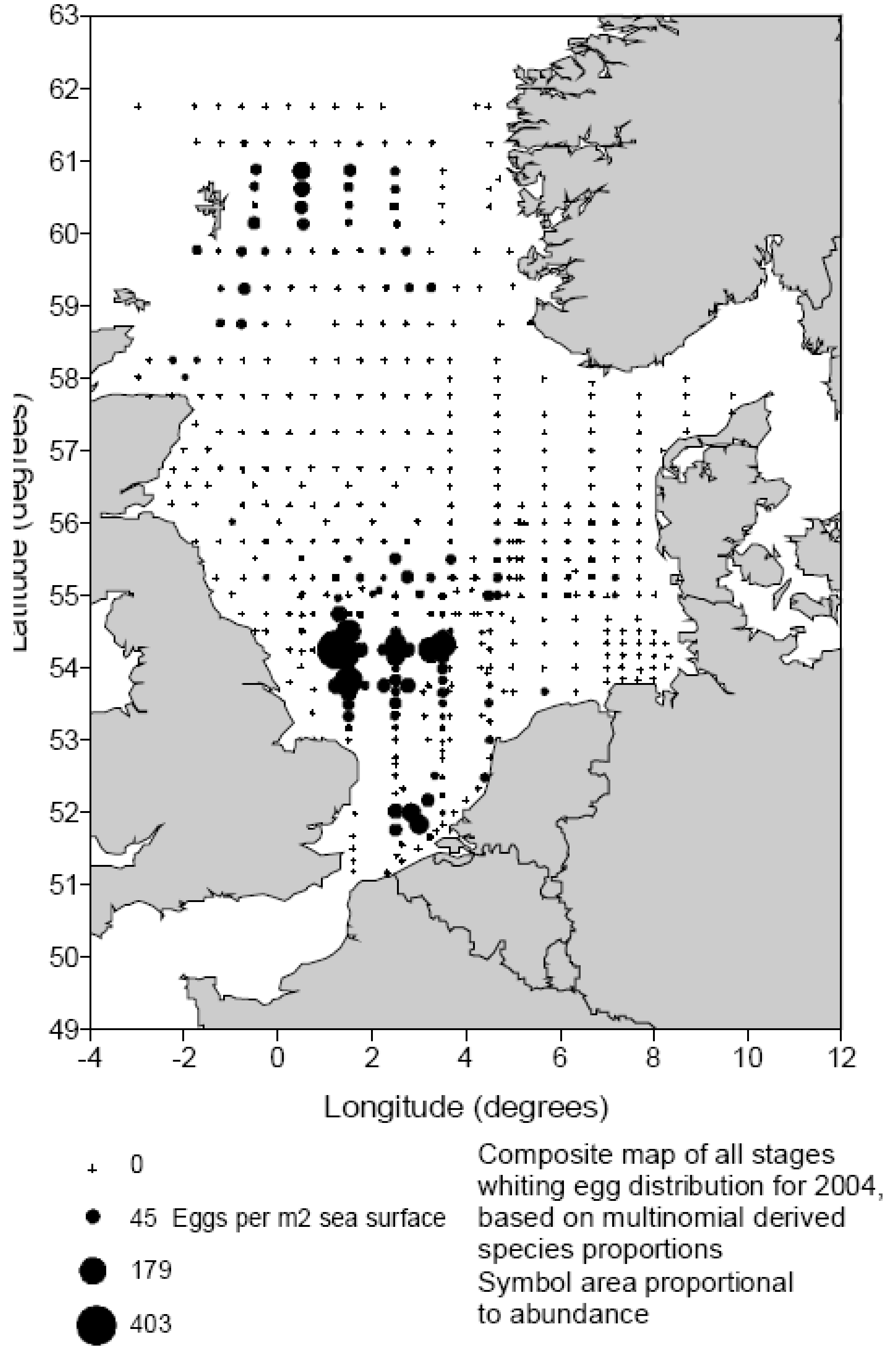


Figure 12.3.3 Whiting in Subarea IV and Division VIId. Density of whiting eggs from the 2004 ICES icthyoplankton survey.

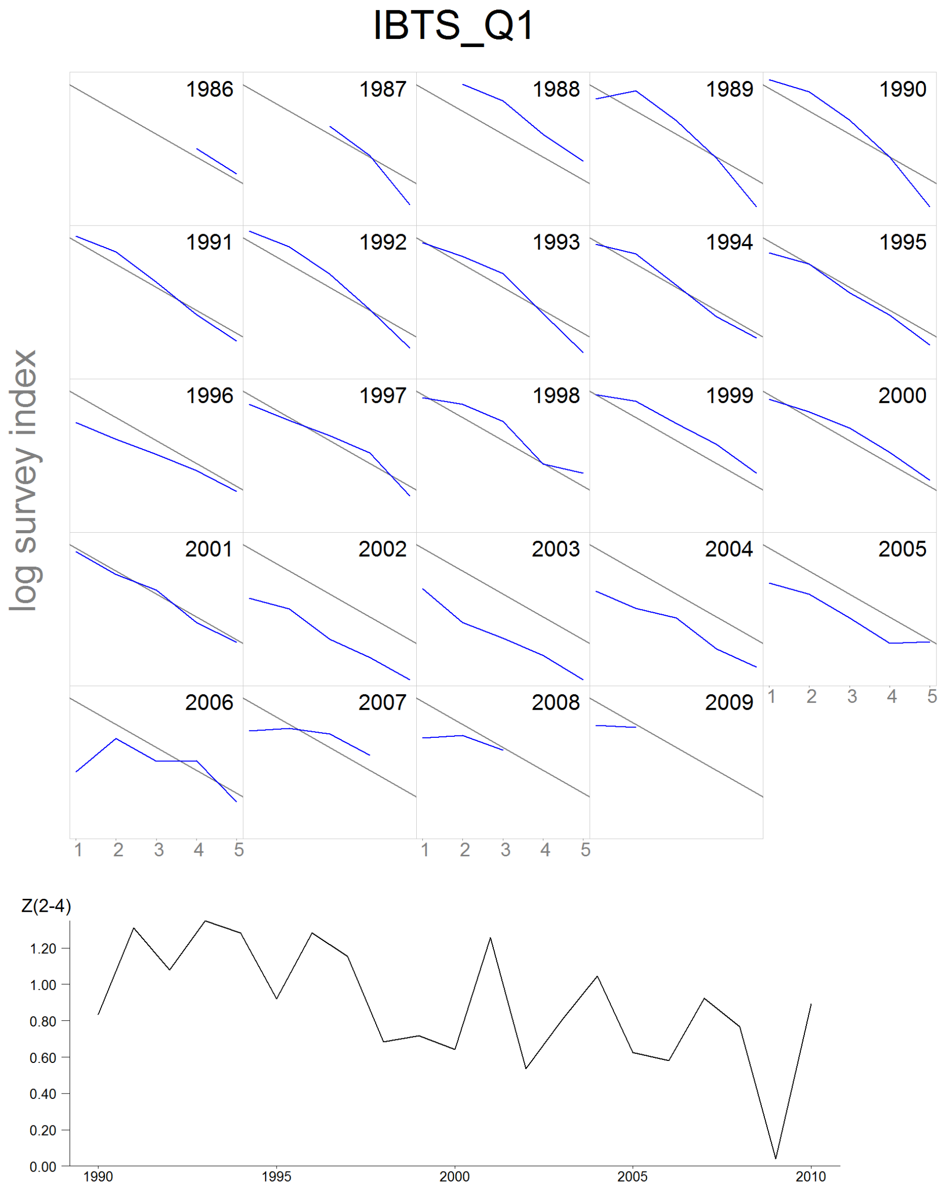


Figure 12.3.4 **Whiting in IV and VIId. Top panel: Log indices by cohort for the IBTS Quarter 1 survey (ages 1 to 5). The year specifies the year-class. A reference a line with constant intercept and gradient representing a Z of 0.8 has been drawn in grey. Bottom panel: a raw estimate of annual mean Z averaged over ages 2 to 4, Z at age was estimated as log index (y, a) – log index (y+1, a+1).**

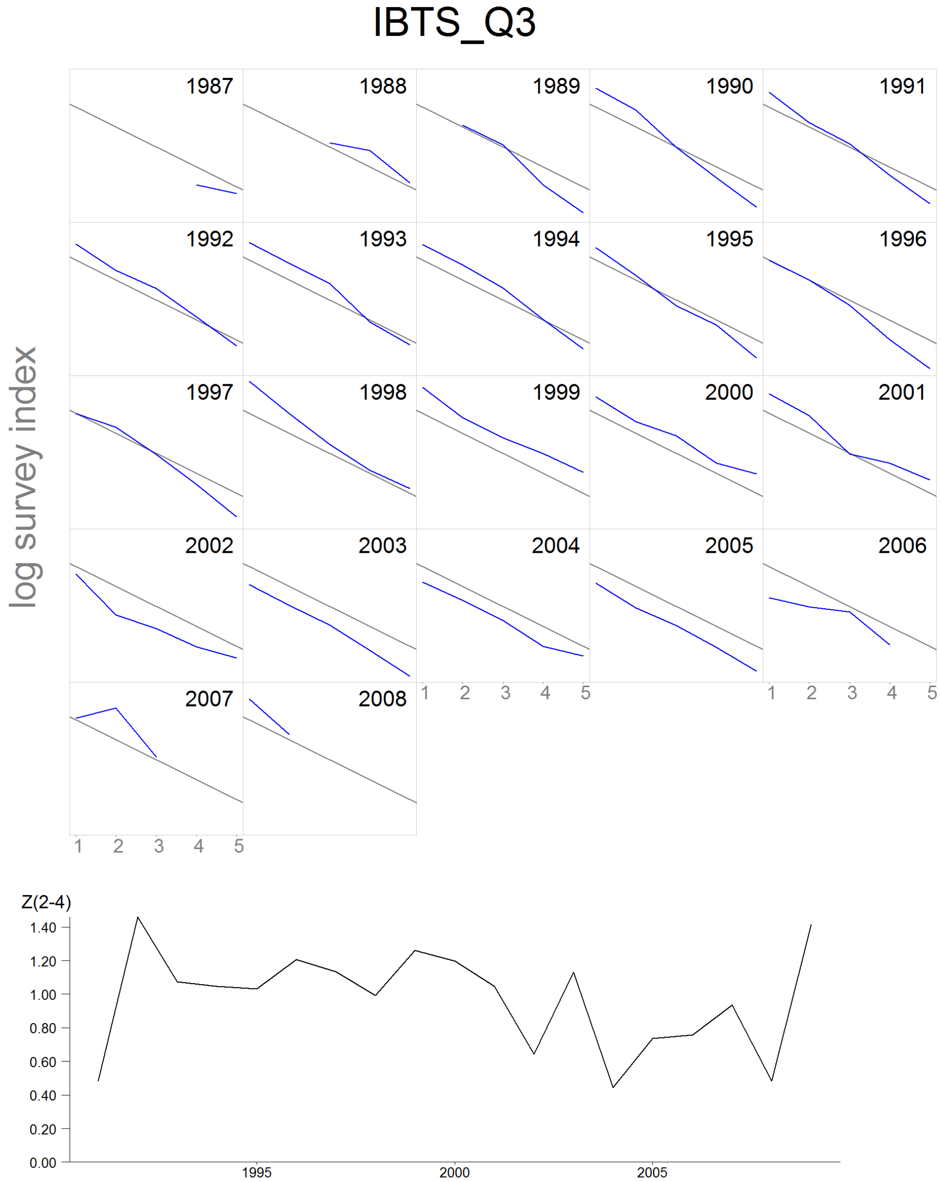


Figure 12.3.5 Whiting in IV and VIId. Top panel: Log indices by cohort for the IBTS Quarter 3 survey (ages 1 to 5). The year specifies the year-class. A reference a line with constant intercept and gradient representing a Z of 0.8 has been drawn in grey. Bottom panel: a raw estimate of annual mean Z averaged over ages 2 to 4, Z at age was estimated as log index (y, a) – log index (y+1, a+1).

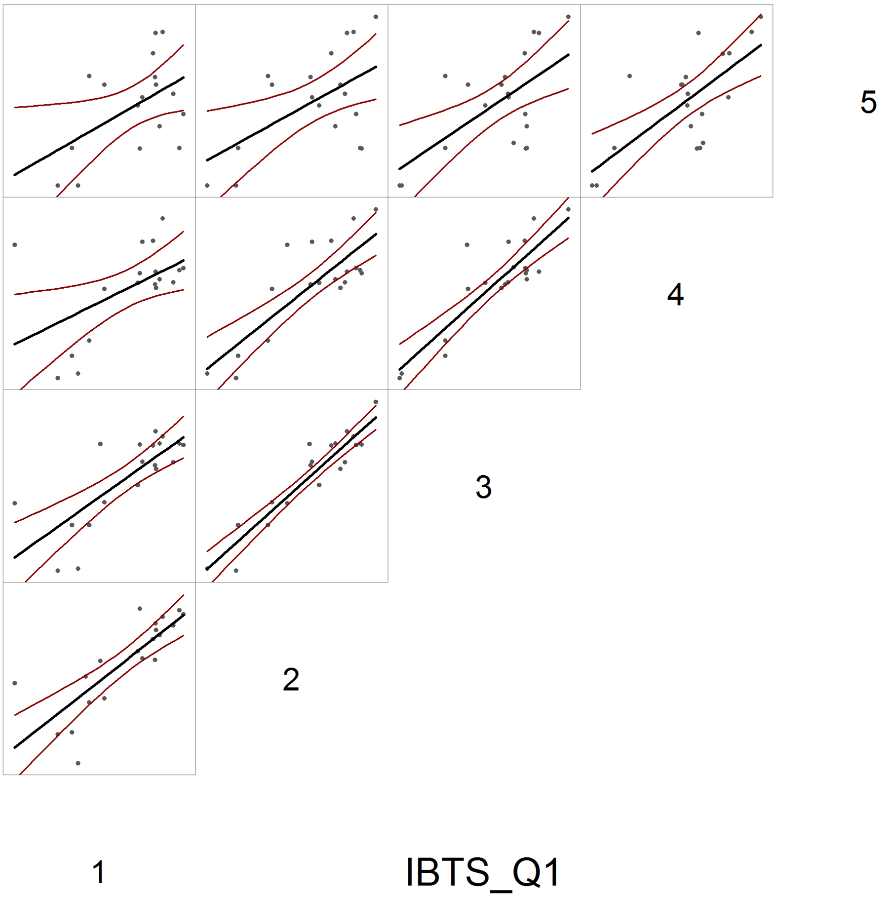


Figure 12.3.6 **Whiting in IV and VIId. Within survey correlations (log index) for the IBTS quarter 1 survey (1990–2011). Each point represents a cohort, the line is a normal linear model fit. Thick lines represent a significant ($p<0.05$) regression and the curved lines are approximate 95% confidence intervals.**

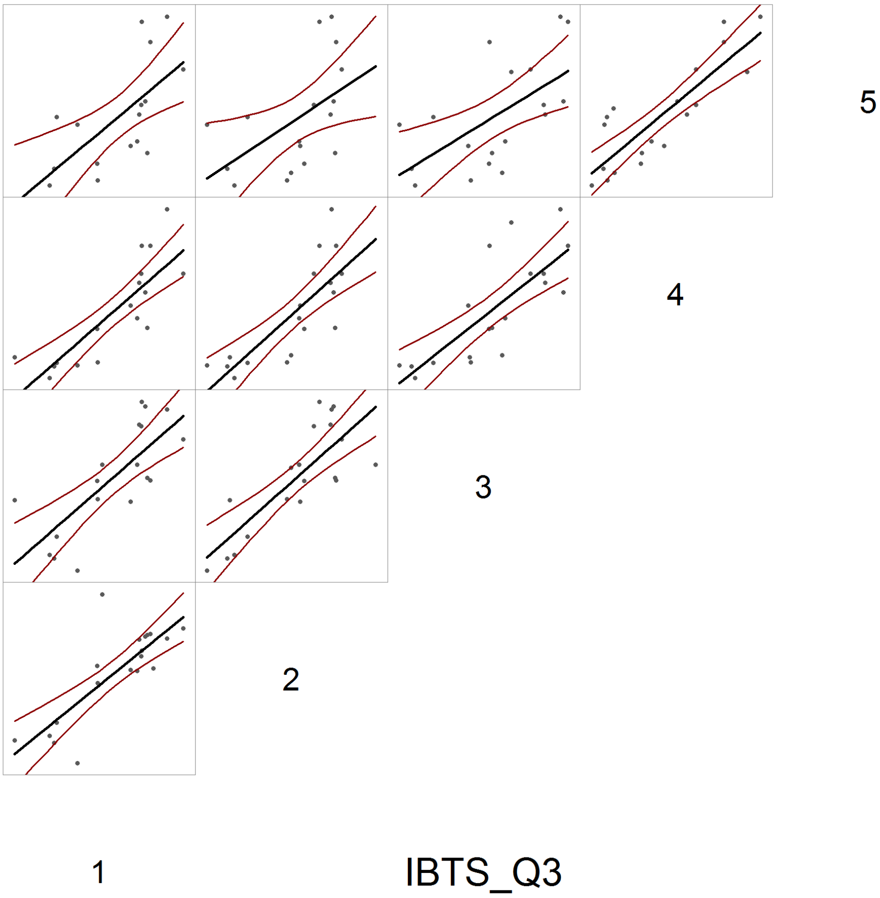


Figure 12.3.7 Whiting in IV and VIId. Within survey correlations (log index) for the IBTS quarter 3 survey (1990–2010). Each point represents a cohort, the line is a normal linear model fit. Thick lines represent a significant (p<0.05) regression and the curved lines are approximate 95% confidence intervals.

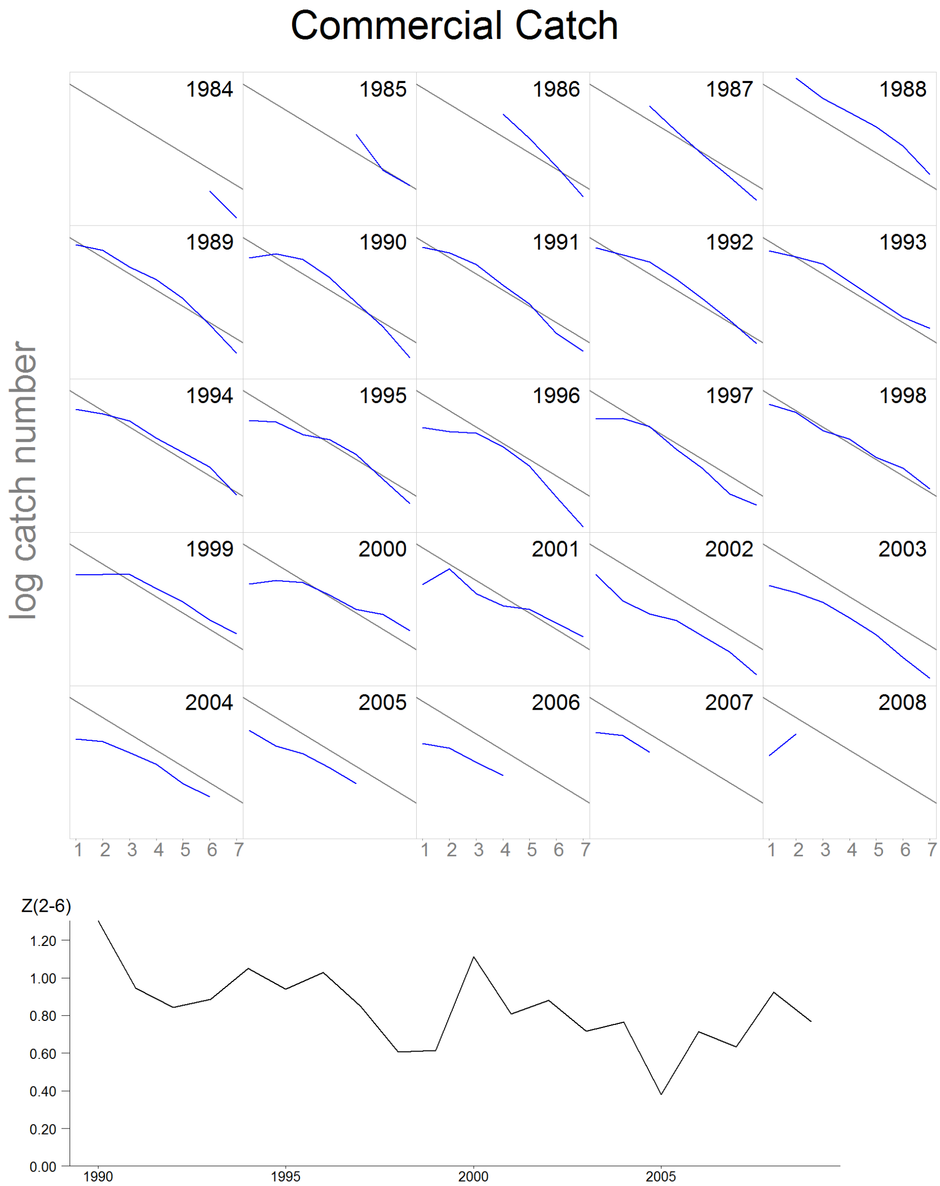


Figure 12.3.8 Whiting in IV and VIId. Top panel: Log catch number by cohort (ages 1 to 7). The year specifies the year-class. A reference a line with constant intercept and gradient representing a Z of 0.8 has been drawn in grey. Bottom panel: a raw estimate of annual mean Z averaged over ages 2 to 6, Z at age was estimated as log catch (y, a) – log catch (y+1, a+1).

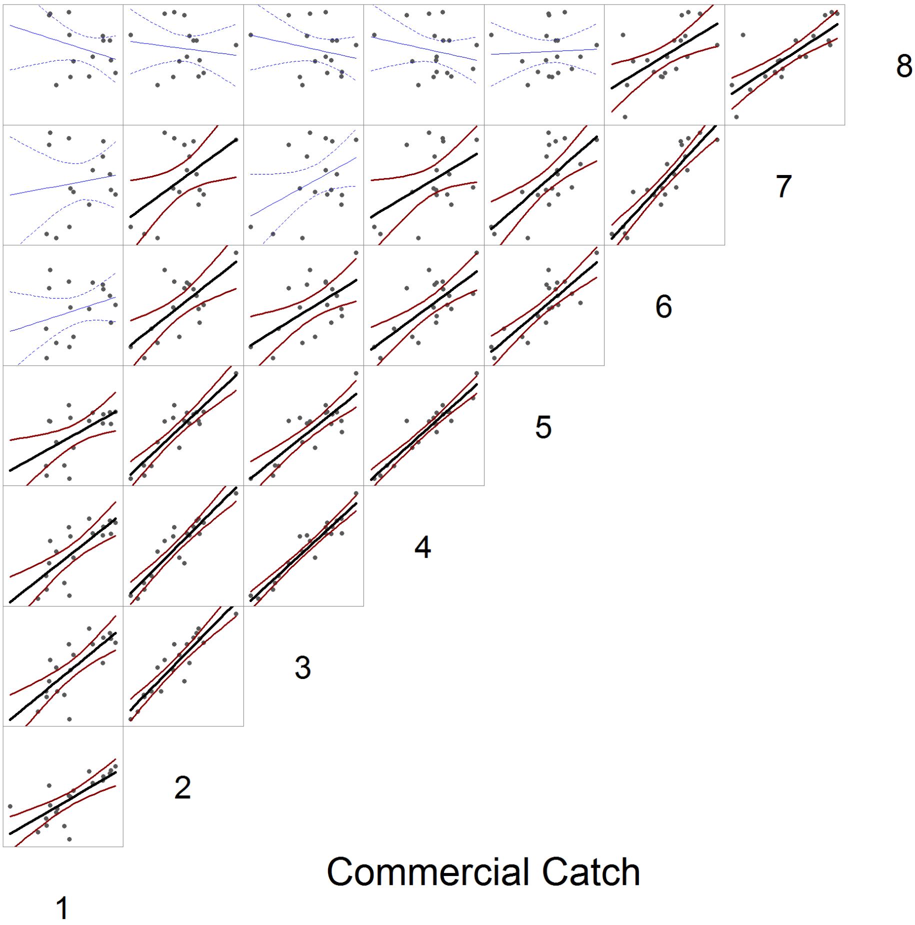


Figure 12.3.9 Whiting in IV and VIId. Correlations in the catch at age matrix (log numbers). Each point represents a cohort, the line is a normal linear model fit. Thick lines represent a significant ($p<0.05$) regression and the curved lines are approximate 95% confidence intervals.

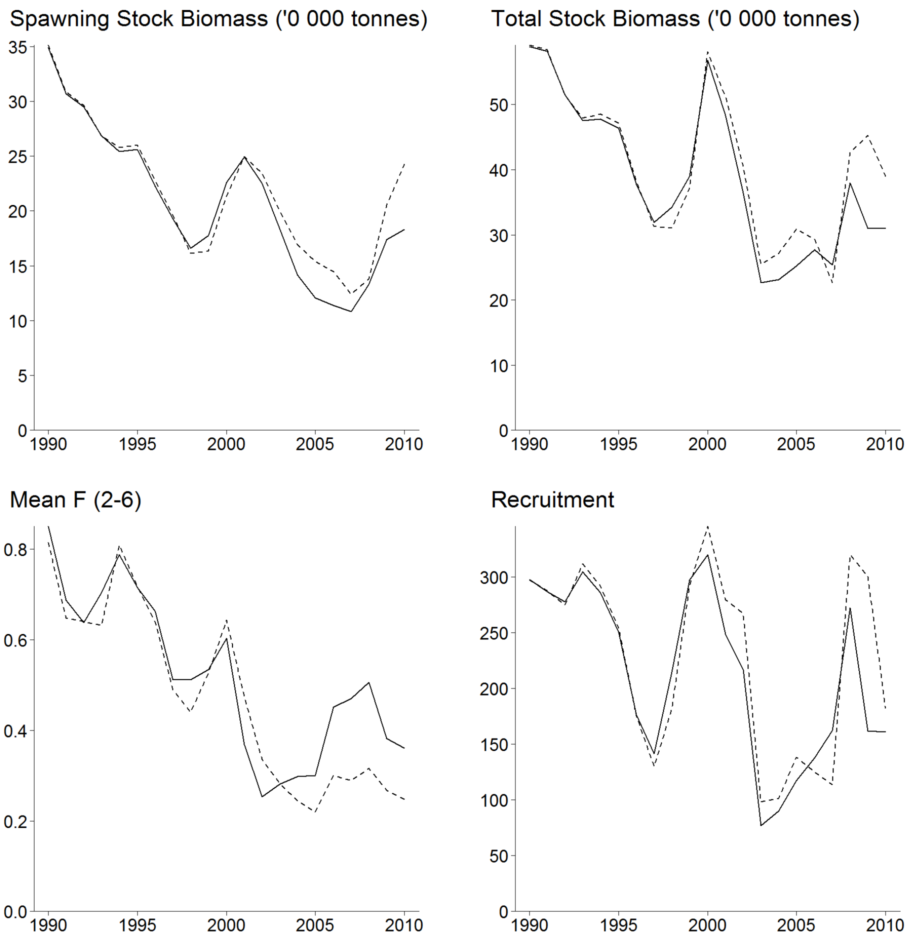


Figure 12.3.10 Whiting in IV and VIId. Comparison of spawning stock biomass, total stock biomass, mean F(2-6) and recruitment for individual tuning fleet XSA runs (with the settings used in the final assessment). Solid line: IBTS Q1; dotted line: IBTS Q3

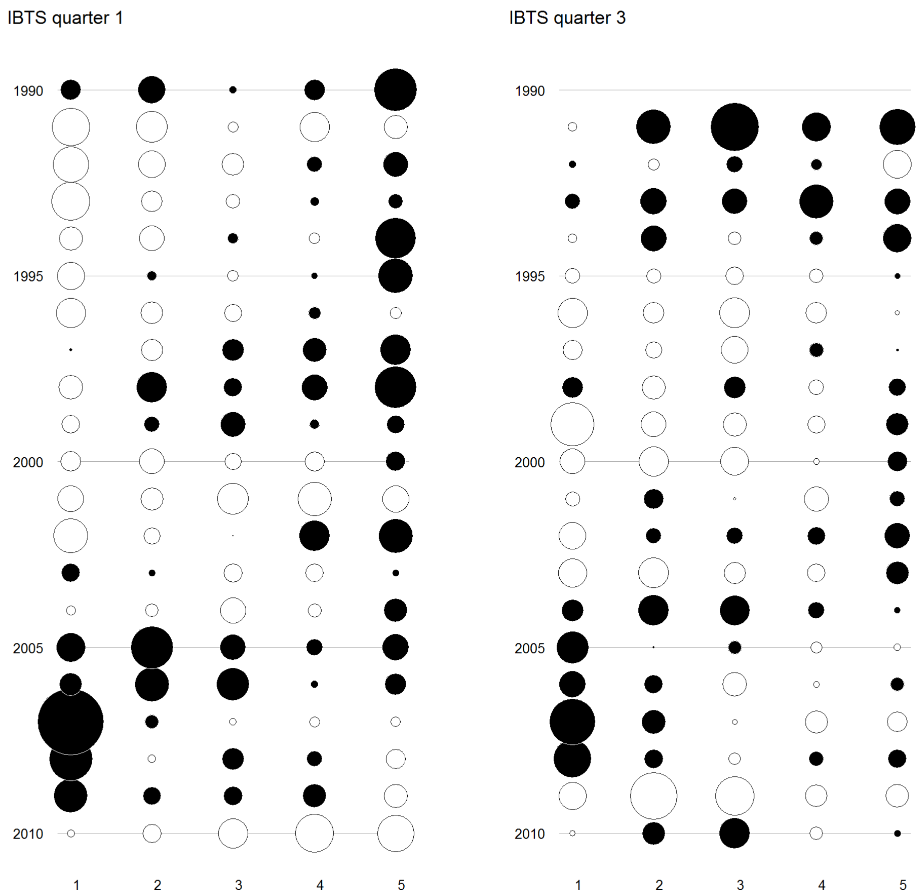


Figure 12.3.11 Whiting in IV and VIId. Residuals from single fleet XSA runs. Black signifies a negative residual and white signifies a positive residual.

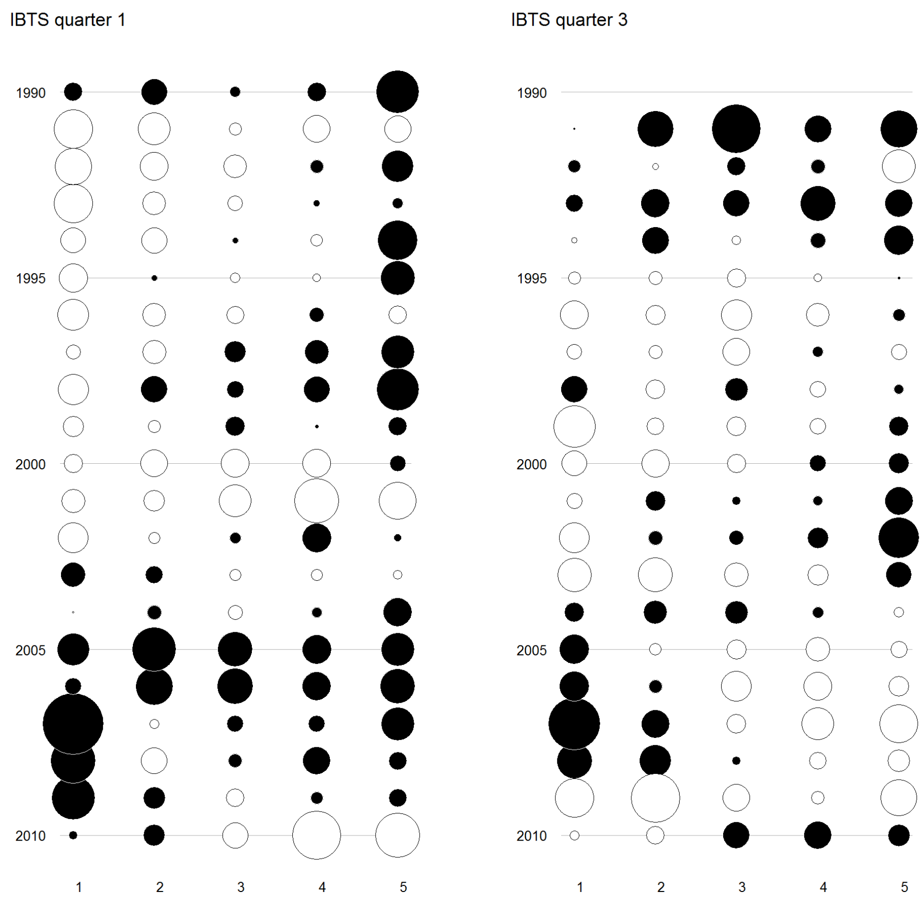


Figure 12.3.12 Whiting in IV and VIId. XSA final run: log catchability residuals. Black signifies a negative residual and white signifies a positive residual.

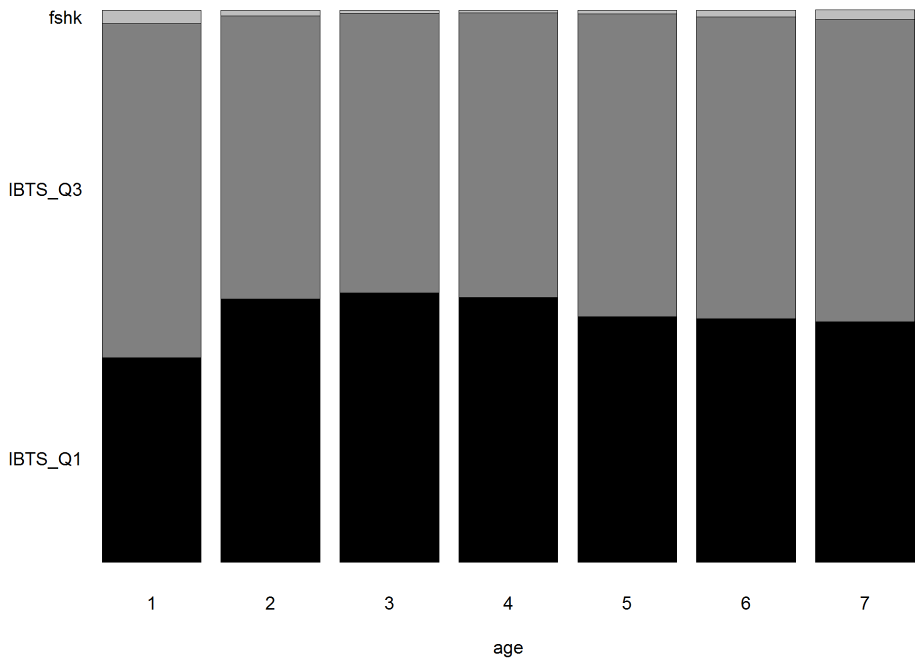


Figure 12.3.13 Whiting in IV and VIId. XSA final run: Contribution by survey and shrinkage to survivors from 2010.

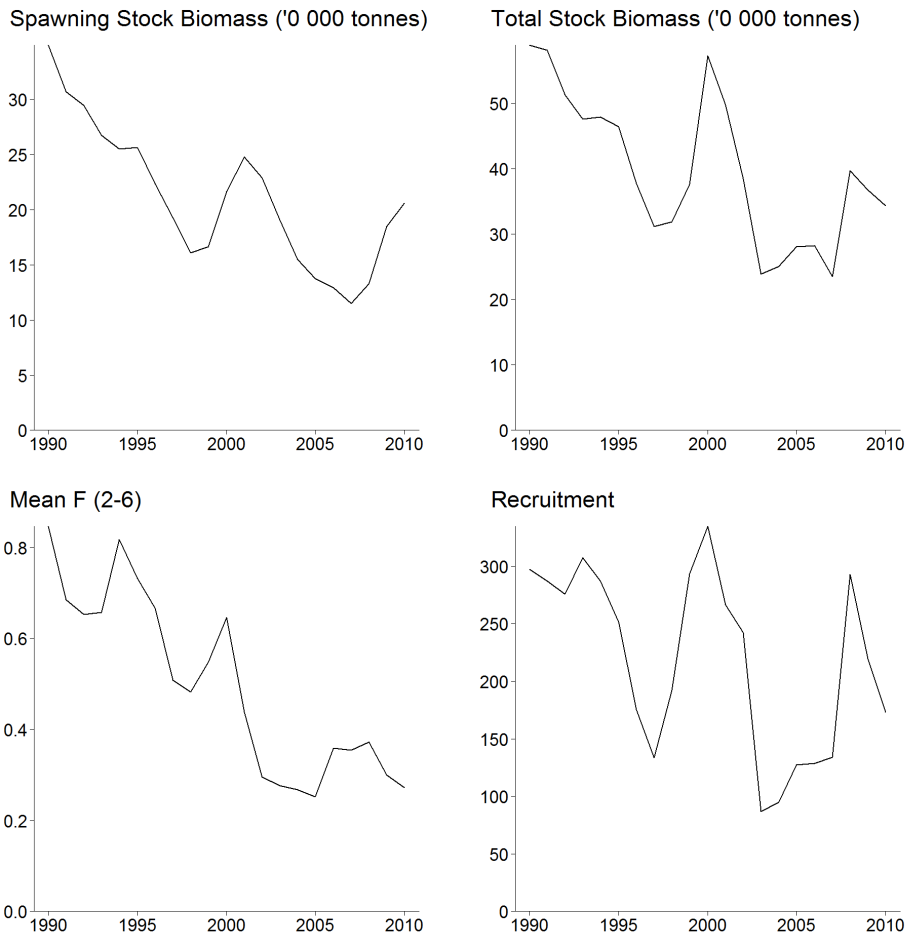


Figure 12.3.14 Whiting in IV and VIId. XSA final run: Summary plots.

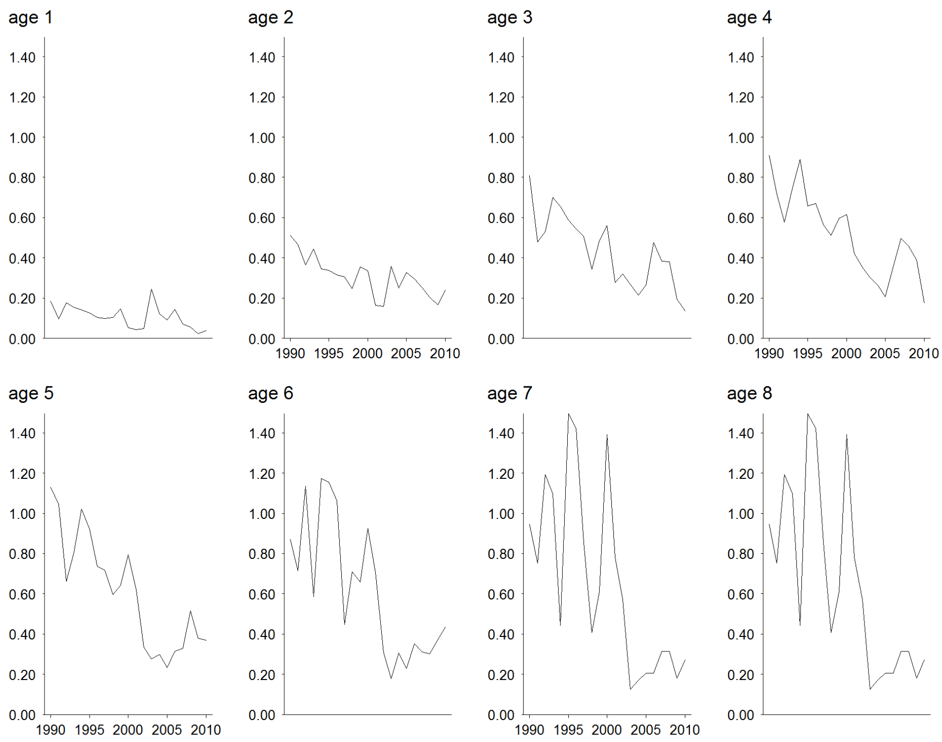


Figure 12.3.15 Whiting in IV and VIId. XSA final run: XSA fishing mortality at age.

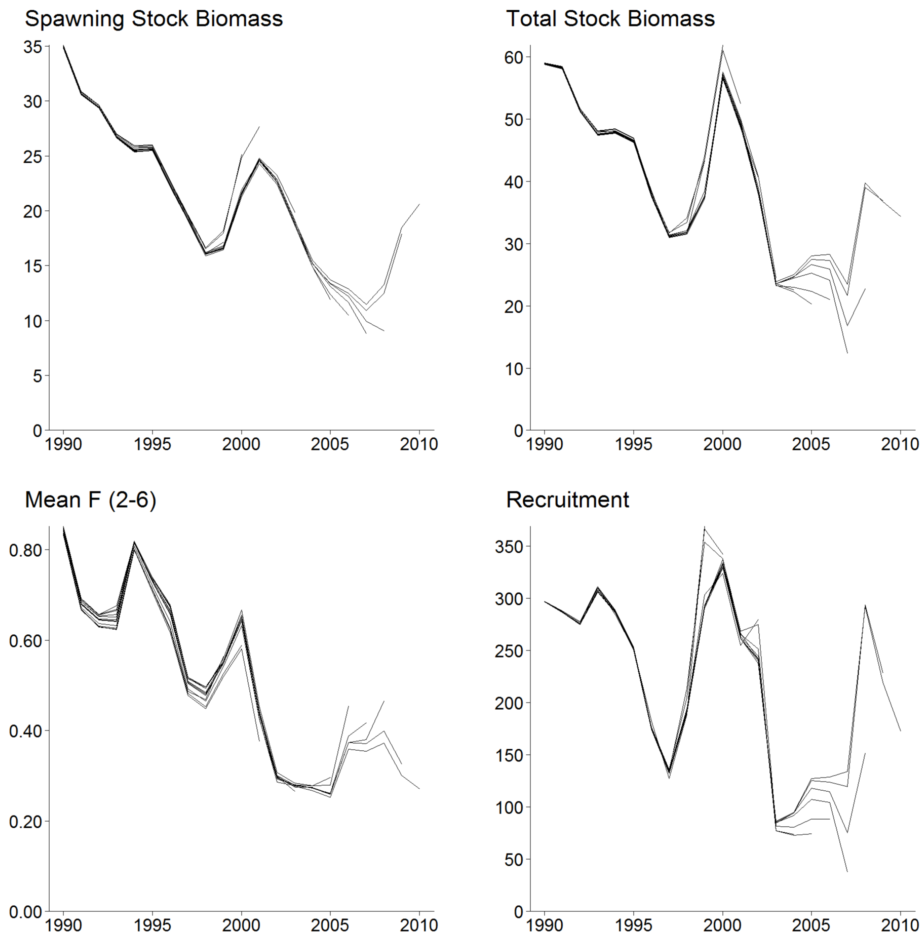


Figure 12.3.16 **Whiting in IV and VIId. XSA final run: retrospective patterns.**

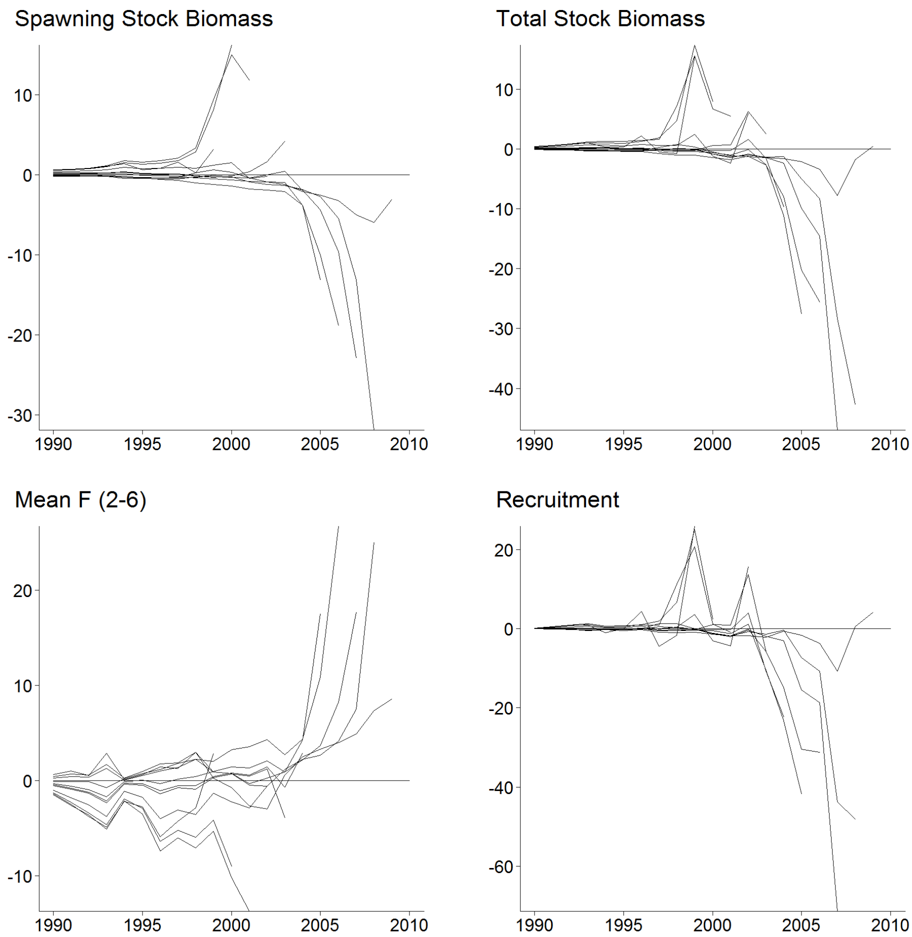


Figure 12.3.17 Whiting in IV and VIId. XSA final run: retrospective patterns. The y axis represents the percentage difference from the most recent assessment.

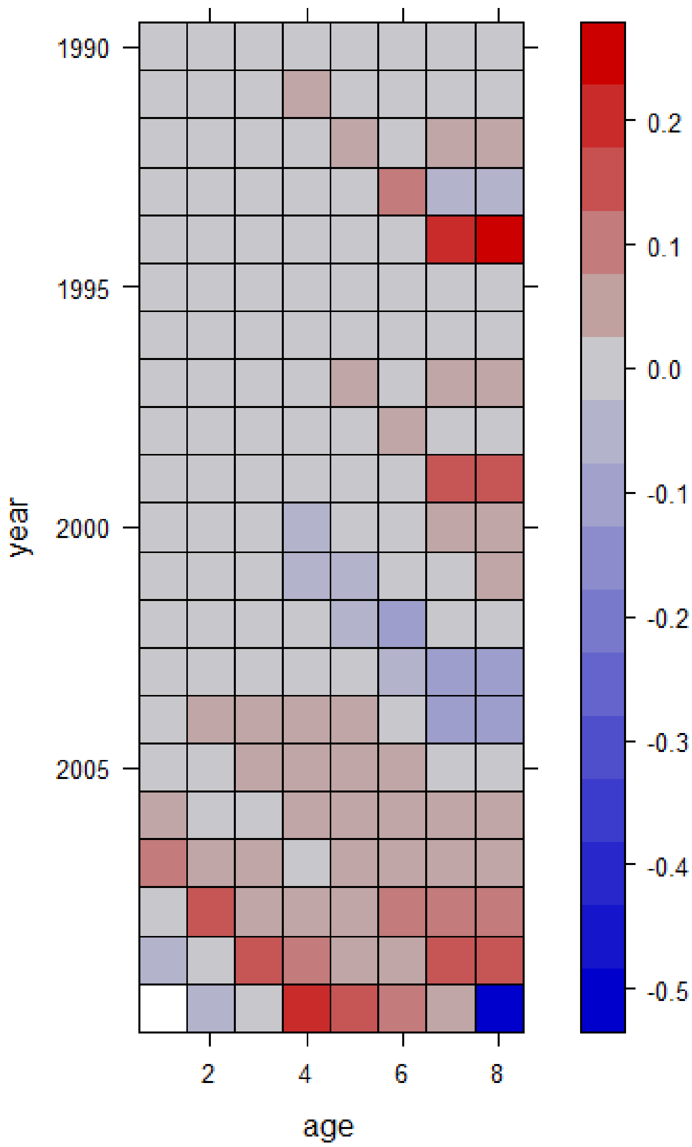


Figure 12.3.18 Whiting in IV and VIId. XSA final run: retrospective patterns. Differences in estimated stock numbers between the final run and one year previous. Red shows an upwards revision, blue a downwards revision. Numbers in 2010 for the retrospective run are XSA survivors.

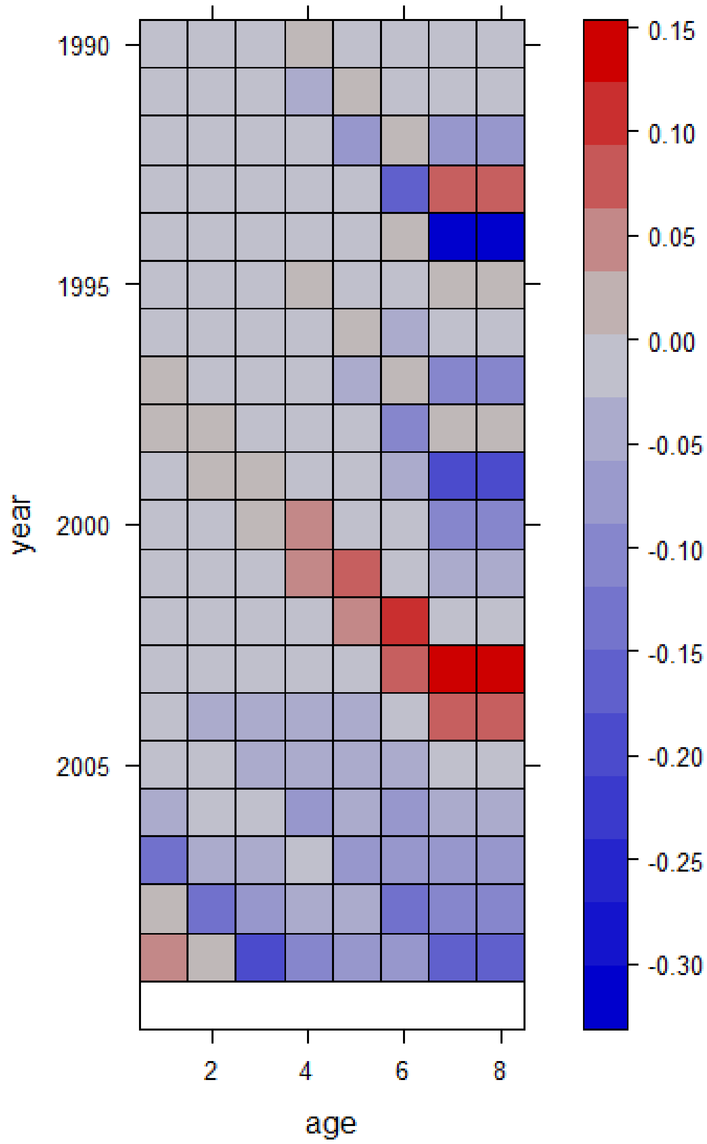


Figure 12.3.19 Whiting in IV and VIId. XSA final run: retrospective patterns. Differences in estimated stock numbers between the final run and one year previous. Red shows an upwards revision, blue a downwards revision. Numbers in 2010 for the retrospective run are XSA survivors.

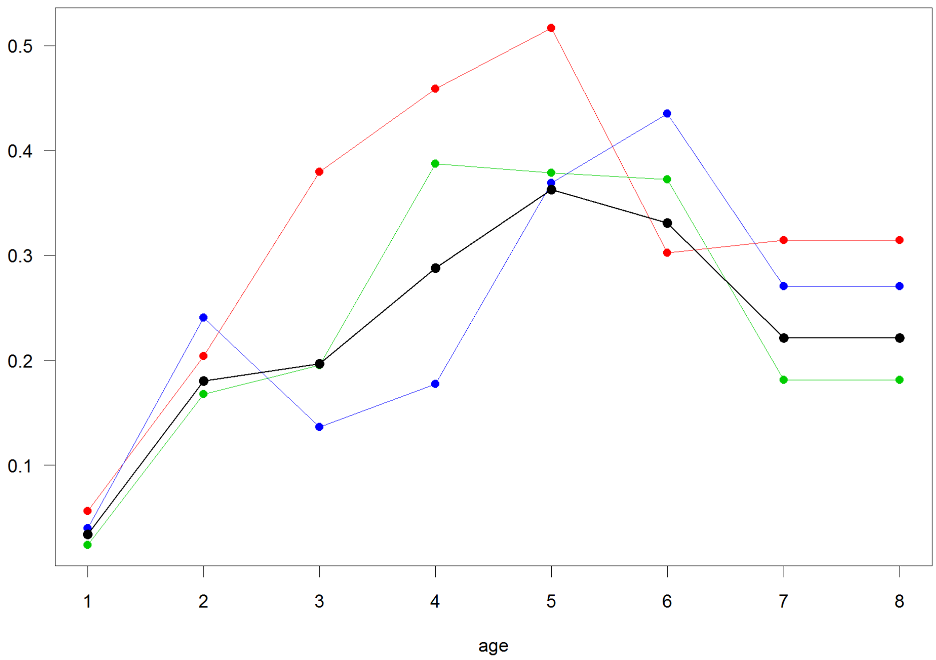


Figure 12.4.1 Whiting in IV and VIId. Changes in estimated exploitation pattern. From 2008 to 2010 from ages 1 to 8+. Red and green lines are 2008 and 2009. Current year F is blue. Forecast F is black.

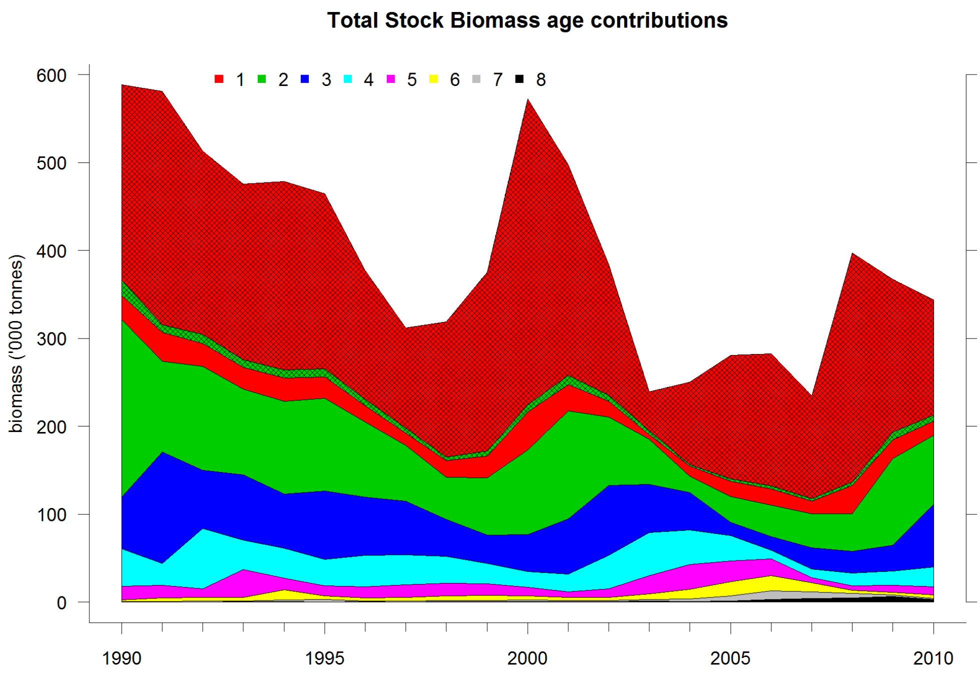


Figure 12.4.2 Whiting in IV and VIId. Age contributions to the SSB and TSB. Biomass not contributing to SSB is overlaid with hatched lines: immature age 1 lies over immature age 2, and the immature biomass lies over mature age 1, mature age 2 etc.

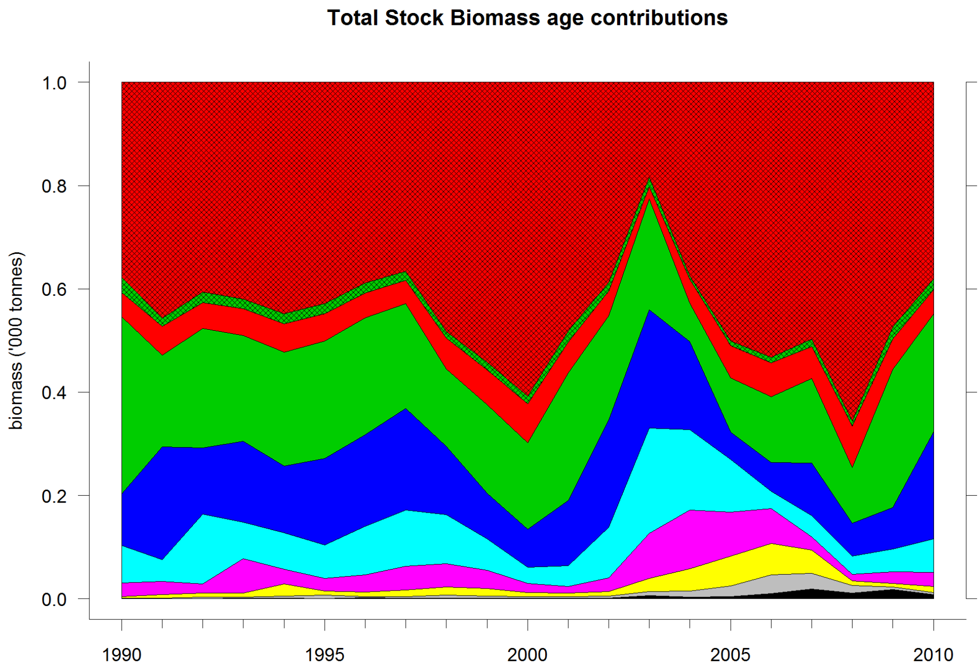


Figure 12.4.3 **Whiting in IV and VIId. Age contributions to the SSB and TSB shown as proportions of the total stock biomass. Biomass not contributing to SSB is overlaid with hatched lines: immature age 1 lies over immature age 2, and the immature biomass lies over mature age 1, mature age 2 etc.**

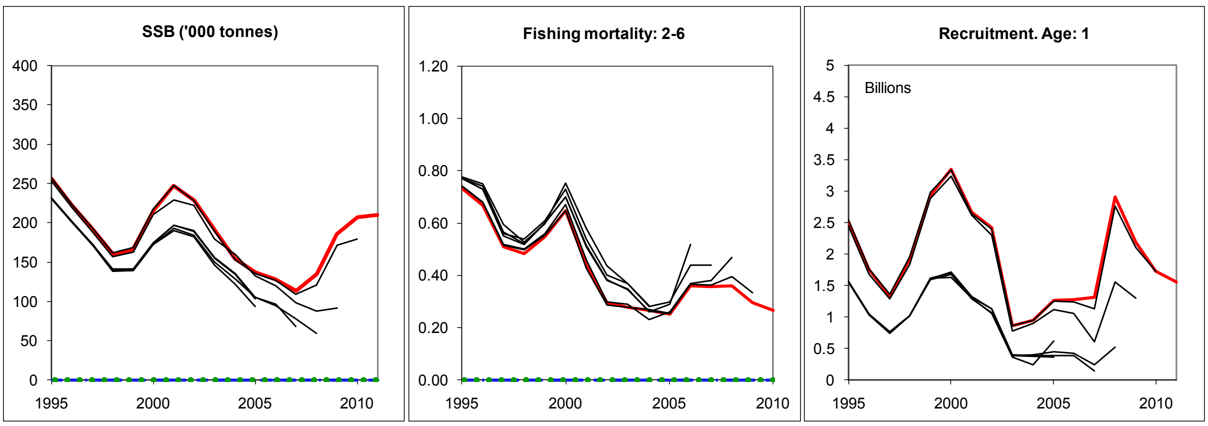


Figure 12.9.1 **Whiting in IV and VIId. Historical performance of the assessment.**

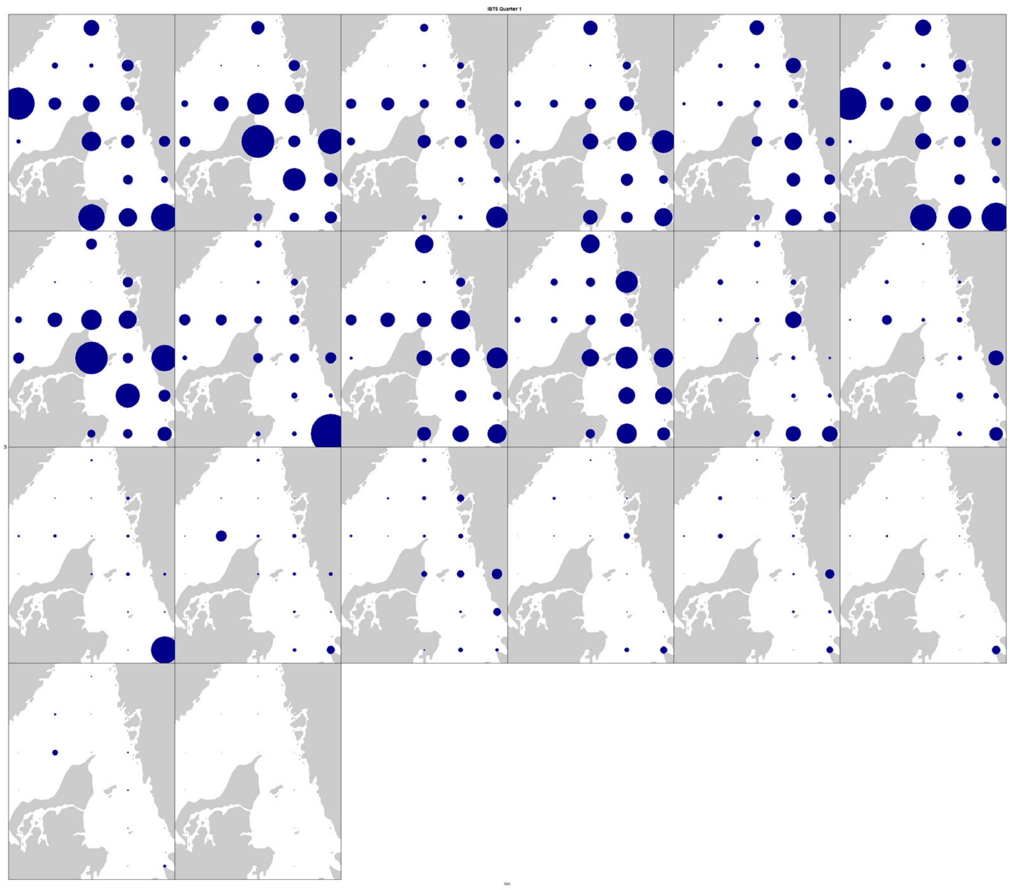


Figure 12.12.1 Whiting in IIIa. Distribution plot of the IBTS quarter 1 Survey age 1 to 4+ for demersal areas 9 and 10. Ages are on rows, years on columns from left to right 2006 to 2011.

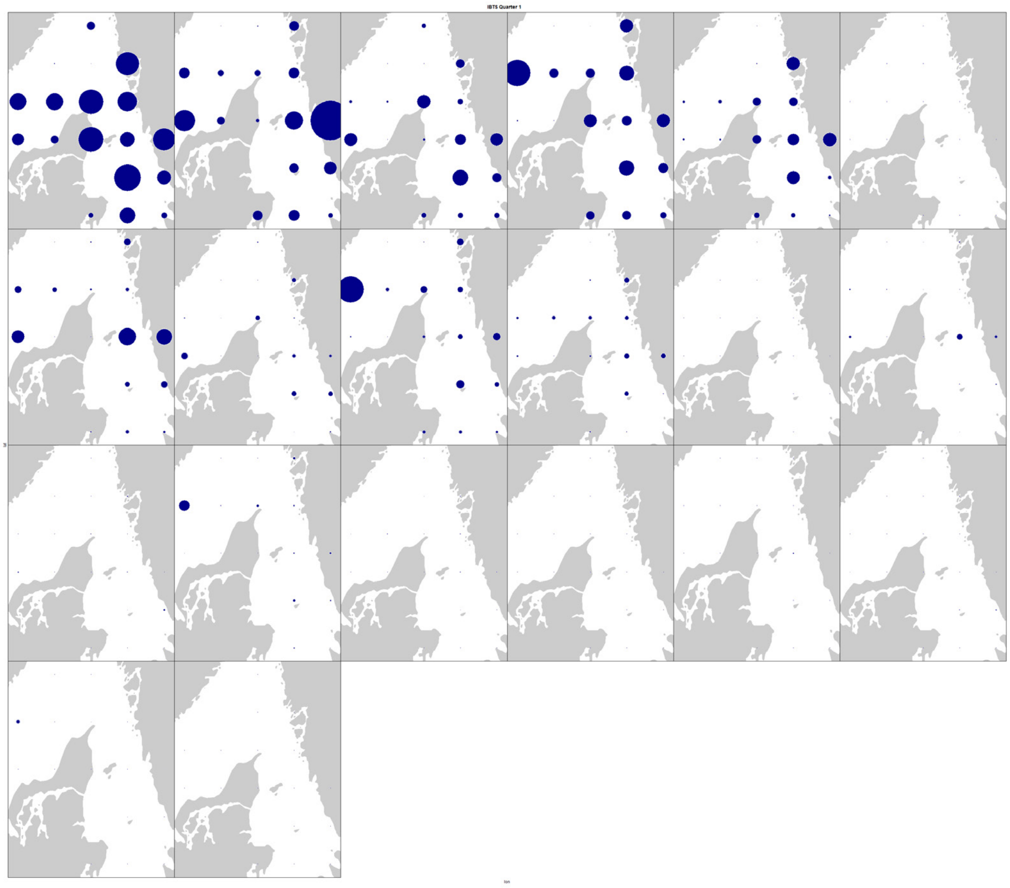


Figure 12.12.2 Whiting in IIIa. Distribution plot of the IBTS quarter 3 Survey age 1 to 4+ for demersal areas 9 and 10. Ages are on rows, years on columns from left to right 2005 to 2010.

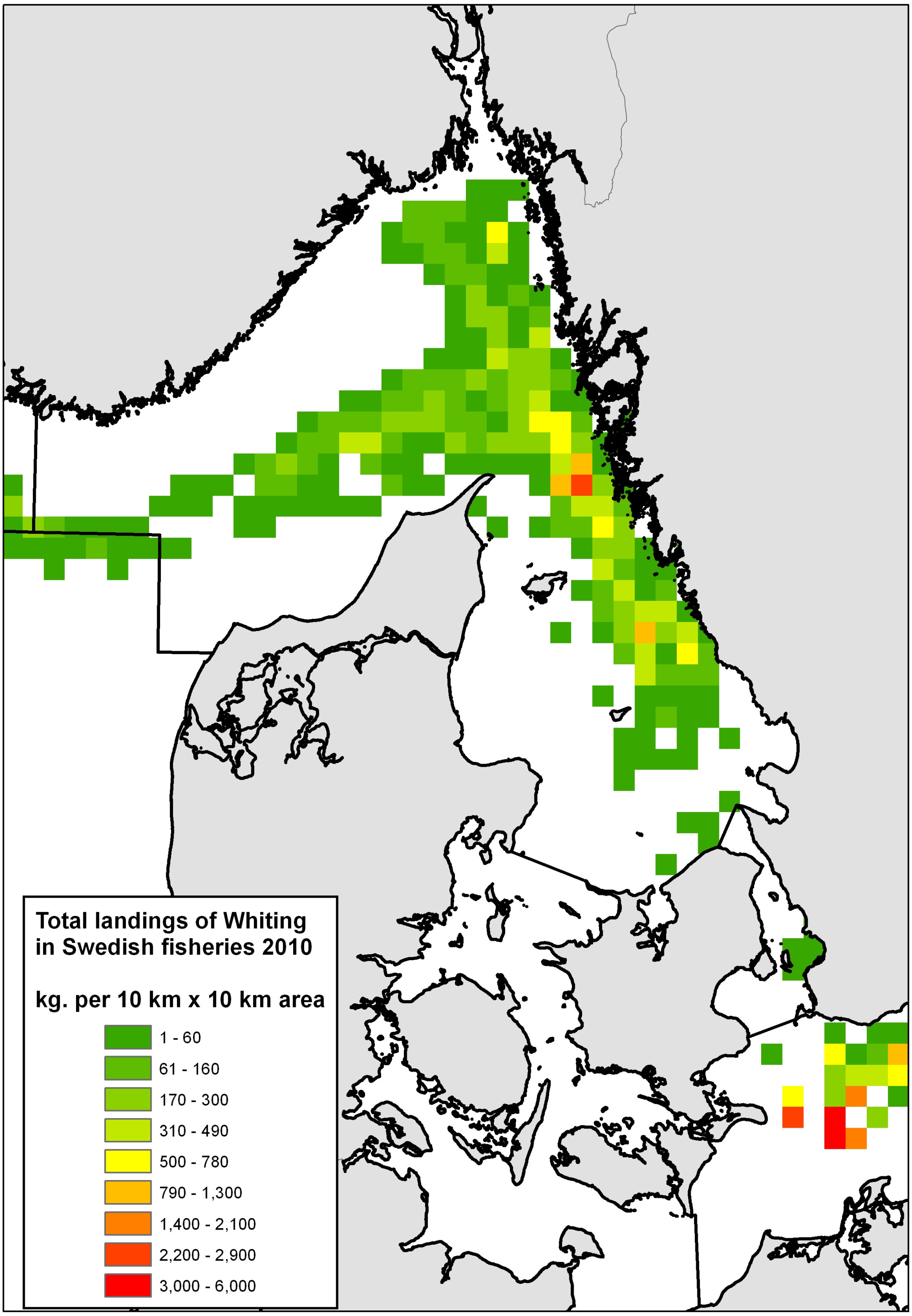
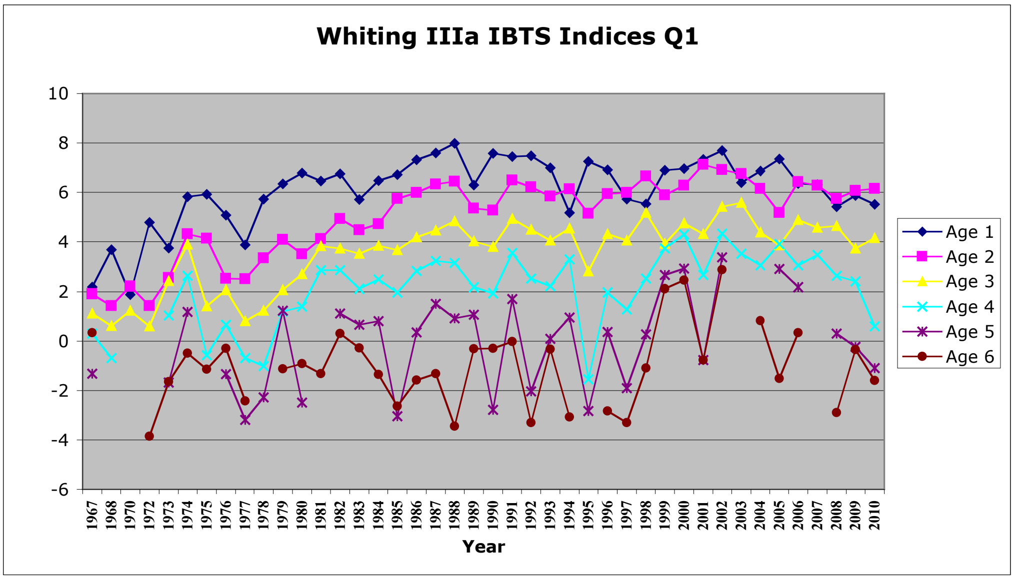


Figure 12.12.1. Whiting in Division IIIa. Spatial distribution of the total landings of Whiting IIIa in Swedish fisheries 2010 from logbooks information.



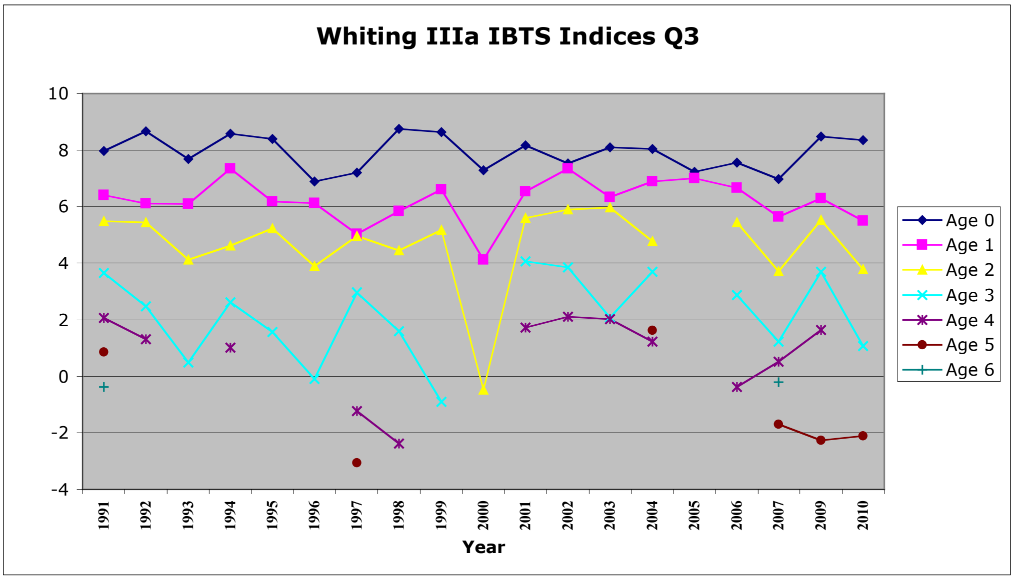


Figure 12.12.2. Whiting in Division IIIa. IBTS indices per age class for Q1 covering the years 1967-2010 and Q3 covering the years 1991-2010.

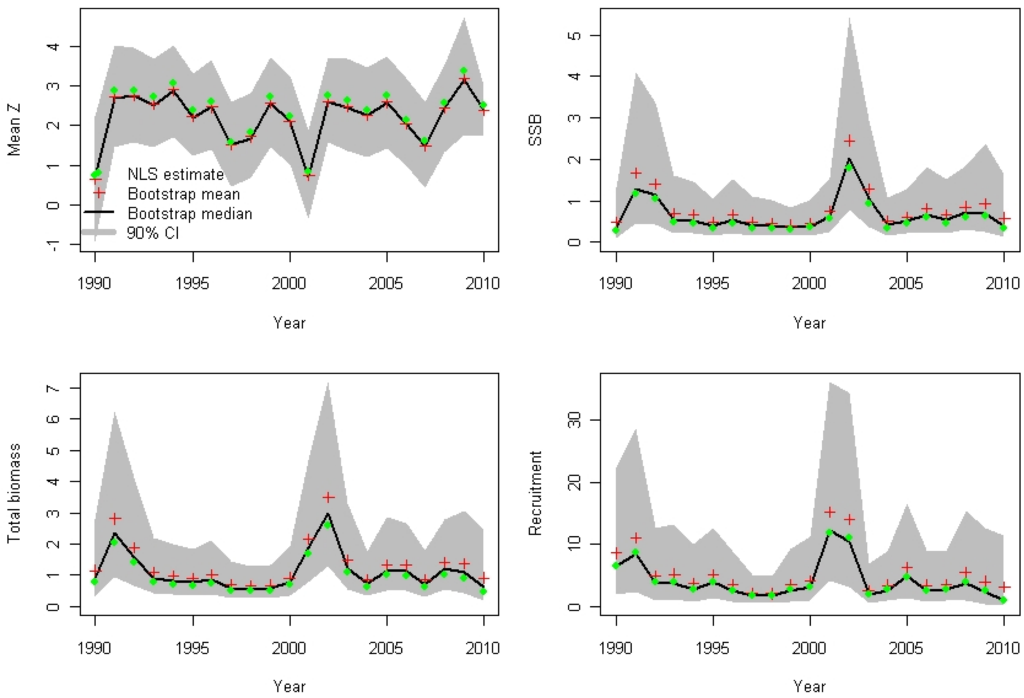


Figure 12.12.3. Whiting in Division IIIa. SURBAR analysis. Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap.

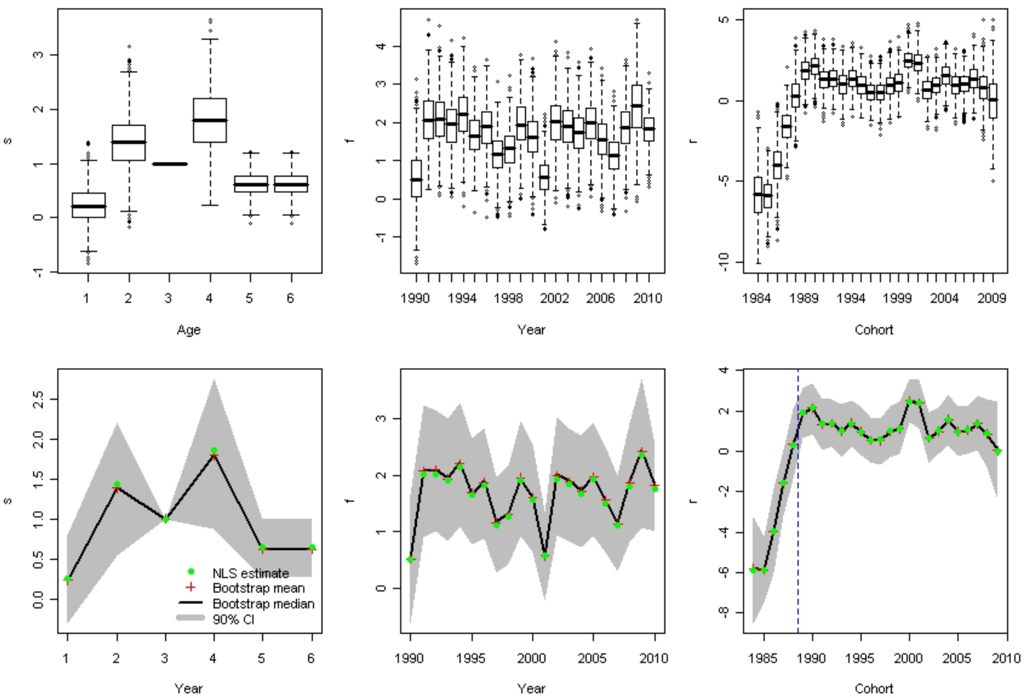


Figure 12.12.4. Whiting in Division IIIa. SURBAR analysis. Parameter estimates for the age-effect in Z (s, left), the year-effect in Z (f, middle) and the cohort effect (r, right). Upper row: boxplot summaries of bootstrap distributions. Lower row: shaded grey areas correspond to the 90% CI. Green points give the model estimates, while red crosses and black lines give (respectively) the mean and median values from the uncertainty estimation bootstrap. The blue line in the bottom right plot separates cohort-effect estimates for older fish (left) from age-1 fish (right).

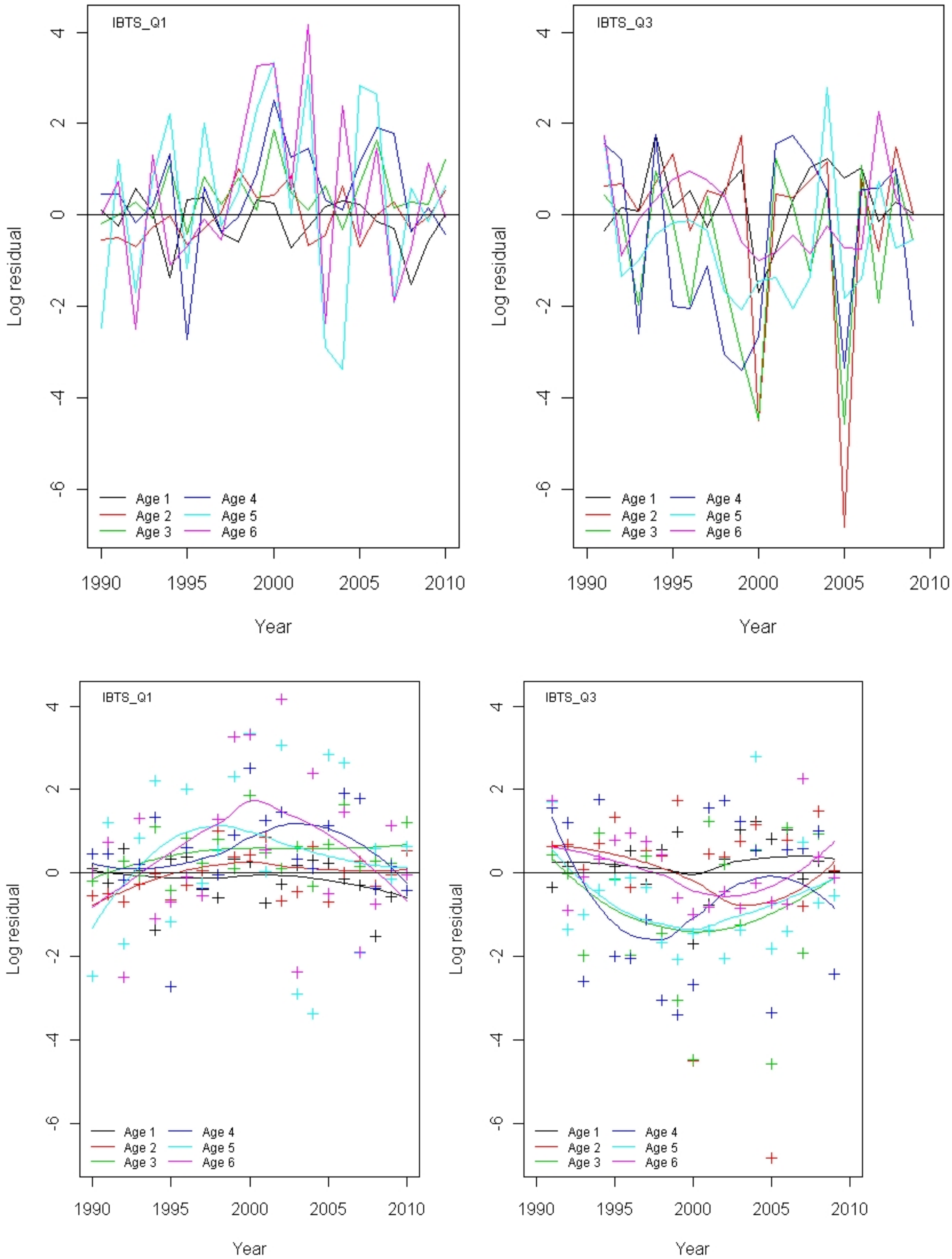


Figure 12.12.5 Whiting in Division IIIa. SURBAR analysis. Log residual estimates per age class for IBTS Q1 and IBTS Q3. Upper: line plots. Lower: point plots, with a loess smoother (span = 2) fitted through the points for each age class.

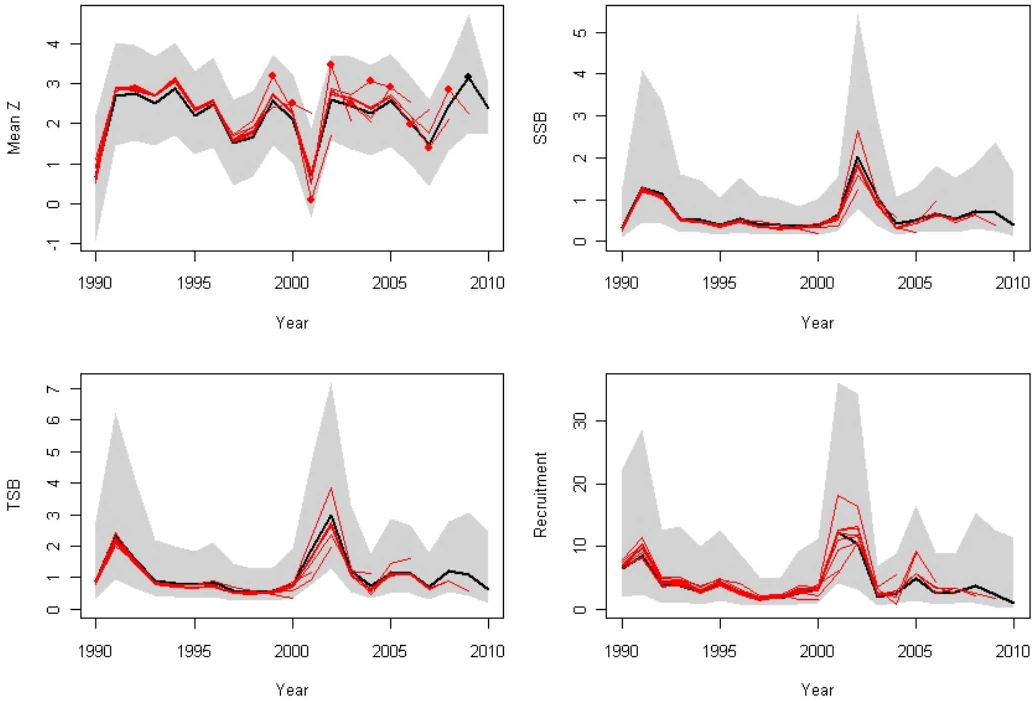


Figure 12.12.6. Whiting in Division IIIa. SURBAR analysis. Retrospective analysis plots for mean total mortality Z over ages 2 to 4, relative spawning stock biomass (SSB), relative total biomass, and relative recruitment. The full time-series run is indicated by a black line, the retrospective runs by red lines. Shaded gray areas indicate the 90% CI. For mean Z, the second-last estimate for each analysis is marked with a point (as the last estimate for each analysis is based on a three year mean and is not directly based on data).

13 Haddock in Subarea IV and Division IIIa (N)

The assessment of haddock presented in this section is an update assessment. Following the benchmark meeting in January 2011 (ICES-WKBENCH 2011), two main changes have been made to the run settings and model configurations used in last year's assessment: an error in the FLXSA settings has been corrected, so that there is no longer a power model assumption for age-0; and a linear growth model is now used for forecasting weights-at-age. Several further recommendations by WKBENCH have not been adopted by WGNSSK, and the text highlights these.

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 2006-2011 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 in 2010 (and the first half of 2011) 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.

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 2010 was around 76%, which is the highest since 2003 (also 76%). The projected UK quota uptake for 2011 is thought to be in line with last year. UK uptake thus far in 2010 (as of 11th May) was 26.8%, compared with 25.3% at the same date in 2010.

13.1.3 ICES advice

ICES advice for 2010

In June 2009, ICES concluded the following:

> *Based on the most recent estimate of SSB (in 2009) and fishing mortality (in 2008), ICES classifies the stock as having full reproductive capacity and being harvested sustainably. SSB in 2009 is estimated to be above Bpa, although SSB has been declining since 2002. Fishing mortality in 2008 is estimated to be below Fpa, and below the target FHCR (0.3) specified in the EU–Norway management plan. Recruitment is characterized by occasional large yield-classes, the last of which was the strong 1999 year class. Apart from the 2005 year class which is about average, recent recruitment has been poor.*

The 2009 Q3 North Sea surveys for haddock (EngGFS and ScoGFS) did indicate a significant change in the perception of recruitment compared to the estimates available in June, with evidence of a larger year class than assumed in the forecast. However, on further inspection it became clear that the increased recruitment would not alter the landings forecast according to the management plan. Therefore, ICES did not change its advice in October 2009.

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.

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 2010 and 2011 TACs for haddock in this area were 35 794 t and 34 057 t respectively. The second area is Divisions IIIa-d, for which the TACs for 2010 and 2011 were 2 201 t and 2 095 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, 59 closures have been implemented by 16th May. The CCS has two central themes aimed at reducing the capture of cod through (i) avoiding areas with elevated abundances of cod through the use of Real Time Closures (RTCs) and (ii) the use of more species selective gears. Within the scheme, efforts are also being made to reduce discards generally. Although the scheme is intended to reduce mortality on cod, it 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. New EU effort regulations for 2010 are listed in Section 14.

13.2 Data available

Collation issues for catch data

Due to continuing problems in InterCatch with the application of foreign discard rate estimates to unsampled fleets (see Section 1.2), the international catch data for haddock have been aggregated using a spreadsheet approach (as has been the case for the previous four years). Some brief notes are provided here which are intended to clarify issues that have arisen with this process. Further information on the data collation method used can be found in the Stock Annex.

Broadly, the approach to collating the data was the same as for the previous years. However, the approach to raising by the responsible stock coordinator (Marine Scotland - Science) changed, as did procedures for dealing with data by France.

For the data collation of the international landings and discards, the approach to the estimating of discards for unsampled catches was essentially the same as for the previous year, i.e. the discard ratio (of sampled landings to the entire fleets landings) 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.

Some notes on particular aspects are given under headings below.

Data revisions

No data revisions were received for 2009 landings. UK (E&W) provided revisions to 2009 discard data. These were supplied in a separate spreadsheet but have not been updated yet in the 2009 data collation spreadsheet.

Danish Industrial By catch data

Danish industrial bycatch in Subarea IV was only sampled in the fourth quarter (and only for one age). It was decided to apply the age composition from discards in Subarea IV as these looked to be more reliably (and consistently through the year) sampled.

The estimated numbers at age and mean weights at age from discards in Subarea VI were applied to the industrial catches, weighted by the estimated numbers at age from the discarded catches.

The same procedure was used for industrial bycatches in Division IIIaN. Here the provided age composition was not used either, partly as it was only sampled in one quarter, but mainly because the reported mean weights at age were very low and dubious. Information on discard age composition from Division IIIaN was used instead.

Belgium

There were problems with Belgian landings data this year and some foreign harbour landings were missing. These values will have to be included next year as revisions.

Germany

Germany did provide sampling information for both landed and discarded catches. However these did not look reliable (SOP discrepancy of +40%), and the German data submitter reported that that sampling levels were low and age reading numbers were not representative. It was decided to disregard these data, but the amounts landed and discarded were kept under the assurance these were reliable.

Intercatch

A comparison between the Intercatch system and the spreadsheets is needed. This relies on the respective national institutes uploading their data – particularly where age compositions are available. Some data for North Sea haddock from 2008, 2009 and 2010 were still missing in Intercatch (as of 28/04/2011). Further notes on Intercatch can be found in Section 1.2.

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. 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 (Germany also provides discard information but declares them to be of poor quality and they are not used). 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.

The approach used to collate discard data changed last year to conform with the EU Data Collection Framework (DCF), beginning with the 2009 data year. The new approach is described in detail in Miller and Fryer (2005) and Fernandes *et al* (in press) and can be summarised as follows:

1) Observer trips that fish in more than one sampling area have historically been split with landings and discard components being recorded for each area. These are also stored on FMD (the Scottish fisheries database) with different trip identification numbers. Hence "trips" extracted from FMD are in fact trips within sampling area, and do not equate to a voyage of a fishing vessel from leaving port, fishing, and returning to port. Where the sampling area is smaller than the reporting area (e.g. sampling area IVa inshore within reporting area ICES area IV) this can lead to pseudo replication of trips in the calculation of confidence intervals on numbers at length or age. To rectify this trips are now merged so that they correspond to a voyage where that voyage has occurred wholly within a reporting area. Hence the correct numbers of replicates are used in the calculation of discard estimates confidence intervals.

2) The auxiliary variable in the calculation of discard estimates is the landed weight of the species of interest, plus the landed weight of gadoids: cod, haddock, whiting and saithe and *Nephrops*. This auxiliary variable overcomes the problem of estimating discard contribution of a trip to the fleet level where the trip has not landed the species of interest. In 2009 the auxil-

iary 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 2009 and 2010 estimates are well within the range of recent variation. This suggests that the new collation method did not change the perception of discard rates for haddock.

13.2.2 Age compositions

Total catch-at-age data are given in Table 13.2.2.1, while catch-at-age data for each catch component are given in Tables 13.2.2–4. The fishery in 2010 (landings for human consumption) was strongly reliant on the moderate 2005 and 2009 year classes. The strong 1999 year class has faded from the fishery, and the size of the plus-group is continuing to decline from its recent high. Discards predominantly consist of medium-sized fish aged 2-4 (from the 2006-2008 year classes). Vessels seldom exhaust 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 for the first time 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+
Natural mortality	2.05	1.65	0.40	0.25	0.25	0.20	0.20	0.20
Proportion mature	0.00	0.01	0.32	0.71	0.87	0.95	1.00	1.00

The 2011 benchmark assessment for North Sea haddock (ICES-WKBENCH 2011) considered time-varying estimates of both natural mortality and maturity, and suggested that the use of these in the update assessment should be investigated further by WGNSSK. The extant estimates are shown in Figures 13.2.4.1 (natural mortality) and 13.2.4.2 (maturity). Following due consideration, WGNSSK decided not to use these values in the update assessment for the 2011 meeting, for the following reasons.

- Changes in maturity-at-age do not have a direct impact on changes in reproductive potential for this stock, as they are moderated through fecundity which is itself a function of age and time. Therefore, the use of new maturity estimates in the calculation of SSB for advisory purposes could be misleading. Peter Wright (Marine Scotland – Science, Marine Laboratory, Aberdeen) provided WGNSSK with total egg production (TEP) estimates based on Scottish observations of fecundity, and these are discussed further in Section 13.2.5 below. However, TEP-based reference points for haddock are not yet available, and it is not yet clear how they would be used in the context of existing MSY approaches or management plans. Thus new maturity estimates cannot be used without consideration of concomitant changes in fecundity (and therefore TEP), and TEP cannot yet be used as the basis for advice.

- A workshop on reproductive potential was held in Aberdeen in April 2011, as part of the EU-FRESH project (see http://www.fresh-cost.org). This considered how (and whether) reproductive potential estimates (such as TEP) could be incorporated in the assessment and advisory cycle. The workshop concluded that such estimates could only be used if a) the estimates can be shown to have significant time-trends, rather than just noise about a mean, and if b) their use did not reduce the ability of managers to manage sustainably (as determined through quantitative management strategy evaluation). Neither of these conditions has been met for natural mortality and maturity estimates for North Sea haddock.

Both of these issues remain under active consideration, and will be revisited in the near future. The Appendix to Section 13 below provides details on current estimates of total egg production, which could form the basis of any new approach.

13.2.5 Catch, effort and research vessel data

Survey distribution and annual density at age is given in Figure 13.2.6.1 for the IBTS Q1 survey (for 2005-2011). All plots show a north to north-westerly distribution of haddock. The moderate 2005 and 2009 year classes can also be identified and tracked through time.

Data available for calibration of the assessment are presented in Table 13.2.6.1. FLXSA cannot use data from the current year (2011). 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.

Effort data series from commercial fishing fleets, as collated by STECF, have been summarised in previous WGNSSK reports (c.f. also Bailey and Rätz, 2011 –available at https://stecf.jrc.ec.europa.eu/reports/effort). The data for 2010 are not yet available from STECF, so a repetition of such an effort plot would be of limited value. However, access to VMS data from (for example) Scottish fleets permits a wide range of effort summaries which have not previously been possible. For example, Figure 13.2.6.3 gives an inferred distribution map of the sources of haddock landed by the Scottish whitefish fleet during December 2010. This was generated by allocating reported haddock landings for each trip evenly over the VMS "fishing" pings for that trip (that is, those pings for which speed was less than 4.5 knots). The distribution map was then built up by aggregating the landings-per-ping index across all trips for the whole fleet. While the assumption that the landed haddock were caught in equal amounts at all fishing pings is very unlikely to hold for a single trip, we hypothesise that the aggregated data do indicate (in a general sense) the haddock distribution from which landed fish originated. Given this, Figure 13.2.6.3 indicates good haddock fishing areas for December 2010 off Lewis, to the east of Orkney, south of the Fladen grounds in the central northern North Sea, and further east towards Norway.

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	**0-7**
	Groundfish survey	Q3	**ScoGFS Q3 GOV**	**1998-2010**	0-8	**0-7**
England	Groundfish survey	Q3	**EngGFS Q3 GRT**	**1977-1991**	0-10+	**0-7**
	Groundfish survey	Q3	**EngGFS Q3 GOV**	**1992-2010**	0-10+	**0-7**
International	Groundfish survey	Q1	**IBTS Q1 (backshifted)**	**1982-2010**	0-5+	**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. Separable VPA results are presented along with catch curves and intra-series correlations to check for data consistency and validity. 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 2010, the North Sea Review Group (RGNS) raised a number of relatively minor issues (as part of a generally positive review). The issues are listed below, along with the WGNSSK response and actions taken (if applicable).

- *"The new approach to collate discard data, though found to provide estimates within historical range, should probably be evaluated quantitatively before use."*

  Further details on the new approach and references to quantitative evaluations of it are now included in Section 13.2.1.

- *"Research into fishing behaviour would likely be useful to better understand effort and discarding behaviour."*

  Work is underway in Scotland and elsewhere to examine the issue of discarding practices, and (more generally) why fishermen make the decisions they make. These are medium- to long-term projects, and it is hoped that they will significantly improve the knowledge base for the assessment and advisory process.

- *"The log catchability residuals for the final assessment (Figure 13.3.5.1) do show some patterns in the residuals for certain years, for example around 1991 for all fleets."*

SSB was at an historical low in or around 1991, while fishing mortality was near to an historical high. It may be that the fleets were able to maintain high catch rates on a stock of low abundance, in which case the mostly negative survey residuals around that time could be explained as an increase in apparent commercial fleet catchability.

- *"It is not stated why the method of F at age estimation for the short term forecast was changed."*

  The following explanation was provided in ICES-WGNSSK (2010): "While this is a change from the update procedure, it gives similar results… and is less subject to noise in the most recent assessment year."

- *"The consistency of Blim and FMSY needs to be evaluated."*

  A great deal of work was carried out during the 2010 meeting on estimates of F_{msy}, the high uncertainty of which are largely due to the lack of a strong stock-recruitment relationship for this stock. WGNSSK therefore showed in 2010 that F_{msy} is very *in*consistent. There is no particular requirement for B_{lim} and F_{msy} to be consistent with each other. However, simulations (Needle 2008) have demonstrated that the combination of a proxy for F_{msy} (0.3) and B_{lim} (100 kt) with a bycatch F (0.1) and B_{pa} (140 kt) in the EU-Norway management plan has a high probability of facilitating sustainable management.

The benchmark meeting in February 2011 (ICES-WKBENCH 2011) provided several recommendations, which are listed below along with comments from WGNSSK on whether (and how) they were adopted in the update assessment.

- *"WKBENCH recommends that a joint IVa–VI dataset be collated in time for the assessment WGs in May 2011, and that a comparative assessment be carried out by WGNSSK using these data. This will provide further evidence for a final decision on appropriate assessment units."*

  A joint dataset was compiled quickly during the WGNSSK meeting, and the results of an FLXSA run on these data are included in Section 13.3.2 below. The collation procedure lacked quality control, however, and the results should be viewed as indicative only.

- *"WKBENCH recommends that the update assessment model remains XSA, using the existing run settings. In addition, exploratory assessments using SAM and SURBA should be run each year."*

  The update assessment has been carried out using XSA (in the FLXSA implementation), and runs have also been completed using SAM and SURBAR (a new R implementation of SURBA).

- *"WKBENCH recommends that weights-at-age for North Sea haddock forecasts be modelled using a linear cohort-based approach."*

  This has been done, following the approach suggested by Jaworski (2011).

- *"WKBENCH recommends that time-varying natural mortality estimates from WGSAM should be used in the subsequent update assessments."*

  This issue is discussed in Section 13.2.4 above.

- *"WKBENCH recommends that refined maturity estimates should be developed before the next WGNSSK meeting in May 2011 and used in subsequent update assessments."*

See Section 13.2.4.

- *"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."*

  As time-varying natural mortality and maturity estimates are not yet used in the assessment (Section 13.2.4), reference points and MSEs can remain unchanged for the time being.

- *"WKBENCH recommends that the next benchmark meeting for North Sea haddock be brought forward if haddock management changes to a system of catch quotas with an enforceable discard ban."*

  This remains under consideration.

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).

Residuals from a separable VPA carried out on the catch data (Figure 13.3.2.4) show very few outliers, and none greater than ±3. This supports the conclusion that catch data are appropriately consistent.

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.

Finally, a joint "northern shelf" dataset was generated, consisting of summed catch-at-age from Subarea IV and Divisions IIIa and VIa. Mean weights-at-age were taken to be the averages of the area-specific mean weights, themselves weighted by the estimated stock numbers in each area. A joint FLXSA assessment was then carried out, using North Sea settings, North Sea values for natural mortality and maturity, and all available surveys. The estimates for mean F(2-4) are compared in Figure 13.3.2.11. These show some discrepancies in level in the early part of the time series, but more recent years are very similar to the assessment using Subarea IV and Division IIIa alone. It would be beneficial to return to this issue at future WGNSSK meetings, as it has the potential better to reflect the biological situation but needs to be considered carefully.

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.

In 2009, the ICES Methods WG (ICES-WGMG 2009) carried out limited simulation analysis that suggested FLXSA may be inflating SSB estimates towards the end of the time series. This year's benchmark meeting (ICES-WKBENCH 2011) agreed that this was a potential concern, but highlighted the unreliability of firm conclusions based on a very small number (10) of simulated datasets. 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. **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		2011
q plateau		6
Tuning fleet year ranges	EngGFS Q3	77-91; 92-10
	ScoGFS Q3	82-97; 98-10
	IBTS Q1*	82-10
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 correctly, so the Table presents the equivalent diagnostics from an XSA run (the stock estimates are identical**). 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.** It should be noted that XSA does not provide an estimate of plus-group survivors, so this has been calculated separately in a spreadsheet.

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 and Figure 13.3.5.3. A retrospective analysis, shown in Figure 13.3.5.4, indicates very little retrospective bias in the assessment.

A new addition to the stock summary (Table 13.3.5.4) is the column of total egg production, generated using the approach outlined in Section 13.2.5. The update FLXSA estimates of SSB are compared with the new TEP estimates in Figure 13.3.5.3. At the start of the time-series the relationship between SSB and TEP was close, but since around 1980 the relative trends have diverged so that TEP is now higher than would be expected if there was a one-to-one relationship with SSB. Increasing maturity (ICES-WKBENCH 2011) has thus had an effect on TEP, even if the earlier-maturing fish are producing less eggs per capita because they are younger. However, the estimation of TEP does not bring us very much closer to an understanding of recruitment dynamics for this stock. The plot of recruitment against TEP in Figure 13.3.5.4 does not show any more pattern than that of recruitment against SSB (Figure 13.4.3).

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 appears to have stabilised at or just above 0.2, which is below the management plan target of 0.3. Fluctuations around the target-F rate of the management plan are an expected consequence of the lag between data collection and management action, and should not be taken to indicate that the plan is not working. The 2006-2008 and 2010 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, and is similar in most respects to the plot of recruitment against TEP in Figure 13.3.5.4.

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 2010 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 2010 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 (3663 millions) has been assumed for recruitment in 2011-2013. Recruitment estimates for 2009 and 2010 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 2011	FLXSA estimate (millions)	Geometric mean of 5 lowest recruitments 1994–2008
2009	2	787	
2010	1	230	
2011	0		3663
2012	Age 0 in 2012		3663
2013	Age 0 in 2013		3663

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 (2008-2010) means by age are used for all forecast years.

Finally, the weights-at-age for 2010-12 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. The principal difference lies in the forecasts of the 2005 year class weights-at-age, which are now thought likely to be rather lower than previously considered.

Fishing mortality

Estimated mean fishing mortality in 2010 was very similar to 2009, at around 0.23. The WG decided that it would be reasonable to assume that this level would continue into the forecast period. Rather than just use the 2010 fishing mortalities at age for the forecast, a three-year average exploitation pattern scaled to the level of the mean 2010 fishing mortality was used. To be precise: the exploitation pattern for each year (2008, 2009 and 2010) 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 2008, 2009 and 2010. The vector of mean exploitation is then scaled by multiplying by the average F over ages 2-4 in the last historical assessment year (2010). 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 2008-2010) 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. No TAC constraint in 2010 was used. The *status quo* forecast indicated landings in the intermediate year of 31716 t, which was around 88% of the available quota for 2011 (36152 t). Although this uptake is higher than in recent years, information from the industry suggests that this is quite likely, and current data on quota uptake for 2011 indicates that a similar level of uptake is to be expected this year. Full quota uptake is not likely, however, so a TAC constraint in the intermediate year was not thought to be appropriate.

Assuming *status quo* F in both 2011 and 2012, SSB is expected to increase to 256 kt in 2012 (as the 2009 year class matures), before falling again slightly in 2013 to 239 kt. In this case, human consumption yield will be around 34 kt in 2012, with associated discards of 11 kt. This substantial decrease in discards is largely due to the growth above minimum landing size of the 2009 year class, and the assumption (Figure 13.6.4) of reduced mortality on younger fish (as compared with 2010).

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 2012 landings yield of 42 kt (the maximum permitted 15% increase on the 2011 quota) and discards of 14 kt lead to SSB in 2013 of 230 kt. All of these SSB forecasts for 2013 are above B_{pa} (140 kt). The trend in SSB for the near future is likely to be slightly downwards, however, and even with continued low F, further strong year classes will be needed to increase SSB again.

The following table compares the intermediate-year (2010) forecast from the 2010 WG with the 2010 observations and assessment results from the 2011 WG:

WG	Landings 2010	F(landings) 2010	Discards 2010	F(discards) 2010	SSB 2011
2010 forecast	30820	0.15	10485	0.084	211757
2011 assessment	29054	0.17	10155	0.081	235072

Landings in 2010 proved to be almost identical to the prediction from last year's assessment. Human consumption fishing mortality was consequently slightly more than predicted, while discards were also very similar to the prediction. On the other hand, SSB in 2011 is rather higher than expected. This latter point may be due to changes in assumptions on mean weights-at-age, but is more likely to be due to under-utilisation of the quota.

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 last year's 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 assessment 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) The estimates of total egg production (TEP) presented in this report are not yet appropriate to be used as the basis of management advice, for the reasons outlined above. However, it is very important that the use of TEP in this context is given due consideration in the near future, as it would represent the incorporation of much more biological realism than exists in the assessment thus far.

4) 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.

13.10Status 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 0.23) in 2010 and now fluctuating around the historical minimum. This is well below F_{pa} (0.7), and is also lower than the mortality rate recommended in the management plan (0.3) and most estimates of F_{msy}. Discards have also decreased slightly in 2010Spawning stock biomass (183 kt in 2010) is predicted to increase in the near future, and remains well above B_{pa} (140 kt). The 2006-2008 and 2010 year classes were estimated to be weak, but evidence suggests that the 2009 year class is stronger.

Figure 13.10.1 gives the results of the North Sea stock survey from 2010 (Napier 2011). This shows that the industry perception is of increasing haddock abundance in all areas of the North Sea in 2010 (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 Subarea 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*.

Appendix: Total Egg Production (TEP)

Following the WKBENCH work on maturity, Peter Wright (Marine Scotland – Science, Marine Laboratory, Aberdeen) provided a working paper on total egg production estimates for North Sea haddock. To prevent this being lost in the grey literature, it is included in full here.

"Changes in stock reproductive potential in North Sea haddock": P. J. Wright, Marine Scotland – Science, Marine Laboratory, Aberdeen

Introduction

Stock reproductive potential (SRP) is the stock's ability to produce viable eggs and larvae that may eventually recruit to the adult population or fishery (Trippel, 1999). The use of spawning stock biomass is predicated on the assumption that a given weight of adult biomass has an equal likelihood of generating the same level of recruitment. The use of spawning stock biomass as a proxy for SRP has been criticised in recent years due to known size, age and condition effects on fecundity, maternal effects on egg size and the influence of spawning time on survival. Moreover, for many ICES stocks, a constant maturity at age key is applied to estimate SSB. In this working document, different indices of SRP for North Sea haddock are presented in order to examine how the addition of biological information affects our perception of the spawning stock time series. The indices calculated builds on evidence for differences in reproductive characteristics linked to time and age in North Sea haddock. A substantial decline in the maturity size and age relationship has been demonstrated in North Sea haddock since the 1970s (Wright et al., in press). Age 2 haddock also have a much lower relative fecundity than older age-classes (Hislop, 1988), although the magnitude of this difference has declined in recent years (Wright et al., in press). Age 2 haddock also spawn late in the spawning season and there is a lower probability of survival of offspring from this part of the spawning period (Wright & Gibb, 2005).

Methods

Maturity-length relationships

Data on sex, maturity, age and length were extracted from the 1st quarter International Council for the Exploration of the Sea (ICES) International Bottom Trawl SMALK (Sex-Maturity-Age-Length Keys) database (DATRAS). The bottom trawl surveys were undertaken between January and March, overlapping the February to May spawning period of haddock in the North Sea (Wright and Gibb 2005). As the estimation of maturity-size relationships required large samples of maturity staged fish, the estimation of SRP indices was limited to year classes after 1973. Proportion mature (M) was estimated using a logistic generalized linear model for each sex according to:

(1) $$\text{logit}(M) \sim \text{length} + \text{age} + \text{cohort}$$

where age and cohort were treated as factors with individual maturity state (immature or mature (stages 2 - 4) as a binary response variable. A quasi-binomial link function was used due to a problem with over dispersion in the survey data. No interactions improved the model fit.

Fecundity relationship

As there are no annual estimates of fecundity (Fec) data from seven years collected over the last four decades were used to derive a relationship that accounted for length and age:

(2) $Fec \sim length \times age_c$

where length is in cm and age_c was treated as two categories; age 2 and 3+. A generalized linear model with a gamma response distribution coupled with a log-link function was chosen to account for the increasing predictor variance with increasing response variable.

Total egg production

In order to link total egg production (TEP) to the stock assessment, the proportion mature and female as well as the potential fecundity were estimated for the stock mean weights at age. As maturity could only be considered in relation to length, mean weights at age were converted to mean lengths at age using the February haddock weight – length relationship given by Coull et al. (1989). TEP was then calculated according to:

(4) $TEP = N \times W \times M \times R \times Fec$

where for a given age, a and length, l, N = numbers at age from the ICES-WKBENCH (2011) FLXSA that incorporated varying natural mortality, W = mean weight at age in the assessment, R = proportion females and M, R and Fec are estimated for the average length at age in each year.

Results

Length, age and cohort all had highly significant effects on the proportion mature ($p < 0.001$). The decline in size at maturity can be seen from the positive trend in the cohort coefficients with cohort (Table 13.2.5.1). The intercept and slope of the fecundity – length relationship differed between the two age-classes (see Table 13.2.5.2), with the total model explaining 69% of the variation in fecundity. The proportion of females deviated from 0.50 in some years and for some ages but there was no clear trend. Consequently, the proportion of females was assumed to be 0.5 for the TEP estimation.

The fixed values currently used by ICES assume a proportion mature of 0.32 and 0.71 for ages 2 and 3, respectively. Temporal changes in the different metrics used to infer SRP are presented in Figure 13.2.5.1. All metrics appeared to converge to a low point in 1991. However, due to a decreasing trend in size at maturity since the 1980s, the fixed and varying estimates of SSB increasingly diverged. Proportion mature ranged between 0.12 and 0.85 for age 2 and 0.44 and 0.98 for age 3, with an increasing temporal trend in all age-classes. By the 1990s these estimates of varying maturity indicate that female SSB should have been heavily influenced by age 2 females. For example, in 2001 female SSB rose sharply with the entry of the very large 1999 year class. However, because age 2 haddock have a lower relative fecundity (eggs.g.soma) than 3+ females, the changes in female SSB were not closely mirrored by changes in TEP. Rather, TEP peaked a year later because of the low relative fecundity of age 2 fish. TEP also indicated that SRP was probably higher in the early 1980s than suggested by SSB measures.

Discussion

The fixed proportion of mature at age used by ICES is similar to that reported by Hislop and Shanks (1981) for the 1970s. However, as these authors reported, their estimate of proportion of mature age 2 females was higher than that reported for the late 1920s (Raitt, 1932). The magnitude of the temporal decline in maturity at size and age appears to have increased between the 1980s and the present time (see also Wright *et al.*, in press). Consequently the proportion mature age 2 and 3 haddock is now markedly higher than the fixed values used by ICES. Hence, using constant values for proportion mature at age can hide important underlying trends in maturation.

Whilst the addition of varying female spawning stock biomass affects the perception of spawning stock trends it is not a wholly accurate reflection of SRP since it exaggerates the contribution of age 2 fish. Estimates of total egg production indicate that the influence of large year classes only begins to be seen when fish reach 3 years old due to the lower relative fecundity of age 2 females. In addition to the lower fecundity of age 2 female it is also likely that fewer of their offspring survive to settlement. Estimates of survival probability have indicated that survival from the age 2 spawning period ranges from 0.22 – 0.96 of that of the total spawning period (Wright and Gibb, 2005). Consequently, the likely contribution of age 2 egg production is lower than the estimated egg production for that age group. In summary then, a change to a more biologically realistic SRP measure can be justified by the trends in underlying reproductive parameters but a revised SRP measures must consider egg production rather than just female SSB.

Table 13.2.1.1. Haddock in Subarea IV and Division IIIa. Nominal landings (000 t) during 2002–2010, as officially reported to, and estimated by, ICES, along with WG estimates of catch components, and corresponding TACs. Landings estimates for 2010 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
Belgium	III a	0	0	0	0	0	0	0	0		
Denmark	III a	3791	1741	1116	615	1001	1054	1052	1263	19	
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	95	
Portugal	III a	0	0	0	0	30	37	0	0		
Sweden	III a	393	165	158	180	246	278	276	166	126	
UK -E+W+NI	III a	0	0	0	0	0	0	0	0		
UK - Scot	III a	0	0	0	0	0	0	0	0		
Official landings	III a	4572	2236	1498	957	1576	1727	1585	1655		
WG landings	III a	4137	1808	1443	764	1537	1515	1374	1515	1287	
WG discards	III a		195	112	217	970	816	646	556	608	
WG total catch	III a	4137	2003	1555	981	2507	2332	2020	2072	1896	
TAC	III a	6300	3150	4940	4018	3189	3360	2856	2590	2201	2095
Belgium	IV	559	374	373	190	105	179	113	108	78	
Denmark	IV	5123	3035	2075	1274	759	645	501	553	725	
Faeroe Islands	IV	25	12	22	22	4	0	3	32	5	
France	IV	914	1108	552	439	444	498	448	125	271	
Germany	IV	852	1562	1241	733	725	727	393	657	634	
Netherlands	IV	359	187	104	64	33	55	29	24	41	
Norway	IV	2404	2196	2258	2089	1798	1706	1482	1278	1114	
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	89	
UK - E+W+NI	IV	3647	1561	1159	651	485	1799	1378	2155		
UK – Scot	IV	39624	31527	39339	25319	31905	24919	25987	26238		
UK – all	IV									24980	
Official landings	IV	54096	42055	47311	30916	36442	30666	30433	31311		
WG landings	IV	54171	40140	47253	47616	36074	29418	28893	31264	27770	
WG discards	IV	45892	23499	15439	8416	16943	27805	12532	9986	9515	
WG IBC	IV	3717	1150	554	168	535	48	199	52	431	
WG total catch	IV	103780	64788	63246	56200	53551	57271	41624	41302	37717	
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	
WG discards	IV & IIIa	45892	23694	15550	8633	17913	28621	13178	10543	10124	
WG IBC	IV & IIIa	3717	1150	554	168	535	48	199	52	431	
WG total catch	IV & IIIa	107917	66792	64800	57181	56058	59603	43644	43374	39612	
TAC	IV & IIIa	110300	54885	81940	70018	55039	58000	49300	44700	37995	36152
WG quota uptake		53%	76%	59%	69%	68%	53%	61%	73%	76%	

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	-	-	-	-	-	-	-	-	31.7	20.7	1.0	52.4
Min	28.9	8.4	0.0	41.6	0.4	0.1	-	0.4	30.3	8.6	0.0	43.6
Mean	118.1	81.0	27.3	226.3	2.9	0.5	-	2.9	121.0	81.1	27.3	229.3
Max	524.1	260.4	338.4	929.5	7.8	1.0	-	7.8	524.8	260.4	338.4	930.0

- denotes missing data.

2011 are intermediate year forecasts.

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

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

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
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

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

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

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
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
1988	9280	3309	12819	2462	620	202	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
1990	2996	7218	1986	359	1491	227	25	78	4	0	0	0	0	0	0	4
1991	116909	22493	3248	601	43	43	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
1993	124495	107664	13220	3214	82	9	0	18	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
1995	198033	102560	2201	888	65	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
1997	21694	45264	10935	4451	184	17	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
1999	69820	10780	4531	2932	344	166	3	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
2001	1987	22946	35776	10127	35	8	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
2003	4145	5983	2101	1285	1524	12	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
2005	0	176	97	26	9	5	201	1	0	0	0	0	0	0	0	0
2006	0	1772	716	241	47	46	74	108	1	0	0	0	0	0	0	1
2007	1	27	218	6	1	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
2009	15	36	97	48	19	6	2	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

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
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

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
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

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
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

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
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

Table 13.2.5.1. Haddock in Subarea IV and Division IIIa. Coefficients and standard errors for maturity relationship for female North Sea haddock.

Explanatory variable	Coefficient	SE	P
Null	-10.038	0.234	0.001
Length	0.179	0.005	0.001
Age			
2	2.288	0.109	0.001
3	3.703	0.126	0.001
4	3.741	0.151	0.001
5	4.095	0.206	0.001
Year-class			
1975	-0.219	0.272	NS
1976	0.463	0.234	0.05
1977	1.222	0.205	0.001
1978	1.331	0.195	0.001
1979	1.060	0.188	0.001
1980	1.234	0.242	0.001
1981	1.905	0.213	0.001
1982	1.661	0.223	0.001
1983	2.370	0.188	0.001
1984	1.673	0.236	0.001
1985	2.070	0.205	0.001
1986	2.234	0.193	0.001
1987	2.024	0.262	0.001
1988	2.985	0.223	0.001
1989	2.005	0.217	0.001
1990	2.743	0.193	0.001
1991	2.662	0.195	0.001
1992	2.999	0.191	0.001
1993	2.632	0.211	0.001
1994	3.032	0.191	0.001
1995	2.551	0.202	0.001
1996	2.481	0.211	0.001
1997	3.449	0.235	0.001
1998	3.131	0.238	0.001
1999	2.873	0.187	0.001
2000	3.154	0.211	0.001
2001	2.817	0.302	0.001
2002	3.658	0.258	0.001
2003	3.558	0.249	0.001
2004	3.260	0.396	0.001
2005	4.393	0.231	0.001
2006	3.679	0.242	0.001
2007	3.474	0.251	0.001
2008	2.997	0.251	0.001

Table 13.2.5.2. Haddock in Subarea IV and Division IIIa. Coefficients and standard errors of the effects of total length and age (2, 3+) on potential fecundity in North Sea haddock. Data (n = 838) is from collections made in 1976, 1977, 1978, 1985, 1996, 1999 and 2007.

EXPLANATORY VARIABLE	COEFFICIENT	SE
Null	6.230	0.295
Length	0.167	0.005
Factor (Age)	3.355	0.156
Length :Factor (Age)	-0.092	0.005

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 – 2010	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

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 - 2010	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

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 - 2010	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

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 table gives the equivalent XSA diagnostics.

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Lowestoft VPA Version 3.1

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 Extended Survivors Analysis

 Haddock in the North Sea and Skagerrak: index

 CPUE data from file hadivef.dat

 Catch data for  48 years. 1963 to 2010. Ages  0 to   8.

      Fleet,            First, Last, First, Last, Alpha,  Beta
                      ,    year, year,  age ,  age
 EngGFS Q3 GRT        ,   1977, 2010,   0,     6,   .500,   .750
 EngGFS Q3 GOV        ,   1992, 2010,   0,     6,   .500,   .750
 ScoGFS Aberdeen Q3   ,   1982, 2010,   0,     6,   .500,   .750
 ScoGFS Q3 GOV        ,   1998, 2010,   0,     6,   .500,   .750
 IBTS Q1              ,   1982, 2010,   0,     4,   .990,  1.000


 Time series weights :

      Tapered time weighting not applied


 Catchability analysis :

      Catchability independent of stock 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 =   2.000

      Minimum standard error for population
      estimates derived from each fleet =    .300

      Prior weighting not applied


 Tuning converged after  117 iterations

1


 Regression weights
       , 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000



 Fishing mortalities
    Age,  2001,  2002,  2003,  2004,  2005,  2006,  2007,  2008,  2009,  2010

      0,  .002,  .039,  .007,  .001,  .000,  .001,  .001,  .001,  .001,  .002
      1,  .059,  .122,  .102,  .049,  .051,  .046,  .038,  .043,  .025,  .039
      2,  .270,  .141,  .329,  .323,  .283,  .456,  .211,  .184,  .157,  .201
      3,  .780,  .180,  .152,  .286,  .404,  .534,  .554,  .160,  .213,  .322
      4,  .425,  .367,  .121,  .180,  .243,  .544,  .428,  .335,  .256,  .176
      5,  .234,  .165,  .183,  .144,  .195,  .366,  .335,  .162,  .176,  .187
      6,  .090,  .087,  .067,  .094,  .130,  .155,  .301,  .144,  .079,  .109
      7,  .069,  .041,  .029,  .021,  .054,  .092,  .094,  .098,  .096,  .052
```

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

XSA population numbers (Thousands)

	AGE							
YEAR ,	0,	1,	2,	3,	4,	5,	6,	7,
2001 ,	2.84E+06,	3.41E+06,	3.26E+06,	6.77E+04,	2.91E+04,	2.18E+04,	2.01E+04,	2.15E+04,
2002 ,	3.73E+06,	3.65E+05,	6.17E+05,	1.67E+06,	2.41E+04,	1.48E+04,	1.41E+04,	1.50E+04,
2003 ,	3.90E+06,	4.62E+05,	6.21E+04,	3.59E+05,	1.09E+06,	1.30E+04,	1.03E+04,	1.06E+04,
2004 ,	3.72E+06,	4.99E+05,	8.01E+04,	2.99E+04,	2.40E+05,	7.50E+05,	8.89E+03,	7.86E+03,
2005 ,	4.23E+07,	4.78E+05,	9.12E+04,	3.89E+04,	1.75E+04,	1.56E+05,	5.32E+05,	6.62E+03,
2006 ,	9.03E+06,	5.45E+06,	8.72E+04,	4.60E+04,	2.02E+04,	1.07E+04,	1.05E+05,	3.82E+05,
2007 ,	5.29E+06,	1.16E+06,	9.99E+05,	3.70E+04,	2.10E+04,	9.14E+03,	6.07E+03,	7.38E+04,
2008 ,	4.29E+06,	6.80E+05,	2.15E+05,	5.42E+05,	1.66E+04,	1.07E+04,	5.35E+03,	3.68E+03,
2009 ,	3.31E+07,	5.52E+05,	1.25E+05,	1.20E+05,	3.60E+05,	9.23E+03,	7.43E+03,	3.80E+03,
2010 ,	1.79E+06,	4.26E+06,	1.03E+05,	7.17E+04,	7.54E+04,	2.17E+05,	6.34E+03,	5.62E+03,

Estimated population abundance at 1st Jan 2011

,	0.00E+00,	2.30E+05,	7.87E+05,	5.67E+04,	4.05E+04,	4.93E+04,	1.47E+05,	4.65E+03,

Taper weighted geometric mean of the VPA populations:

,	1.94E+07,	2.71E+06,	4.22E+05,	1.51E+05,	5.03E+04,	1.72E+04,	6.27E+03,	2.58E+03,

Standard error of the weighted Log(VPA populations) :

,	1.1714,	1.1631,	1.1835,	1.2005,	1.2263,	1.2885,	1.3241,	1.5608,

1

Log catchability residuals.

Fleet : EngGFS Q3 GRT

Age ,	1977,	1978,	1979,	1980
0 ,	.54,	-.28,	.02,	.72
1 ,	-.50,	-.24,	-.01,	.16
2 ,	.22,	-.30,	-.11,	.31
3 ,	-.24,	-.81,	.12,	.56
4 ,	.36,	.18,	-.14,	.38
5 ,	.22,	.19,	-.09,	.28
6 ,	.25,	-.67,	-.41,	.21

Age ,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990
0 ,	1.40,	.16,	.05,	.11,	-.15,	-.79,	-.80,	-.50,	-.09,	-.19
1 ,	.43,	.30,	.36,	.16,	.39,	-.21,	-.32,	-.12,	.21,	.02
2 ,	.54,	.38,	.10,	-.04,	.06,	.08,	-.44,	.18,	.05,	-.08
3 ,	.82,	.36,	.30,	.17,	.23,	-.41,	-.51,	.17,	.03,	-.12
4 ,	.49,	.04,	.00,	.03,	.09,	-.21,	-.47,	-.15,	.01,	-.04
5 ,	.04,	.17,	-.08,	-.18,	.47,	.05,	-.48,	.13,	-.38,	-.19
6 ,	-1.02,	1.53,	-.72,	.26,	-.22,	-.07,	-.19,	.96,	.15,	.95

Age ,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000
0 ,	-.22,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
1 ,	-.64,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
2 ,	-.96,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
3 ,	-.68,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
4 ,	-.56,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
5 ,	-.14,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
6 ,	-1.00,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99

Age ,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010
0 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
1 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
2 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
3 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
4 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
5 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99
6 ,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99,	99.99

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age ,	0,	1,	2,	3,	4,	5,	6
Mean Log q,	-16.9668,	-15.5118,	-15.0309,	-15.2063,	-15.3470,	-15.5246,	-15.9586,
S.E(Log q),	.5678,	.3307,	.3662,	.4603,	.2912,	.2556,	.7385,

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

Fleet : EngGFS Q3 GOV

Age ,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000
0 ,	99.99,	1.17,	.53,	1.00,	.73,	.45,	.55,	-.15,	.90,	.64
1 ,	99.99,	.30,	.12,	.16,	.22,	.15,	.28,	.26,	.05,	.06
2 ,	99.99,	.50,	.05,	-.06,	.35,	-.03,	.09,	.11,	.05,	-.31
3 ,	99.99,	.41,	.09,	-.49,	.23,	.23,	.20,	-.11,	-.19,	-.31
4 ,	99.99,	-.22,	-.34,	-.10,	-.10,	-.09,	-.10,	-.13,	-.21,	-.45
5 ,	99.99,	.10,	.36,	-.03,	.15,	-.03,	.14,	-.04,	.00,	-.52
6 ,	99.99,	1.22,	99.99,	-.57,	.14,	.37,	.06,	-.45,	-.61,	-.08

Age ,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010
0 ,	-1.56,	-.90,	-.80,	-.70,	.45,	-.26,	-.14,	-1.11,	-.74,	-.07
1 ,	-.44,	-.15,	.02,	.00,	.44,	-.28,	-.37,	-.33,	-.29,	-.20
2 ,	-.28,	-.15,	-.63,	.24,	.52,	.06,	.06,	-.43,	.25,	-.36
3 ,	.52,	-.06,	-.01,	-.88,	.68,	-.23,	.21,	-.14,	.02,	-.19
4 ,	.16,	-.12,	.35,	.01,	.96,	-.07,	.20,	.53,	-.31,	.02
5 ,	-.13,	-1.06,	1.08,	.19,	.82,	-.19,	-.53,	.27,	-.48,	-.09
6 ,	-.59,	-.11,	-1.58,	.70,	-.54,	-.35,	.19,	.78,	.09,	1.32

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age ,	0,	1,	2,	3,	4,	5,	6
Mean Log q,	-16.5404,	-14.7883,	-14.3319,	-14.4976,	-14.8099,	-15.2483,	-15.7460,
S.E(Log q),	.7956,	.2588,	.3085,	.3629,	.3317,	.4771,	.7165,

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,

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

Fleet : ScoGFS Aberdeen Q3

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	99.99	-.18	-.79	-.37	-.76	-.73	-.10	-.42	-.39	.41
1	99.99	-.22	-.10	-.43	.17	-.04	-.76	.10	.02	.16
2	99.99	.29	.18	-.10	-.03	.01	-.27	-.06	.13	-.20
3	99.99	.24	.61	.01	.07	-.09	-.07	.01	.15	-.27
4	99.99	.03	.62	.19	.36	-.07	.03	.25	.09	.00
5	99.99	-1.09	.58	.09	.10	.44	-.01	-.10	-.17	.15
6	99.99	-.28	.16	-.09	.11	-.23	.01	.03	.07	-.22

Age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	.54	.99	-.10	1.20	.42	.23	.03	99.99	99.99	99.99
1	-.52	.32	.34	-.03	.33	.41	.24	99.99	99.99	99.99
2	-.66	-.22	.20	.06	.14	.44	.08	99.99	99.99	99.99
3	-1.02	-.43	-.06	-.21	.51	.25	.30	99.99	99.99	99.99
4	-.64	-.40	-1.00	-.21	.21	.33	.23	99.99	99.99	99.99
5	-.49	.13	.42	-.86	.41	.27	.13	99.99	99.99	99.99
6	.18	.08	.22	-.06	.09	-.02	-.05	99.99	99.99	99.99

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age	0	1	2	3	4	5	6
Mean Log q	-12.8464	-10.6315	-10.1131	-10.3498	-10.6208	-10.8823	-11.1386
S.E(Log q)	.5987	.3378	.2593	.3852	.4029	.4624	.1481

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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.18	.54	.48
1	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.84	-.10	-.03
2	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.06	.16	-.49
3	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.04	.33	-.12
4	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.05	.11	-.03
5	99.99	99.99	99.99	99.99	99.99	99.99	99.99	-.13	.16	.11
6	99.99	99.99	99.99	99.99	99.99	99.99	99.99	.00	.00	-.13

Age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	-2.30	.76	.69	.52	.52	-.09	-.27	.46	-.02	-1.46
1	-.46	.09	.39	.31	-.10	-.28	-.13	-.50	-.12	.09
2	-.31	-.19	.08	.40	.42	-.31	.11	-.07	-.15	.28
3	-.12	-.05	.28	-.19	.04	-.02	-.09	.02	-.08	.04
4	-.22	.01	.17	.05	.72	-.46	-.02	-.55	.06	.21
5	-.14	.13	-.26	-.17	.03	-.40	-.50	.02	.60	.54
6	-.09	.26	.51	.03	-.05	-.31	-.04	.17	.08	-.43

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

Mean log catchability and standard error of ages with catchability independent of year class strength and constant w.r.t. time

Age ,	0,	1,	2,	3,	4,	5,	6
Mean Log q,	-11.5247,	-9.8892,	-9.5366,	-9.7764,	-10.0697,	-10.4945,	-11.3499,
S.E(Log q),	.9071,	.3600,	.2825,	.1494,	.3137,	.3227,	.2365,

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

Age ,	1981,	1982,	1983,	1984,	1985,	1986,	1987,	1988,	1989,	1990
0 ,	99.99,	-.37,	-.30,	-.48,	.10,	-.17,	.11,	.18,	.14,	.09
1 ,	99.99,	-.15,	-.32,	-.22,	.08,	-.13,	-.15,	.41,	.03,	.04
2 ,	99.99,	-.07,	-.22,	.05,	-.20,	-.25,	-.02,	.15,	.40,	-.15
3 ,	99.99,	-.01,	-.04,	-.07,	-.23,	-.05,	.11,	.08,	-.02,	.05
4 ,	99.99,	.09,	-.14,	-.25,	-.08,	.25,	.16,	.09,	.20,	-.16
5 ,	No data for this fleet at this age									
6 ,	No data for this fleet at this age									

Age ,	1991,	1992,	1993,	1994,	1995,	1996,	1997,	1998,	1999,	2000
0 ,	.64,	.31,	-.21,	.09,	-.13,	.60,	.24,	-.04,	.20,	.42
1 ,	-.27,	.20,	-.25,	.01,	-.11,	.42,	.23,	.10,	-.35,	-.05
2 ,	-.82,	.09,	-.27,	-.32,	-.20,	.18,	.01,	.03,	-.24,	-.01
3 ,	-.67,	.21,	-.23,	-.08,	-.26,	.24,	-.09,	.30,	-.22,	-.33
4 ,	-.41,	-.07,	-.07,	-.23,	.22,	-.05,	.38,	.07,	.25,	-.16
5 ,	No data for this fleet at this age									
6 ,	No data for this fleet at this age									

Age ,	2001,	2002,	2003,	2004,	2005,	2006,	2007,	2008,	2009,	2010
0 ,	-.07,	.13,	-.18,	-.16,	.26,	-.60,	-.67,	-.24,	-.06,	.16
1 ,	.09,	-.16,	.31,	-.08,	-.28,	.28,	-.38,	.43,	-.04,	.30
2 ,	.15,	-.02,	.51,	.16,	-.14,	.32,	-.48,	.19,	.29,	.90
3 ,	-.24,	-.08,	.32,	.18,	-.17,	.34,	.53,	-.33,	.26,	.50
4 ,	.26,	-.17,	.13,	.01,	.06,	-.05,	-.98,	-.35,	.08,	.90
5 ,	No data for this fleet at this age									
6 ,	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 ,	0,	1,	2,	3,	4
Mean Log q,	-13.2847,	-11.8398,	-11.8534,	-12.1592,	-12.4640,
S.E(Log q),	.3176,	.2440,	.3237,	.2719,	.3156,

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,

1

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

```
Terminal year survivor and F summaries :

 Age  0   Catchability constant w.r.t. time and dependent on age

 Year class = 2010

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 EngGFS Q3 GRT       ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 EngGFS Q3 GOV       ,    214203.,   .816,       .000,    .00,   1,  .120,     .000
 ScoGFS Aberdeen Q3  ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 ScoGFS Q3 GOV       ,     53309.,   .941,       .000,    .00,   1,  .091,     .000
 IBTS Q1             ,    270186.,   .323,       .000,    .00,   1,  .769,     .000

   F shrinkage mean  ,    592566.,   2.00,,,,                        .020,     .001

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
    230428.,       .28,      .28,    4,    .983,   .002


 Age  1   Catchability constant w.r.t. time and dependent on age

 Year class = 2009

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 EngGFS Q3 GRT       ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 EngGFS Q3 GOV       ,    604094.,   .282,       .176,    .62,   2,  .301,     .050
 ScoGFS Aberdeen Q3  ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 ScoGFS Q3 GOV       ,    852054.,   .347,       .039,    .11,   2,  .198,     .036
 IBTS Q1             ,    897603.,   .220,       .182,    .83,   2,  .494,     .034

   F shrinkage mean  ,    665744.,   2.00,,,,                        .006,     .046

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
    786996.,       .15,      .10,    7,    .631,   .039


 Age  2   Catchability constant w.r.t. time and dependent on age

 Year class = 2008

 Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
      ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
 EngGFS Q3 GRT       ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 EngGFS Q3 GOV       ,     38986.,   .210,       .139,    .66,   3,  .313,     .281
 ScoGFS Aberdeen Q3  ,         1.,   .000,       .000,    .00,   0,  .000,     .000
 ScoGFS Q3 GOV       ,     65535.,   .227,       .146,    .64,   3,  .270,     .176
 IBTS Q1             ,     68590.,   .183,       .342,   1.87,   3,  .413,     .169

   F shrinkage mean  ,     42265.,   2.00,,,,                        .004,     .262

 Weighted prediction :

 Survivors,        Int,      Ext,    N,    Var,     F
 at end of year,   s.e,      s.e,     ,   Ratio,
     56653.,       .12,      .14,   10,   1.218,   .201
```

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

Age 3 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
EngGFS Q3 GRT ,	1.,	.000,	.000,	.00,	0,	.000,	.000
EngGFS Q3 GOV ,	36986.,	.184,	.142,	.77,	4,	.290,	.347
ScoGFS Aberdeen Q3 ,	1.,	.000,	.000,	.00,	0,	.000,	.000
ScoGFS Q3 GOV ,	34747.,	.182,	.117,	.65,	4,	.305,	.366
IBTS Q1 ,	48576.,	.157,	.262,	1.67,	4,	.400,	.275
F shrinkage mean ,	33639.,	2.00,,,,				.004,	.376

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N,	Var, Ratio,	F
40457.,	.10,	.11,	13,	1.068,	.322

Age 4 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
EngGFS Q3 GRT ,	1.,	.000,	.000,	.00,	0,	.000,	.000
EngGFS Q3 GOV ,	40798.,	.164,	.103,	.63,	5,	.296,	.209
ScoGFS Aberdeen Q3 ,	1.,	.000,	.000,	.00,	0,	.000,	.000
ScoGFS Q3 GOV ,	49325.,	.161,	.070,	.44,	5,	.315,	.175
IBTS Q1 ,	57277.,	.143,	.270,	1.89,	5,	.386,	.153
F shrinkage mean ,	21521.,	2.00,,,,				.003,	.364

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N,	Var, Ratio,	F
49278.,	.09,	.10,	16,	1.130,	.176

Age 5 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
EngGFS Q3 GRT ,	1.,	.000,	.000,	.00,	0,	.000,	.000
EngGFS Q3 GOV ,	127382.,	.158,	.076,	.48,	6,	.299,	.213
ScoGFS Aberdeen Q3 ,	1.,	.000,	.000,	.00,	0,	.000,	.000
ScoGFS Q3 GOV ,	172696.,	.148,	.117,	.80,	6,	.368,	.162
IBTS Q1 ,	140926.,	.142,	.150,	1.05,	5,	.331,	.195
F shrinkage mean ,	107666.,	2.00,,,,				.003,	.248

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N,	Var, Ratio,	F
147219.,	.09,	.07,	18,	.797,	.187

Age 6 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
EngGFS Q3 GRT ,	1.,	.000,	.000,	.00,	0,	.000,	.000
EngGFS Q3 GOV ,	6150.,	.175,	.213,	1.21,	7,	.269,	.084
ScoGFS Aberdeen Q3 ,	1.,	.000,	.000,	.00,	0,	.000,	.000
ScoGFS Q3 GOV ,	4046.,	.149,	.180,	1.21,	7,	.486,	.125
IBTS Q1 ,	4558.,	.155,	.186,	1.20,	5,	.241,	.112
F shrinkage mean ,	3055.,	2.00,,,,				.004,	.162

Weighted prediction :

Survivors, at end of year,	Int, s.e,	Ext, s.e,	N,	Var, Ratio,	F
4654.,	.09,	.11,	20,	1.169,	.109

Table 13.3.5.1 cont.. 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 table gives the equivalent XSA diagnostics.

```
Age  7   Catchability constant w.r.t. time and age (fixed at the value for age)  6

Year class = 2003

Fleet,                 Estimated,    Int,       Ext,    Var,    N, Scaled,  Estimated
     ,                 Survivors,    s.e,       s.e,   Ratio,    , Weights,    F
EngGFS Q3 GRT       ,         1.,   .000,       .000,    .00,   0,  .000,     .000
EngGFS Q3 GOV       ,      5043.,   .173,       .102,    .59,   7,  .270,     .045
ScoGFS Aberdeen Q3  ,         1.,   .000,       .000,    .00,   0,  .000,     .000
ScoGFS Q3 GOV       ,      4760.,   .148,       .057,    .38,   7,  .485,     .048
IBTS Q1             ,      3206.,   .150,       .254,   1.69,   5,  .242,     .070

  F shrinkage mean  ,      1363.,   2.00,,,,                           .004,     .158

Weighted prediction :

Survivors,        Int,      Ext,    N,    Var,     F
at end of year,   s.e,      s.e,     ,   Ratio,
     4371.,       .09,      .08,   20,    .875,   .052
```

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

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

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)	TEP
1963	2314960	3412683	137050	271851	68821	189330	13700	0.502	0.745	9.868E+12
1964	9155375	1281817	417713	379915	131006	160309	88600	0.314	0.794	2.097E+13
1965	26286881	1080997	521738	299343	162418	62325	74600	0.311	0.639	4.947E+13
1966	68923158	1480495	427838	346349	226184	73465	46700	0.529	0.662	5.557E+13
1967	388351133	5527447	224790	246664	147742	78222	20700	0.657	0.626	3.188E+13
1968	17114813	6852013	259397	301821	105811	161810	34200	0.408	0.597	2.347E+13
1969	12133861	2477679	810544	930043	331625	260065	338353	0.409	1.121	4.214E+13
1970	87605720	2541768	900221	805776	524773	101274	179729	0.583	1.152	8.539E+13
1971	78203289	2546401	420401	446824	237502	177776	31546	0.565	0.773	5.000E+13
1972	21425991	2182179	302976	353084	195545	127954	29585	0.645	1.119	3.139E+13
1973	72938535	4087838	297147	307594	181592	114735	11267	0.611	0.866	2.456E+13
1974	132845377	4710721	260752	366992	153057	166429	47505	0.587	0.962	2.577E+13
1975	11406566	2385147	238279	453205	151349	260370	41487	0.635	1.102	1.843E+13
1976	16397329	1097473	309487	375305	172680	154462	48163	0.558	0.973	2.225E+13
1977	26203002	1069043	242297	224516	145118	44376	35022	0.599	1.033	2.357E+13
1978	39808657	1137542	138098	179375	91683	76789	10903	0.664	1.062	1.314E+13
1979	72620594	1352096	117086	145019	87069	41710	16240	0.744	0.987	1.192E+13
1980	15795472	1470716	169227	222127	105041	94614	22472	0.621	0.899	1.950E+13
1981	32606103	996405	257248	213240	136132	60067	17041	0.529	0.659	2.551E+13
1982	20488195	1091776	320939	233283	173335	40564	19383	0.54	0.659	4.640E+13
1983	66943546	2253195	276470	244212	165337	65977	12898	0.598	0.884	4.162E+13
1984	17180273	1690885	224030	218946	133568	75298	10080	0.596	0.873	3.564E+13
1985	23917418	1188181	261091	255366	164119	85249	5998	0.629	0.872	3.565E+13
1986	49002387	1941134	237140	223081	168236	52203	2643	0.709	1.203	3.384E+13
1987	4154844	1097088	166839	173852	110299	59143	4410	0.661	1.024	2.566E+13
1988	8337202	630204	159929	173124	106973	62148	4002	0.669	1.108	1.693E+13
1989	8604153	623382	127707	106526	78439	25677	2410	0.614	0.952	1.683E+13
1990	28334295	1581748	80676	88934	53780	32565	2589	0.667	1.114	1.087E+13
1991	27456974	1551974	63074	93287	47715	40185	5386	0.756	0.888	9.207E+12
1992	41943346	1363931	103105	131650	72790	47934	10927	0.706	0.98	1.418E+13
1993	13122801	1018311	138475	172551	82176	79609	10766	0.593	0.896	1.762E+13
1994	55983396	1485103	161327	151020	82074	65370	3576	0.509	0.83	1.868E+13
1995	14292721	1170059	162662	142524	77458	57371	7695	0.476	0.733	2.030E+13
1996	21442638	1058031	201674	156609	79148	72461	5000	0.392	0.688	2.092E+13
1997	12752842	975541	225758	141347	82574	52089	6684	0.366	0.537	2.758E+13
1998	9957388	791581	202849	131316	81054	45160	5101	0.4	0.604	2.416E+13
1999	138417502	3673171	156880	112021	65588	42598	3835	0.418	0.714	1.865E+13
2000	26490420	3556209	135081	104457	47553	48770	8134	0.352	0.765	1.652E+13
2001	2843508	1236908	316340	166960	40856	118225	7879	0.129	0.492	2.920E+13
2002	3727538	896641	524367	107923	58348	45857	3717	0.111	0.229	6.576E+13
2003	3898976	781120	517010	66805	41964	23691	1150	0.081	0.201	6.111E+13
2004	3716574	775860	444700	64839	48734	15551	554	0.11	0.263	5.205E+13
2005	42319097	2836645	386936	57162	48357	8637	168	0.125	0.31	4.833E+13
2006	9031849	1422690	310074	56056	37613	17908	535	0.121	0.511	4.016E+13
2007	5287388	775740	221317	59643	30939	28657	48	0.14	0.398	3.075E+13
2008	4293403	605339	223563	43640	30248	13193	199	0.135	0.227	3.356E+13
2009	33107554	1950891	192276	43407	32807	10548	52	0.171	0.209	2.861E+13

2010	1794179	633149	182559	39640	29054	10155	431	0.159	0.233	2.592E+13

Table 13.6.1. Haddock in Subarea IV and Division IIIa. Short-term forecast input.

MFDP version 1a						
Run: had02						
Time and date: 13:47 08/05/2011						
Fbar age range (Total) : 2-4						
Fbar age range Fleet 1 : 2-4						
Fbar age range Fleet 2 : 2-4						
2011						
Age	N	M	Mat	PF	PM	SWt
0	3662978	2.05	0	0	0	0.038
1	230512	1.65	0.01	0	0	0.158
2	786666	0.4	0.32	0	0	0.288
3	56672	0.25	0.71	0	0	0.446
4	40450	0.25	0.87	0	0	0.546
5	49252	0.2	0.95	0	0	0.543
6	147225	0.2	1	0	0	0.57
7	4655	0.2	1	0	0	0.9
8	10012	0.2	1	0	0	1.152
Catch						
Age	Sel	CWt	DSel	DCWt		
0	0	0	0.001	0.038		
1	0.001	0.362	0.035	0.149		
2	0.052	0.441	0.134	0.228		
3	0.149	0.427	0.092	0.328		
4	0.238	0.513	0.03	0.409		
5	0.175	0.485	0.007	0.378		
6	0.113	0.473	0.001	0.388		
7	0.086	0.823	0	0.594		
8	0.086	1.077	0	0.61		
IBC						
Age	Sel	CWt				
0	0	0.0446				
1	0.001	0.1352				
2	0.002	0.2621				
3	0.001	0.3149				
4	0.001	0.3661				
5	0.001	0.4682				
6	0	0.4155				
7	0	0.4092				
8	0	0.4				

Table 13.6.1. cont. Haddock in Subarea IV and Division IIIa. Short-term forecast input.

2012						
Age	N	M	Mat	PF	PM	SWt
0	3662978	2.05	0	0	0	0.038
1	.	1.65	0.01	0	0	0.158
2	.	0.4	0.32	0	0	0.288
3	.	0.25	0.71	0	0	0.367
4	.	0.25	0.87	0	0	0.578
5	.	0.2	0.95	0	0	0.67
6	.	0.2	1	0	0	0.641
7	.	0.2	1	0	0	0.655
8	.	0.2	1	0	0	1.121

Catch				
Age	Sel	CWt	DSel	DCWt
0	0	0	0.001	0.038
1	0.001	0.362	0.035	0.149
2	0.052	0.441	0.134	0.228
3	0.149	0.427	0.092	0.27
4	0.238	0.502	0.03	0.418
5	0.175	0.56	0.007	0.495
6	0.113	0.512	0.001	0.44
7	0.086	0.492	0	0.441
8	0.086	1.006	0	0.663

IBC		
Age	Sel	CWt
0	0	0.0446
1	0.001	0.1352
2	0.002	0.2621
3	0.001	0.3149
4	0.001	0.3661
5	0.001	0.4682
6	0	0.4155
7	0	0.4092
8	0	0.4

2013						
Age	N	M	Mat	PF	PM	SWt
0	3662978	2.05	0	0	0	0.038
1	.	1.65	0.01	0	0	0.158
2	.	0.4	0.32	0	0	0.288
3	.	0.25	0.71	0	0	0.367
4	.	0.25	0.87	0	0	0.483
5	.	0.2	0.95	0	0	0.71
6	.	0.2	1	0	0	0.794
7	.	0.2	1	0	0	0.738
8	.	0.2	1	0	0	0.749

Table 13.6.1. cont. Haddock in Subarea IV and Division IIIa. Short-term forecast input.

Catch				
Age	Sel	CWt	DSel	DCWt
0	0	0	0.001	0.038
1	0.001	0.362	0.035	0.149
2	0.052	0.441	0.134	0.228
3	0.149	0.427	0.092	0.27
4	0.238	0.502	0.03	0.32
5	0.175	0.638	0.007	0.508
6	0.113	0.607	0.001	0.582
7	0.086	0.538	0	0.502
8	0.086	0.521	0	0.498
IBC				
Age	Sel	CWt		
0	0	0.0446		
1	0.001	0.1352		
2	0.002	0.2621		
3	0.001	0.3149		
4	0.001	0.3661		
5	0.001	0.4682		
6	0	0.4155		
7	0	0.4092		
8	0	0.4		
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.

2011											
		Catch			Landings		Discards		IBC Landings		
Biomass	SSB	FMult	Fbar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield
575921	235072	1	0.232	52441	0.146	31716	0.085	20724	0.003	0	1

2012												2013		2011 TAC	36152
		Catch			Landings		Discards		IBC	Landings					
Biomass	SSB	FMult	Fbar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	TAC change	
527138	255885	0.00	0.001	193	0.000	0	0.000	0	1.0	0.0013	193	542566	286526	-100%	No HC fishery
.	255885	0.10	0.024	5190	0.015	3769	0.009	1230	1.0	0.0013	191	536713	281334	-90%	
.	255885	0.20	0.048	10087	0.029	7463	0.017	2435	1.0	0.0013	189	530983	276251	-79%	
.	255885	0.30	0.071	14886	0.044	11082	0.026	3616	1.0	0.0013	188	525373	271276	-69%	
.	255885	0.40	0.094	19588	0.059	14629	0.034	4773	1.0	0.0013	186	519882	266405	-60%	
.	255885	0.50	0.117	24196	0.073	18105	0.043	5907	1.0	0.0013	184	514507	261637	-50%	0.5 * Fsq
.	255885	0.60	0.140	28711	0.088	21512	0.051	7017	1.0	0.0013	182	509244	256969	-40%	
.	255885	0.70	0.163	33137	0.102	24850	0.060	8106	1.0	0.0013	181	504091	252398	-31%	
	255885	0.75	0.175	35250	0.110	26444	0.064	8626	1.0	0.0013	180	501633	250218	-27%	0.75 * Fsq
.	255885	0.80	0.187	37475	0.117	28123	0.068	9173	1.0	0.0013	179	499046	247923	-22%	
.	255885	0.88	0.205	40930	0.129	30729	0.075	10023	1.0	0.0013	177	495031	244362	-15%	15% quota decrease
.	255885	0.90	0.210	41726	0.132	31330	0.077	10219	1.0	0.0013	177	494106	243541	-13%	0.9 * Fsq
.	255885	1.00	0.233	45893	0.146	34474	0.085	11243	1.0	0.0013	176	489269	239250	-5%	Status quo

Table 13.6.2. cont. Haddock in Subarea IV and Division IIIa. Short-term forecast output. A number of management options are highlighted.

2012												2013		2011 TAC	36152
		Catch			Landings		Discards		IBC	Landings					
Biomass	SSB	FMult	Fbar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	TAC change	
527138	255885	1.05	0.246	48117	0.154	36152	0.090	11790	1.0	0.0013	175	486690	236963	0%	Roll-over TAC
.	255885	1.10	0.256	49978	0.161	37556	0.094	12248	1.0	0.0013	174	484533	235049	4%	
.	255885	1.20	0.279	53983	0.176	40577	0.102	13233	1.0	0.0013	173	479895	230935	12%	
.	255885	1.23	0.287	55305	0.181	41575	0.105	13558	1.0	0.0013	172	478365	229577	15%	15% quota increase
	255885	1.26	0.291	56145	0.184	42209	0.107	13765	1.0	0.0013	172	477393	228715	17%	1.25 * Fsq
.	255885	1.29	0.300	57500	0.189	43231	0.110	14098	1.0	0.0013	171	475825	227324	20%	~ F(msy)
.	255885	1.30	0.302	57908	0.190	43539	0.111	14198	1.0	0.0013	171	475353	226905	20%	
.	255885	1.40	0.326	61757	0.205	46443	0.120	15144	1.0	0.0013	170	470905	222960	28%	
.	255885	1.50	0.349	65530	0.220	49290	0.128	16072	1.0	0.0013	168	466549	219095	36%	
.	255885	1.60	0.372	69230	0.234	52081	0.137	16982	1.0	0.0013	167	462282	215311	44%	
.	255885	1.70	0.395	72857	0.249	54818	0.145	17874	1.0	0.0013	165	458104	211604	52%	
.	255885	1.80	0.418	76415	0.263	57502	0.154	18749	1.0	0.0013	164	454011	207973	59%	
.	255885	1.90	0.441	79901	0.278	60133	0.162	19606	1.0	0.0013	162	450002	204417	66%	
.	255885	2.00	0.465	83323	0.293	62714	0.171	20448	1.0	0.0013	161	446074	200933	73%	
.	255662	3.02	0.700	113628	0.441	85576	0.257	27904	1.0	0.0013	148	411253	170048	137%	F(pa) in 2012
	255599	3.30	0.766	122103	0.483	91969	0.282	29989	1.0	0.0013	145	401515	161411	154%	
	255599	4.45	1.032	149292	0.651	112459	0.380	36701	1.0	0.0013	133	371034	140000	211%	B(pa) in 2013
	255599	4.50	1.044	150488	0.659	113360	0.384	36996	1.0	0.0013	132	369693	133200	214%	

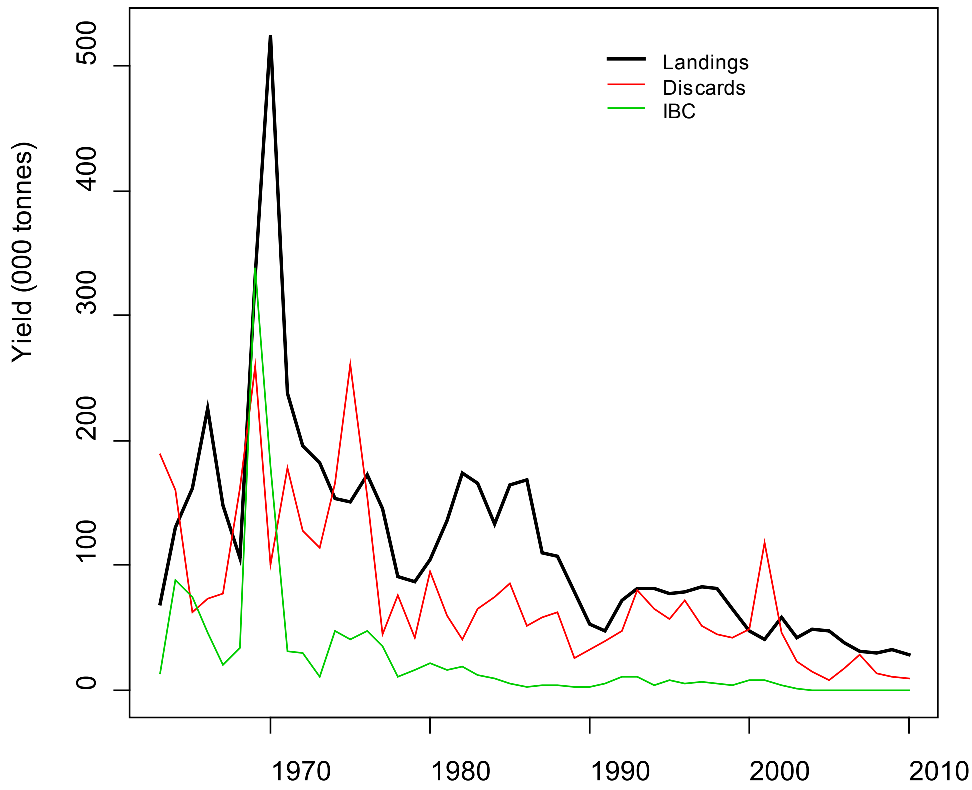

Figure 13.2.1.1. Haddock in Subarea IV and Division IIIa. Yield by catch component.

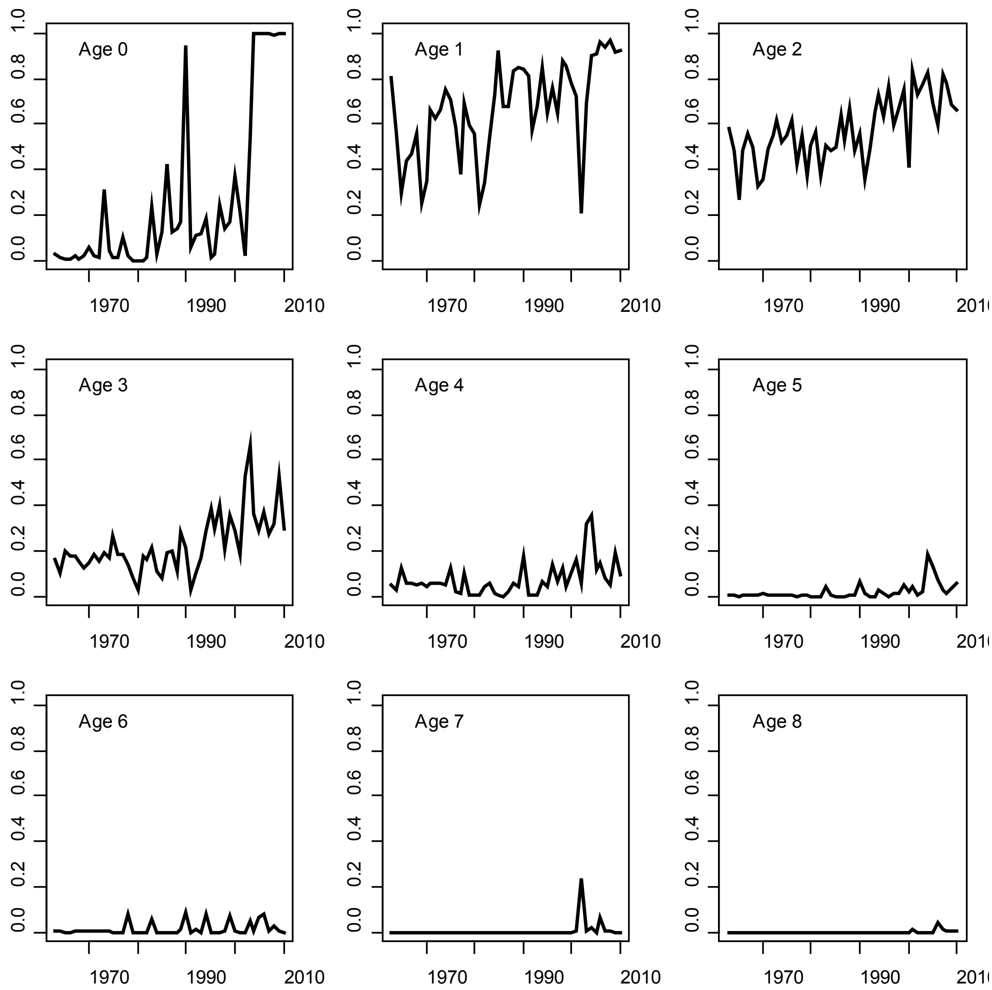

Figure 13.2.1.2. Haddock in Subarea IV and Divisions IIIa. Proportion of total catch discarded, by age and year.

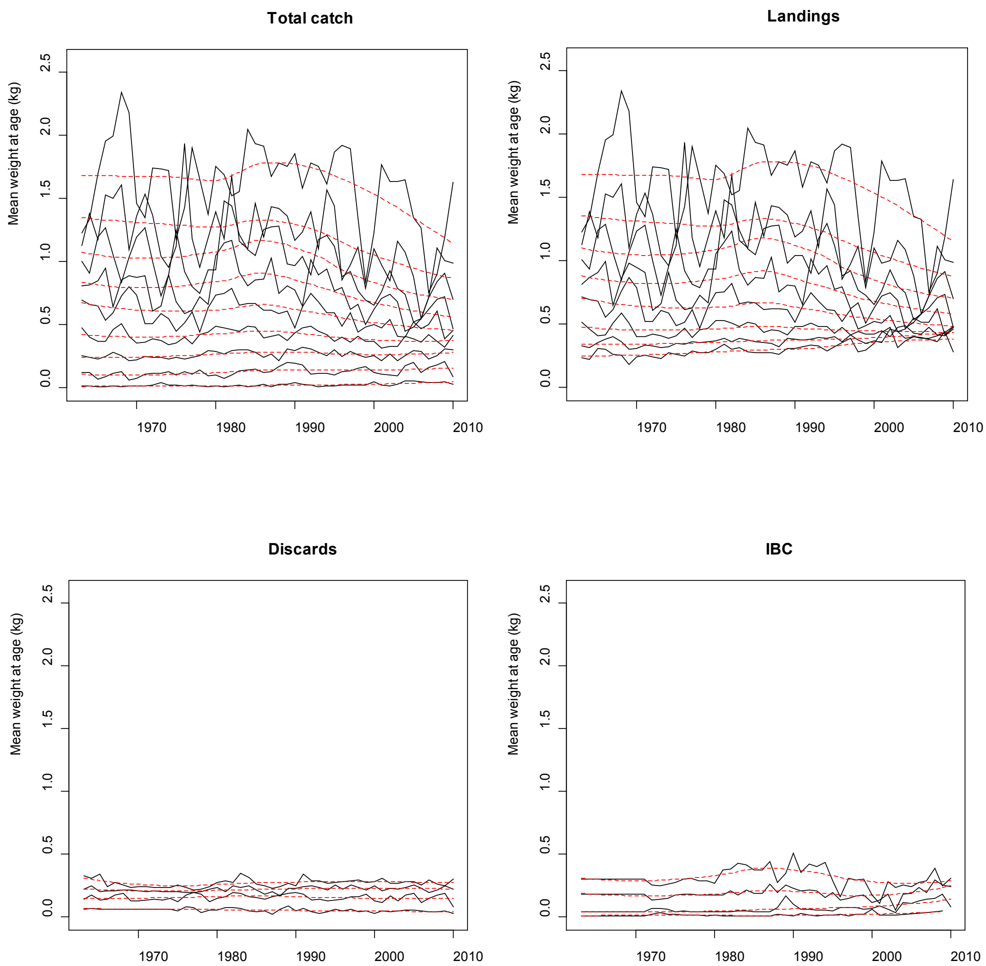

Figure 13.2.3.1. Haddock in Subarea IV and Division IIIa. Mean weights-at-age (kg) by catch component. Catch mean weights are also used as stock mean weights. Red dotted line give loess smoothers through each time-series of mean weights-at-age.

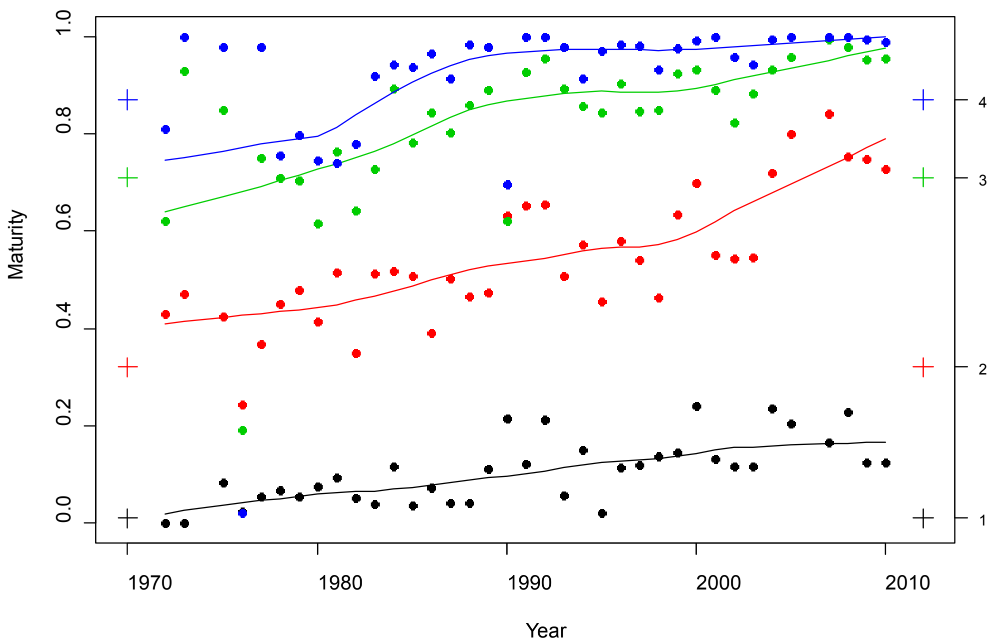

Figure 13.2.4.1. Haddock in Subarea IV and Division IIIa. Estimates of proportion mature for ages 1-4 from IBTS Q1 SMALK data (via DATRAS). Dots = point estimates, lines = smoothed fits (loess smoother, span = 0.5). Crosses at each side indicate values assumed in current assessment.

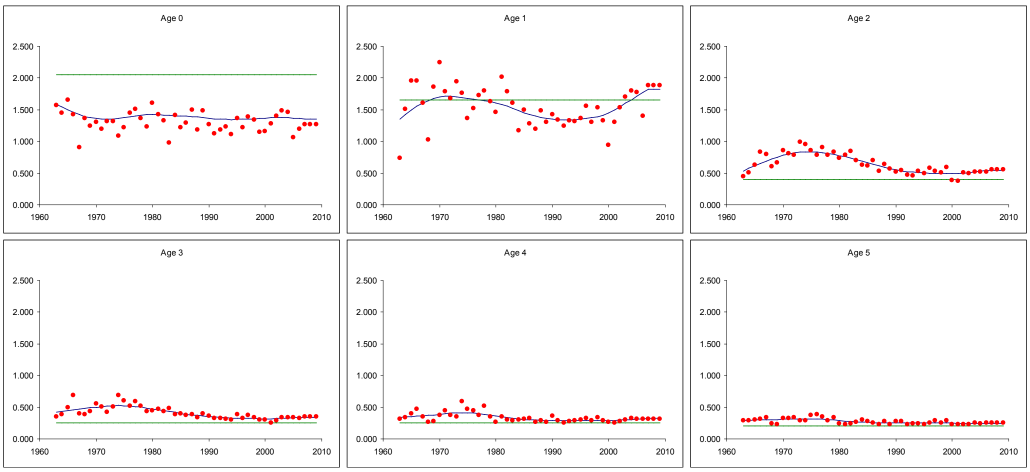

Figure 13.2.4.2. Haddock in Subarea IV and Division IIIa. Estimates of natural mortality from ICES-WGSAM (2008) (ages 0-2 along the top row, ages 3-5 along the bottom row). Red dots give the annual estimates, while the blue lines give the smoothed values that are recommended for use by WGSAM. The green lines give the fixed values currently used in the assessment.

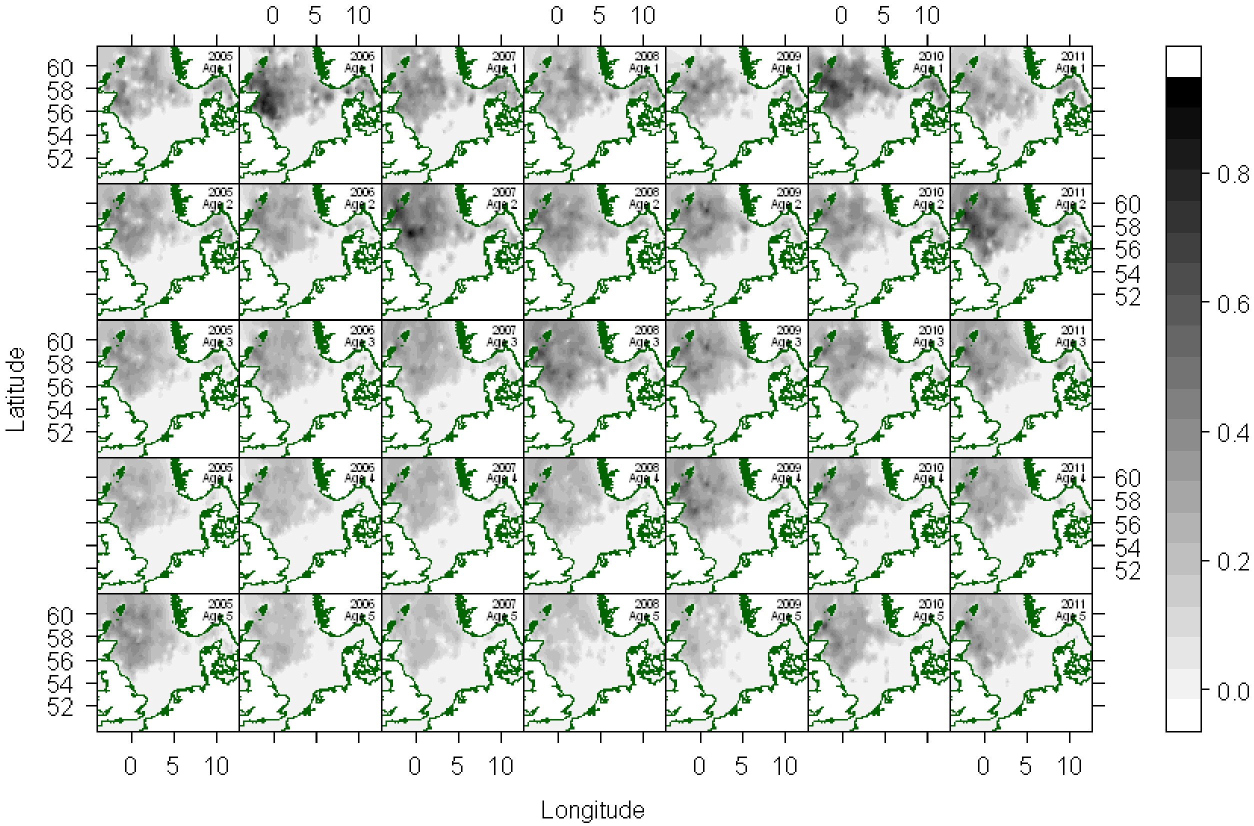

Figure 13.2.6.1. Haddock in Subarea IV and Division IIIa. Spatial distribution from the IBTS Q1 survey. Contour scale (given in the bar to the right) is the square root of survey CPUE, rescaled to lie between 0 and 1.

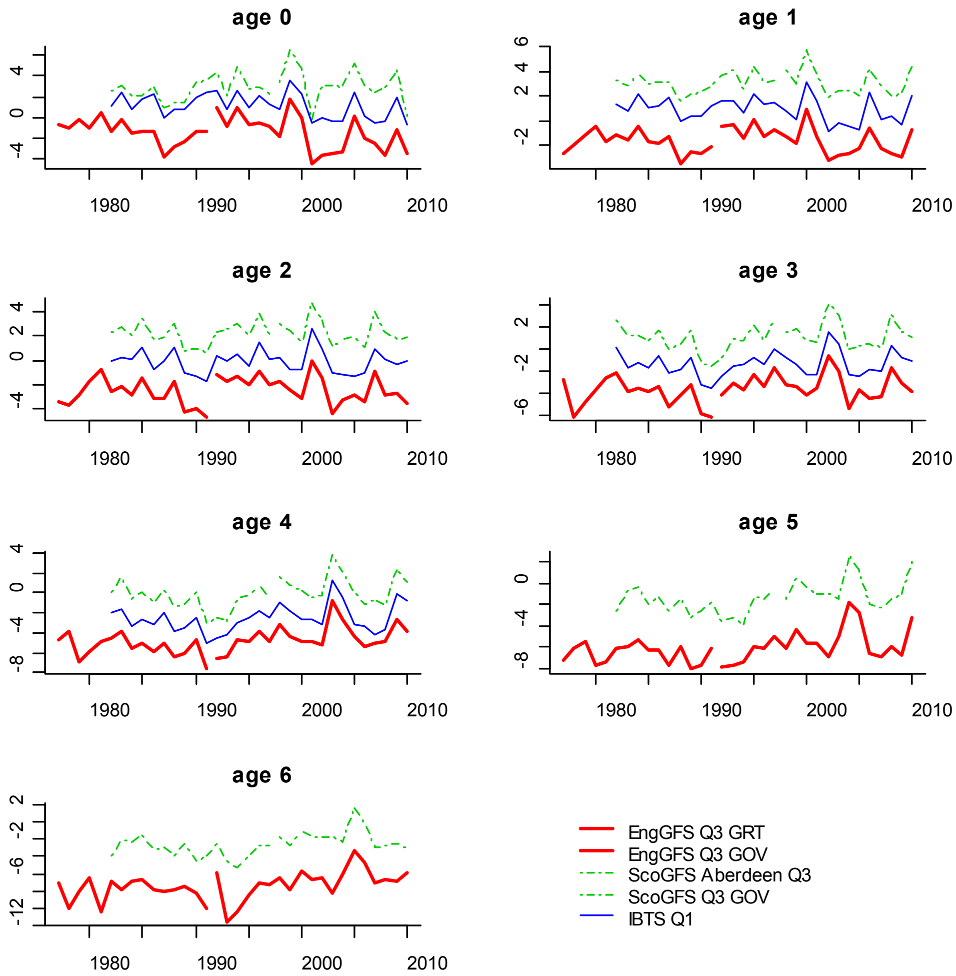

Figure 13.2.6.2. Haddock in Subarea IV and Division IIIa. Survey log CPUE (catch per unit effort) at age.

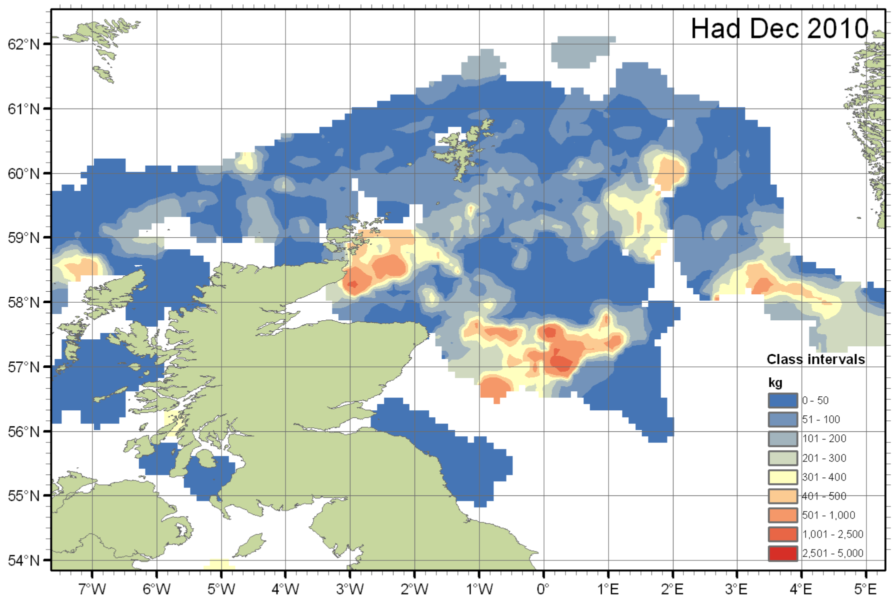

Figure 13.2.6.3. Haddock in Subarea IV and Division IIIa. VMS-derived distribution map of source of haddock landed by the Scottish whitefish fleet, December 2010. See text for details.

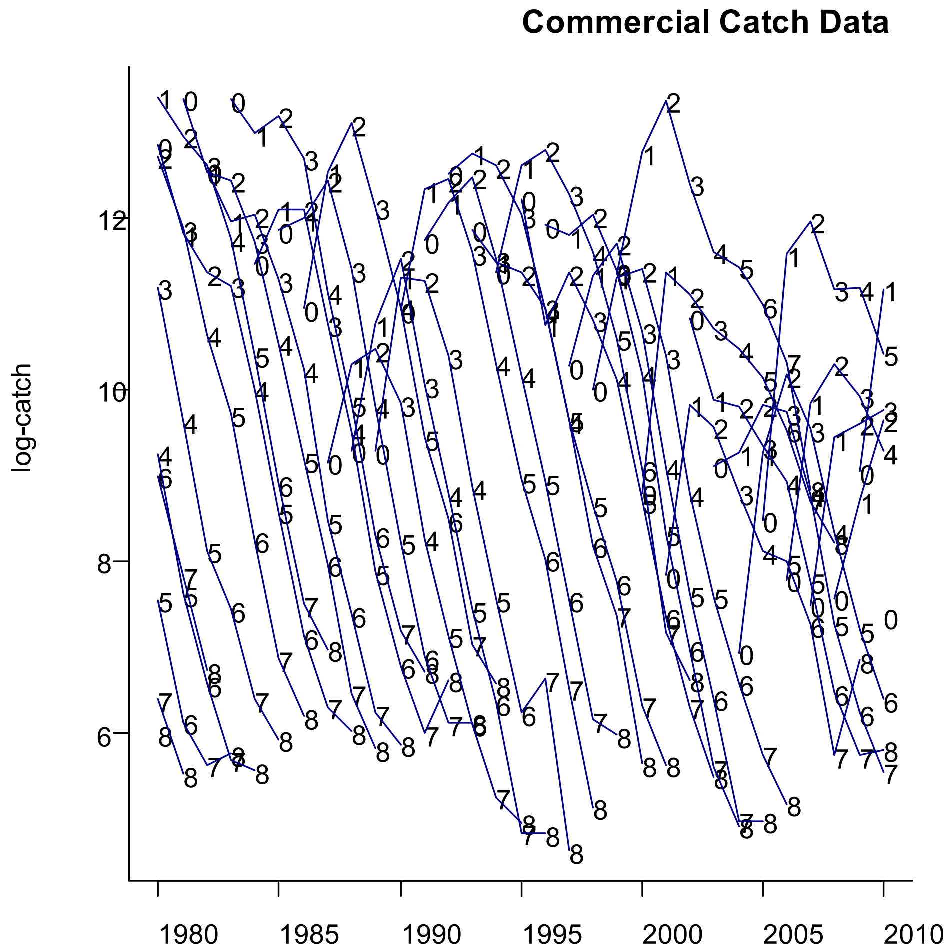

Figure 13.3.2.1. Haddock in Subarea IV and Division IIIa. Log catch curves by cohort for total catches.

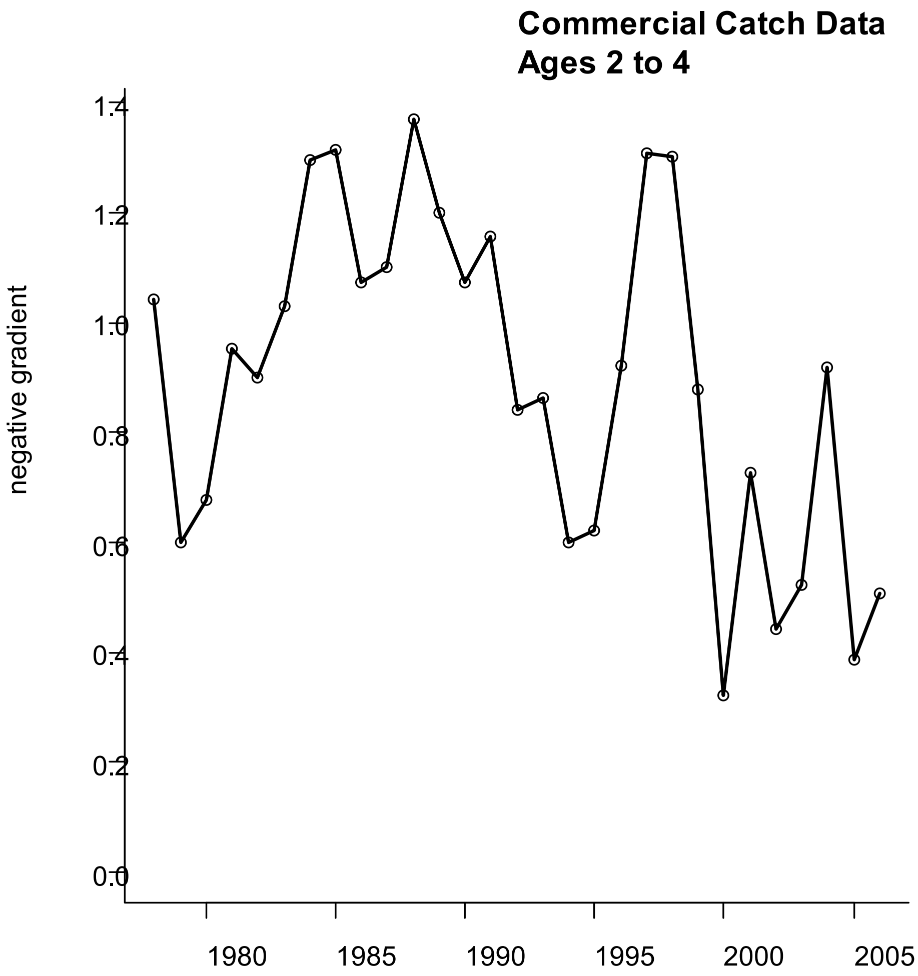

Figure 13.3.2.2. Haddock in Subarea IV and Division IIIa. Negative gradients of log catches per cohort, averaged over ages 2-4. The x-axis represents the spawning year of each cohort.

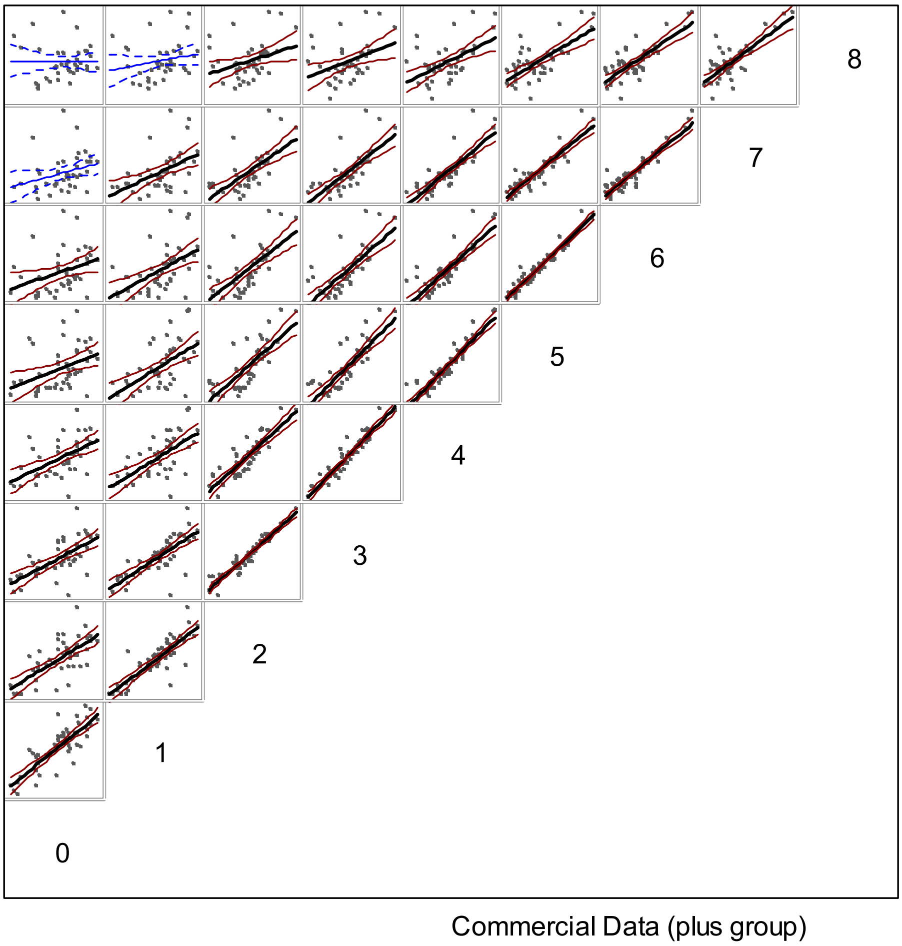

Figure 13.3.2.3. Haddock in Subarea IV and Division IIIa. Correlations in the catch-at-age matrix (including the plus-group for ages 8 and older), comparing estimates at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (and 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.

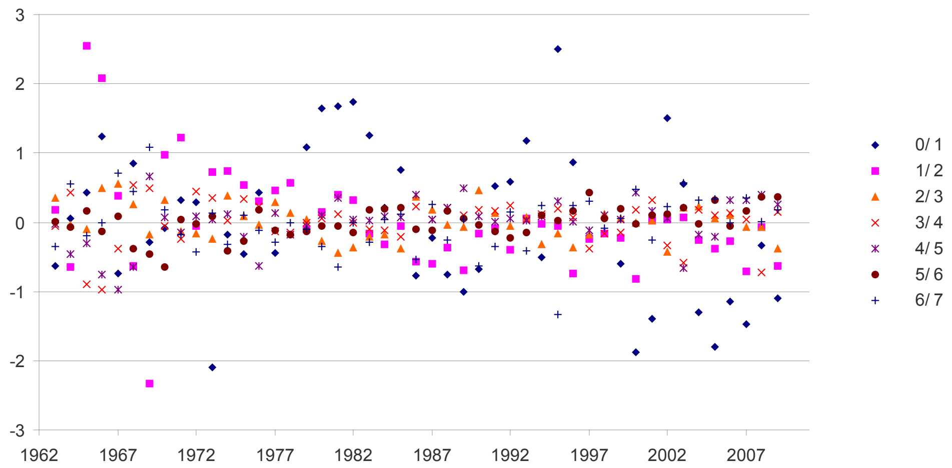

Figure 13.3.2.4. Haddock in Subarea IV and Division IIIa. Residuals from separable VPA analysis. The x-axis labels give the first year only of the actual year ratio used (so "1970" denotes 1970/1971). The y-axis labels for the lower plot give the first age only of the actual age ratio used (so "1" denotes ½).

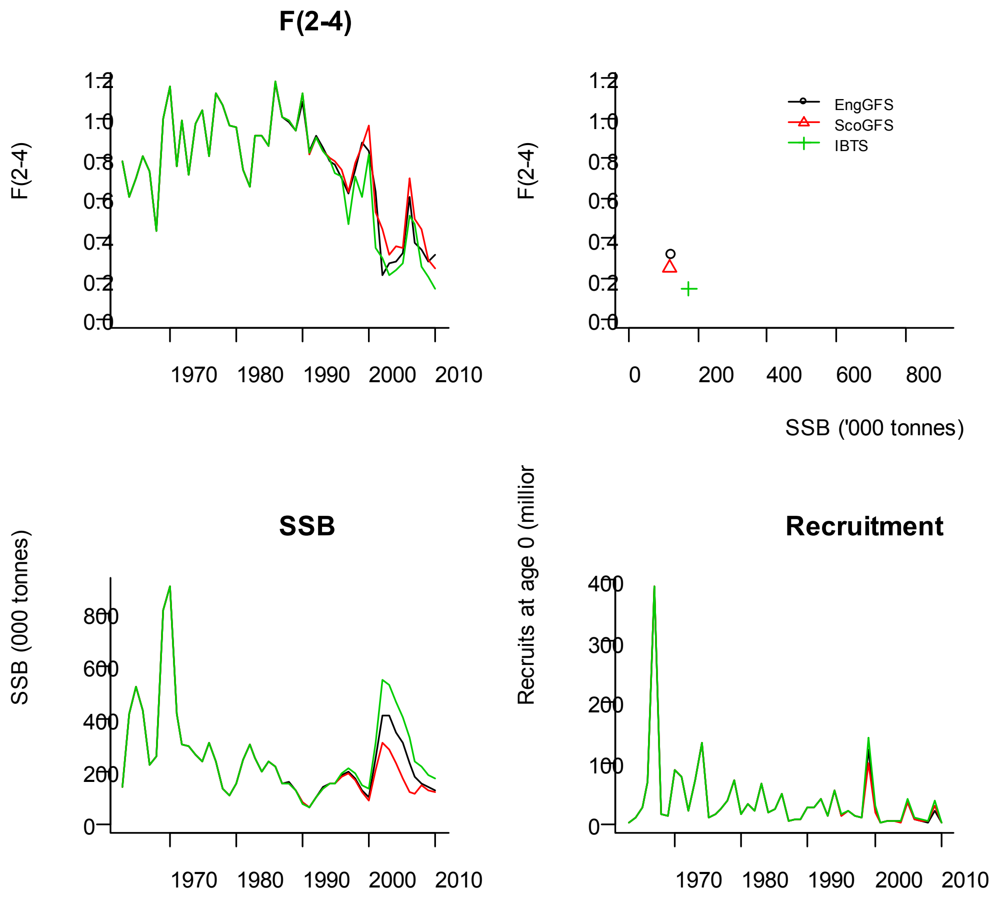

Figure 13.3.2.5. Haddock in Subarea IV and Division IIIa. Stock summary plots for single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here. Final year (2010) values of SSB and mean F(2-4) are plotted against each other in the upper right plot.

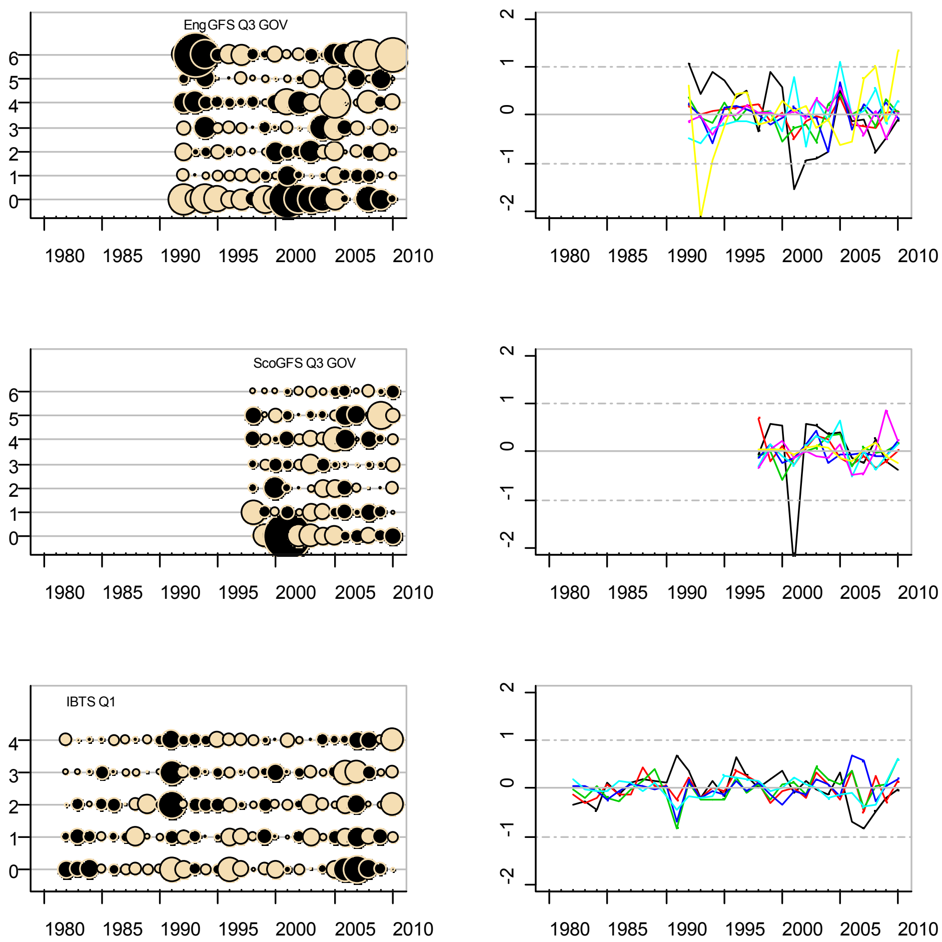

Figure 13.3.2.6. Haddock in Subarea IV and Division IIIa. Log catchability residuals from single-fleet XSA runs. Only the more recent segments of the EngGFS and ScoGFS surveys have been used here.

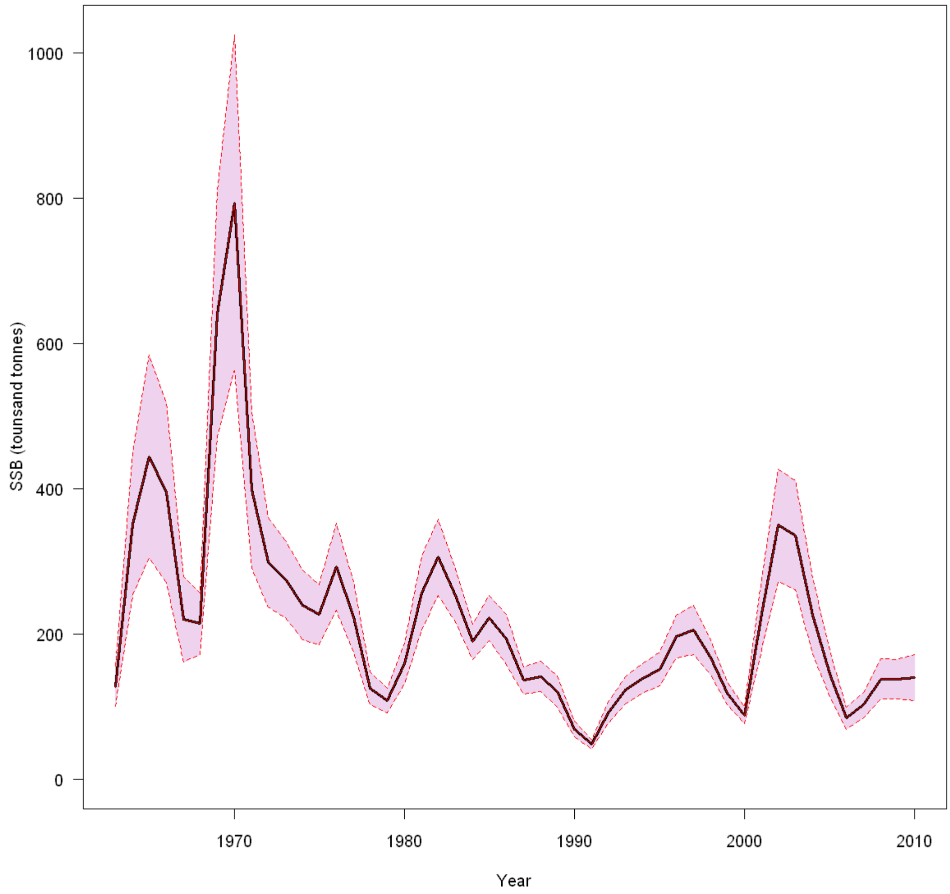

Figure 13.3.2.7. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated SSB (black line) along with 95% confidence interval.

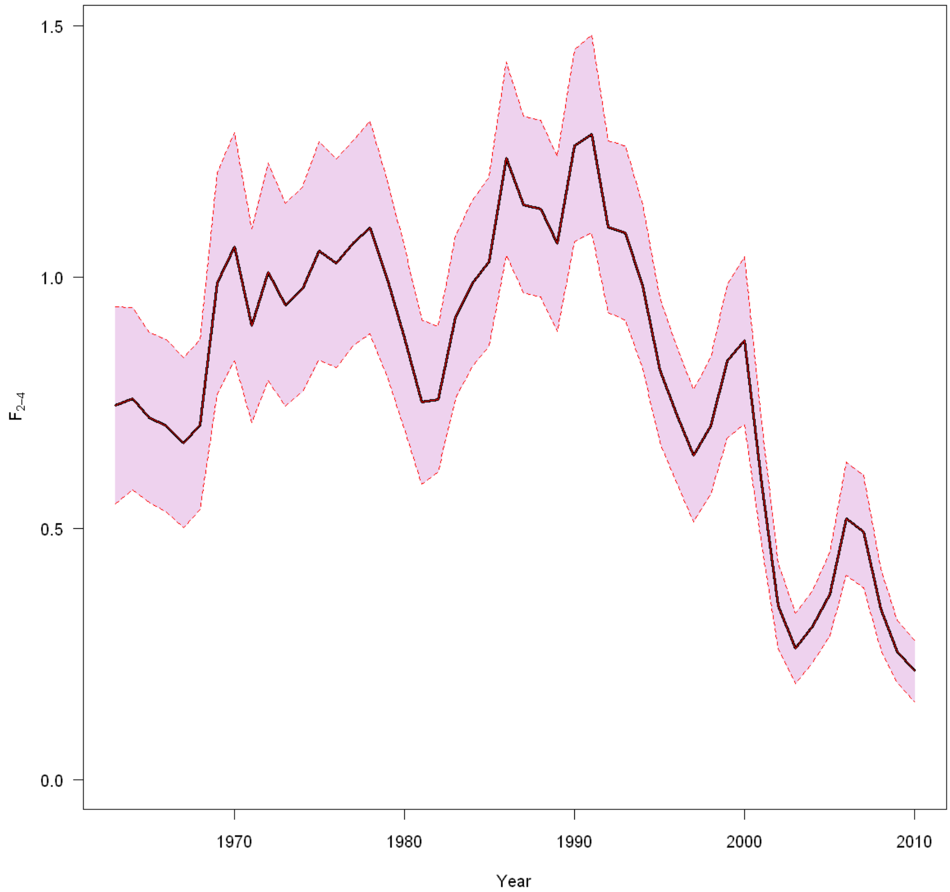

Figure 13.3.2.8. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated mean F(2-4) (black line) along with 95% confidence interval.

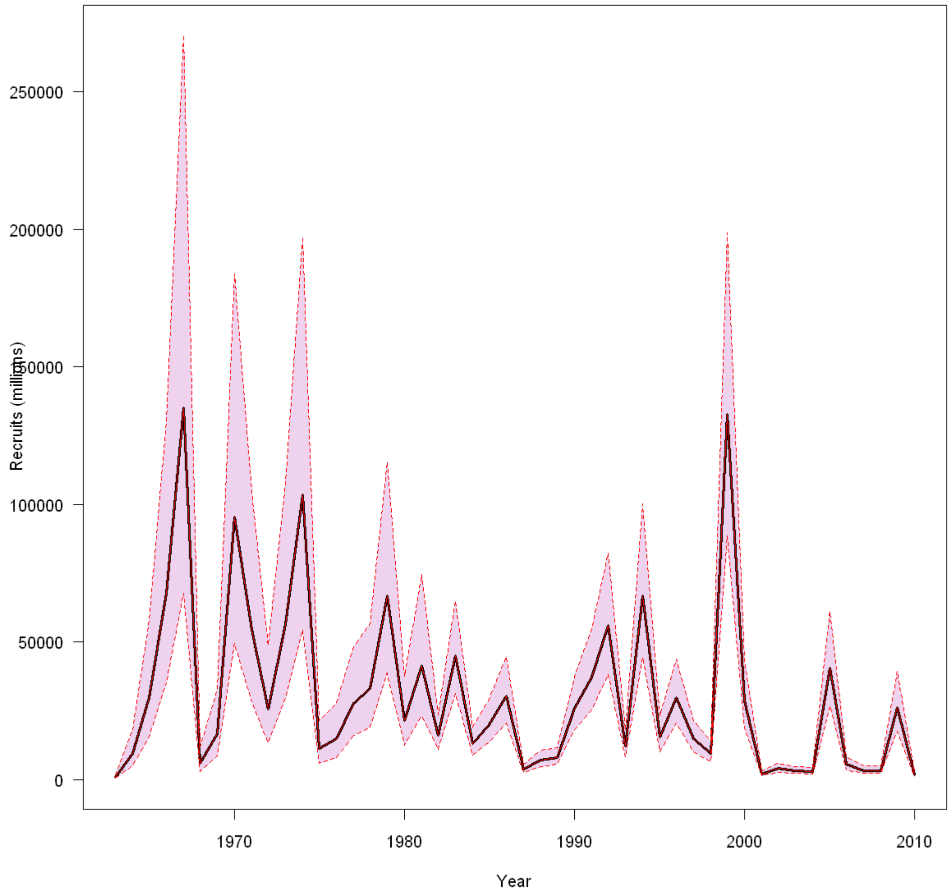

Figure 13.3.2.9. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: estimated recruitment at age 0 (black line) along with 95% confidence interval.

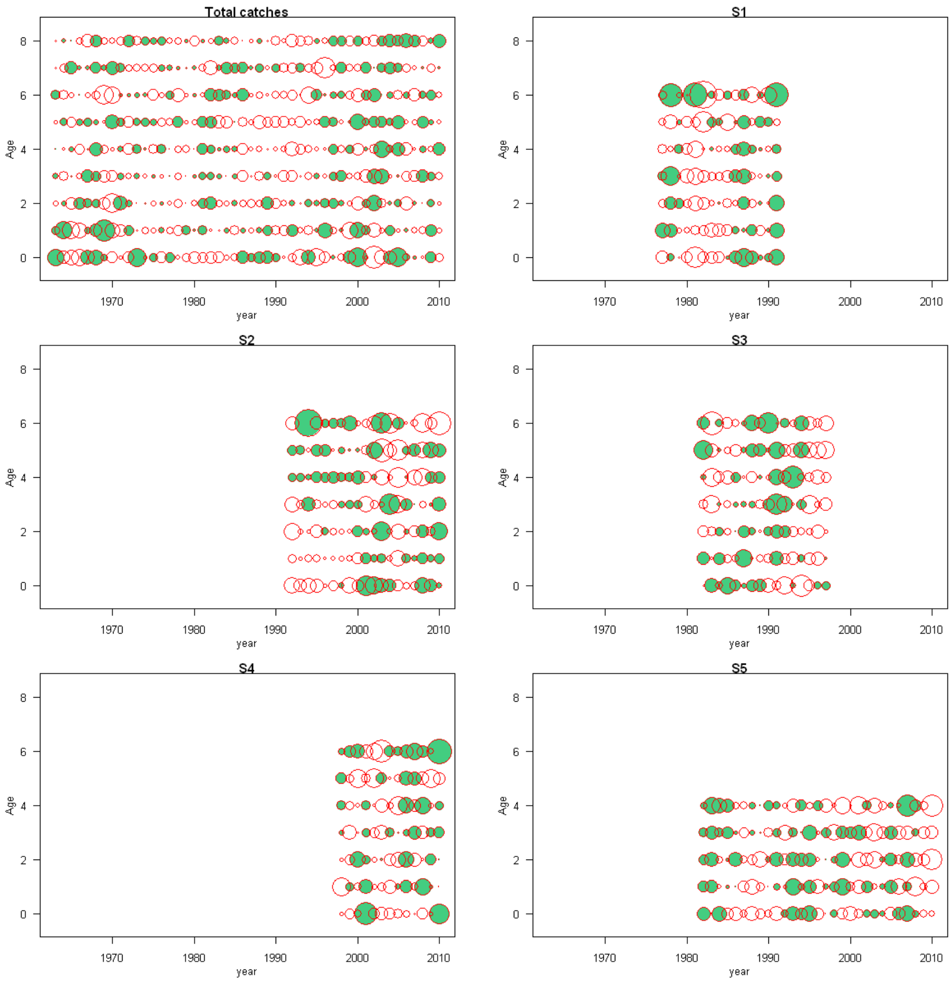

Figure 13.3.2.10. Haddock in Subarea IV and Division IIIa. Summary plots from the SAM assessment run: log residuals (open points = positive values, closed points = negative values).

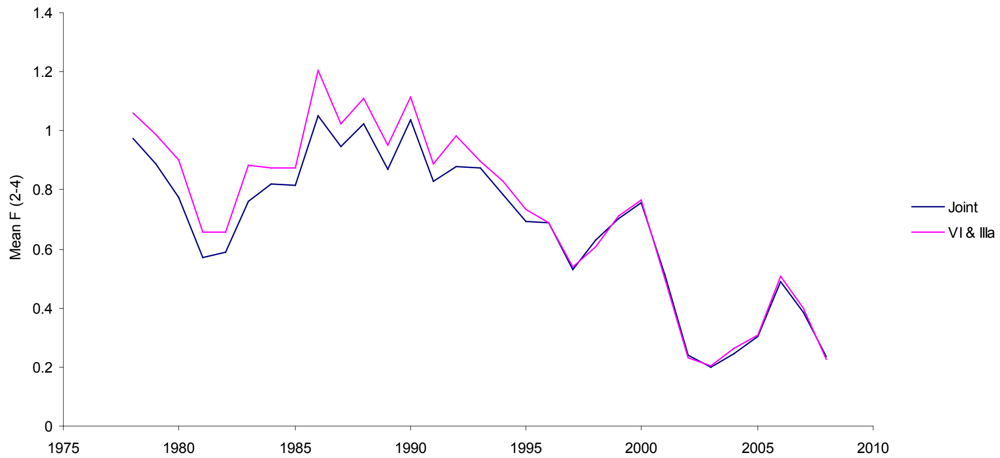

Figure 13.3.2.11. Haddock. Comparison of mean F(2-4) estimates from the update FLXSA assessment for Sub-area IV and Division IIIa (pink) with equivalent estimates from an FLXSA run using data from Sub-area IV, Division IIIa *and* Division VIa (blue). Note that the figure legend is incorrect (the legend for the pink line should read "IV & IIIa").

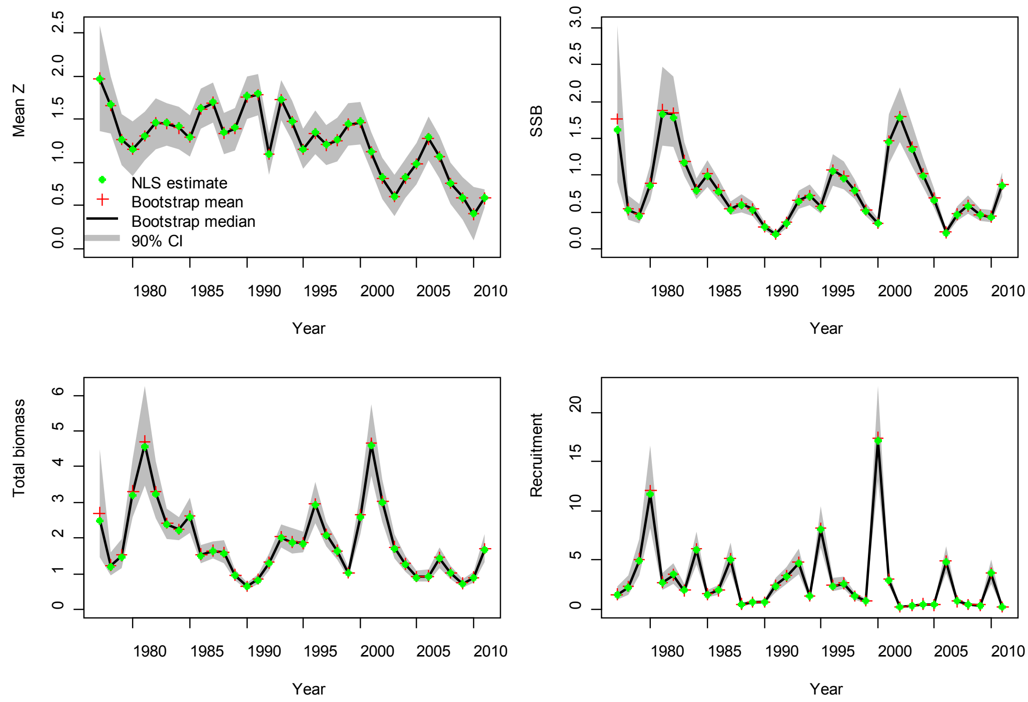

Figure 13.3.3.1. Haddock in Subarea IV and Division IIIa. Summary plots from an exploratory SURBAR assessment, using all available surveys (EngGFS Q3, ScoGFS Q3, IBTS Q1). Mean mortality Z (ages 2 to 4), relative spawning stock biomass (SSB), relative total biomas (TSB), and relative recruitment. Shaded 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.

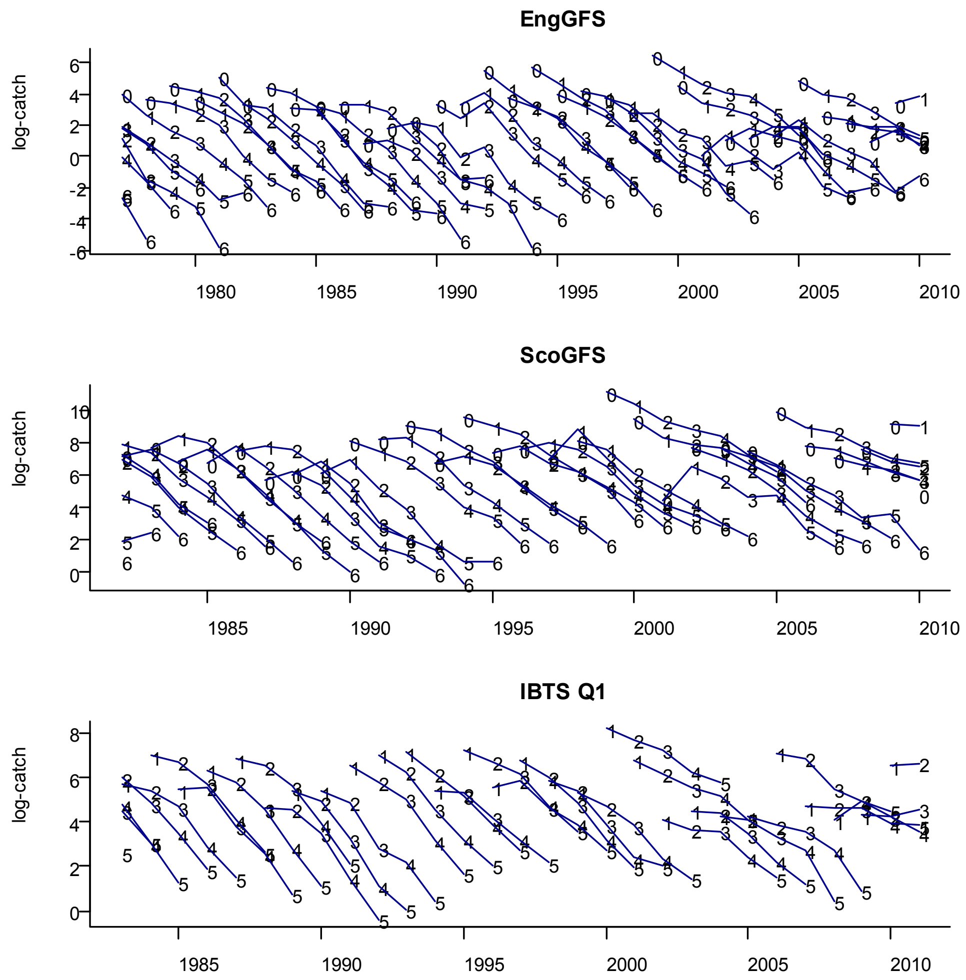

Figure 13.3.3.2. Haddock in Subarea IV and Division IIIa. Log abundance indices by cohort for each of the five survey indices. The separate sections of the ScoGFS and EngGFS Q3 surveys have been combined for the purposes of this plot.

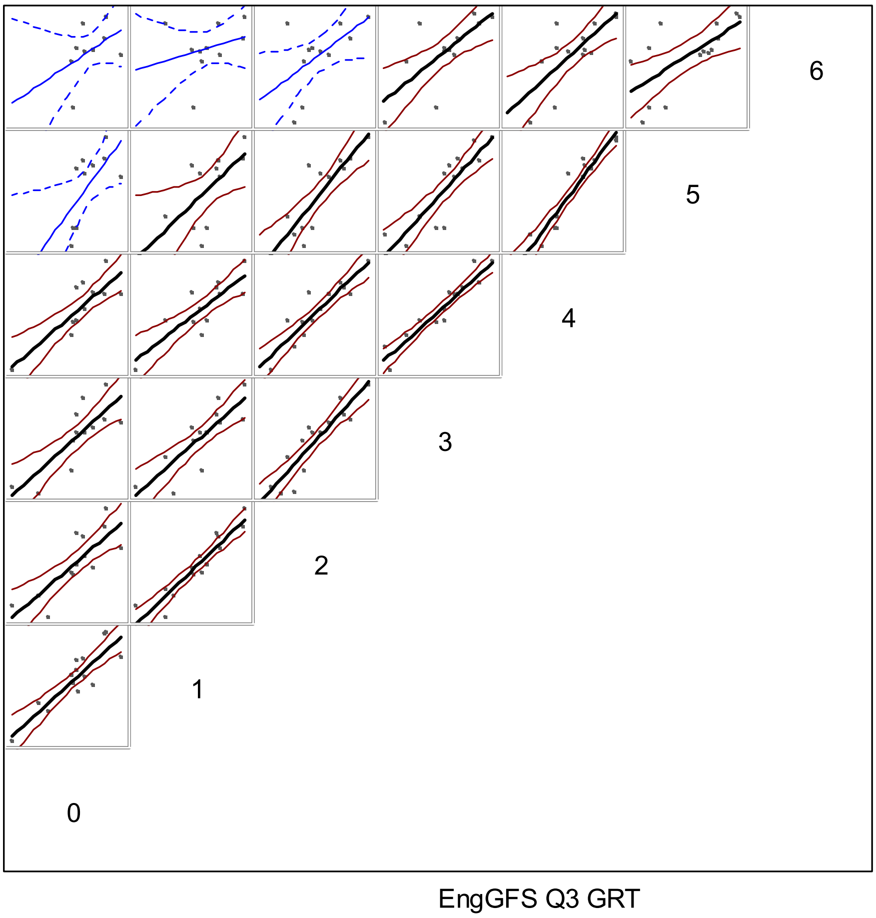

Figure 13.3.3.3. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GRT) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.**

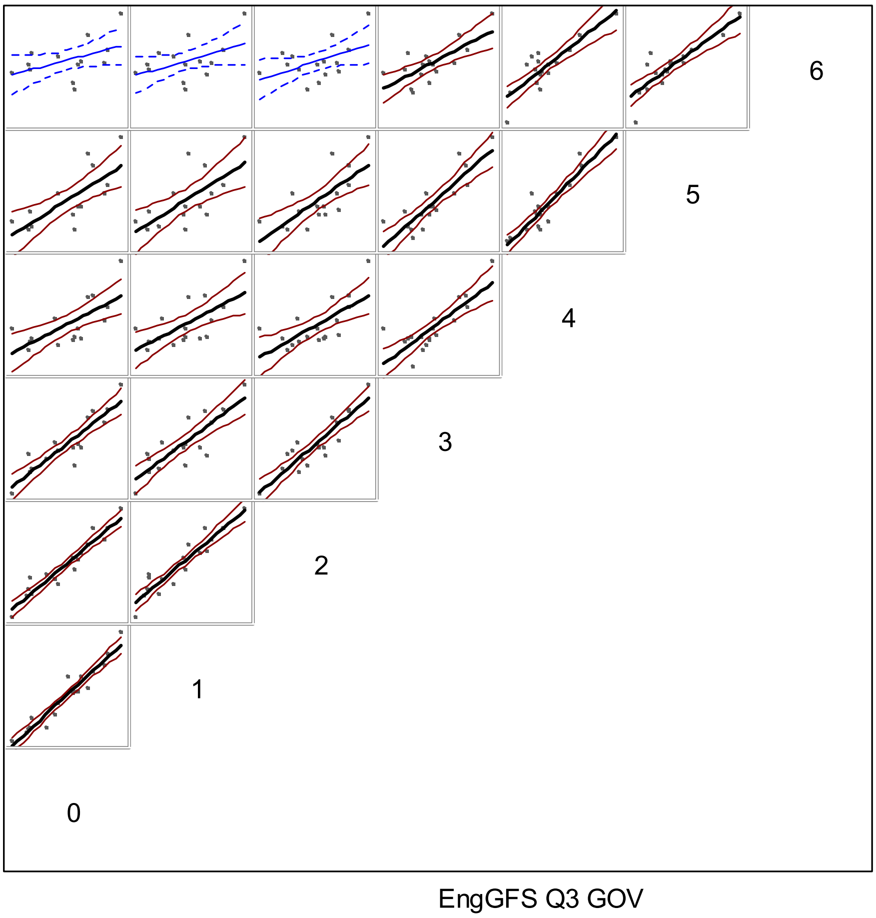

Figure 13.3.3.3. cont. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the EngGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.**

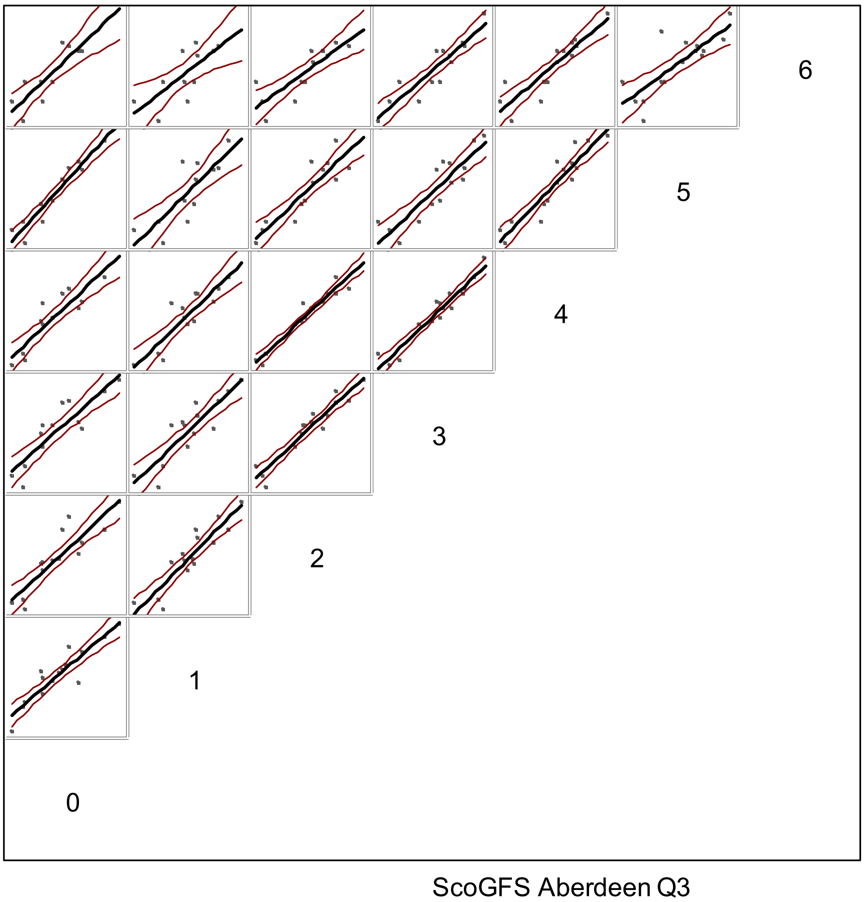

Figure 13.3.3.3. cont. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (Aberdeen) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.**

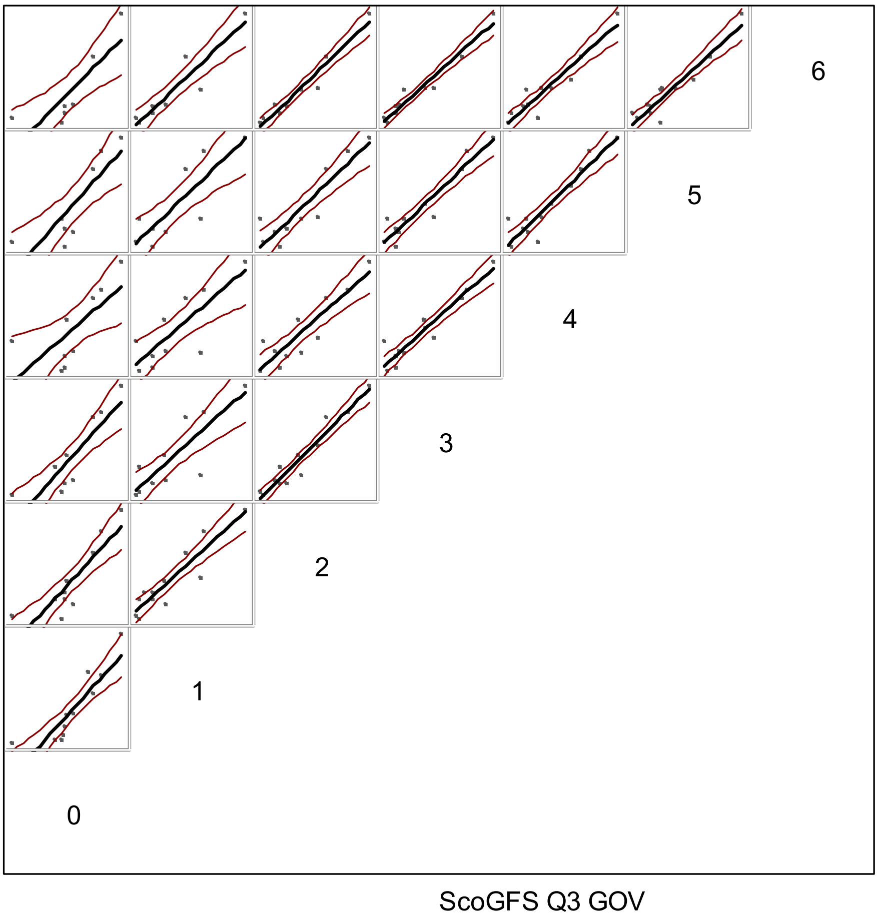

Figure 13.3.3.3. cont. **Haddock in Subarea IV and Division IIIa. Within-survey correlations for the ScoGFS (GOV) survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) 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.**

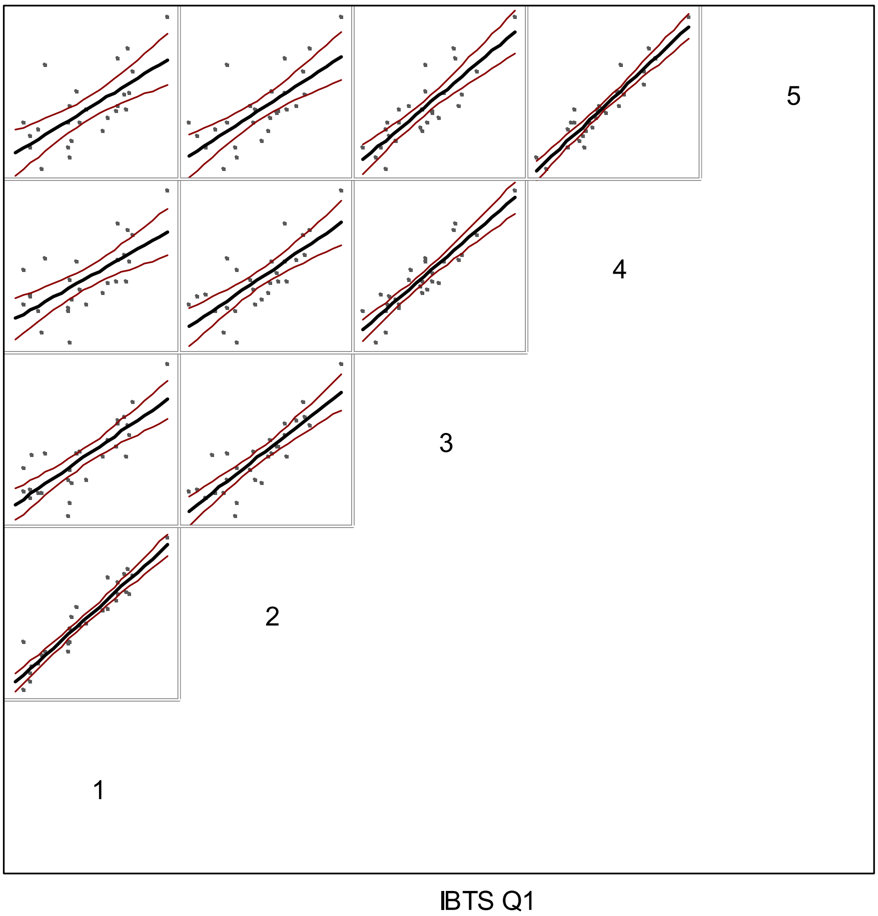

Figure 13.3.3.3. cont. Haddock in Subarea IV and Division IIIa. Within-survey correlations for the IBTS Q1 survey series, comparing index values at different ages for the same year-classes (cohorts). In each plot, the straight line is a normal linear model fit: a thick line (with black points) represents 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.

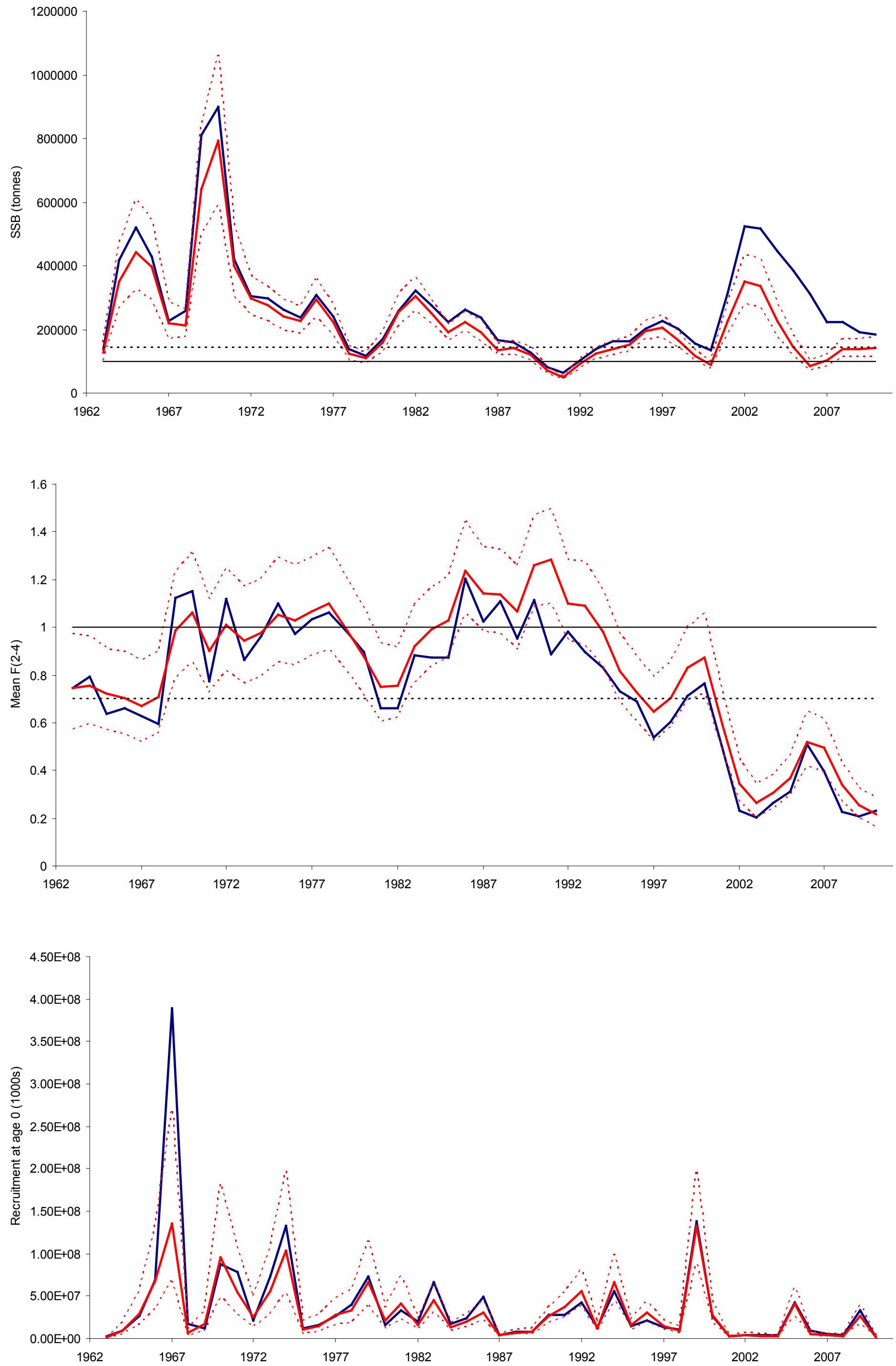

Figure 13.3.4.1. Haddock in Subarea IV and Division IIIa. Comparisons of stock summary estimates from XSA (blue) and SAM (red) models. The SAM estimates are presented along with 95% confidence intervals. Top: SSB. Middle: mean F(2-4). Bottom: recruitment.

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.**

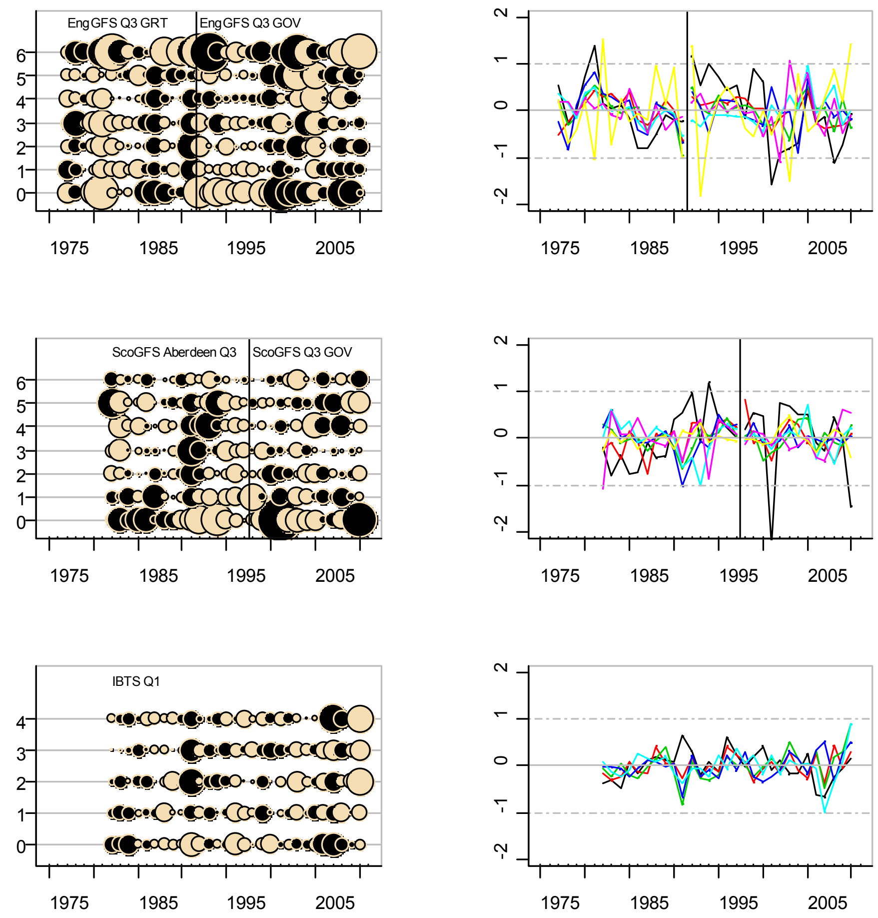

Figure 13.3.5.1 Haddock in Subarea IV and Division IIIa. Log catchability residuals for final XSA assessment. Both EngGFS and ScoGFS are split when used as tuning indices, and this split is shown by vertical lines on the relevant plots.

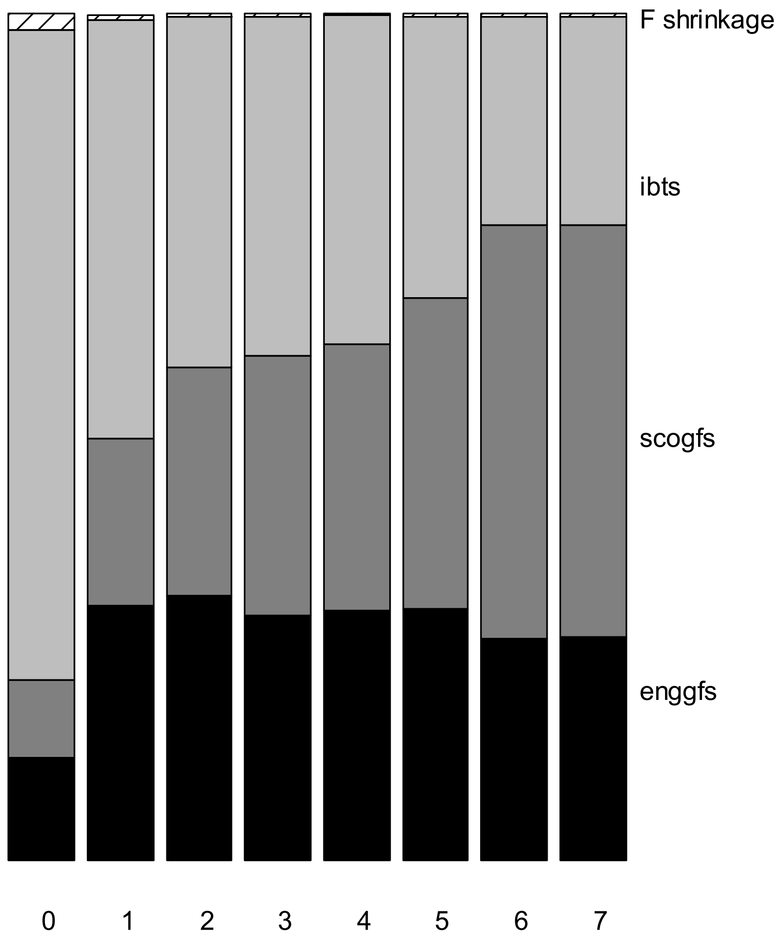

Figure 13.3.5.2. Haddock in Subarea IV and Division IIIa. Contribution to survivors' estimates in final XSA assessment.

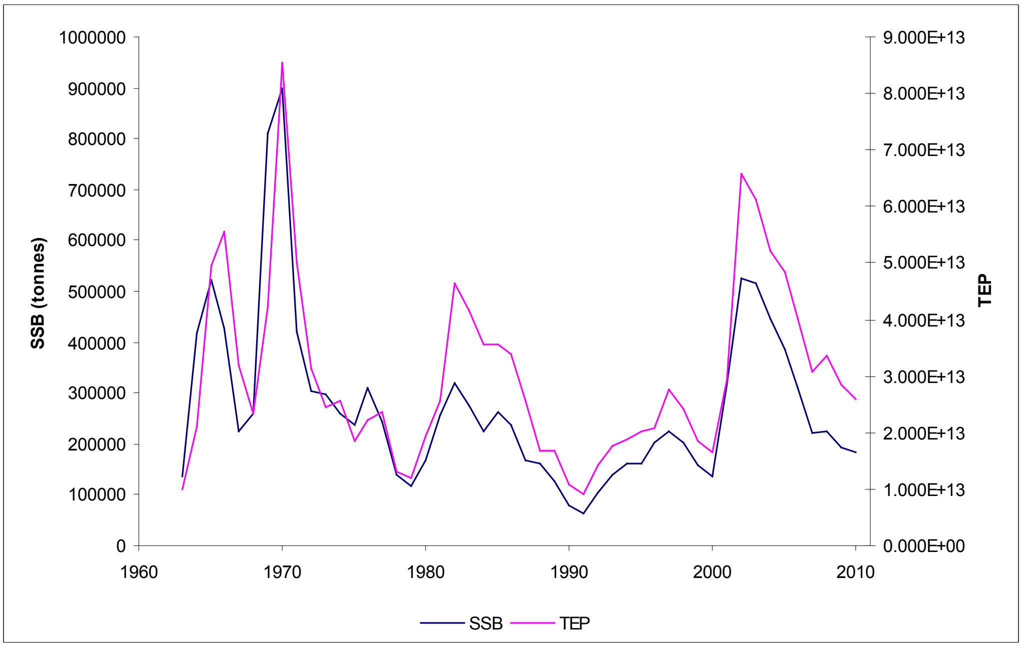

Figure 13.3.5.3. Haddock in Subarea IV and Division IIIa. Estimated SSB from the final XSA assessment, and total egg production (TEP).

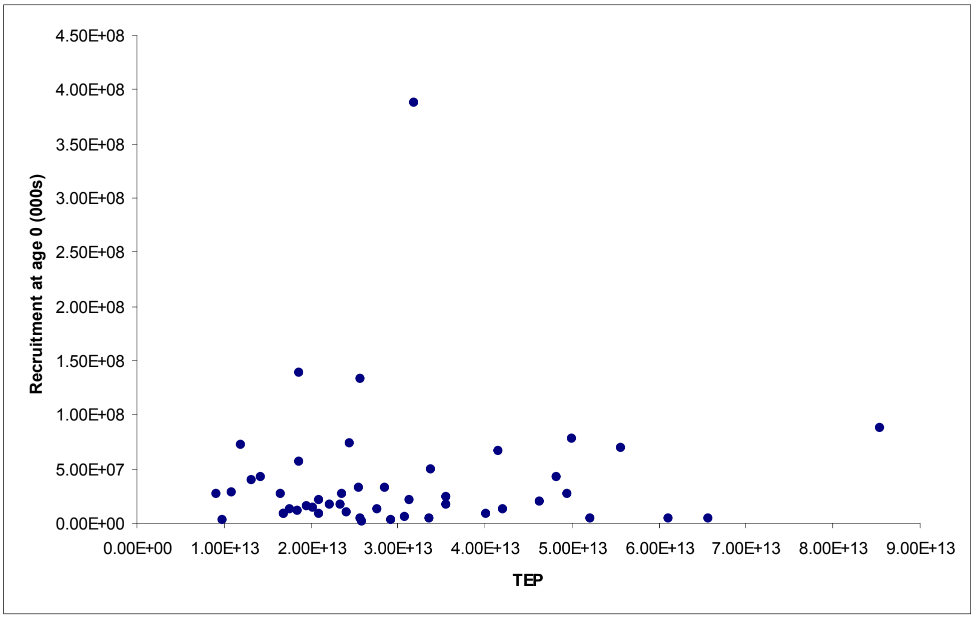

Figure 13.3.5.4. Haddock in Subarea IV and Division IIIa. Scatterplot of recruitment at age 0 from the final XSA assessment, against total egg production (TEP).

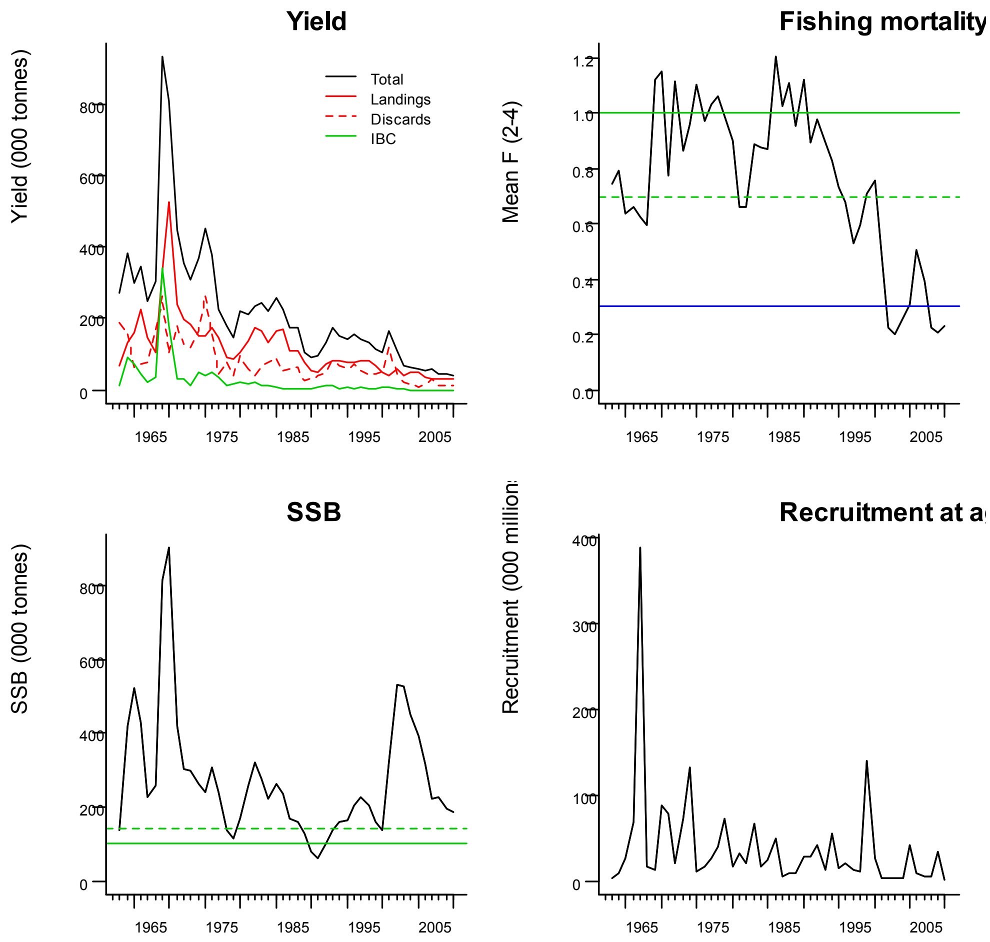

Figure 13.4.1. Haddock in Subarea IV and Division IIIa. Summary plots for final XSA assessment. Dotted horizontal green lines indicate F_{pa} (top right plot) and B_{pa} (bottom left plot), while solid horizontal green lines indicate F_{lim} and B_{lim} in the same plots. The solid blue line in the top 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}.

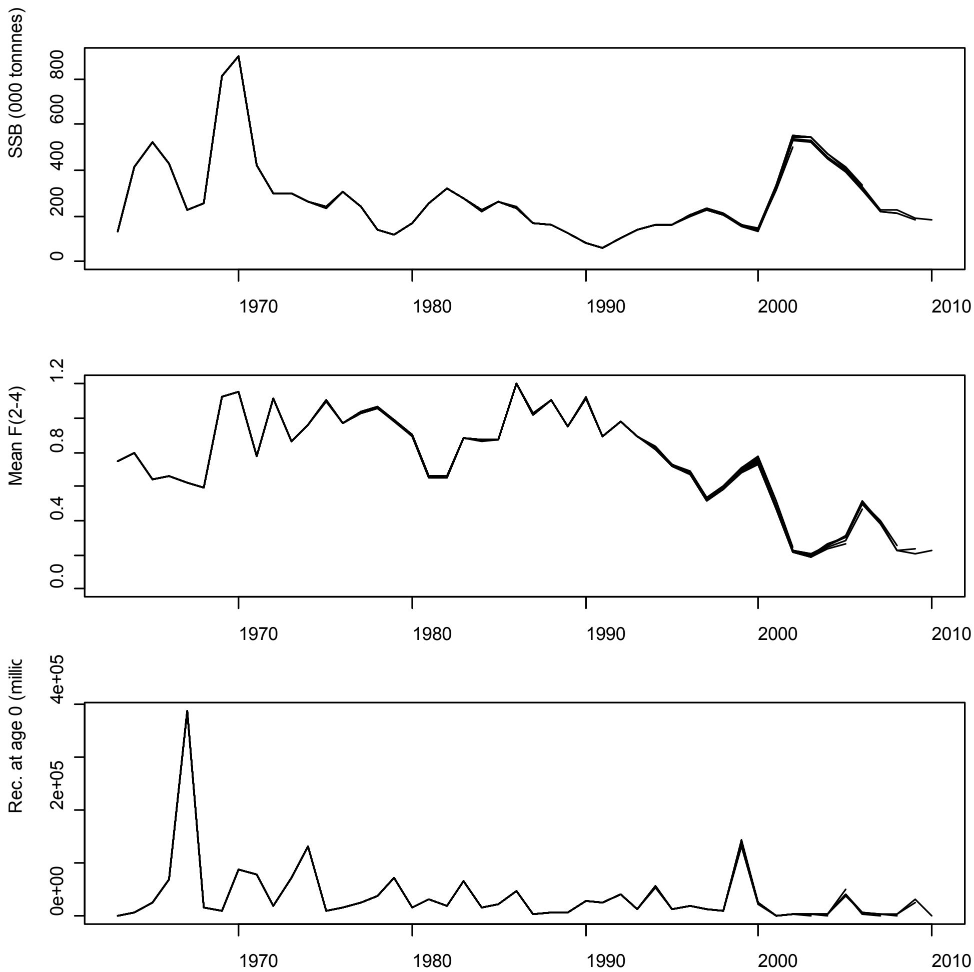

Figure 13.4.2. Haddock in Subarea IV and Division IIIa. Eight-year retrospective plots for final XSA assessment.

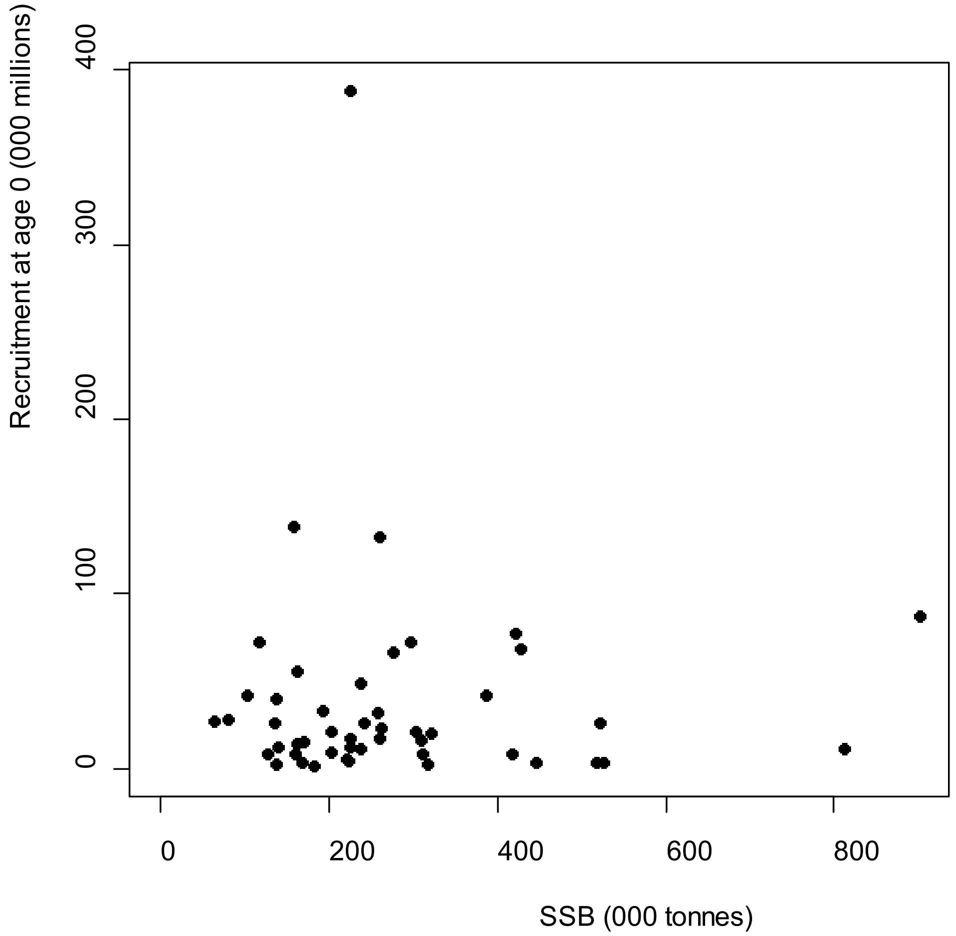

Figure 13.4.3. Haddock in Subarea IV and Division IIIa. Stock-recruitment plot from the update FLXSA assessment.

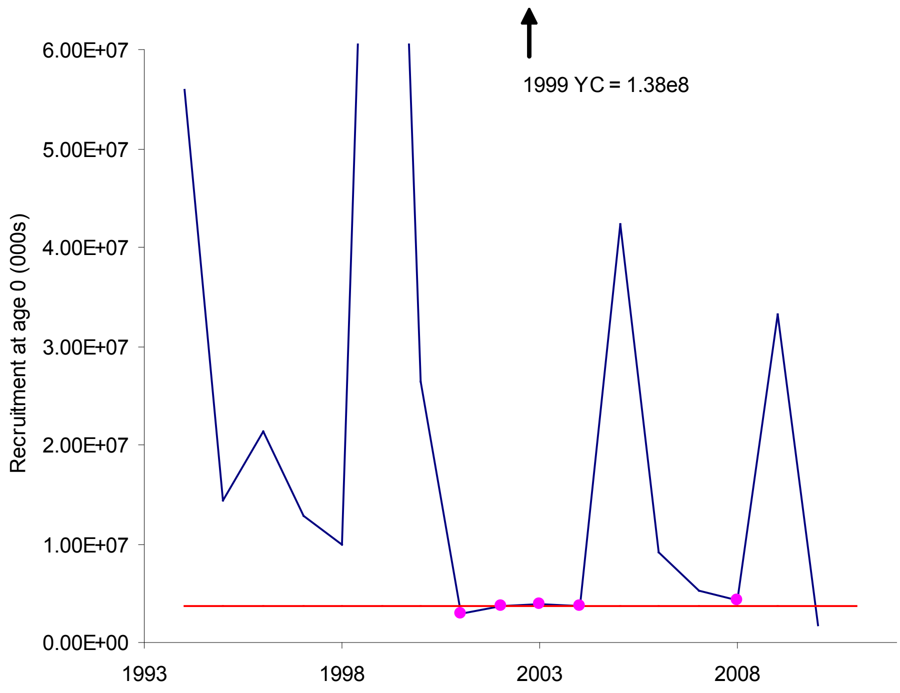

Figure 13.5.1.1. Haddock in Subarea IV and Division IIIa. Estimated recruitment from the final XSA assessment for 1994-2009 (black line), with 5 lowest values (pink dots) and the geometric mean of these (red line).

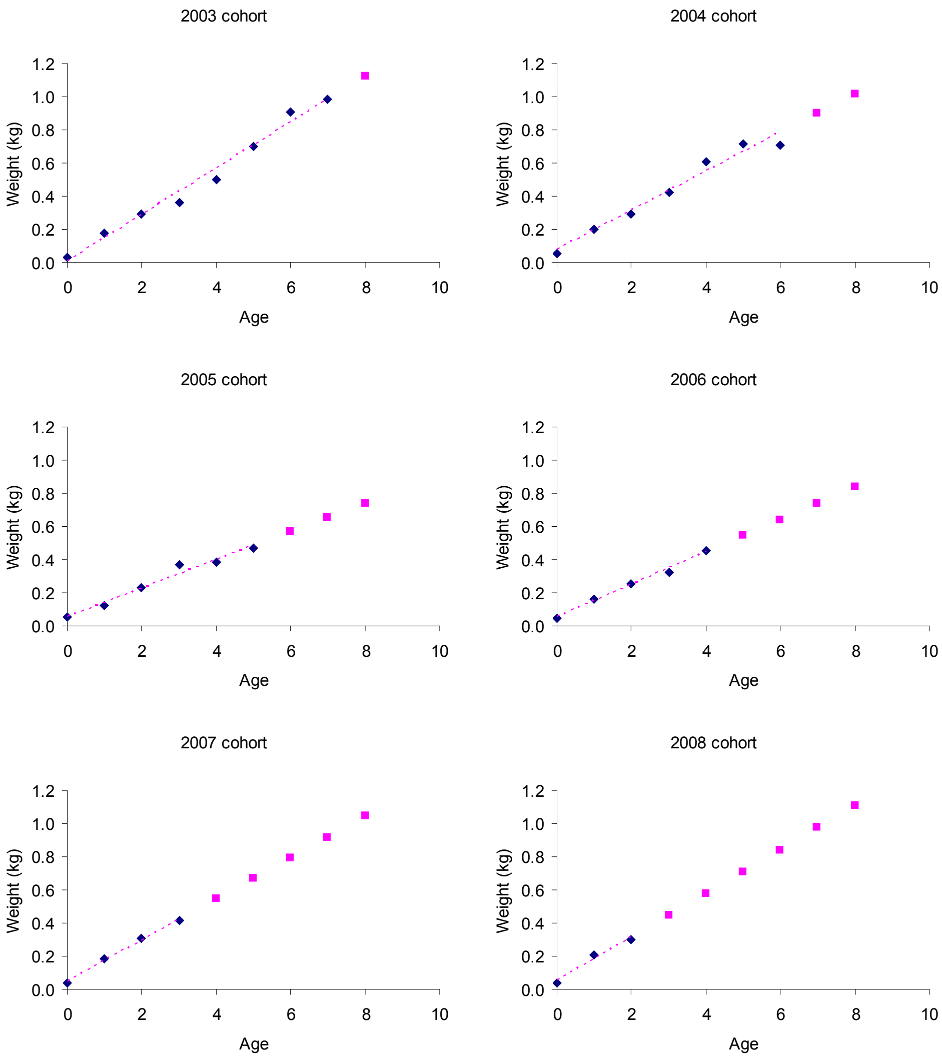

Figure 13.6.1. Haddock in Subarea IV and Division IIIa. Results of growth modelling for total catch weights (also used as stock weights) using cohort-based linear models (Jaworski 2011). Cohorts 2003-2008 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

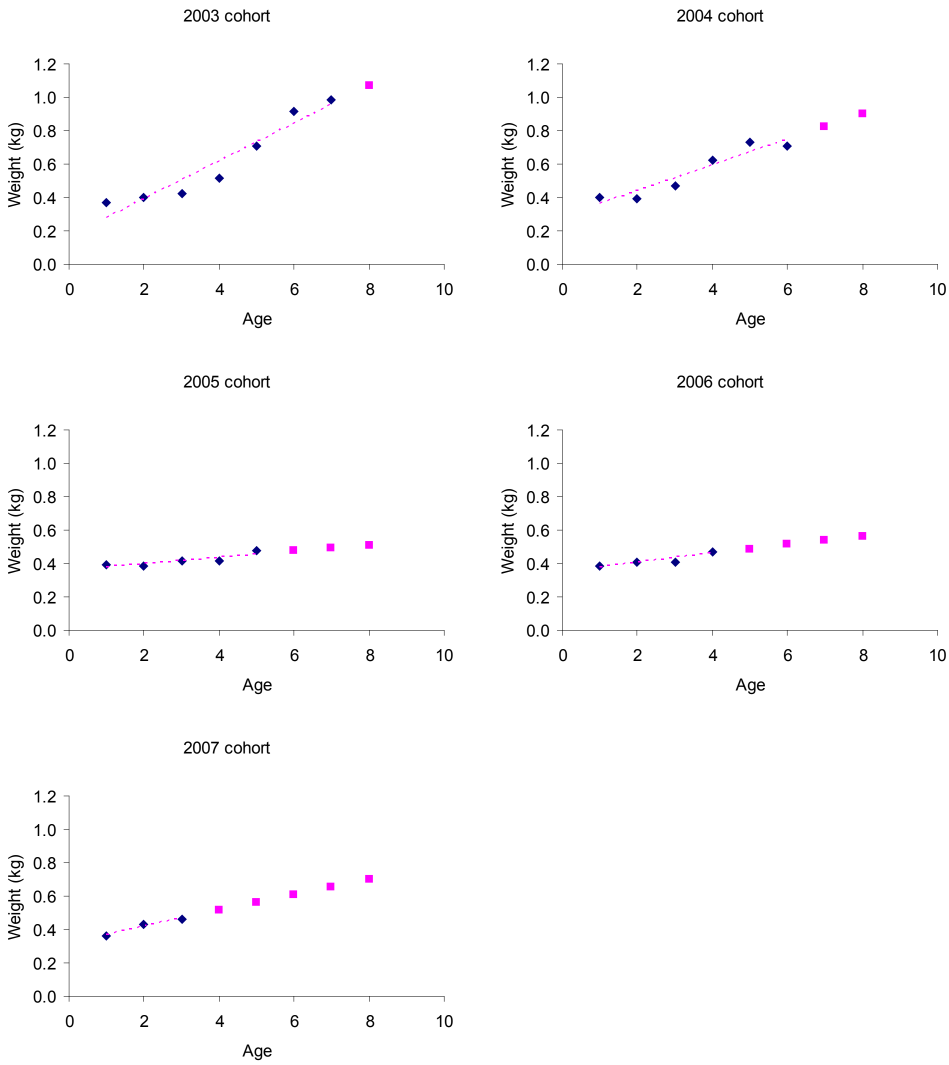

Figure 13.6.2. Haddock in Subarea IV and Division IIIa. Results of growth modelling for landings weights using cohort-based linear models (Jaworski 2011). Cohorts 2003-2007 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages.

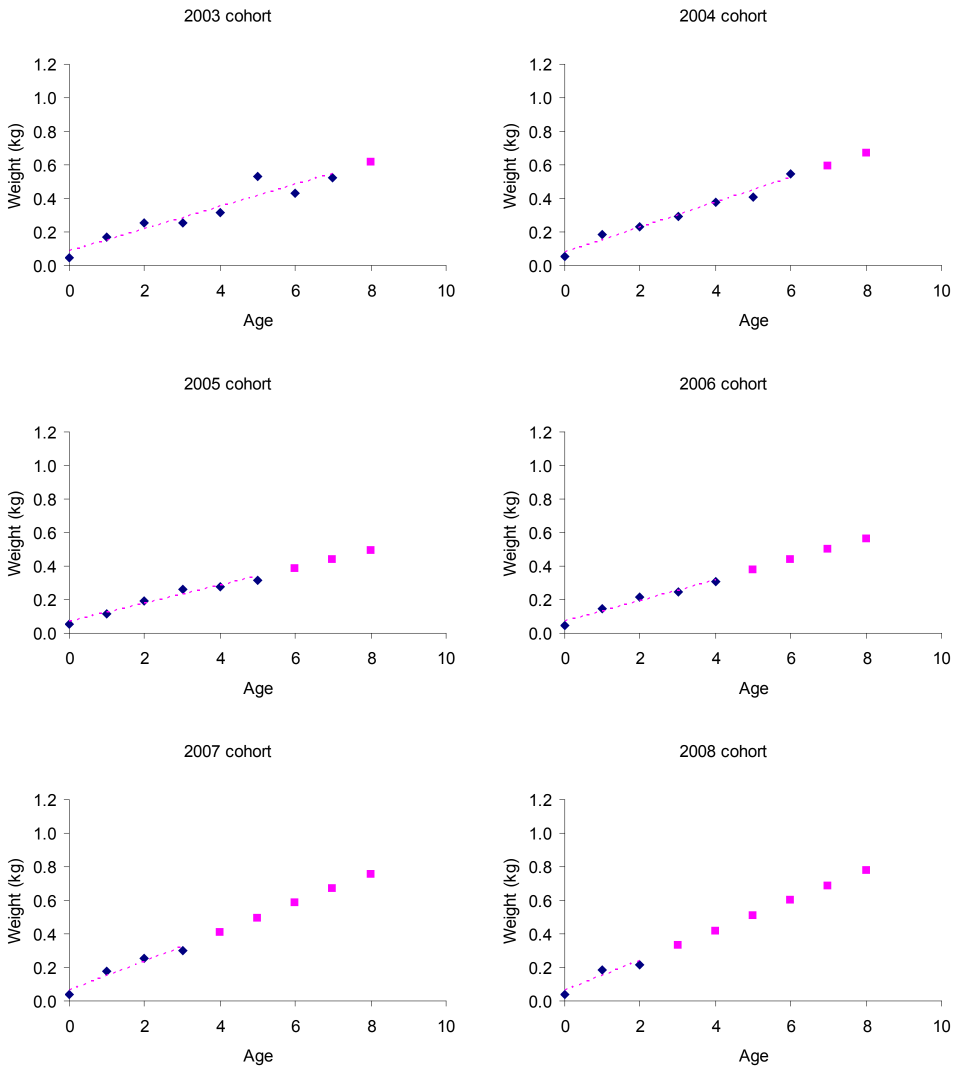

Figure 13.6.3. Haddock in Subarea IV and Division IIIa. Results of growth modelling for discard weights using cohort-based linear models (Jaworski 2011). Cohorts 2003-2008 are shown here. Blue points are available observations, pink dotted lines show linear fits to these points, and pink points indicate projected weights for older ages

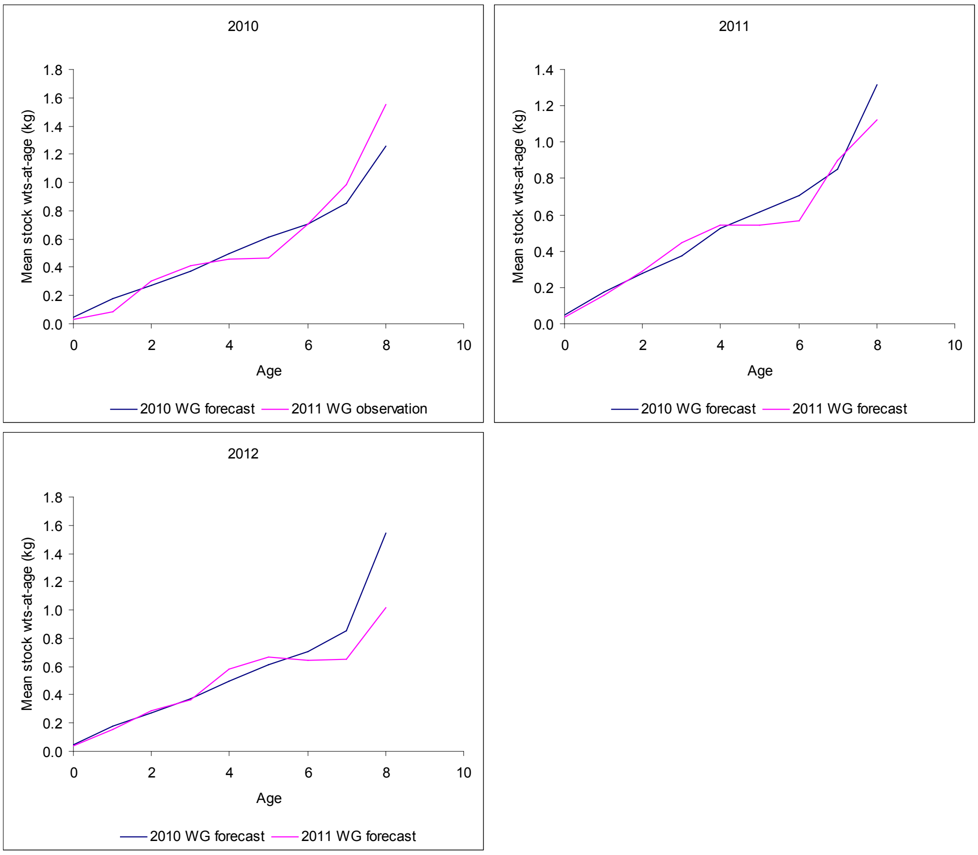

Figure 13.6.4. Haddock in Subarea IV and Division IIIa. Comparison of weights-at-age for 2010-12 from the 2010 WG, with the weights-at-age for 2010-12 from the 2011 WG.

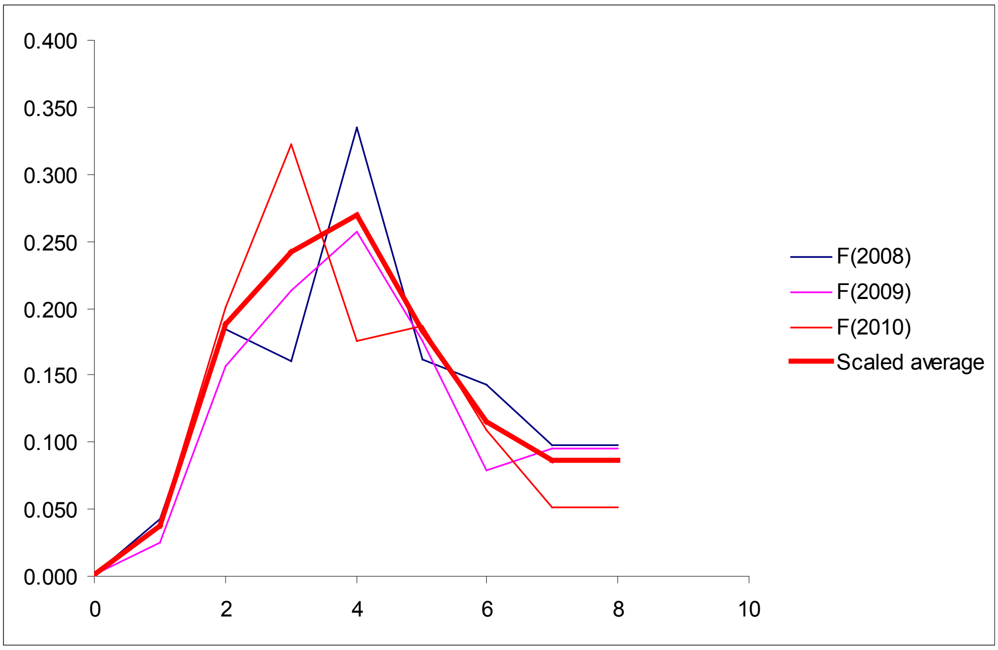

Figure 13.6.5. Haddock in Subarea IV and Division IIIa. Comparison of fishing mortality estimates for 2008-2010 with a three-year (2008-2010) mean exploitation pattern scaled to the mean level of the 2010 estimates.

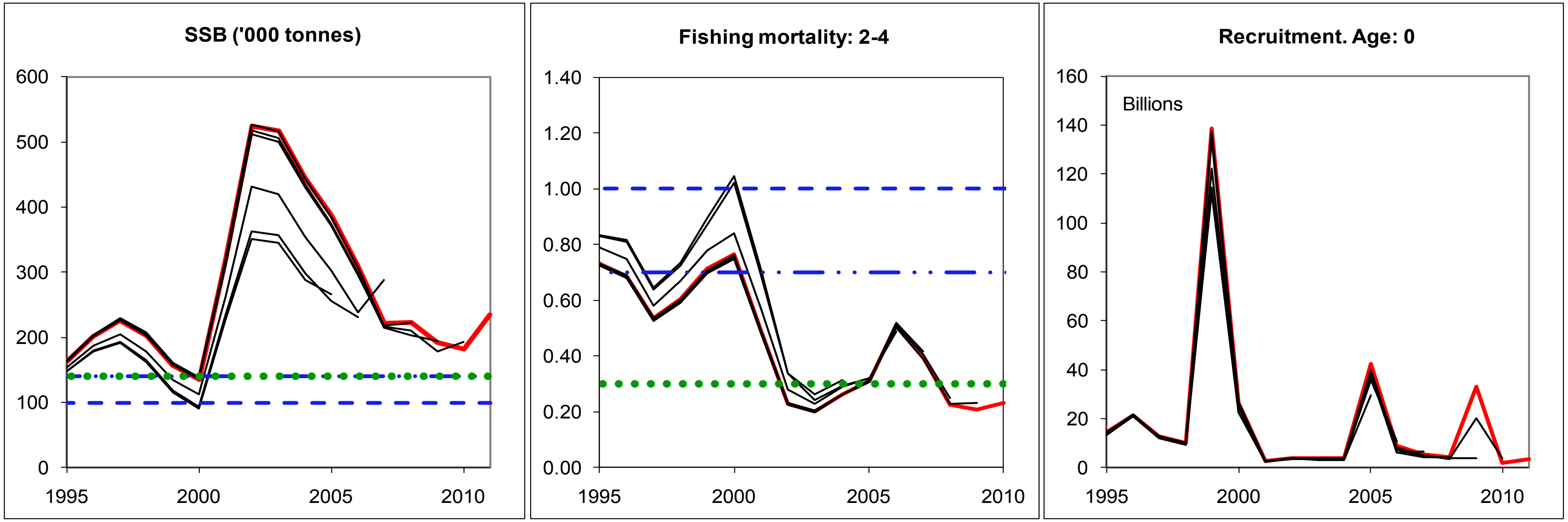

Figure 13.9.1. Haddock in Subarea IV and Division IIIa. Historical assessment quality plot.

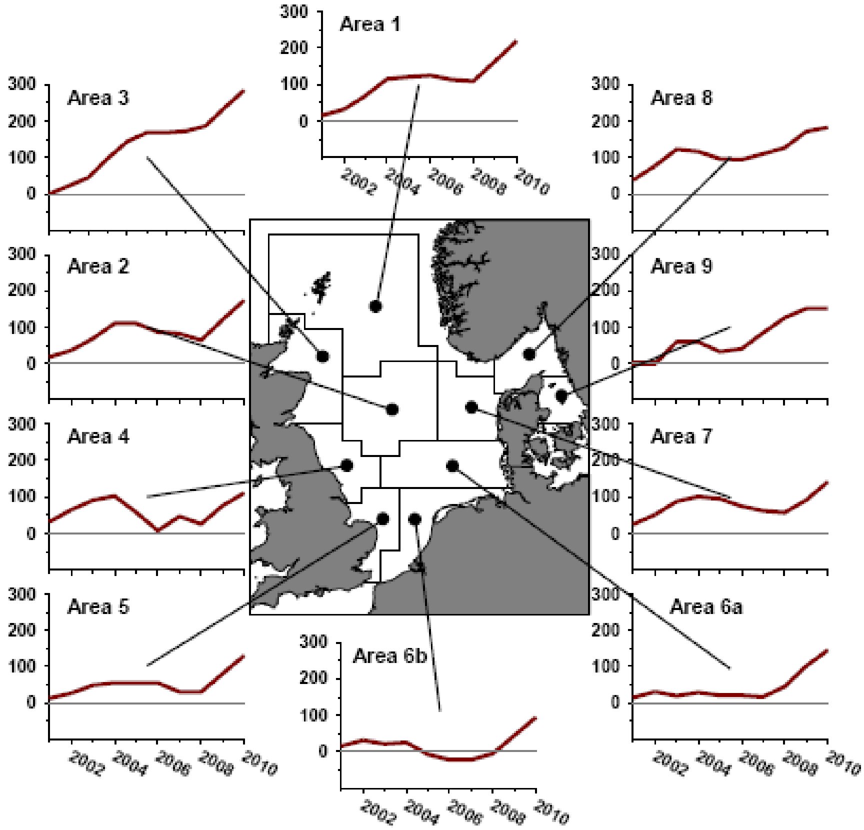

Figure 13.10.1. Haddock in Subarea IV and Division IIIa. Results of 2010 North Sea Stock Survey: cumulative time series of index of perceptions of haddock abundance Source: Napier (2011)

14 Cod

This assessment relates to the cod stock in the North Sea (Sub-area IV), the Skagerrak (the northern section of Division IIIa) and the eastern Channel (Division VIId). This assessment is presented as a benchmark assessment based on the revised assessment protocol specified by the 2011 meeting of WKCOD (ICES-WKCOD 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

A Working Document about North Sea cod movements and population structure was provided to the North Sea cod inter-benchmark meeting by Wright, Neat and Righton (WD7 in ICES-WKCOD, 2011). The main findings are as follows:

1) The hypothesis that fish may be "lost" northwards out of the range of the survey appears inconsistent with recent and historical information on cod movements since age 2+ from the southern North Sea are only likely to migrate as far as the central North Sea.
2) Direct observations on cod in relation to sea temperature do not suggest they actively avoid the warm southern North Sea in summer.
3) As a proportion of cod from the eastern channel may migrate into the North Sea, abundance near the southern edge of the IBTS Q3 survey may have been important to recent trends in IBTS Q3.
4) Two subpopulations of cod have been indicated from genetic studies and there do appear to be long-term differences in recruitment trends. The presence of two subpopulations largely inhabiting different regions of the North Sea will mean that there is the potential for regional differences in mortality, because cod from the deep-water subpopulation would not be expected to recolonize areas depleted in the southern North Sea.

A summary of further 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). 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. 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.

Scotland implemented in February 2008 a national scheme known as the 'Conservation Credits Scheme'. The principle of this two-part scheme involves additional time at sea in return for the adoption of measures which aim to reduce mortality on cod and lead to a reduction in discard numbers. The WG notes that cod discarding rates in Scotland have decreased from 62% in the scheme's initial year of operation (2008) to 36% in 2010. 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). 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 (Needle and Catarino 2011). WGFTFB (2010) notes that French vessels have been fully respecting the "real-time" closures in the North Sea introduced under the UK Conservation Credit Scheme.

Changes in national fleet dynamics

The ICES WGFTFB meeting, which provides information on developments of fleets and gear impacting on the North Sea fisheries, was scheduled to meet after the WGNSSK 2011; a summary of information on fleet dynamics for all countries will be available in the ICES WGFTFB 2011 report.

The expansion of the CCTV programmes in 2010 (and subsequently in 2011) in Scotland, Denmark and England is expected to have reduced cod mortality – vessels carrying CCTV systems are not permitted to discard 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.

Industry representative in Scotland report that fishers are now managing opportunity in a more sensible way. Fishers are avoiding known cod areas so as not to have to discard quality fish due to the effect that this now has on the morale of crews. This new approach to management is further prompted by the requirement to retain suitable levels of quota in the main species in order to gain entry to the Norwegian zone (EU Norway Accord) of the North Sea. Many whitefish vessels operate in the Norwegian zone at some point in the year.

Several larger French trawlers using mesh size range 70–99 mm have continued to fish further north in the North sea (south east of Scotland in Area IVb) because of the low abundance of whiting in VIId, and also to reduce fuel consumption by increasing the duration of their individual trip (from 2 days long to 4 or 5 days long).

Fisheries Science Partnerships

A series of new and ongoing collaborative studies were presented 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 and Peach 2011) 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 and whiting. 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. The FSP survey estimates the 2006 and 2007 year classes to be 30-40%, and the 2008 and 2009 year classes around 60% of the relatively strong 2005 year class. This is in contrast to the IBTS Q1 survey, which estimates the 2009 year class to almost the same size as the 2005 year class (see Figure 14.6), but 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*., 2010). 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 and 2010.

Results from the first two surveys are encouraging. The NSW survey recorded a good range of ages for all target species in all of the areas surveyed. Variations in the distributions and catch rates across the North Sea will, as the time series develops, allow the testing of a number of questions related to substratum, gear and spatial distribution of the target species.

In 2009 catch rates of the target gadoid species (including cod) were higher on hard ground than on soft; in 2010 catch rates between the substrates 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 between years is 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 both years with differences in age distribution related to the area of fishing rather than the substrate 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 were similar in 2009 and 2010. Catches of older fish were more frequent and showed less noise in the NSW data than in the IBTSq3, particularly for cod.

The results indicate the potential for a time-series based on commercial vessels, derived across the areas surveyed. Such a series could be used to follow the development of the stock dynamics of key North Sea species and to investigate the dynamics of each on soft and hard substrata as population abundance changes over time.

Denmark - REX

Many fishermen do not consider the IBTS as representative for the stock status as the commercial fishery maintained viable catch rates also in areas where the IBTS reported no or low densities of cod above minimum landing size. In addition IBTS does not cover rough bottom where highest commercial cpue of cod is usually obtained and have thus 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 and the Danish Fishermen Association in summer 2006.

Based on the REX project, Wieland, Pedersen and Beyer (WD5 in ICES-WKCOD, 2011) compare catch rates of cod by a commercial trawler with IBTS catches in small area of the North Sea in 2007 to 2010. Mean cpue at age for the surveys with the commercial trawler were significantly higher on rough bottom than on smooth bottom for all age groups in the years 2007 to 2009. However, the difference in cpue between the two bottom categories decreased for age 1 and age 2 in 2010 and for the older ages slightly higher catch rates on smooth than on rough bottom were observed in that year. More data and analysis on the distribution of cod on hard and soft bottom are needed to investigate the potential bias in the IBTS index which is mainly done on soft bottom.

Length distributions from the commercial trawler revealed 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 small numbers of medium and large sizes of cod in the IBTS catches may, however, be as a result of 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.

The North Sea Stock Survey

The North Sea Stock Survey (Napier 2010) was available to WGNSSK in order for the fishers' perception of the state of the stock to be considered as part of the assessment process. 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 trawl, beam trawl and gill nets each accounted for around 20-30% of responses, with most of the remainder from *Nephrops* trawls.

The spatial distribution of the change in the perceived abundance since 2001 is recorded by survey area in Figure 14.15. Overall, 66% respondents reported that cod were 'more' or 'much more' abundant in 2010, somewhat less than in 2009, and around 30% reported 'no change' in the abundance of cod in 2010, substantially more than in 2009. By area, proportions of respondents reporting 'more' or 'much more' were highest in the central and north-western North Sea (~80%) and lowest in the Kattegat and Skagerrak (25-35%)

Overall, 73% reported catching 'all sizes' of cod in 2010, slightly less than in 2009. Of the remainder, somewhat more (18%) reported 'mostly large' cod than 'mostly small', a substantially higher proportion than in 2009, with the highest proportions occurring in the south and east. The proportion reporting 'mostly small' cod also increased markedly from 2009 to 2010, likely reflecting the larger 2009 year class (since the survey covers the first half of the year only), and these were highest in the Skagerrak, Kattegat, and to a lesser extent off the north-east of Scotland.

Overall, 46% of respondents reported 'no change' in the level of discarding of cod in 2010. There was a substantial increase (to almost one-third) in the proportion reporting 'less' or 'much less' discarding, and a similar decrease (to about one-quarter) in the proportion reporting 'more' or 'much more' discarding. Higher levels of discarding of cod were most commonly reported in the western and northern North Sea. In most areas (except the south-east) about one-third of respondents reported lower levels of discarding of cod.

Overall, 94% of respondents reported either 'moderate' or 'high' levels of recruitment of cod in 2010, with the proportion reporting 'moderate' levels substantially higher than in 2009 but with a similar decline in the proportion reporting 'high' levels.

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
IIIa (Skagerrak)	3.3	2.9	3.2	4.1	4.8	3.8
IIa + IV	23.2	20.0	22.2	28.8	33.6	26.8
VIId				1.7	2.0	1.6

There was no TAC for cod set for Division VIId alone until 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 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 and 2011, Council Regulations (EC) N°53/2010 and N°57/2011 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.

Fisheries in Division IIIa (Skagerrak–Kattegat), in Subarea IV (North Sea), and in Division VIId (Eastern Channel) should in 2011 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.

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 is currently conducting a historical evaluation of these plans in the first semester of 2011 (ICES-WKROUNDMP, 2011), with a possible view to developing a new plan if the evaluation points to such a need.

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.

Article 8: Procedure for setting TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel

1. Each year, the Council shall decide on the TACs for the cod stock in the North Sea, the Skagerrak and the eastern Channel. The TACs shall be calculated by applying the reduction rules set out in Article 7 paragraph 1(a) and (b).

2. The TACs shall initially be calculated in accordance with paragraphs 3 and 5. From the year where the TACs resulting from the application of paragraphs 3 and 5 would be lower than the TACs resulting from the application of paragraphs 4 and 5, the TACs shall be calculated according to the paragraphs 4 and 5.

3. Initially, the TACs shall not exceed a level corresponding to a fishing mortality which is a fraction of the estimate of fishing mortality on appropriate age groups in 2008 as follows: 75 % for the TACs in 2009, 65 % for the TACs in 2010, and applying successive decrements of 10 % for the following years.

4. Subsequently, if the size of the stock on 1 January of the year prior to the year of application of the TACs is:

(a) above the precautionary spawning biomass level, the TACs shall correspond to a fishing mortality rate of 0,4 on appropriate age groups;

*(b) between the minimum spawning biomass level and the precautionary spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate on appropriate age groups equal to the following formula: 0,4 – (0,2 * (Precautionary spawning biomass level – spawning biomass) / (Precautionary spawning biomass level – minimum spawning biomass level))*

(c) at or below the limit spawning biomass level, the TACs shall not exceed a level corresponding to a fishing mortality rate of 0,2 on appropriate age groups.

5. Notwithstanding paragraphs 3 and 4, the Council shall not set the TACs for 2010 and subsequent years at a level that is more than 20 % below or above the TACs established in the previous year.

6. Where the cod stock referred to in paragraph 1 has been exploited at a fishing mortality rate close to 0,4 during three successive years, the Commission shall evaluate the application of this Article and, where appropriate, propose relevant measures to amend it in order to ensure exploitation at maximum sustainable yield.

Article 9: Procedure for setting TACs in poor data conditions

Where, due to lack of sufficiently accurate and representative information, STECF is not able to give advice allowing the Council to set the TACs in accordance with Articles 7 or 8, the Council shall decide as follows:

(a) where STECF advises that the catches of cod should be reduced to the lowest possible level, the TACs shall be set according to a 25 % reduction compared to the TAC in the previous year;

(b) in all other cases the TACs shall be set according to a 15 % reduction compared to the TAC in the previous year, unless STECF advises that this is not appropriate.

Article 10: Adaptation of measures

1. When the target fishing mortality rate in Article 5(2) has been reached or in the event that STECF advises that this target, or the minimum and precautionary spawning biomass levels in Article 6 or the levels of fishing mortality rates given in Article 7(2) are no longer appropriate in order to maintain a low risk of stock depletion and a maximum sustainable yield, the Council shall decide on new values for these levels.

2. In the event that STECF advises that any of the cod stocks is failing to recover properly, the Council shall take a decision which:

(a) sets the TAC for the relevant stock at a level lower than that provided for in Articles 7, 8 and 9;

(b) sets the maximum allowable fishing effort at a level lower than that provided for in Article 12;

(c) establishes associated conditions as appropriate.

14.2 Data available

14.2.1 Catch

Landings data from human consumption fisheries for recent years as officially reported to ICES together with those estimated by the WG are given for each area separately and combined in Table 14.1.

The Netherlands, France, Belgium and Sweden, who respectively landed 8%, 7%, 2% and 1% by weight of all cod for combined area IV and VIId in 2010, do not provide discard estimates for this combined area. Similarly, the Netherlands and Belgium, who landed 1% or less of all cod in area IIIa, do not provide discard estimates for this area. Norwegian discarding is illegal, so although this nation landed in 2010 14% and 2% by weight of all cod in combined area IV and VIId, and area IIIa respectively, it does not provide discard estimates.

The landings estimate for 2010 is 37.2 thousand tonnes, split as follows for the separate areas (thousand tonnes):

<table>
<tr><th></th><th>Landings</th><th>TAC</th><th>Discards</th></tr>
<tr><td>IIIa-Skagerrak</td><td>4.1</td><td>4.8</td><td>1.8</td></tr>
<tr><td>IV</td><td>31.3</td><td>33.6</td><td rowspan="2">8.2</td></tr>
<tr><td>VIId</td><td>1.8</td><td>2.0</td></tr>
<tr><td>Total</td><td>37.2</td><td>40.3</td><td>10.0</td></tr>
</table>

*A separate TAC for Division VIId was provided for the first time in 2009.

WG estimates of discards are also shown in the above table.

Discard numbers-at-age were 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. Although in some cases other nations' discard proportions are available for a range of years, these are either unsuitable for use in the overall raising procedure or have not been transmitted to the relevant WG data coordinator in an appropriate form for inclusion in the international dataset. 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 are 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 substantially increasing the pressure on the fleet.

The Danish Fisheries Directorate expresses the view that there is no indication of 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 reposts of landed cod, and a calculation of the difference between the total quantity of cod registered in the logbooks and the 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 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 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 2010 was 212 tonnes (Table 2.1.3##).

Age compositions

Age compositions were provided by Denmark, England, Germany, the Netherlands, Norway, Scotland and Sweden (see Section 1.2.4##).

Landings in numbers at age for age groups 1-11+ and 1963-2010 are given in Table 14.2a. SOP values are shown. 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 79% of the international landings in number were accounted for by juvenile cod aged 1-3; this averages rises to 92% when considering landings and discards combined. In 2010, age 1 cod comprised 33% of the total catch by number, age 2, 38% and age 3, 18%.

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 1-3, in Figure 14.1c. Estimated total numbers 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 56% in 2010. 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. During the last five years, it is estimated to be above 90%. At ages 2 to 4 discard proportions increased to a maximum around 2007-9, but have subsequently declined to 57% at age 2, 21% of age 3 and 3% of 4 year old cod in 2010. 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 as a data repository only this year for North Sea cod. The use of InterCatch by data submitters has been decent, with few countries failing to upload data. The spreadsheet method employed in previous years was used for the final collation of data. InterCatch does not at the present allow data for discards and landings from the same country to be uploaded with differing temporal resolution. Several countries are able to provide quarterly landings data but will provide annual discard data only. Once this is made possible the remaining discard data can be loaded and the spreadsheet method can be tested against InterCatch outputs.

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

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. Table 14.5b shows estimates of M, based on multi species considerations adopted for the revised assessment. For 2008-10 the same natural mortalities were applied as for 2007 since no new estimates are available. WKROUND also concluded 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.

Values for maturity are given in Table 14.5a, they are applied to all years and are unchanged from those used in recent assessments. 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.

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 (areas A and B in Figure 14.3a). 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.

The cod catch rates in the NW compared with the SE demonstrate similar absolute values and similar trend over the time period 2000–2010. This is in line with the similarities observed in the densities in the Q3 survey observed in the last three years and supports the conclusion that exclusion of the survey area west of Shetland is unlikely to have caused significant bias in the survey indices given how they are currently compiled.

These findings were consistent with a study by Fernandes and Coull (WD6 in ICES-WKCOD, 2011), which examined the catch rates of cod in additional survey stations sampled as part of the Scottish August groundfish survey to the north and west of the Shetland Isles (area A in Figure 14.3a); stations outside the area usually sampled by the International Bottom Trawl Survey. Over the 3 years available for comparison catch rates in the additional areas were not significantly different from those around Shetland which were inside the area that is usually sampled by the IBTS survey (area B in Figure 14.3a). The authors concluded that the density of cod in the region was adequately represented by the existing stations contained in the IBTS cod area and so the survey indices, expressed as average catch rates, should not have been biased by the presence of cod outside the survey area.

Two survey series are available for use within this assessment:

- Quarter 1 international bottom-trawl survey (IBTS Q1): ages 1–6+, covering the period 1976–2010. 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 1991–2009. 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 include catch rates from the three most easterly rectangles of Skagerrak. WKROUND (2009) compared the standard and an extended area IBTS index for IBTS Q1 and Q3. The indices show minor changes for the ages used in the assessment (1–5 for IBTS Q1 and 1–4 for IBTS Q3) when the index is extended. The largest changes occur 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 14.3b).

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 14.3b) showed only minor differences. The extended index (i.e. the standard area extended to include green rectangles with crosses and yellow ones without in Figure 14.3b) is used for the first time in the assessment presented this year.

Maps showing the IBTS distribution of cod are presented in Figures 14.3c-d (ages 1-3+). 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 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. There is some indication of increased abundance of age 1 fish (2009 year class) in the north west and generally in the northern North Sea in 2010 (Figure 14.3c and d).

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 of 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 mortality rate 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 to 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 working group on improving use of survey data for assessment and advice. The lack of Norwegian participation in the 2009 IBTS Q3 survey also raised concerns last year (ICES-WGNSSK, 2010), with an analysis highlighting the sensitivity of the survey index to the inclusion/exclusion of the Norwegian data; the above proposed working group should also consider this aspect.

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 2010 (ICES-WGNSSK, 2010), and were satisfied that the assessment had been done as outlined in the Stock Annex. Responses to some of their comments are given below:

1. *Landings of cod ages 1-3 in 2009 is described as 69% however should it be 85% (age-1= 32% + age-2 32% + age-3 14%) (See page 11 Age compositions, 2nd paragraph)?*
   The estimates pertained to landings, so they were correct as written. The revised estimate given by the RG pertained to total catch.
2. *Table 14.8 should include a column for year as well column headings for ages.*
   The Table (14.6 this year) is in standard format, and the year and age descriptors are given in the headings.
3. *A detailed map of the stock areas and fishing banks (Dogger Bank, German-Bights, Moray Firth), should be included in the Annex.*
   A suitable map should be available in due course.
4. *Revised natural mortality estimates from updated seal stomach sampling results should be included in the next assessment.*
   WGSAM did not perform a key-run during 2010, so no new estimates are available to the assessment.
5. *Causes for the divergent behaviour of residual patterns seen in the IBTS Q1 and Q3 indices should be examined prior to the next assessment.*
   These have been explored by WKCOD (ICES-WKCOD, 2011) and reported in Section 14.2.

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 – Both time series estimated in SURBA indicate that 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 that it has subsequently increased again because of the stronger 2005 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 – In all SURBA model fits, there is a high level of uncertainty in the model estimates, and trends in mean Z cannot be determined with any confidence.

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 and 2011 data from the IBTS Q1 indicate that the 2009 year class may be the same level as the 2005 year class.

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 is not being 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

Assessment models considered during the February 2011 North Sea cod inter-benchmark workshop were: SURBA, B-Adapt, TSA and SAM. A description of these models can be found in the WKCOD report and associated working documents (ICES-WKCOD, 2011).

SURBA (presented in Section 14.3.2) does not use catch data at all, with results based on survey indices. As a consequence, it can only provide estimates of total mortality Z and cannot separate natural and fishing mortality. Estimates of population abundance are on a relative rather than on an absolute scale, given that survey catchabilities are unknown.

The other three models use both catch and survey data. Several configurations were explored for all of them, but the main ones in all cases were based on the assumption that the catch data from 1993 are uncertain, particularly with regards to total amount caught (in weight). B-Adapt and SAM both estimate an annual multiplicative factor for the catch-at-age data from 1993, which is assumed to be the same for all ages but different between years, whereas TSA does not use catch data at all from 1993.

Methodologically, B-Adapt is an extension of Adapt, the main feature being the estimation of the abovementioned catch multiplicative factors. Therefore, B-Adapt is based on the VPA principle and treats the catch-at-age data as exact (except for the annual multiplicative factors from 1993, which are unknown parameters). Survey indices-at-age are treated as observations and linked to underlying model abundances via log-Normal distributions. Smoothing penalties on the interannual variability of either total annual catch in weight or on F-at-age are used to help stabilize results.

TSA and SAM can be both viewed as state-space models. 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. TSA applies this equation deterministically. SAM, on the other hand, 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 considered at the workshop, because part of the interannual changes estimated along cohorts are deemed to arise from "other sources of variability" instead of from changes in F.

Both TSA and SAM put 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. TSA models log [F(y,a)] using a similar, but more complex structure, incorporating persistent and transitory variability components and, like SAM, correlation between the ages.

Both TSA and SAM have 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, as already indicated, in order to deal with the uncertain overall catch levels from 1993, SAM estimates annual catch multipliers from 1993 (as B-Adapt does), whereas TSA completely ignores the catch data from 1993.

SURBA was considered as an exploratory rather than a full assessment tool. Of the other three models, the general approach followed by TSA or SAM was considered more appropriate than the VPA approach on which B-Adapt is based because the additional variability/uncertainty considered in various components of TSA or 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 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 highly uncertain, whereas TSA does not use any aspect of the catch data during those years, potentially missing a relevant source of information. Balancing all these considerations, the conclusion was reached that SAM was the most appropriate modelling approach for the North Sea cod stock assessment at this time.

Figure 14.9 compares B-Adapt (the model used for the final assessment in 2010) with SAM, both models using the latest data available for the assessment (but using IBTS Q1 as the only source of survey data) and showing general agreement in population trends.

Once the decision to use SAM was reached, several model configurations were considered and compared. Only the IBTS Q1 survey was finally 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.

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 over-estimate 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 age 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, 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 and 2008 year classes are estimated to be weak, and there is some indication (Figures 14.3c and 14.6) that the 2010 year class may also be weak.

Fishing mortality increased until the early 1980's remained high until 2000 after which it has declined.

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 abundance 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, and is expected to continue to increase on the short-term because the 2009 year class is around the level of the 2005 year class and does not appear to have been discarded to the same extent that earlier larger year classes (e.g. the 1996, 1999 and 2005 year classes) have been at age 1 (Figure 14.7).

The North Sea Fishers' Survey (Figure 14.15) indicates that perceptions of cod abundance in recent years has been of a general increase throughout the North Sea, which is 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 (S-R) 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.

Three sets of forecasts are presented, each differing by the assumption made about fishing mortality in 2011, the intermediate year. The first set (Basis A) assumes that F in 2011 follows the management plan, so it assumes there has been a 15% cut in effort (compare effort allocations in Council Regulations (EC) N°53/2010 and N°57/2011) so that Fbar (2011) = 0.85×Fbar (2010). The second set (Basis B) assumes that the management plan is not followed in the intermediate year so that there is no cut in effort and Fbar (2011) = Fbar (2010). The third set (Basis C) assumes that the TAC is adhered to in terms of landings in 2011, and an Fbar (2011) = 0.41 will result in this criterion being met. Eight scenarios are considered for each set, with an additional scenario added for the third set, as follows:

1. MSY framework: Fbar (2012) = F_{MSY}×SSB_{2012}/$B_{trigger}$
2. MSY transition rule: Fbar (2012) = min{0.6×Fbar (2010) + 0.4×(F_{MSY}×SSB_{2012}/$B_{trigger}$); F_{pa}}, where $B_{trigger}$=B_{pa}
3. Management plan: Fbar (2012) = 0.45×Fbar (2008); ensure TAC (2012) is within 20% of TAC (2011)
4. Zero catch: Fbar (2012) = 0
5. Status quo: Fbar (2012) = Fbar (2011)
6. MSY: Fbar (2012) = F_{MSY}
7. Upper TAC constraint: Fbar (2012) such that TAC (2012) = 1.2×TAC (2011)
8. Lower TAC constraint: Fbar (2012) such that TAC (2012) = 0.8×TAC (2011)
9. B_{pa} in one year: Fbar (2012) such that SSB_{2013} = B_{pa} (Basis C only)

Forecasts for these three sets (Basis A-C) and associated scenarios are given in Table 14.12.

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:

	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
$\mathbf{F}_{max}$	0.19	0.62	3.36
$\mathbf{F}_{0.1}$	0.13	0.59	4.73
$\mathbf{F}_{med}$	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 (see Section 14.10).

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 onwards, 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. While discarding data are available from The Netherlands, because of the patchiness of cod bycatches by the Dutch fleet and low observer coverage on these trips, these estimates are not very meaningful. Hence Dutch discard data are not used in the assessment.

Historical SSB trends for the current SAM assessment are similar to those resulting from the previous B-Adapt assessment (Figure 14.14); recent increases are estimated to be less than before as a consequence of lower catch multipliers in recent years; the stock is still well below B_{pa}. Fishing mortality is declining rather than increasing sharply and is still well above the target.

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: 89%, 72% and 56%, respectively. Hence, unsurprisingly, the age 1 catch residuals are very large in some years and this could provide an explanation for the difference with B-Adapt recruitment estimates, given that B-Adapt follows exactly the catch data (except that there are annual catch multipliers estimated from

1993). The large age 1 catch residuals obtained with SAM are a further indication of the need to re-evaluate discards estimates or to examine the possibility of accounting for landings and discards separately in future developments of the assessment model.

Additionally, the fact that the CVs of the observed age 1 catch and survey index and the stock–recruitment relationship are all so large suggests 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 0.11) 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 (0.84) 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). Although the SAM model structure agreed at the workshop is considered the most appropriate that could be fitted in the time available, a refined model structure will only be completed with further work. In the medium term 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. WKCOD recommended that the reference points are not revised in the short term until the assessment model has been finalised.

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 used in the assessment, 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; WKCOD has recommended that a working group on improving the use of survey data for assessment and advice be established for this purpose (ICES-WKCOD, 2011).

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 have not been updated this year; they are smoothed annual model estimates from a multi-species VPA fitted by the Multi-species WG in 2007. The maturity 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, but remains below 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, but is estimated to be well above the level that achieves the long-term objective of maximum yield, and is just above F_{pa}.

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. 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). There are indications from the IBTS Q1 index that the 2010 year class is weak.

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 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 have been considerable problems with the effectiveness of the cod recovery plans; a joint ICES-STECF meeting to be held in the first half of 2011 will be looking into this matter. 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 third of the total fishing mortality, 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).

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 2005–2010 fluctuated between 35% and 59% 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 2010, the proportion of fish discarded by number continued to decline to 91% of 1 year old, 57% of 2 year old, 21% of 3 year old and 3% 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 class 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).

Several nations who make substantial landings of cod do not supply the WG with estimates of discards, despite the requirement to do so according to EU data collection regulations. In order to improve the quality of the assessment, and hence management advice, those nations with informative data on cod discarding should be encouraged to supply these data.

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 Eliminator Trawl, should be encouraged. .

The reported landings in 2010 were 37.2 thousand tonnes and the estimated discards in 2010 were 10.0 thousand tonnes, giving a total of 47.2 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 inline 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. 2010. North Sea Whitefish Survey: 2010. Fisheries Science Partnership 2010/11: 38pp. [Accessed online, 17/05/2011: http://www.cefas.defra.gov.uk/media/444125/nsw%202010%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. and D.J. Peach. 2011. NE cod survey: 2003-2011, Final Report. Fisheries Science Partnership 2010/11: 47pp [Accessed online, 17/05/2011: http://www.cefas.defra.gov.uk/media/446164/fsp201011necodfinal.pdf]

ICES-IBTSWG. 2009. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 30 March-3 April 2009, Bergen, Norway. ICES CM 2009/RMC:04. 241 pp.

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. 2008. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 21-25 April 2008, Tórshavn, Faroe Islands. ICES CM 2008/FTC:02. 265 pp.

ICES-WGFTFB. 2009. Report of the ICES - FAO Working Group on Fishing Technology & Fish Behaviour (WGFTFB), 18-22 May 2009, Ancona, Italy. ICES CM 2009/FTC:06. 252 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. 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, ICES Copenhagen, and September 2008, by correspondence. ICES CM 2008\ACOM:09: 912pp.

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-WGSAM. 2008. Report of the Working Group on Multi Species Assessment Methods (WGSAM). ICES. CM. 2008/ RMC:06.

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 evalua-tions for roundfish stocks (WKROUNDMP/EWG 11-01), 28 February - 4 March 2011, ICES Headquarters, Copenhagen. . 67 pp.

Large, P., Brown, M., South, A., Robinson, P. and Hale, N. 2009. Programme 18: North Sea Codwatch. Fisheries Science Partnership 2007/09 Final Report. 37 pp. [Accessed online, 10/05/2010: http://www.cefas.co.uk/media/135494/codwatch%20contract%20final%20reportsept18.pdf]

Lewy., P and Vinther, M., 2004. A stochastic age-length-structured multispecies model applied to North Sea stocks. ICES CM 2004/ FF:20.

Napier, I. R. 2010. Fishers' North Sea stock survey 2010. NAFC Marine Centre, Shetland, Scotland: 120pp. [Accessed online, 17/05/2011: www.nsss.eu]

Needle, C. L. and Catarino, R. 2011. Evaluating the effect of real-time closures on cod targeting. ICES Journal of Marine Science, in press.

Vinther, M., P. Lewy and L. Thomsen, 2002: Specification and documentation of the 4M package containing multi-species, multi-fleet and multi-area models. The Danish Institute for Fisheries and Marine Research, Report. 62 pp.

Table 14.1 Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1991-2010 as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	2,331	3,356	3,374	2,648	4,827	3,458	4,642	5,799	3,882	3,304
Denmark	18,997	18,479	19,547	19,243	24,067	23,573	21,870	23,002	19,697	14,000
Faroe Islands	23	109	46	80	219	44	40	102	96	.
France	975	2,146	1,868	1,868	3,040	1,934	3,451	2,934	.	1,222
Germany	7,278	8,446	6,800	5,974	9,457	8,344	5,179	8,045	3,386	1,740
Greenland	-	-	-	-	-	-	-	-	-	-
Netherlands	6,831	11,133	10,220	6,512	11,199	9,271	11,807	14,676	9,068	5,995
Norway	6,022	10,476	8,742	7,707	7,111	5,869	5,814	5,823	7,432	6,410
Poland	15	-	-	-	-	18	31	25	19	18
Sweden	784	823	646	630	709	617	832	540	625	640
UK (E/W/NI)	14,249	14,462	14,940	13,941	14,991	15,930	13,413	17,745	10,344	6,543
UK (Scotland)	29,060	28,677	28,197	28,854	35,848	35,349	32,344	35,633	23,017	21,009
Total Nominal Catch	86,565	98,107	94,380	87,457	111,468	104,407	99,423	114,324	77,566	60,881
Unallocated landings	1,968	-758	10,200	7,066	8,555	2,161	2,746	7,779	826	-1,114
WG estimate of total landings	**88,533**	**97,349**	**104,580**	**94,523**	**120,023**	**106,568**	**102,169**	**122,103**	**78,392**	**59,767**
Agreed TAC	**100,000**	**100,000**	**101,000**	**102,000**	**120,000**	**130,000**	**115,000**	**140,000**	**132,400**	**81,000**

Division VIId

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	182	187	157	228	377	321	310	239	172	110
Denmark	-	1	-	9	-	-	-	-	-	-
France	.	2,079	1,771	2,338	3,261	2,808	6,387	7,788	.	3,084
Netherlands	-	2	-	-	-	-	-	19	3	4
UK (E/W/NI)	341	443	530	312	336	414	478	618	454	385
UK (Scotland)	2	22	2	<0.5	<0.5	4	3	1	-	-
Total Nominal Catch	525	2,734	2,460	2,887	3,974	3,547	7,178	8,665	629	3,583
Unallocated landings	1,361	-65	-28	-37	-10	-44	-135	-85	6,229	-1,258
WG estimate of total landings	**1,886**	**2,669**	**2,432**	**2,850**	**3,964**	**3,503**	**7,043**	**8,580**	**6,858**	**2,325**

Division IIIa (Skagerrak)**

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Denmark	10,294	11,187	11,994	11,921	15,888	14,573	12,159	12,339	8,682	7,656
Germany	3	-	530	399	285	259	81	54	54	54
Norway	924	1,208	1,043	850	1,039	1,046	1,323	1,293	1,146	926
Sweden	3,846	2,523	2,575	1,834	2,483	1,986	2,173	1,900	1,909	1,293
Others	38	102	88	71	134	-	-	-	-	-
Norwegian coast *	854	923	909	760	846	748	911	976	788	624
Danish industrial by-catch *	953	1,360	511	666	749	676	205	97	62	99
Total Nominal Catch	15,105	15,020	16,230	15,075	19,829	17,864	15,736	15,586	11,791	9,929
Unallocated landings	-3,046	-1,018	-1,493	-1,814	-7,720	-1,615	-790	-255	-817	-652
WG estimate of total landings	**12,059**	**14,002**	**14,737**	**13,261**	**12,109**	**16,249**	**14,946**	**15,331**	**10,974**	**9,277**
Agreed TAC	**15,000**	**15,000**	**15,000**	**15,500**	**20,000**	**23,000**	**16,100**	**20,000**	**19,000**	**11,600**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Nominal Catch	102,195	115,861	113,070	105,419	135,271	125,818	122,337	138,575	89,986	74,393
Unallocated landings	283	-1,841	8,679	5,215	825	502	1,821	7,439	6,239	-3,024
WG estimate of total landings	**102,478**	**114,020**	**121,749**	**110,634**	**136,096**	**126,320**	**124,158**	**146,014**	**96,225**	**71,369**

** 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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Norwegian coast *	854	923	909	760	846	748	911	976	788	624
Danish industrial by-catch *	953	1,360	511	666	749	676	205	97	62	99
Total	**1,807**	**2,283**	**1,420**	**1,426**	**1,595**	**1,424**	**1,116**	**1,073**	**850**	**723**

Table 14.1 cont. Nominal landings (in tons) of COD in IIIa (Skagerrak), IV and VIId, 1991-2009 as officially reported to ICES, and as used by the Working Group.

Sub-area IV

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	2,470	2,616	1,482	1,627	1,722	1,309	1,009	894	946	666
Denmark	8,358	9,022	4,676	5,889	6,291	5,105	3,430	3,831	4,402	5,686
Faroe Islands	9	34	36	37	34	3	-	16	45	32
France	717	1,777	620	294	664	354	659	573	928	775
Germany	1,810	2,018	2,048	2,213	2,648	2,537	1,899	1,736	2,374	2,844
Greenland	-	-	-	-	35	23	17	17	11	.
Netherlands	3,574	4,707	2,305	1,726	1,660	1,585	1,523	1,896	2,649	2,656
Norway	4,369	5,217	4,417	3,223	2,900	2,749	3,057	4,128	4,234	4,483
Poland	18	39	35	-	-	-	1	2	3	.
Sweden	661	463	252	240	319	309	387	439	378	362
UK (E/W/NI)	4,087	3,112	2,213	1,890	1,270	1,491	1,587	1,546	2,384	
UK (Scotland)	15,640	15,416	7,852	6,650	4,936	6,857	6,511	7,185	9,052	
UK (combined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	14,112
Others	-	-	-	-	-	786	.	.	.	.
Norwegian indust by-catch *	.	.	.	.	.	48	101	22	4	201
Danish industrial by-catch *	.	.	.	.	.	34	18	46	76	11
Total Nominal Catch	41,713	44,421	25,936	23,789	22,479	23,108	20,080	22,263	27,406	31,616
Unallocated landings	-740	-121	-89	-240	1,391	-1,012	-336	-68	-1,778	-317
WG estimate of total landings	**40,973**	**44,300**	**25,847**	**23,549**	**23,870**	**22,096**	**19,744**	**22,195**	**25,628**	**31,300**
Agreed TAC	**48,600**	**49,300**	**27,300**	**27,300**	**27,300**	**23,205**	**19,957**	**22,152**	**28,798**	**33,552**

Division VIId

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	93	51	54	47	51	80	84	154	73	57
Denmark	-	-	-	-	-	-	.	.	.	.
France	1,677	1,361	1,730	810	986	1,124	1,743	1,326	1,761	1,565
Netherlands	17	6	36	14	9	9	59	30	35	43
UK (E/W/NI)	249	145	121	103	184	267	175	144	134	
UK (Scotland)	-	-	-	-	-	1	12	7	3	
UK (conbined)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	127
Total Nominal Catch	2,036	1,563	1,941	974	1,230	1,481	2,073	1,661	2,006	1,792
Unallocated landings	-463	1,534	-707	-167	-197	-353	-331	-307	-759	0
WG estimate of total landings	**1,573**	**3,097**	**1,234**	**807**	**1,033**	**1,128**	**1,742**	**1,354**	**1,247**	**1,792**
Agreed TAC									**1,678**	**1,955**

Division IIIa (Skagerrak)**

Country	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	5,870	5,511	3,054	3,009	2,984	2,478	2,228	2,552	3,023	3,289
Germany	32	83	49	99	86	84	67	52	55	56
Norway	762	645	825	856	759	628	681	779	440	434
Sweden	1,035	897	510	495	488	372	370	365	459	458
Others	-	-	27	24	21	373	385	13	2	26
Norwegian coast *	846	.	.	720	759	524	494	498	342	369
Danish industrial by-catch *	687	.	.	10	18	9	.	-	1	0
Total Nominal Catch	7,699	7,136	4,465	4,483	4,338	3,935	3,731	3,761	3,979	4,263
Unallocated landings	-613	332	-674	-696	-533	-569	-784	-463	-101	-175
WG estimate of total landings	**7,086**	**7,468**	**3,791**	**3,787**	**3,805**	**3,366**	**2,947**	**3,298**	**3,878**	**4,089**
Agreed TAC	**7,000**	**7,100**	**3,900**	**3,900**	**3,900**	**3,315**	**2,851**	**3,165**	**4,114**	**4,793**

Sub-area IV, Divisions VIId and IIIa (Skagerrak) combined

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Nominal Catch	51,448	53,120	32,342	29,246	28,047	28,524	25,884	27,685	33,391	37,672
Unallocated landings	-1,816	1,745	-1,470	-1,103	661	-1,934	-1,451	-838	-2,638	-492
WG estimate of total landings	**49,632**	**54,865**	**30,872**	**28,143**	**28,708**	**26,590**	**24,433**	**26,847**	**30,753**	**37,180**

** 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	2001	2002	2002	2004	2003	2006	2007	2008	2009	2010
Norwegian coast *	846	.	.	720	759	524	494	498	342	369
Norwegian indust by-catch *	.	.	.	.	.	48	101	22	4	201
Danish industrial by-catch *	687	.	.	10	18	43	18	46	77	11
Total	**1,533**	**.**	**.**	**730**	**777**	**615**	**613**	**566**	**423**	**582**

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
1	1241	556	620	904
2	6852	3400	4403	5175
3	2443	4293	2763	4450
4	1532	1064	2693	1567
5	307	697	547	1281
6	114	170	245	238
7	39	70	52	87
8	36	30	29	19
9	6	21	20	9
10	1	4	7	5
+gp	0	3	2	3
TOTALNUM	12573	10307	11381	13737
TONSLAND	24433	26847	30753	37180
SOPCOF %	100	99	100	101

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
1	14622	8384	8600	9443
2	20183	9165	7020	6829
3	1506	7474	1435	1192
4	371	149	586	52
5	49	21	34	22
6	25	13	16	0
7	0	0	8	0
8	2	3	0	0
9	0	0	0	0
10	0	0	2	0
+gp	0	0	0	0
TOTALNUM	36757	25210	17701	17538
TONSDISC	23636	21814	14022	9982
SOPCOF %	100	100	101	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
1	15862	8940	9220	10347
2	27035	12565	11423	12004
3	3949	11767	4198	5642
4	1903	1212	3280	1618
5	356	718	581	1303
6	139	183	261	238
7	39	71	60	87
8	38	33	29	19
9	6	21	20	9
10	1	4	9	5
+gp	0	3	2	3
TOTALNUM	49330	35517	29083	31275
TONSLAND	48069	48661	44775	47163
SOPCOF %	100	100	100	101

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
1	0.805	0.801	0.717	0.803
2	1.161	1.503	1.33	1.287
3	2.376	2.511	2.671	2.712
4	4.046	4.026	4.109	4.233
5	5.523	5.777	5.996	6.06
6	8.197	7.164	7.511	7.694
7	8.986	9.358	8.152	9.235
8	9.777	10.909	10.291	10.312
9	12.358	11.596	9.999	10.801
10	13.725	15.278	11.886	11.462
+gp	9.482	13.653	13.597	10.522

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
1	0.231	0.299	0.366	0.244
2	0.762	0.683	0.84	0.831
3	1.881	1.660	1.689	1.484
4	4.136	2.459	3.339	3.169
5	6.141	2.848	6.769	5.414
6	9.724	8.051	7.951	5.291
7	1.735	1.239	13.127	6.378
8	12.032	0.576	1.967	3.119
9	0.000	0.000	0.000	0.000
10	0.000	0.000	12.014	0.000
+gp	0.500	0.500	0.000	0.000

Table 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Catch weights at age (kg), also assumed to represent stock weights at age.

Catch weights at age (kg)

AGE/YEAI	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.314	0.357	0.313	0.314	0.326	0.328	0.416	0.449	0.313	0.300	0.335
2	0.808	0.762	0.900	0.836	0.868	0.847	0.755	0.845	0.834	0.729	0.700
3	2.647	2.367	2.295	2.437	2.395	2.215	2.127	2.028	2.188	2.080	1.912
4	4.491	4.528	4.512	4.169	3.153	4.094	3.852	4.001	4.258	3.968	3.776
5	6.794	6.447	7.274	7.027	6.803	5.341	5.715	6.131	6.528	6.011	5.488
6	9.409	8.520	9.498	9.599	9.610	8.020	6.722	7.945	8.646	8.246	7.453
7	11.562	10.606	11.898	11.766	12.033	8.581	9.262	9.953	10.356	9.766	9.019
8	11.942	10.758	12.041	11.968	12.481	10.162	9.749	10.131	11.219	10.228	9.810
9	13.383	12.340	13.053	14.060	13.589	10.720	10.384	11.919	12.881	11.875	11.077
10	13.756	12.540	14.441	14.746	14.271	12.497	12.743	12.554	13.147	12.530	12.359
+gp	0.000	18.000	15.667	15.672	19.016	11.595	11.175	14.367	15.544	14.350	12.886

AGE/YEAI	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.304	0.304	0.199	0.295	0.432	0.291	0.258	0.329	0.358	0.403	0.304
2	0.901	0.760	0.722	0.673	0.743	0.905	0.917	0.769	0.908	0.882	0.921
3	2.206	2.348	2.449	2.128	2.001	2.411	1.948	2.186	1.856	1.833	2.156
4	4.156	4.226	4.577	4.606	4.146	4.423	4.401	4.615	4.130	3.880	3.972
5	6.174	6.404	6.494	6.714	6.530	6.579	6.109	7.045	6.785	6.491	6.190
6	8.333	8.691	8.620	8.828	8.667	8.474	9.120	8.884	8.903	8.423	8.362
7	9.889	10.107	10.132	10.071	9.685	10.637	9.550	9.933	10.398	9.848	10.317
8	10.791	10.910	11.340	11.052	11.099	11.550	11.867	11.519	12.500	11.837	11.352
9	12.175	12.339	12.888	11.824	12.427	13.057	12.782	13.338	13.469	12.797	13.505
10	12.425	12.976	14.139	13.134	12.778	14.148	14.081	14.897	12.890	12.562	13.408
+gp	13.731	14.431	14.760	14.362	13.981	15.478	15.392	18.784	14.608	14.426	13.472

AGE/YEAI	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
1	0.314	0.293	0.437	0.466	0.364	0.382	0.392	0.395	0.327	0.305	0.420
2	0.800	0.782	0.773	0.753	0.931	0.690	0.889	0.970	0.845	0.788	0.768
3	2.132	1.822	1.955	1.974	1.810	2.165	1.994	2.545	2.478	2.188	2.207
4	4.164	3.504	3.650	3.187	3.585	3.791	3.971	4.223	4.551	4.471	4.293
5	6.324	6.230	6.052	5.992	5.273	5.931	6.082	6.247	6.540	7.167	7.220
6	8.430	8.140	8.307	7.914	7.921	7.890	8.033	8.483	8.094	8.436	8.980
7	10.362	9.896	10.243	9.764	9.724	10.235	9.545	10.101	9.641	9.537	10.282
8	12.074	11.940	11.461	12.127	11.212	10.923	10.948	10.482	10.734	10.323	11.743
9	13.072	12.951	12.447	14.242	12.586	12.803	13.481	11.849	12.329	12.223	13.107
10	14.443	13.859	18.691	17.787	15.557	15.525	13.171	13.904	13.443	14.247	12.052
+gp	16.588	14.707	16.604	16.477	14.695	23.234	14.989	15.794	13.961	12.523	13.954

AGE/YEAI	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	0.433	0.386	0.372	0.317	0.354	0.372	0.456	0.275	0.341	0.348	0.217
2	0.831	0.797	0.633	0.732	0.903	0.605	0.916	0.752	0.671	0.895	0.771
3	2.095	2.117	1.622	1.405	1.747	2.093	1.712	1.533	1.713	1.945	1.972
4	4.034	3.821	3.495	3.305	3.216	3.663	3.857	3.191	3.096	3.695	3.610
5	6.637	6.228	5.387	5.726	4.903	5.871	5.372	5.113	5.172	5.055	5.590
6	8.494	8.394	7.563	7.403	7.488	7.333	7.991	7.270	7.426	7.555	6.848
7	9.729	9.979	9.628	8.582	9.636	9.264	9.627	8.630	8.675	9.607	8.911
8	11.080	11.424	10.643	10.365	10.671	10.081	10.403	12.056	9.797	11.229	10.639
9	12.264	12.300	11.499	11.600	10.894	12.062	10.963	12.846	11.684	11.501	12.216
10	12.756	12.761	13.085	12.330	11.414	12.009	12.816	10.771	13.058	13.333	9.212
+gp	11.304	13.416	14.921	11.926	15.078	10.196	11.842	17.351	14.140	15.340	10.773

AGE/YEAI	2007	2008	2009	2010
1	0.276	0.330	0.390	0.293
2	0.863	0.904	1.029	1.028
3	2.187	1.971	2.335	2.453
4	4.064	3.834	3.972	4.199
5	5.607	5.692	6.041	6.049
6	8.467	7.228	7.538	7.692
7	8.917	9.321	8.795	9.234
8	9.902	9.879	10.212	10.311
9	12.358	11.596	9.999	10.801
10	13.725	15.278	11.915	11.462
+gp	8.154	13.295	13.597	10.522

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

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	0.78	0.42	0.33	0.22	0.21	0.22	0.2
1964	0.82	0.43	0.34	0.22	0.21	0.22	0.2
1965	0.85	0.44	0.35	0.22	0.21	0.22	0.2
1966	0.87	0.45	0.36	0.22	0.21	0.22	0.2
1967	0.89	0.46	0.37	0.22	0.21	0.22	0.2
1968	0.91	0.46	0.37	0.22	0.21	0.22	0.2
1969	0.92	0.47	0.38	0.22	0.21	0.22	0.2
1970	0.92	0.47	0.38	0.22	0.21	0.22	0.2
1971	0.92	0.47	0.38	0.22	0.21	0.23	0.2
1972	0.93	0.47	0.38	0.22	0.21	0.23	0.2
1973	0.92	0.46	0.38	0.22	0.21	0.23	0.2
1974	0.92	0.46	0.37	0.22	0.21	0.23	0.2
1975	0.92	0.45	0.37	0.22	0.21	0.23	0.2
1976	0.92	0.45	0.37	0.22	0.21	0.23	0.2
1977	0.92	0.44	0.36	0.22	0.22	0.23	0.2
1978	0.92	0.43	0.36	0.23	0.22	0.23	0.2
1979	0.92	0.43	0.36	0.23	0.22	0.24	0.2
1980	0.91	0.42	0.36	0.23	0.22	0.24	0.2
1981	0.9	0.41	0.36	0.23	0.22	0.24	0.2
1982	0.89	0.41	0.36	0.23	0.22	0.24	0.2
1983	0.87	0.4	0.36	0.23	0.22	0.25	0.2
1984	0.85	0.39	0.36	0.23	0.22	0.25	0.2
1985	0.83	0.38	0.36	0.23	0.23	0.25	0.2
1986	0.81	0.38	0.36	0.23	0.23	0.26	0.2
1987	0.79	0.37	0.36	0.24	0.23	0.26	0.2
1988	0.77	0.36	0.37	0.24	0.23	0.27	0.2
1989	0.75	0.35	0.37	0.24	0.24	0.28	0.2
1990	0.73	0.35	0.38	0.24	0.24	0.28	0.2
1991	0.72	0.34	0.39	0.25	0.24	0.29	0.2
1992	0.7	0.34	0.4	0.25	0.25	0.3	0.2
1993	0.7	0.34	0.41	0.26	0.25	0.31	0.2
1994	0.69	0.33	0.42	0.26	0.25	0.31	0.2
1995	0.68	0.33	0.43	0.26	0.26	0.32	0.2
1996	0.67	0.32	0.44	0.27	0.26	0.33	0.2
1997	0.65	0.31	0.44	0.27	0.26	0.34	0.2
1998	0.63	0.31	0.45	0.27	0.27	0.34	0.2
1999	0.61	0.3	0.45	0.27	0.27	0.34	0.2
2000	0.58	0.29	0.44	0.27	0.27	0.35	0.2
2001	0.56	0.29	0.44	0.27	0.27	0.35	0.2
2002	0.53	0.28	0.43	0.27	0.27	0.35	0.2
2003	0.51	0.28	0.42	0.27	0.27	0.34	0.2
2004	0.5	0.27	0.41	0.27	0.27	0.34	0.2
2005	0.49	0.27	0.4	0.26	0.26	0.34	0.2
2006	0.47	0.27	0.39	0.26	0.26	0.33	0.2
2007	0.46	0.26	0.38	0.26	0.26	0.33	0.2
2008*	0.46	0.26	0.38	0.26	0.26	0.33	0.2
2009*	0.46	0.26	0.38	0.26	0.26	0.33	0.2
2010*	0.46	0.26	0.38	0.26	0.26	0.33	0.2

*No new keyrun was carried out in these years by WGSAM, so 2008-10 values are set equal to the 2007 values. This implicitly assumes that cannibalism is still at the same magnitude as in 2007. The next WGSAM keyrun is due sometime in 2011.

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 the extended survey. Updated 4 May 11
101
IBTS_Q1_ext, 6 is a plusgroup

1983	2011					
1	1	0	0.25			
1	5					
1	**5.696**	**17.403**	**2.997**	**2.050**	**0.793**	1.275
1	**17.107**	**9.913**	**4.375**	**0.930**	**0.995**	0.820
1	**1.096**	**20.221**	**4.562**	**3.649**	**0.768**	1.103
1	**18.112**	**3.793**	**7.787**	**2.756**	**1.368**	0.981
1	**9.626**	**33.252**	**1.845**	**2.032**	**0.659**	0.792
1	**6.990**	**7.737**	**7.960**	**0.702**	**0.865**	1.072
1	**14.953**	**6.776**	**5.877**	**2.668**	**0.412**	0.944
1	**4.606**	**15.376**	**2.141**	**1.046**	**0.965**	0.596
1	**2.688**	**5.061**	**4.757**	**1.042**	**0.551**	0.773
1	**16.439**	**4.821**	**1.364**	**1.023**	**0.312**	0.445
1	**13.619**	**20.429**	**2.400**	**0.807**	**0.693**	0.356
1	**14.856**	**4.510**	**3.015**	**0.860**	**0.486**	0.498
1	**12.798**	**27.878**	**3.461**	**1.363**	**0.306**	0.348
1	**4.384**	**9.512**	**6.368**	**0.796**	**0.663**	0.397
1	**38.005**	**7.597**	**2.670**	**1.142**	**0.455**	0.392
1	**2.951**	**27.555**	**2.309**	**1.087**	**0.552**	0.401
1	**3.304**	**1.878**	**8.104**	**0.804**	**0.452**	0.509
1	**6.626**	**5.488**	**0.877**	**2.146**	**0.433**	0.587
1	**3.378**	**9.315**	**1.887**	**0.293**	**0.409**	0.251
1	**11.465**	**4.231**	**4.528**	**0.666**	**0.143**	0.225
1	**0.756**	**4.168**	**1.301**	**1.415**	**0.480**	0.205
1	**8.370**	**2.114**	**1.525**	**0.435**	**0.556**	0.268
1	**2.721**	**3.290**	**0.953**	**0.646**	**0.234**	0.431
1	**8.551**	**2.123**	**1.462**	**0.321**	**0.179**	0.313
1	**3.666**	**8.115**	**1.371**	**0.461**	**0.331**	0.353
1	**3.661**	**2.275**	**3.094**	**0.723**	**0.464**	0.189
1	**2.168**	**3.531**	**1.178**	**0.987**	**0.333**	0.274
1	**5.843**	**4.659**	**1.889**	**0.658**	**0.537**	0.231
1	**1.093**	**7.032**	**1.940**	**0.750**	**0.417**	0.415

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
18
  # Then the actual years
1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
  # 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
# 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 = 34  Objective function value = 95.9857  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
1	logFpar	-10.40	0.13	1																																	
2	logFpar	-9.28	0.06	0.22	1																																
3	logFpar	-9.06	0.06	0.17	0.37	1																															
4	logFpar	-8.82	0.06	0.16	0.35	0.39	1																														
5	logFpar	-8.46	0.06	0.16	0.34	0.37	0.40	1																													
6	logSdLogFsta	-2.78	0.16	-0.01	-0.03	-0.05	-0.05	-0.05	1																												
7	logSdLogN	-0.65	0.12	0.02	-0.02	-0.02	-0.03	-0.03	-0.01	1																											
8	logSdLogN	-2.26	0.16	0.01	0.01	0.00	-0.02	-0.01	-0.10	0.22	1																										
9	logSdLogObs	-0.26	0.11	0.00	0.01	0.02	0.02	0.02	-0.03	-0.09	-0.09	1																									
10	logSdLogObs	-1.48	0.16	0.01	0.03	0.05	0.06	0.06	-0.04	-0.16	-0.21	0.16	1																								
11	logSdLogObs	-2.47	0.15	-0.01	-0.02	-0.01	0.00	0.00	-0.06	-0.14	-0.63	0.05	0.08	1																							
12	logSdLogObs	-0.47	0.14	0.00	0.06	0.06	0.06	0.06	0.02	-0.08	-0.08	-0.01	0.02	0.05	1																						
13	logSdLogObs	-1.42	0.08	0.00	0.00	0.00	0.00	0.00	-0.02	-0.09	-0.22	0.04	0.11	0.11	0.03	1																					
14	rec_loga	1.19	0.15	-0.12	-0.06	0.00	0.01	0.02	-0.02	-0.03	0.01	0.02	0.05	-0.02	0.02	0.00	1																				
15	rec_logb	-15.48	5.33	-0.06	-0.04	0.01	0.01	0.02	-0.02	-0.02	0.03	0.02	0.05	-0.02	0.00	0.00	0.84	1																			
16	logScale	-0.04	0.08	-0.10	-0.21	-0.23	-0.23	-0.23	0.03	0.00	0.03	-0.01	-0.03	0.00	-0.03	-0.02	-0.01	-0.01	1																		
17	logScale	0.07	0.09	-0.13	-0.27	-0.29	-0.29	-0.29	0.04	0.01	-0.01	0.01	-0.01	0.01	-0.05	0.00	-0.01	-0.01	0.48	1																	
18	logScale	0.20	0.10	-0.15	-0.30	-0.32	-0.32	-0.32	0.08	0.02	0.00	0.00	0.02	-0.02	-0.06	0.00	0.00	-0.01	0.31	0.55	1																
19	logScale	0.03	0.10	-0.15	-0.32	-0.34	-0.34	-0.34	0.10	0.04	0.06	-0.03	-0.05	-0.05	-0.06	-0.04	-0.01	-0.01	0.21	0.36	0.57	1															
20	logScale	-0.07	0.10	-0.15	-0.32	-0.34	-0.34	-0.34	0.09	0.04	-0.03	-0.02	-0.05	0.02	-0.05	-0.01	0.00	-0.01	0.16	0.25	0.37	0.57	1														
21	logScale	-0.26	0.10	-0.15	-0.32	-0.34	-0.34	-0.34	0.12	0.03	-0.03	-0.02	-0.04	0.01	-0.05	-0.02	0.00	-0.01	0.13	0.19	0.26	0.38	0.58	1													
22	logScale	-0.19	0.10	-0.15	-0.31	-0.34	-0.34	-0.34	0.14	0.04	0.05	-0.04	-0.13	-0.02	-0.05	-0.07	-0.01	-0.01	0.13	0.17	0.20	0.28	0.38	0.58	1												
23	logScale	0.00	0.10	-0.15	-0.31	-0.34	-0.33	-0.33	0.11	0.02	-0.03	-0.03	-0.07	0.03	-0.03	-0.03	-0.01	-0.01	0.13	0.16	0.18	0.21	0.27	0.38	0.58	1											
24	logScale	0.40	0.10	-0.15	-0.31	-0.33	-0.33	-0.32	0.04	0.01	-0.05	-0.02	-0.02	0.03	-0.03	0.02	0.00	-0.01	0.13	0.16	0.17	0.18	0.21	0.26	0.36	0.56	1										
25	logScale	0.23	0.10	-0.15	-0.31	-0.33	-0.33	-0.33	0.02	0.05	-0.03	-0.03	-0.14	0.07	-0.04	-0.01	0.00	-0.01	0.13	0.16	0.17	0.18	0.20	0.21	0.27	0.38	0.57	1									
26	logScale	0.64	0.10	-0.15	-0.31	-0.33	-0.32	-0.32	0.03	0.02	-0.01	0.00	0.00	0.00	-0.06	0.00	0.01	0.00	0.13	0.17	0.19	0.19	0.19	0.19	0.20	0.26	0.37	0.56	1								
27	logScale	0.31	0.10	-0.15	-0.31	-0.33	-0.33	-0.32	-0.01	0.01	-0.01	-0.02	-0.07	0.02	-0.06	0.04	0.00	0.00	0.13	0.17	0.18	0.19	0.19	0.18	0.18	0.20	0.26	0.38	0.57	1							
28	logScale	0.35	0.10	-0.15	-0.31	-0.32	-0.32	-0.32	-0.06	-0.01	-0.03	-0.01	-0.05	0.04	-0.07	0.08	0.00	-0.01	0.13	0.17	0.18	0.18	0.19	0.18	0.17	0.18	0.21	0.27	0.37	0.58	1						
29	logScale	0.32	0.10	-0.15	-0.30	-0.32	-0.31	-0.31	-0.13	-0.01	-0.06	0.00	-0.02	0.05	-0.08	0.12	0.00	0.00	0.13	0.17	0.18	0.18	0.19	0.17	0.16	0.16	0.19	0.21	0.26	0.39	0.59	1					
30	logScale	0.40	0.10	-0.15	-0.31	-0.31	-0.31	-0.31	-0.12	0.02	-0.01	0.00	-0.02	0.02	-0.08	0.08	0.01	0.00	0.13	0.17	0.18	0.18	0.19	0.18	0.17	0.17	0.18	0.18	0.21	0.28	0.40	0.60	1				
31	logScale	0.22	0.10	-0.15	-0.31	-0.31	-0.31	-0.31	-0.07	0.05	0.11	-0.03	-0.06	-0.07	-0.09	0.01	0.01	0.01	0.13	0.17	0.18	0.20	0.19	0.19	0.19	0.17	0.17	0.18	0.18	0.22	0.29	0.41	0.60	1			
32	logScale	0.25	0.10	-0.15	-0.31	-0.32	-0.31	-0.31	-0.03	0.03	0.05	-0.03	-0.09	-0.02	-0.07	0.02	0.02	0.01	0.13	0.17	0.18	0.20	0.20	0.19	0.20	0.19	0.18	0.19	0.18	0.20	0.23	0.30	0.42	0.61	1		
33	logScale	0.26	0.10	-0.15	-0.30	-0.31	-0.32	-0.32	0.01	0.03	0.02	-0.04	-0.09	0.01	-0.04	0.00	0.02	0.01	0.13	0.17	0.18	0.20	0.20	0.20	0.20	0.19	0.18	0.19	0.17	0.18	0.19	0.22	0.29	0.41	0.60	1	
34	rho	0.83	0.11	0.00	0.02	0.04	0.02	0.01	0.25	-0.03	0.11	0.10	0.25	0.02	-0.02	-0.04	0.03	0.05	0.01	0.01	0.03	0.02	-0.02	0.00	-0.02	-0.03	-0.06	-0.08	-0.03	-0.07	-0.09	-0.13	-0.10	-0.07	-0.07	-0.05	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	0.185	0.517	0.500	0.468	0.447	0.471	0.471	0.495
1964	0.194	0.540	0.531	0.491	0.471	0.491	0.491	0.521
1965	0.203	0.567	0.563	0.516	0.493	0.508	0.508	0.549
1966	0.210	0.588	0.584	0.529	0.509	0.523	0.523	0.567
1967	0.227	0.636	0.630	0.567	0.551	0.562	0.562	0.611
1968	0.237	0.669	0.658	0.594	0.576	0.581	0.581	0.640
1969	0.235	0.666	0.648	0.584	0.569	0.570	0.570	0.633
1970	0.240	0.687	0.663	0.592	0.578	0.570	0.570	0.647
1971	0.262	0.759	0.722	0.643	0.625	0.617	0.617	0.708
1972	0.285	0.832	0.780	0.692	0.670	0.670	0.670	0.768
1973	0.281	0.826	0.763	0.677	0.653	0.652	0.652	0.755
1974	0.279	0.822	0.748	0.661	0.641	0.642	0.642	0.744
1975	0.291	0.862	0.781	0.685	0.665	0.665	0.665	0.776
1976	0.302	0.898	0.813	0.703	0.683	0.682	0.682	0.805
1977	0.302	0.898	0.817	0.695	0.684	0.680	0.680	0.803
1978	0.322	0.949	0.880	0.740	0.732	0.716	0.716	0.856
1979	0.305	0.888	0.843	0.702	0.687	0.670	0.670	0.811
1980	0.324	0.935	0.903	0.751	0.720	0.713	0.713	0.863
1981	0.334	0.959	0.938	0.782	0.734	0.738	0.738	0.893
1982	0.365	1.039	1.031	0.862	0.797	0.811	0.811	0.977
1983	0.361	1.024	1.016	0.860	0.786	0.803	0.803	0.967
1984	0.343	0.968	0.955	0.820	0.745	0.765	0.765	0.914
1985	0.332	0.937	0.918	0.801	0.721	0.744	0.744	0.885
1986	0.347	0.975	0.957	0.849	0.756	0.785	0.785	0.927
1987	0.348	0.975	0.954	0.858	0.756	0.792	0.792	0.929
1988	0.349	0.973	0.960	0.867	0.763	0.793	0.793	0.933
1989	0.354	0.984	0.969	0.886	0.780	0.808	0.808	0.946
1990	0.334	0.928	0.908	0.839	0.740	0.763	0.763	0.892
1991	0.336	0.925	0.907	0.848	0.751	0.781	0.781	0.893
1992	0.326	0.890	0.878	0.829	0.735	0.761	0.761	0.866
1993	0.330	0.893	0.894	0.843	0.750	0.774	0.774	0.877
1994	0.333	0.892	0.911	0.856	0.764	0.786	0.786	0.886
1995	0.342	0.909	0.944	0.882	0.794	0.809	0.809	0.912
1996	0.351	0.921	0.971	0.909	0.830	0.847	0.847	0.934
1997	0.356	0.918	0.983	0.931	0.855	0.863	0.863	0.944
1998	0.364	0.926	1.005	0.963	0.892	0.883	0.883	0.965
1999	0.372	0.928	1.023	0.990	0.922	0.914	0.914	0.980
2000	0.373	0.922	1.014	1.003	0.941	0.917	0.917	0.980
2001	0.363	0.892	0.975	0.980	0.922	0.899	0.899	0.949
2002	0.355	0.863	0.946	0.958	0.901	0.883	0.883	0.922
2003	0.347	0.842	0.918	0.933	0.878	0.860	0.860	0.898
2004	0.332	0.802	0.874	0.892	0.832	0.830	0.830	0.856
2005	0.315	0.759	0.824	0.839	0.791	0.793	0.793	0.807
2006	0.295	0.710	0.773	0.775	0.740	0.744	0.744	0.753
2007	0.282	0.679	0.745	0.736	0.706	0.711	0.711	0.720
2008	0.275	0.661	0.728	0.707	0.692	0.703	0.703	0.699
2009	0.270	0.646	0.711	0.693	0.680	0.695	0.695	0.683
2010	0.267	0.638	0.705	0.686	0.675	0.688	0.688	0.676

Table 14.9 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM base run estimated population numbers at age.

Stock numbers at age (start of year) (thousands)

Year\Age	1	2	3	4	5	6	7+	Total
1963	285501	153737	23110	10615	8800	3448	1696	486907
1964	520216	109864	57815	11870	5458	4802	2399	712424
1965	654090	194853	44667	23695	6527	2702	3232	929766
1966	838190	228433	76191	17151	10089	3436	3002	1176492
1967	771429	286359	80822	29882	8148	4946	3394	1184980
1968	404740	255761	99509	28941	14672	3615	3688	810926
1969	371016	125995	83117	34787	11589	6869	3212	636585
1970	1122423	117948	43347	32761	15579	4821	4097	1340976
1971	1452795	358613	38330	15294	15831	6928	4202	1891993
1972	358255	452254	102437	12623	6244	6920	5547	944280
1973	533919	103259	120934	30485	5101	2589	4610	800897
1974	490902	157472	27584	37798	11261	2207	3198	730422
1975	836515	144495	42617	9836	16529	4700	2301	1056993
1976	515555	249696	38716	14050	4022	6953	2793	831785
1977	1266794	147561	59576	11462	5400	1772	4057	1496622
1978	771429	378511	35207	19366	5343	2305	2292	1214453
1979	866312	230268	91217	9655	7364	1828	1782	1208426
1980	1368191	253216	65710	25978	4106	2864	1680	1721745
1981	533919	401515	65841	18615	9376	1667	1821	1032754
1982	842391	153430	101519	17806	6913	3885	1453	1127397
1983	483110	241591	36571	22629	5718	2540	1850	794009
1984	832343	143487	58513	8650	7185	2113	1612	1053903
1985	218163	253470	38139	16544	3085	2755	1403	533559
1986	999490	68803	65578	11114	6057	1225	1670	1153937
1987	389648	321579	18974	16744	3457	2149	1078	753629
1988	268874	126500	80017	5706	5396	1334	1016	488843
1989	452254	87641	34892	18890	1977	2046	872	598572
1990	192529	148896	23365	8637	5563	694	983	380667
1991	214058	65186	36975	6585	2904	2122	728	328558
1992	459549	74832	18367	9759	2225	1052	942	566726
1993	254486	166209	22449	5795	3265	864	701	453769
1994	553491	89859	45433	6318	2002	1174	549	698826
1995	321258	201793	28681	12022	2058	749	580	567141
1996	233982	115497	50970	6724	3785	778	534	412270
1997	620946	86077	32991	11328	2234	1257	419	755252
1998	96858	231422	26056	8145	3365	781	483	367110
1999	173685	34718	62442	6072	2331	995	456	280699
2000	310519	65644	11458	12355	1754	735	396	402861
2001	116658	124119	20398	2878	3011	453	349	267866
2002	139107	46351	38063	5420	846	852	238	230877
2003	63959	55938	16401	9639	1605	262	291	148095
2004	107045	26849	17021	4578	2890	443	192	159018
2005	75282	45161	9349	4539	1375	1080	193	136979
2006	181317	32761	16256	3012	1397	462	409	235614
2007	72620	84881	12612	5476	1202	499	294	177584
2008	87728	33323	31984	3880	2017	499	331	159762
2009	94750	41399	13014	9688	1655	758	324	161588
2010	165215	45615	17001	4662	3721	688	369	237271
2011	94278	80580	18652	5746	1866	1461	400	202983

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	33806	51601	7854	3590	2884	1173	582
1964	63361	38014	20492	4173	1864	1689	851
1965	82199	69585	16478	8645	2312	976	1177
1966	107689	83608	28785	6388	3664	1268	1118
1967	105251	110614	32196	11731	3143	1928	1335
1968	57040	102519	40937	11751	5854	1445	1487
1969	51642	50136	33681	13956	4582	2706	1276
1970	159452	48002	17850	13281	6227	1900	1629
1971	223552	156686	16773	6586	6708	2883	1772
1972	59142	210386	47297	5728	2781	3058	2483
1973	87439	48007	54979	13622	2232	1122	2023
1974	79770	72962	12419	16620	4860	945	1388
1975	141210	69411	19765	4434	7325	2065	1024
1976	89743	123094	18453	6446	1817	3111	1266
1977	221018	73079	28598	5217	2432	791	1836
1978	142102	194814	17751	9176	2524	1067	1074
1979	152482	113584	44734	4407	3326	804	797
1980	254562	129625	33668	12428	1916	1316	786
1981	102570	209651	34579	9153	4433	785	872
1982	174940	84162	56500	9340	3459	1950	742
1983	100208	131926	20180	11853	2835	1261	938
1984	166525	75993	31067	4392	3434	1015	791
1985	42847	132032	19771	8272	1436	1300	676
1986	205644	36750	34902	5773	2912	597	834
1987	80911	172405	10073	8719	1662	1053	541
1988	56421	67969	42476	2991	2609	651	511
1989	96964	47596	18631	10041	966	1008	444
1990	39624	78018	11929	4434	2623	329	482
1991	44449	34204	18803	3390	1384	1017	362
1992	93723	38338	9105	4950	1040	494	461
1993	52423	85315	11209	2960	1548	408	347
1994	115462	46286	22880	3259	961	560	274
1995	68789	105166	14711	6324	1010	363	295
1996	51462	60949	26521	3589	1913	387	280
1997	139414	45515	17300	6138	1151	631	223
1998	22355	123020	13793	4506	1775	398	261
1999	41155	18560	33446	3419	1256	518	251
2000	74653	35063	6122	7008	957	382	219
2001	27675	64906	10641	1610	1621	233	191
2002	32787	23830	19557	2990	449	432	128
2003	14897	28317	8302	5231	838	131	154
2004	24089	13212	8377	2415	1458	217	99
2005	16271	21410	4444	2310	673	512	97
2006	37350	14825	7427	1455	654	211	197
2007	14453	37358	5638	2551	545	221	137
2008	17089	14391	14084	1758	900	219	153
2009	18144	17588	5635	4330	729	330	149
2010	31332	19205	7311	2069	1632	297	168

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	285501	209274	389493	435391	392320	483190	154817	139522	171789	126754	112862	142355	0.495	0.440	0.557
1964	520216	384985	702949	562418	500122	632472	168215	152762	185232	154662	139522	171446	0.521	0.468	0.579
1965	654090	487332	877911	702219	628396	784714	206489	188528	226160	205664	183964	229924	0.548	0.496	0.606
1966	838190	623697	1126448	852561	762052	953820	230729	211785	251368	252458	226533	281350	0.567	0.514	0.625
1967	771429	572759	1039011	932850	838034	1038394	255250	234729	277565	301040	269328	336487	0.611	0.555	0.673
1968	404740	298009	549696	830680	759118	908989	267533	246389	290492	301342	272949	332688	0.640	0.582	0.704
1969	371016	274301	501832	704328	642490	772119	264607	243725	287278	241591	221448	263566	0.633	0.576	0.695
1970	1122423	832560	1513204	999490	856634	1166168	275130	253004	299192	271848	239300	308824	0.647	0.590	0.710
1971	1452795	1075870	1961775	1113479	967612	1281336	275406	253966	298655	353982	308666	405950	0.708	0.648	0.774
1972	358255	265052	484232	852561	768190	946199	244019	224970	264680	359691	316868	408300	0.768	0.700	0.842
1973	533919	395632	720543	689692	625353	760650	218382	202009	236081	259886	237116	284844	0.755	0.691	0.826
1974	490902	363691	662609	633490	574460	698586	234451	215729	254797	240145	216634	266208	0.744	0.680	0.813
1975	836515	611616	1144113	678744	597284	771315	214701	197981	232832	237281	212029	265540	0.776	0.711	0.848
1976	515555	375998	706911	557936	501077	621247	184241	170416	199188	233748	205610	265737	0.804	0.735	0.880
1977	1266794	926751	1731606	747882	634685	881267	161135	149378	173819	242316	209719	279980	0.803	0.735	0.878
1978	771429	569048	1045787	844922	730593	977143	158419	147343	170328	317109	270146	372236	0.856	0.784	0.935
1979	866312	639716	1173170	807744	717731	909045	167879	156044	180612	312388	276223	353288	0.811	0.743	0.885
1980	1368191	1004158	1864195	896273	779631	1030365	181317	168634	194953	337055	294212	386136	0.863	0.794	0.938
1981	533919	394376	722838	815046	726974	913788	194853	181725	208929	360411	314985	412388	0.893	0.823	0.969
1982	842391	628493	1129087	801307	707968	906953	190613	177942	204186	331705	294549	373547	0.977	0.898	1.063
1983	483110	362885	643167	641138	570891	720028	155593	145249	166673	278730	245553	316390	0.967	0.891	1.049
1984	832343	624346	1109633	625934	550177	712122	133252	124511	142607	243531	215595	275087	0.914	0.844	0.991
1985	218163	162615	292687	480220	433377	532126	128412	119887	137543	223463	196832	253697	0.886	0.815	0.962
1986	999490	748660	1334357	570918	489722	665575	117830	110075	126131	204843	179030	234378	0.927	0.855	1.005
1987	389648	293256	517725	568638	499839	646907	109098	101870	116839	245242	210866	285221	0.929	0.857	1.006
1988	268874	202400	357182	450900	406893	499665	103570	96672	110960	197402	177435	219617	0.933	0.861	1.01
1989	452254	337743	605591	413329	363487	470007	96858	90160	104053	167209	148306	188522	0.946	0.872	1.027
1990	192529	145002	255633	308970	278536	342730	82537	76890	88598	135131	119760	152475	0.892	0.820	0.969
1991	214058	161058	284498	284077	256118	315088	76726	71776	82018	119134	107336	132227	0.893	0.824	0.969
1992	459549	345760	610785	374745	323932	433528	72548	67723	77716	133786	116633	153462	0.866	0.798	0.939
1993	254486	191680	337871	341465	304852	382475	69633	65246	74316	147561	129041	168740	0.877	0.809	0.950
1994	553491	412116	743363	397122	347101	454353	73571	68889	78570	150844	133108	170943	0.886	0.818	0.960
1995	321258	241987	426497	432787	382235	490024	81471	76129	87188	183139	159409	210402	0.912	0.842	0.987
1996	233982	175849	311334	368428	331982	408875	81064	75913	86565	161943	144921	180965	0.933	0.863	1.010
1997	620946	464000	830979	450449	383516	529064	75735	70940	80855	165049	141998	191843	0.944	0.874	1.020
1998	96858	71898	130483	282095	250262	317978	61451	57550	65617	139525	120672	161324	0.965	0.893	1.042
1999	173685	129752	232494	213203	193439	234986	57526	53734	61586	98322	89022	108592	0.981	0.906	1.062
2000	310519	233029	413776	246965	214401	284474	50161	46609	53984	101114	87598	116715	0.979	0.905	1.060
2001	116658	86308	157680	196222	176130	218605	42489	39746	45421	90853	80130	103011	0.949	0.878	1.026
2002	139107	103910	186227	205664	184436	229336	43827	40929	46930	88965	79352	99743	0.922	0.851	0.999
2003	63959	47923	85361	128541	117601	140498	38949	36154	41959	61574	55457	68366	0.898	0.829	0.973
2004	107045	80436	142455	117948	106386	130767	34718	32343	37267	49021	44277	54272	0.856	0.789	0.929
2005	75282	56735	99894	118658	107315	131200	32958	30680	35405	50262	44790	56402	0.807	0.742	0.879
2006	181317	136459	240920	122272	109672	136318	29437	27392	31634	46351	41493	51778	0.753	0.689	0.822
2007	72620	54753	96319	157000	140687	175204	36864	34173	39768	65186	57039	74496	0.720	0.656	0.790
2008	87728	65891	116803	155438	141690	170519	42362	39056	45948	61390	55771	67575	0.699	0.631	0.774
2009	94750	68241	131558	167209	149951	186453	50767	46038	55982	63831	57390	70996	0.684	0.605	0.772
2010	165215	106483	256340	187963	161259	219089	52733	46518	59778	69286	60927	78792	0.676	0.579	0.790
2011							54721	44838	66783						

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	112758	14118	126754		126754
1964	140787	13837	154662		154662
1965	183322	22181	205664		205664
1966	218819	33456	252458		252458
1967	266199	34648	301040		301040
1968	279568	21703	301342		301342
1969	229120	12585	241591		241591
1970	246965	25034	271848		271848
1971	291268	63070	353982		353982
1972	325462	34372	359691		359691
1973	234920	24810	259886		259886
1974	214915	25135	240145		240145
1975	205048	32177	237281		237281
1976	197205	36425	233748		233748
1977	179872	62380	242316		242316
1978	278452	38754	317109		317109
1979	270493	41940	312388		312388
1980	270763	66237	337055		337055
1981	322223	38216	360411		360411
1982	291851	39895	331705		331705
1983	253723	25160	278730		278730
1984	197798	45844	243531		243531
1985	201189	22248	223463		223463
1986	160492	44445	204843		204843
1987	215777	29437	245242		245242
1988	184795	12640	197402		197402
1989	134996	32338	167209		167209
1990	113664	21397	135131		135131
1991	104715	14464	119134		119134
1992	106831	27011	133786		133786
1993	126694	26148	152899	0.97	147561
1994	104349	35721	140154	1.08	150844
1995	122165	27423	149661	1.22	183139
1996	135372	21912	157280	1.03	161943
1997	133517	44090	177546	0.93	165049
1998	139145	41826	180822	0.77	139525
1999	101165	17499	118600	0.83	98322
2000	79549	21070	100622	1.00	101114
2001	47830	13156	60986	1.49	90853
2002	62941	7636	70541	1.26	88965
2003	27313	5221	32537	1.89	61574
2004	28852	7039	35916	1.36	49021
2005	29466	6005	35454	1.42	50262
2006	26001	7718	33721	1.37	46351
2007	22707	20982	43714	1.49	65186
2008	27155	22099	49233	1.25	61390
2009	32653	16798	49498	1.29	63831
2010	38963	14401	53336	1.30	69286

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	1.13
1994	1.08	0.89	1.29
1995	1.22	1.01	1.49
1996	1.03	0.84	1.25
1997	0.93	0.76	1.13
1998	0.77	0.63	0.94
1999	0.83	0.68	1.01
2000	1.00	0.82	1.23
2001	1.49	1.22	1.81
2002	1.26	1.03	1.54
2003	1.89	1.55	2.30
2004	1.36	1.12	1.66
2005	1.42	1.16	1.73
2006	1.37	1.12	1.68
2007	1.49	1.22	1.82
2008	1.25	1.02	1.53
2009	1.29	1.05	1.58
2010	1.30	1.06	1.59

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(2011) = 0.85*F(2010) =	**0.58**
Recruitment resampled from 1998-2010 =	**107**
SSB(2012) =	**66.9**
HC landings (2011) =	**41.8**
Discards (2011) =	**14.8**
Unallocated (2011) =	**15.8**

Rationale	Landings (2012)	Basis	Ftotal (2012)	F land (2012)	F disc (2012)	F unal (2012)	Discards (2012)	Unalloc. (2012)	SSB (2013)	%SSB change	%TAC change
MSY framework	9.5	FMSY *SSB2012/Btrigger	0.08	0.05	0.02	0.02	2.3	3.3	134.6	101	-71
MSY transition	42.0	Transition rule	0.44	0.25	0.09	0.10	10.6	14.6	95.1	42	30
Management Plan	31.8	F08*0.45 with TAC constr	0.32	0.18	0.07	0.07	8.0	11.1	107.4	60	-1
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	146.2	119	-100
Status quo	51.8	Fsq	0.58	0.33	0.13	0.13	13.2	18.1	83.2	24	61
MSY	20.3	FMSY	0.19	0.11	0.04	0.04	5.0	7.0	121.3	81	-37
TAC constraint	38.6	TAC2011+20%	0.40	0.23	0.09	0.09	9.7	13.5	99.1	48	20
TAC constraint	26.0	TAC2011-20%	0.25	0.14	0.05	0.05	6.4	9.0	114.4	71	-20

Basis B

Assume no reduction in F: F(2011) = F(2010) =	**0.68**
Recruitment resampled from 1998-2010 =	**107**
SSB(2012) =	**60.7**
HC landings (2011) =	**47.1**
Discards (2011) =	**16.8**
Unallocated (2011) =	**17.8**

Rationale	Landings (2012)	Basis	Ftotal (2012)	F land (2012)	F disc (2012)	F unal (2012)	Discards (2012)	Unalloc. (2012)	SSB (2013)	%SSB change	%TAC change
MSY framework	7.9	FMSY *SSB2012/Btrigger	0.08	0.05	0.02	0.02	2.0	2.8	124.4	105	-75
MSY transition	38.3	Transition rule	0.44	0.25	0.09	0.10	10.2	13.5	87.6	44	19
Management Plan	29.2	F08*0.45 with TAC constr	0.32	0.18	0.07	0.07	7.6	10.3	98.6	62	-9
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	134.1	121	-100
Status quo	53.6	Fsq	0.68	0.39	0.14	0.15	14.6	19.0	69.2	14	66
MSY	18.6	FMSY	0.19	0.11	0.04	0.04	4.8	6.5	111.4	84	-42
TAC constraint	38.6	TAC2011+20%	0.44	0.25	0.09	0.10	10.3	13.6	87.3	44	20
TAC constraint	25.9	TAC2011-20%	0.27	0.16	0.05	0.06	6.8	9.1	102.6	69	-20

Basis C

Assume F(2011) so that HC landings (2011) = TAC(2011) =	**0.41**
Recruitment resampled from 1998-2010 =	**107**
SSB(2012) =	**78.1**
HC landings (2011) =	**32.2**
Discards (2011) =	**11.3**
Unallocated (2011) =	**12.1**

Rationale	Landings (2012)	Basis	Ftotal (2012)	F land (2012)	F disc (2012)	F unal (2012)	Discards (2012)	Unalloc. (2012)	SSB (2013)	%SSB change	%TAC change
MSY framework	12.6	FMSY *SSB2012/Btrigger	0.1	0.05	0.02	0.02	2.9	4.3	152.1	95	-61
MSY transition	48.5	Transition rule	0.45	0.26	0.09	0.10	11.3	16.7	108.3	39	51
Management Plan	36.4	F08*0.45 with TAC constr	0.32	0.18	0.07	0.07	8.4	12.5	122.9	57	13
Zero Catch	0.0	F=0	0.00	0.00	0.00	0.00	0.0	0.0	167.8	115	-100
Status quo	45.8	Fsq	0.41	0.24	0.08	0.09	10.7	15.7	111.5	43	42
MSY	23.2	FMSY	0.19	0.11	0.04	0.04	5.3	8.0	139.1	78	-28
TAC constraint	38.8	TAC2011+20%	0.34	0.20	0.07	0.07	9.0	13.3	120.0	54	20
TAC constraint	25.7	TAC2011-20%	0.21	0.13	0.04	0.05	5.9	8.8	136.1	74	-20
Bpa in one year	14.4	SSB2013=Bpa	0.11	0.06	0.02	0.02	3.2	4.9	150.0	92	-55

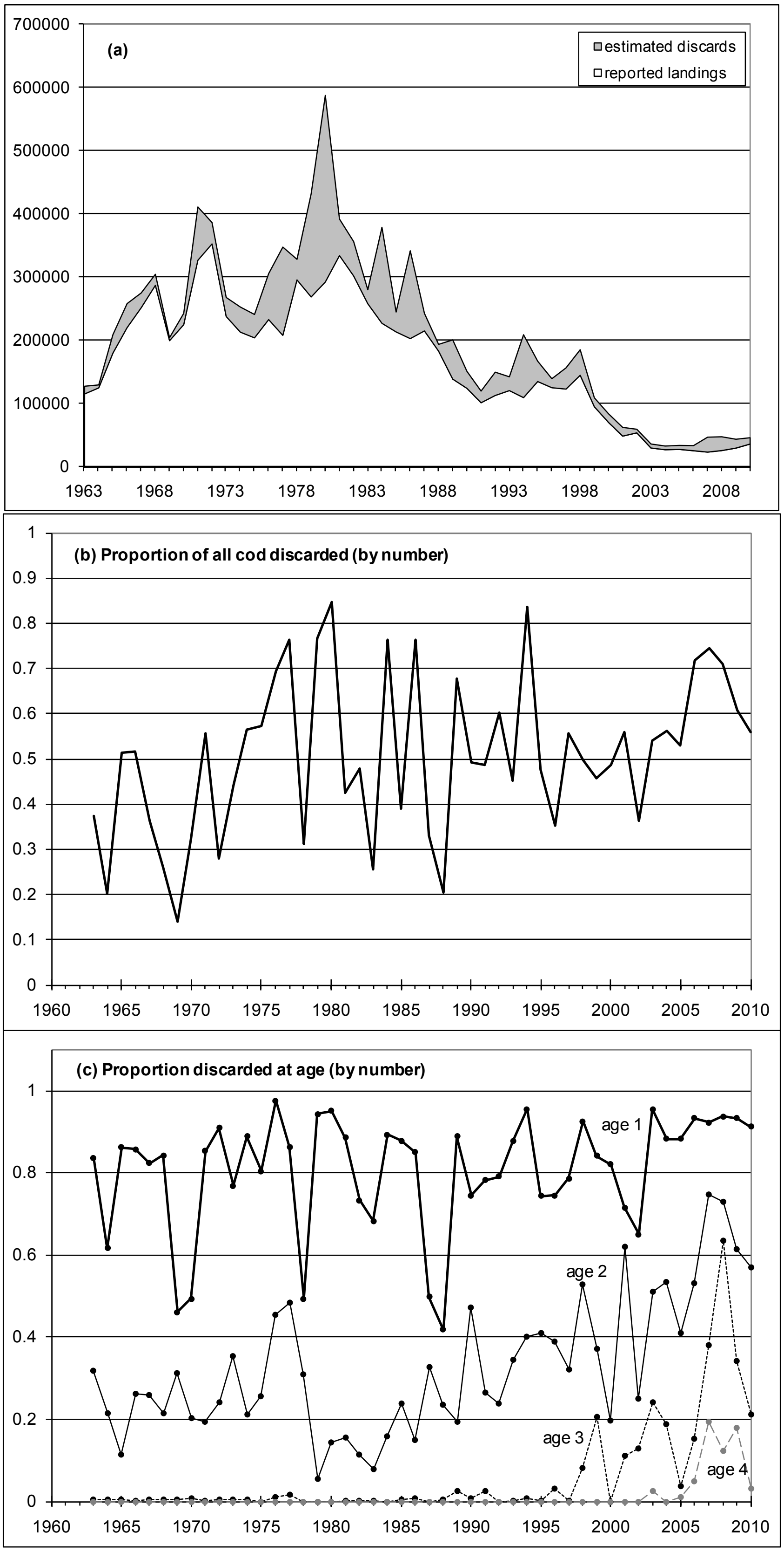

Figure 14.1 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: (a) stacked area plot of reported landings and estimated discards (in tons); (b) proportion of total numbers caught that are discarded; and (c) proportion of total numbers caught at age that are discarded

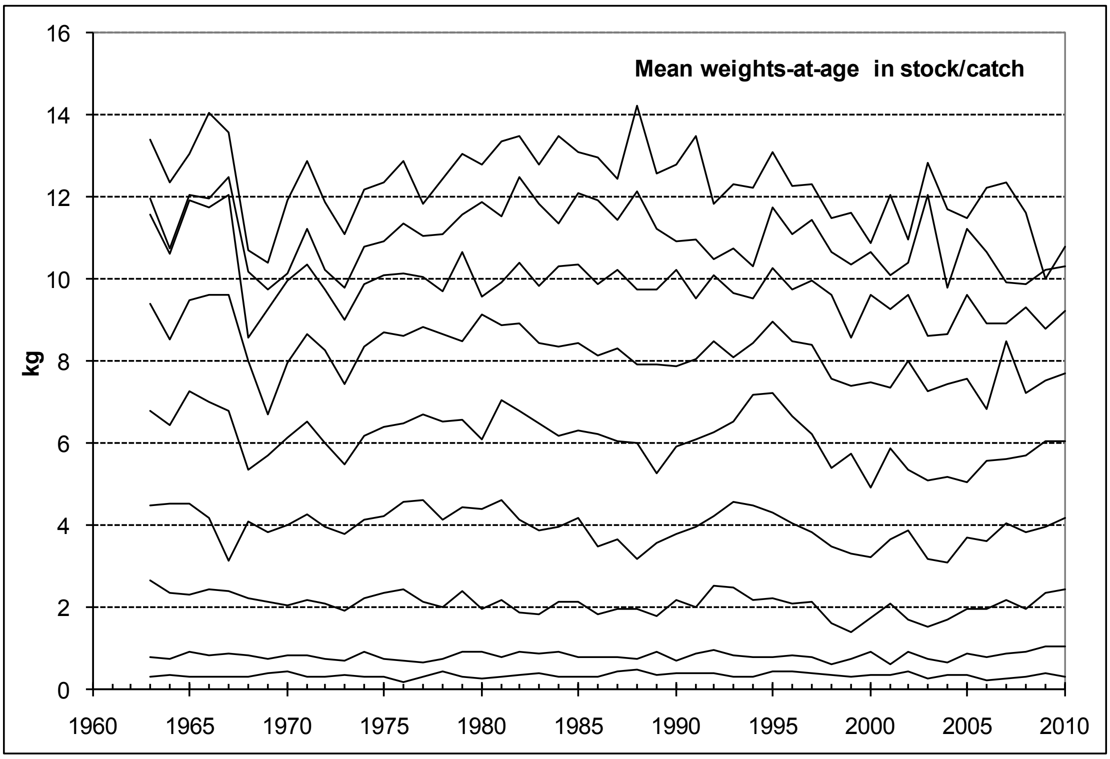

Figure 14.2 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId: Mean weight at age in the catch for ages 1-9.

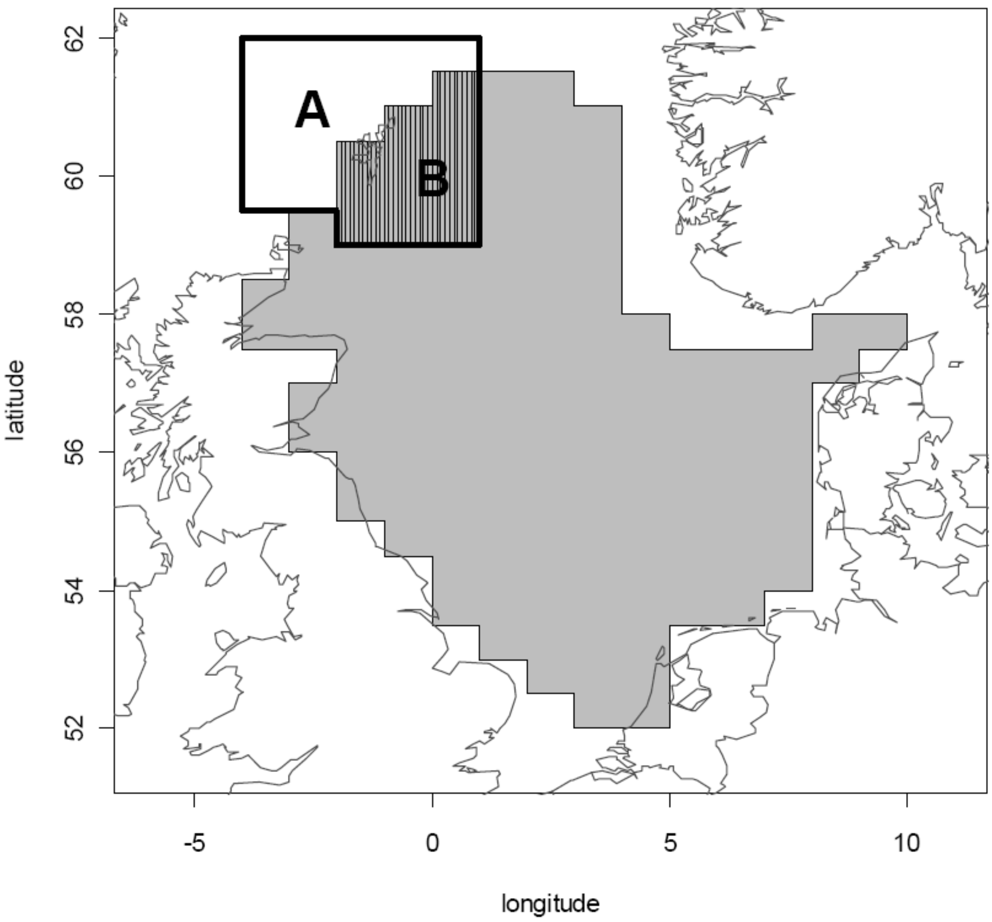

Figure 14.3a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. The IBTS cod standard area, shaded in grey; the Shetland demersal sampling area (thick black line) and two areas of interest to the north-west and south east of Shetland Isles; lying outside and overlapping the IBTS cod area.

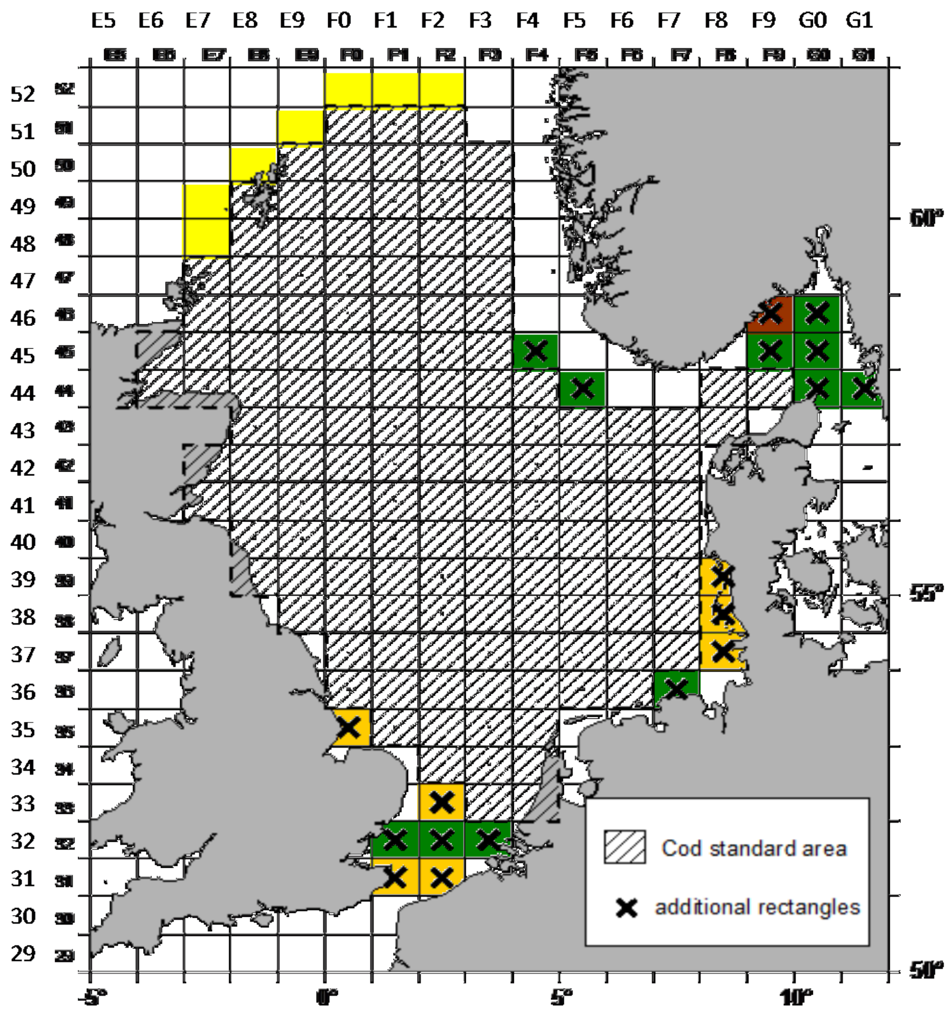

Figure 14.3b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Extension of cod standard area used for the revision of IBTS indices. Crosses indicate suggested extensions to the survey (ICES-WKROUND, 2009); green squares indicate where the IBTS group indicate data is available; orange and brown squares (with crosses) indicate where intermittent coverage does not allow inclusion and the IBTS WG considered should be omitted; yellow squares (without crosses) indicate the recommended extension around Shetland (ICES-WKCOD, 2011).

Figure 14.3c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1992-2011 in the North Sea.

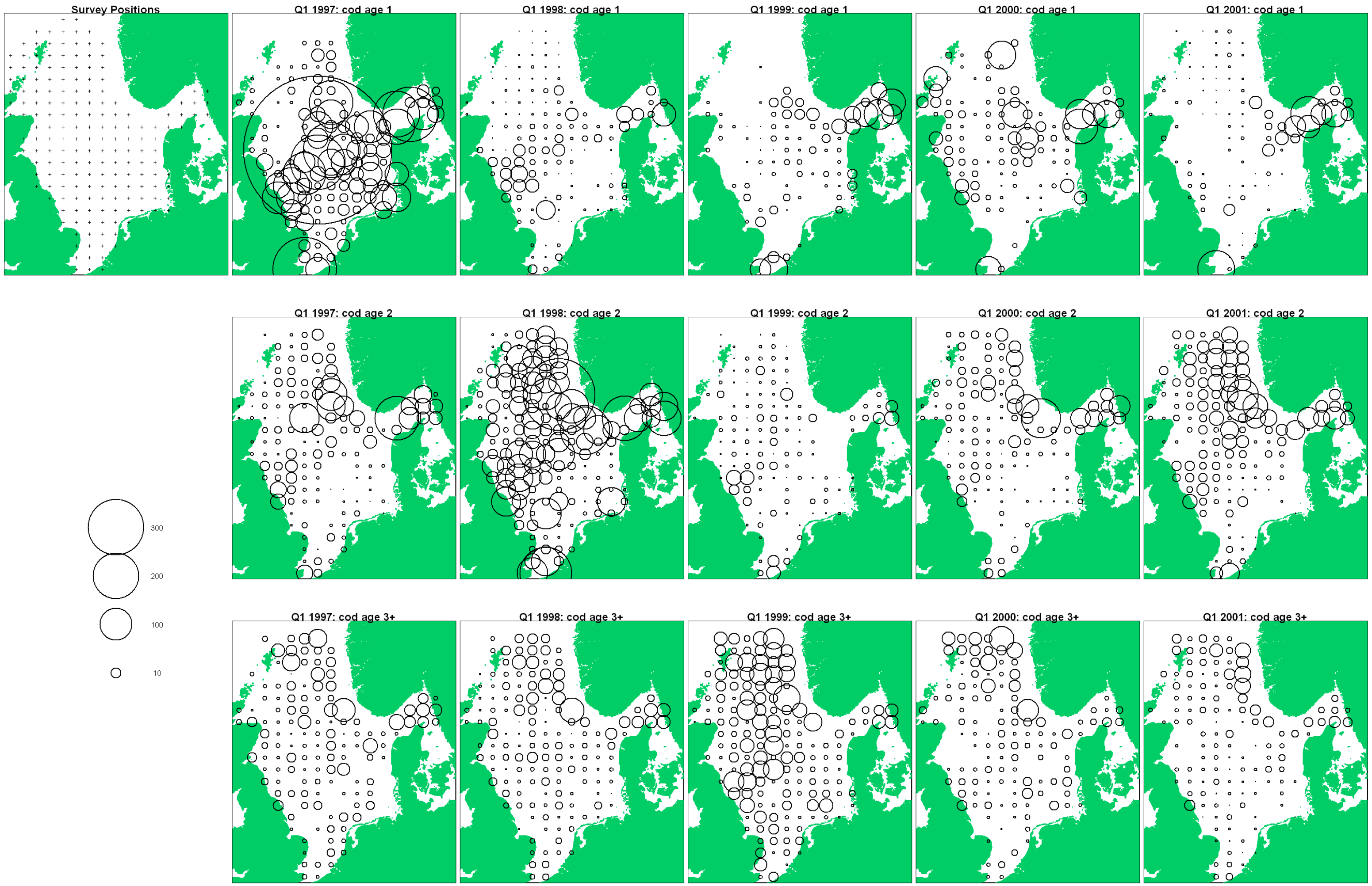

Figure 14.3c contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q1 survey 1992-2011 in the North Sea.

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 Q1 survey 1992-2011 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 Q1 survey 1992-2011 in the North Sea.

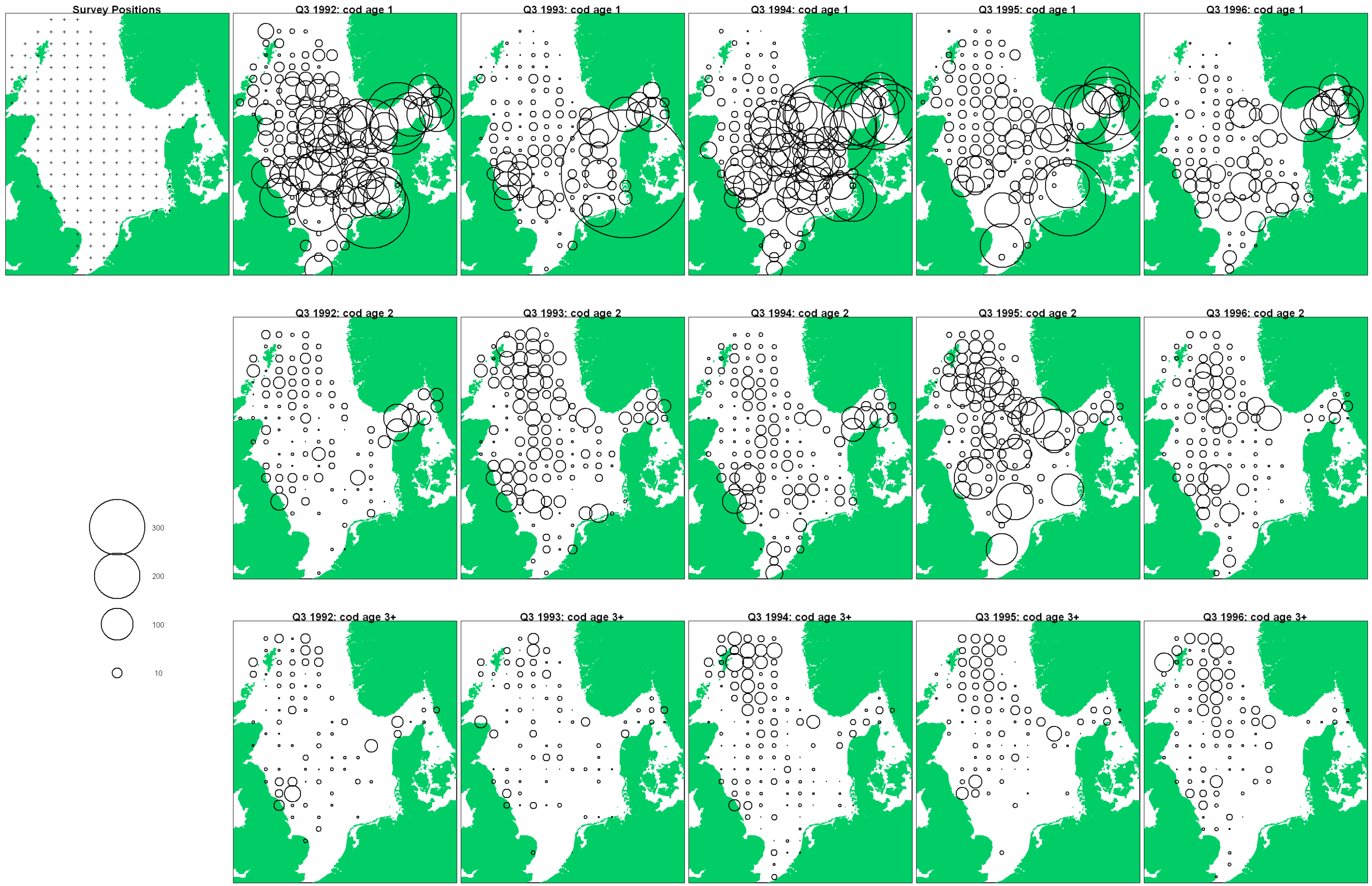

Figure 14.3d Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1992-2010 in the North Sea.

Figure 14.3d contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1992-2010 in the North Sea.

Figure 14.3d contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1992-2010 in the North Sea.

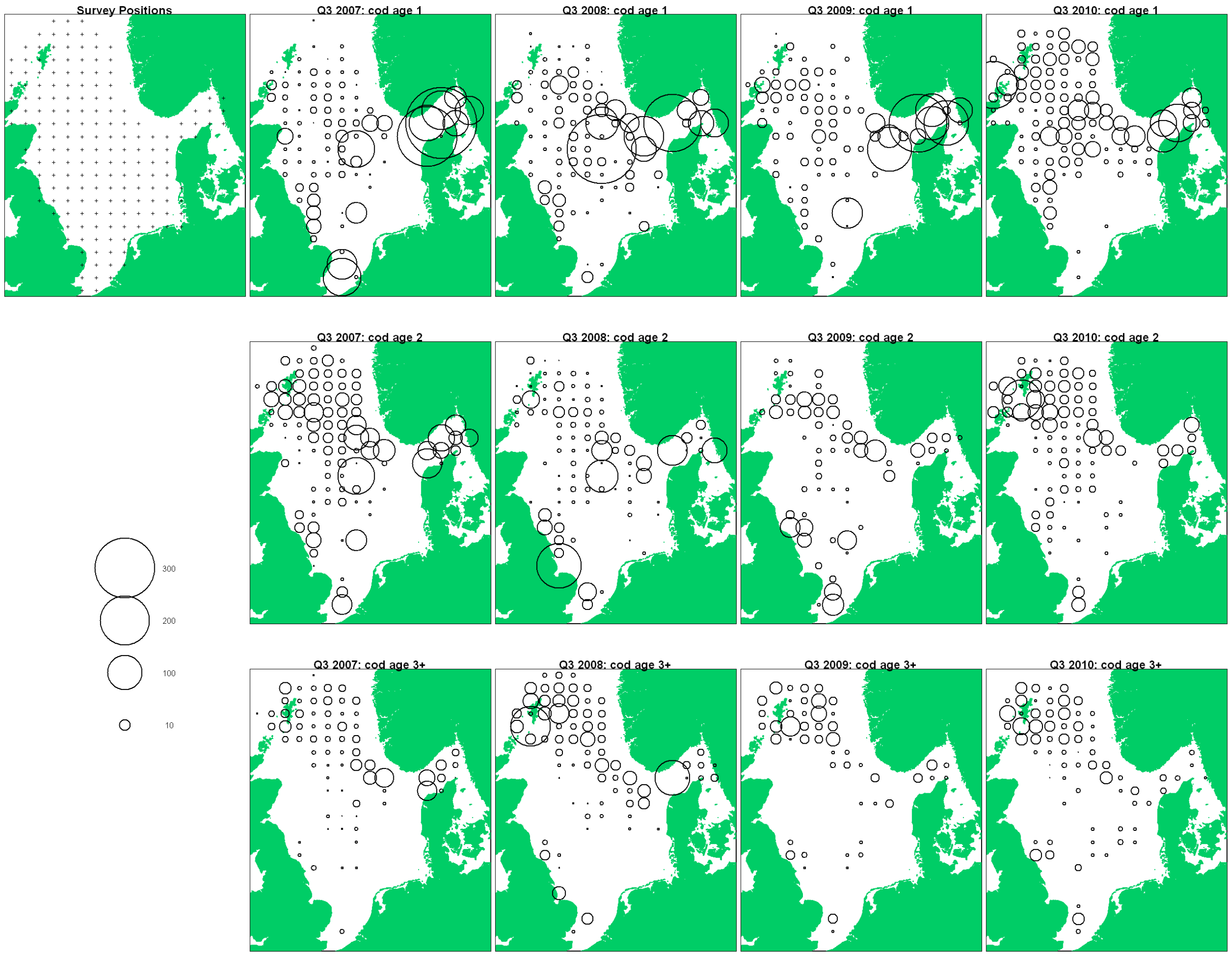

Figure 14.3d contd. Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Distribution charts of cod ages 1-3+ caught in the IBTS Q3 survey 1992-2010 in the North Sea.

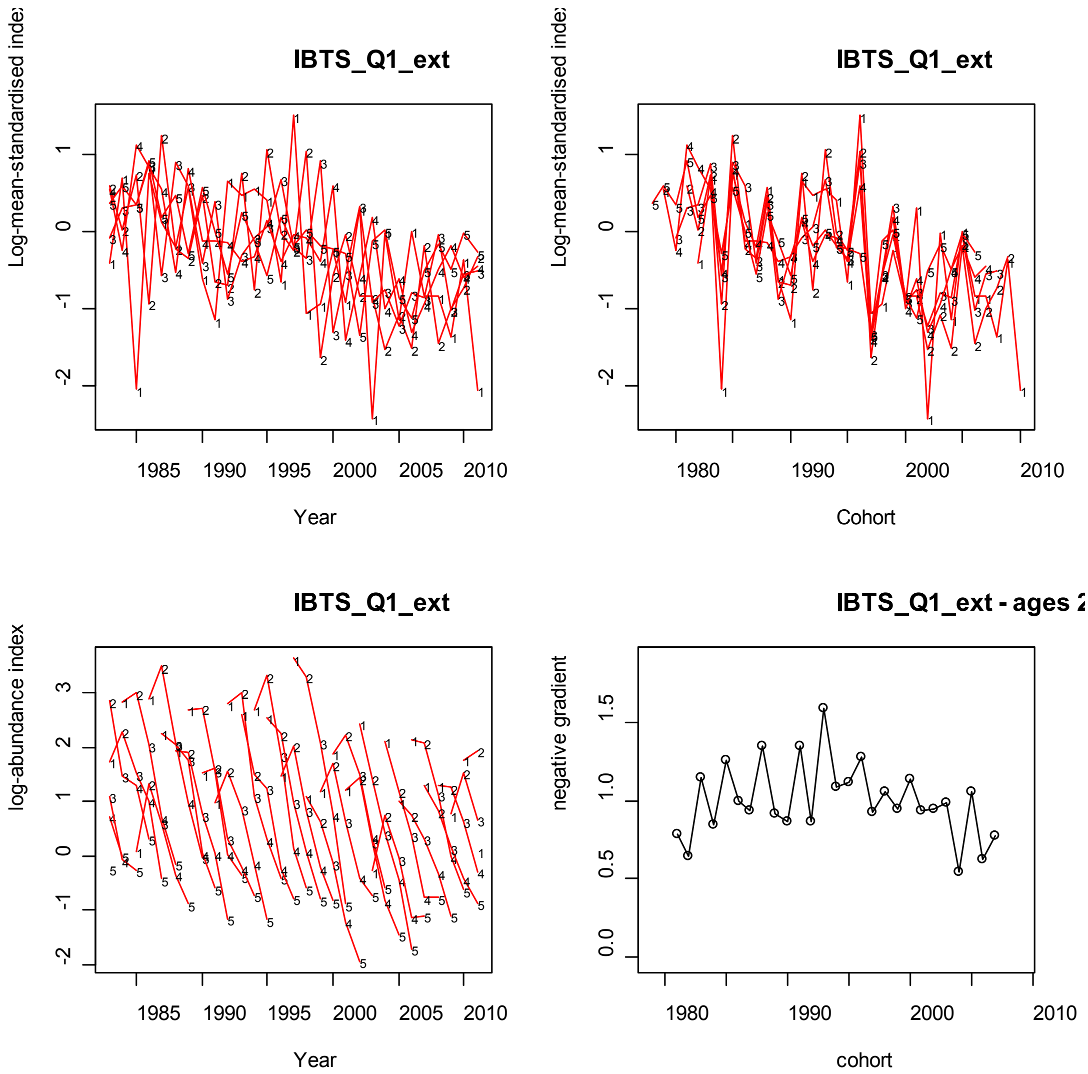

Figure 14.4a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ1 extended area groundfish survey.

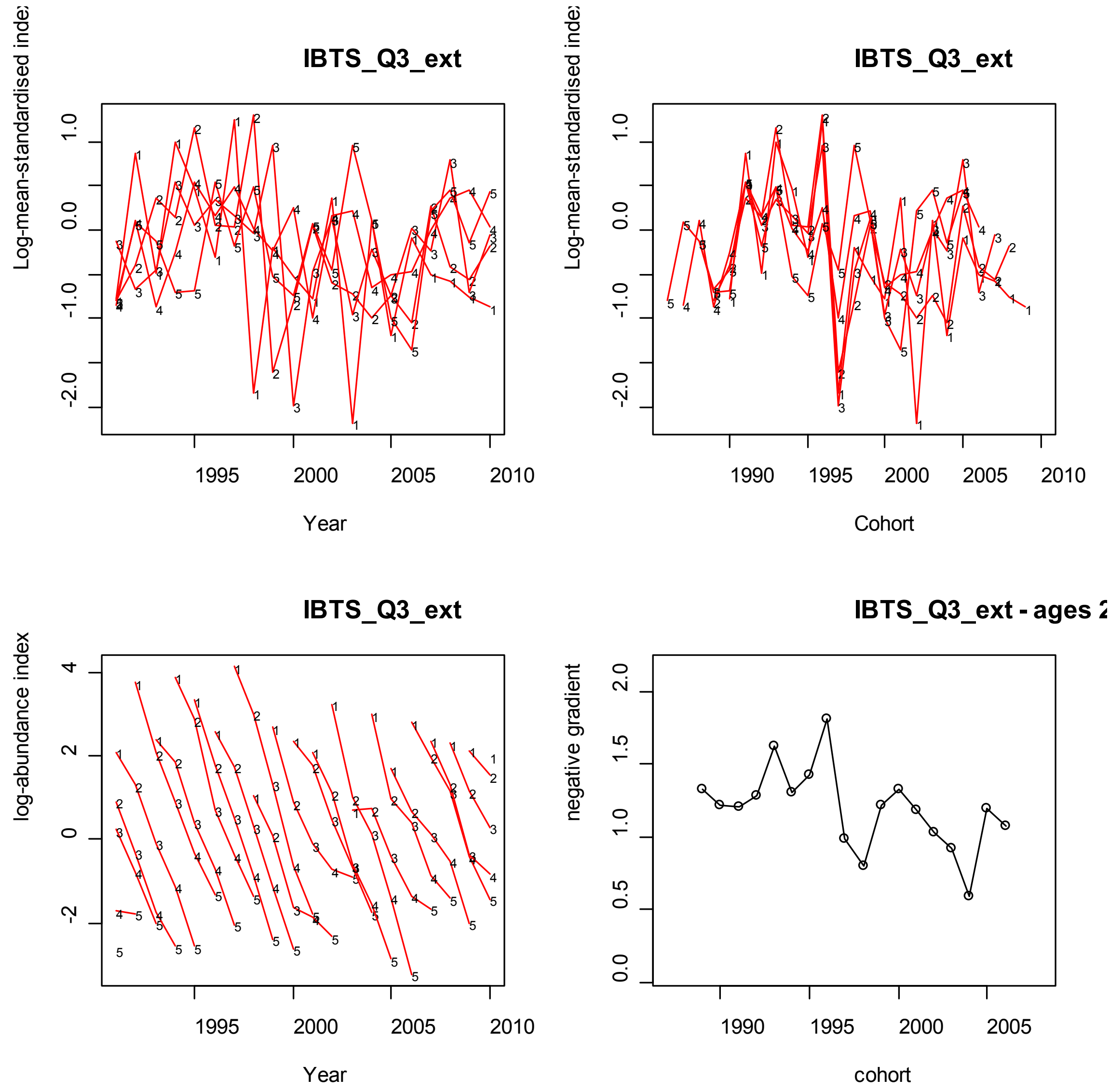

Figure 14.4b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log mean standardised indices plotted by year (top left) and cohort (top right), log abundance curves (bottom left) and associated negative gradients for each cohort across the reference fishing mortality of age 2-4 (bottom right), for the IBTSQ3 extended area groundfish survey.

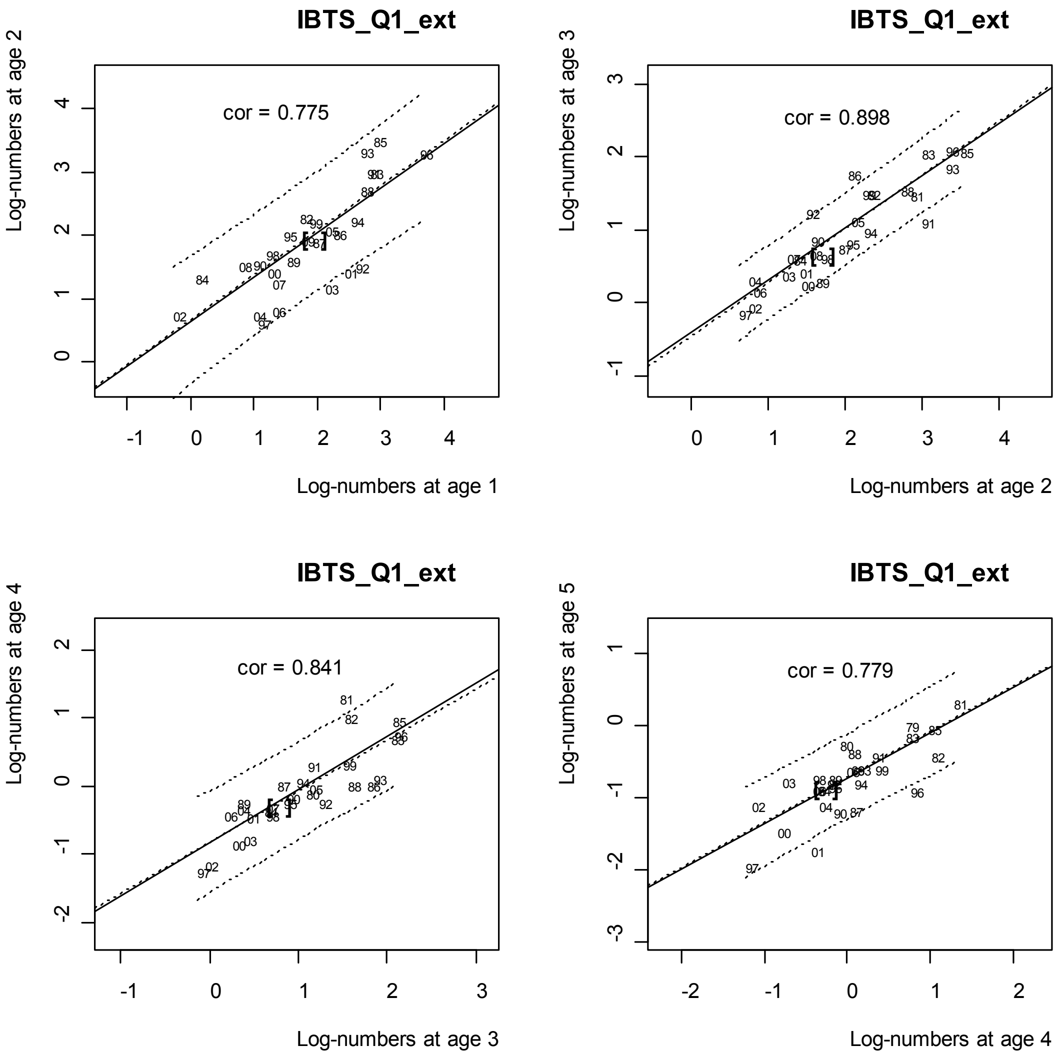

Figure 14.5a Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ1 for the period 1983-2011. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

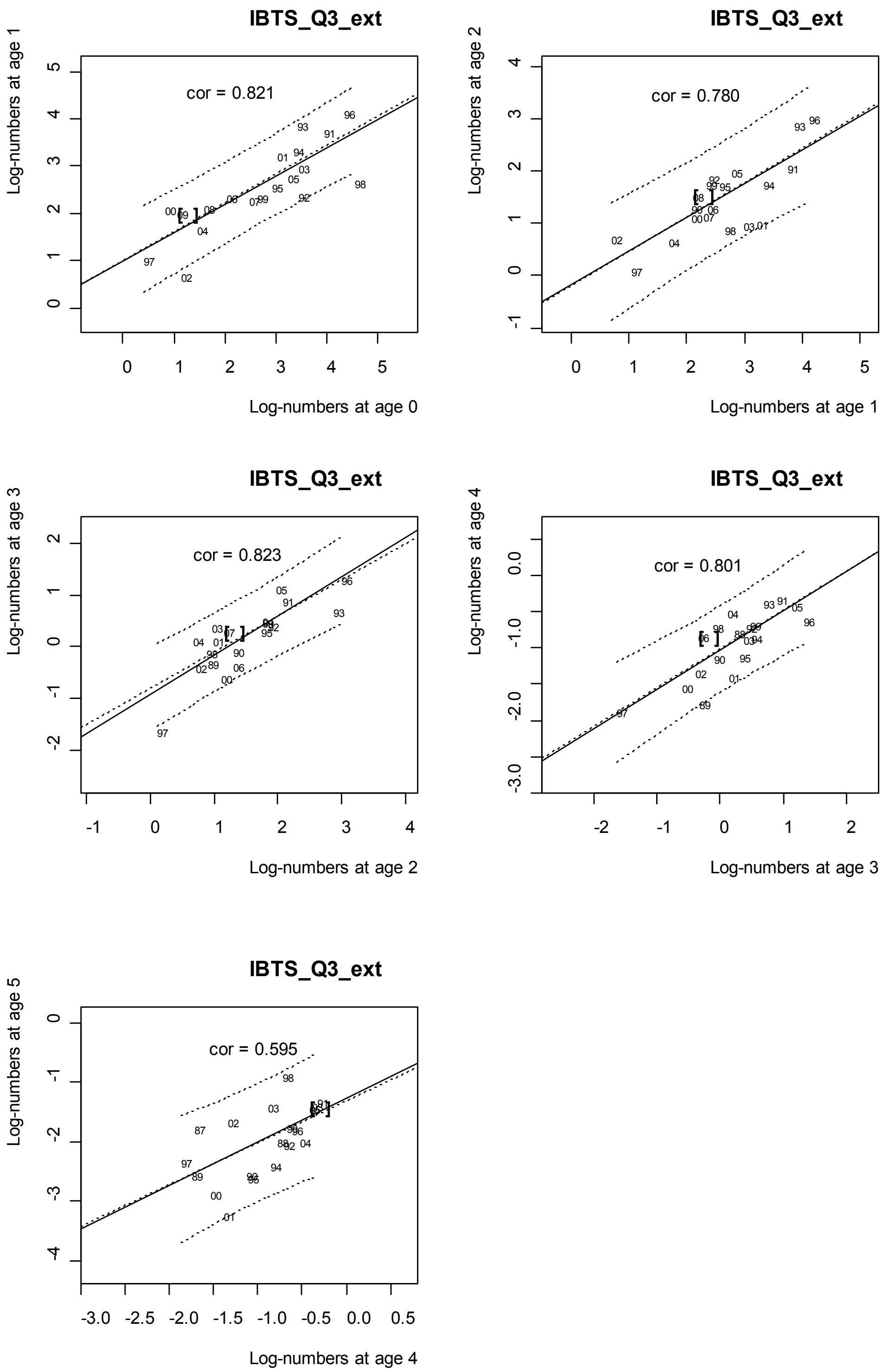

Figure 14.5b Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Within-survey correlations for IBTSQ3 for the period 1991-2010. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, the broken line nearest to it a robust linear regression line, 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.

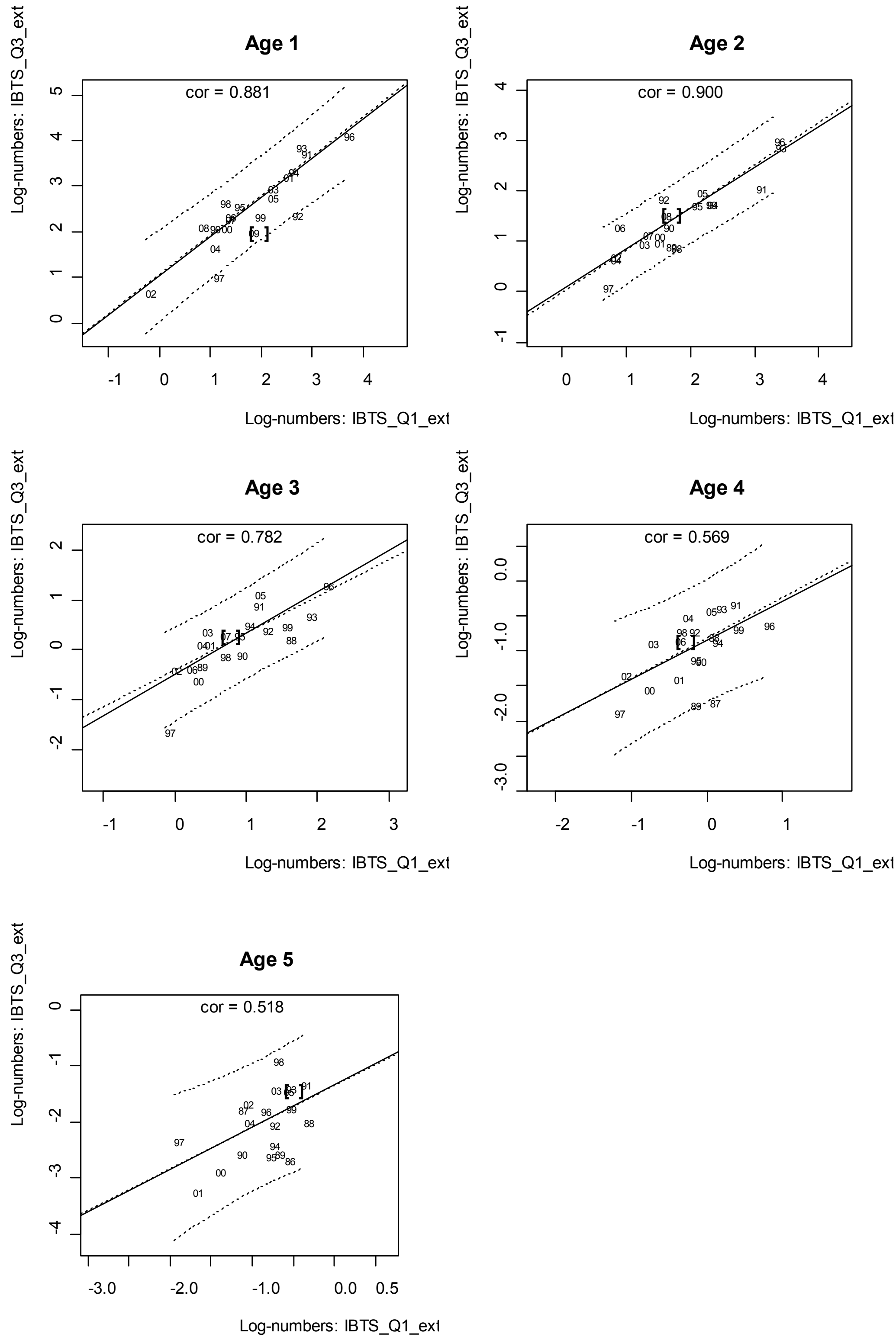

Figure 14.5c Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Between-survey correlations for IBTSQ1 and Q3 surveys for the period 1991-2010. Individual points are given by cohort (year-class), the solid line is a standard linear regression line, and the broken line nearest to it a robust linear 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.

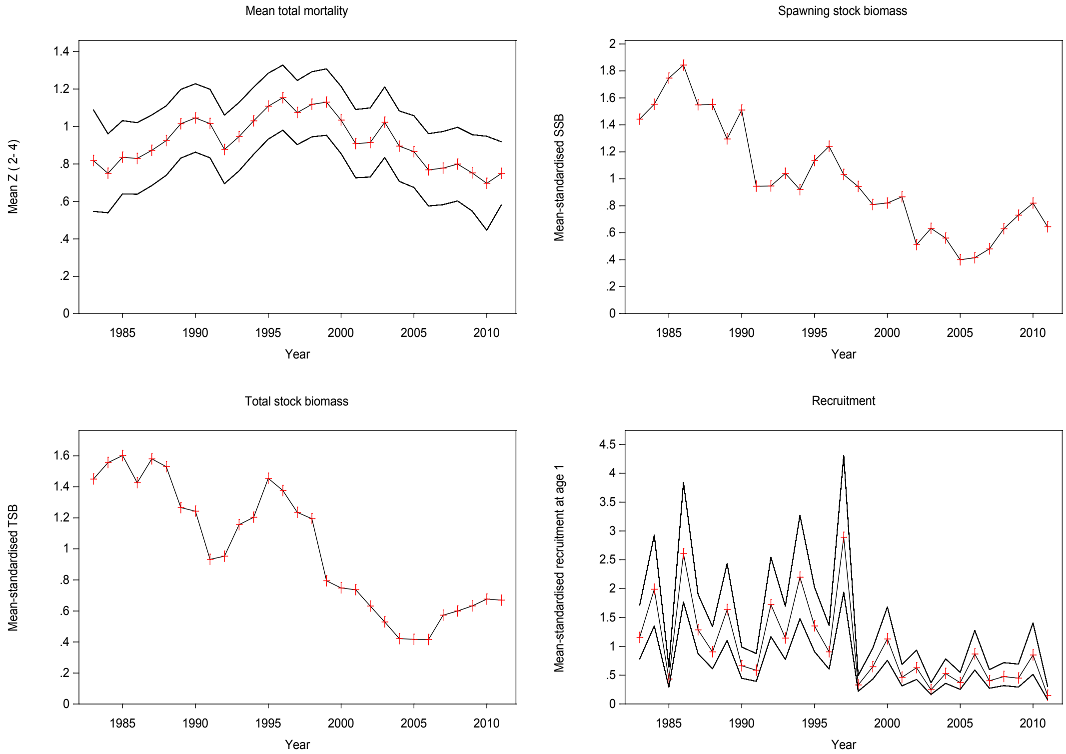

Figure 14.6 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Surba summary plots for estimates of total mortality, spawning stock biomass, total biomass and recruitment for the IBTSQ1 survey. The smoothing parameter λ is set to 2, and reference age at 3. Broken lines are 95% confidence bounds.

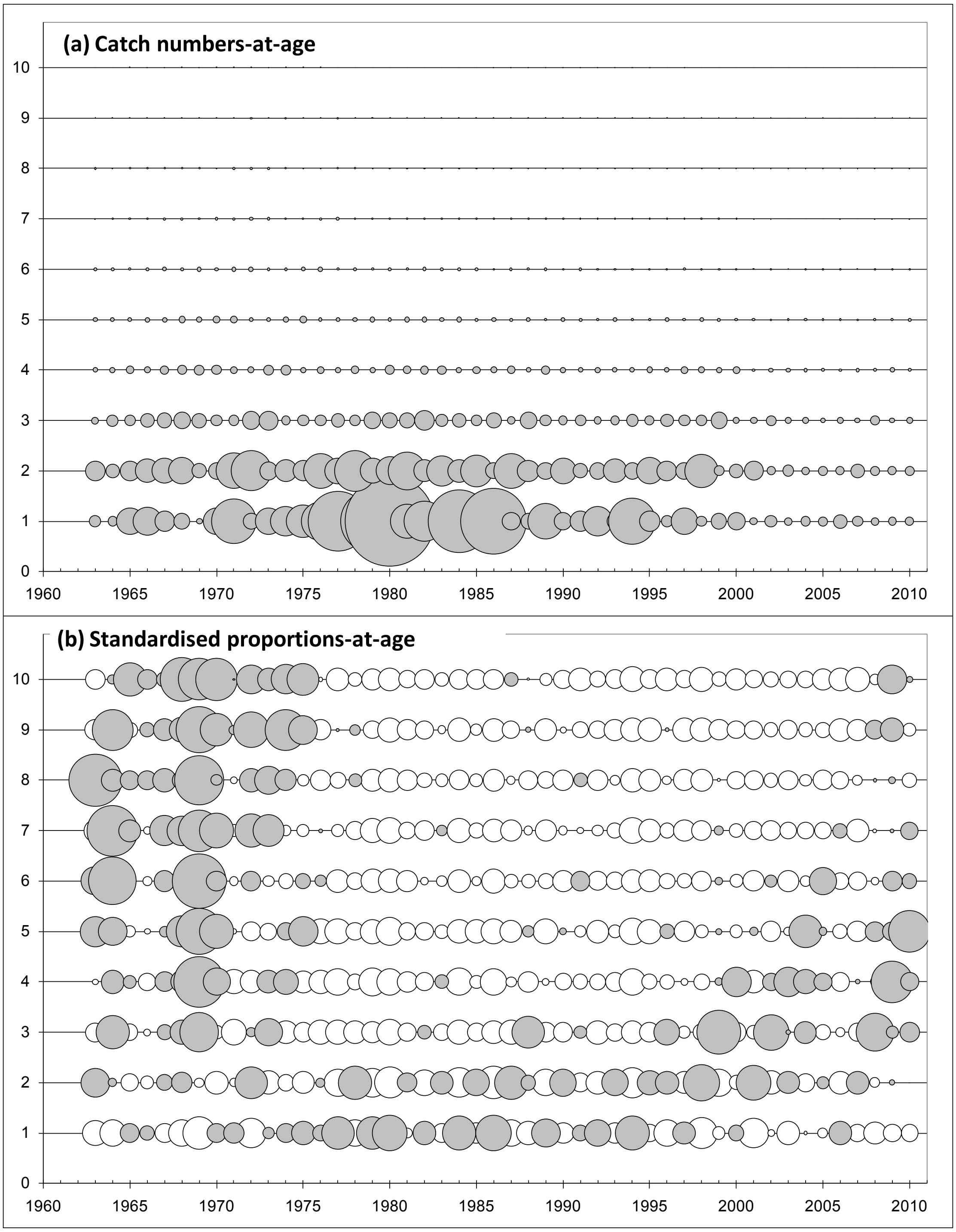

Figure 14.7 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Total catch-at-age matrix expressed as (a) numbers-at-age and (b) proportions-at-age, which have been standardised over time (for each age, this is achieved by subtracting the mean proportion-at-age over the time series, and dividing by the corresponding variance). Grey bubbles indicate proportions above the mean over the time series at each age.

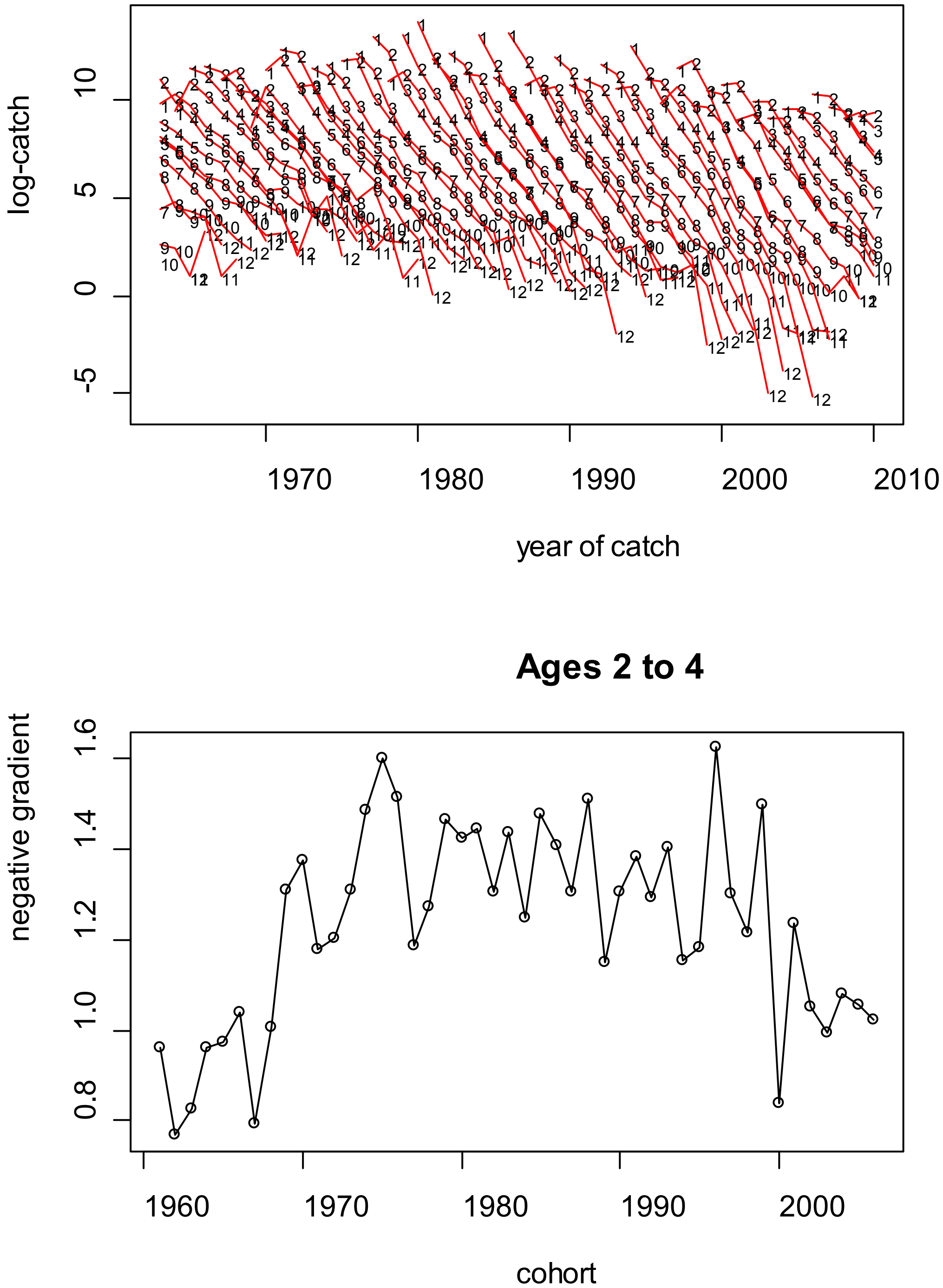

Figure 14.8 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Log-catch cohort curves (top panel) and the associated negative gradients for each cohort across the reference fishing mortality of age 2-4.

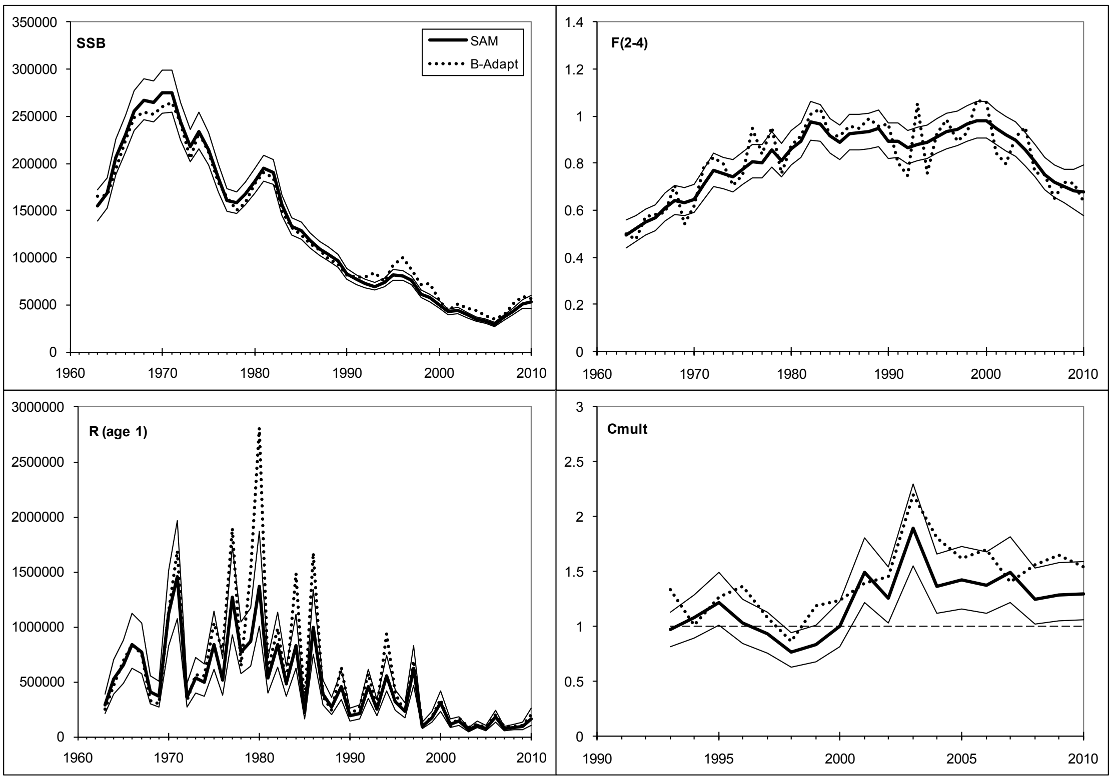

Figure 14.9 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Estimated SSB, F (2-4), recruitment (age 1) and the catch multiplier from the SAM base run. Solid black lines (heavy lines=estimate, light lines=point-wise 95% confidence intervals) are from the SAM model, and dotted lines medians from the B-ADAPT model using the same data as the SAM base run.

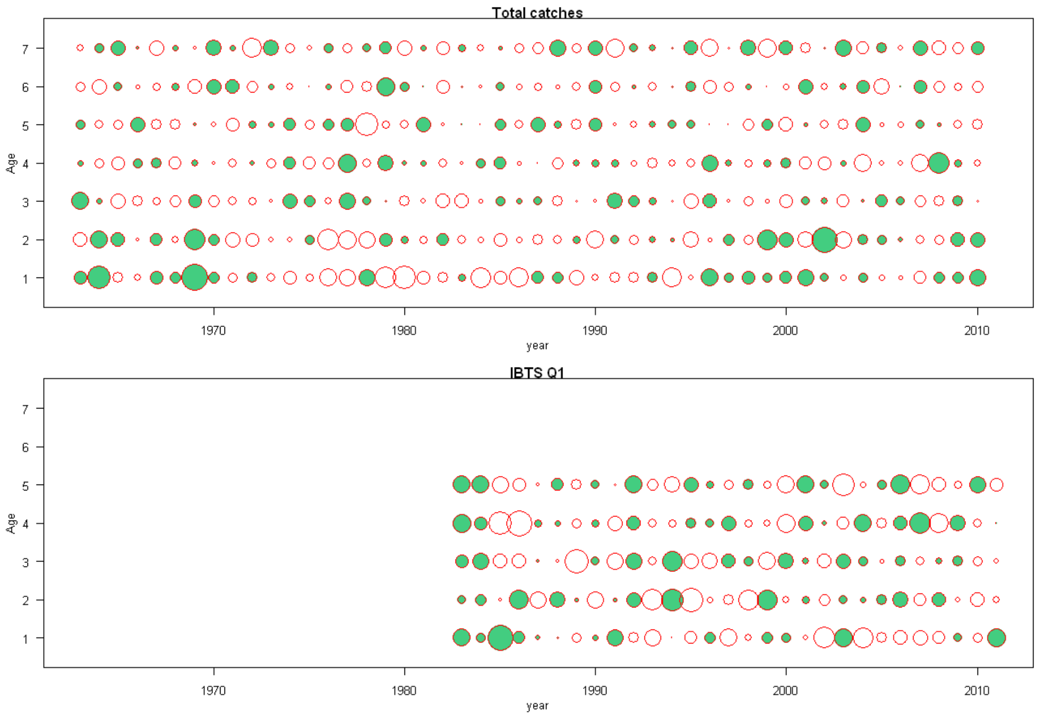

Figure 14.10 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Normalized residuals for the SAM base run, for total catch and IBTSQ1. Empty circles indicate a positive residual and filled circles negative residual.

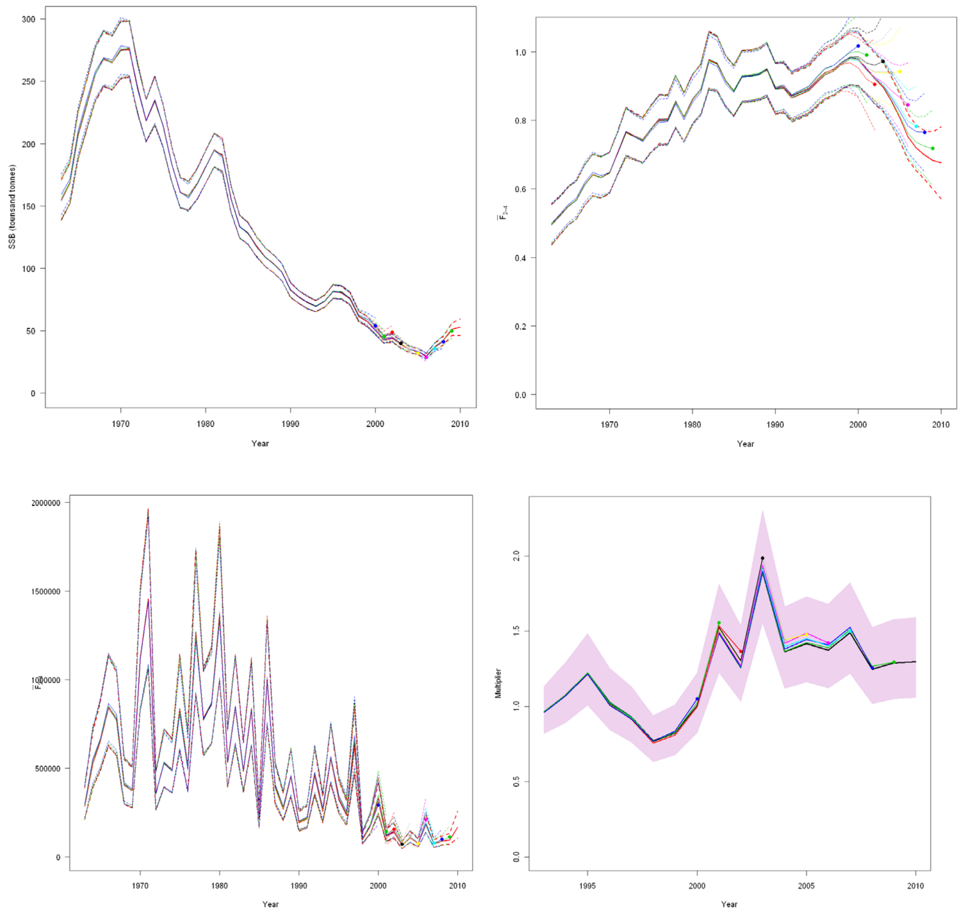

Figure 14.11 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Retrospective estimates (10 years) from the SAM base run. Estimated yearly SSB (top-left), average fishing motality (top-right), recruitment age 1 (bottom-left) and catch multiplier (bottom-right), together with corresponding point-wise 95% confidence intervals.

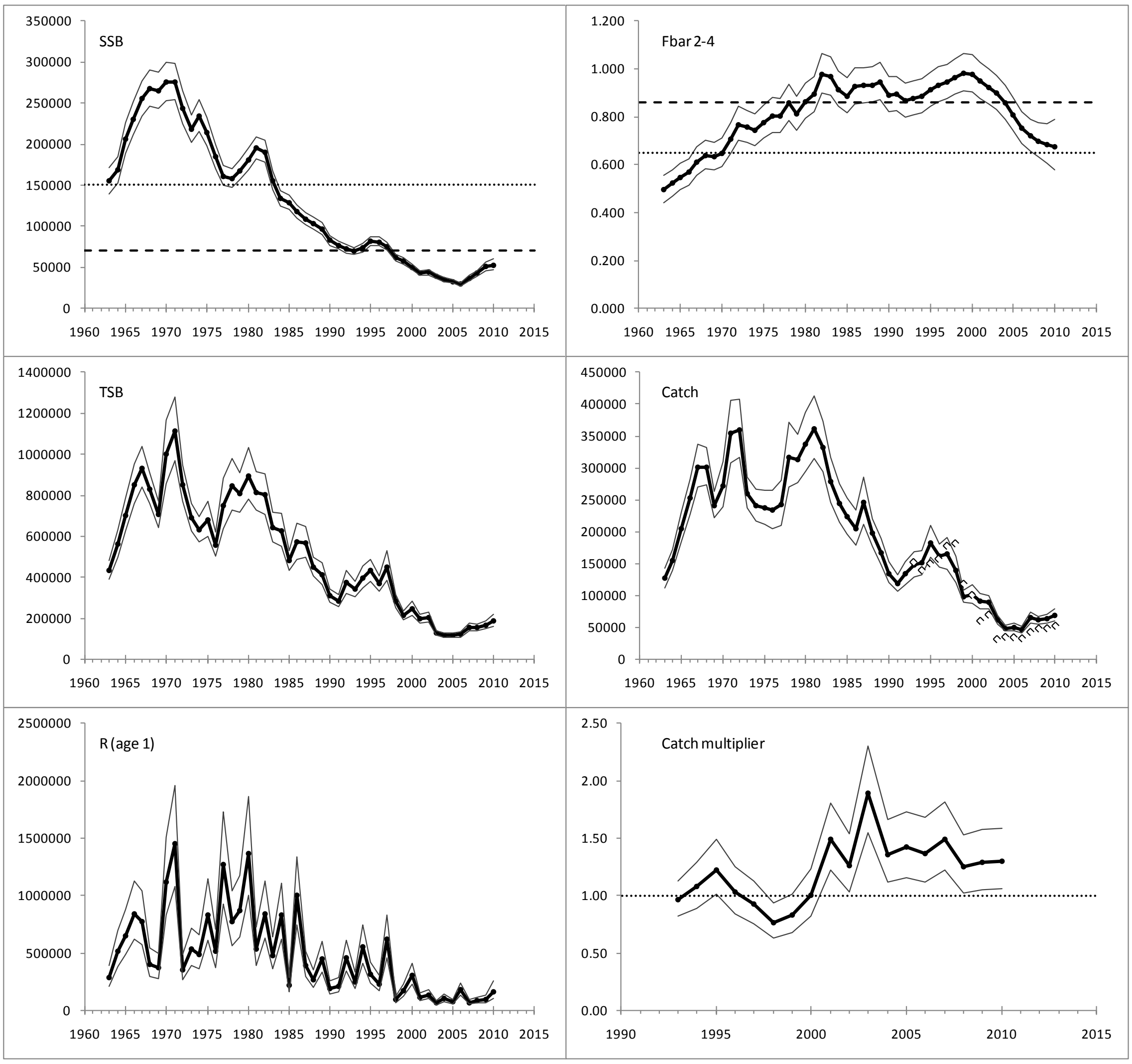

Figure 14.12 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Clockwise from top left, point-wise estimates and 95% confidence intervals of spawning stock biomass (SSB), total stock biomass (TSB), recruitment (R(age 1)), the catch multiplier, catch and mean fishing mortality for ages 2-4 (F(2-4)), 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.

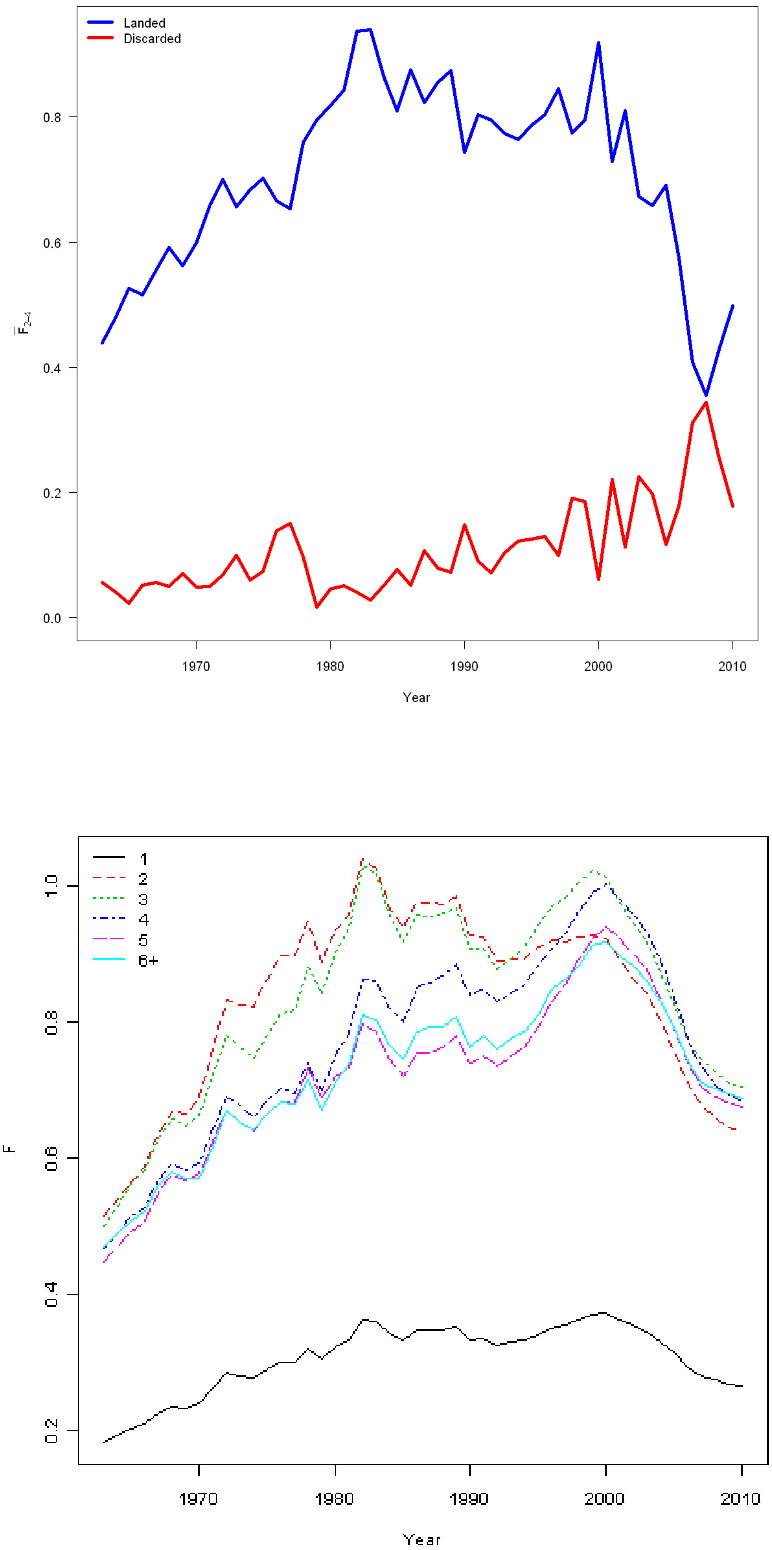

Figure 14.13 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. SAM model base run estimates of fishing mortality. The top panel shows mean fishing mortality for ages 2-4 (shown in Figure 14.12), but split into landings and discards components by using ratios calculated from the landings and discards numbers at age from the reported catch data, while the bottom panel shows fishing mortality for each age.

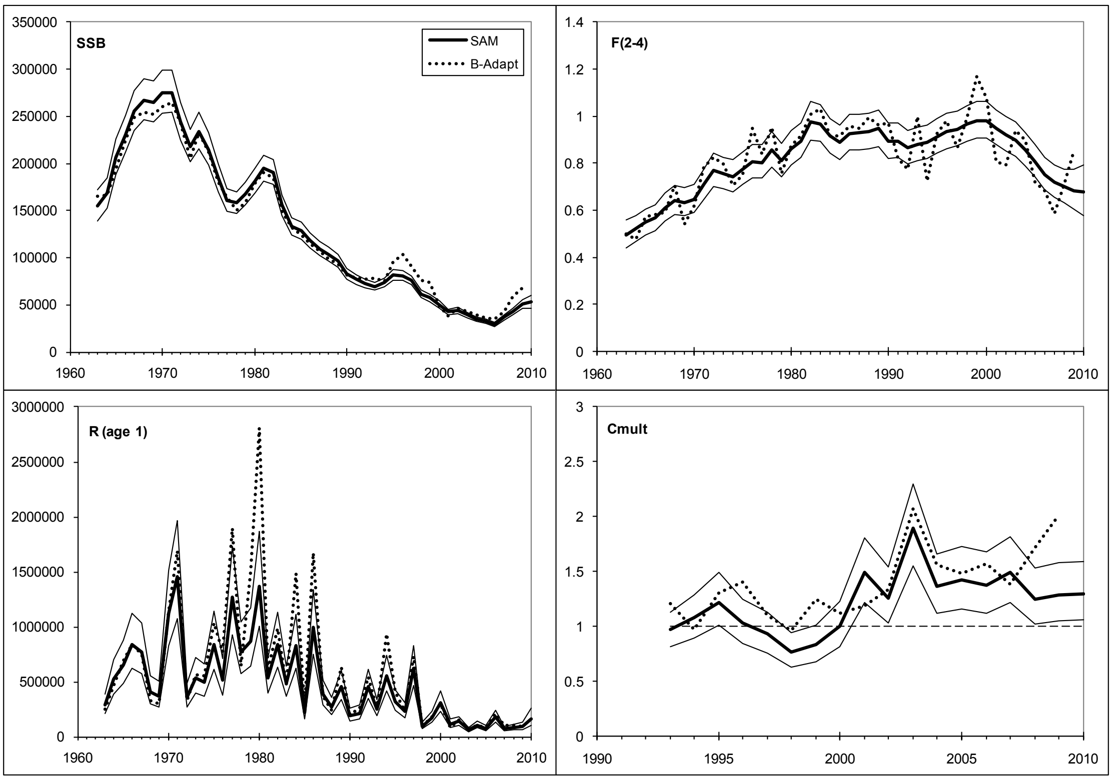

Figure 14.14 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. Comparison of final SAM assessment for 2011 with the final assessment for 2010 (B-Adapt). Plots are as described in Figure 14.12. Note that the IBTS Q3 survey is included in the 2010 assessment but not in the final assessment this year (both assessments include the IBTS Q1 survey).

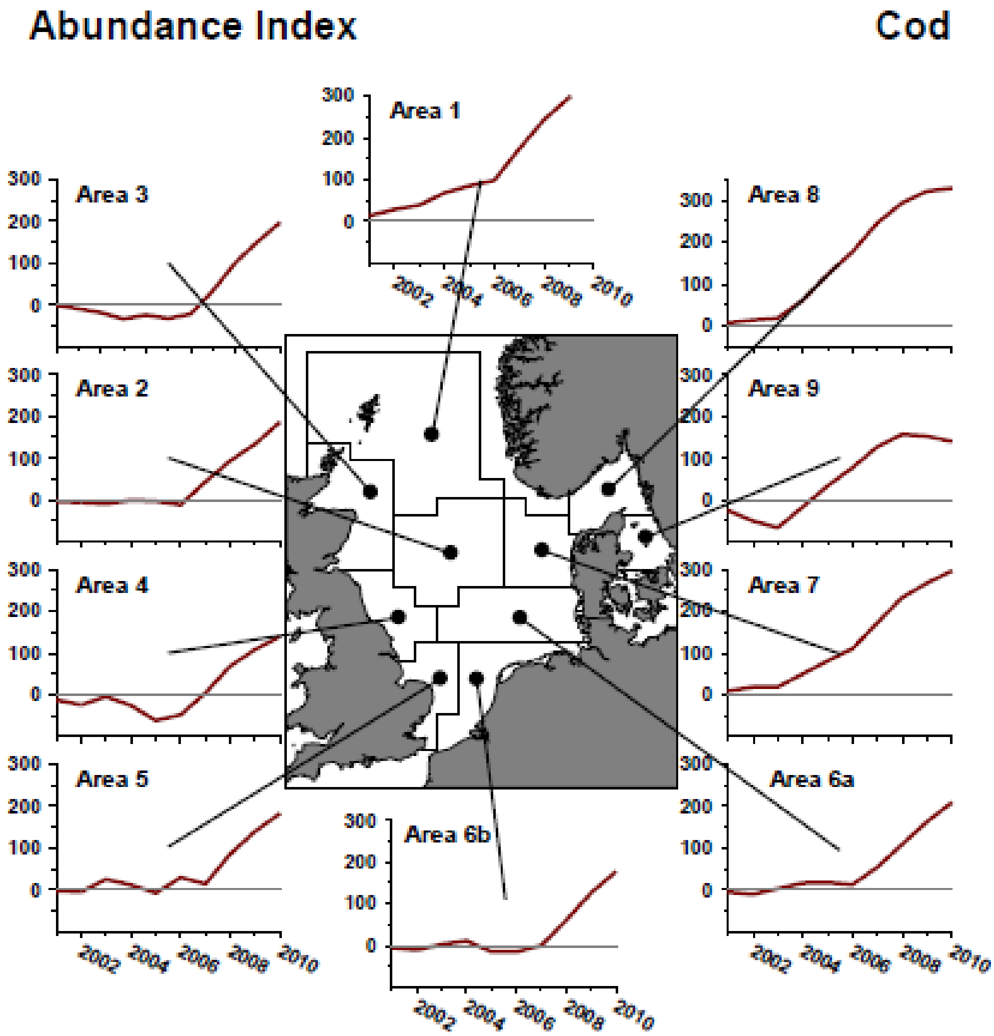

Figure 14.15 Cod in Subarea IV and Divisions IIIa (Skagerrak) and VIId. The North Sea Stock Survey fishers perception of the change abundance of North Sea cod since 2003 (Napier 2010).

15 Pollack

15.1 Biology

There is little published information on pollack biology. The species is restricted to the Northeast Atlantic with main distribution from the Biscay northwards around the British Isles, in Skagerrak and along the Norwegian coast where it is fairly common up to the Lofoten Islands. It is rare at Faroe and Iceland and in the Baltic.

According to FAO Fishbase pollack is benthopelagic, found mostly close to the shore over hard bottom. It usually occurs at 40-100 m depth but is found down to 200 m. Spawning takes place from January to May, mainly in March, and mostly at 100 m depth. Feeding is mainly on fish, and incidentally on crustaceans and cephalopods. FAO Fishbase gives a maximum length of 130 cm, and maximum published weight of 18.1 kg and maximum reported age of 8 years.

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.

French observations from the Western Channel/Celtic Sea region mainly support the information in Fishbase, although a higher maximum age (15 years) is given. Growth is thus fairly rapid, approaching 10 cm per year. There is a migration from the coast to deeper waters as it grows. Maturity occurs at approximately 3 years, and spawning time is given as March-July, i.e. somewhat later than Fishbase states.

French observations also show that it is most available for fishing when it forms spawning aggregations. Otherwise it has a preference for wrecks and rocky bottom, making it difficult to catch with trawls and therefore poorly suited for monitoring by research surveys.

Judging by landings data, there are two fairly distinct centres of distribution. 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.

15.2 Fisheries

Pollack appears to be mainly a bycatch in various fisheries. A more thorough analysis of landings data would provide more information on this.

15.3 Data

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 landing figures are thus probably reflecting at least the main trends in landings in the different areas.

The landings by country 1977-2009 in Skagerrak and the North Sea and are shown in Tables 15.1 and 15.2. Figure 15.1 show total landings in Subarea IV and Division IIIa 1977-2009. Figure 15.2 shows landings along the Norwegian coast north of 62°N (IIa), in Skagerrak (IIIa), the North Sea (IV), and West of Scotland (VIa), which together cover the northern complex indicated by the landings data.

Table 15.3 gives an overview of the more detailed landings data submitted to the WG: In addition there are some length measurements from Denmark and Norway. Data on life history parameters are missing, and an analytical assessement would require a time series of age samples representative for the area.

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	1,764		3	449	706		2932
1978	1	2,077			556	794		3428
1979	13	1,898			824	1,066		3801
1980	13	1,860			987	1,584		4444
1981	5	1,661			839	1,187	1	3693
1982	1	1,272			575	417		2265
1983	2	972			438	288		1700
1984	2	930			371	276		1579
1985		824			350	356		1530
1986	4	759			374	271		1408
1987	6	665			342	246		1259
1988	4	494			350	136		984
1989	3	554			313	152		1022
1990	8	1,842			246	253		2349
1991	2	1,824			324	281		2431
1992	8	1,228			391	320		1947
1993	6	1,130	1		364	442		1943
1994	5	645			276	238		1164
1995	10	497			322	271		1100
1996		680			309	273		1262
1997		364			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		471

Table 15.2. Pollack. Landings by country in Subarea IV. As officially reported to ICES.

	ICES Subarea IV										
	Belgium	**Denmark**	**Faroes**	**France**	**Germany**	**Netherl.**	**Norway**	**Poland**	**Sweden**	**UK**	**Total**
1977	121	275		75	142	38	419	9		442	1521
1978	102	249		98	154	21	492	2		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		880	2	106	315	1902
1985	14	308		69	23		686		51	363	1514
1986	44	550		45	21		602		67	362	1691
1987	21	427		988	21		471		40	290	2258
1988	32	432		367	30	10	560		20	296	1747
1989	31	273			21	4	568		37	269	1203
1990	44	924			34	3	651		126	366	2148
1991	31	1464			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			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		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	3	5	50	1	668		32	658	1551

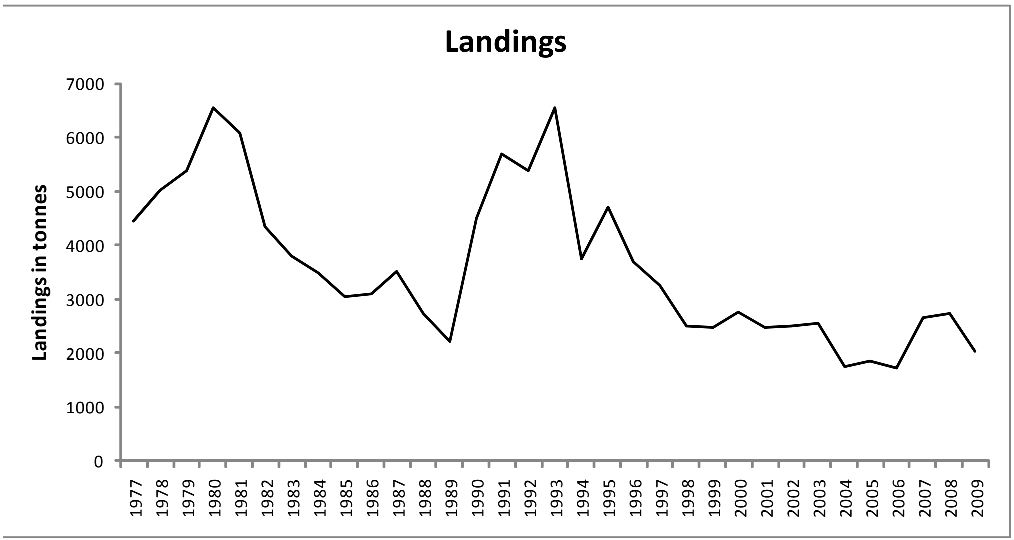

Figure 15.1. Total landings of Pollack in Division IIIa and Subarea IV.

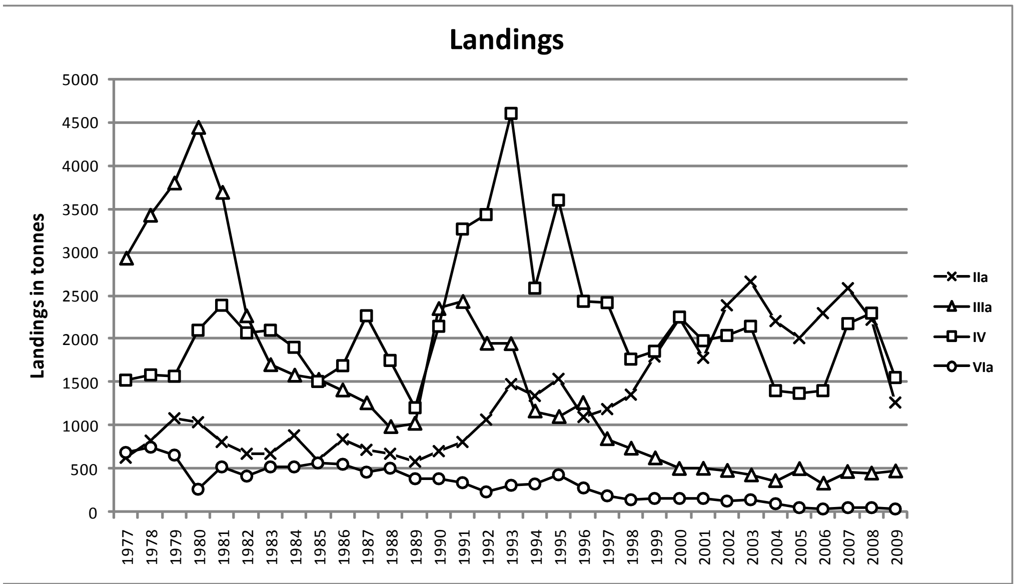

Figure 15.2. Landings of Pollack in Div. Iia, Div. IIIa, Subarea IV and Div. VIa.

16 Management Plan Evaluations

16.1 Evaluations of the long term management plan from sole and plaice in the North Sea, including implications for F_{MSY} framework reference points for these two stocks.

A long term management plan proposed by the Commission of the European Community was adopted by the Council of the European Union in June 2007 and first implemented in 2008 (EC Council Regulation No 676/2007). The plan consists of two stages. The first phase aims to ensure the return of the stocks of plaice and sole to within safe biological limits. This should be reached through a reduction of fishing mortality by 10% in relation to the fishing mortality estimated for the preceding year until an F of *circa* 0.2 is reached, in the case of sole, and *circa* 0.3, in the case of plaice. The plan sets a maximum change of 15% in TAC between consecutive years. Essentially this first phase represents a recovery plan, and this phase is considered to have been completed once both stocks have been found to be within safe biological limits for two consecutive years. The management plan then enters into a second phase during which the aim is to sustainably manage both stocks whilst simultaneously producing high long term yields. This is to be achieved by exploiting the stocks at the target F values. Full details of the management plan are available in Miller and Poos (2010). Full text of the plan (Articles 1-9) are included as an Appendix to this section.

16.1.1 Evaluations of the LTMP

ICES initially evaluated the management plan for North Sea plaice and sole at the end of May 2008 (unpublished review of an evaluation of the management plan for fisheries exploiting the stocks of plaice and sole in the North Sea (EC 676/2007) by ICES in 2008; Machiels et al. ICES WGNSSK 2008, Working Document 2; Machiels *et al*. 2008). It was accepted for sole and ICES concluded that it was in accordance with the precautionary approach. Subsequent ICES advice for this stock followed from the management plan. For plaice, the management plan evaluation was found to be inconclusive with regards to consistency with the precautionary approach and was therefore not used as the basis for ICXS advice.

In 2010 IMARES provided ICES with 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 (in accordance with the precautionary approach). 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.

16.1.2 The ICES MSY Framework

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. Given the computational difficulties in accurately determining F_{MSY} for most stock, ICES has said that advice for MSY reference points should be based on stock specific knowledge and broad experience. Accordingly, in 2010 the expert group provided provisional estimates of MSY framework reference points (F_{MSY} and MSY Btrigger) for sole and plaice in the North Sea (ICES 2010). ICES has stated that in principle the 2010 values would be used unless subsequent analyses indicated that updates were necessary.

In 2011 the Workshop on Implementing the ICES Fmsy Framework (WKFRAME-2) refined the procedure for how advice would be made on the basis of this framework (ICES 2011). This lead to the recommendation that for stocks that have approved management plans, advice should follow from these. Given that the LTMP has now been approved by ICES for both North Sea sole and plaice, ICES advice will now follow from the rules of this plan, and the F target it contains. It is worth noting here that the 2011 assessments of these stocks show that both have been within safe biological limits for at least two consecutive years, signaling the end of phase one of the management plan.

16.1.3 Sustainable yield analyses for North Sea sole and plaice

The recommendation by WKFRAME2 that simulation tested management plans supercede alternatively estimated F_{MSY} management was, in part, an acknowledgement that F_{MSY} is often poorly estimated, particularly for stocks with ill-defined stock recruitment relationships. In such cases, management procedures that have been extensively simulation tested could provide a more sound basis for long term sustainable yield and such management plans are often chosen taking long term yield into account as well. Both sole and plaice poor fits for most stock-recruit functional relationships (Figure 16.1.1) and as a result it is difficult to calculate F_{MSY} reference points for these stocks. However, the simulation studies carried out in the management plan evaluations provide useful information in determining what levels of exploitation are sustainable, as well as likely long term yields at these levels.

In addition to the management strategy evaluation simulation studies, the STECF evaluation report (Simmonds et al. 2010) also included an additional equilibrium analysis approach to determining F_{MSY}, taking into account uncertainty in stock recruitment relationships. These analyses compliment the CEFAS ADMB approach used at the ICES WGNSSK 2010 meeting in the setting of the initial F_{MSY} reference points for these stocks (ICES 2010).

In light of these simulation studies and new analyses it seems appropriate that the MSY framework reference points, and ranges, for both sole and plaice in the North Sea should be revisited. In the following sections, the key results of these analyses will be summarised. These results were presented at the WGNSSK 2011 meeting and the conclusions made follow on from these discussions.

It is considered sufficient to briefly describe the approaches and document the main conclusion here, detailed results of the various analyses are available in the published reports (ICES 2010, Miller and Poos 2010, and Simmonds et al. 2010). The CEFAS ADMB approach used in 2010 is detailed in the 2010 report of WGNSSK (ICES 2010). These equilibrium analyses take into account uncertainty in the input parameters, such as weights at age, maturity and stock numbers at age. The MSE simulations performed by Miller and Poos (2010) consisted of a detailed age-structured population model, including a range of different stock dynamics around the base case model. This incorporated uncertainty in stock recruitment function, measurement error and variability in the fishery. Several alternative stock dynamics and mixed fishery scenarios were tested. A range of management scenarios examined the likely impacts of varying aspects of the multi-annual plan on the stocks and the fishery, including different candidate F targets for each stock. The Simmonds equilibrium analysis (Simmonds et al. 2010, 2011) models recruitment stochastically based on multiple stock recruitment models for the populations. The set of models are based on Bayesian analysis to give a joint distribution of model coefficients (A,B and σ) for each functional type. The proportion of functional types is chosen based on probability estimates given the quality of the fit. The procedure is documented in Simmonds et al (2011) for the example of NE Atlantic mackerel. For the North Sea flatfish stocks the stock recruitment functions chosen were the Hockey-Stick (segmented regression) and the Ricker model.

16.1.4 F_{MSY} reference points for North Sea plaice

The chosen value for MSY Btrigger for plaice is considered to be appropriate (MSY $B_{trigger}$ = B_{pa} = 230 000t SSB). Further discussion focuses on the appropriate exploitation rate for this stock. The current management plan target for plaice is 0.3, and, given the new hierarchy of advice following WKFRAME2 (ICES 2011), this is the value that will be used to provide advice (given other constraints included within the management plan). On the basis of the CEFAS ADMB analyses (Table 16.1.1), an F range of 0.2-0.3 was considered appropriate as a basis for F_{MSY}. The MSE simulations conducted by IMARES (Table 16.1.2) indicated that alternative F targets in the 0.15 to 0.3 range lead to the stock stabilising at different levels of SSB, all above B_{pa} and precautionary with regards to the limit reference points in the short and long term. In additional, long term yields for Fs over the range 0.2-0.3 showed negligible differences. The equilibrium analyses taking into account uncertainty in stock recruitment relationships (Figure 16.1.2) indicated that alternative F targets over the range 0.2-0.3 all lead to similar long term TAC values (because these values lie on a flat-topped F_{MSY} distribution). The estimates of F_{MSY} from the long term equilibrium analysis method using 2010 assessment values, gives a value for North Sea plaice of F=0.25 (latest calculations; Simmonds, *et al*. 2010).

On the basis of these analyses the working group has 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. This finding is supported by all analyses including simulation tests, uncertainty in input parameters and uncertainty in stock recruit relationships. 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. This range also includes the management plan target value, thereby ensuring that ICES will not provide advice on the basis of this, while simultaneously stating that the stock is being unsustainably fished at this level.

16.1.5 F_{MSY} reference points for North Sea sole

The chosen value for MSY $B_{trigger}$ for sole is considered to be appropriate (MSY $B_{trigger}$ = B_{pa} = 35 000t SSB). Further discussion focuses on the appropriate exploitation rate for this stock. The current management plan target for plaice is 0.2, and, given the new hierarchy of advice following WKFRAME2 (ICES 2011), this is the value that will be used to provide advice (given other constraints included within the management plan). On the basis of the CEFAS ADMB analyses (Table 16.1.1), an F target of 0.22, within the range 0.13-0.39, was considered appropriate as a basis for F_{MSY}. The MSE simulations conducted by IMARES (Table 16.1.2) indicated that alternative F target values in the range 0.15 to 0.35 result in both short term and long term differences in

TAC. An F target of 0.15 produces lower TAC in both the short and long term, while a F target of 0.3 provides higher short term TACs, slowly becoming more similar to the long term TACs from F targets in the 0.2-0.25 range. There is a short term difference between 0.2 and 0.25, though in the long term this is less substantial. 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. The equilibrium analyses taking into account uncertainty in stock recruitment relationships (Figure 16.1.3) using 2010 assessment values gives an F_{MSY} value for North Sea sole of F=0.32. However, it is considered that it is important to take the risk into account when setting the target F for sole. An increase in F target might lead to higher catches, but the risks associated with increase in target F above 0.3 are considered to be not precautionary.

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. This finding is supported by all analyses including simulation tests, uncertainty in input parameters and uncertainty in stock recruit relationships. 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.

16.1.6 References

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.

Machiels, M.A.M., Kraak S.B.M., and Poos J.J. 2008. Biological evaluation of the first stage of the management plan for fisheries exploiting the stocks of plaice and sole in the North Sea according to Council Regulation (EC) no676/2007. IMARES Report number C031/08: 39 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 16.1.1. Stochastic and deterministic F_{MSY} estimates for the plaice and sole stocks in the North Sea given three different stock-recruit functions. Fmax estimates are also included. Data come from the WGNSSK 2010 assessments for the stocks (ICES 2010).

	Stochastic percentiles			Deterministic
	5%	50%	95%	
PLE				
Hockey Stick	0.02	0.19	0.3	0.2
Beverton and Holt	0.02	0.16	0.26	0.2
Ricker	0.19	0.32	0.7	0.36
Fmax	0.02	0.17	0.29	0.2
SOL				
Hockey Stick	0.1	0.29	0.57	0.49
Beverton and Holt	0.02	0.16	0.36	0.58
Ricker	0.13	0.22	0.39	0.31
Fmax	*	*	*	0.58

***Not Examined**

Table 16.1.2. Management strategy evaluation simulation results for alternative F target values in the North Sea flatfish long term management plan. Medium term (MT; 2015-2024) average annual yield and long term (LT) risk to the stock (chance of falling below precautionary limit reference points) for plaice and sole in the North Sea are shown. Data come from Miller and Poos (2010).

	PLE		**SOL**	
F	MT Yield (t)	Risk_Blim (%)	MT Yield (t)	Risk_Blim (%)
0.15	101979	0	15904	0
0.2	111468	0	17687	2
0.22	*	*	18215	2
0.23	113152	0	*	*
0.25	112885	0	19151	6
0.3	111376	0	20236	19
0.35	*	*	20568	20

***Not Examined**

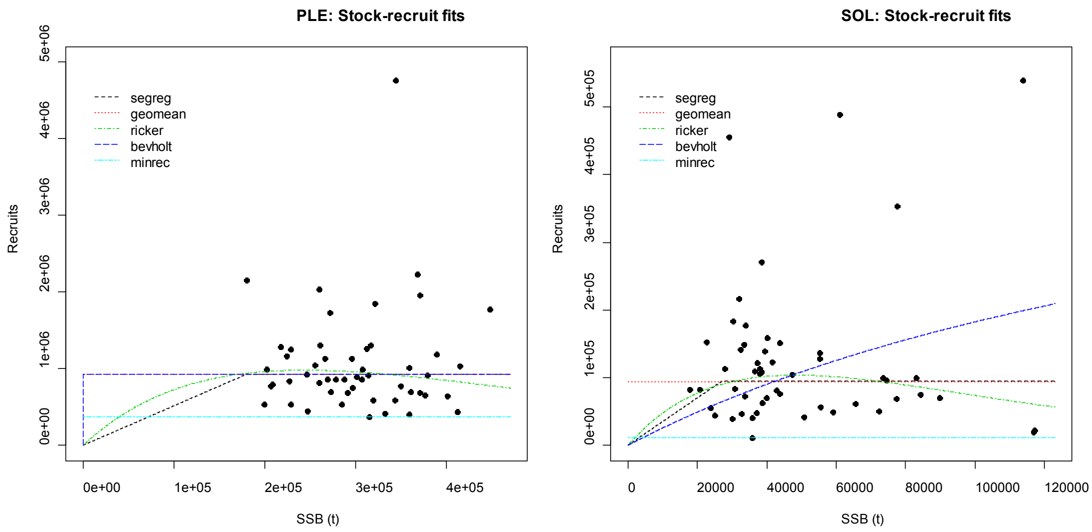

Figure 16.1.1. Stock-recruit scatters for the North Sea plaice (left) and sole (right) stocks. Data is from the 2010 assessments of the stocks (ICES 2010). The geometric mean (red) and minimum recruitment level (light blue) are plotted as well as segmented regression (black), Ricker (green), Beverton and Holt (dark blue) function fits.

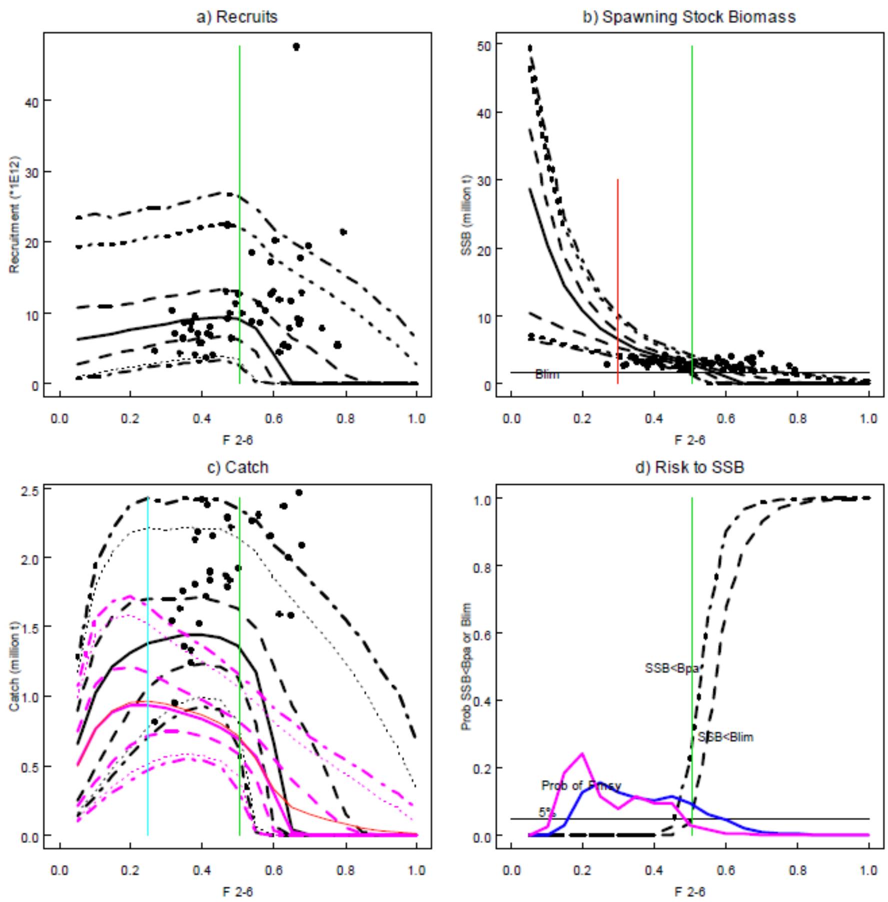

Figure 16.1.2. Equilibrium exploitation of NS plaice against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch: black lines and Landings pink lines. Historic Recruits, SSB and Catch: black dots. c) mean landings: red line. 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. From Simmonds *et al.* (2010).

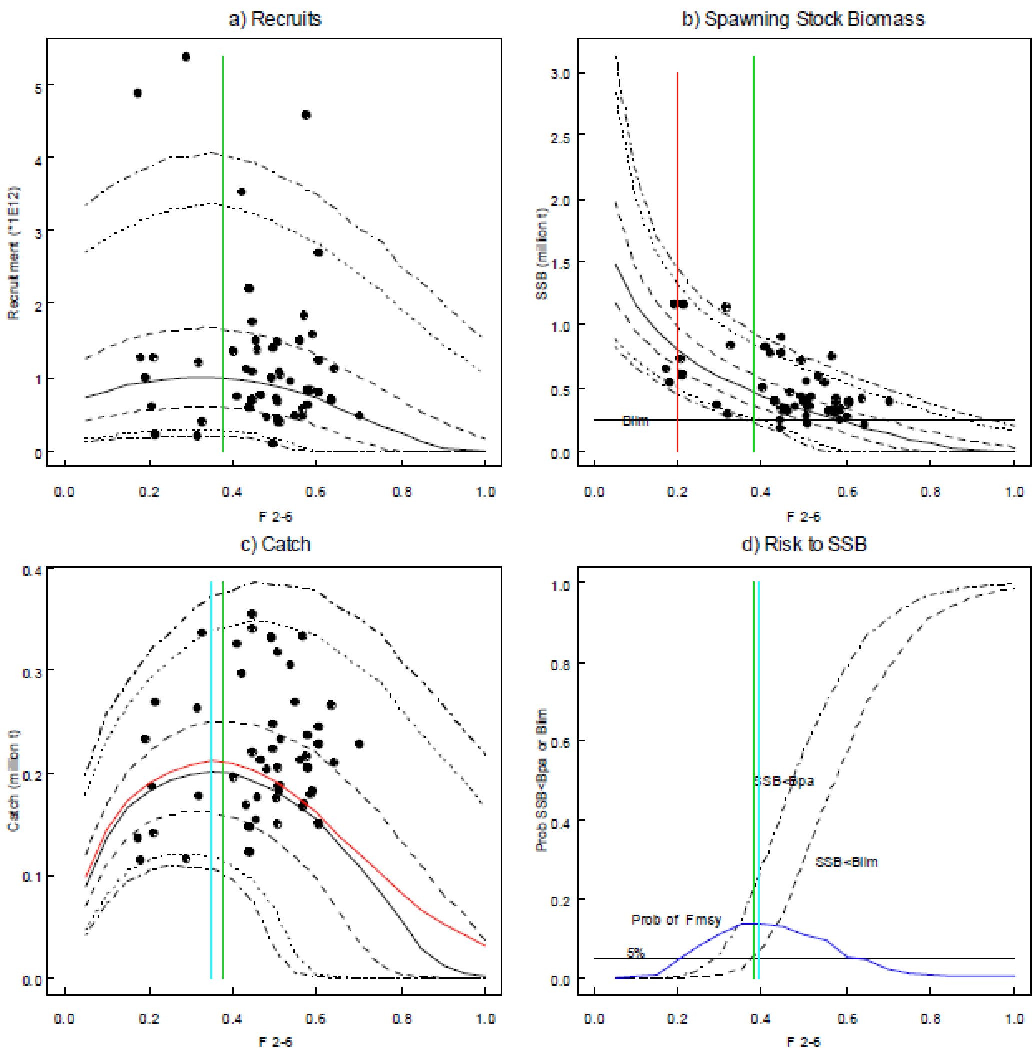

Figure 16.1.3. Equilibrium exploitation of NS sole against target F from F=0.05 to 1.0. Quantiles (0.025, 0.5, 0.25, 0.5, 0.75, 0.95, 0.975) of simulated a) Recruits, b) SSB and c) Catch/Landings: black lines. Historic Recruits, SSB and Catch/Landings black dots. c) mean catch/landings: red line. d) 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/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. From Simmonds et al. (2010).

Appendix A: *Articles 1 to 9 of Council Regulation (EC) No 676/2007 of 11 June 2007 establishing a multiannual plan for fisheries exploiting stocks of plaice and sole in the North Sea. Official Journal L 157 , 19/06/2007 P. 0001–0006*

CHAPTER I

SUBJECT-MATTER AND OBJECTIVE

Article 1

Subject-matter

This Regulation establishes a multiannual plan for the fisheries exploiting the stocks of plaice and sole that inhabit the North Sea.

For the purposes of this Regulation, "North Sea" means the area of the sea delineated by the International Council for the Exploration of the Sea as Subarea IV.

Article 2

Safe biological limits

1) *For the purposes of this Regulation, the stocks of plaice and sole shall be deemed to be within safe biological limits in those years in which, according to the opinion of the Scientific, Technical, and Economic Committee for Fisheries (STECF), all of the following conditions are fulfilled:*

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.

If the STECF advises that other levels of biomass and fishing mortality should be used to define safe biological limits, the Commission shall propose to amend paragraph 1.

Article 3

Objectives of the multiannual plan in the first stage

2) *The multiannual plan shall, in its first stage, ensure the return of the stocks of plaice and of sole to within safe biological limits.*

3) *The objective specified in paragraph 1 shall be attained by reducing the fishing mortality rate on plaice and sole by 10% each year, with a maximum TAC variation of 15% per year until safe biological limits are reached for both stocks.*

Article 4

Objectives of the multiannual plan in the second stage

4) *The multiannual plan shall, in its second stage, ensure the exploitation of the stocks of plaice and sole on the basis of maximum sustainable yield.*

5) *The objective specified in paragraph 1 shall be attained while maintaining the fishing mortality on plaice at a rate equal to or no lower than 0,3 on ages two to six years.*

6) *The objective specified in paragraph 1 shall be attained while maintaining the fishing mortality on sole at a rate equal to or no lower than 0,2 on ages two to six years.*

Article 5

Transitional arrangements

7) *When the stocks of plaice and sole have been found for two years in succession to have returned to within safe biological limits the Council shall decide on the basis of a proposal*

from the Commission on the amendment of Articles 4(2) and 4(3) and the amendment of Articles 7, 8 and 9 that will, in the light of the latest scientific advice from the STECF, permit the exploitation of the stocks at a fishing mortality rate compatible with maximum sustainable yield.

8) *The Commission's proposal for review shall be accompanied by a full impact assessment and shall take into account the opinion of the North Sea Regional Advisory Council.*

CHAPTER II

TOTAL ALLOWABLE CATCHES

Article 6

Setting of total allowable catches (TACs)

Each year, the Council shall decide, by qualified majority on the basis of a proposal from the Commission, on the TACs for the following year for the plaice and sole stocks in the North Sea in accordance with Articles 7 and 8 of this Regulation.

Article 7

Procedure for setting the TAC for plaice

9) *The Council shall adopt the TAC for plaice at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:*

a) *that TAC the application of which will result in a 10% reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year;*

b) *that TAC the application of which will result in the level of fishing mortality rate of 0,3 on ages two to six years in its year of application.*

Where application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15%, the Council shall adopt a TAC which is 15% greater than the TAC of that year.

Where application of paragraph 1 would result in a TAC which is more than 15% less than the TAC of the preceding year, the Council shall adopt a TAC which is 15% less than the TAC of that year.

Article 8

Procedure for setting the TAC for sole

10) *The Council shall adopt a TAC for sole at that level of catches which, according to a scientific evaluation carried out by STECF is the higher of:*

c) *that TAC the application of which will result in the level of fishing mortality rate of 0,2 on ages two to six years in its year of application;*

d) *that TAC the application of which will result in a 10% reduction in the fishing mortality rate in its year of application compared to the fishing mortality rate estimated for the preceding year.*

Where the application of paragraph 1 would result in a TAC which exceeds the TAC of the preceding year by more than 15%, the Council shall adopt a TAC which is 15% greater than the TAC of that year.

Where the application of paragraph 1 would result in a TAC which is more than 15% less than the TAC of the preceding year, the Council shall adopt a TAC which is 15% less than the TAC of that year.

CHAPTER III

FISHING EFFORT LIMITATION

Article 9

Fishing effort limitation

11) *The TACs referred to in Chapter II shall be complemented by a system of fishing effort limitation established in Community legislation.*

12) *Each year, the Council shall decide by a qualified majority, on the basis of a proposal from the Commission, on an adjustment to the maximum level of fishing effort available for fleets where either or both plaice and sole comprise an important part of the landings or where substantial discards are made and subject to the system of fishing effort limitation referred to in paragraph 1.*

13) *The Commission shall request from STECF a forecast of the maximum level of fishing effort necessary to take catches of plaice and sole equal to the European Community's share of the TACs established according to Article 6. This request shall be formulated taking account of other relevant Community legislation governing the conditions under which quotas may be fished.*

14) *The annual adjustment of the maximum level of fishing effort referred to in paragraph 2 shall be made with regard to the opinion of STECF provided according to paragraph 3.*

15) *The Commission shall each year request the STECF to report on the annual level of fishing effort deployed by vessels catching plaice and sole, and to report on the types of fishing gear used in such fisheries.*

16) *Notwithstanding paragraph 4, fishing effort shall not increase above the level allocated in 2006.*

17) *Member States whose quotas are less than 5% of the European Community's share of the TACs of both plaice and sole shall be exempted from the effort management regime.*

18) *A Member State concerned by the provisions of paragraph 7 and engaging in any quota exchange of sole or plaice on the basis of Article 20(5) of Regulation (EC) No 2371/2002 that would result in the sum of the quota allocated to that Member State and the quantity of sole or plaice transferred being in excess of 5% of the European Community's share of the TAC shall be subject to the effort management regime.*

19) *The fishing effort deployed by vessels in which plaice or sole are an important part of the catch and which fly the flag of a Member State concerned by the provisions of paragraph 7 shall not increase above the level authorised in 2006.*

Annex 1 – List of Participants

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak

4 - 10 May 2011

Name	Address	Phone/Fax	Email
Ewen Bell (Co-Chair)	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
Clara Ulrich Rescan (Co-Chair)	Clara Ulrich 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
Doug Beare	Wageningen IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31(0)317487233 Fax +31	douglas.beare@wur.nl
Andrea Belgrano	Swedish Board of Fisheries Institute of Marine Research, Lysekil P.O. Box 4 SE-453 21 Lysekil Sweden	Phone +46 523 18722 Fax + 46 523 13977	andrea.belgrano @fiskeriverket.se
Stijn Bierman	Wageningen IMARES Haringkade 1 1976 CP IJmuiden Netherlands	Phone +31 317481222 Fax +31 317487326	stijn.bierman@wur.nl
Ulrich Damm	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 268 Fax +49 40 38905 263	ulrich.damm@vti.bund.de
Chris Darby	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1502 524329 /+44 7909 885 157 Fax +44 1502 513865	chris.darby@cefas.co.uk
Helen Dobby	Marine Scotland – Science Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen Torry United Kingdom	Phone +44 1224 295411 Fax +44 1224 295511	dobbyh@marlab.ac.uk
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

Name	Address	Phone/Fax	Email
Espen Johnsen	Institute of Marine Research P.O. Box 1870 N-5817 Bergen Norway	Phone +47 55 23 53 55 Fax +47 55 23 86 87	espen.johnsen @imr.no
Alexander Kempf	Johann Heinrich von Thunen Institutr Institute for Sea Fisheries, Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 194	alexander.kem pf@vti.bund.de
Ana Leocadio	Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1502 524280 Fax +44	Ana.leocadio@ cefas.co.uk
Colin Millar	Marine Scotland – Science Marine Laboratory P.O. Box 101 AB11 9DB Aberdeen Torry United Kingdom	Phone +44 1224 295575 Fax +44 1224 295511	millarc@marla b.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
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@marla b.ac.uk coby.needle@sc otland.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
Sofie Nimmegeers	Institute for Agricultural and Fisheries Research (ILVO) Ankerstraat 1 8400 Oostende Belgium	Phone +32 59569806 Fax +32 59330629	sofie.nimmeg eers@ilvo.vlaa nderen.be
José De Oliveira	Centre for Environment, Fisheries and Aquaculture Science Lowestoft Laboratory Pakefield Road NR33 0HT Lowestoft Suffolk United Kingdom	Phone +44 1502 527 7 27 Fax +44 1502 524 511	jose.deoliveira @cefas.co.uk
Jan Jaap Poos	Wageningen IMARES P.O. Box 68 NL-1970 AB IJmuiden Netherlands Email	Phone +31 317 487 189 Fax IMARES general +31 317 480 900	Janjaap.Poos@ wur.nl
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.ulmestra nd@fiskeriver ket.se

Name	Address	Phone/Fax	Email
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: Ewen Bell, UK and Clara Ulrich, DK) met by correspondence at the beginning of October 2011 to evaluate new information from the fisheries independent surveys carried out during 2011 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 2011 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 potential for re-opening of the advice for sole, resulting in a 3.2% increase of the TAC under the Management Plan, and for saithe, with a 15% decrease of the TAC compared to last year. The estimates of recruitment for plaice and haddock are also significantly different from the values used in the spring, with an increase for plaice and a reduction for haddock. However, the 15% cap on interannual TAC variation implemented in the Management Plans for both stocks implies that the advice remains unchanged for 2012. But a 2% reduction in haddock biomass for 2013 is expected, compared to the spring advice. No significant changes were observed for whiting.

2.2 Cod in Sub-Area 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 2011), 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 (WKFREQ) was to have considered potential revisions to the protocol, but has been postponed several times and will not now meet until 2012 at the earliest.

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 (2011) year class at age 0. The RCT3 input and output files are given in Tables 2.3.2 and 2.3.3.

Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2011 year-class	
Log WAP from RCT3	7.42
Log of recruitment assumed in spring	8.21
Int SE of log WAP	0.36
Distance D	**-2.18**

2.3.3 Conclusions from protocol

As the distance D < -1.0, the protocol concludes that **the advisory process for North Sea haddock should be reopened.** The autumn indices suggest that the incoming year-class is significantly weaker than assumed in the forecast produced in May 2011.

2.3.4 Revised forecast

The forecast was re-run, using the new estimate of recruitment for the 2011 year-class (1669034) in place of the value assumed in May 2011 (3662978). The values assumed for the 2012 year-class and beyond were left unchanged from the May 2011 forecast, as were all other run settings (see ICES-WGNSSK 2011 for details). The results of the new forecast (catch option table) are shown in Table 2.3.4. As with the May forecast, this new forecast indicates that the target F in the EU-Norway management plan (F = 0.3) would lead to landings in 2012 that were 19% greater than the TAC in 2011. Since the forecast biomass for the start of 2013 (the year after the quota) is greater than Bpa (140 kt) for this level of fishing mortality, the TAC constraint of +/- 15% applies. The management plan, therefore, leads to an advised landings quota of **41575 t**, which is 15% greater than the quota for 2011. This is the same conclusion as was reached in May: the reason for this is that, although the estimated recruitment for 2011 is much smaller than forecast in May, this reduction will not have a large effect on either landings or SSB by 2013.

Finally, although the baseline advice is not changed by this new forecast, the implications for SSB in 2013 are more significant. The following text table summarises the percentage change in landings (2012) and SSB (2013) when forecasting according to the target F in the management plan (0.3), using recruitment estimates generated in May and October.

Effect on landings 2012		Effect on SSB 2013	
	Plan target		Plan target
May	43231	May	227324
October	43156	October	222675
Difference	-0.174%	Difference	-2.045%

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 2009 are highlighted.

EngGFS Q3 GOV							
1992	2011						
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

ScoGFS Q3 GOV							
1998	2011						
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

Table 2.3.2. Haddock in Sub-Area IV and Division IIIa. RCT3 input file. Data from surveys in autumn 2009 are highlighted in bold.

HADDOCK IN IV, RCT3 INPUT VALUES									
8	31	2							
'YEARCLASS'	'VPA'	'IBTS1'	'IBTS2'	'EGFS0'	'EGFS1'	'EGFS2'	'SGFS0'	'SGFS1'	'SGFS2'
1981	32606.103	-1	403.079	-1	-1	-1	-1	-1	-1
1982	20488.195	302.278	221.275	-1	-1	-1	-1	-1	-1
1983	66943.546	1072.285	833.257	-1	-1	-1	-1	-1	-1
1984	17180.273	230.968	266.912	-1	-1	-1	-1	-1	-1
1985	23917.418	573.023	328.062	-1	-1	-1	-1	-1	-1
1986	49002.387	912.559	677.641	-1	-1	-1	-1	-1	-1
1987	4154.844	101.691	98.091	-1	-1	-1	-1	-1	-1
1988	8337.202	219.705	139.114	-1	-1	-1	-1	-1	-1
1989	8604.153	217.448	134.076	-1	-1	-1	-1	-1	-1
1990	28334.295	680.231	331.044	-1	-1	29.133	-1	-1	-1
1991	27456.974	1141.396	519.521	-1	58.746	17.435	-1	-1	-1
1992	41943.346	1242.121	491.051	246.059	73.145	26.992	-1	-1	-1
1993	13122.801	227.919	201.069	40.336	23.990	13.223	-1	-1	-1
1994	55983.396	1355.485	813.268	279.344	113.775	43.044	-1	-1	-1
1995	14292.721	267.411	353.882	53.435	26.747	12.608	-1	-1	-1
1996	21442.638	849.943	420.926	61.301	45.346	16.778	-1	-1	1924.000
1997	12752.842	357.597	222.907	40.653	26.497	8.404	-1	6349.000	1141.225
1998	9957.388	211.139	107.060	15.747	16.551	4.528	3280.000	1907.141	460.380
1999	138417.502	3734.185	2255.213	626.610	249.813	96.498	66067.310	30610.761	11352.408
2000	26490.420	894.651	492.299	92.139	28.622	22.559	11902.085	3789.563	2632.471
2001	2843.508	58.211	38.585	1.097	3.954	1.247	78.620	674.629	306.570
2002	3727.538	89.958	79.622	2.721	6.015	3.864	2149.357	1171.747	547.075
2003	3898.976	71.875	60.993	3.199	6.599	5.992	2159.063	1197.900	657.000
2004	3716.574	69.976	47.784	3.398	9.740	3.226	1729.375	761.000	272.366
2005	42319.097	1212.163	963.325	122.383	54.403	43.401	19708.000	7274.775	5527.486
2006	9031.849	109.096	106.489	12.838	10.628	5.801	2280.197	1809.595	1002.000
2007	5287.388	60.115	140.045	8.463	6.494	6.781	1118.878	733.000	547.365
2008	4293.403	74.687	72.980	2.613	5.532	2.959	1885.000	877.189	679.988
2009	33107.554	685.730	772.865	28.978	46.229	32.591986	9014.824	8328.400	5192.4737
2010	1794.179	46.416	-1	3.065	2.7918481	-1	115.438	252.27632	-1
2011	-1	-1	-1	0.549313	-1	-1	316.8815	-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   31 years :  1981 - 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
+                                                   excluded
 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

 IBTS1
 IBTS2
 EGFS0      .72   7.07    .35   .923     19    .44    7.39     .406     .785
 EGFS1
 EGFS2
 SGFS0      .77   3.09    .66   .806     13   5.76    7.52     .776     .215
 SGFS1
 SGFS2

                                        VPA Mean =    9.58    1.076     .000


 Year     Weighted      Log     Int     Ext     Var     VPA      Log
 Class     Average      WAP     Std     Std    Ratio             VPA
          Prediction           Error   Error

 2011        1663      7.42     .36     .05      .02
```

Table 2.3.4. Haddock in Sub-Area IV and Division IIIa. Revised catch option table, generated using a recruitment estimate for 2011 from RCT3 applied to 2011 autumn survey data.

MFDP version 1a
Run: 13oct
Time and date: 15:26 13/10/2011
Fbar age range (Total) : 2-4
Fbar age range Fleet 1 : 2-4
Fbar age range Fleet 2 : 2-4

2011

		Catch			Landings		Discards		IBC	Landings	
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield
500151	235072	1	0.233	52745	0.146	31699	0.085	20674	1	0.001	372

2012												2013			
		Catch			Landings		Discards		IBC	Landings					
Biomass	SSB	FMult	FBar	Yield	FBar	Yield	FBar	Yield	FMult	FBar	Yield	Biomass	SSB	TAC change	
486231	255194	0.00	0.001	176	0.000	0	0.000	0	1	0.001	176	528004	281645	-100%	No HC fishery
.	255194	0.10	0.024	5096	0.015	3759	0.009	1163	1	0.001	174	522210	276477	-90%	
.	255194	0.20	0.048	9916	0.029	7443	0.017	2301	1	0.001	172	516540	271419	-79%	
.	255194	0.30	0.071	14636	0.044	11052	0.026	3414	1	0.001	170	510990	266467	-69%	
.	255194	0.40	0.094	19263	0.059	14589	0.034	4505	1	0.001	169	505557	261620	-60%	
.	255194	0.50	0.117	23794	0.073	18055	0.043	5572	1	0.001	167	500240	256875	-50%	
.	255194	0.60	0.140	28233	0.088	21452	0.051	6616	1	0.001	165	495035	252230	-41%	
.	255194	0.70	0.163	32585	0.102	24782	0.060	7639	1	0.001	164	489940	247682	-31%	
.	255194	0.80	0.187	36847	0.117	28045	0.068	8640	1	0.001	162	484952	243229	-22%	
.	255194	0.88	0.206	40352	0.129	30729	0.075	9463	1	0.001	160	480854	239570	-15%	15% quota decrease
.	255194	0.90	0.210	41023	0.132	31243	0.077	9620	1	0.001	160	480069	238870	-14%	
.	255194	1.00	0.233	45116	0.146	34378	0.085	10579	1	0.001	159	475289	234601	-5%	Fsq
.	255194	1.06	0.246	47431	0.155	36152	0.090	11121	1	0.001	158	472587	232189	0%	Roll-over TAC
.	255194	1.10	0.256	49126	0.161	37451	0.094	11518	1	0.001	157	470609	230422	4%	
.	255194	1.20	0.279	53057	0.176	40463	0.102	12438	1	0.001	156	466027	226329	12%	
.	255194	1.24	0.288	54507	0.181	41575	0.106	12777	1	0.001	155	464338	224820	15%	15% quota increase
.	255194	1.29	0.300	56569	0.189	43156	0.110	13259	1	0.001	154	461936	222675	19%	F(msy) = target
.	255194	1.30	0.302	56908	0.190	43416	0.111	13338	1	0.001	154	461541	222322	20%	
.	255194	1.40	0.326	60684	0.205	46311	0.120	14220	1	0.001	153	457148	218397	28%	
.	255194	1.50	0.349	64384	0.220	49150	0.128	15083	1	0.001	151	452847	214554	36%	
.	255194	1.60	0.372	68012	0.234	51933	0.137	15929	1	0.001	150	448635	210791	44%	
.	255194	1.70	0.395	71566	0.249	54661	0.145	16757	1	0.001	148	444510	207105	51%	
.	255194	1.80	0.418	75051	0.263	57337	0.154	17567	1	0.001	147	440471	203494	59%	
.	255194	1.90	0.441	78467	0.278	59960	0.162	18361	1	0.001	146	436516	199958	66%	
.	255194	2.00	0.465	81816	0.293	62533	0.171	19139	1	0.001	144	432642	196495	73%	

Input units are thousands and kg - output in tonnes

2.4 Saithe in Subarea IV, VI and Division IIIa

New Survey Information

The autumn 2011 survey data for saithe were available from three surveys and the AGCREFA procedure (ICES-ACREFA 2008) was used for evaluating the new information in these data. As age 3 and 4 are not fully recruited, the protocol was applied on both ages. The RCT3 analysis showed no significant difference between the May assessment and the autumn survey estimates for 3 year old, but for 4 year old, the RCT3 showed a significant increase in abundance in all three surveys.

Two different forecasts were presented:

[option 1] A revised short term forecast was therefore run using the same settings as in May but with the age 4 population abundance adjusted to the new RCT3 value.

[option 2] The assessment rerun with the pre-benchmark settings based on the latest input data. This options was used as the basis for the November update of the advice (see review group technical minutes Annex 8).

Option 1 results saithe assessment

Observations on the Assessment.

The 2011 ICES Roundfish Benchmark meeting (ICES-WKBENCH 2011) revised the North Sea saithe (ICES Divisions IV and VIa) assessment model structure, removing the commercial data series used for calibration at ages 3-5 and retaining ages 6-9. Only survey data was used to fit ages 3-5 as the group considered that survey data were fishery independent and potentially less biased (despite evidence of strong, autocorrelated time trends in the residuals).

Assessment model estimates derived by the subsequent WGNSSK May meeting (ICES- WGNSSK 2011) indicated strong increases in the fishing mortality at the youngest ages (3-5) in the final year. Older age fishing mortality remained relatively constant. The reference fishing mortality was estimated to have increased to above Flim (0.6) in 2010. The assumption of TAC constraint in 2011 (at 103kt) implies a decrease in F to 0.46 in 2011.

Concerns were raised that the increase in fishing mortality at the youngest ages between 2008 and 2010 could be a result from either targeted fishing of less abundant year classes during a declining stock abundance (hyperstability in the fishing process) or from the change to the assessment model structure giving more weight to survey data. WGNSSK noted that new survey would be available in the autumn and the annual update process should establish whether the cause of the estimated sudden increase in mortality at the youngest ages could be ascertained.

Updated assessment analysis

There now appear to have been a sequence of strong year effects in the fisheries surveys (IBTSQ3 and NORASS) which have significantly impaired the ability of these surveys to track year class strength. These year effects may be the driving force behind the strong increase in F on the younger ages (2008-2010) as estimated by the Benchmark-approved assessment model fitted in May. The 2011 survey results show a strong increase in abundance at all ages in both surveys (and are therefore likely to force a reduction in recent F estimates in the 2012 assessment). The current estimate of fishing mortality in 2010 (close to Flim) is therefore considered highly uncertain.

A number of alternative assessment models have been run in order to explore the influence of these apparent year effects in survey catchability. The outlook for the stock is sensitive to the various assessment model structures, all of which indicate the stock is in a better position than the May assessment suggests with higher SSB and lower F, although the lower recruitments in 2008 and 2009 remain an issue. The output from assessment models cannot be accepted without a benchmark meeting and consequently WGNSSK has compared their estimates with that of the May assessment with revised recruitment for the provision of advice. **It is recommended that survey data are reviewed and the implications for an assessment model structure revisited before WGNSSK 2012 convenes**.

Conclusion

The new forecast with update recruitment indicates that the stock status in 2013 is projected to be considerably improved compared to the ICES May advice. SSB is expected to decline to between Blim and Bpa in 2012 but then begin to rebuild in 2013. Following the AGCREFA protocol and updating the forecast performed in May indicates that if the -15% TAC constraint is used for landings in 2010 the SSB in 2013 will be comfortably away from B_{lim}.

There is a high degree of uncertainty in the recent assessment estimates as a result of recent year effects in the fishing and acoustic surveys and consequently the recent fishing mortality may be over-estimated and the SSB trajectory pessimistic. The inclusion of a +/-15% TAC constraint in the management plan was partly designed to allow for assessment uncertainty.

The results of following the AGCREFA protocol are supported by the alternative models fitted this autumn. All of the fitted models indicate that recent fishing mortality has been increasing and recent recruitment low, therefore WGNSSK considers that the appropriate TAC advice should be in line with clause 5 of the management plan that is a 15% TAC reduction. The advice to enact clause 6 of the Management Plan (i.e. go beyond a 15% TAC reduction) is no longer considered appropriate.

Saithe 3 years, RCT3 analysis

Input file

3	22	2		
1990	152278	-11	7.965	-11
1991	103458	-11	1.117	-11
1992	225510	56244	13.959	-11
1993	111978	21480	3.825	-11
1994	165232	22585	3.756	-11
1995	70716	15180	1.027	-11
1996	140145	16933	2.1	-11
1997	92990	34551	3.479	-11
1998	225967	72108	21.496	-11
1999	194161	82501	10.748	-11
2000	126370	67774	19.272	-11
2001	96016	34153	4.979	-11
2002	184032	48446	8.893	-11
2003	56778	18909	10.636	7.66
2004	116407	77958	34.018	55.47
2005	60102	7122	3.467	30.89
2006	41462	-11	1.346	27.68
2007	81056	2490	1.365	30.79
2008	-11	19659	2.762	28.86
2009	-11	-11	-11	-11
2010	-11	-11	-11	-11
2011	-11	-11	-11	-11

NORACU
IBTSq3
NORASS

Data for 3 surveys over 22 years : 1990 – 2011
Regression type = C
Tapered time weighting applied
power = 3 over 20 years
Survey weighting not applied
Final estimates shrunk towards mean
Minimum S.E. for any survey taken as .20
Minimum of 3 points used for regression
Forecast/Hindcast variance correction used.

Yearclass = 2007

2010	I-----------Regression----------I					I-----------Prediction---------I			
Survey/Series	Slope	Intercept	Std Error	Rsquare	No. Pts	Index Value	Predicted value	Std Error	WAP Weights
NORACU	0.82	3.09	0.48	0.525	14	7.82	9.52	0.783	0.253
IBTSq3	1.15	9.23	0.91	0.276	17	0.86	10.22	1.113	0.125
NORASS	1.05	7.65	0.86	0.278	4	3.46	11.28	1.373	0.082

VPA Mean = 11.58 .536 .540

Yearclass = 2008

2010	I-----------Regression----------I					I-----------Prediction---------I			
Survey/Series	Slope	Intercept	Std Error	Rsquare	No. Pts	Index Value	Predicted value	Std Error	WAP Weights
NORACU	0.64	5.11	0.56	0.436	15	9.89	11.42	0.648	0.297
IBTSq3	1.05	9.47	0.85	0.295	18	1.32	10.86	0.989	0.127
NORASS	1.06	7.61	0.71	0.289	5	3.4	11.21	1.009	0.122

VPA Mean = 11.54 .524 .453

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2007	52142	10.86	0.39	0.52	1.72	81057	11.30
2008	87411	11.38	0.35	0.13	0.13		
2009	No valid	surveys					
2010	No valid	surveys					
2011	No valid	surveys					

********************RESULT FOR AGE 3 **********************************

This gives a D=(Log WAP from RCT3) – (Log of 3 year old assumed in May)/(Internal Std Error in RCT3) =(11.38-11.68)/0.35=-0.86, for 3 year old, this does not suggest a reopening of the advice.

****

Saithe 4 years, RCT3 analysis

Input:3 20 2

1991	66645	4756	2.501	-11
1992	160506	29698	6.533	-11
1993	81667	16188	3.351	-11
1994	121676	48295	3.921	-11
1995	48521	21109	2.019	-11
1996	106210	82338	8.836	-11
1997	69741	28764	6.173	-11
1998	170481	163524	18.974	-11
1999	140947	107730	23.802	-11
2000	92912	43811	6.896	-11
2001	73802	36560	6.87	-11
2002	138065	58132	29.82	17.89
2003	37555	12070	5.594	6.28
2004	79484	18989	5.86	23.42
2005	40437	-11	1.703	11.83
2006	25508	5225	0.962	5.07
2007	-11	50840	4.059	286.41
2008	-11	-11	-11	-11
2009	-11	-11	-11	-11
2010	-11	-11	-11	-11

NORACU

IBTSq3

NORASS

Analysis by RCT3 ver3.1 of data from file :

Data for 3 surveys over 20 years : 1991 - 2010

Regression type = C

Tapered time weighting applied

power = 3 over 20 years

Survey weighting not applied

Final estimates shrunk towards mean

Minimum S.E. for any survey taken as .20

Minimum of 3 points used for regression

Forecast/Hindcast variance correction used.

Yearclass = 2006

2010	I-----------Regression----------I					I-----------Prediction---------I			
Survey/Series	Slope	Intercept	Std Error	Rsquare	No. Pts	Index Value	Predicted value	Std Error	WAP Weights
NORACU	0.67	4.4	0.36	0.65	14	8.56	10.09	0.51	0.339
IBTSq3	0.87	9.52	0.45	0.581	15	0.67	10.1	0.583	0.259
NORASS	1.53	6.98	0.64	0.581	4	1.8	9.74	1.329	0.05

VPA Mean = 11.34 .500 .353

Yearclass = 2007

2010	I-----------Regression----------I					I-----------Prediction---------I			
Survey/Series	Slope	Intercept	Std Error	Rsquare	No. Pts	Index Value	Predicted value	Std Error	WAP Weights
NORACU	0.65	4.56	0.31	0.795	15	10.84	11.59	0.366	0.491
IBTSq3	0.84	9.55	0.41	0.701	16	1.62	10.91	0.467	0.3
NORASS	1.31	7.61	0.47	0.732	5	5.66	15.03	1.747	0.022

VPA Mean = 11.23 .592 .187

Year Class	Weighted Average Prediction	Log WAP	Int Std Error	Ext Std Error	Var Ratio	VPA	Log VPA
2006	36935	10.52	0.3	0.35	1.42	25509	10.15
2007	88762	11.39	0.26	0.35	1.92		
2008	No valid	surveys					
2009	No valid	surveys					
2010	No valid	surveys					

This gives D=(Log WAP from RCT3) – (Log of 4 year old assumed in May)/(Internal Std Error in RCT3) =(11.39-10.72)/0.26= 2.58, which is a distance that suggest reopening of the advice.

Saithe results: Updated option table for summary sheet

Outlook for 2012

Basis: F(2011) = estimated from landings constraint 2011 =0.46; R11–13 = GM88–08 =118.030; SSB(2012) = 142; landings (2011) = 103.

Rationale	landings 2012	landings IIIa&IV 20121)	landings VI 20121)	Basis	F 2012	SSB 2013	%SSB change 2)	% TAC change 3)
Management plan 4) § 5	87.548	79.318	8.230	15 % TAC constraint	0.36	158.683	+ 9%	-15 %
MSY framework	56.599	51.279	5.320	FMSY*SSB2012/Btrigger	0.22	183.244	+ 26%	-45 %
MSY	74.415	67.420	6.995	MSY	0.3	169.056	+ 16%	-28 %
Bpa	35.581	32.216	3.342	Fpa	0.13	200.134	+ 38 %	- 65 %
Zero catch	0	0	0	F=0	0	229.069	+ 58 %	- 100 %

Option 2 results saithe assessment

Assessment, forecasts and advice based on settings used before the Benchmark in January 2011

As a result of concerns about the quality of recent survey information, in which year effects appear to dominate, an alternative assessment was carried out with the settings used before the Benchmark in January 2011. The assessment structure reintroduces the commercial CPUE time series at ages 3-5 excluded in Benchmark assessment. Given the latest observations of strong year effects in scientific surveys this assessment structure provides a robust alternative to the settings determined by the Benchmark meeting by giving the different data sources a more equal weighting. All other settings followed the Benchmark protocol. Input data were identical to the ones used in May 2011 (Table 1-4), apart from the inclusion of commercial CPUE tuning series for ages 3-5.

Results of the alternative assessment and forecasts

The status of the stock has deteriorated in the last few years (Figure 1; Table 5-8). SSB is estimated to have been above B_{pa} since 2001 but has declined during the last three years. From 2001–2007, F has been at or below the fishing mortality target of the management plan (0.3), but has now increased above the target value of 0.3. The increase stopped in 2009. Because of lack of input data, no assessment was conducted in 2010, and these trends could not be recognized until now.

The residual plot shows that there are patterns in the scientific surveys but not in the commercial CPUE tuning series (Figure 2). Apart from recruits, the retrospective bias in the assessment is low. A systematic underestimation in F and an overestimation in SSB occurred in the past 5 years (Figure 3). The retrospective bias for recruits is highest and recruitment was overestimated in the last 5 years.

The alternative assessment and forecasts indicate that the estimate of stock status is improved compared to the ICES May advice. SSB is expected to decline to between Blim and Bpa in 2012, but then begin to rebuild in 2013 (Table 9-10). The forecasts based on the alternative assessment indicate that if the -15% TAC constraint is used for landings in 2012 the SSB in 2013 will be considerably above Blim.

Potential advice 2012 based on the alternative assessment and forecasts

Management plan

The EU–Norway management plan does not clearly state whether the SSB in the intermediate year or the SSB at the beginning or end of the TAC year should be used to determine the status of the stock; ICES uses the SSB at the beginning of the intermediate year (2011). Since SSB at the beginning of 2011 is above B_{lim}, but below B_{pa}, clause 3 of the harvest control rule applies.

The more positive results of this alternative assessment supported by new August 2011 survey information suggest that the situation of the stock has improved compared to the assessment and 2010 survey data available for the assessment in May. Consequently, WGNSSK considers that the appropriate TAC advice should be in line with clause 5 of the management plan that is a 15% TAC reduction. The 15% TAC constraint (§ 5) leads to a TAC of 87 547 t, which results in SSB in 2013 of 183 000 t. The advice given in May to enact clause 6 of the Management Plan (i.e. go beyond a 15% TAC reduction) is no longer considered appropriate.

The EU–Norway agreement management plan was evaluated by ICES in 2008 to be precautionary in the short term (~5 years). However, the HCRs in the management plan are not clear enough when the stock falls below the SSB of 200 000 t. The change in fishery distribution and stock productivity (lower growth and recruitment) imply that a re-evaluation of the management plan is needed.

MSY approach

Following the ICES MSY framework implies a fishing mortality of F_{MSY}*SSB2012/MSY $B_{trigger}$ = 0.25, which results in landings of less than 71347 t in 2012.

The MSY transition implies a fishing mortality of (0.6*F_{2010}) + (0.4*0.22) = 0.33. The scheme will lead to landings of 90 671 t in 2012.

PA approach

Forecasts suggest that Bpa can be reached in 2013 with landings below 66 707 t.

Uncertainties in assessment and forecast

During the Benchmark (ICES, 2011b) the influence of the commercial cpue indices was reduced by using these indices to tune only the older ages (6–9) instead of using them for all ages (3–9). However, the latest information indicates strong year effects also in the scientific surveys. WGNSSK noted in May 2011 that there is a discrepancy between increasing catches of three year old saithe in commercial data, but very low values in the scientific surveys. Latest survey information for 4 year old saithe, one year later, bring both observations more in line, supporting the information from the commercial CPUE tuning fleets. Therefore, the option to include the commercial CPUE tuning fleets again at ages 3-5 has to be considered.

However, there is a trade off. Any changes in the fishing pattern e.g. hyperstabilty, could lead to bias in the assessment. Data on the geographical distribution of the catches was provided during the benchmark meeting. It would improve the assessment if these data were available annually from all major fishing nations (Norway, Germany, Scotland, France); they mayhelp to resolve the issues with the survey information, which appear could be spatial changes in distribution of the stock seen by the commercial fleets but not considered in the surveys. Landings in 2012 and SSB in 2013 depend on the assumption of incoming recruitments (59% and 44% respectively).

Comparison with previous assessment and advice

No assessment was conducted in 2010. The forecast conducted in 2010 used a 20-year average for recruitment assumed for 2009–2011 as the size of these year classes was unknown at the time. The present information shows that these year classes are poor. SSB 2010 was corrected 15% downward in the May assessment. Estimates of F in 2009 were revised upward by 63% between 2010 and 2011. Using the settings of the pre-benchmark assessments would indicate a considerably better stock status compared to the assessment in May. SSB 2010 would be corrected 8% upwards and F in 2010 by 36% downwards. The advice given in May to enact clause 6 of the Management Plan (i.e. go beyond a 15% TAC reduction) is no longer considered appropriate.

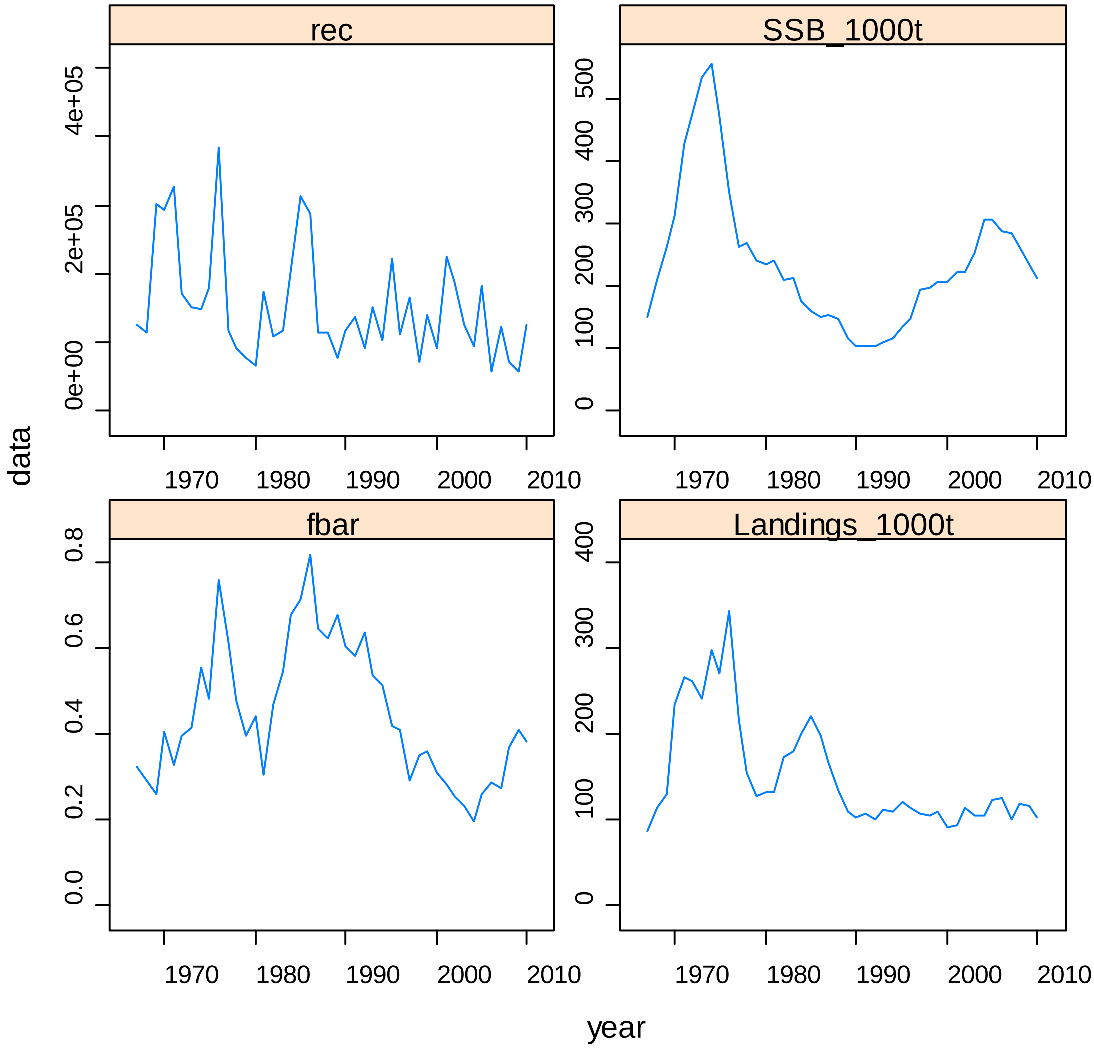

Figure 1: Summary of the assessment

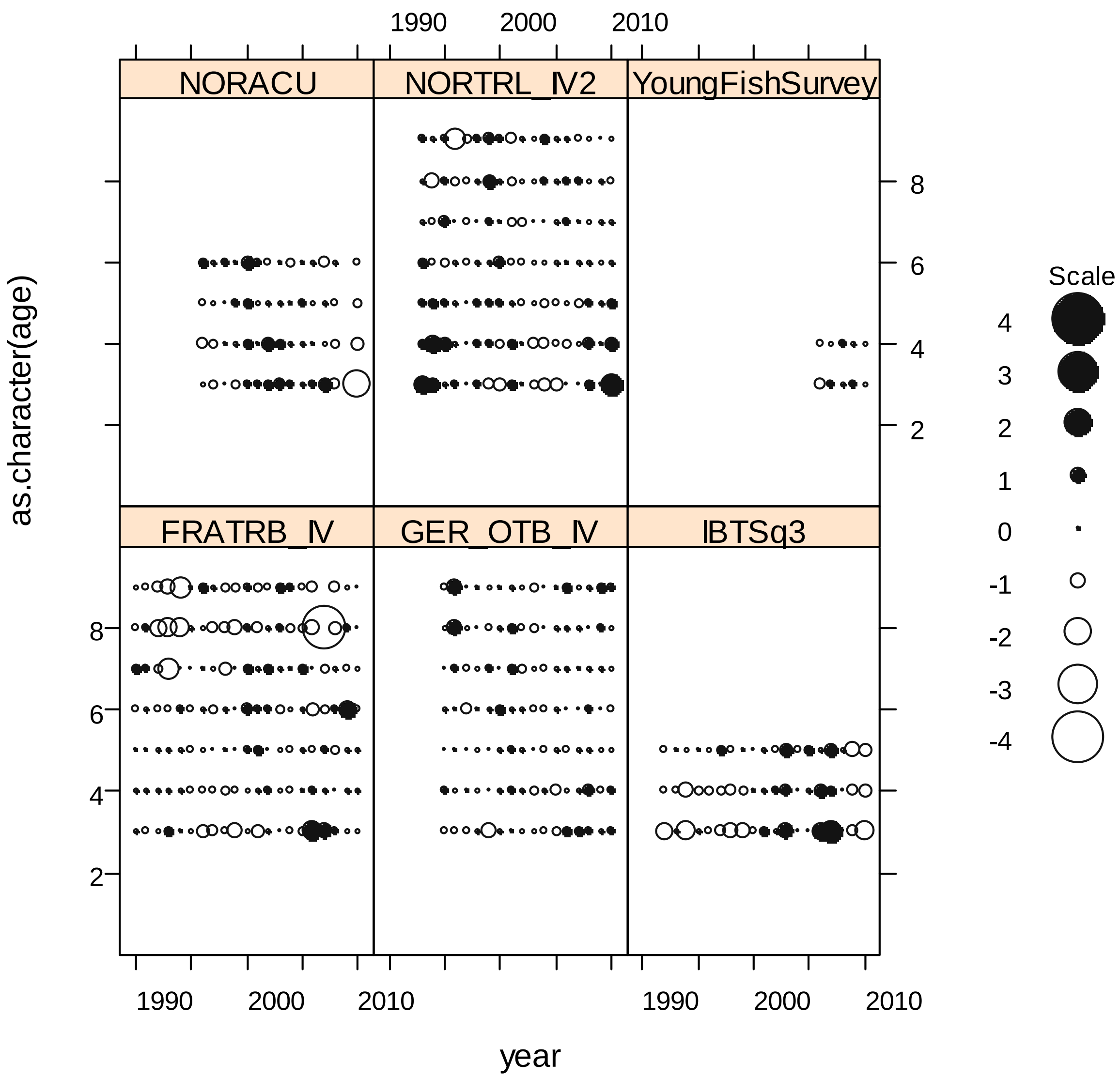

Figure 2: Residual plot

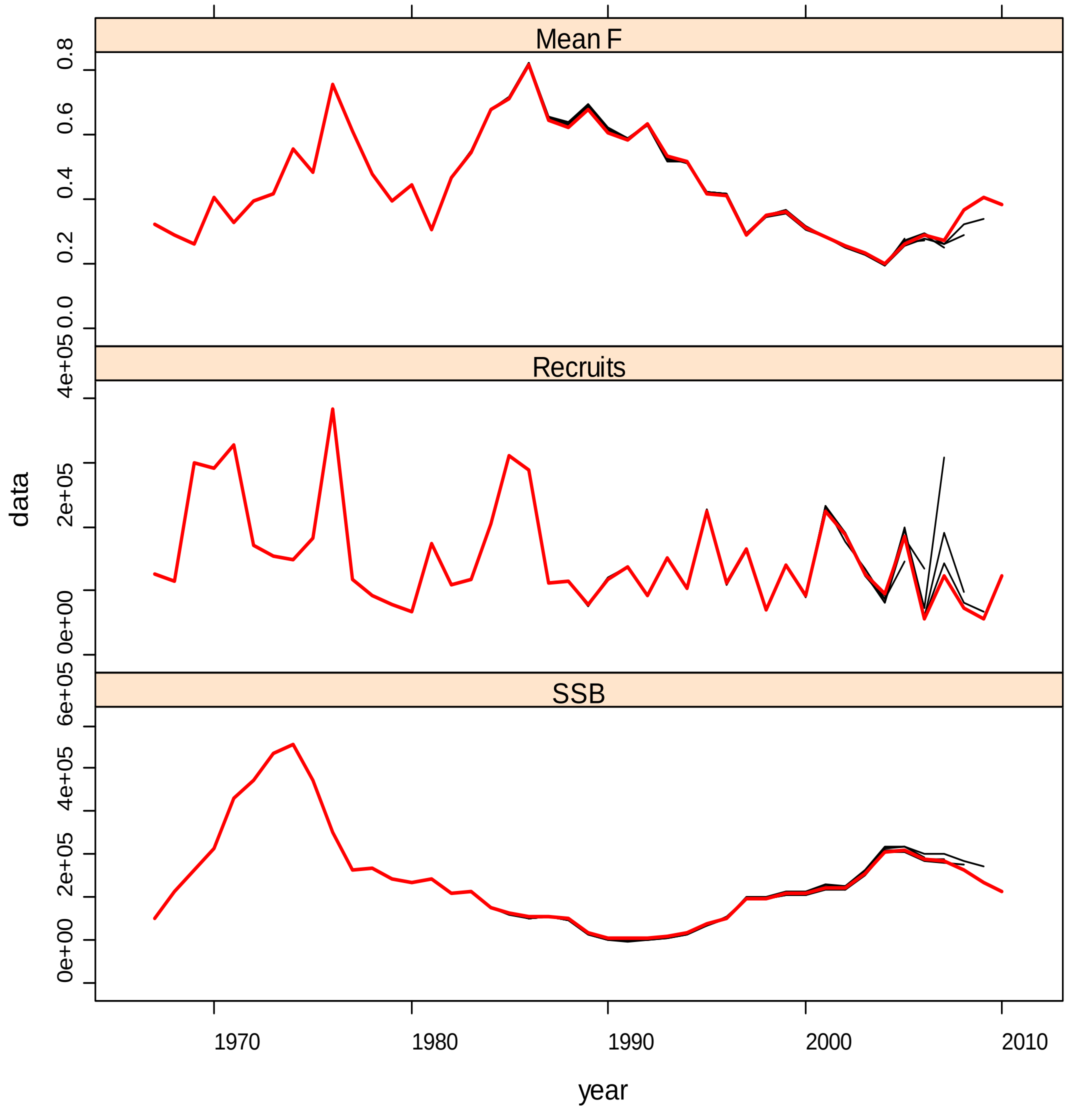

Figure 3: Retrospective analysis

Table 1: Landings numbers at age

year	3	4	5	6	7	8	9	10
1967	17330	16220	15531	2303	1594	292	198	183
1968	23223	21231	13184	6023	429	242	123	145
1969	30235	17681	11057	7609	5738	791	626	150
1970	37249	76661	15000	12128	3894	1792	318	267
1971	69808	57792	32737	4736	4248	2843	1874	774
1972	48075	66095	25317	21207	3672	2944	1641	1607
1973	54332	37698	26849	16061	8428	2000	1357	2381
1974	66938	33740	14123	20688	14666	5199	1477	1955
1975	56987	25864	10319	7566	13657	9357	3501	2687
1976	207823	53060	11696	6253	3976	5362	3586	3490
1977	27461	54967	14755	5490	3777	3447	3812	4701
1978	35059	27269	18062	3312	1138	1033	768	3484
1979	16332	14216	11182	8699	2805	733	540	2089
1980	17494	12341	9015	6718	5658	1150	509	2302
1981	26178	8339	6739	3675	3335	3396	657	2536
1982	31895	40587	9174	5978	2145	1454	982	1254
1983	28242	20604	26013	5678	4893	1494	1036	1327
1984	80933	32172	12957	13011	1657	1252	335	646
1985	134024	55605	13281	4765	3005	682	399	742
1986	55434	91223	15186	5381	2603	1456	445	900
1987	31220	97470	13990	3158	1811	1240	910	700
1988	32578	26408	35323	3828	1908	1104	776	680
1989	22128	30752	13187	10951	1557	739	419	488
1990	40808	19583	11322	4714	2776	745	281	364
1991	46117	29871	7467	3583	1716	953	367	458
1992	18404	33614	12753	3193	1524	696	518	422
1993	37823	20828	11845	3125	1568	1511	814	1026
1994	19958	40194	13034	4297	947	346	427	794
1995	26664	26034	14797	3774	3494	674	552	800
1996	11066	38861	11786	7731	3163	808	210	491
1997	15036	19299	30177	3676	2640	1012	291	288
1998	10363	31017	16367	16077	2231	1206	567	277
1999	9429	13872	26684	8389	10070	2346	891	657
2000	7064	17295	8940	12339	3159	3226	641	441
2001	16052	17646	22421	3349	3586	1772	1614	245
2002	19914	42331	8871	8899	2437	2976	1865	1623
2003	11661	20209	25759	6269	7061	1512	1979	1039
2004	5315	14987	17696	13412	3820	4104	1118	806
2005	13933	12508	16861	17796	11585	2838	2248	460
2006	9871	28211	12355	9364	11375	5958	1545	1432
2007	17486	7982	21443	7367	5639	5230	1800	975
2008	9692	24765	8119	17113	4561	3418	2407	1737
2009	9325	13046	16675	4970	10604	3600	2226	3191
2010	23319	12286	10381	6663	1930	3058	1315	2422

Table 2. Landings weight at age

year	3	4	5	6	7	8	9	10
1967	0.93	1.362	2.103	3.185	3.754	5.315	5.89	7.718
1968	1.279	1.652	1.989	3.01	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	1.44	2.058	2.718	3.599	4.462	5.686	6.844
1971	0.84	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	4.63	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	2.49	3.3	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	0.76	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.34	4.523	4.901	5.45	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	3.03	4.09	5.127	5.94	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.981	8.724
1982	1.086	1.575	2.53	3.22	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	2.69	3.896	4.664	6.183	8.473
1985	0.663	1.265	1.95	2.772	3.407	4.95	5.865	8.854
1986	0.694	1.035	1.794	2.431	3.572	4.209	5.65	8.218
1987	0.674	0.876	1.824	3.075	4.21	5.33	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	8.19
1992	0.964	1.189	1.607	2.242	3.668	4.33	5.412	7.045
1993	0.899	1.26	1.754	2.636	3.185	3.98	5.08	6.89
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	1.11	1.36	2.17	2.638	3.61	4.29	6.362
2002	0.861	0.918	1.415	1.873	2.446	3.322	4.19	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	1.74	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	1.77	2.457	3.028	3.6	4.6
2009	0.741	1.226	1.52	2.053	2.321	2.971	3.501	4.442
2010	0.741	1.325	1.858	2.527	3.205	3.281	3.778	4.823

Table 3. Stock weight at age

year	3	4	5	6	7	8	9	10
1967	0.93	1.362	2.103	3.185	3.754	5.315	5.89	7.718
1968	1.279	1.652	1.989	3.01	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	1.44	2.058	2.718	3.599	4.462	5.686	6.844
1971	0.84	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	4.63	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	2.49	3.3	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	0.76	1.256	1.935	3.111	4.162	4.605	4.859	6.542
1978	0.822	1.327	2.155	3.34	4.523	4.901	5.45	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	3.03	4.09	5.127	5.94	8.148
1981	0.961	1.821	2.718	3.587	4.536	5.478	6.981	8.724
1982	1.086	1.575	2.53	3.22	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	2.69	3.896	4.664	6.183	8.473
1985	0.663	1.265	1.95	2.772	3.407	4.95	5.865	8.854
1986	0.694	1.035	1.794	2.431	3.572	4.209	5.65	8.218
1987	0.674	0.876	1.824	3.075	4.21	5.33	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	8.19
1992	0.964	1.189	1.607	2.242	3.668	4.33	5.412	7.045
1993	0.899	1.26	1.754	2.636	3.185	3.98	5.08	6.89
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	1.11	1.36	2.17	2.638	3.61	4.29	6.362
2002	0.861	0.918	1.415	1.873	2.446	3.322	4.19	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	1.74	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	1.77	2.457	3.028	3.6	4.6
2009	0.741	1.226	1.52	2.053	2.321	2.971	3.501	4.442
2010	0.741	1.325	1.858	2.527	3.205	3.281	3.778	4.823

Table 4. "Saithe in IV, VI and IIIa - Combined tuning data"

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FRATRB_IV

1990	2010						
1	1	0	1				
3	9						
21758	3379	2471	1405	304	290	32	14
15248	1381	2538	731	372	130.79	67	11.93
7902	717	1480	498	73.572	24	7	5.741
13527	3917.8	2253.44	1162.23	103.625	8.299	8.648	6.183
14417	1770.754	3652.84	1381.104	434.086	38.895	5.317	2.71
14632	3151.807	1682.869	921.653	225.695	70.393	24.088	13.317
16241	895.031	4286.247	1053.226	535.95	107.63	24.634	15.158
12903	1087.28	1914.745	3175.192	190.091	83.908	16.535	13.738
13559	799.753	2538.413	1870.453	1480.902	52.256	23.023	10.381
14588	852.467	1233.817	2666.699	620.174	399.661	24.212	13.688
8695	889.314	1993.229	1038.898	1195.148	214.774	180.514	31.751
6366	724.1021	1339.454	2372.881	269.951	144.906	25.554	29.28
11022	3275.662	7576.645	1220.435	1242.118	175.302	151.434	40.935
10536	1516.931	3235.528	2354.784	264.339	325.113	80.521	112.883
5234	447.218	977.66	1020.943	494.617	92.582	35.628	19.772
3015	406.936	660.534	643.107	428.406	209.713	15.685	14.262
5710	1681.537	3142.212	551.3929	144.5056	199.2849	39.65778	13.23932
8255	4200.934	1040.925	2807.48	240.7597	99.80143	3.070924	NA
7016	878.509	1522.508	245.447	949.847	164.9	34.288	33.32

7093 407.5046469 1194.149134 1134.039085 540.4349602 127.1412692 96.39487902 38.31497546

6035 661.264 672.455 565.188 184.331 27.539 82.603 28.021

NORTRL_IV1

1980	1992						
1	1	0	1				
3	9						
18317	186	1290	658	980	797	261	60
28229	88	844	1345	492	670	699	119
47412	6624	12016	2737	2112	341	234	19
43099	4401	4963	8176	1950	2367	481	357
47803	20576	7328	2207	3358	433	444	106
66607	27088	21401	5307	1569	637	56	46
57468	5297	29612	3589	818	393	122	25
30008	2645	18454	2217	290	235	201	198
18402	3132	2042	2214	141	157	74	134
17781	649	2126	835	694	309	154	65
10249	804	781	924	519	203	63	12
28768	14348	4968	1194	518	203	51	56
35621	3447	9532	4031	1087	465	165	109

NORTRL_IV2

1993	2010						
1	1	0	1				
3	9						
24572	7635	4028	2878	1018	526	365	252
30628	3939	16098	4276	926	251	72	203
32489	4347	9366	5412	833	1644	273	203
40400	3790	14429	4414	2765	1144	189	16
36026	2894	5266	9837	1419	892	299	72
24510	1376	8279	5454	5662	977	489	243
21513	813	2595	6869	2368	3602	1168	346
15520	284	1628	2054	4261	1066	1203	221
23106	4808	5228	6513	935	1235	509	390
38114	4015	12063	3474	3775	981	1632	1050
41645	1630	5451	10452	3602	4432	792	1004
32726	663	2677	5709	6578	2256	2640	656
34964	1202	3080	5177	9204	6954	1728	1434
30190	797	4116	3842	4611	7310	3974	811
26354	1563	1442	4684	3506	2655	3121	887
32550	2308	10354	3664	8357	2155	1619	1234
34360 1071 3257 5936 1254 5334 1636 933							
24101	9219	3850	3756	2764	728	1052	416

GER_OTB_IV

1995	2010						
1	1	0	1				
3	9						
21167	1158	2359	1350	589	152	30	16
19064	510	3167	1081	517	257	148	41
21707	816	2475	3636	292	163	70	24
20153	591	2744	1395	1776	238	100	39
18596	284	1065	2264	943	1015	77	36
12223	542	2185	823	1216	242	325	38
11008	892	1329	2317	372	532	249	155
12789	650	3658	1230	1100	99	140	69
14560	500	1399	2630	438	392	58	72
13708	334	2040	1928	1079	200	235	47
11700	434	510	1623	1543	787	205	119
10815	374	1575	690	668	685	350	147
12606	937	713	2813	607	405	417	175
12871	477	3151 627 1662	354	220	223		
16692 359 759 1263 316 708 314 271							
16046 1046 1115 721 441 100 242 161							

NORACU

1995	2010			
1	1	0.5	0.75	
3	6			
1	56244	4756	1214	174
1	21480	29698	6125	4593
1	22585	16188	24939	3002
1	15180	48295	13540	11194
1	16933	21109	27036	4399
1	34551	82338	14213	13842
1	72108	28764	17405	3870
1	82501	163524	17479	4475
1	67774	107730	41675	4581
1	34153	43811	31636	6413
1	48446	36560	27859	10174
1	18909	58132	11378	7922
1	77958	12070	32445	2384
1	7122	18989	4180	10262

1 NA NA NA NA

1 2490	5225	4891	2899

IBTSq3

1991	2010		
1	1	0.5	0.75
3	5		
1	1.946	0.402	0.064
1	1.077	2.76	0.516
1	7.965	2.781	1.129
1	1.117	1.615	0.893
1	13.959	2.501	1.559
1	3.825	6.533	1.112
1	3.756	3.351	7.461
1	1.027	3.921	1.333
1	2.1	2.019	2.949
1	3.479	8.836	1.081
1	21.496	6.173	3.937
1	10.748	18.974	1.327
1	19.272	23.802	13.402
1	4.979	6.896	3.158
1	8.893	6.87	4.994
1	10.636	29.82	2.934
1	34.018	5.594	11.763
1	3.467	5.86	1.122

1 1.346 1.703 0.568

1 1.365 0.962 0.465

YoungFishSurvey

2005	2010			
1	1	0	1	
2	5			
NA	NA	NA	NA	NA
1	15.63	7.66	17.89	1.86
1	9.83	55.47	6.28	20.01
1	5.1	30.89	23.42	2.4
1	7.96	27.68	11.83	4.35
1	18.29	30.79	5.07	1.35

Table 5: XSA diagnostics

FLR XSA Diagnostics 2011-10-30 11:58:44

CPUE data from xsa.indices

Catch data for 44 years. 1967 to 2010. Ages 3 to 10.

	fleet	first age	last age	first year	last year	alpha	beta
1	FRATRB_IV	3	9	1990	2010	0	1
2	NORTRL_IV2	3	9	1993	2010	0	1
3	GER_OTB_IV	3	9	1995	2010	0	1
4	NORACU	3	6	1996	2010	0.5	0.75
5	IBTSq3	3	5	1992	2010	0.5	0.75
6	YoungFishSurvey	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

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	0.751	0.82	0.877	0.921	0.954	0.976	0.99	0.997	1	1

Fishing mortalities

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3	0.082	0.124	0.109	0.064	0.088	0.212	0.170	0.160	0.199	0.232
4	0.330	0.324	0.179	0.199	0.212	0.257	0.266	0.386	0.337	0.438
5	0.426	0.274	0.334	0.235	0.360	0.334	0.317	0.476	0.490	0.494
6	0.298	0.298	0.318	0.291	0.393	0.347	0.341	0.452	0.608	0.369
7	0.264	0.370	0.410	0.327	0.440	0.471	0.365	0.368	0.566	0.506
8	0.280	0.366	0.414	0.446	0.432	0.426	0.412	0.394	0.560	0.312
9	0.267	0.537	0.445	0.622	0.471	0.444	0.218	0.337	0.485	0.408
10	0.267	0.537	0.445	0.622	0.471	0.444	0.218	0.337	0.485	0.408

XSA population number (NA)

year \ age	3	4	5	6	7	8	9	10
2001	224469	69420	71405	14345	17060	8015	7615	1151
2002	188847	169255	40869	38174	8714	10723	4959	4269
2003	125163	136596	100271	25434	23203	4929	6087	3166
2004	94411	91924	93550	58787	15151	12608	2667	1901
2005	183674	72488	61700	60580	35995	8948	6609	1340
2006	57042	137773	48031	35259	33497	18988	4758	4372
2007	123740	37770	87272	28145	20395	17132	10155	5468
2008	72254	85488	23702	52050	16377	11596	9294	6656
2009	57098	50387	47583	12058	27130	9281	6401	9090
2010	124682	38310	29449	23870	5376	12618	4342	7926

Estimated population abundance at 1st Jan 2011

year \ age	3	4	5	6	7	8	9	10
2011	0	80982	20249	14718	13515	2655	7564	2365

Fleet: FRATRB_IV

Log catchability residuals.

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
3	0.249	-0.450	-0.148	0.553	0.044	-0.211	-0.891	-0.863	-0.343	-1.079
4	0.140	0.245	0.169	0.130	0.212	-0.321	-0.472	-0.383	-0.540	-0.400
5	0.029	0.045	0.264	0.193	0.257	-0.434	-0.222	-0.058	0.034	-0.027
6	-0.378	0.234	-0.405	-0.376	0.302	-0.432	0.125	-0.666	0.155	-0.095
7	0.683	0.398	-0.678	-1.776	-0.063	-0.093	0.002	-0.151	-0.934	-0.002
8	-0.453	0.298	-1.292	-1.484	-1.614	0.248	-0.219	-0.826	-0.805	-1.082
9	-0.137	-0.425	-0.872	-1.249	-1.832	0.049	0.570	0.190	-0.597	-0.607

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
3	-0.099	-0.880	0.272	-0.048	-0.309	-0.506	1.502	1.255	0.386	-0.139
4	-0.264	0.138	0.428	-0.231	-0.323	0.080	0.380	0.205	-0.014	0.239
5	0.471	0.642	-0.083	-0.251	-0.364	0.199	-0.354	0.300	-0.600	0.229
6	0.799	0.408	0.406	-0.681	-0.205	0.219	-0.985	-0.621	0.349	1.305
7	0.494	0.143	0.505	0.206	0.038	0.593	-0.010	-0.622	0.264	-0.424
8	0.361	-0.829	0.149	0.362	-0.679	-0.611	-1.077	-3.908	-0.950	0.369
9	0.482	-0.648	-0.311	0.503	0.363	-0.386	-0.782	NA	-0.783	-0.215

age \ year	2010
3	-0.260
4	0.145
5	0.176
6	-0.398
7	-0.200
8	-0.042
9	-0.013

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	-13.4770	-12.5911	-12.5077	-12.9005	-13.4474	-13.4474	-13.4474
S.E_Logq	0.6541	0.2987	0.3117	0.5521	0.5751	0.9802	0.6187

Fleet: NORTRL_IV2

Log catchability residuals.

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
3	1.450	0.917	0.139	0.467	-0.085	0.434	-0.689	-0.993	0.550	0.062	-0.524
4	0.502	1.329	0.986	0.219	-0.010	0.438	0.343	-0.657	0.599	0.040	-0.696
5	0.360	0.491	0.396	0.157	-0.096	0.370	0.388	0.431	0.220	-0.420	-0.277
6	0.575	-0.431	-0.660	0.118	-0.419	0.168	0.120	0.755	-0.375	-0.459	-0.179
7	0.280	-0.449	0.764	-0.042	-0.311	-0.094	0.311	0.021	-0.499	-0.510	-0.052
8	0.165	-1.258	0.382	-0.589	-0.455	0.162	0.909	0.182	-0.623	-0.210	-0.223
9	0.366	0.234	0.480	-1.784	-0.676	0.468	0.738	0.347	-0.844	0.197	-0.183

age	2004	2005	2006	2007	2008	2009	2010
3	-0.922	-1.048	-0.084	-0.069	0.644	0.075	1.817
4	-0.760	-0.443	-0.627	-0.242	0.756	0.052	0.894
5	-0.618	-0.308	-0.220	-0.492	0.427	0.165	0.543
6	-0.187	0.100	0.076	0.161	0.253	-0.167	0.189
7	-0.098	0.148	0.430	0.002	-0.197	0.238	0.194
8	0.297	0.144	0.368	0.359	-0.126	0.127	-0.378
9	0.535	0.278	0.171	-0.464	-0.202	-0.096	-0.196

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	-14.3032	-12.9793	-12.3654	-12.1642	-11.9511	-11.9511	-11.9511
S.E_Logq	0.7986	0.6330	0.3819	0.3706	0.3368	0.4966	0.6136

Fleet: GER_OTB_IV

Log catchability residuals.

age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
3	-0.357	-0.389	-0.446	0.183	-1.196	0.290	0.005	-0.269	-0.257	-0.339	-0.573
4	0.361	-0.221	0.067	-0.145	-0.076	0.201	0.296	0.264	-0.679	0.164	-0.820
5	-0.035	0.031	-0.055	-0.269	-0.047	0.285	0.457	0.163	-0.077	-0.303	0.156
6	0.230	0.000	-0.686	0.012	0.153	0.548	0.252	0.208	-0.428	-0.316	0.216
7	-0.010	0.394	-0.325	-0.132	0.369	-0.044	0.579	-0.533	-0.247	-0.472	0.242
8	-0.219	1.096	-0.221	-0.050	-0.486	0.291	0.582	-0.395	-0.607	-0.073	0.286
9	-0.454	1.087	-0.089	0.013	-0.200	0.004	0.153	-0.255	-0.588	-0.052	0.062

age	2006	2007	2008	2009	2010
3	0.585	0.556	0.393	0.103	0.446
4	-0.236	0.117	0.820	-0.357	0.387
5	-0.381	0.265	0.119	-0.132	-0.171
6	-0.022	-0.048	0.373	-0.015	-0.432
7	0.268	0.038	0.103	0.120	-0.206
8	0.144	0.263	-0.015	0.377	-0.262
9	0.669	-0.171	0.194	0.568	0.441

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	-14.7016	-13.3049	-12.8948	-12.9721	-13.1298	-13.1298	-13.1298
S.E_Logq	0.4846	0.4153	0.2303	0.3277	0.3180	0.4353	0.4312

Fleet: NORACU

Log catchability residuals.

age	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
3	-0.172	-0.520	-0.030	-0.662	0.473	0.320	0.653	0.859	0.428	0.126	0.432
4	-0.738	-0.682	0.026	0.142	0.613	0.069	0.912	0.619	0.128	0.192	0.042
5	-0.329	-0.114	-0.050	0.312	0.577	-0.191	0.277	0.285	0.017	0.384	-0.276
6	0.623	0.150	0.303	0.066	0.942	0.417	-0.417	0.025	-0.493	0.001	0.264

age	2007	2008	2009	2010
3	1.048	-0.813	NA	-2.365
4	-0.230	-0.519	NA	-0.975
5	0.163	-0.484	NA	-0.533
6	-0.715	0.199	NA	-0.337

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	-1.2794	-0.6200	-0.8304	-1.4162
S.E_Logq	0.8755	0.5506	0.3416	0.4510

Fleet: IBTSq3

Log catchability residuals.

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	-1.414	0.140	-1.489	0.204	-0.411	-0.827	-1.236	-1.263	-0.336	0.596	0.102
4	-0.376	-0.335	-1.182	-0.508	-0.573	-0.578	-0.806	-0.527	0.059	0.209	0.437
5	-0.295	0.033	-0.240	0.028	-0.131	0.583	-0.464	0.000	-0.095	0.227	-0.397

age	2003	2004	2005	2006	2007	2008	2009	2010
3	1.088	-0.011	-0.082	1.344	1.705	-0.046	-0.733	-1.479
4	0.788	-0.043	0.199	1.053	0.679	-0.016	-0.754	-0.988
5	1.055	-0.383	0.569	0.272	1.053	0.105	-1.264	-0.982

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	-9.6737	-9.2064	-9.6423
S.E_Logq	0.9562	0.6215	0.5902

Fleet: YoungFishSurvey

Log catchability residuals.

age	2005	2006	2007	2008	2009	2010
3	NA	-0.846	0.339	0.288	0.431	-0.228
4	NA	-0.359	-0.108	0.446	0.270	-0.258

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	-7.8703	-8.3703
S.E_Logq	0.5366	0.3462

Terminal year survivor and F summaries:

Age 3 Year class = 2007

source	survivors	N	scaledWts
FRATRB_IV	62458	1	0.126
NORTRL_IV2	498147	1	0.107
GER_OTB_IV	126447	1	0.300
NORACU	7609	1	0.074
IBTSq3	18446	1	0.071
YoungFishSurvey	64471	1	0.225
fshk	116466	1	0.097

Age 4 Year class = 2006

source	survivors	N	scaledWts
FRATRB_IV	22653	2	0.293
NORTRL_IV2	38280	2	0.092
GER_OTB_IV	26452	2	0.191
NORACU	7639	1	0.076
IBTSq3	8058	2	0.073
YoungFishSurvey	18662	2	0.236
fshk	32645	1	0.039

Age 5 Year class = 2005

source	survivors	N	scaledWts
FRATRB_IV	18312	3	0.259
NORTRL_IV2	23007	3	0.135
GER_OTB_IV	12973	3	0.275
NORACU	8462	2	0.128
IBTSq3	6891	3	0.065
YoungFishSurvey	19369	2	0.111
fshk	19216	1	0.027

Age 6 Year class = 2004

source	survivors	N	scaledWts
FRATRB_IV	14524	4	0.197
NORTRL_IV2	16772	4	0.243
GER_OTB_IV	11819	4	0.326
NORACU	10021	3	0.104
IBTSq3	9258	3	0.040
YoungFishSurvey	20540	2	0.067
fshk	11181	1	0.025

Age 7 Year class = 2003

source	survivors	N	scaledWts
FRATRB_IV	2677	5	0.199
NORTRL_IV2	2930	5	0.313
GER_OTB_IV	2536	5	0.337
NORACU	1828	3	0.058
IBTSq3	4424	3	0.023
YoungFishSurvey	1981	2	0.041
fshk	3117	1	0.029

Age 8 Year class = 2002

source	survivors	N	scaledWts
FRATRB_IV	7796	6	0.159
NORTRL_IV2	7061	6	0.325
GER_OTB_IV	7726	6	0.361
NORACU	8858	4	0.081
IBTSq3	18192	3	0.020
YoungFishSurvey	5281	1	0.026
fshk	4898	1	0.026

Age 9 Year class = 2001

source	survivors	N	scaledWts
FRATRB_IV	2302	7	0.186
NORTRL_IV2	2174	7	0.313
GER_OTB_IV	2696	7	0.385
NORACU	1671	4	0.068
IBTSq3	2882	3	0.017
fshk	2434	1	0.031

Table 6: XSA estimated stock numbers

age

year	3	4	5	6	7	8	9	10
1967	127456	77470	54512	6638	5177	1407	680	621
1968	114114	88671	48750	30578	3351	2796	888	1041
1969	300689	72416	53388	27984	19585	2356	2070	490
1970	291836	218825	43291	33705	16026	10843	1213	1008
1971	327931	205231	109793	21871	16622	9597	7256	2974
1972	171373	205322	115736	60269	13622	9765	5286	5132
1973	152852	96808	108298	71849	30155	7830	5330	9288
1974	148740	75983	45149	64373	44292	17063	4601	6037
1975	181239	61210	31681	24186	33985	22993	9266	7036
1976	384112	96822	26712	16601	12956	15467	10359	9984
1977	118016	126438	31260	11287	7934	7009	7811	9495
1978	92453	71776	53782	12243	4273	3078	2620	11785
1979	77650	43972	34091	27690	7027	2469	1586	6075
1980	67143	48797	23138	17793	14800	3215	1358	6076
1981	172821	39143	28785	10787	8489	6997	1592	6076
1982	109947	117807	24502	17469	5506	3932	2656	3357
1983	118228	61157	59727	11760	8893	2567	1904	2399
1984	205232	71242	31429	25363	4491	2854	750	1427
1985	311831	94798	29217	14007	8993	2178	1204	2219
1986	288209	134036	27301	11904	7157	4644	1166	2330
1987	113363	185806	27197	8611	4878	3504	2485	1891
1988	115490	64565	63930	9608	4193	2355	1746	1510
1989	77856	65078	28967	20380	4403	1706	929	1069
1990	118845	43721	25456	11784	6777	2196	728	932
1991	138334	60378	18076	10596	5383	3037	1124	1391
1992	92997	71530	22404	8043	5433	2854	1624	1310
1993	152289	59487	28149	6803	3696	3069	1707	2121
1994	103504	90460	29859	12329	2742	1607	1146	2108
1995	223795	66683	37694	12653	6206	1388	1003	1430
1996	111714	159102	31039	17472	6944	1919	526	1218
1997	165296	81451	95099	14748	7310	2824	841	824
1998	71056	121728	49224	50555	8748	3595	1396	674
1999	140289	48799	71597	25492	26844	5144	1853	1348
2000	92597	106328	27401	34475	13280	12866	2089	1426
2001	224469	69420	71405	14345	17060	8015	7615	1151
2002	188847	169255	40869	38174	8714	10723	4959	4269
2003	125163	136596	100271	25434	23203	4929	6087	3166
2004	94411	91924	93550	58787	15151	12608	2667	1901
2005	183674	72488	61700	60580	35995	8948	6609	1340
2006	57042	137773	48031	35259	33497	18988	4758	4372
2007	123740	37770	87272	28145	20395	17132	10155	5468
2008	72254	85488	23702	52050	16377	11596	9294	6656
2009	57098	50387	47583	12058	27130	9281	6401	9090
2010	124682	38310	29449	23870	5376	12618	4342	7926
[1] 2011	0	80981	20249	14717	13514	2655	7563	6681

Table 7. Estimated fishing mortalities

	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	0.769	0.609	0.609
1982	0.387	0.479	0.534	0.475	0.563	0.525	0.525	0.525
1983	0.307	0.466	0.656	0.763	0.937	1.030	0.920	0.920
1984	0.572	0.691	0.608	0.837	0.524	0.663	0.681	0.681
1985	0.644	1.045	0.698	0.472	0.461	0.424	0.456	0.456
1986	0.239	1.395	0.954	0.692	0.514	0.425	0.548	0.548
1987	0.363	0.867	0.841	0.520	0.528	0.496	0.519	0.519
1988	0.374	0.602	0.943	0.580	0.699	0.730	0.676	0.676
1989	0.377	0.739	0.699	0.901	0.496	0.652	0.689	0.689
1990	0.477	0.683	0.676	0.583	0.603	0.470	0.557	0.557
1991	0.460	0.791	0.610	0.468	0.434	0.426	0.447	0.447
1992	0.247	0.733	0.992	0.578	0.371	0.314	0.435	0.435
1993	0.321	0.489	0.626	0.709	0.633	0.785	0.749	0.749
1994	0.240	0.675	0.659	0.486	0.481	0.272	0.531	0.531
1995	0.141	0.565	0.569	0.400	0.974	0.770	0.936	0.936
1996	0.116	0.315	0.544	0.671	0.700	0.626	0.581	0.581
1997	0.106	0.304	0.432	0.322	0.509	0.505	0.483	0.483
1998	0.176	0.331	0.458	0.433	0.331	0.463	0.596	0.596
1999	0.077	0.377	0.531	0.452	0.535	0.701	0.758	0.758
2000	0.088	0.198	0.447	0.503	0.305	0.325	0.414	0.414
2001	0.082	0.330	0.426	0.298	0.264	0.280	0.267	0.267
2002	0.124	0.324	0.274	0.298	0.370	0.366	0.537	0.537
2003	0.109	0.179	0.334	0.318	0.410	0.414	0.445	0.445
2004	0.064	0.199	0.235	0.291	0.327	0.446	0.622	0.622
2005	0.088	0.212	0.360	0.393	0.440	0.432	0.471	0.471
2006	0.212	0.257	0.334	0.347	0.471	0.426	0.444	0.444
2007	0.170	0.266	0.317	0.341	0.365	0.412	0.218	0.218
2008	0.160	0.386	0.476	0.452	0.368	0.394	0.337	0.337
2009	0.199	0.337	0.490	0.608	0.566	0.560	0.485	0.485
2010	0.232	0.438	0.494	0.369	0.506	0.312	0.408	0.408

Table 8: XSA summary table

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	890440	0.408	0.75
1971	327931	429605	265381	265381	1018390	0.329	0.62
1972	171373	474021	261877	261877	903520	0.395	0.55
1973	152852	534465	242499	242499	847458	0.416	0.45
1974	148740	554915	298351	298351	833753	0.556	0.54
1975	181239	472028	271584	271584	743380	0.482	0.58
1976	384112	351614	343967	343967	752445	0.76	0.98
1977	118016	263126	216395	216395	509441	0.615	0.82
1978	92453	268126	155141	155141	463888	0.477	0.58
1979	77650	241074	128360	128360	419173	0.396	0.53
1980	67143	235180	131908	131908	396812	0.443	0.56
1981	172821	241232	132278	132278	495209	0.306	0.55
1982	109947	210478	174351	174351	511768	0.469	0.83
1983	118228	214301	180044	180044	467298	0.548	0.84
1984	205232	176700	200834	200834	466016	0.677	1.14
1985	311831	160952	220869	220869	490696	0.715	1.37
1986	288209	152003	198596	198596	487640	0.82	1.31
1987	113363	153681	167514	167514	386017	0.648	1.09
1988	115490	148992	135172	135172	322018	0.625	0.91
1989	77856	116319	108877	108877	259741	0.679	0.94
1990	118845	104931	103800	103800	264372	0.605	0.99
1991	138334	103265	108048	108048	284123	0.582	1.05
1992	92997	104488	99742	99742	279053	0.637	0.95
1993	152289	109227	111491	111491	326511	0.536	1.02
1994	103504	118317	109622	109622	319382	0.515	0.93
1995	223795	135287	121810	121810	456715	0.419	0.9
1996	111714	147803	114997	114997	437409	0.412	0.78
1997	165296	196206	107327	107327	470199	0.291	0.55
1998	71056	196566	106123	106123	389251	0.349	0.54
1999	140289	207826	110716	110716	406205	0.359	0.53
2000	92597	207044	91322	91322	436372	0.309	0.44
2001	224469	221494	95042	95042	505835	0.284	0.43
2002	188847	222947	115395	115395	542154	0.255	0.52
2003	125163	255098	105569	105569	508750	0.235	0.41
2004	94411	306390	104237	104237	533645	0.197	0.34
2005	183674	307682	124532	124532	547195	0.263	0.4
2006	57042	288530	125681	125681	487136	0.288	0.44
2007	123740	283740	101202	101202	457284	0.274	0.36
2008	72254	262860	119305	119305	437242	0.368	0.45
2009	57098	235531	115747	115747	354575	0.408	0.49
2010	124682	213451	102543	102543	371401	0.383	0.48
2011		168811					

Table 9: Forecast input

age	year		f	stock.n	stock.wt	landings.wt	mat	M
3	2011	1	0.203	119028	0.81	0.81	0.00	0.2
4	2011	1	0.398	80981	1.24	1.24	0.15	0.2
5	2011	1	0.501	20249	1.64	1.64	0.70	0.2
6	2011	1	0.490	14717	2.12	2.12	0.90	0.2
7	2011	1	0.494	13514	2.66	2.66	1.00	0.2
8	2011	1	0.434	2655	3.09	3.09	1.00	0.2
9	2011	1	0.422	7563	3.63	3.63	1.00	0.2
10	2011	1	0.422	6681	4.62	4.62	1.00	0.2

Table 10: Option table for 2012

Outlook for 2012

Basis: F(2011) = estimated from landings constraint 2011 =0.4; R11–13 = GM88–08 =119.028; SSB(2012) = 166; landings (2011) = 103.

Rationale	**landings 2012**	**landings IIIa&IV 2012[1)]**	**landings VI 2012[1)]**	**Basis**	**F 2012**	**SSB 2013**	**%SSB change [2)]**	**% TAC change [3)]**
Management plan[4)] § 5	87.547	79.318	8.229	15 % TAC constraint	0.32	182.570	+10%	- 15 %
MSY framework	71.347	64.640	6.707	F_{MSY}*SSB_{2012}/$B_{trigger}$	0.25	196148	+ 18 %	- 31 %
MSY transition	90.671	82.148	8.523	(0.6*F2010)+(0.4*Fmsy framework)	0.33	179.965	+8%	- 12%
Fmsy	83.603	75.744	7.859	Fmsy	0.3	185.865	+ 12 %	- 19 %
Zero catch	0	0	0	F=0	0	257.133	+ 55%	- 100 %
Bpa	66.707	60437	6270	SSB2013 >B_{pa}	0.23	200.058	+21%	- 35%
Status quo	103.452	93.728	9.724	Fsq	0.39	169.355	+ 2%	0%

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 2013 relative to SSB 2012.

3) Landings 2012 relative to TAC 2011.

4) Assuming stock status is determined in the beginning of the TAC year.

2.5 Whiting in Sub-Area IV and VIID

2.5.1 New survey information

Several research vessel surveys were conducted in the third quarter of 2011 combining to produce the 2011 Quarter 3 IBTS indices.

2.5.2 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 (2010) year class at age 1. The RCT3 input data and output are given in Tables 2.5.1 and 2.5.2.

2.5.3 Update protocol calculations

The outcome of the application of the protocol was as follows:

Calculations for 2009 year class	
Log WAP from RCT3	7.25
Log of recruitment assumed in spring	7.35
Int SE of log WAP	0.26
Distance D	**-0.46**

2.5.4 Conclusions from protocol

The value of D is not less than -1 and not greater than 1, so the most recent information is not sufficiently different from that available in May, 2011. Therefore the forecast from September still stands and the advice will not be reopened.

Table 2.5.1. Whiting in Sub-Area IV and Division VIId. RCT3 input data.

yearclass	recruitment	ibtsq3age1
1988	NA	NA
1989	2970.9049	NA
1990	2868.4911	7.03368
1991	2755.2944	6.00867
1992	3074.7808	6.38722
1993	2869.5105	6.77645
1994	2513.0042	6.19786
1995	1751.1257	5.45708
1996	1335.0932	3.32968
1997	1920.8226	3.30600
1998	2932.5666	12.03503
1999	3343.4192	9.41658
2000	2665.7830	6.45003
2001	2420.5303	7.32137
2002	867.5380	2.46155
2003	949.8614	1.61559
2004	1274.1312	1.79500
2005	1288.4866	1.72792
2006	1340.1150	0.95645
2007	2926.5657	3.56898
2008	2197.5736	7.67238
2009	1729.7820	3.53620
2010	NA	2.67808

Table 2.5.2. Whiting in Sub-Area IV and Division VIId. RCT3 output.

```
Data for 1 surveys over 23 year classes : 1988 - 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    .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
 ibtsq3age1 0.7486     6.511 0.296  0.6764 20  0.9851      7.249  0.3235           1
   VPA Mean     NA        NA    NA      NA 21      NA      7.618  0.4151           0

                WAP logWAP int.se
yearclass:2010 1406  7.249 0.2552
```

D = (7.249 – 7.354)/0.255= -0.459, negative signal, but no different from spring assumptions.

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

This survey is usually conducted with the RV Isis (BTS-Isis). However, some issues occurred in 2011.. 2 out of 60 stations were taken over by RV Tridens, using the RV Isis gear (an 8-m beam trawl with 40 mm stretched mesh codend); therefore, the index is calculated for the complete Isis index area.

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 2010 and age 2 of year class 2009. 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 a positive signal (D=+1.31), significantly different from the spring assumption. For age 2 the D value indicates a positive index (D=0.37). Because the D value for age 1 is larger than 1, one could consider updating the spring assessment. However, the direction of the updated TAC advice would be upward, while the advice is already bounded by the +15% TAC change constraint in the management plan. Therefore, no further calculations are needed.

2.6.4 Conclusions from protocol

The TAC is advised according to the management plan. The spring advice was already bounded by the 15% TAC change constraint. The TAC advice is thus equal to the advice of June 2011 (84 410t). The rationale behind this is that The TAC is bound by the upper 15% TAC change constraint, at 84 410t.

Following the AGCREFA protocol, the new available survey indices for North Sea plaice age 1 indicates an increase in abundance but the revised level of catch is constrained by the limitation on TAC change 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      27     2
1984   1848339      136.8
1985   4764511      667.4
1986   1964497      225.8
1987   1770620      680.2
1988   1187006      467.9
1989   1036812      185.3
1990   914859       291.4
1991   777188       360.9
1992   531145       189
1993   443366       193.3
1994   1164491      265.6
1995   1290778      310.3
1996   2157357      1046.8
1997   775489       347.6
1998   841728       293.3
1999   992460       267.5
2000   541719       206.5
2001   1728682      519.2
2002   535123       132.8
2003   1260826      233.7
2004   771300       163
2005   920161       128.6
2006   1078318      312
2007   -11          221.6
2008   -11          409
2009   -11          261.1
2010   -11          486.2
BTS1

North Sea Plaice Age 2
1      27     2
1983   843904       173.893
1984   1286717      131.704
1985   3246664      764.186
1986   1433663      146.993
1987   1270527      319.272
1988   869960       146.071
1989   798445       159.424
1990   652215       174.526
1991   567997       283.4
1992   385636       77.139
1993   340756       40.618
1994   933236       206.883
1995   1061070      59.241
1996   1828830      402.657
1997   602066       121.551
1998   639993       69.252
1999   797087       72.236
2000   457012       44.475
2001   1268291      159.12
2002   419124       39.623
2003   918751       66.176
2004   606087       36.385
2005   622512       67.169
2006   901007       120.728
2007   -11          105.222
2008   -11          84.254
2009   -11          148.217

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, NS Plaice Age 1, 1 sur-
vey over  1984 - 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

BTS1      1.67   4.45    .75   .355     23   6.19   14.80     .823    1.000
                                         VPA Mean =   13.90     .547     .000

Year     Weighted      Log     Int
Class     Average      WAP     Std
         Prediction           Error
2010     2677446     14.80     .82
```

Plaice age 1 D= (14.80 - log(**915399**))/0.82 = 1.31, positive signal, and different from spring assumptions.

D calculation North Sea plaice age 2

```
Analysis by RCT3 ver3.1 of data from file: ple_iv2.txt, NS Plaice Age 2, 1 sur-
vey over 1983 - 2009

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.

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

BTS2       .90   9.32    .48   .550     24   5.01   13.82     .513    1.000
                                         VPA Mean =   13.62     .519     .000

Year     Weighted      Log     Int
Class     Average      WAP     Std
         Prediction           Error

2009     1009115     13.82     .51
```

Plaice age 2 D= (13.82 - log(830649))/0.51= 0.37, positive signal, but no different from spring assumptions.

2.7 North Sea sole

2.7.1 New survey information

The new survey information that is available comes from the Beam Trawl Survey (BTS). The BTS was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea

The BTS survey is usually conducted with the RV Isis (BTS-Isis). However, some issues occurred in 2011. 2 out of 60 stations were taken over by RV Tridens, using the RV Isis gear (an 8-m beam trawl with 40 mm stretched mesh codend); therefore, the index is calculated for the complete Isis index area.

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 2010 and age 2 of year class 2009. 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 indicates a strongly positive signal (D=1.49). As this value is above 1, the forecast should be recalculated. For age 2 the D value was 0.07 indicating no revision of the year class compared to the spring assessment. 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 new available survey indices for North Sea sole age 1 indicate a large increase in estimated recruitment using the new information and the forecast should be recalculated. The estimate of age 2 is unaltered.

As a result of this, TAC advice under the management plan increases by 3.2%. The advice compared to the June advice, which was 15 700t in June, and would now be 16 200t, bounded by the +15% TAC change constraint.

Table 2.7.1 North Sea sole RCT3 input data

```
Sole    North   Sea     1
2       40      2
1971    76415           -11             -11
1972    105141          -11             -11
1973    109999          -11             -11
1974    40846           -11             -11
1975    113310          168.84          -11
1976    140363          82.28           -11
1977    47164           33.8            -11
1978    11666           96.87           -11
1979    151653          392.08          -11
1980    148978          404             -11
1981    152495          293.93          -11
1982    141577          328.52          -11
1983    70888           104.38          -11
1984    81645           186.53          7.03
1985    159358          315.03          7.17
1986    72698           73.22           6.97
1987    456494          523.86          83.11
1988    108214          50.07           9.01
1989    177225          77.8            37.84
1990    70390           21.09           4.03
1991    352998          391.93          81.63
1992    69162           25.3            6.35
1993    56983           25.13           7.66
1994    95963           69.11           28.13
1995    49378           19.07           3.98
1996    271069          59.62           169.34
1997    113801          44.08           17.11
1998    82278           -11             11.96
1999    123249          -11             14.59
2000    62938           15.51           8.00
2001    184939          85.31           20.99
2002    83375           64.97           10.51
2003    45234           16.82           4.19
2004    49131           40.1            5.53
2005    213023          46.81           17.09
2006    55653           14.69           7.5
2007    -11             23.51           15.25
2008    -11             26.74           15.95
2009    -11             39.59           54.811
2010    -11             58.4            26.166
DFS0
BTS1
```

Table 2.7.1 (continued) North Sea sole RCT3 input data

Sole North Sea-Age 2

```
Sole North Sea-Age 2
1       27      2
1983    63961           7.12
1984    73718           5.18
1985    143837          12.55
1986    65690           12.51
1987    413043          68.08
1988    97805           24.49
1989    159539          28.84
1990    63578           22.28
1991    318474          42.35
1992    62529           7.12
1993    50878           8.46
1994    82264           7.64
1995    44516           4.92
1996    243761          27.42
1997    102739          18.36
1998    74176           6.14
1999    109284          9.96
2000    56108           4.18
2001    166336          9.94
2002    74444           4.35
2003    40438           3.40
2004    43356           2.33
2005    186269          19.5
2006    50055           9.06
2007    -11             5.00
2008    -11             10.71
2009    -11             17.39
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, NS Sole Age 1, Data for
1 survey over 1984 - 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

BTS1       .78   9.47    .38   .752     23   3.30   12.06     .414    1.000
                                       VPA Mean =   11.56     .653     .000

Year     Weighted      Log     Int
Class     Average      WAP     Std
         Prediction           Error
2010      171969     12.06     .41
Sole age 1 D = (12.06 - log( 94000 ))/0.41 = 1.49 strong positive signal, dif-
ferent from spring assumptions
```

D calculation North Sea sole age 2

```
Analysis by RCT3 ver3.1 of data from file: altin_2.txt, NS Sole Age 2, Data for
1 survey over 1983 - 2009

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.

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

BTS2      1.01   8.93    .44   .691     24   2.91   11.87     .473    1.000
                                        VPA Mean =   11.44     .645     .000

Year     Weighted      Log     Int
Class     Average      WAP     Std
          Prediction           Error

2009      142759     11.87     .47

Sole age 2 D= (11.87 - log(138158 ))/0.47= 0.07 positive signal, but no differ-
ent from spring assumptions.
```

Table 2.7.3 North Sea sole full RCT3 output all survey data

Age 1

```
Analysis by RCT3 ver3.1 of data from file : altin_1.txt, NS Sole age 1, Data
for 2 surveys over  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/  Slope  Inter-   Std  Rsquare  No.  Index Predicted   Std     WAP
 Series           cept   Error          Pts  Value   Value    Error   Weights

 DFS0      1.18   6.34   1.07   .326     30   4.08   11.17    1.123     .090
 BTS1       .78   9.47    .38   .752     23   3.30   12.05     .414     .666

                                        VPA Mean =   11.48     .683     .244


 Year     Weighted      Log      Int     Ext     Var      VPA      Log
 Class     Average      WAP      Std     Std    Ratio              VPA
          Prediction            Error   Error

 2010      138093     11.84      .34     .23      .45
```

Table 2.7.4 Updated North Sea sole recruitment table

Recruitment table. Choices are bold and underlined

YEAR CLASS	AGE IN 2010	XSA THOUSANDS	RCT3 THOUSANDS	GM(1957 – 2007) THOUSANDS
2009	2	**<u>138 158</u>**	135 764	83 039
2010	1		**<u>138 093</u>**	94 000
2011	Recruit			**<u>94 000</u>**

Table 2.7.5 North Sea sole STF Input table

age	year	F	stock.n	stock.wt	landings.wt	mat	M
1	2011	0.016	138093	0.05	0.15	0	0.1
2	2011	0.160	138158	0.15	0.18	0	0.1
3	2011	0.342	64656	0.19	0.22	1	0.1
4	2011	0.428	30168	0.22	0.25	1	0.1
5	2011	0.384	14952	0.26	0.27	1	0.1
6	2011	0.380	32571	0.30	0.31	1	0.1
7	2011	0.354	3344	0.30	0.31	1	0.1
8	2011	0.403	2417	0.30	0.32	1	0.1
9	2011	0.589	1857	0.31	0.33	1	0.1
10	2011	0.589	3597	0.40	0.40	1	0.1
1	2012	0.016	93627	0.05	0.15	0	0.1
2	2012	0.160		0.15	0.18	0	0.1
3	2012	0.342		0.19	0.22	1	0.1
4	2012	0.428		0.22	0.25	1	0.1
5	2012	0.384		0.26	0.27	1	0.1
6	2012	0.380		0.30	0.31	1	0.1
7	2012	0.354		0.30	0.31	1	0.1
8	2012	0.403		0.30	0.32	1	0.1
9	2012	0.589		0.31	0.33	1	0.1
10	2012	0.589		0.40	0.40	1	0.1
1	2013	0.016	93627	0.05	0.15	0	0.1
2	2013	0.160		0.15	0.18	0	0.1
3	2013	0.342		0.19	0.22	1	0.1
4	2013	0.428		0.22	0.25	1	0.1
5	2013	0.384		0.26	0.27	1	0.1
6	2013	0.380		0.30	0.31	1	0.1
7	2013	0.354		0.30	0.31	1	0.1
8	2013	0.403		0.30	0.32	1	0.1
9	2013	0.589		0.31	0.33	1	0.1
10	**2013**	**0.589**		**0.40**	**0.40**	**1**	**0.1**

Table 2.7.6 North Sea sole Detailed STF table

Detailed STF table

age	year	F	stk.n	stkwt	landwt	mat	M	land n	landings	SSB	TSB
1	2011	0.016	138093	0.05	0.15	0	0.1	2118	321	0	6905
2	2011	0.160	138158	0.15	0.18	0	0.1	19514	3593	0	20493
3	2011	0.342	64656	0.19	0.22	1	0.1	17877	3881	12565	12565
4	2011	0.428	30168	0.22	0.25	1	0.1	10024	2470	6778	6778
5	2011	0.384	14952	0.26	0.27	1	0.1	4552	1246	3818	3818
6	2011	0.380	32571	0.30	0.31	1	0.1	9830	3011	9641	9641
7	2011	0.354	3344	0.30	0.31	1	0.1	952	296	1004	1004
8	2011	0.403	2417	0.30	0.32	1	0.1	765	243	725	725
9	2011	0.589	1857	0.31	0.33	1	0.1	790	258	580	580
10	2011	0.589	3597	0.40	0.40	1	0.1	1530	616	1440	1440
1	2012	0.016	93627	0.05	0.15	0	0.1	1436	218	0	4681
2	2012	0.160	122938	0.15	0.18	0	0.1	17364	3197	0	18236
3	2012	0.342	106480	0.19	0.22	1	0.1	29441	6392	20693	20693
4	2012	0.428	41554	0.22	0.25	1	0.1	13807	3402	9336	9336
5	2012	0.384	17800	0.26	0.27	1	0.1	5419	1483	4545	4545
6	2012	0.380	9215	0.30	0.31	1	0.1	2781	852	2728	2728
7	2012	0.354	20155	0.30	0.31	1	0.1	5740	1782	6053	6053
8	2012	0.403	2123	0.30	0.32	1	0.1	672	213	637	637
9	2012	0.589	1462	0.31	0.33	1	0.1	622	203	457	457
10	2012	0.589	2739	0.40	0.40	1	0.1	1165	469	1096	1096
1	2013	0.016	93627	0.05	0.15	0	0.1	1436	218	0	4681
2	2013	0.160	83352	0.15	0.18	0	0.1	11773	2168	0	12364
3	2013	0.342	94750	0.19	0.22	1	0.1	26198	5688	18413	18413
4	2013	0.428	68433	0.22	0.25	1	0.1	22738	5602	15375	15375
5	2013	0.384	24518	0.26	0.27	1	0.1	7464	2042	6260	6260
6	2013	0.380	10970	0.30	0.31	1	0.1	3311	1014	3247	3247
7	2013	0.354	5702	0.30	0.31	1	0.1	1624	504	1713	1713
8	2013	0.403	12795	0.30	0.32	1	0.1	4050	1284	3839	3839
9	2013	0.589	1284	0.31	0.33	1	0.1	546	178	401	401
10	2013	0.589	2110	0.40	0.40	1	0.1	898	362	845	845

Table 2.7.7 North Sea sole STF results: Management summary table

fmult	year	ssb	f2-6	recruit	landings
1	2011	36550	0.339	138093	15934

year	fmult	f2-6	landings	ssb	ssb2013
2012	0.0	0.000	0	45544	67728
2012	0.1	0.034	2106	45544	65680
2012	0.2	0.068	4143	45544	63701
2012	0.3	0.102	6113	45544	61790
2012	0.4	0.136	8017	45544	59943
2012	0.5	0.169	9859	45544	58158
2012	0.6	0.203	11642	45544	56434
2012	0.7	0.237	13366	45544	54767
2012	0.8	0.271	15034	45544	53155
2012	0.9	0.305	16648	45544	51598
2012	1.0	0.339	18211	45544	50092
2012	1.1	0.373	19723	45544	48636
2012	1.2	0.407	21187	45544	47228
2012	1.3	0.440	22604	45544	45866
2012	1.4	0.474	23976	45544	44549
2012	1.5	0.508	25305	45544	43275
2012	1.6	0.542	26592	45544	42042
2012	1.7	0.576	27838	45544	40850
2012	1.8	0.610	29046	45544	39696
2012	1.9	0.644	30216	45544	38580
2012	2.0	0.678	31350	45544	37499

Table 2.7.8 North Sea sole STF results: Updated option table for summary sheet

Basis: F (2011) = Fsq = mean (F2008–2010) scaled to 2010 = 0.34; R(2011) = RCT3 = 138 million; Landings(2011) = 15.9; SSB (2012) = 45.5.

Rationale	Landings (2012)	Basis	F (2012)	SSB (2013)	% SSB change 1)	% TAC change 2)
Management plan	16.2	TAC +15%	0.30	52.0	+14%	+ 15 %
MSY framework	12.5	FMSY	0.22	55.6	+ 22 %	-11 %
MSY transition	16.0	FMSY Transition= ((0.34*0.6) + (0.22 *0.4))	0.29	52.2	+ 15 %	+ 13 %
Precautionary approach	20.9	Fpa	0.4	47.5	+4 %	+ 48 %
Zero catch	0	F=0	0	67.7	+ 49 %	-100 %
Status quo	5.1	Fsq *0.25	0.09	62.7	+ 38 %	-64 %
	9.9	Fsq *0.5	0.17	58.2	+ 28 %	-29 %
	12	TAC - 15% (Fsq * 0.62)	0.21	56.1	+ 23 %	-15 %
	14.1	TACsq (Fsq * 0.74)	0.25	54.1	+ 19 %	+ 0 %
	16.2	TAC + 15% (Fsq * 0.87)	0.30	52.0	+14 %	+ 15 %
	16.6	Fsq * 0.9	0.31	51.6	+13 %	+ 18 %
	18.2	Fsq	0.34	50.1	+10 %	+ 29 %

Weights in '000 t.

1) SSB(2013) relative to SSB(2012).

2) Calculated landings (2012) relative to TAC 2011 (14 100 t).

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

Annex 3 Stock Annexes

Stock Annex: FU32 Norwegian Deep

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Norwegian Deep *Nephrops* (FU32)
Date:	07/05/2011 (WGNSSK2010)
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. 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 %. As the Danish landings have decreased in recent years (2007-2010) while the Norwegian landings have increased, the Danish share of the landings has decreased as well (69 % in 2009 and 2010). The decreased Danish landings are probably due to economic reasons, for instance increased fuel prices. The number of Danish fishing vessels has also decreased.

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

The Norwegian fleet fish *Nephrops* all year round. The *Nephrops* fishery north of 60 °N (with 15-30% of the Norwegian FU 32 landings (2001-2010)) is mainly a creel fishery, with some landings from *Nephrops* trawls (Figure A2-3). 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. Landings per ICES statistical rectangle was available for the first time in 2009 (Figure A2-4). Figure A2-4 illustrates the spatial distribution of the Norwegian fishery, which in FU 32 has its main distribution west of Stavanger.According to the logbooks there has been a change in the most commonly used mesh size. In 1999, 90% of the vessels used 70-80 mm trawls according to the logbooks. In 2000-2005 small-meshed trawls (70-80 mm) taking 17% of the *Nephrops* catches performed 22% of the trawling hours. In 2008 all logbook recorded catches (except bycatch in shrimp trawls) were from trawls with mesh size of 120 mm. According to the logbooks most vessels undertake 1-3 hauls per day, with an average duration of each haul of 6.3 hrs. The fishing trips last from 1 to 9 days.

The recreational fishery for *Nephrops* along the Norwegian coast has increased in recent years, but the extent of this fishery is unknown.

Regulations

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. Size can also be measured as total length, with a minimum legal size of 130 mm.

Trawls with mesh sizes down to 70 mm are legal, but require square meshes in the cod end. It is illegal to fish with more than two trawls south of 62 °N. When fishing for *Nephrops* with gear with mesh size not less than 70 mm, the bycatch of halibut, cod, haddock, hake, plaice, witch flounder, dab, lemon sole, sole, turbot, brill, megrim, whiting, fluke, eel, saithe, lobster, and crab may not exceed 70 % of the total weight of the catch.

A.3. Ecosystem aspects

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).

The *Nephrops* directed trawl fisheries are characterised by large amounts of non-commercial bycatch and *Nephrops* below MLS. The discard mortality is considered to be high (75 %, Wyman *et al*. 1999). The *Nephrops* trawl is constructed to scare the animals out of their burrows and as such is destructive to the bottom habitat.

B. Data

B.1. Commercial catch

Onboard sampling of catches (split into discard and landings component) are carried out by Danish observers, providing information on size distribution and sex ratio

(Figure A2-1). Onboard sampling of the landings components are also carried out by the Norwegian coast guard, mainly on Danish trawlers.

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.

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 CPUE

A catch-per-unit-effort time-series is available from the Danish trawl fleet (Figure A2-1). CPUE 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 15-40% of the landings in 2001-2008. Therefore, the catch-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, records on the use of *Nephrops* trawls are completely lacking in the 2006-2008 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.

The state of the stock is assessed based on the Danish CPUE.

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

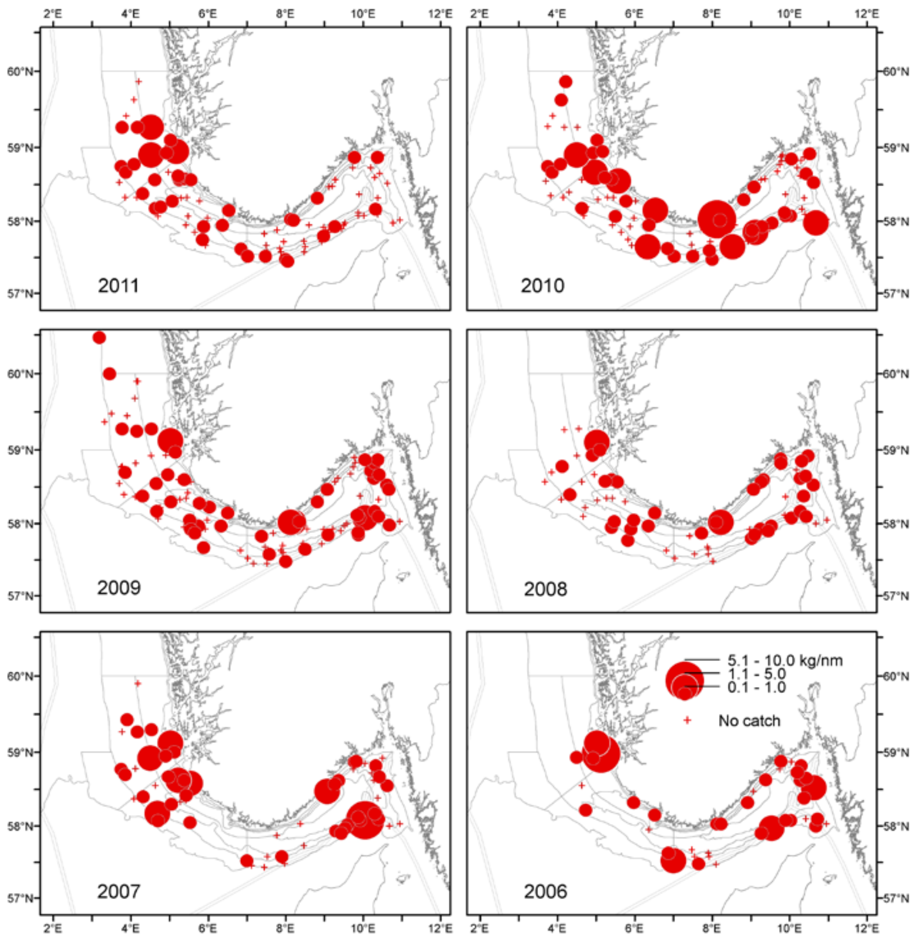


Figure A1-1. ***Nephrops*** **Norwegian Deep (FU 32). Catches (kg/nm trawled) from the Norwegian shrimp survey, January-February 2006-2011.**

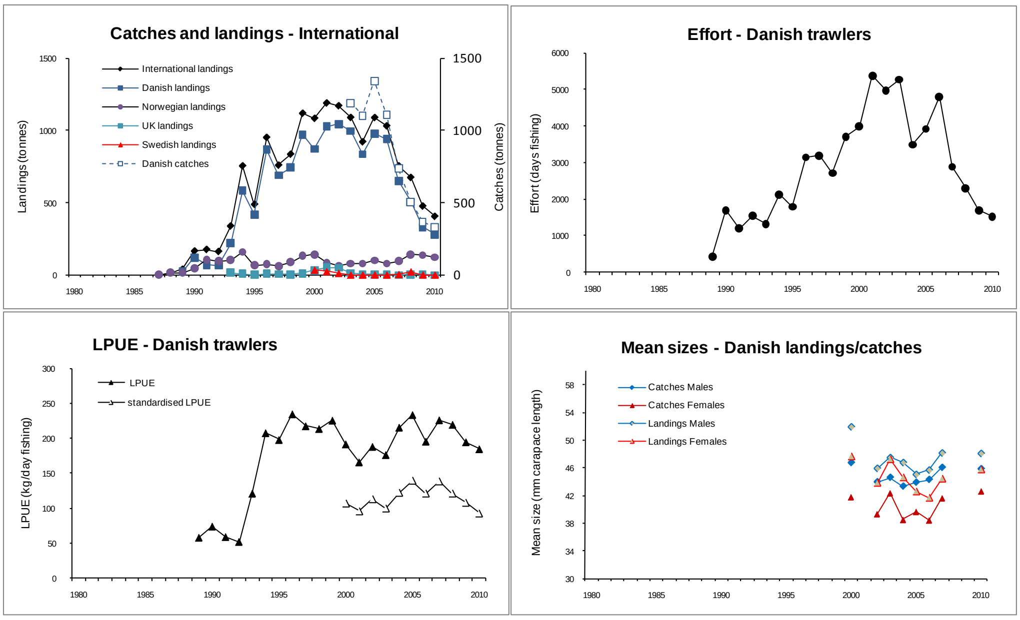


Figure. A2-1. ***Nephrops*** **Norwegian Deep (FU 32). Long term landings, Danish effort, Danish LPUE and Danish mean sizes of catches and landings.**

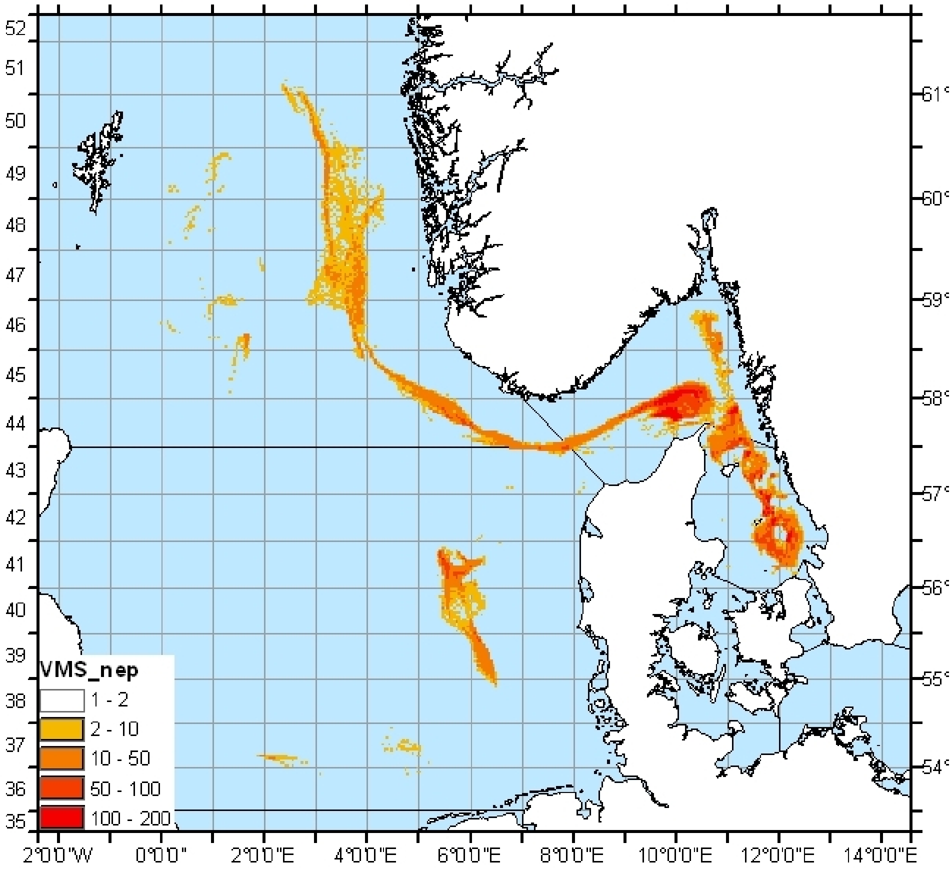


Figure A2-2. ***Nephrops*** **Norwegian Deep (FU 32). VMS data showing the spatial distribution of the Danish and Swedish fleet fishing for** ***Nephrops*** **in Skagerrak and the North Sea. The Swedish vessels are mainly fishing in Kattegat and the northeastern part of Skagerrak.**

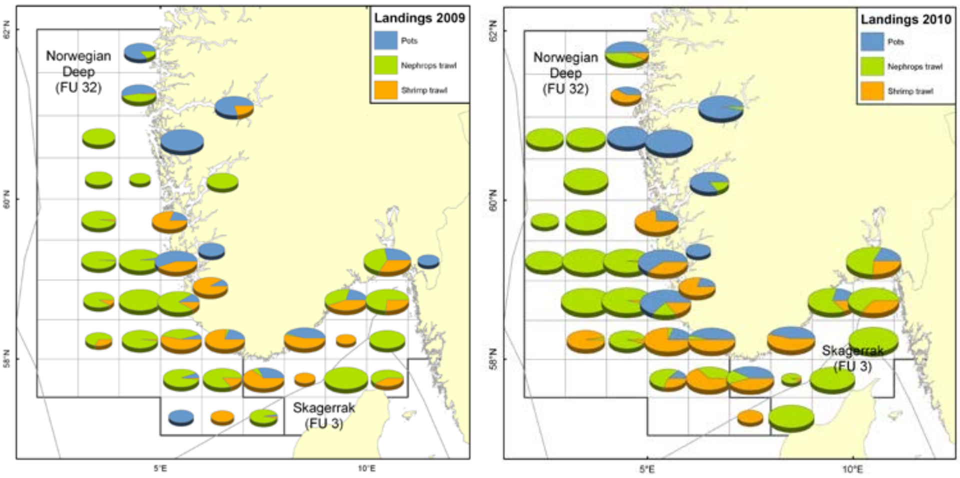


Figure A2-3. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings per gear type and ICES statistical rectangle in 2009-2010. The size of the symbols are porportional to the catch in the corresponding rectancles (scaled down by a log-transformation).**

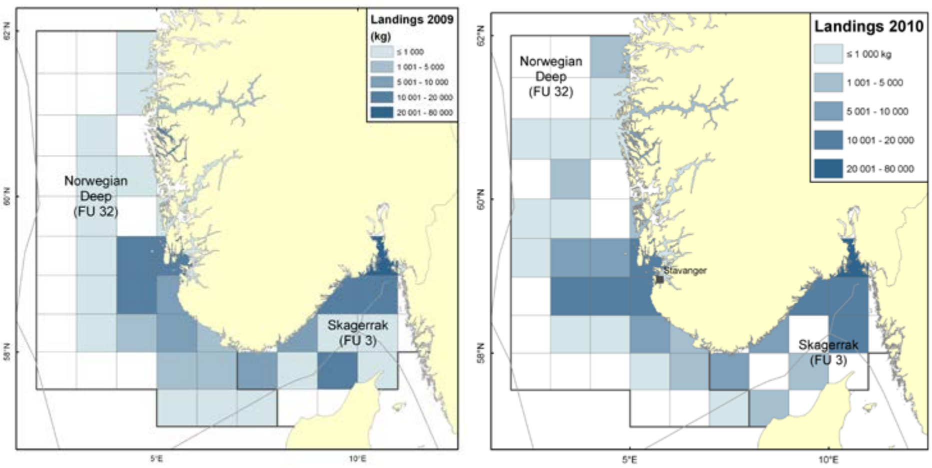


Figure A2-4. ***Nephrops*** **Norwegian Deep (FU 32). Norwegian landings (kg) per ICES statistical rectangle in 2009 and 2010.**

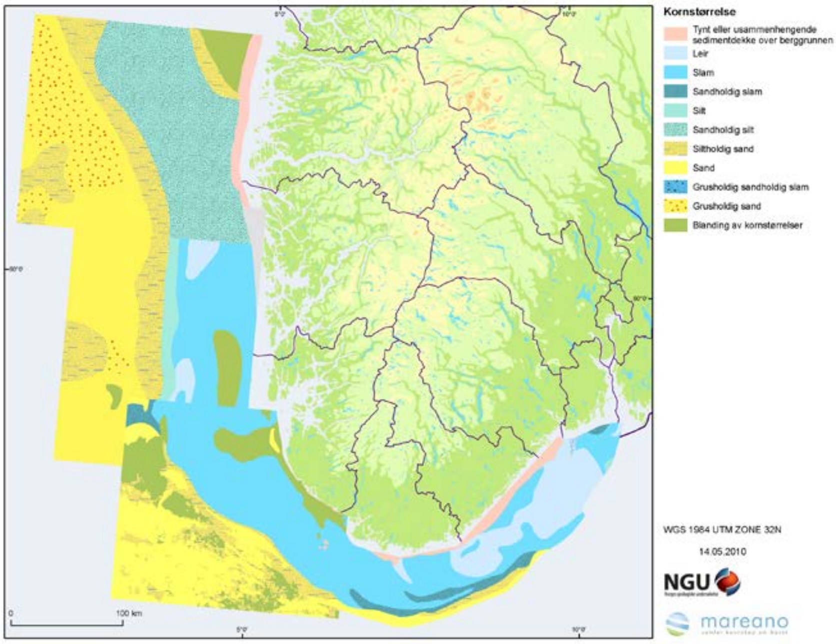


Figure A3-1. Sediment map of the Norwegian Deep and Skagerrak. Map from www.mareano.no.

Table A2-1. *Nephrops* Norwegian Deep (FU 32). Landings, and Danish effort and LPUE.

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	1084	3986	192
2001	1190	5372	166
2002	1171	4968	188
2003	1090	5273	177
2004	922	3488	216
2005	1089	3919	234
2006	1032	4796	196
2007	755	2878	226
2008	675	2301	220
2009	477	1694	195
2010	406	1522	185

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.

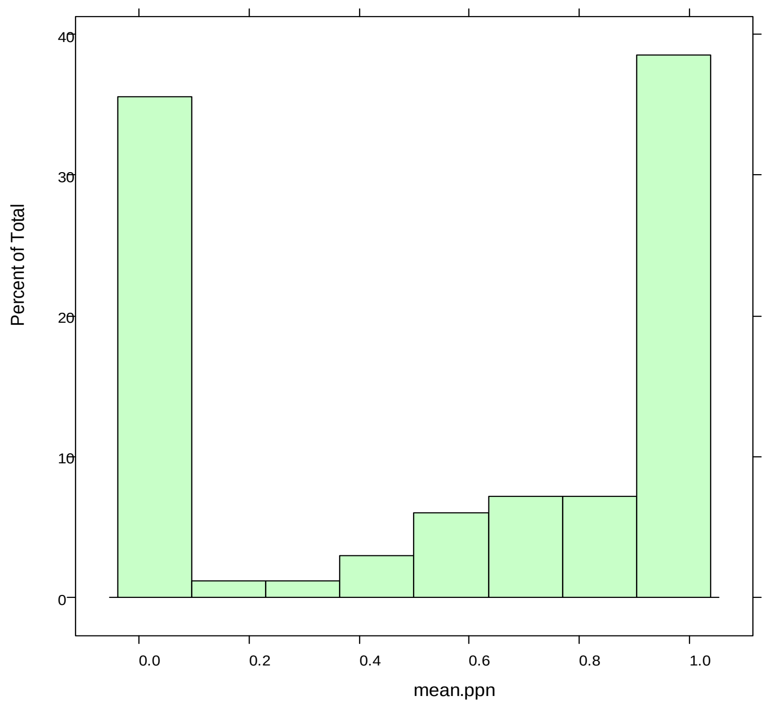


Figure B.1.1. Farn Deeps (FU 6): Histogram of proportion individuals <26mm discarded.

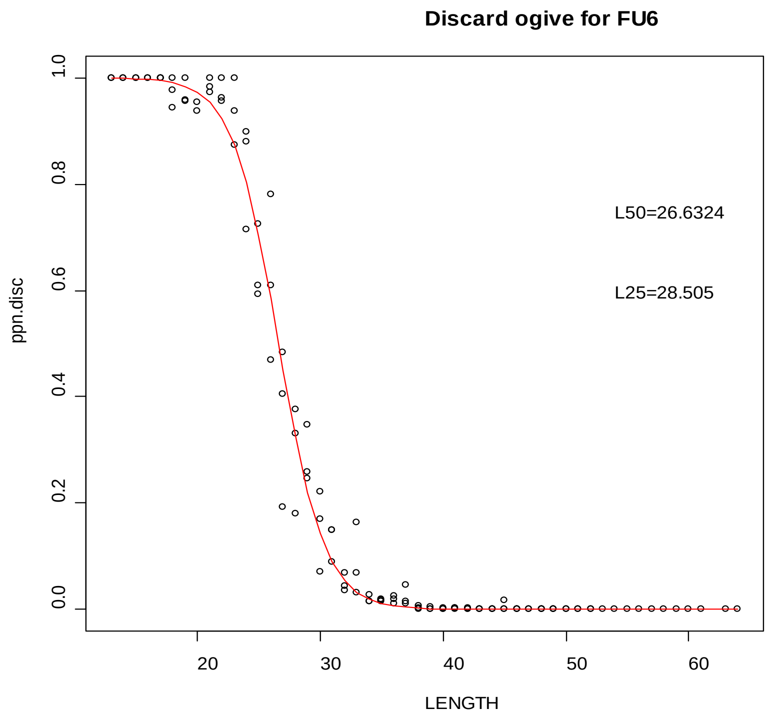


Figure B.1.2. Farn Deeps (FU 6): Discard ogive selected for FU6 *Nephrops*, trip level data pooled to year 2002-2007

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.

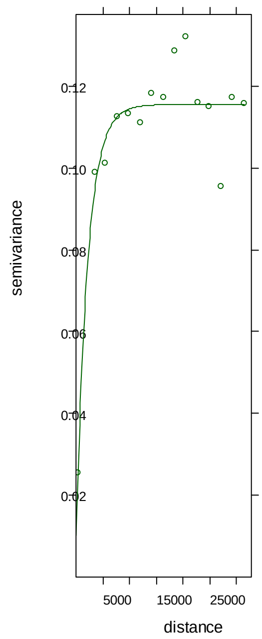
Mean density per station and the geographical coordinates (transformed from latitude and longitude into metres displacement from 54.67275 N, -1.332769 E) are first fitted with a variogram model. The following commands are used to fit the variogram (the data is held in dataframe “recounts7”)

```
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 F_{max}. 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 F_{max} 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	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) 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	Fbar(20-40 mm) F	HR (%)	SPR (%) M	SPR (%) F	SPR (%) T
$F_{0.1}$	M	0.14	0.09	9.5	40.3	47.6	43.3
	F	0.19	0.12	12.1	32.6	40.0	35.7
	T	0.16	0.10	10.3	37.8	45.2	40.9
F_{max}	M	0.28	0.18	16.2	23.6	30.8	26.5
	F	0.49	0.32	24.1	13.5	19.5	16.0
	T	0.33	0.21	18.5	20.0	26.9	22.8
$F_{35\%SpR}$	M	0.18	0.11	11.4	34.5	41.9	37.6
	F	0.24	0.15	14.4	27.1	34.5	30.1
	T	0.20	0.13	12.4	31.7	39.1	34.8

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

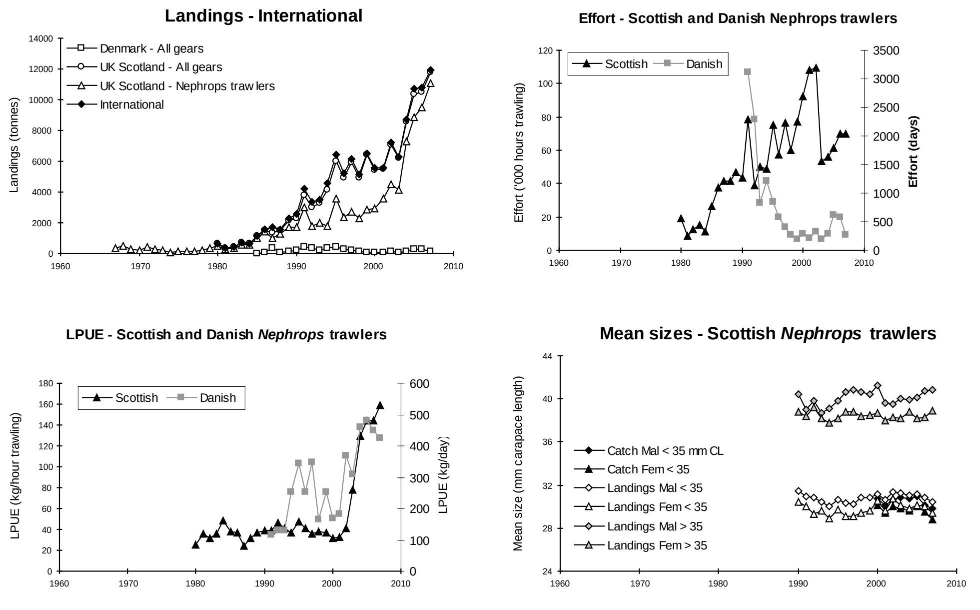


Figure B1-1. *Nephrops*, Fladen (FU 7), Long term landings, effort, LPUE and mean sizes.

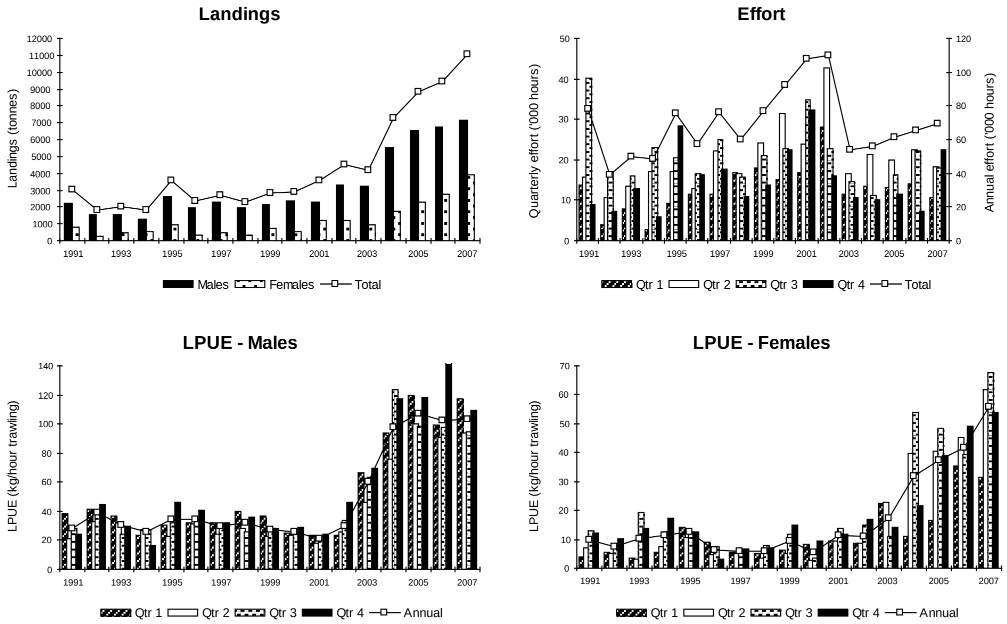


Figure B1-2. ***Nephrops*****, Fladen (FU 7), Landings, effort and LPUEs by quarter and sex from Scottish** ***Nephrops*** **trawlers.**

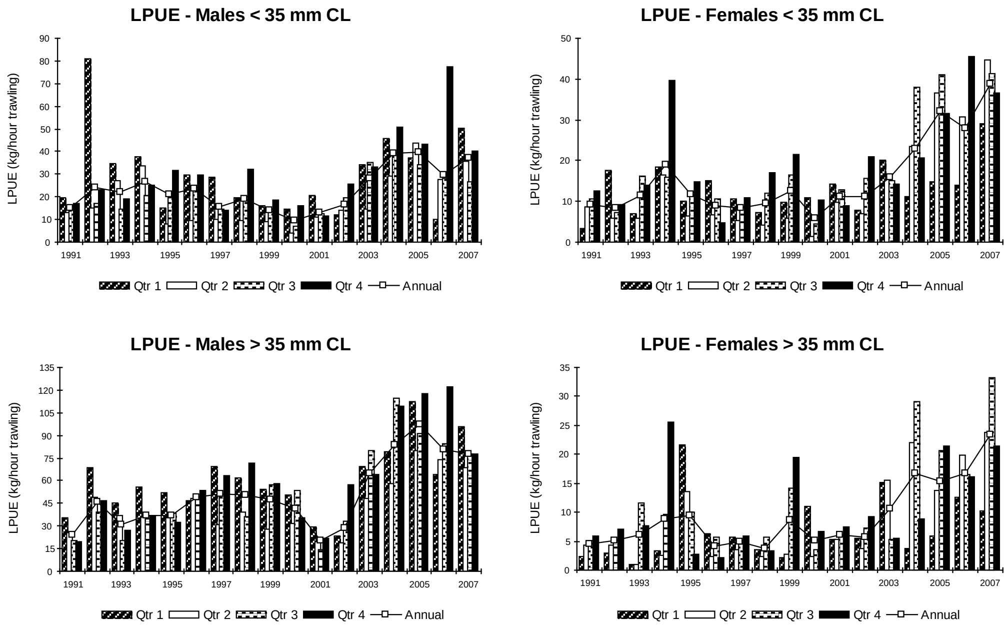


Figure B1-3. ***Nephrops*****, Fladen (FU 7), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

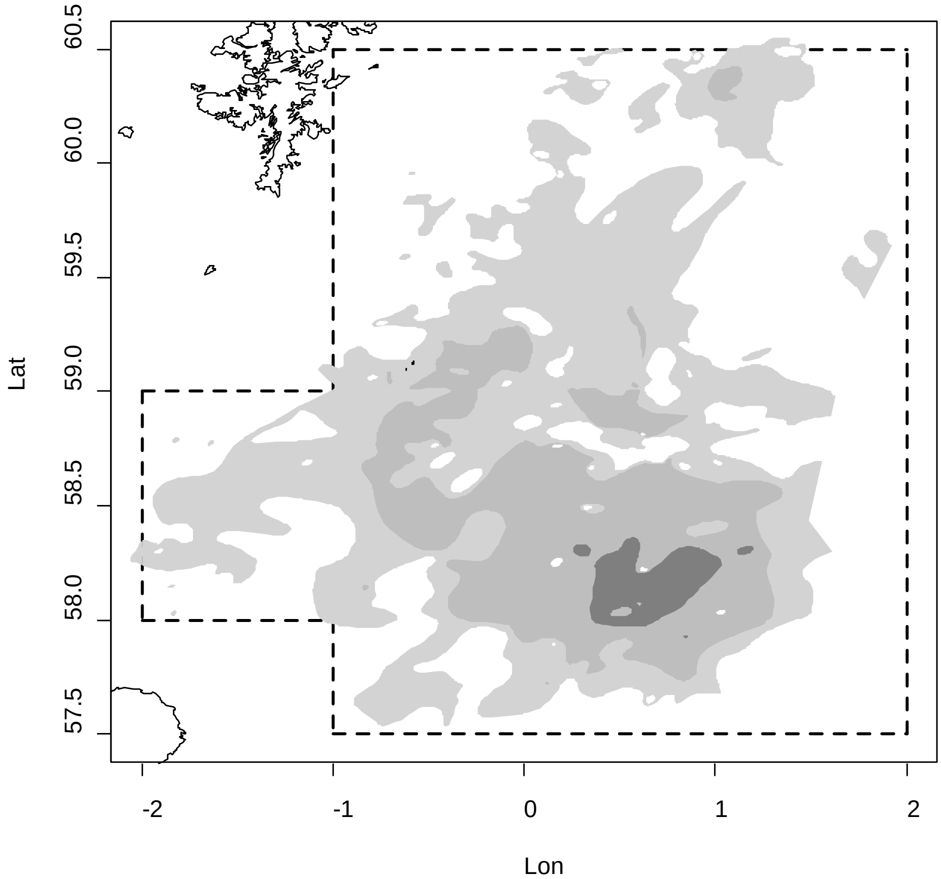


Figure B3–4. Distribution of *Nephrops* sediments in the Fladen Ground (FU 7). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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
$F_{0.1}$	M	0.13	0.06	7.5	42.3	64.5	51.7
	F	0.29	0.13	14.2	23.0	44.8	32.2
	T	0.16	0.07	8.7	37.3	60.0	46.9
F_{max}	M	0.24	0.11	12.3	26.9	49.5	36.5
	F	0.54	0.24	23.4	12.1	29.0	19.2
	T	0.31	0.14	15.0	21.6	43.0	30.6
$F_{35\%SpR}$	M	0.18	0.08	9.7	34.1	57.0	43.8
	F	0.42	0.19	19.3	15.8	35.0	23.9
	T	0.26	0.12	13.1	25.1	47.4	34.5

At the 2011 WG, the analysis was updated using data from 2008-10 to account for the apparent changes in the discard pattern in this fishery. The complete range of the current per-recruit F_{msy} proxies is given in the table below:

WGNSSK 2011		Fbar(20-40 mm) M	F	HR (%)	SPR (%) M	F	T
$F_{0.1}$	M	0.14	0.06	7.7	40.8	62.3	49.9
	F	0.31	0.13	15.2	20.5	40.7	29.0
	T	0.17	0.07	9.4	34.6	56.6	43.9
F_{max}	M	0.25	0.11	12.7	25.3	46.8	34.4
	F	0.64	0.28	26.7	9.1	22.9	14.9
	T	0.34	0.14	16.3	18.8	38.5	27.1
$F_{35\%SpR}$	M	0.17	0.07	9.4	34.6	56.6	43.9
	F	0.39	0.17	18.3	16.0	34.5	23.9
	T	0.25	0.11	12.7	25.3	46.8	34.4

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

For this FU, the absolute density observed n the UWTV survey is relatively high (average of ~ 0.8 m^{-2}). Harvest ratios (which are likely to have been underestimated prior to 2006) has been well above F_{max} and in addition there is a long time series of relatively stable landings (average reported landings ~ 2000 tonnes, well above those predicted by currently fishing at F_{max}) suggesting a productive stock. For these reasons, it is suggested that $F_{max(T)}$ is chosen as the F_{msy} proxy which is estimated to be 16.3 %.

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

H. Other Issues

I. References

Table B1-1. *Nephrops*, Firth of Forth (FU 8): Landings (tonnes), effort ('000 hours trawling) and LPUE (kg/hour trawling) of Scottish *Nephrops* trawlers, 1981-2007 (data for all *Nephrops* gears combined, and for single and multirigs separately).

Year	All *Nephrops* gears combined			Single rig			Multirig		
	Landings	Effort	LPUE	Landings	Effort	LPUE	Landings	Effort	LPUE
1981	945	42.6	22.2	945	42.6	22.2	na	na	na
1982	1138	51.7	22.0	1138	51.7	22.0	na	na	na
1983	1681	60.7	27.7	1681	60.7	27.7	na	na	na
1984	2078	84.7	24.5	2078	84.7	24.5	na	na	na
1985	1908	73.9	25.8	1908	73.9	25.8	na	na	na
1986	2204	74.7	29.5	2204	74.7	29.5	na	na	na
1987	1582	62.1	25.5	1582	62.1	25.5	na	na	na
1988	2455	94.8	25.9	2455	94.8	25.9	na	na	na
1989	1833	78.7	23.3	1833	78.7	23.3	na	na	na
1990	1901	81.8	23.2	1901	81.8	23.2	na	na	na
1991	1359	69.4	19.6	1231	63.9	19.3	128	5.5	23.3
1992	1714	73.1	23.4	1480	63.3	23.4	198	8.5	23.3
1993	2349	100.3	23.4	2340	100.1	23.4	9	0.2	45.0
1994	1827	87.6	20.9	1827	87.6	20.9	0	0.0	0.0
1995	1708	78.9	21.6	1708	78.9	21.6	0	0.0	0.0
1996	1621	69.7	23.3	1621	69.7	23.3	0	0.0	0.0
1997	2137	71.6	29.8	2137	71.6	29.8	0	0.0	0.0
1998	2105	70.7	29.8	2105	70.7	29.8	0	0.0	0.0
1999	2192	67.7	32.4	2192	67.7	32.4	0	0.0	0.0
2000	1775	75.3	23.6	1761	75.0	23.5	14	0.3	46.7
2001	1484	68.8	21.6	1464	68.3	21.4	20	0.5	40.0
2002	1302	63.6	20.5	1286	63.3	20.3	16	0.3	53.3
2003	1115	53.0	21.0	1082	52.4	20.6	33	0.6	55.0
2004	1651	63.2	26.1	1633	62.9	26.0	18	0.4	49.7
2005	1973	66.6	29.6	1970	66.5	29.6	3	0.1	58.8
2006	2437	61.4	39.7	2432	61.0	39.9	5	0.4	14.2
2007	2622	57.6	45.5	2601	57.1	45.6	21	0.5	43.2

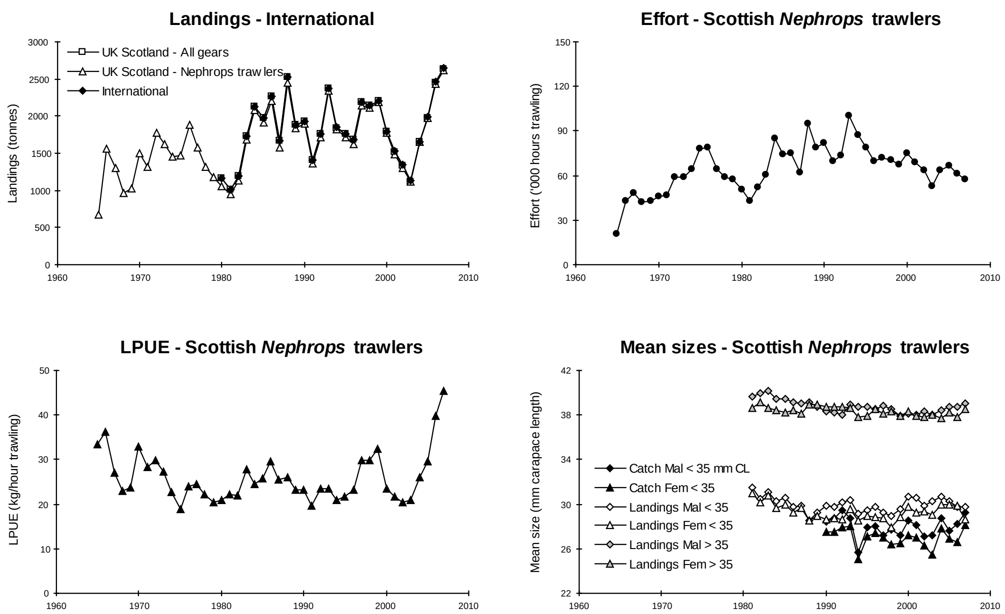


Figure B1-1. *Nephrops*, Firth of Forth (FU 8), Long term landings, effort, LPUE and mean sizes.

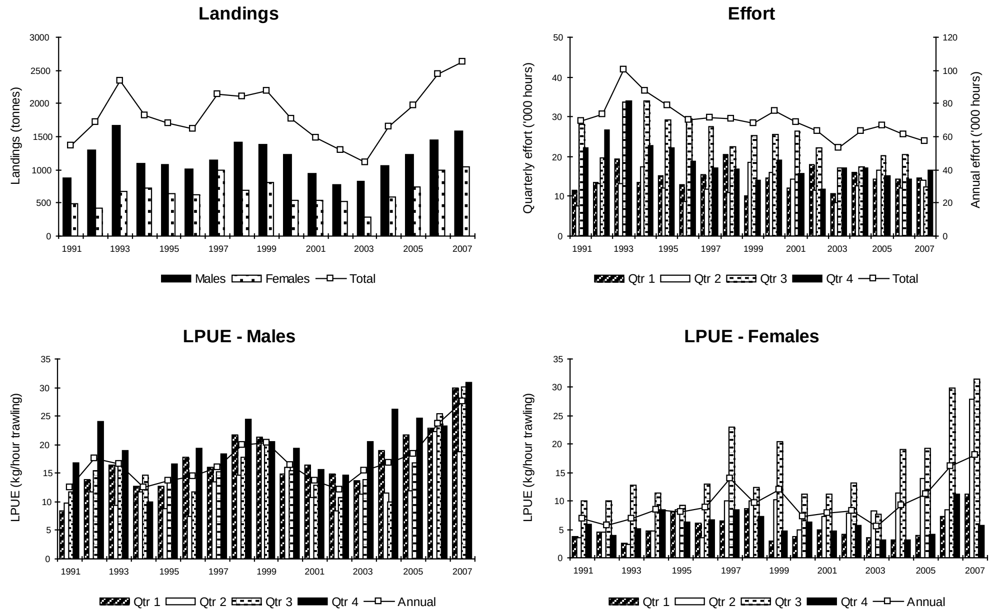


Figure B1-2. ***Nephrops*, Firth of Forth (FU 8), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**

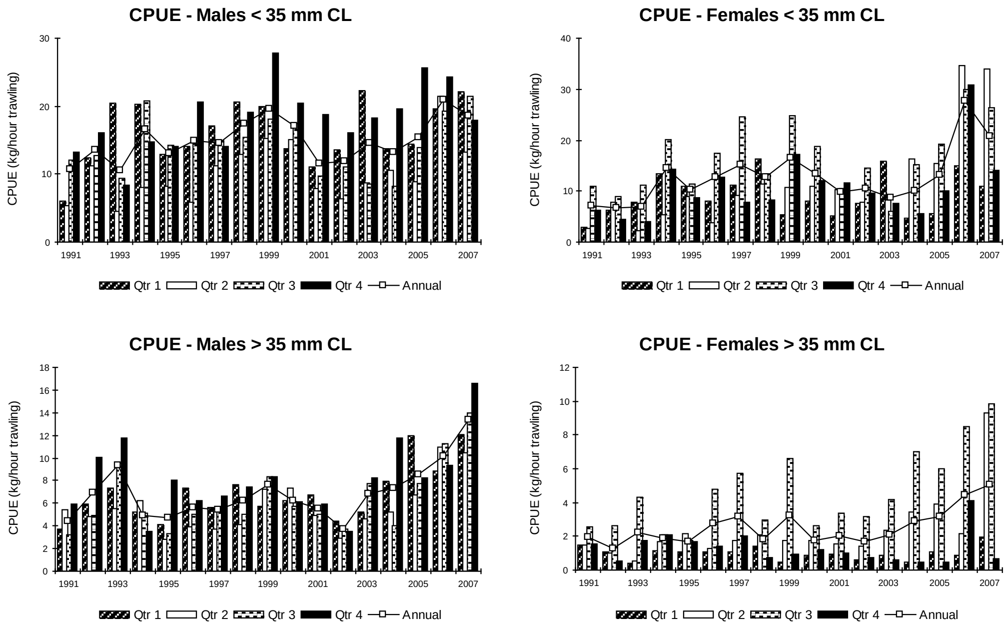


Figure B1-3. ***Nephrops*, Firth of Forth (FU 8), CPUEs by sex and quarter for selected size groups, Scottish *Nephrops* trawlers.**

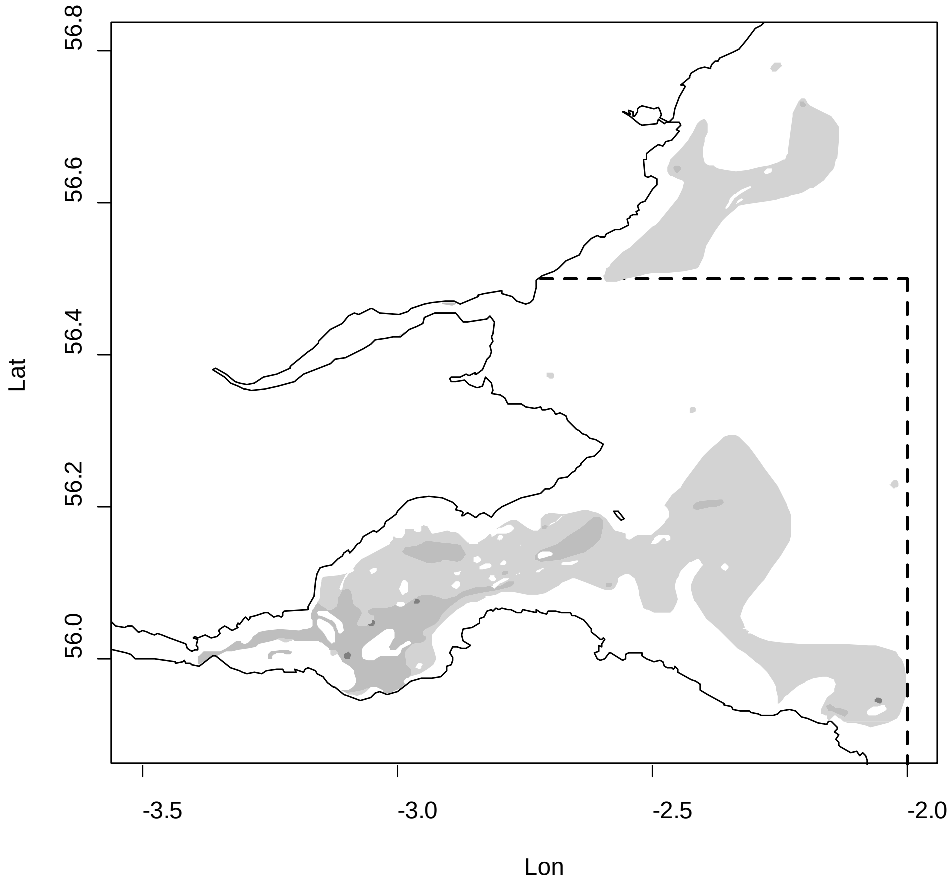


Figure B3–1. Distribution of *Nephrops* sediments in the Firth of Forth (FU 8). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

Stock Annex: FU9, Moray Firth

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Moray Firth *Nephrops* (FU 9)
Date:	09 March 2009 (WKNEPH2009)
Updated:	16 May 2011

Revised by Sarah Clarke/Carlos Mesquita/Helen Dobby

A General

A.1 Stock definition

Throughout its distribution, *Nephrops* is limited to muddy habitat, and requires sediment with a silt & clay content of between 10–100% to excavate its burrows. This means that the distribution of suitable sediment defines the species distribution. Adult *Nephrops* only undertake very small scale movements (a few 100 m) but larval transfer may occur between separate mud patches in some areas. The Moray Firth is located to the north west of Division IV and consists of statistical rectangles 44-45E6-E7 and 44E8. In common with other *Nephrops* fisheries the bounds of the Functional Unit are defined by the limits of muddy substrate. The major *Nephrops* fisheries within this management area fall within 30 miles of the UK coast. The Moray Firth (FU9) is a relatively sheltered inshore area, that supports populations of juvenile pelagic fish and relatively high densities of squid at certain times. The Moray Firth borders the Fladen functional unit (FU7) and there is some evidence of *Nephrops* populations lying across this boundary.

A.2 Fishery

The Moray Firth area is fished by a number of the smaller class of *Nephrops* boat (12-16m) regularly fishing short trips from Buckie, Helmsdale, Macduff and Burghead. Most boats still fish out of Burghead, and are about 15 in number; leaving and returning to port within 24 hours (day boats). Many of the smaller boats are now only manned by one or two people. Several of the larger *Nephrops* trawlers fish the outer Moray Firth grounds on their way to or from the Fladen grounds (especially when they are fishing the Skate Hole area). Also in times of bad weather many of the larger *Nephrops* trawlers which would normally be fishing the Fladen grounds fish the Moray Firth grounds. In recent years a squid fishery has been seasonally important in the Moray Firth. Squid appear to the east of the Firth and gradually move west during the Summer, increasing in size as they shift. During the autumn the movement is reversed. A large fishery took place in 2004 that attracted a number of *Nephrops* vessels and in 2005, additional vessels joined in the seasonal fishery, but catches were noticeably down in 2006. In 2007 however the fishery for squid improved again and a number of boats switched effort until around October, with some boats fishing squid until December.

A.3 Ecosystem aspects

No information on the ecosystem aspects of this stock has been collated by the Working Group.

B Data

B.2 Commercial catch

Length compositions of landings and discards are obtained during monthly market sampling and quarterly on-board observer sampling respectively. Levels of sampling are considered adequate for providing representative length structure of removals in the Moray Firth. Although assessments based on detailed catch analysis are not presently possible, examination of length compositions can provide a preliminary indication of exploitation effects.

LPUE data were available for Scottish *Nephrops* trawls. Table B1-1 shows the data for single trawls, multiple trawls and combined. Examination of the long term commercial LPUE data (Figure B1-1) suggests that the stock increased in the early- 1980s, declined to a stable level over the next 12 years or so and has recently increased to its highest level in 2007. It is thought that gear efficiency changes have occurred over time, particularly in relation to multiple trawl gears but this has not been quantified. Additionally, improved reporting of landings data in recent years arising from 'buyers and sellers' legislation is likely to also to have contributed to the increase in LPUE. Furthermore, effort recording is non-mandatory in terms of hours fish and therefore it is unclear whether these trends and those that are discussed below are actually indicative of trends in LPUE.

Males generally make the largest contribution to the landings (Figure B1-2), although the sex ratio does vary, and females landings exceeded males in 1994. Effort is generally highest in the 3rd quarter of the year in this fishery, but the pattern varies between years, and the seasonal pattern does not appear as strong in recent years. LPUE of both sexes remained relatively constant up to 2002, but has shown an increase since then. LPUE is generally higher for males in the 1st and 4th quarters, and for females in the 3rd quarter – the period when they are not incubating eggs.

CPUE data for each sex, above and below 35 mm CL, are shown in Figure B1-3. This size was chosen for all the Scottish stocks examined as the general size limit for discarded animals. The data show a slight peak in CPUE for smaller individuals (both sexes) in 1995, with a slight decline after this and relatively stable values from 2001 onwards. There is a peak in catches of small males in 2006 quarter 4 but taken annually the pattern is relatively stable. The CPUE for larger males shows relatively stable levels during the late 1990's, and slightly higher levels in the most recent years, particularly from 2003 onwards. CPUE for large females declined in 2005 but have risen again over the past two years, and showed a significant large value in 2007 quarter 3.

Biological

Dynamics for this stock are poorly understood and studies to estimate growth have not been carried out. Assumed biological parameters are as follows: natural mortality was assumed to be 0.3 for males of all ages and in all years. Natural mortality was assumed to be 0.3 for immature females, and 0.2 for mature females.

SUMMARY

Growth parameters:

Males; L_∞ = 62mm, k = 0.165

Immature Females; L_∞ = 62mm, k = 0.165

Mature Females; L_∞ = 56mm, k = 0.06,

Size at maturity = 25mm

Weight length parameters:

Males a = 0.00028, b = 3.24

Females a= 0.00074, b = 2.91

Discards

Discard survival rate: 25%

Discard rate: 3 year average (7.4% at benchmark WG)

B.3 Surveys

TV surveys are available for FU 9 since 1993 (missing survey in 1995). Underwater television surveys of *Nephrops* burrow number and distribution, reduce the problems associated with traditional trawl surveys that arise from variability in burrow emergence of *Nephrops.*

On average, about 36 stations have been considered valid each year, and are raised to a stock area of 2195 km^2. General analysis methods for underwater TV survey data are similar for each of the Scottish surveys. The ground is predominantly of coarser muddy sand (Figure B3–1) and most of the variance in the survey is associated with a patchy area of this sediment to the west of the ground. Abundance has generally been higher towards the west of the ground but in recent years higher densities have been recorded throughout, and are quite evenly distributed at the east and west ends in 2006 and 2007. With the exception of 2003, the confidence intervals have been fairly stable in this survey.

A number of factors are suspected to contribute bias to the surveys. In order to use the survey abundance estimate as an absolute it is necessary to correct for these potential biases. The history of bias estimates are given in the following table and are based on simulation models, preliminary experimentation and expert opinion, the biases associated with the estimates of *Nephrops* abundance in the Moray Firth are:

	Time period	**Edge effect**	**detection rate**	**species identification**	**occupancy**	**Cumulative bias**
FU 9: Moray Firth	<=2009	1.31	0.9	1	1	1.21

B.4 Commercial CPUE

Scottish *Nephrops* trawl gears: Landings at age and effort data for Scottish *Nephrops* trawl gears are used to generate a CPUE index. CPUE is estimated using officially recorded effort (hours fished) although the recording of effort is not mandatory. Combined effort for *Nephrops* single trawl and multiple *Nephrops* trawl is raised to landings reported by the four gears listed above. Discard sampling commenced in

1990 for this fishery, and for years prior to this, an average of the 1990 and 1991 values is applied. There is no account taken of any technological creep in the fleet.

For more information see section B.1

B.5 Other relevant data

C Historical Stock Development

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

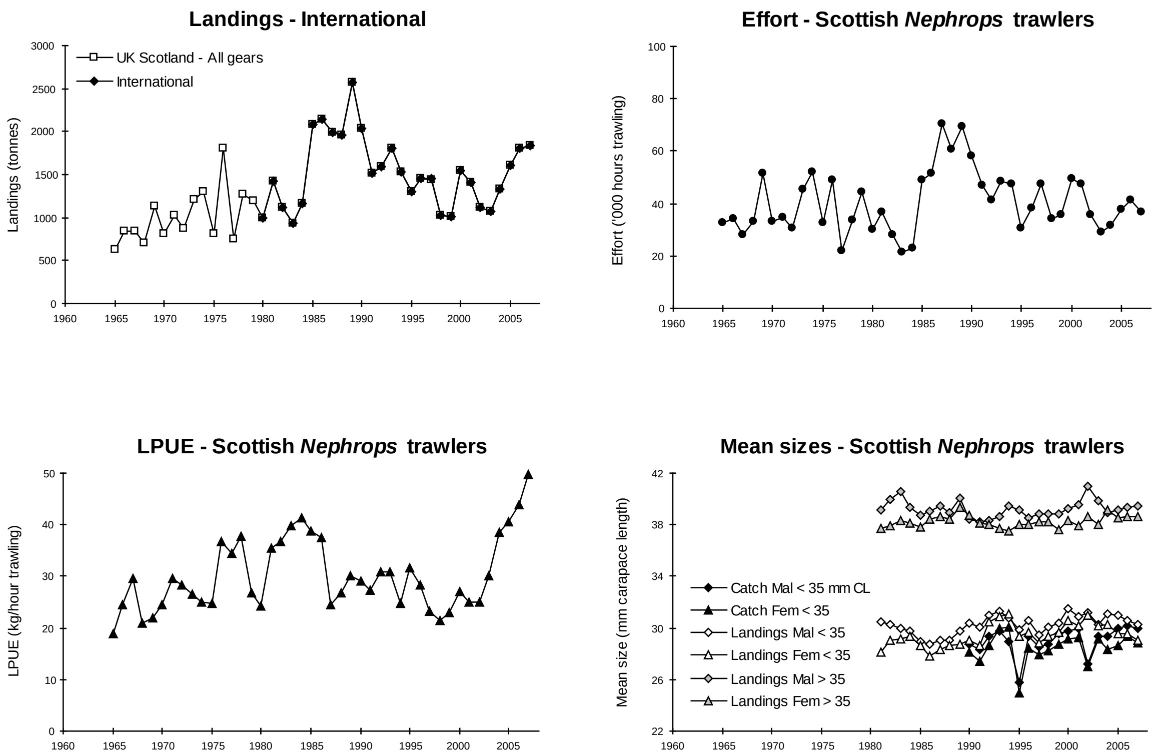


Figure B1-1. ***Nephrops*****, Moray Firth (FU 9), Long term landings, effort, LPUE and mean sizes.**

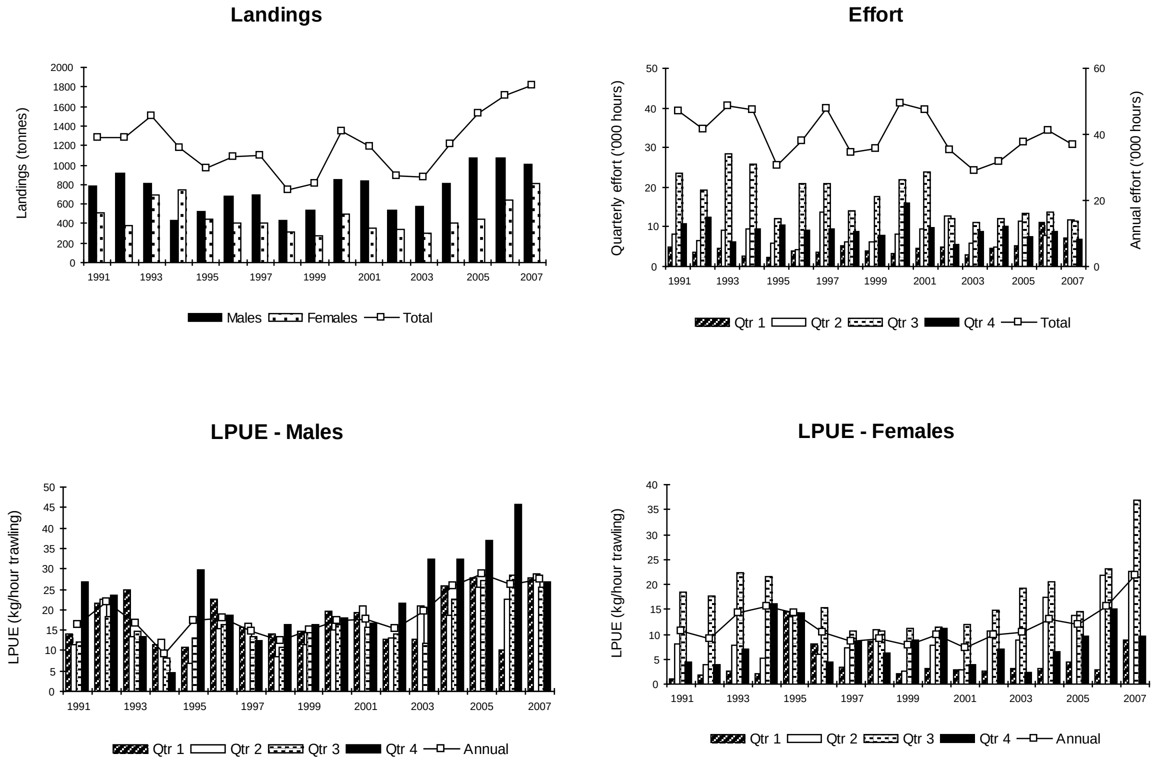
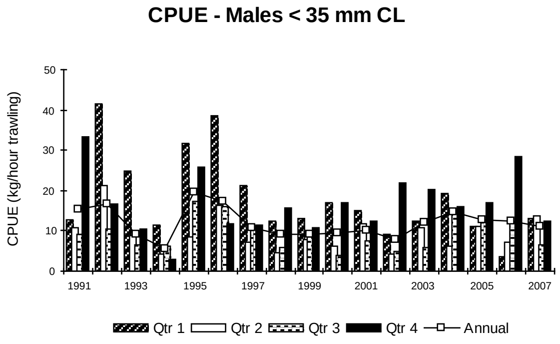
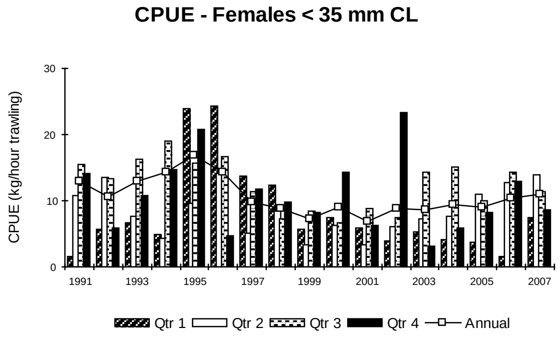
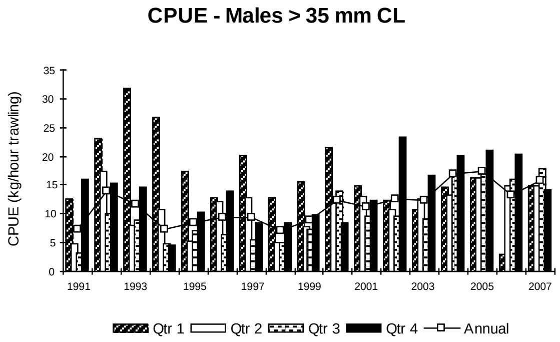


Figure B1-2. ***Nephrops*****, Moray Firth (FU 9), Landings, effort and unstandardised LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**







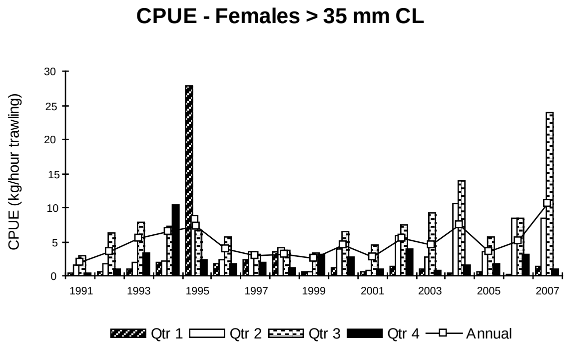


Figure B1-3. ***Nephrops*****, Moray Firth (FU 9), CPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

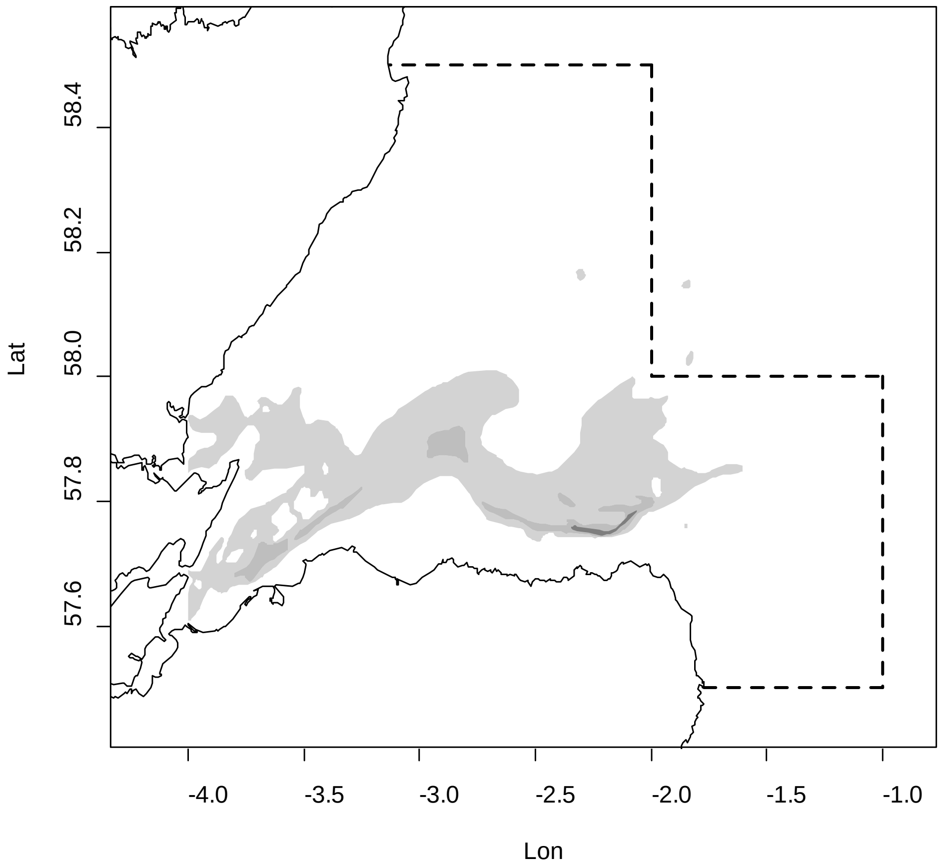


Figure B3–1. Distribution of *Nephrops* sediments in the Moray Firth (FU 9). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.

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	-

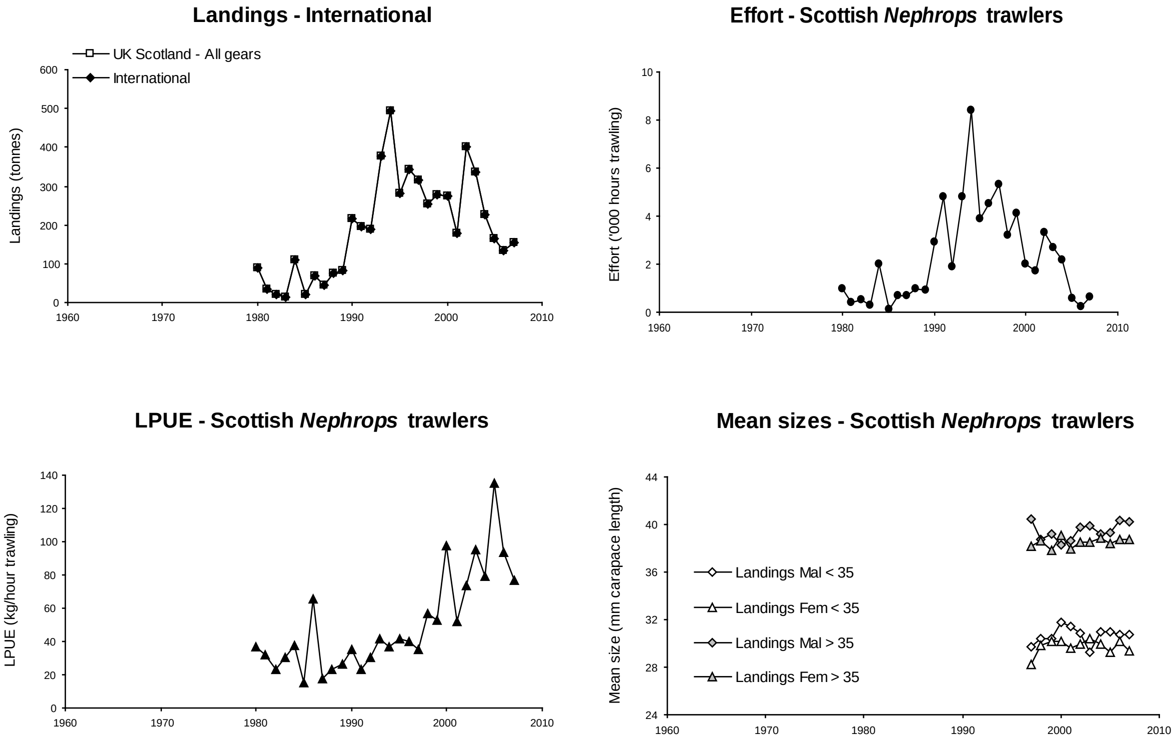


Figure 3.4.1.11 ***Nephrops*, Noup (FU 10), Long term landings, effort, LPUE and mean sizes.**

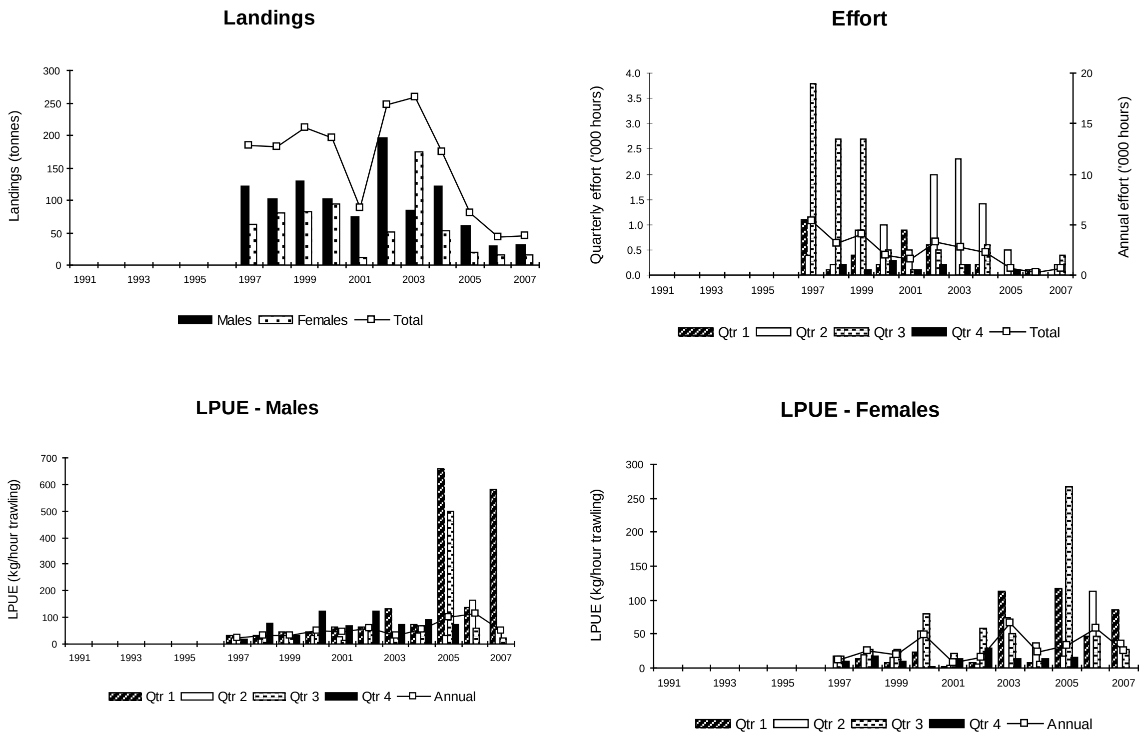


Figure 3.4.1.12 ***Nephrops*, Noup (FU 10), Landings, effort and LPUEs by quarter and sex from Scottish *Nephrops* trawlers.**

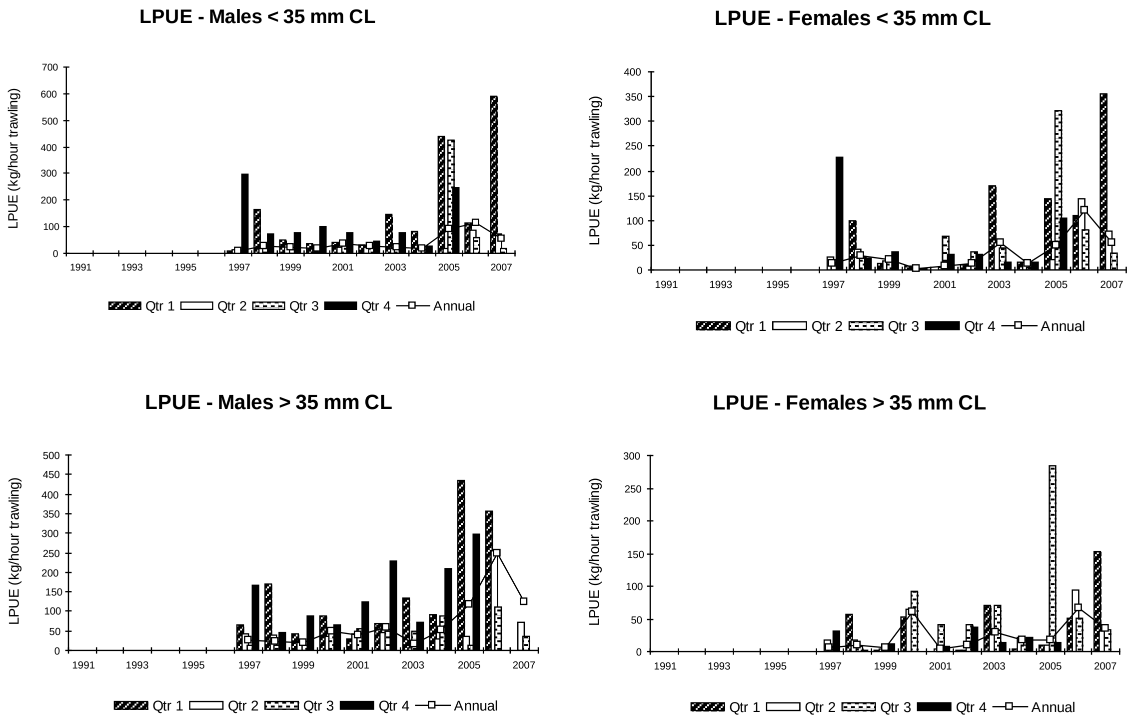


Figure 3.4.1.13 ***Nephrops*****, Noup (FU 10), LPUEs by sex and quarter for selected size groups, Scottish** ***Nephrops*** **trawlers.**

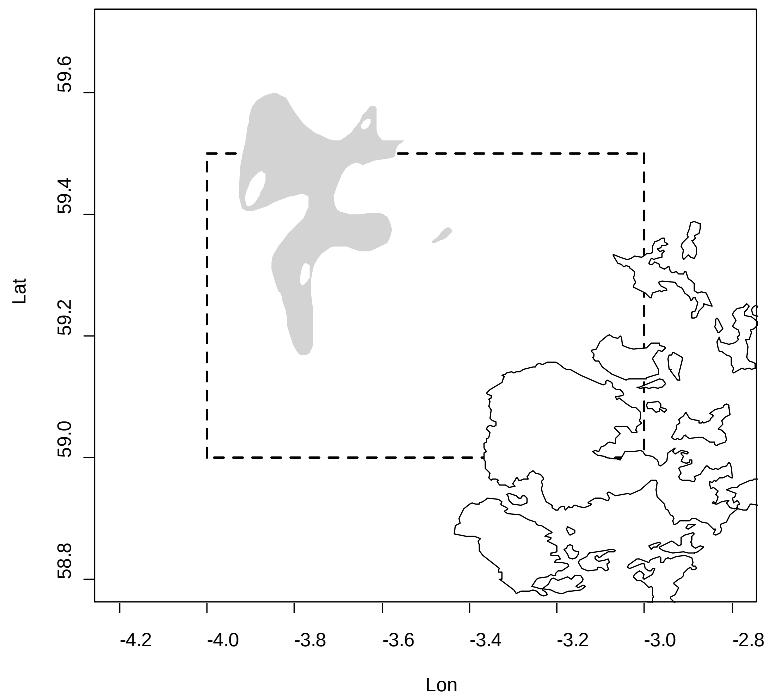


Figure B3–1. Distribution of ***Nephrops*** **sediments in Noup (FU 10). Thick dashed lines represent the boundary of the functional unit. Sediments are: Dark grey – Mud; Grey – Sandy Mud, Light Grey – Muddy.**

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: 10.5.11

A. General

A.1. Stock definition

Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (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, Nielsen, Larsen and Sparholt, 2009). Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway (Lambert, Nielsen, Larsen and Sparholt, 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, Nielsen, Larsen and Sparholt (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, Nielsen, Larsen and Sparholt (2009).

Spawning distribution: So far 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 a recent paper (Lambert, Nielsen, Larsen and Sparholt (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 only 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. 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 iso-cline) (Lambert, Nielsen, Larsen and Sparholt (2009).

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, Nielsen, Larsen and Sparholt (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.

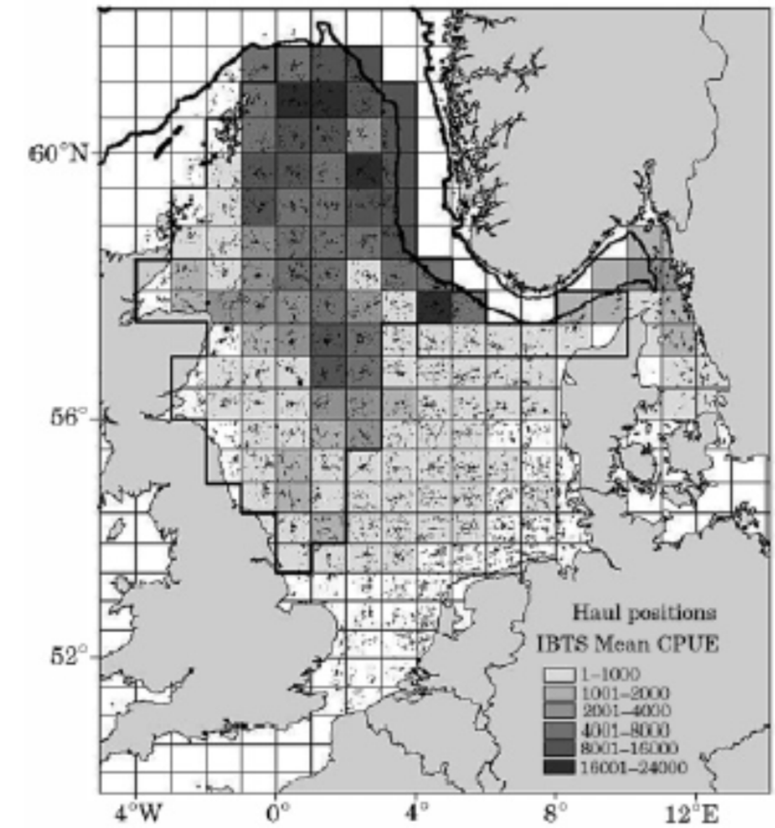


Figure 1 Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al.*, 2002b].

A.2. Fishery

The fishery is mainly 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. Norway pout is caught in small meshed trawls (16-31 mm) in a mixed fishery with blue whiting, i.e. in addition to the directed Norway pout fishery, the species is also taken as by-catch in the 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.

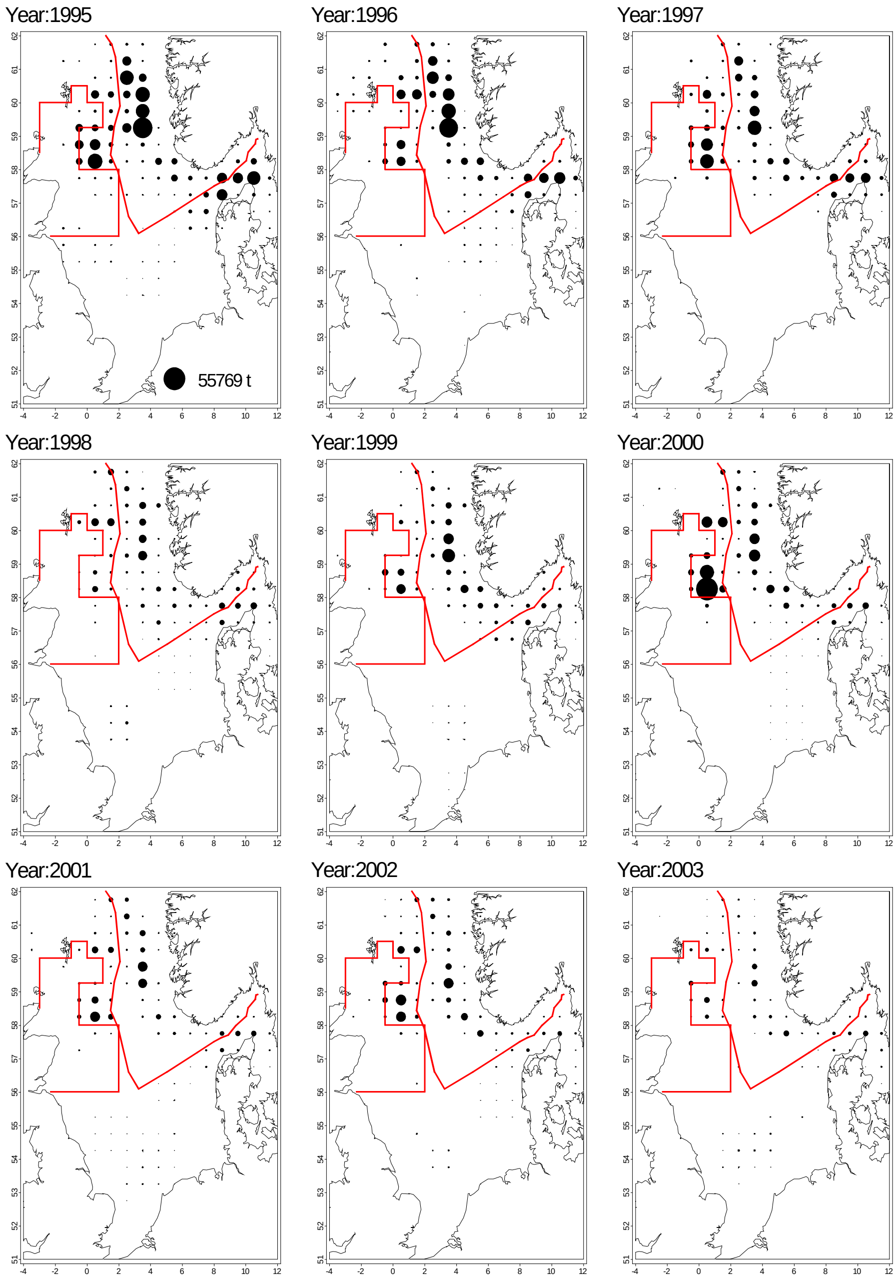


Figure 2. Landings of Norway pout by year and ICES rectangles for the period 1995-2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map.

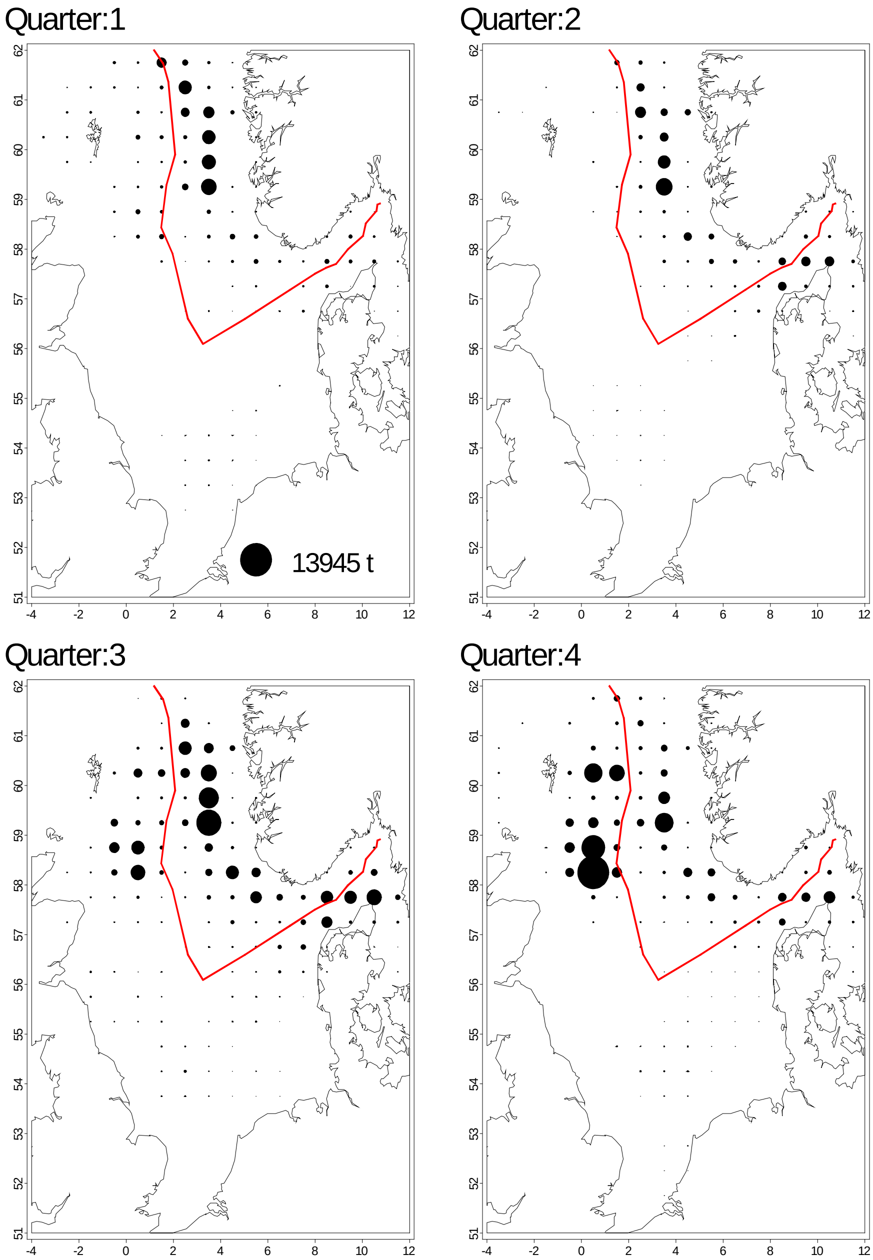


Figure 3. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994-2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map

Landings have been low since 2001, and the 2003-2004 landings were the lowest on record. Effort in 2003 and 2004 has been 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 for 2005, in the first half year of 2006, as well as in all of 2007, but Norway pout were in the periods of closure taken as a by-catch in the Norwegian mixed blue whiting and Norway pout 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 based on the 2005 and 2007 year classes, respectively, both being on the long term average level. However, the Norwegian part of the Norway pout fishery was only open from May to August in 2008. Despite opening of the fishery by 1st January 2008 (with an preliminary EU quota of 36 500 t and a Norwegian quota of 4 750 t as well as a final EU quota of 110 000 t set late in 2008) only 30.4 kt was taken by Denmark, and the Norwegian catches were 5.7 kt, i.e. 36.1 kt in total. The fishery has been open full year in the period 2008 to 2010 based on recent strong year classes being on or above the long term average level, especially the 2009 year class has been strong. The 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 and 162 kt in 2010, and the respective landings were 36 kt, 55kt and 126kt in 2008, 2009 and 2010. Consequently, the TAC has not been taken in recent years (2008, 2009 and 2010). This is due to high fishing (fuel) costs in all years as well as bycatch regulations in 2009 and 2010 (mainly in relation to whiting bycatch), which is a recent problem. Also, there might be an effect of late setting of the final yearly quota affecting the trade of individual Danish vessel quotas and accordingly the fishing opportunities. The 2010 landings was 126 kt based on the strong 2009 year class, but based on a very low 2010 year class being at the same level as the low 2003-04 year classes the fishery has so far been closed in 2011.

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 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. Review of scientific documentation reveals that by-catch reduction 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 (Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22). ICES advice that such species selective devices are used in the Norway pout fishery. By-catches of other species should also be taken into account in management of the fishery. 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 this **Stock Quality Handbook (Q5)**.

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 below 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 (Sparholt, Larsen and Nielsen 2002a,b; Lambert, Nielsen, Larsen and Sparholt (2009). 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 (ICES WGNSSK Reports). However, 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, haddock, cod and mackerel) (ICES-SGMSNS 2006). Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock from the most recent multi-species stock assessment performed by ICES (ICES-SGMSNS 2006). Growth and mean weight-at-age for the above mentioned predators seems independent of the stock size of Norway pout.

Natural mortality varies between age groups, and natural mortality at age varies over different time periods. Even though different sources of information (surveys, MSVPA) give slightly different perception of natural mortality at age (see below), the natural mortalities obtained from the most recent run with the North Sea MSVPA model (presented and used in the ICES SGMSNS (2006)) indicate high predation mortality on Norway pout. 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. 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, Nielsen, Larsen and Sparholt, 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.

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 (Q5)**. 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.

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 1994-2004 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 has not been prepared because of introduction of selective grids in the Norwegian fishery in 2010.

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 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.

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. 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. In general, the mean weights at age in the catches are variable between seasons of year. The same mean weight at age in the stock is used for all years. The reason for mean weight at age in catch is not used as estimator of weight in the stock is mainly because of the smallest 0-group fish are not fully recruited to the fishery in 3rd quarter of the year because of likely strong effects of selectivity in the fishery. 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 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 there has also been used information from other quarters. No age composition data for the Danish landings in first half year 2010 have been sampled because of very small catches. Mean weight at age data is available from both Danish and Norwegian fishery in 2009 and second half year 2010.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.

Maturity and natural mortality

Spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway. Around 10 % (varying between years and sex – see below) of the Norway pout reach maturity already at age 1, however, most individuals reach maturity at age 2. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in Larsen *et al*. (2001), indicated variation in maturity between years and sexes, especially for the 1-group. Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (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 only around 90% and 95%, respectively, as compared to 100% used in the assessment.

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, 10% of the 1-group and 100% of the 2+-group independent of sex. The natural mortality is set to 0.4 for all age groups in all seasons that result in an annual natural mortality of 1.6 for all age groups.

In the 2001 and 2002 assessment exploratory runs were made with revised input data for natural mortality based on the results from two papers presented to the working group in 2001, (*both papers published in ICES J. Mar. Sci. in 2002, Sparholt, Larsen and Nielsen 2002a,b).* This was not explored further in the 2003 up-date assessment but the 2004 benchmark assessment of the stock includes an exploratory run with revised natural mortalities. These revised natural mortalities are given in Table 12.2.3 in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005); ICES CM2005/ACFM:07).

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared to those for the accepted run with standard settings. It appears that the implications of these revised input data are very significant. The working group in 2002 suggested that an assessment with partly the traditional settings (constant M) and a new assessment with the revised values for M were made for at least a 3 year period in order to compare the output and the performance of the assessments before the working group decided on final adoption of the revised values for M to be used in the assessment. This attitude was adopted by the Working Group again in the 2004 benchmark assessment where an exploratory run with revised values for M was performed as well. The results of the exploratory runs have been consistent throughout the 3 years of exploratory runs.

Research results on population dynamics parameters (e.g. natural mortality and maturity)

Investigations on population dynamics (natural mortality, distribution, and spawning and maturity as well as growth patterns) of Norway pout in the North Sea are ongoing. Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (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 only around 90% and 95%, respectively, as compared to 100% used in the assessment.

Studies presented to the working group in 2001 and published in 2002 indicate that natural mortality may be significantly different between age groups compared to constant as currently assumed in the assessment model Sparholt, Larsen and Nielsen (2002a,b). This result is further supported by the results of the population dynamics analyses performed in Lambert, Nielsen, Larsen and Sparholt (2009).

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, Larsen and Nielsen, 2002a,b*) as well as natural mortality estimates from the North Sea MSVPA model in the 2006 assessment (ICES CM 2006/ACFM:35).

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared to those for the accepted run with standard settings. It appeared that the implications of these revised input data are very significant. The working group in 2002 suggested that an assessment with partly the traditional settings (constant M) and a new assessment with the revised values for M were made for at least a 3 year period in order to compare the output and the performance of the assessments before the working group decided on final adoption of the revised values for M to be used in the assessment. This attitude was adopted by the working group again in the 2004 benchmark assessment where an exploratory run with revised values for M was performed as well. The results of the exploratory runs have been consistent throughout all years of exploratory runs.

The working group recommended in 2005 that there was made a limited benchmark assessment for Norway pout in the 2006 assessment (ICES CM 2006/ACFM:35) with specific reference to evaluation of effects of using revised natural mortalities, and that the WG on this basis decides on which natural mortalities to use in the assessment. Here three data time series for natural mortality was considered and compared through exploratory assessment runs:

1. Constant natural mortalities by age, quarter and year as used in previous years standard (baseline) assessment
2. Revised natural mortalities obtained from and based on the results from Sparholt *et al* (2002a,b)
3. Revised natural mortalities obtained from the most recent run with the North Sea MSVPA model (presented and used in the ICES SGMSNS (2006).

The estimates of natural mortality by Sparholt *et al* (2002a,b) indicate age and periodical tendencies and differences in natural mortality with higher M for age 2 and 3 compared to age 1 (and 0). The proportion of the natural mortality due to predation was found highest at age 1. Non-predation mortality on Norway pout increases with age and is very high for age 2 and older fish resulting in relatively higher overall M values for age 2 and 3 compared to age 1. The estimates are based on analysis of IBTS quarter 1 survey time series in two periods from 1977-1981 and 1987-1991. The results also revealed high variation in total mortality (Z) by age and period using different survey time series (IBTS Q1 1977-81, 1987-1991, 1979-1999, SGFS Q3 1987-1991, 1980-1997, and EGFS Q3 1982-1992) as well as other source time series (commercial catch data time series 1977-1981, 1987-1991, and numbers consumed by year class 1977-1981, 1987-1991). Even though the results using different sources and surveys confirmed overall age specific tendencies in Z there were high variability and some inconsistency in the estimates from different sources in different periods.

The estimated M and Z values by age based on the 1987-1991 IBTS Q1 data from this study are shown in ICES CM 2006/ACFM:35, **Figures** 5.2.3-4 as well as in **Table** 5.2.6. The M values from 1987-1991 were extrapolated and used as constant values by age and quarter for all years for the period 1983-2006 in exploratory SMS assessment runs comparing use of baseline M and M from Sparholt *et al* (2002a,b) (**Figure** 5.2.3-4). The results showed different levels of SSB, F, recruitment and TSB but the same perception of stock dynamics in accordance with previous years results (**Figure** 5.3.10).

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 (as given in **Table** 5.3.2 of ICES CM 2007/ACFM:18 and 30) covering the period 1983-2005 was also presented in **Figure** 5.2.3**.** It appeared that for the period up to 1990-1995 Z estimated from SURBA and Sparholt, Larsen and Nielsen (2002a,b) is on 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, Larsen and Nielsen (2002a,b). In recent years from 2002-03 SURBA estimates of Z increases again compared to the period 1995-2001.

In conclusion, the survey based mortality estimates indicate age specific differences in Z and M. However, different survey time series indicate high variability in the mortality with somewhat contradicting tendencies between periods. Sparholt, Larsen and Nielsen (2002a,b) discussed their results in context of changed catchability in the surveys, migration out of the area, or age specific distribution patterns of Norway pout and concluded that the mortality patterns were not caused by this.

The MSVPA estimates of Z in the period 1983-2003 also shown in **Figure** 5.2.3-4 of ICES CM 2007/ACFM: 18 and 30 and obtained from ICES SGMSNS (2006) are higher than the survey based estimates from Sparholt, Larsen and Nielsen (2002a,b) and from SURBA for the 1-2 age groups, but on the same level for the 2-3 age groups indicating relatively high difference for the 1-group. Higher natural mortality (M) values for the 1-group from MSVPA compared to those from Sparholt, Larsen and Nielsen (2002a,b) are evident from **Figure** 5.2.4. The MSVPA indicate that M by quarter of year is on the same level for all three age groups (1-3) by year during the whole assessment period.

MSVPA M increase in 2002 and 2003 for both age 1, 2 and 3 (as was also observed in SURBA estimated Z). Whether this tendency of change in level of MSVPA M for in recent years has continued is unknown because MSVPA M estimates in 2004 and 2005 are not available (ICES-SGMSNS 2006). The SURBA estimates for 2003-2005 might indicate that the increasing tendency in Z (and accordingly M as F is 0) is not continuing from 2003 to 2004-05 (**Figure** 5.2.3). Accordingly, when using the MSVPA natural mortalities it is necessary to make assumptions about natural mortality for the years 2004 and 2005. The rather constant level of natural mortality for all age groups in the MSVPA in previous years might be changing (increasing) in recent years from 2002 and onwards as indicated on **Figure** 5.2.3-4, but this cannot be finally documented. When up-date estimates of MSVPA M-values are available it should again be considered whether to use MSVPA estimates of M in the assessment. In the exploratory runs with SMS using MSVPA values, the M for 2004 and 2005 was assumed to be equal to the 2003 values. The results of this exploratory run revealed that there was no difference in perception of the stock compared to the baseline assessment with constant M (**Figure** 5.3.11). This should be seen in context of the constant M by age and quarter chosen in the baseline assessment at 0.4 by quarter and age is based on the rather constant level of M estimates from MSVPA in the period 1983-2001.

Consequently, the MSVPA estimates indicate rather constant M between age groups (and years), and do not provide the most recent estimates of M.

Overall, the independent sources of information on mortality are contradicting between age groups and inconclusive between periods (variable). Consequently, it has been chosen to continue using the baseline assessment constant values for M at age and quarter as in previous years assessment.

Executive summary and conclusions of the explorative comparison runs using recent research results:

In response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea a summary of the September 2006 benchmark assessment on this issue is given here (see also ICES CM 2006/ACFM:35):

Investigations on population dynamics (natural mortality, distribution, and spawning and maturity as well as growth patterns) of Norway pout in the North Sea are ongoing.

Studies presented to the working group in 2001 and published in 2002 as well as results published in 2009 indicate that natural mortality may be significantly different between age groups compared to constant as currently assumed in the assessment model (Sparholt, Larsen and Nielsen, 2002a,b; Lambert, Nielsen, Larsen and Sparholt, 2009).

Exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 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, Larsen and Nielsen, 2002a,b*) as well as natural mortality estimates from the North Sea MSVPA model in the 2006 assessment.

The resulting SSB, TSB (3rd quarter of year), TSB (1st quarter of year) and F for the final exploratory run was compared to those for the accepted run with standard settings. It appeared that the implications of these revised input data are very significant. The results of the exploratory runs have been consistent throughout all years of exploratory runs. The working group recommended in 2005 that there was made a limited benchmark assessment for Norway pout in the 2006 assessment with specific reference to evaluation of effects of using revised natural mortalities, and that the WG on this basis decides on which natural mortalities to use in the assessment.

The benchmarking evaluated three independent sources and data time series for natural mortality and made exploratory SMS assessment model runs for those:

1. Constant natural mortalities by age, quarter and year as used in previous years standard assessment
2. Revised natural mortalities obtained from and based on the results from Sparholt *et al.* (2002a,b)
3. Revised natural mortalities obtained from most recent run with the North Sea MSVPA model (presented and used in the ICES-SGMSNS 2006).

The survey based mortality estimates all indicate age specific differences in Z and M. These mortality estimates show high within-survey variability and, periodically, contradictory patterns between the surveys. Sparholt, Larsen and Nielsen (2002a,b) discussed their results in context of changed catchability in the surveys, migration out of the area, or age specific distribution patterns of Norway pout and concluded that the mortality patterns were not caused by this.

In contrast, the MSVPA estimates indicate rather constant M between age groups and years, and do not provide the most recent estimates of M.

In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. However, with respect to the exploratory runs using different natural mortalities no conclusions could be reached as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources 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 baseline assessment constant values for natural mortality at age and quarter by year as in previous years assessment. This has been adopted in this years up-date assessment.

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 the most 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. The overall Z estimates for the period 2003-2007 indicates present levels of Z at age between 1.2 - 1.9. Also, these results confirm the results from the 2006 benchmark assessment on different natural mortality at age. The assessment uses constant values of M at age of 0.4 per quarter (totally 1.6 per year). A comprehensive study on Norway pout natural mortality is in the process of being published on this work which should also be addressed in the coming benchmark assessment.

Maturity

Preliminary results from an analysis of regionalized survey data on Norway pout maturity is presented in a Working Document to the 2000 meeting of the Working Group (Larsen, Lassen, Nielsen and Sparholt, 2001 in ICES C.M.2001/ACFM:07). Results in a recent paper (Lambert, Nielsen, Larsen and Sparholt (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 only around 90% and 95%, respectively, as compared to 100% used in the 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 correlation between the age groups 1-2 and 2-3 is very poor while the within correlation between age groups 0-1 is good. The quarter 3 0-group survey index for EGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment.

4) The IBTS Q1 tuning fleet has remained unchanged compared to previous years assessment.

From 2009 and onwards the SGFS changed it survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted sub-area averages.

For an overview of the time series included and used by year and age in the assessment see Table 5.3.1 in section 5 of the assessment report. The table is also given in up-dated form here under section C.

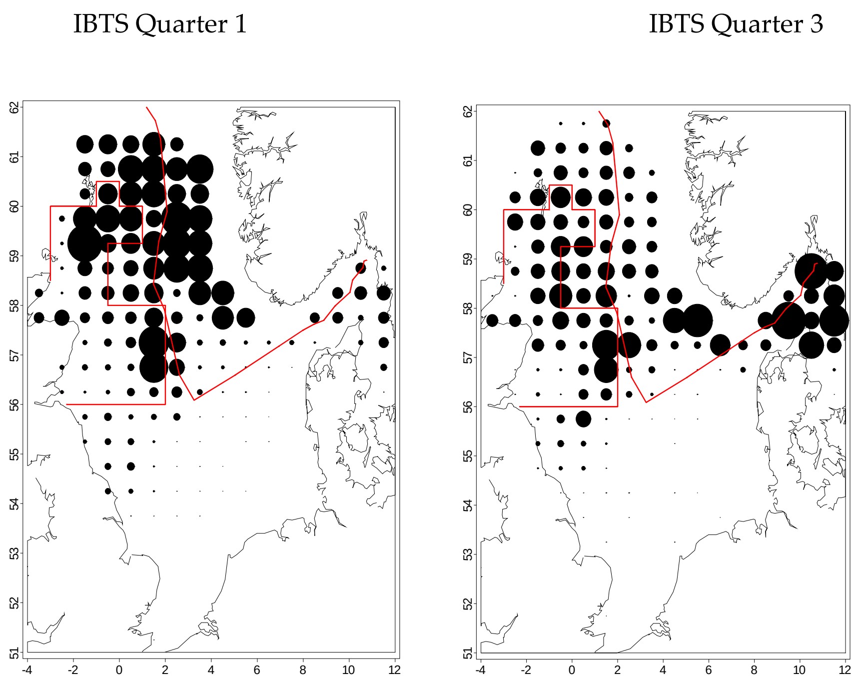


Figure 4 IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually.

B.5. Commercial CPUE data

Combined CPUE indices by age and quarter for the Danish and Norwegian commercial fishery tuning fleet (including data up to 2006) is calculated from effort data obtained from the method of effort standardization of the commercial fishery tuning fleet described under section B.1 (and B.3) and vessel category specific catches by area. CPUE is estimated on a quarterly basis for the Danish and Norwegian commercial fleets.

The resulting combined, commercial fishery CPUE data by age and quarter is presented in the input data to the yearly performed assessment. The commercial fleet data (up to 2006) are used in tuning of the assessment based on the combined and standardized Danish and Norwegian effort data and on the catch data for the commercial fishery

See also section B.1 and B3 concerning the commercial fishery tuning fleet.

Commercial fishery tuning fleets:

In addition to the analyses of the commercial fishery assessment tuning fleet (including data up to 2006) as described above (effort standardization) the quarterly CPUE indices of the commercial fishery tuning fleet were analyzed during the 2004 benchmark assessment:

1. The indices for the 0-group in 3rd quarter of the year have been excluded from the commercial fishery tuning fleet. The main argumentation for doing that is that this age group indicate clear patterns in trends in catchability over the assessment period as shown in the single fleet/quarter assessment runs in section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Secondly, there is no correlation between the commercial fishery 3rd quarter 0-group index and the commercial fishery 4th quarter 0-group index, and no correlation between the 3rd quarter commercial fishery 0-group index in a given year with the 1-group index of the 3rd quarter commercial fishery the following year.

2. The 2nd quarter indices for all age groups have been excluded from the commercial fishery tuning fleet. This is mainly because of indications of strong trends in catchability over time in the assessment period for this part of the tuning fleet for all age groups as indicated by single fleet tuning runs in the section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Also, the within quarter and between quarter correlation indices are in general relatively poor. The cohorte analyses of the 2nd quarter commercial fishery indices indicate as well relative changes over time.

C. Historical Stock Development

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 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.

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 period 1983-2005 where the estimated catchability, that, 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).

In exploratory and comparison runs between the SXSA model and other models, especially the SMS model has been used 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 log-normal 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.

<u>Summary of conclusions from the exploratory catch at age analyses in the 2004 benchmark assessments</u>:

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.

Software used:

SXSA program available from ICES. Used for the final assessment as standard software.

SMS program available from Morten Vinther, DIFRES, Copenhagen (Exploratory run, 2004 and 2005, April 2006 and September 2006). Used in exploratory runs.

XSA program from ICES. Used in exploratory runs.

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:

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 were used:

```
Year range:
        1983 - 2007
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 were included:

```
Fleet  1: (Q1: Age 1-3; Q2: None; Q3: Age 1-3; Q4: Age 0-2) 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 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:                                          propmat.qrt
Tuning data (CPUE):                                      tun2007.xsa
Weighting for rhats:                                            rweigh.xsa
```

SXSA: In the SXSA the following options 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

SMS-Model: 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 (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)
```

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1983-present	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	1983-present	0-1	Yes
Matprop	Proportion mature at age	1983-present	1-3+	No, 10%age 1, 100% 2+
Natmor	Natural mortality	1983-present	0-3+	No, 0.4 per quarter per age group

Tuning data used in the present and historical assessments:

Table 5.3.1 **Norway pout IV & IIIaN (Skagerrak). Stock indices and tuning fleets used in final 2004 benchmark assessment as well as in the 2005-2011 assessments compared to the 2003 assessment.**

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-11 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	1982-2011
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2010
	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	1998-2010
	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	1991-2010
	Quarter		3	3	Q3
	Ages		2-3	2-3	2-3

D. Short-Term Projection

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 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).

The forecast was calculated as a stock projection up to 1st of January of the forecast year using full assessment information for the assessment year.

The projection up to 1st of January of the forecast year is based on the SXSA assessment estimate of stock numbers at age at the start of the assessment year. The forecast is using the geometric mean recruitment for the stock-recruitment relationship.

The forecast uses relevant recent exploitation pattern according to temporal changes in this according to changes in exploitation between seasons and between ages.

Ten percent 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.

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. 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.

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).

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.

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 2011 forecast assumes a 2011 (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 also the **Stock Annex (Q5)**).

E. Biological Reference Points

From 2010 and onwards:

	Type	Value	Technical basis
MSY Approach	MSY $B_{escapement}$	150 000 t	= B_{pa}
	F_{MSY}	Undefined	None advised
Precautionary Approach	B_{lim}	90 000 t	B_{lim} = B_{loss}, the lowest observed biomass in the 1980s
	B_{pa}	150 000 t	= $B_{lim}\ e^{0.3*1.65}$
	F_{lim}	Undefined	None advised
	F_{pa}	Undefined	None advised

(unchanged since: 2010)

Biomass based reference points have been unchanged since 1997 given MSY $B_{escapement}$ = B_{pa}.

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: Sparholt, Larsen and Nielsen 2002a,b; Lambert, Nielsen, Larsen and Sparholt 2009). Furthermore, 10 % 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 B_{MSY}. 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_{MSY} = 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_{MSY} = B_{pa} (90 000 and 150 000 t) is 0.6. B_{lim} is 90 000 t, the lowest observed biomass.

There is not established any F-reference points.

Previous to 2010:

Precautionary Approach reference points:

ICES considers that:	ICES proposes that:
B_{lim} is 90 000 t	B_{pa} be established at 150 000 t. Below this value the probability of below average recruitment increases.
Note:	

Technical basis:

B_{lim} = B_{loss} = 90 000 t.	$B_{pa} = B_{lim}\ e^{0.3\text{-}0.4*1.65}$ (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 (Q5)**.

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.

Norway pout is a short lived species and most likey 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: Sparholt, Larsen and Nielsen 2002a,b; Lambert, Nielsen, Larsen and Sparholt 2009). On this basis B_{pa} is considered a good proxy for a SSB reference level for MSY $B_{escapement}$.

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-SGMSNS 2006).

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 (Q5).**

From the results of the recent May 2011 forecast presented 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 2012 then a catch around 6 000 t can be taken in 2011 according to the escapement strategy. Under a fixed F-management-strategy with F around 0.35 a catch around 82 000 t can be taken in 2011. Under a fixed TAC strategy a TAC of 50 000 t can be taken in 2011 (corresponding to a F around 0.21) 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 2011 as well as under a fixed TAC strategy with a TAC of 50 000 t 2011 the stock will decrease to be under Bpa by 1st of January 2012 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 Stock Quality Handbook (Q5) 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.

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 Benchmark assessments:

A benchmark-assessment is planned and organized for the stock in 2012.

The primary aim of the benchmark will be to consider and change the values of a number of biological parameters (maturity, growth, natural mortality) based on new biological information from some work mainly in 2007-2008 and summarized in 2 scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. It will for the benchmarking be relevant to have up-dated natural mortality information from a updated MSVPA model / SMS model run.

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.

New research findings on developments in by-catch reducing gear devices should be reported and evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Other issues to be considered at a later stage:

Consideration of revision of the tuning fleets with special focus on the commercial tuning fleets should be done at a certain point (see also the May 2007 assessment ICES CM 2007/ACFM:18 and 30, as well as this **Stock Quality Handbook (Q5)).** This includes evaluation of the quality of the assessment with respect to inclusion of historical time series for fisheries data. The fluctuations in the fisheries effort over times and between seasons should be evaluated.

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, e.g. the SAM model or further developments of the SMS model.

Evaluation of survey based assessment and/or more simple assessment methods: Assessment of stock status based exclusively on survey indices should be considered, and robustness of survey indices should be further evaluated and considered.

New research findings on developments in by-catch reducing gear devices should be reported and evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Trends and dynamics in landings and other available relevant information of Norway pout in VIa should be evaluated and brought forward to ACOM.

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.

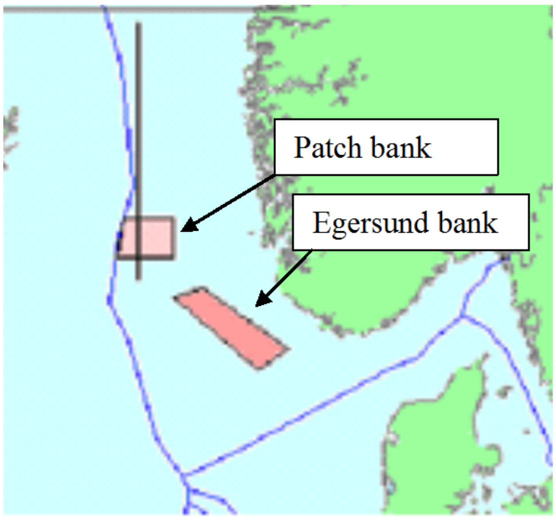
ACFM recommended that effort in 2005 should not exceed 40 % of the effort in 2004. Based upon this advice, the sandeel season in the Norwegian economic zone was further shortened in 2005. The sandeel season, defined as the period when smaller mesh size than 16 mm can be used, was 8 months (March – October) 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. 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.

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

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

Larsen, L.I., Lassen, H., Nielsen, J.R., and Sparholt, H. 2001. Working Document to the 2000 meeting of the WGNSSK. ICES C.M.2001/ACFM:07).

Nielsen, J.R., and Madsen, N. 2006. Gear technological approaches to reduce un-wanted by-catch in commercial Norway pout fishery in the North Sea. Working Document No. 23 to the 2006 meeting of the WGNSSK, 11 pp. ICES C.M.2006/ACFM:35

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

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 (Q5).**

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.

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 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.

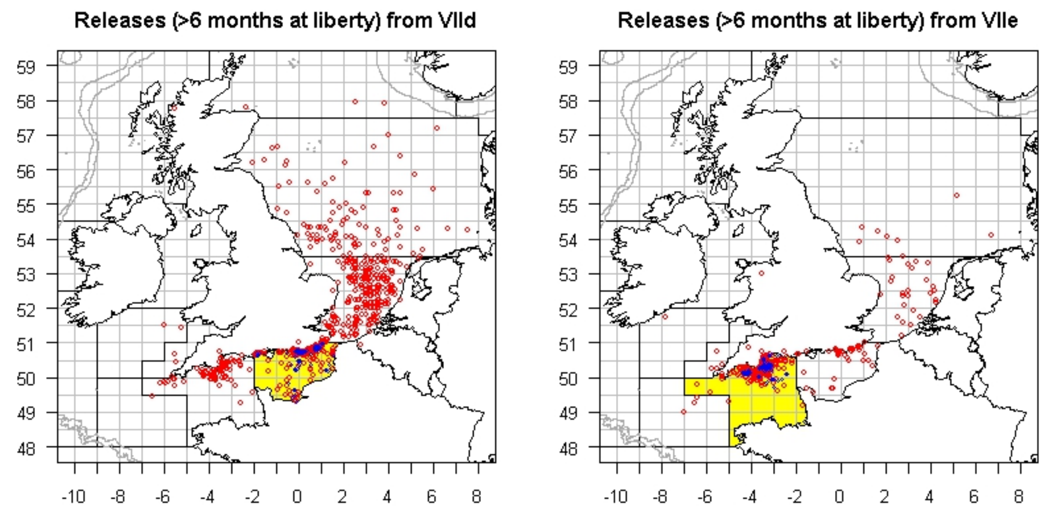


Figure 1 Locations of recaptures (red circles) after 6 or more months at liberty for tagged plaice released (blue crosses) in the English Channel: bottom left, released in the eastern (VIId) Channel and bottom right, released in western (VIIe) Channel.

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).

					WEIGHTED BY INTN CATCH AND SSB			
Release Information		**period**			**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 who 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:

5) Tapered time weighting not applied

6) Catchability independent of stock size for all ages

7) Catchability independent of age for ages >= 7

8) Survivor estimates shrunk towards the mean F of the final 5 years or the 3 oldest ages

9) S.E. of the mean to which the estimate are shrunk = 1.0

10) Minimum standard error for population estimates derived from each fleet = 0.300

11) Prior weighting not applied

12) Input data types and characteristics:

- 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.
- 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

No short-term forecast has been provided since 2005 as the review group deemed it unhelpful in the management of the stock given the strong retrospective bias in F.

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:

B_{lim} = 5400 t.
B_{pa} = 8000 t.
F_{lim} = 0.54
F_{pa} = 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.

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

ANNEX 1 – ELEMENTS OF BIOLOGY ON PLAICE VIId.

Excerpts from the project InterReg 3A CHARM Phase II.

Pleuronectes platessa

Linnaeus,1758

Plie commune
European plaice

Embranchement-Phylum : Chordata

Classe-Class : Actinopterygii

Ordre-Order : Pleuronectiformes

Famille-Family : Pleuronectidae

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Biologie - La plie commune adulte se nourrit de polychètes, de mollusques bivalves, de cœlentérés, de crustacés, d'échinodermes et de petits poissons. En Manche, la reproduction s'étale de décembre à mars sur des fonds de 20 à 40 m de profondeur, avec un pic en janvier-février. En général, les œufs flottent tout d'abord à la surface avant de s'enfoncer progressivement dans la colonne d'eau au cours du développement. L'éclosion a lieu environ 20 (à 5-6°C) à 30 jours (à 2-2.5°C) après fécondation. Les larves ont alors une vie pélagique durant une quarantaine de jours avant de se métamorphoser (lorsque 10-17 mm de longueur) et de rejoindre le fond pour migrer vers les eaux littorales. La croissance en première année est assez élevée.

Caractères démographiques - Taille maximale 100 cm ; taille commune 25-45 cm ; taille minimale de capture 22 cm sauf Skagerrak et Kattegat 27 cm (UE) ; longévité maximale 50 ans ; âge et taille à maturité 2-7 ans et 18-35 cm ; paramètres de von Bertalanffy : taille asymptotique L_{inf}=71.65 cm, taux de croissance *k* = 0.23 an^{-1}, âge théorique t_0 = -0.83 ; paramètres de fécondité *alpha* = 2.33 ovules.cm^{-beta} et *beta* = 3.10 (50 000 à 500 000 ovules par femelle).

Environnement - Espèce bentho-démersale vivant préférentiellement sur les fonds sableux mais aussi graveleux ou vaseux de la côte jusqu'à 200 m de profondeur, et se répartissant dans les eaux salées à saumâtres tempérées.

Répartition géographique - Atlantique nord-est, du nord de la Norvège et du Groenland au Maroc ; mer Méditerranée, dont la mer Noire.

Biology - Adult plaice essentially feed on polychaetes, bivalves, coelenterates, crustaceans, echinoderms, and small fish. In the English Channel spawning occurs from December to March at depths ranging from 20 to 40 m, with a peak in January-February. Initially, pelagic eggs generally float at the surface. They then progressively sink into deeper waters during their development. Hatching occurs around 20 (at 5-6°C) to 30 (at 2-2.5°C) days after fertilisation. Larvae spend about 40 days in the plankton before metamorphosing (when 10-17 mm in length). They then move to the bottom and migrate towards coastal waters. The fry undergoes relatively fast growth during the first year.

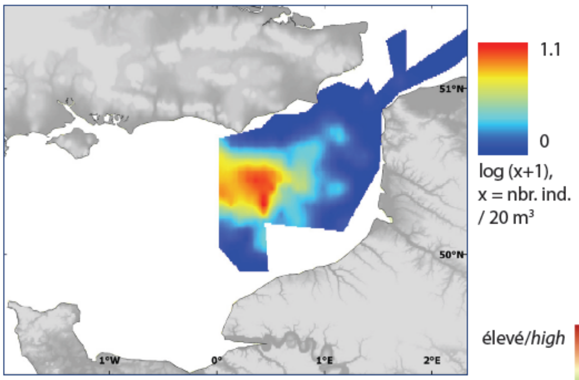
Life history parameters - Maximum length 100 cm; common length 25-45 cm; minimum landing size 22 cm except in Skaggerak and Kattegat 27 cm (EU); maximum lifespan 50 years; age and length at maturity 2-7 years and 18-35 cm; von Bertalanffy parameters: asymptotic length L_{inf} = 71.65 cm, growth rate *k* = 0.23 year^{-1}, theoretical age t_0 = -0.83; fecundity parameters *alpha* = 2.33 oocytes.cm^{-beta} and *beta* = 3.10 (50,000 to 500,000 oocytes per female).

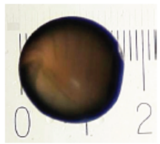
Environment - This bentho-demersal species prefers to live on sand but also on gravely or muddy substrates, from the coast to 200 m in depth. The species is found in marine to brackish temperate waters.

Geographical distribution - North-east Atlantic, from northern Norway and Greenland down to Morocco; Mediterranean including the Black Sea.

Œufs / Eggs - Pleuronectes platessa

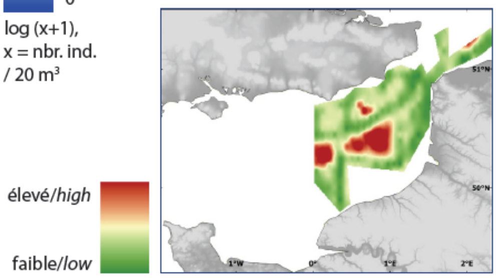
Abondance en janvier (IBTS, 2007)
Abundance in January (IBTS, 2007)



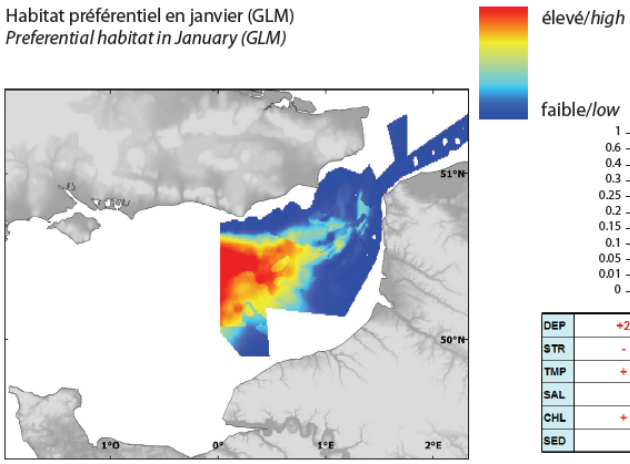


stade 1
stage 1

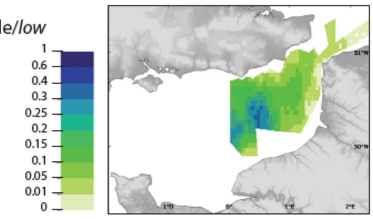
Erreur de krigeage
Kriging error



Habitat préférentiel en janvier (GLM)
Preferential habitat in January (GLM)



Erreur du modèle / *Model error*



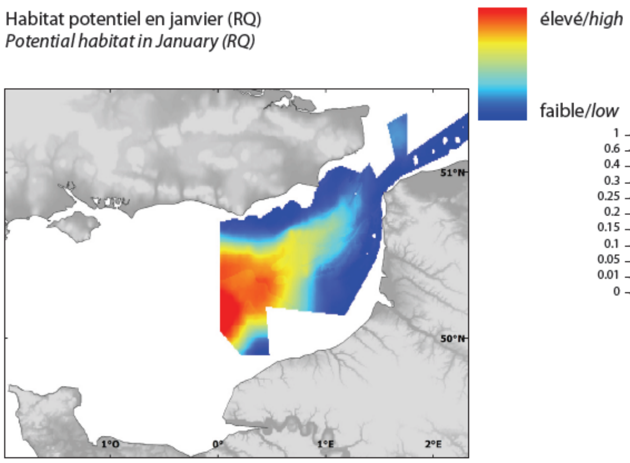
0/1 GLM

DEP	+2
STR	-
TMP	+
SAL	
CHL	+
SED	

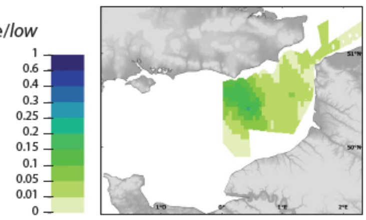
+ GLM

DEP	
STR	
TMP	2
SAL	
CHL	
SED	CS M - G - FS - P

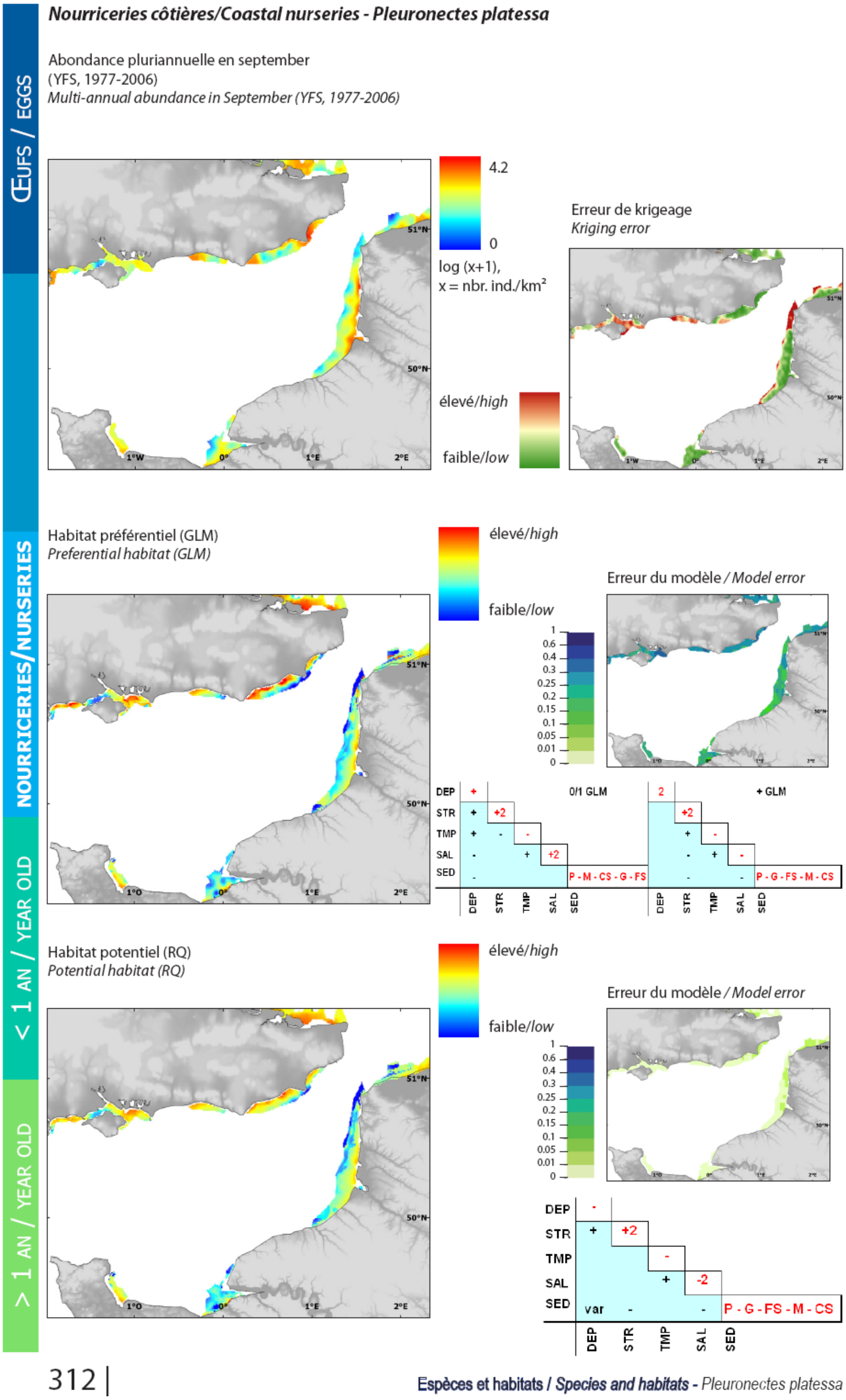
Habitat potentiel en janvier (RQ)
Potential habitat in January (RQ)



Erreur du modèle / *Model error*



DEP	+2
STR	-2
TMP	-2
SAL	-2
CHL	+2
SED	CS M - FS - G - P


Nourriceries côtières/Coastal nurseries - Pleuronectes platessa
ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
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 - M - CS
Habitat potentiel (RQ)
Potential habitat (RQ)
var
P - G - FS - M - CS
312
Espèces et habitats / Species and habitats - Pleuronectes platessa

Pour cette espèce, les données disponibles couvrent presque l'ensemble du cycle de vie (sauf les larves) et les deux saisons pour les individus de moins et plus d'un an.

Œufs

Lors de la campagne IBTS de janvier, la plie est en pleine période de reproduction en Manche orientale. Les œufs de stade 1 récoltés alors suggèrent que les zones de frai sont situées dans les eaux centrales de la Manche orientale, dans des zones relativement profondes. Les abondances sont bien prédites par le modèle d'habitat préférentiel qui situe la zone de frai dans la partie centrale de la Manche donc dans des eaux relativement profondes mais protégées des forts courants de marées. Cependant, l'erreur du modèle est assez importante. Le modèle d'habitat potentiel montre la même zone comme favorable, avec un schéma de distribution un peu plus étendu au niveau des sédiments sableux.

Nourriceries côtières

La carte d'abondance issue des campagnes YFS (septembre) montre une répartition très côtière des individus sur presque toute la zone échantillonnée, avec toutefois des abondances plus fortes en face des baies de Somme, Canche, Authie et Rye. Les modèles d'habitats préférentiel et potentiel sont très semblables et sont en accord avec les abondances des campagnes. Ils favorisent la bande côtière et surtout le large des baies à l'exception notable de la baie de Seine. Les zones optimales pour les nourriceries sont situées dans des zones peu profondes, proches des apports d'eaux douces et froides en cette saison mais qui présentent cependant des sédiments grossiers et où les courants de marées sont relativement forts. Ces zones correspondent vraisemblablement à un front hydrologique côtier potentiellement très productif au niveau benthique.

< 1 an

Les individus de moins d'un an (< 18.0 cm) ont été séparés des autres sur la base de leur taille.

En juillet, les jeunes individus ont été échantillonnés face aux baies de Somme, Canche, Authie, autour de la presqu'île du Cotentin et un peu en baie de Seine, côté français et aux alentours de Dungeness, à l'ouest de l'île de Wight et surtout dans l'estuaire de la Tamise, coté britannique. Ces zones plutôt constantes sont plus ou moins étendues selon l'année d'étude. La carte d'habitat préférentiel n'est pas vraiment en accord avec les distributions observées. Elle favorise des zones très côtières proches des estuaires, sur les côtes française et britannique, hors dans la plupart de ces zones les abondances observées sont très faibles voire nulles. L'incertitude du modèle est plus forte sur les côtes mais très faible dans les zones centrales signifiant qu'il n'y a pratiquement aucune incertitude concernant l'absence de cette espèce à ces endroits. Le modèle d'habitat potentiel propose également des zones côtières mais qui s'étendent plus au large, ce qui est plus en accord avec les distributions observées. Le modèle d'habitat potentiel s'appuie sur de faibles température et tension de cisaillement et sur des sédiments grossiers. L'erreur est nulle sur presque toute la région sauf dans le sud-ouest de la zone étudiée où elle atteint des valeurs assez importantes.

For this species, data are available for almost the entire life cycle (except larvae), and two seasons for individuals of less and more than one year.

Eggs

The IBTS survey takes place during the reproductive period of plaice in the eastern English channel. Stage 1 eggs sampled during the survey indicate that spawning areas were located in the central eastern English channel, in relatively deep areas. Survey abundance levels were accurately predicted by the preferential habitat which showed spawning areas as being located in the central Channel, in fairly deep areas protected from strong tidal currents. Nevertheless, the model errors were high. The potential habitat model showed the same areas as favourable, though favourable habitats included sandy areas.

Coastal nurseries

The multi-annual abundance map from the YFS surveys (September) indicates a very coastal spatial distribution of plaice across the sampled area, with some high abundance areas in front of the Bays of Somme, Canche, Authie and Rye. The potential and preferential habitat models are very similar and agree with the survey abundance levels. They both favour the coast and bays, with the exception of the Bay of Seine. Suitable sites for nurseries are located in shallow areas, close to fresh and cool seasonal water inputs. These areas are characterised by coarse sediments and strong tidal currents, i.e. corresponding to a coastal hydrological front, potentially very productive at the benthic level.

< 1 year old

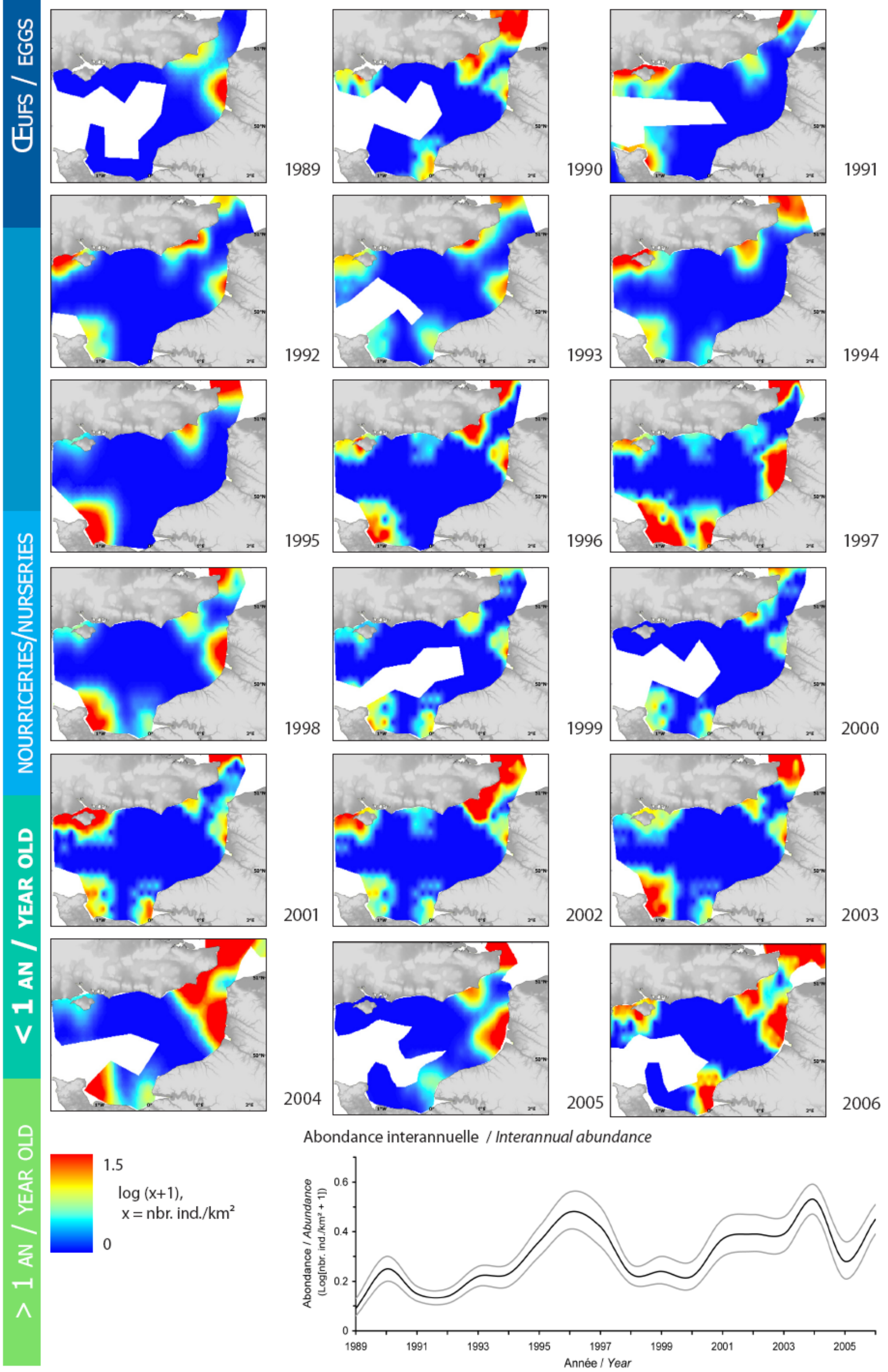
Individuals of less than one year were defined as such on the basis of their length (< 18.0 cm).

On the French side, young individuals were found off the Bays of Somme, Canche, Authie, around the Cherbourg Peninsula and a few in the Bay of Seine, in July. On the British side, they were located around Dungeness, west of the Isle of Wight and especially in the Thames estuary. The areas covered varied in size over time. The preferential habitat model did not really agree with the survey distribution. It favours very coastal zones near to estuaries on both French and British coasts but in most of these areas survey abundance levels were very low and sometimes null. The model uncertainty was higher on the coasts but very low in central areas which means that there is almost no uncertainty about the spatial extent of areas where this species is absent. The potential habitat model highlights coastal areas extending offshore as favourable, which is more coherent with survey distributions. The potential habitat model highlights areas of low temperature, weak bed shear stress and coarse sediments. The model error was almost null across the region except in the south-west, where it could reach high values.

In October, the distribution of young plaice was more spatially restricted than in July, and seemed to be concentrated the Bays of Somme, Canche, Authie and Seine. Some young individuals were also found around the Cherbourg Peninsula. Occurrence areas of young plaice did not change a lot between July and October. The kriging error was more important in the north-west of the study area, where observa-

< 1 An / Year old - Pleuronectes platessa

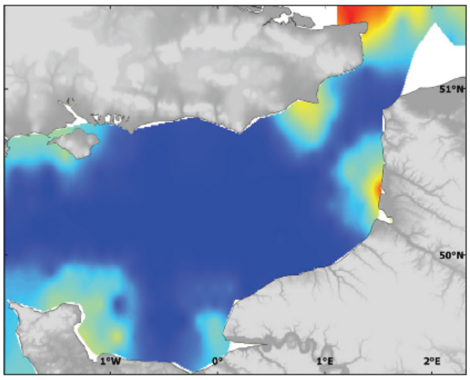
Abondance en juillet (BTS, 1989-2006) / *Abundance in July (BTS, 1989-2006)*



< 1 An / Year old - Pleuronectes platessa

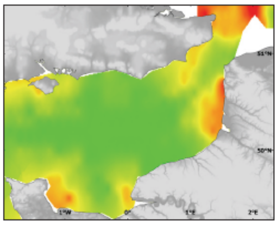
Abondance moyenne en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)

1.5
log (x+1),
x= nbr. ind./km²
0



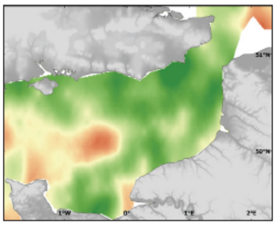
Ecart-type / *Standard deviation*

élevé/*high*
faible/*low*



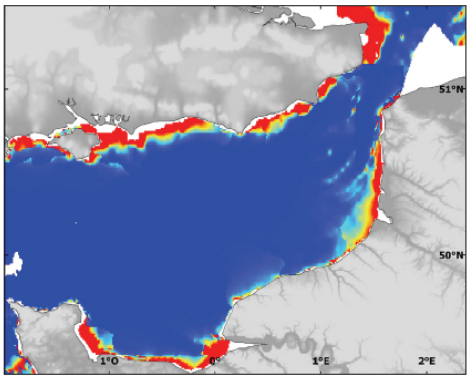
Erreur de krigeage / *Kriging error*

élevé/*high*
faible/*low*

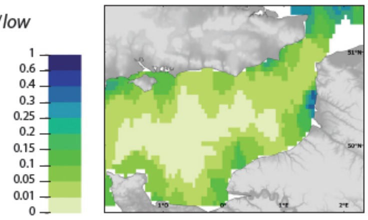


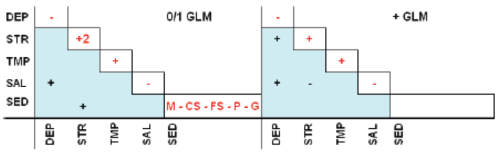
Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)

élevé/*high*
faible/*low*



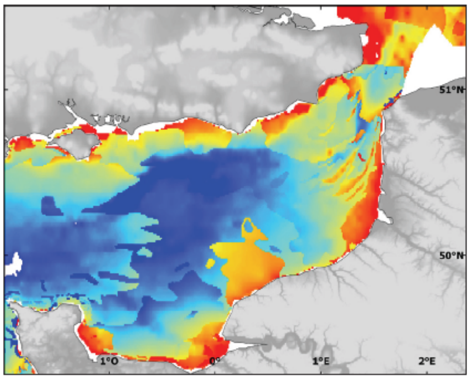
Erreur du modèle / *Model error*



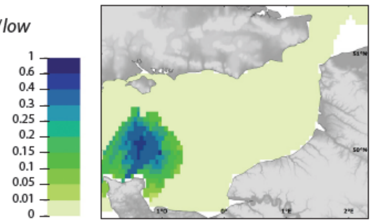


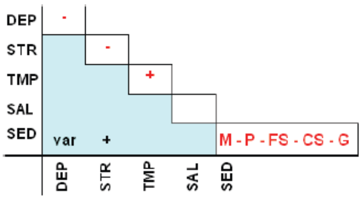
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)

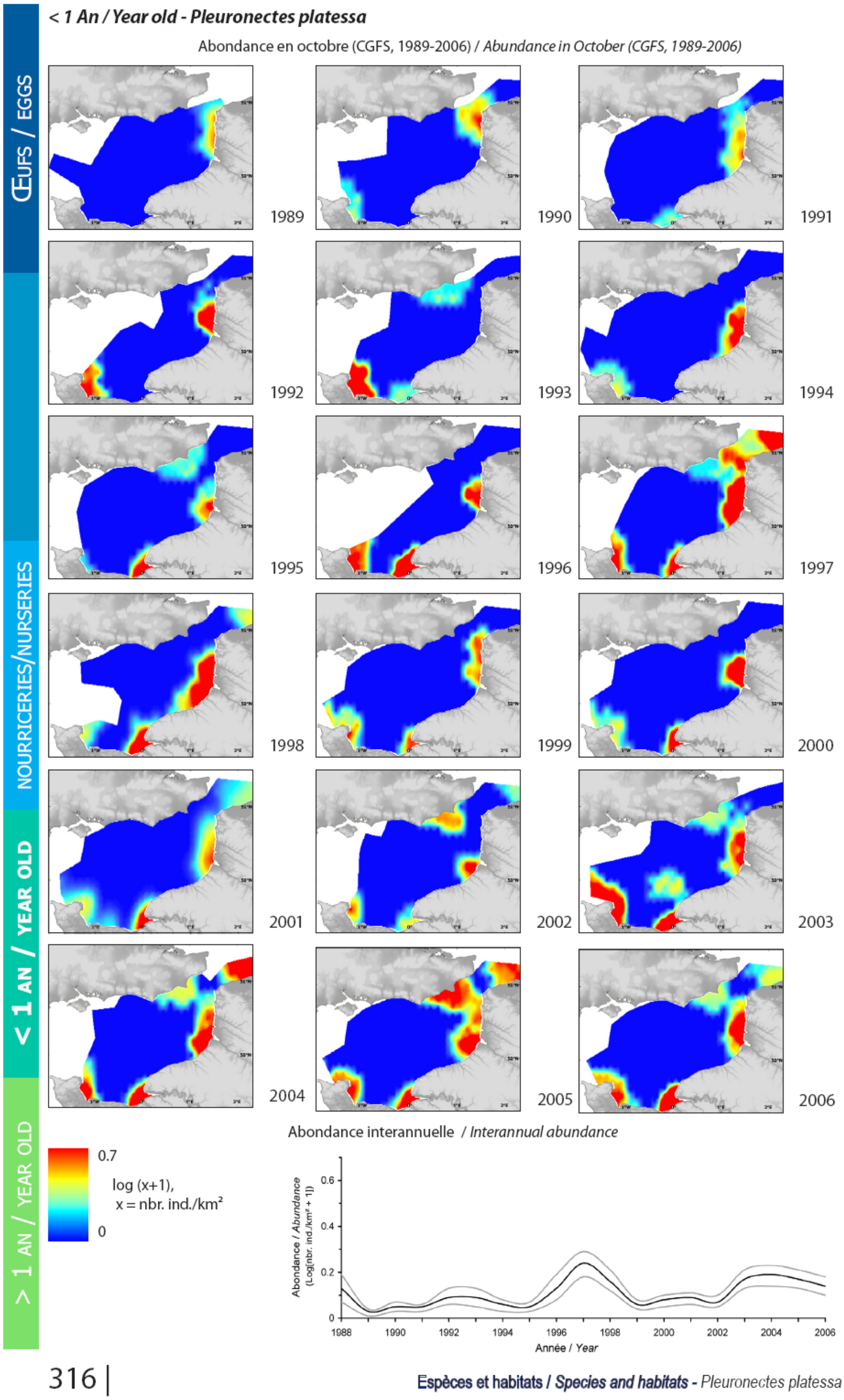
élevé/*high*
faible/*low*



Erreur du modèle / *Model error*

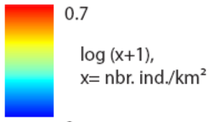


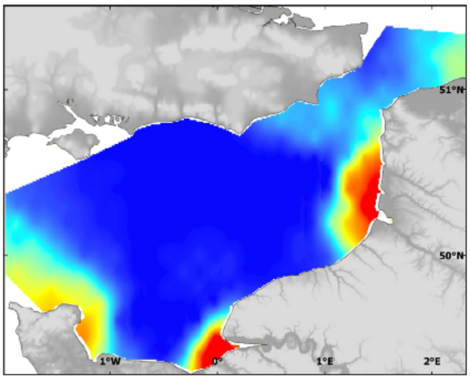



ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
< 1 An / Year old - Pleuronectes platessa
Abondance en octobre (CGFS, 1989-2006) / Abundance in October (CGFS, 1989-2006)
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Abondance interannuelle / Interannual abundance
0.7
log (x+1),
x = nbr. ind./km²
0
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
316
Espèces et habitats / Species and habitats - Pleuronectes platessa

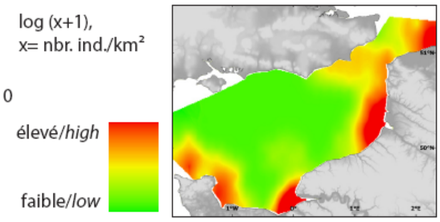
< 1 An / *Year old* - *Pleuronectes platessa*

Abondance moyenne
en octobre (CGFS, 1988-2006)
Mean abundance in October (CGFS, 1988 -2006)

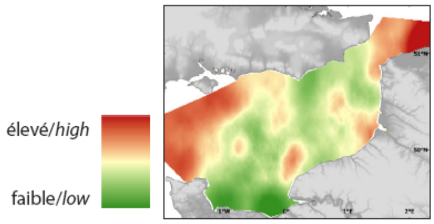




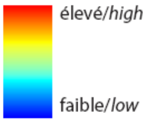
Ecart-type / *Standard deviation*

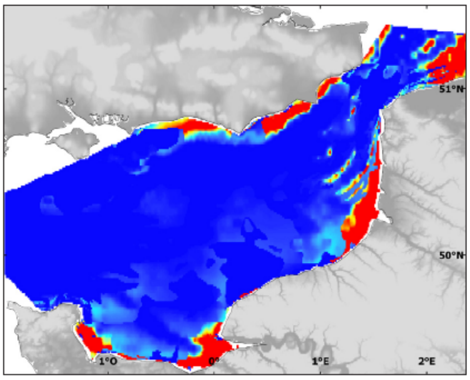


Erreur de krigeage / *Kriging error*

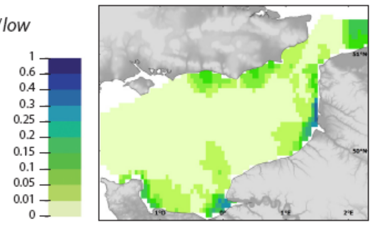


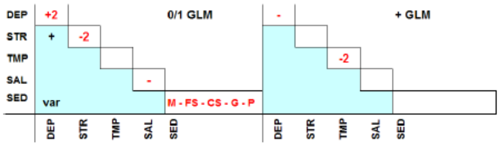
Habitat préférentiel en octobre (GLM)
Preferential habitat in October (GLM)



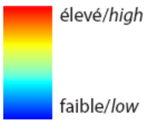


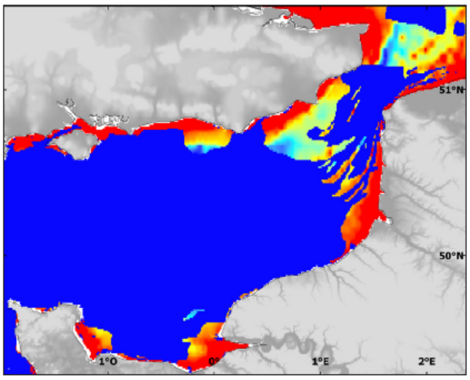
Erreur du modèle / *Model error*



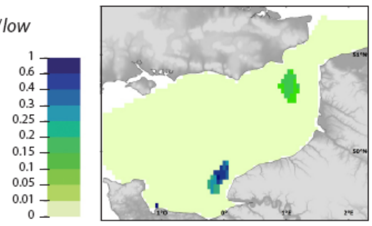


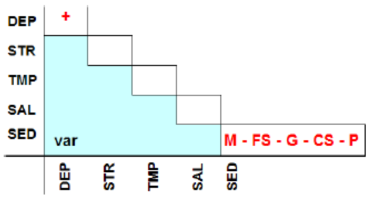
Habitat potentiel enoctobre (RQ)
Potential habitat in October (RQ)





Erreur du modèle / *Model error*





En octobre, la distribution des jeunes plies est moins étendue qu'en juillet et les individus semblent s'être concentrés au large des baies de Somme, Canche, Authie et Seine. On retrouve également des individus au niveau de la presqu'île du Cotentin. Les zones d'occurrence de la plie juvénile ne changent pas vraiment entre les deux saisons. L'erreur de krigeage est plus importante dans le nord-ouest de la zone où l'échantillonnage est plus clairsemé. Comme en juillet, le modèle d'habitat préférentiel favorise des habitats très côtiers au niveau des estuaires, ce qui ici concorde avec la distribution observée. Le modèle d'habitat potentiel se rapproche de celui de l'habitat préférentiel en allant un peu plus au large dans le détroit du Pas-de-Calais et le sud de la mer du Nord.

> 1 an

Les individus de plus d'un an (> 18.1 cm) sont échantillonnés dans les mêmes zones que les plus jeunes mais leur distribution s'étend plus au large.

En juillet, ils sont présents en forte proportion dans tout le détroit du Pas-de-Calais, dans le sud de la mer du Nord et dans les baies de Seine et des Veys. Aucun individu n'a été trouvé dans la partie centrale de la Manche orientale où les eaux sont plus profondes. Le modèle d'habitat préférentiel prédit bien la distribution observée, favorisant les zones à faibles profondeurs mais avec des courants de marées assez importants. Le modèle d'habitat potentiel est beaucoup plus optimiste, étendant les zones favorables, plus au large.

En octobre, la distribution semble se resserrer près des côtes. Beaucoup d'individus sont présents le long des côtes d'Opale ou belge et autour de Dungeness. Des zones d'abondance apparaissent également dans les baies de Seine et des Veys. L'erreur de krigeage est toujours associée aux zones où l'échantillonnage est plus épars. Les modèles d'habitats préférentiel et potentiel sont en accord avec les abondances de campagnes, toutefois l'erreur du modèle d'habitat préférentiel n'est pas négligeable. Le modèle d'habitat potentiel illustre l'affinité de cette espèce pour les fonds sableux à graveleux dans des zones de températures moyennes à faible profondeur et où les courants de marées se font ressentir.

tions were more sparse. As in July, the preferential habitat model strongly favoured coastal areas close to estuaries, which this time agrees with the survey data. The potential habitat model resembles the preferential habitat model but exhibits a more dispersed offshore spatial distribution in the Dover Strait as well as in the southern North Sea.

> 1 year old

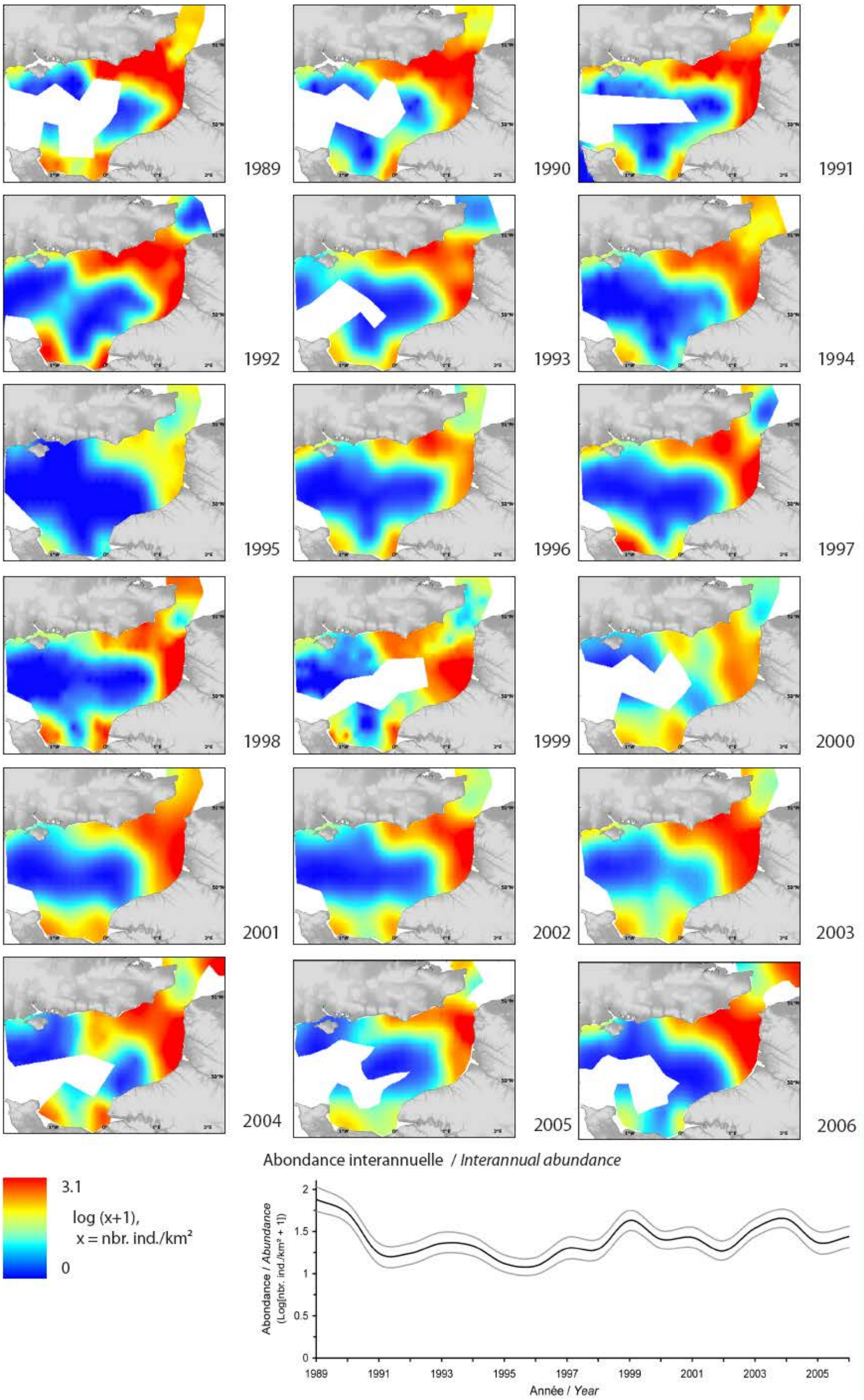
Older than one year individuals (length > 18.1 cm) were found in the same areas as younger ones but had a more offshore distribution pattern.

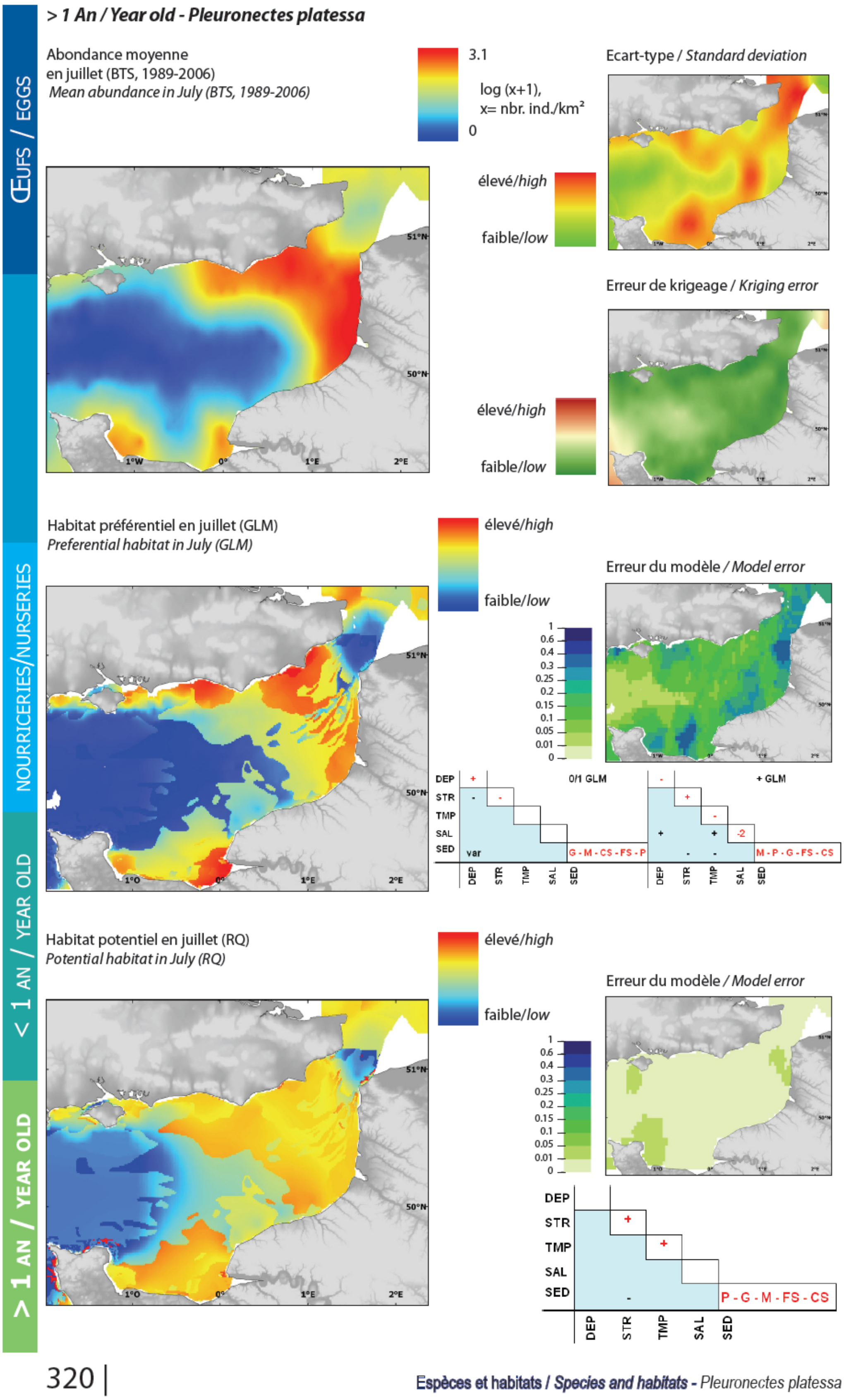
In July, high abundance levels were found in all of the Dover Strait, in the southern North Sea and in the Bays of Seine and Veys. No individual was found in the central Channel where waters are deeper. The preferential habitat model predicts the survey distribution well, favouring shallow waters with quite strong tidal currents. The potential habitat model was more optimistic, extending favourable habitats further offshore.

In October, the distribution pattern seemed to contract along the coasts. Many individuals were found along the Opale and Belgium coasts and around Dungeness. Some patches occured in the Bays of Seine and Veys. The kriging error was again associated with more sparse observations. The preferential and potential habitat models agreed with survey abundance levels though the preferential habitat model error was not negligible. The potential habitat model illustrates the affinity of this species for the sandy to gravely sediment types, shallow areas displaying average temperature conditions and where tidal currents can be strong.

> 1 An / Year old - *Pleuronectes platessa*

Abondance en juillet (BTS, 1989-2006) / *Abundance in July (BTS, 1989-2006)*

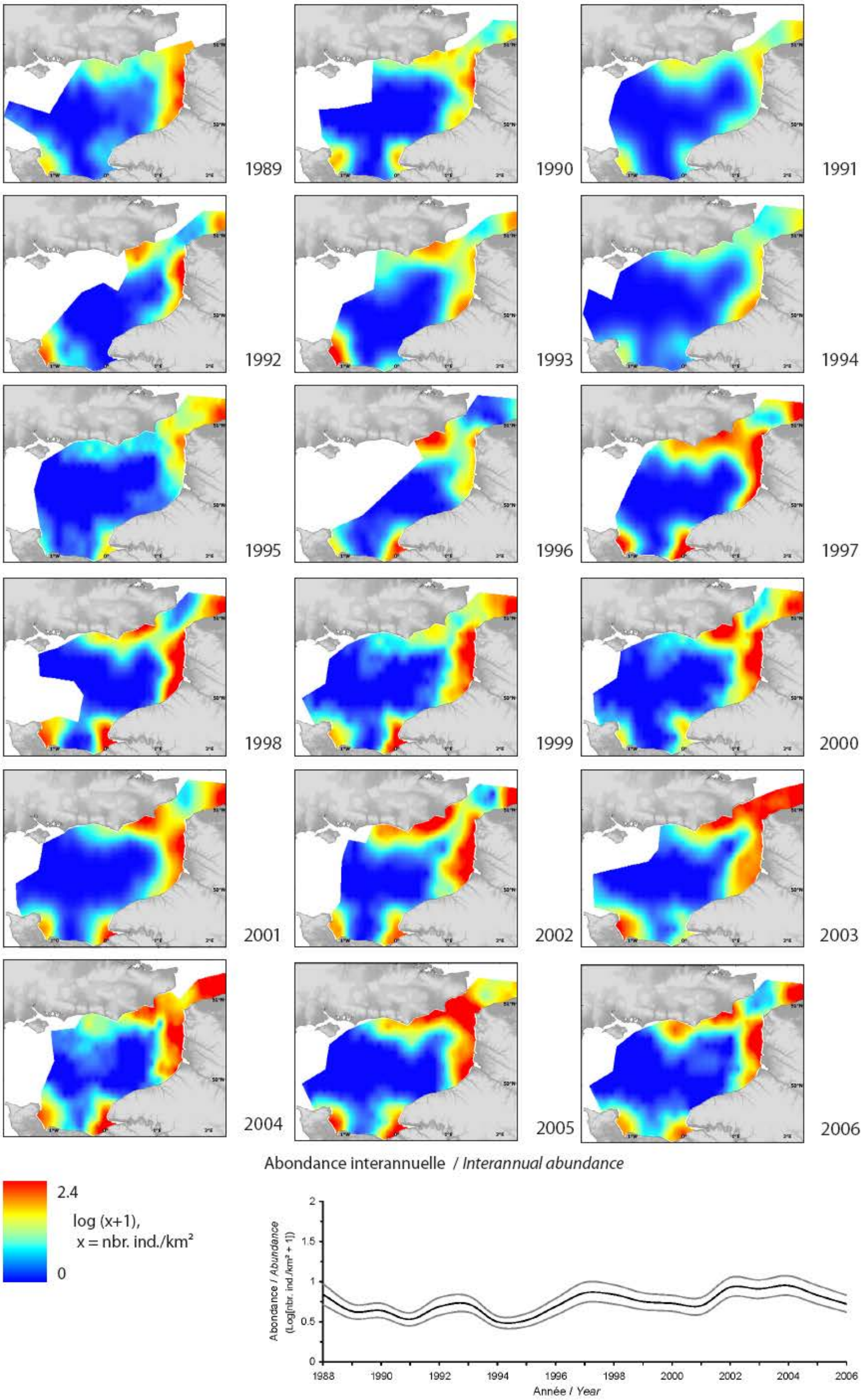


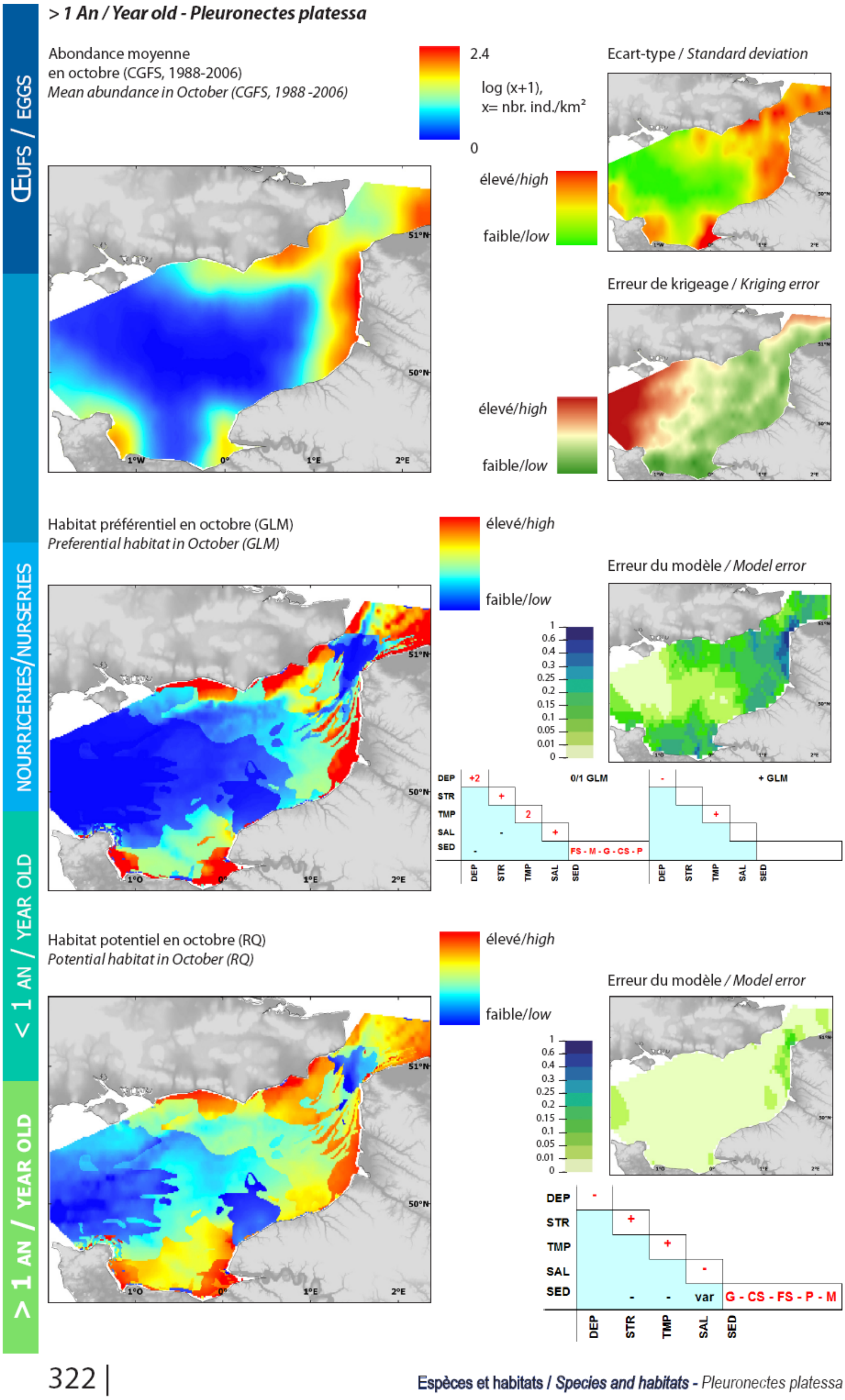


ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
> 1 An / Year old - Pleuronectes platessa
Abondance moyenne
en juillet (BTS, 1989-2006)
Mean abundance in July (BTS, 1989-2006)
3.1
log (x+1),
x= nbr. ind./km²
0
Ecart-type / Standard deviation
élevé/high
faible/low
Erreur de krigeage / Kriging error
élevé/high
faible/low
Habitat préférentiel en juillet (GLM)
Preferential habitat in July (GLM)
élevé/high
faible/low
Erreur du modèle / Model error
0/1 GLM
+ GLM
DEP
STR
TMP
SAL
SED
var
G - M - CS - FS - P
M - P - G - FS - CS
Habitat potentiel en juillet (RQ)
Potential habitat in July (RQ)
élevé/high
faible/low
Erreur du modèle / Model error
P - G - M - FS - CS
320
Espèces et habitats / Species and habitats - Pleuronectes platessa

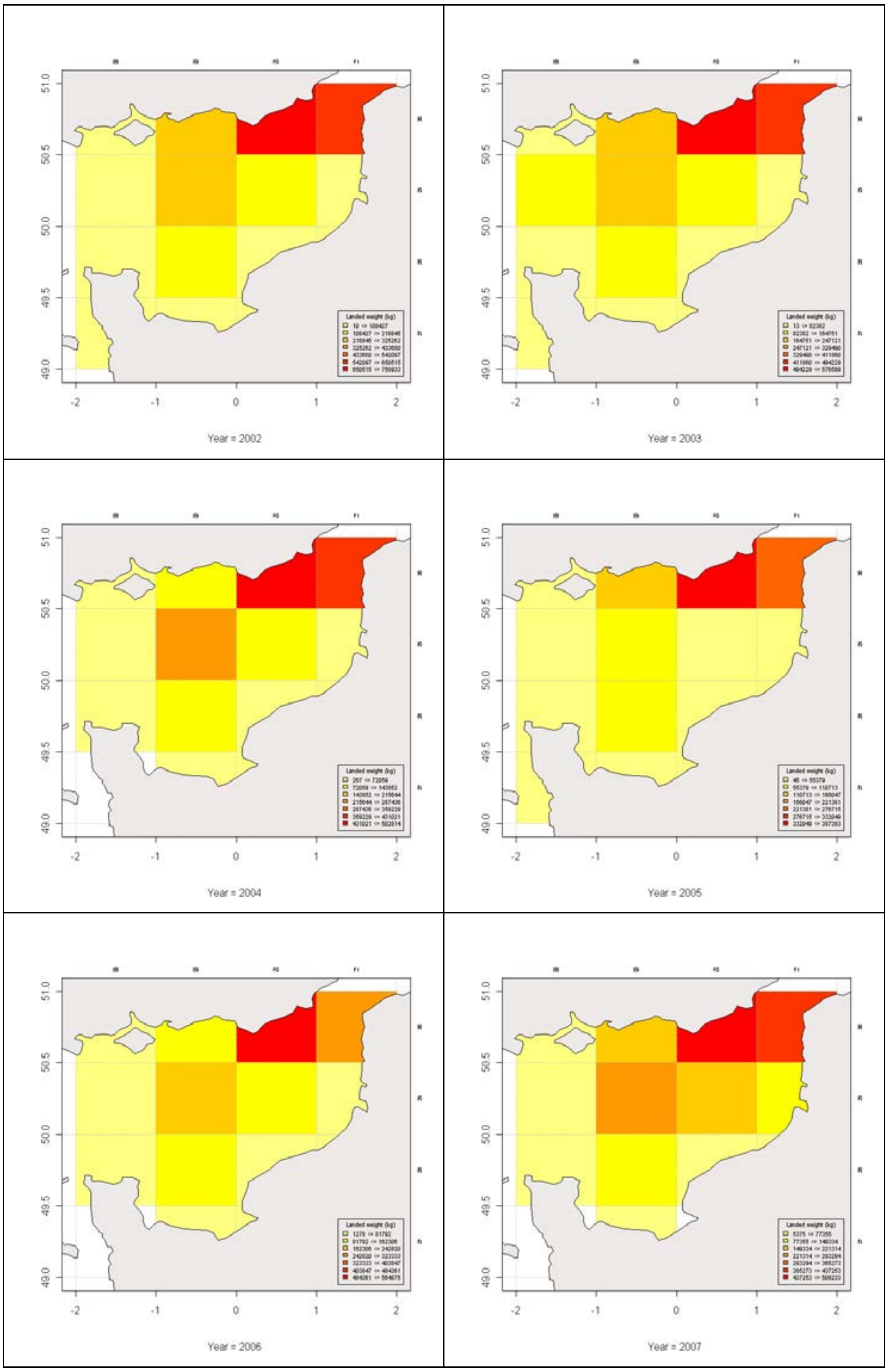
> 1 An / Year old - Pleuronectes platessa

Abondance en octobre (CGFS, 1989-2006) / *Abundance in October (CGFS, 1989-2006)*




> 1 An / Year old - Pleuronectes platessa
ŒUFS / EGGS
NOURRICERIES/NURSERIES
< 1 AN / YEAR OLD
> 1 AN / YEAR OLD
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
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
DEP
STR
TMP
SAL
SED
var
G - CS - FS - P - M
1°W
0°
1°E
2°E
50°N
51°N
322 |
Espèces et habitats / Species and habitats - Pleuronectes platessa

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



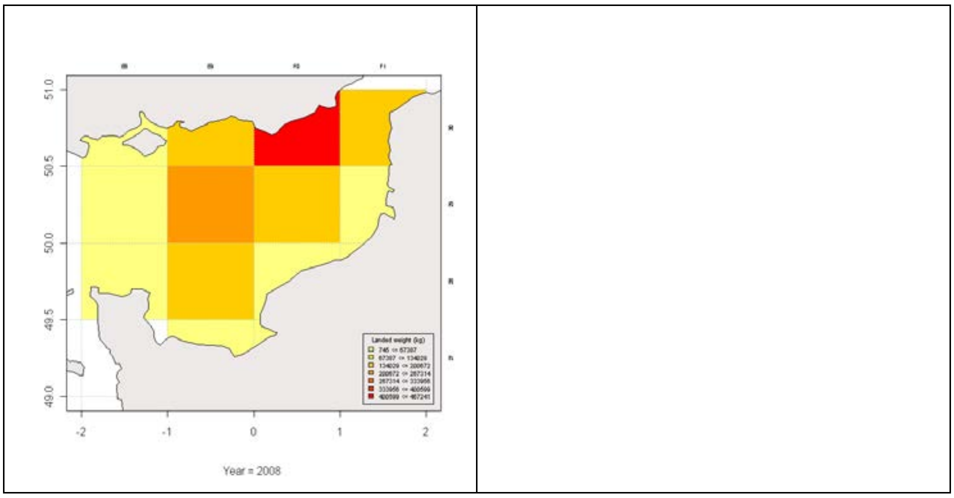
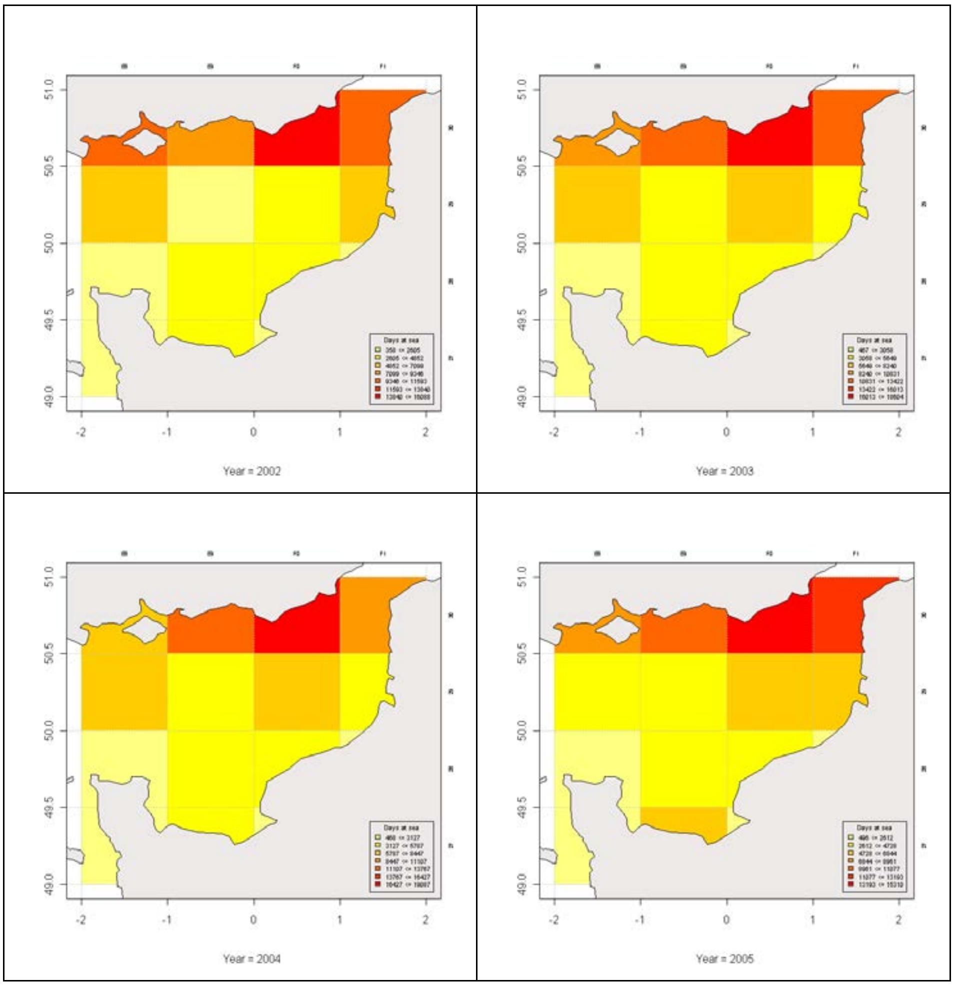


Figure . Plaice in VIId. - International landings from 2002 to 2008.



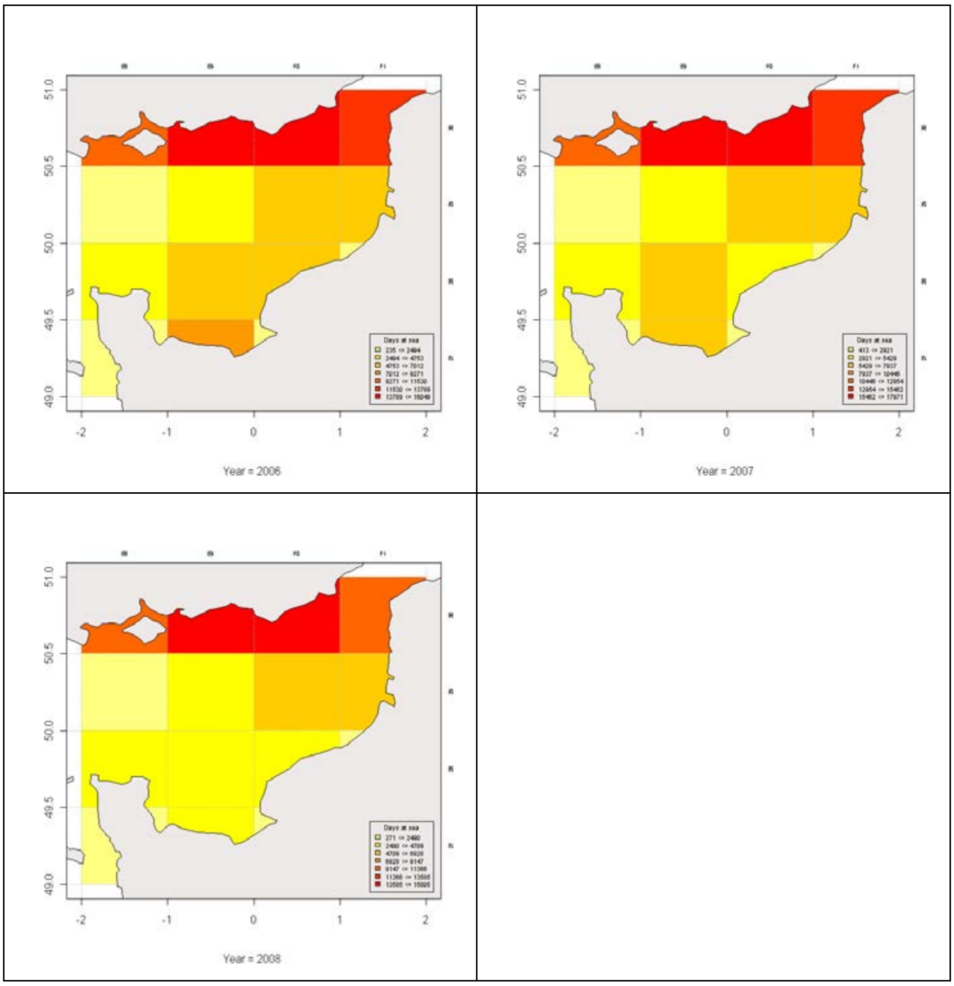


Figure Plaice in VIId - International effort in days at sea from 2002 to 2008.

Stock Annex: Plaice in Division IIIa

Stock specific documentation of standard assessment procedures used by the ICES WGNSSK.

Working group: North Sea Demersal Working Group

Updated: 17/05/2011 (partially only. A number of chap ters 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.

1. General

1.1 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.

1.2 Fishery (NOT UPDATED)

The fishery is dominated by Denmark, with Danish landings usually accounting for 80 to 90% of the total. Landings are taken year round with a predominance of the period from spring to autumn, by Danish seiners, flatfish gillnetters and beam trawlers. Plaice is also caught within a mixed cod-plaice fishery by otter trawlers, and is a by-catch of other gillnet fisheries. .Plaice is also caught as by-catch in the directed *Nephrops* fishery. Since 1978, landings have declined from 27 000 to 9 000 tonnes in the late nineties. However, landings in 2001 were the highest since 1992. The fishery exploits traditionally three age classes (ages 4 to 6). The TAC is usually not restrictive.

The use of beam trawl in the Kattegat is prohibited, but allowed in the Skagerrak. Minimum mesh size is 90 mm for towed gears, and 100 mm for fixed gears. The minimum landing size is 27 cm. Danish fleets are prohibited to land females in area IIIa from january 15th to april 30th.

2 Data

2.1 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.

2.2 Biological

2.2.1 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 reveled 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 subarea 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.

2.2.2 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.

2.2.3 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.

2.3 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.

2.4 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.

2.5 Other relevant data

None.

3 Historical Stock Development

Analytical assessments were performed every year except in 2008, but they have not been accepted since 2005.

4 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

4.1 uncertainty analysis

4.2 Retrospective analysis

Performed with FLR packages

5 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

6 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

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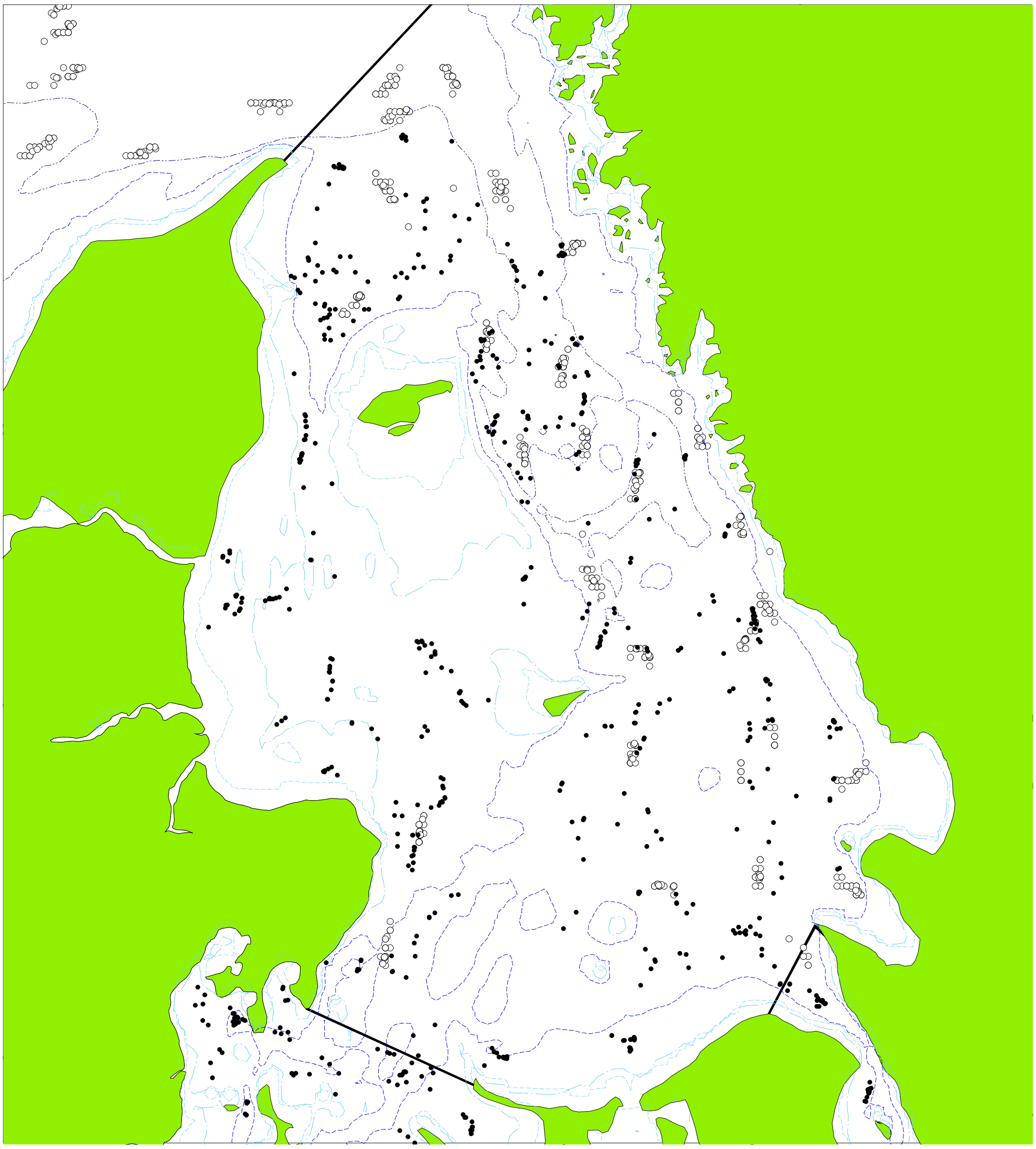


Figure 1. Location for the IBTS (open dots) and KASU stations (black dots).

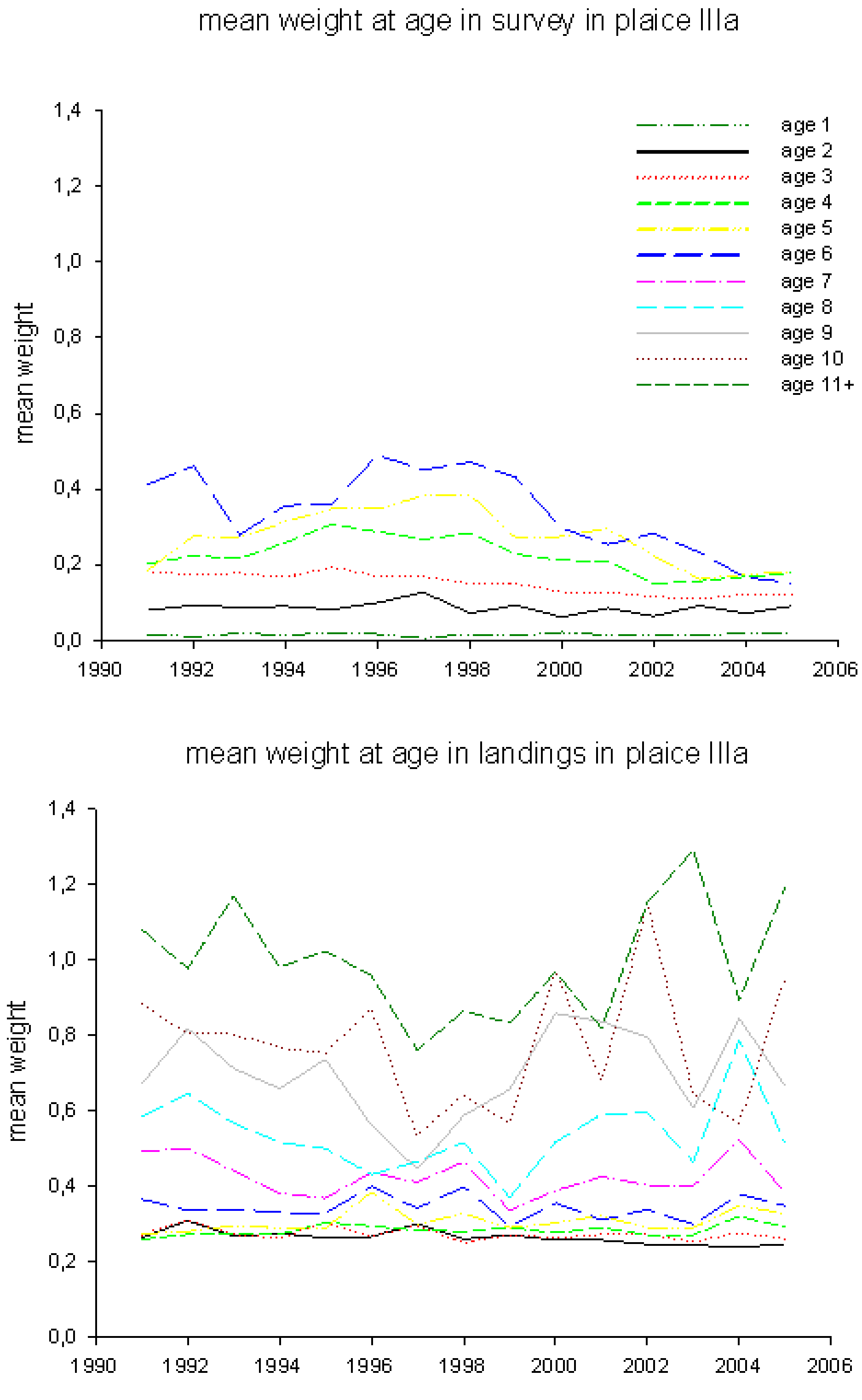


Figure 2: Mean weight at age from IBTS and commercial fleets in IIIa between 1991-2005.

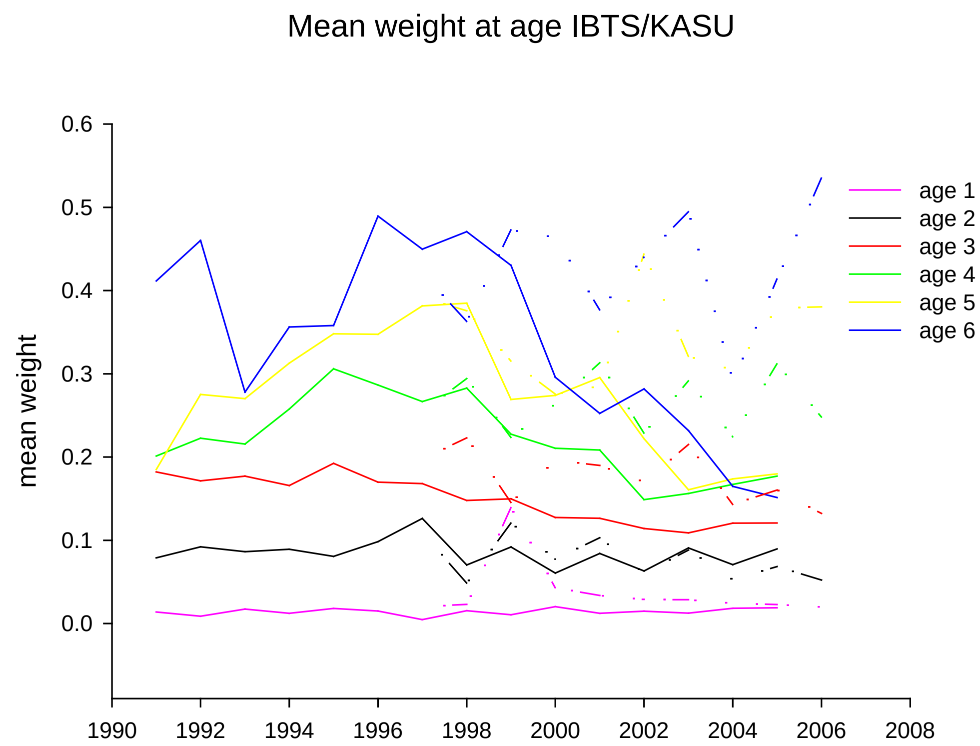


Figure 3. Comparison between IBTS q1 in area IIIa (solid line) 1991-2005 and KASU q1 in IIIa+22 (dotted line)1996-2006 in area IIIa.

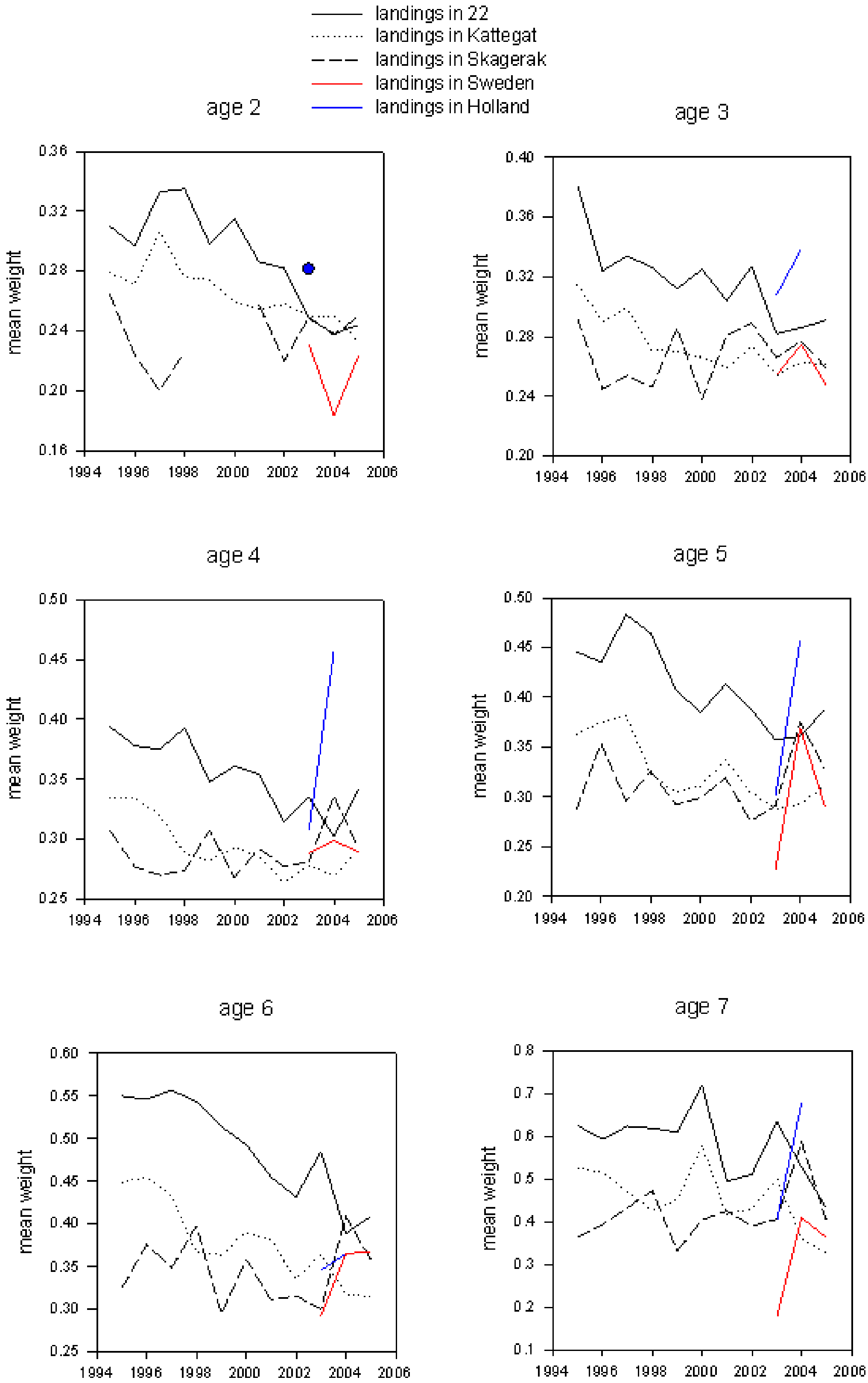


Figure 4: Mean weight at age 2-7 from 5 different commercial fleets.

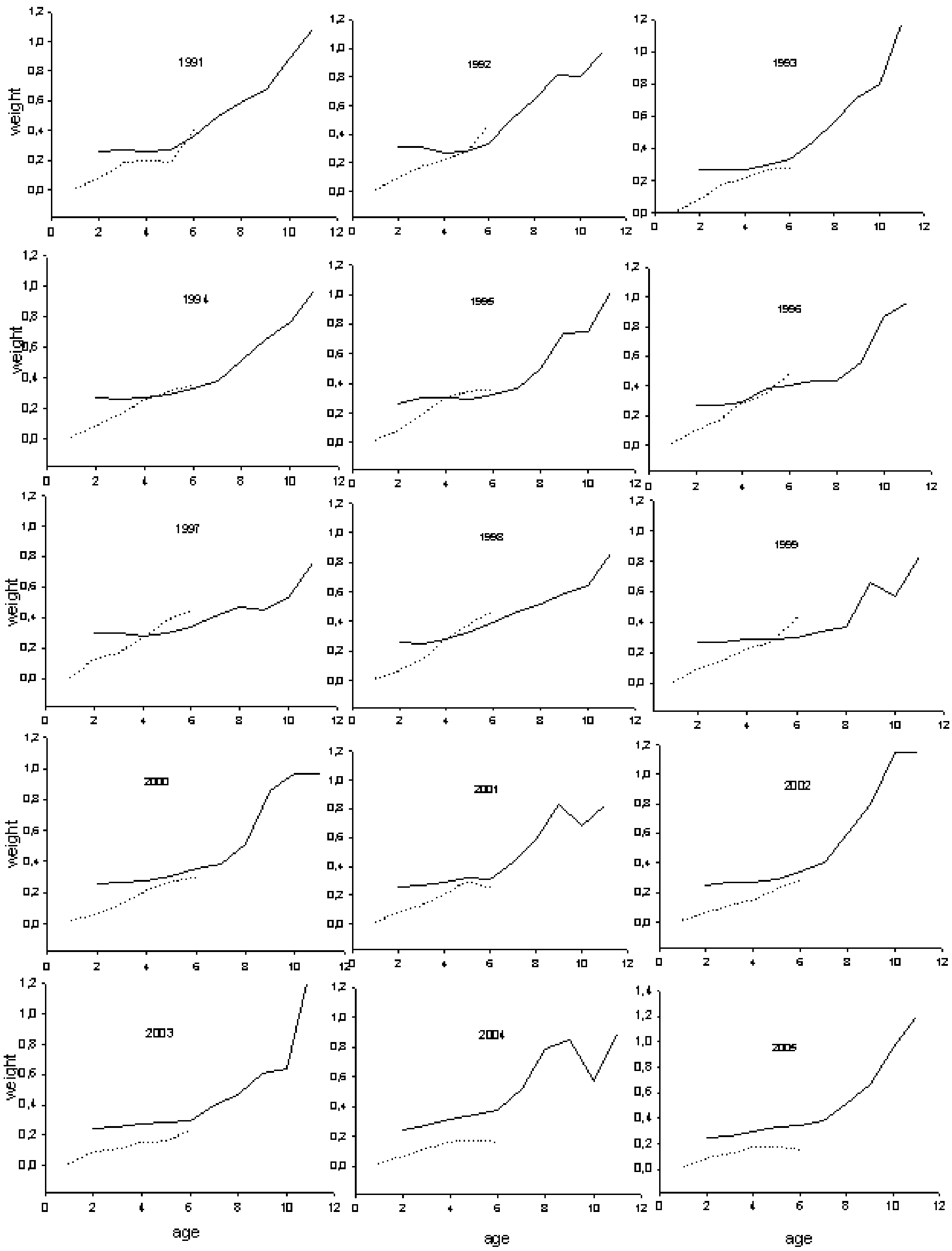


Figure 5. Comparison of mean weight at age between the IBTS survey (dottet line) and commercial samples (solid line) in IIIa in the years 1991-2005

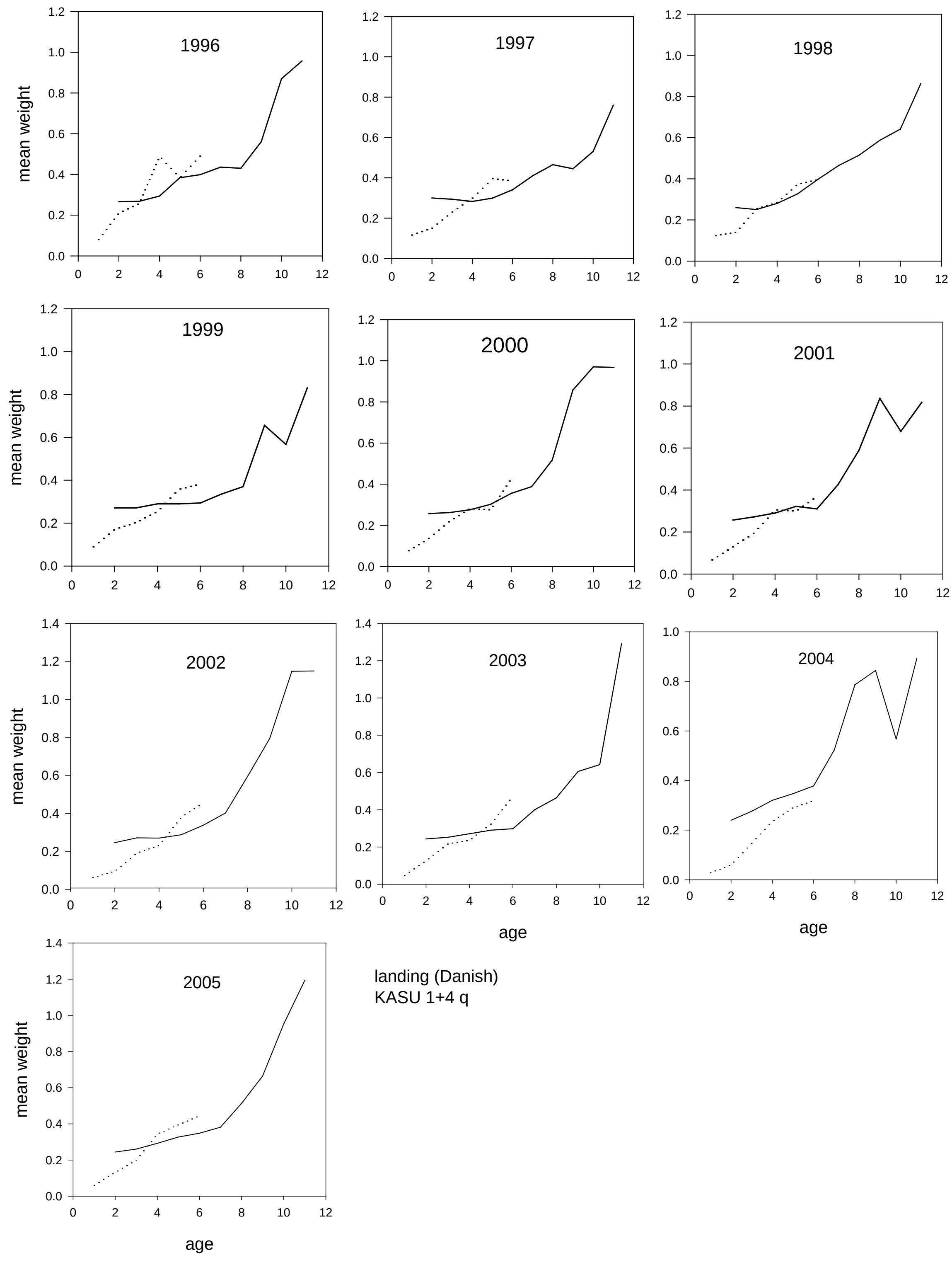


Figure 6. Comparison of mean weight at age between the KASU survey 1+ 4 q (dottet line) and commercial samples (solid line) in IIIa in the years 1996-2005

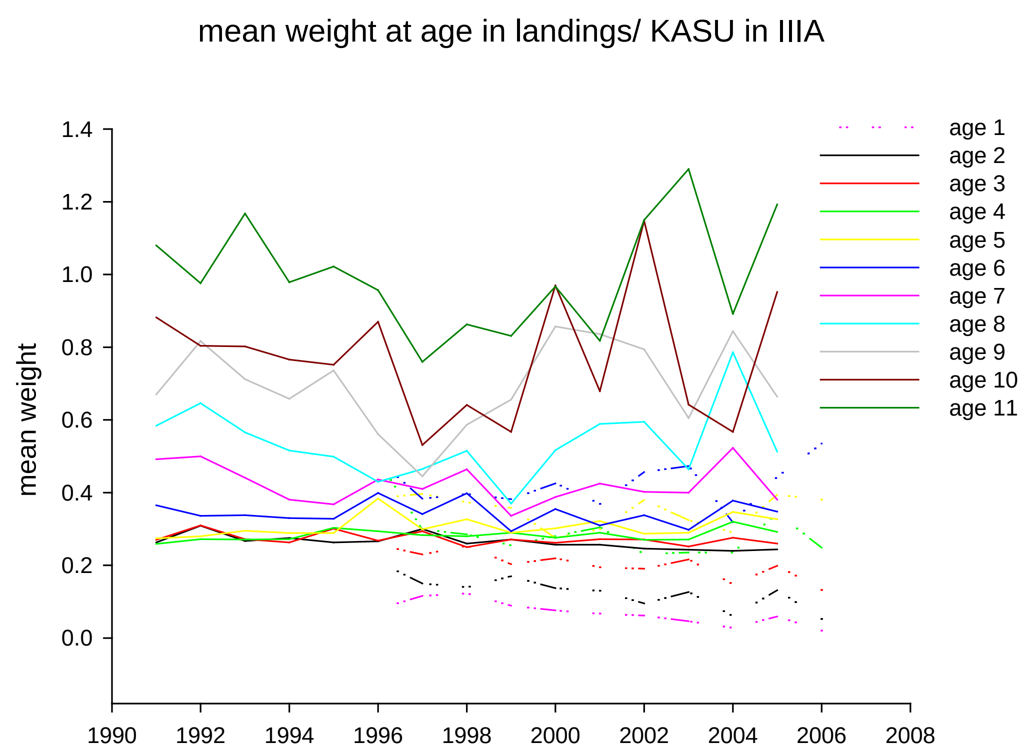


Figure 7. Mean weight at age in KASU 1+4 q and commercial landings from the Danish fleet.

Stock Annex: Plaice in area IV

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea plaice
Working Group:	WGNSSK
Date:	7 February 2009
By:	Jan Jaap Poos

A. General

A.1 Stock definition

The North Sea plaice is defined to be a single stock in ICES area IV. However, data from data storage tag experiments reveal that about one third of plaice released in the Southern Bight of the North Sea visit the eastern English Channel in December and January. In contrast, analysis of the movements of mark-recapture experiments with plaice of a similar size and released at similar times indicates that only 13% of plaice released in the Southern Bight visit the eastern English Channel at this time (Hunter et al., 2004). This difference between DST and mark-recapture experiments is not observed in the central North Sea and German Bight, where the movements of plaice derived from the two approaches are relatively similar (Bolle et al., 2005). The differences may possibly be due to the fact that these fish migrate to their spawning grounds by selective tidal stream transport. Studies (Kell et al., 2004) have shown that the migration between North Sea and the adjacent areas is more problematic for the smaller adjacent areas than it is for management in IV.

Genetic analysis of plaice population structure in northern Europe using microsatellites and mitochondrial DNA data (Hoarau et al., 2004) reveals relatively strong differentiation between “shelf” plaice and those from Iceland and Faeroe, suggesting that deep water may serve as a barrier to movement between these populations. However, within the area of the European continental shelf, only weak differentiation could be detected between North Sea-Irish Sea and other areas (Norway, the Baltic and the Bay of Biscay, Hoarau *et al*., 2004). Although the spatial location of sampling within the North Sea was not sufficient to reveal any sub-structure. The lack of any genetic differentiation between Irish Sea and North Sea plaice populations (Hoarau et al., 2004) despite the evidence from mark-recapture studies that indicate extremely low transfer of individuals between these sea areas (0.36% over 17 years, calculated from (Dunn and Pawson, 2002)) shows how differently genetic and tagging studies provide an understanding fish population structure. Nonetheless, it seems unlikely that Irish Sea and North Sea plaice are a single “stock”, at least in a fisheries management sense.

A.2 Fishery

North Sea plaice is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea. Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. Due to the minimum mesh size enforced (80 mm in the mixed beam trawl fishery), large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea plaice have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. For example, approximately 85% of plaice landings from the UK (England and Scotland) is landed into the Netherlands by Dutch vessels fishing on the UK register. Vessels fishing under foreign registry are referred to as flag vessels. As described by the ICES WGNSSK in 2001(ICES CM 2002/ACFM:01), the fishing pattern of flag vessels can be very different from that of other fleet segments. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box). Also, the decrease in fleet size may partially have been compensated by slight increases in the technical efficiency of vessels. In the Dutch beam trawl fleet indications of an increase of technical efficiency of around 1.65% by year was found over the period 1990 – 2004 (Rijnsdorp et al., 2006). Because the commercial tuning series are not currently used in the assessment, these estimates do not affect the current assessment.

The Dutch beam trawl fleet, one of the major operators in the mixed flatfish fishery in the North Sea, has seen a shift towards more inshore fishing grounds, changing the catchability of the fleet. This shift may be caused by a number of factors, such as the implementation of fishing effort restrictions, the increase in fuel prices and changes in the TAC for the target species (Quirijns, 2008). However, the contribution of each of these factors is yet unknown. Other factors affecting the catchability of the fleet include the changes in the fishing speed of the vessels, and discarding marketable fish in certain seasons and areas, as a result of the TAC management (Rijnsdorp, 1991)

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001; EC Council Regulation No 51/2006; e.g N°40/2008, annex IIa). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammel nets could fish between 140 and 205 days per year.

Several technical measures are applicable to the plaice fishery in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55 N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the plaice fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100mm is required. In addition to this, since 2002 a small part of North Sea plaice fishery is affected by the additional cod recovery plan (EU regulation 2056/2001) that prohibits trawl fisheries with a mesh size <120mm in the area to the north of 56°N.

The minimum landing size of North Sea plaice is 27 cm. The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are ex-empted from the regulation. An evaluation of the plaice box has indicated that: From trends observed it was inferred that the Plaice Box has likely had a positive effect on the recruitment of Plaice but that its overall effect has decreased since it was established. There are two reasons to assume that the Plaice Box has a positive effect on the recruitment of Plaice: 1) at present, the Plaice Box still protects the majority of undersized Plaice. Approximately 70 % of the undersized Plaice are found in the Plaice Box and Wadden Sea, and despite the changed distribution, densities of juvenile Plaice inside the Box are still higher than outside; 2) In the 80 mm fishery, discard percentages in the Box are higher than outside. Because more than 90 % of the Plaice caught in the 80 mm fishery in the Box are discarded, any reduction in this fishery would reduce discard mortality. There is, however, no proof of a direct relationship between total discard mortality and recruitment.

Generally, it is assumed that the majority of discarded animals do not survive (Beek et al. 1990; Chopin et al. 1996). Reviews of studies that have tested this assumption acknowledge that discard mortality is determined by a range of biological, technical, or environmental factors or 'stressors' (Broadhurst *et al*. 2006). Biological factors relate to e.g. the species, physiology, size, catch weight/ volume, composition; technical stressors relate to e.g. gear design, deployment duration, fishing speed; environmental stressors relate to e.g. temperature, hypoxia, depth, wind force, availability of sunlight.

For the beam trawl fishery, discard mortality is influenced by the duration the organisms are confined in the codend and concurrent injuries (Beek et al. 1990; Broadhurst et al. 2006). If the fish were brought on board alive, then the processing of the catch on board would also matter. However, in fact, processing on board hardly affects the survival of the discards because approximately 70% of the catch is moribund upon landing already (Beek *et al*. 1990). It is estimated based on experimental studies on board commercial vessels that less than 10% of the plaice and sole discards in the beam trawl fisheries survive the process of discarding (Bult and Schelvis-Smit 2007; Beek *et al*. 1990).

A.3 Ecosystem aspects

Adult North Sea plaice have an annual migration cycle between spawning and feeding grounds. The spawning grounds are located in the central and southern North Sea, overlapping with the distribution area of Sole. The feeding grounds are located more northerly than the sole distribution areas. Juvenile stages are concentrated in shallow inshore waters and move gradually off-shore as they become larger. The nursery areas on the eastern side of the North Sea contribute most of the total recruitment. Sub-populations have strong homing behaviour to specified spawning grounds and rather low mixing rate with other sub-populations during the feeding season (de Veen, 1978, Rijnsdorp and Pastoors, 1995). Genetically, North Sea and Irish Sea plaice are weakly distinguishable from Norway, Baltic and Bay of Biscay stocks using mitochondrial DNA (Hoarau *et al*., 2004).

Juvenile plaice were distributed more offshore in recent years. Surveys in the Wadden Sea have shown that 1-group plaice is almost absent from the area where it was very abundant in earlier years (van Keeken et al., 2007). The Wadden Sea Quality Status Report 2004 (Vorberg *et al*., 2005) notes that increased temperature, lower levels of eutrophication, and de-cline in turbidity have been suggested as causal factors, but that no conclusive evidence is available; taking into account the temperature tolerance of the species there is ground for the hypothesis that a temperature rise contributes to the shift in distribution.

A shift in the age and size at maturation of plaice has been observed (Grift *et al*., 2007, Grift *et al*., 2003): plaice become mature at younger ages and at smaller sizes in recent years than in the past. This shift is thought to be a genetic fisheries-induced change: Those fish that are genetically programmed to mature late at large sizes are likely to have been removed from the population before they have had a chance to reproduce and pass on their genes. This results in a population that consists ever more of fish that are genetically programmed to mature early at small sizes. Reversal of such a genetic shift may be difficult. This shift in maturation also leads to mature fish being of a smaller size at age, because growth rate is reduced after maturation.

B. Data

B.1 Commercial catch

Discard sampling programmes started in the late 1990s to obtain discard estimates from several fleets fishing for flatfish. These sampling programmes give information on discard rates from 1999 but not for the historical time series. Observations indicate that the proportions of plaice catches discarded are high (80% in numbers and 50% in weight: (van Keeken et al., 2004)) and have increased since the 1970s (51% in numbers and 27% in weight: (van Beek, 1998)) The discards time series are derived from Dutch, Danish, German and UK discards observations for 2000 – 2007. For the period prior to that, a reconstructed discard time series for 1957 – 1999 exists, based on a reconstructed population and selection and distribution ogives (ICES CM 2005/ACFM:07 Section 9.2.3).

The discard data from the sampling programmes in the individual countries are raised totals, based on samples from onboard observers. These observers generally take length structured samples that are

The UK discards estimates have strong interannual variation, caused by the low sample sizes, and sampling different strata in the UK fleet. For example, the UK discard samples for 2007 were taken mainly from the UK *Nephrops* and otter trawl fishery. These fisheries represent only a small fraction of the total UK plaice landings, and raising the UK discards using only samples from this fleet would potentially lead to incorrect estimates. Since the UK landings represents 24% of the total nominal landings, obtaining accurate discard estimates is crucial. In order to gain better estimates of discards, the proportionality of the English discards to the Dutch discards is calculated in the observations since 2000. The UK estimates are recalculated assuming a constant ratio between the UK and Dutch discard numbers at age:

$$\hat{D}^{UK}_{a,y} = \frac{\sum_{y=2002}^{2007} D^{UK}_{a,y}}{\sum_{y=2002}^{2007} D^{NL}_{a,y}} \times D^{NL}_{a,y} \qquad 1.$$

where $D^{UK}_{a,y}$, $\hat{D}^{UK}_{a,y}$, and $D^{NL}_{a,y}$ are the observed and estimated UK, and observed Dutch discard numbers of year *y* and age *a*, respectively

After raising to the fleet total and estimation of discards-at age using age length keys from the Dutch BTS surveys, discard observations at age are thus available from the Dutch, Danish, German and the UK discard sampling programmes. The sampling effort in the Dutch and UK programmes is given in The quality of the estimation of total discards numbers at age depends on the quality of the available discards data, which are derived from low sampling level discards observations within the four countries that have provided discard estimates.

Discards at age were raised from the Dutch and UK sampling programmes by effort ratio (based on hp days at sea for the Dutch fleets, and on trips for the UK fleets). Discards at age from the Danish and German sampling programs were raised by landings. Discards at age for the other fleets for which no estimates were available, were calculated as a weighted average of the Dutch, Danish, German and UK discards at age and raised to the proportion in landings (tonnes). This is the same method as used in the final assessment by WGNSSK 2005 (method B).

A self sampling programme for discards was started by the Dutch beam trawl fishery in 2004, and is still running. This sampling program has a high number of samples, taken on board by the fishermen, estimating the percentage of discards by volume. The program indicates a strong spatial pattern in the discarding of the fleet. The percentage discards estimated in the self sampling program is significantly lower than that in the Dutch sampling programme in the same years (Aarts and van Helmond, 2007).

To reconstruct the number of plaice discards at age before 2000 that are required for an XSA assessment, catch numbers at age are calculated from fishing mortality at age corrected for discard fractions, using a reconstructed population and selection and distribution o-gives (ICES CM 2005/ACFM:07 Appendix 1). Alternatively, the discards previous to 2000 can be estimated using the statistical catch-at-age approach as described in (Aarts and Poos, 2009).

Landings

The landings by country are collected by different countries, segregated by sex for the Netherlands and Belgium (accounting for approximately 50 % of the landings). Age structure is available for the Netherlands, France, Germany, Denmark and Belgium (accounting for approximately 75% of the landings). The total age structured landings are estimated using a weighed procedure for the age structure by country, based on the proportionality of the weight of the total landings.

B.2 Biological

Weight at age

The stock weights of age groups 1-4 are calculated using modeled mean lengths from survey and back-calculation data (see ICES CM 2005/ACFM:07 Appendix 1) and converted to mean weight using a fixed length-weight relationship. Stock weights of the older ages are based on the market samples in the first quarter. Stock weight at age has varied considerably over time, especially for the older ages. Discard weights at age are calculated the same way as the stock weights of age groups 1-4, after which gear selection and discarding ogives are applied. Landing weights at age are derived from market sampling programmes. Catch weights at age are calculated as the weighted average of the discard and landing weights at age. There appear to be cohort effects on landings weight at age, which are also reflected in the stock weights at age. In addition to the cohort effects, there is a long term decline in weight at age for the older ages. The stock weights of the older ages are based on the market samples in the first quarter. In these market samples, the sex ratio for the older ages may be skewed towards one of the sexes. The WG suggests a more in depth study into the causes and consequences of the perceived decreases in stock weights for the next benchmark assessment.

Natural mortality

Natural mortality is assumed to be 0.1 for all age groups and constant over time. These values are probably derived from war-time estimates (Beverton and Holt, 1957).

Maturity

A fixed maturity ogive is used for the estimation of SSB from the assessment in North Sea plaice, assuming maturity-at-age 1 is 0, maturity-at-age 1 and 2 is 0.5, and older ages are fully mature. However maturity at-age is not likely to be constant over time (Grift *et al*. 2003, Grift *et al*. 2007) (Grift et al., 2007, Grift *et al*., 2003). The effects of assuming a constant maturity-at-age on the management advice was discussed in a study by (Kell and Bromley, 2004). However, a study of the effect of the fluctuations of natural mortality on the SSB by the WG in 2004 showed that incorporating the historic fluctuations had little effect on SSB estimates in the period 1999-2003.

B.3 Surveys

Three different survey indices can been used as tuning fleets are:

- Beam Trawl Survey RV Isis (BTS-Isis)
- Beam Trawl Survey RV Tridens (BTS-Tridens)
- Sole Net Survey in September-October (SNS)

Additional Survey indices that can be used for recruitment estimates are (Table 8.2.12):

- Demersal Fish Survey (DFS)

The Beam Trawl Survey RV Isis (BTS-Isis) was initiated in 1985 and was set up to obtain indices of the younger age groups of plaice and sole, covering the south-eastern part of the North Sea (RV Isis). Since 1996 the BTS-Tridens covers the central part of the North Sea, extending the survey area of the surveys. Both vessels use an 8-m beam trawl with 40 mm stretched mesh codend, but the Tridens beam trawl is rigged with a modified net. Owing to the spatial distribution of both BTS surveys, consider-able numbers of older plaice and sole are caught. Previously age groups 1 to 4 were used for tuning the North Sea plaice assessment, but the age range has been extended to 1 to 9 in the revision done by ACFM in October 2001.

The Sole Net Survey (SNS & SNSQ2) was carried out with RV Tridens until 1995 and then continued with the RV Isis. Until 1990 this survey was carried out in both spring and autumn, but after that only in autumn. The gear used is a 6 m beam trawl with 40 mm stretched mesh cod-ends. The stations fished are on transects along or perpendicular to the coast. This survey is directed to juvenile plaice and sole. Ages 1 to 3 are used for tuning the North Sea plaice assessment; the 0-group index is used in the RCT3. In an attempt to solve the problem of not having the survey indices in time for the WG, the SNS was moved to spring in 2003. However, because of the gap in the spring series these data could not be used in the plaice assessment or in RCT3. In 2004, the SNS was moved back to autumn as before, based on the recommendation of the WGNSSK in 2004.

The 1997 survey results for the 1995 and 1996 year classes (at ages 1 and 2) in the BTS and SNS surveys cannot be used in the assessment, owing to age reading problems in that year. Also, the research vessel survey time series have been revised in May 2006 by WGBEAM (ICES 2006), because of small corrections in data bases and new solutions for missing lengths in the age-length-keys.

When WGBEAM will provide these combined series, those should be used instead in the assessment.

The Demersal Fish Survey (DFS) is the more coastal of the surveys, conducted by several countries. This survey is not used in the assessment, but rather used to estimate the recruitment of juvenile fish in the RCT3 analysis. The survey estimates abundances for North Sea plaice age 0 and age 1. However, the age 1 has not been used for recruitment estimation since a number of years, and the time series for this age was stopped in 2005. The UK contribution to the DFS survey was revised in 2008, affecting the estimates between 2001 and 2006.

B.4 Commercial LPUE

Commercial age structured LPUE series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are:

- The Dutch beam trawl fleet (since 1989)
- The Dutch beam trawl fleet corrected for spatial effort allocation (since 1997)
- The UK beam trawl fleet excluding all flag vessels (between 1990 and 2002)

Effort has decreased in the Dutch beam trawl fleet since the early/mid 1990s. Up until 2002, the age-classes available in both the Dutch and the UK fleets generally show equal trends in LPUE through time.

The WG used both survey data and commercial LPUE data for tuning until the mid 1990s. The commercial LPUE was calculated as the ratio of the annual landings over the total number of fishing days of the fleet. At that time, however, it was realised that the commercial LPUE data of the Dutch beam trawl-fleet, which dominated the fishery, were likely to be biased due to quota restrictions. Vessels were reported to adjust their fishing patterns in accordance to the individual quota available for that year. Fishers reported to leave productive fishing grounds because they lacked the fishing rights and moved to areas with lower catch rates of the restricted species with a bycatch of non-quota, or less restricted species.

A method that corrects for the spatial effort allocation is to calculate LPUEs at a smaller spatial scale, e.g. ICES rectangles, and then calculate the average of these ICES rectangle-specific LPUEs. Age-information is available at this spatial level since 1997, and LPUE series could be used for tuning an age structured assessment method (alternatively, age-aggregated tuning series could be used in other analytical assessment methods than XSA). Only under the assumption that discarding is negligible for the older ages, the LPUE represents CPUE, and this time-series could be used to tune age structured assessment methods.

Also, age-aggregated LPUE series, corrected for directed fishing under a TAC-constraint (see Quirijns and Poos 2007), by area and fleet component, can be used as indication of stock development. Available are

- The Dutch beam trawl fleet (only large cutters with engine powers above 221 kW)
- The UK beam trawl flag vessels landing in the Netherlands (only large cutters with engine powers above 221 kW)
- Several Danish fleets (trawl, gillnet and seines) mainly operating in the Northern area

- Effort of the Dutch beam trawl fleet and of the English beam trawl vessels landing in the Netherlands, by area and fleet component.

B.5 Other relevant data

To be done

C Historical Stock Development

There are currently two methods that could be used to provide an assessment of North Sea plaice, being XSA, and a model developed by (Aarts and Poos, 2009). The XSA uses the reconstructed discard set described in the catch section. The Aarts and Poos method (Appendix A) 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 $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.6 is consistent with an SSB of around 230 000 t. In 2008, a target F was added to the reference points, based on the F stated in the long term management plan for plaice an 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.

HUNTER, E.,METCALFE, J. D., O'BRIEN, C. M., ARNOLD, G. P., REYNOLDS, J. D. 2004. Vertical activity patterns of free-swimming adult plaice in the southern North Sea. Mar. Ecol. Prog. Ser., 279: 261–273.

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.

Appendix A. The Statistical Catch at Age (SCA) model

Model description

The model is elaborately described in Aarts and Poos (2009). Here we present the text from Aarts and Poos (2009), changing parts to make the text more concise, and to describe the differences between the sole and plaice assessment. For an in-depth description we refer to Aarts and Poos (2009). In short, the model is a traditional discrete-time age-structured population dynamics model

$$N_{a+1,t+1} = N_{a,t}\mathrm{e}^{-Z_{a,t}},$$

where $N_{a,t}$ are the numbers at age a at time t, and $Z_{a,t}$ the total mortality, which is composed of the instantaneous natural mortality rate M and the fishing mortality rate $F_{a,t}$.

Natural and fishing mortality

Natural mortality is assumed to be constant (0.1) in time and equal for all ages. Fishing mortality $F_{a,t}$ is the result of catchability q, annual fishing effort e_t, and the selectivity pattern $f_{a,t}$, such that

$$F_{a,t} = qe_t f_{a,t}.$$

Catchability q is the extent to which a stock is susceptible to fishing. The fishing effort e_t is the total amount of fishing in a year. With the available data, it is only possible to estimate the product of these two. The selectivity pattern $f_{a,t}$ defines the relative likelihood that an individual of age a in the population is caught and is constrained to have a maximum of 1. A smooth function of age is used, constructed using four b-spline basis functions $h_k(a)$. Each b-spline basis function is a cubic polynomial of the explanatory variable, but it is only non-zero within a certain range (defined by so-called knots) of the explanatory variable. Next, each basis function $h_k(a)$ is weighted by a constant $b_{k,t}$. Summing these weighted functions results in the complex smooth function of age:

$$f_{a,t} = \mathrm{logit}^{-1}\left(\sum_{k=1}^{4} b_{k,t}h_k(a)\right).$$

In this function, logit^{-1} is exp(·)/(1 + exp(·)) and ensures that $f_{a,t}$ takes values between 0 and 1. Because of the local nature of the basis function, the fit of the smooth function in one range of the data (e.g. at low ages) is independent of its fit at the other extreme (e.g. at high ages). Similar to many other assessment techniques, we assume that the fishing mortality of the last age class is equal to the fishing mortality of the preceding age. Temporal changes in the spatial overlap between fishing effort and the different age classes of the fish population can result in changes in the selectivity pattern. This is captured by modelling the weighting constants as a function of time, hence the subscript t in $b_{k,t}$. To prevent overparameterization, only a linear function for the temporal changes in selectivity was inspected, i.e.

$$b_{k,t} = \beta_{0,k} + \beta_{1,k}t.$$

Discards and landings

The expected catch $C_{a,t}$ for age a and year t is calculated from

$$C_{a,t} = \frac{F_{a,t}}{Z_{a,t}} N_{a,t}(1 - e^{-Z_{a,t}}).$$

For plaice, the catch consist of discards $D_{a,t}$ and landings $L_{a,t}$.We assume that an age-dependent fraction $d_{a,t}$ of the catch is discarded, such that

$$D_{a,t} = d_{a,t} C_{a,t},$$

$$L_{a,t} = (1 - d_{a,t}) C_{a,t}.$$

Although landings data are generally available, discard data are often lacking or, as in our study, only available for the most

recent years. For sole, we assume that the landings are equal to the catches, and there in no discarding. For plaice, we assume that the discard fraction $d_{a,t}$ is a smooth function of age where each smooth parameter is modeled as a second-order orthogonal polynomial function of time.

1.1.1 Tuning series

The tuning series data for plaice are collected over a short period (August–September) of each year. Because the survey vessel catches are a very small part of the population, it is assumed that these catches do not affect the mortality of the population as a whole. The population size $N_{a,t}$ represents the population size on 1 January of year t. When the scientific survey takes place later in the year, the population size may be reduced considerably by fishing and natural mortality. To correct for this, the mean population size during the time of the survey is estimated as

$$N^U_{a,t} = N_{a,t} \frac{e^{-\kappa Z_{a,t}} - e^{-\lambda Z_{a,t}}}{(\lambda - \kappa) Z_{a,t}},$$

where κ and λ are the start and end, respectively, of each survey expressed as a fraction of a year. Consequently, the catch of survey $U_{a,t}$ of age a in year t can easily be calculated as

$$U_{a,t} = s_{u,a} N^U_{a,t} q_u,$$

where q_u is the efficiency, which is survey vessel u-specific, and $s_{u,a}$ the age-specific selectivity of the survey vessel u. Again, we model $s_{u,a}$ as a smooth function of age. Survey selectivity $s_{u,a}$ is assumed to remain constant in time. It should be noted that for sole, the commercial LPUE series of the Dutch beam trawl fleet is used in the assessment (similar to the ICES WGNSSK assessment). Here, the assumption of constant q_u may be violated. Because the LPUE series span the entire year, κ and λ are set to 0 and 1, respectively

Likelihood function

The available datasets for parameter estimation are (i) landings-at-age, (ii) discards-at-age, and (iii) tuning series from three surveys. Conforming with most other statistical catch-at-age assessment, the data are assumed to be lognormally distributed, with means and age-specific standard deviations predicted by the model. Zero values were replaced by half of the lowest value observed in the dataset where each occurred. This approach guards against zeros in the likelihood function by taking account of the scale of the data. The total log-likelihood is then:

$$\ell = \ell_D + \ell_L + \ell_U,$$

$$\text{where } \ell_D = \sum_{a,t} \mathrm{n}(\log(D_{a,t}); \log(\hat{D}_{a,t}), \sigma_a^D),$$

$$\ell_L = \sum_{a,t} \mathrm{n}(\log(L_{a,t}); \log(\hat{L}_{a,t}), \sigma_a^L),$$

$$\ell_U = \sum_{a,t} \mathrm{n}(\log(U_{a,t}); \log(\hat{U}_{a,t}), \sigma_a^U).$$

The values of σ_a are modelled as the exponent of an orthogonal polynomial function of age, with 2 d.f. The standard deviations are constrained to be at least 0.05, to facilitate convergence of the minimizer used to find the maximum likelihood. For sole, the likelihood function for the discards observations is removed from the total likelihood function, because we assume there are no discards.

Parameter estimation and model selection

All model fitting was done using the FLR package. The negative of the likelihood function was minimized using the BFGS quasi-Newton or variable metric algorithm. Several starting values were selected randomly from a uniform distribution within appropriate boundaries, leading to different parameter estimates. This suggests that the likelihood function had several local maxima. We therefore selected the parameter estimates corresponding to the highest maximum likelihood among >50 runs. The model often converged to these parameter estimates, and we assumed that these correspond to the global maximum. Also, all eigenvalues of the numerically differentiated Hessian matrix at the parameter values presented here were positive, indicating that the parameter values indeed represented a maximum of the log-likelihood function.

Quantifying uncertainty

Maximizing the log-likelihood function results in maximum likelihood parameter estimates and the variance–covariance matrix that is derived from the inverse of the Hessian. For estimating parameter uncertainty, we selected 10 000 random values from a multivariate normal distribution with those parameter means and variance–covariances. The resulting random realizations are then used to estimate 95% confidence intervals for population and fisheries characteristics of interest, using the percentile method.

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 Demer sal 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

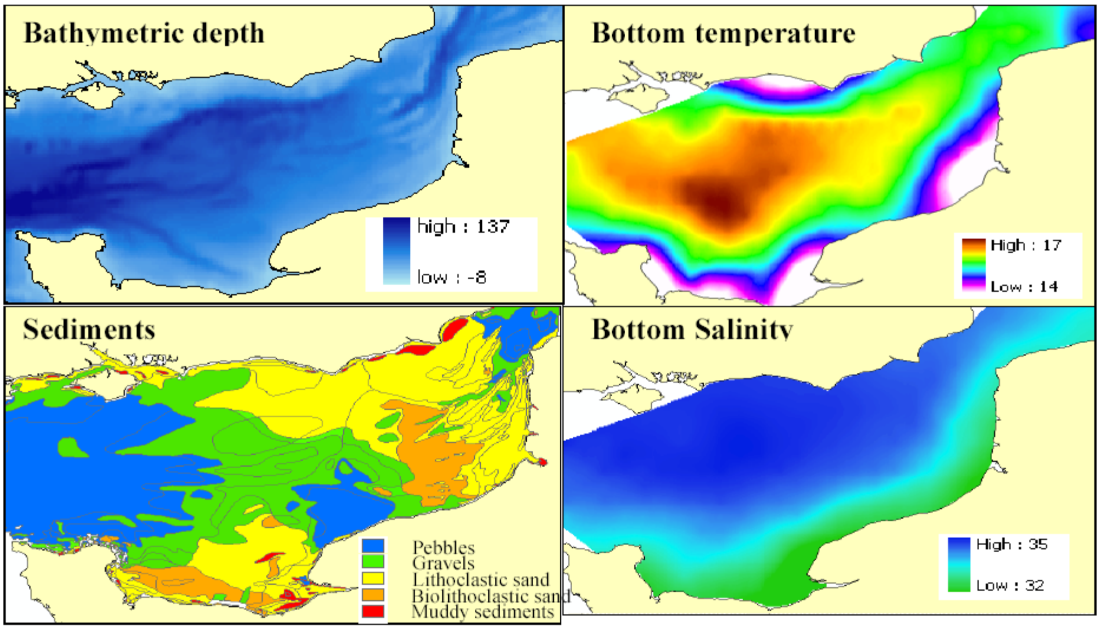


Figure 1. Eastern English Channel physical and hydrological features: Bathymetric depth and simplified sediment types representation. Survey bottom temperature and bottom salinity (averaged for 1997 to 2003) obtained by Kriging. (in Vaz *et al.*, 2004).

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.

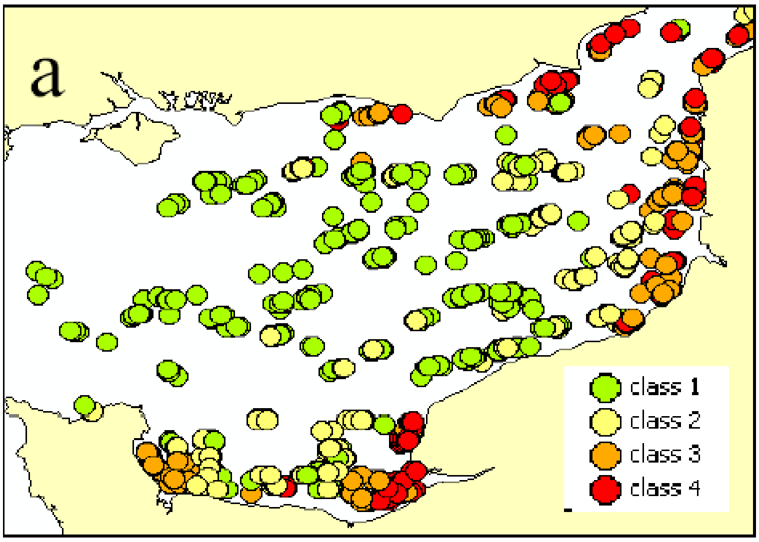


Figure 2. Spatial distribution of Fish Subcommunities in the Eastern Channel from 1988 to 2003. Observed assemblage type at each station, These illustrate the gradation from open sea community to coastal and estuarine communities (In Vaz *et al.*, 2004).

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.

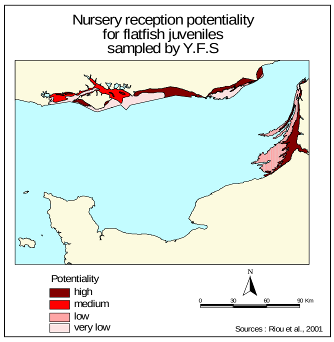
B.3 Surveys

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 - North Sea Sole

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea sole
Working Group:	WGNSSK
Date:	3 March 2010
By:	Jan Jaap Poos

A General

A.1 Stock definition

The North Sea sole is defined to be a single stock in ICES area IV. The stock assessment is done accordingly, assuming sole in the North Sea is a closed stock.

A.2 Fishery

North Sea sole is taken mainly in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea (see Figure 1). Directed fisheries are also carried out with seines, gill nets, and twin trawls, and by beam trawlers in the central North Sea. The minimum mesh sizes enforced in these fisheries (80 mm in the mixed beam trawl fishery) are chosen such that they correspond to the Minimum Landing Size for sole. Due to the minimum mesh size, large numbers of (undersized) plaice are discarded. Fleets exploiting North Sea sole have generally decreased in number of vessels in the last 10 years. However, in some instances, reflagging vessels to other countries has partly compensated these reductions. Besides having reduced in number of vessels, the fleets have also shifted towards two categories of vessels: 2000HP (the maximum engine power allowed) and 300 HP (the maximum engine power for vessels that are allowed to fish within the 12 mile coastal zone and the plaice box).

In recent times the days at sea regulations, high oil prices, and different patterns in the history of changes in the TACs of plaice and sole have led to a transfer of effort from the northern to the southern North Sea. Here, sole and juvenile plaice tend to be more abundant leading to an increase in discarding of small plaice. A change in efficiency of the commercial Dutch beam trawl fleet has been described by Rijnsdorp *et al.* (2006). This change in efficiency is related to changes in targeting and the change in spatial distribution (Quirijns *et al.* 2008, Poos *et al.* 2010). An analysis of the changes in efficiency by the 2006 North Sea demersal assessment working group showed that the increase in efficiency was especially pronounced between 1990 (the beginning of the time series for which data was available) to 1996-1998, after which the efficiency seemed to decrease slightly. The data for which this could be analyzed spanned 1990 to 2002, so the efficiency changes since 2002 could not be estimated.

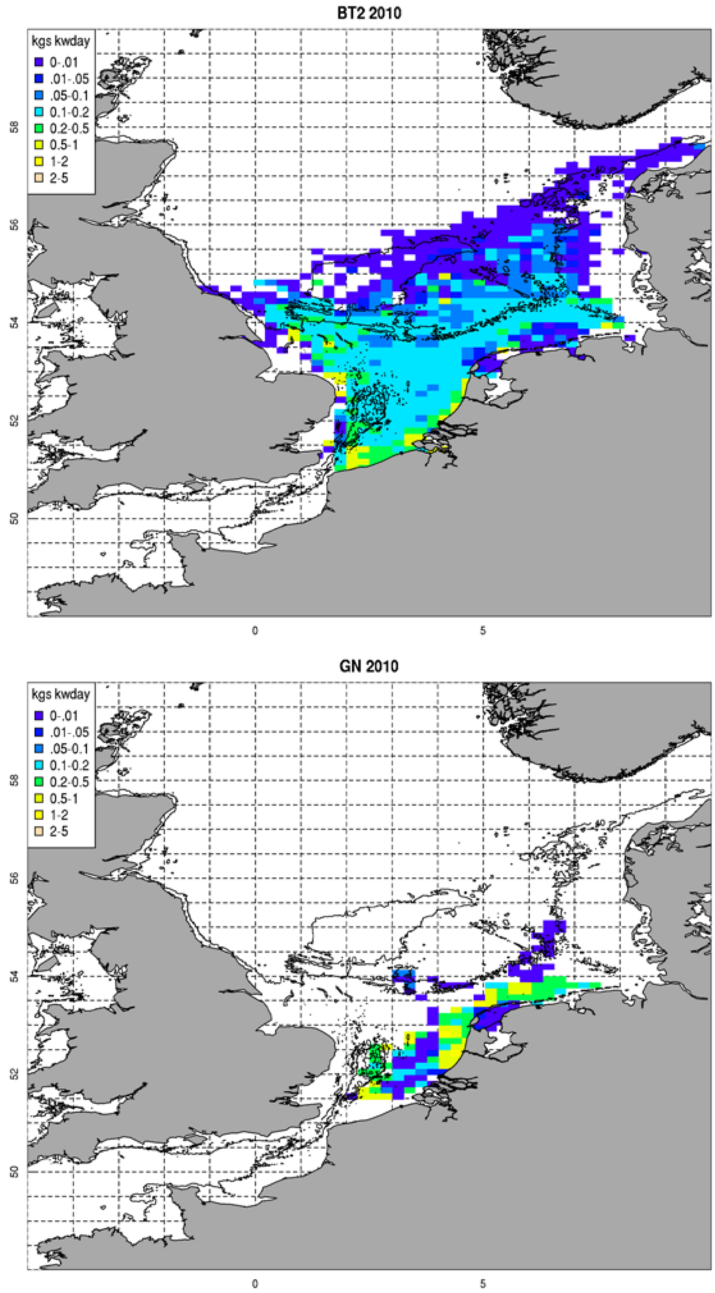


Figure 1. Landing rates (kgs kwday-1) in 2010 by Dutch flagged BT2 (beam trawlers working 80-89mm mesh, top) and GN (gillnetters, bottom). Data are based on combining VMS and logbook data. 40m depth contour also added.

Conservation schemes and technical conservation measures

Fishing effort has been restricted for demersal fleets in a number of EC regulations (EC Council Regulation No. 2056/2001, No. 51/2006, No. 41/2007 and No. 40/2008, annex II_a). For example, for 2007, Council Regulation (EC) No 41/2007 allocated different days at sea depending on gear, mesh size, and catch composition: Beam Trawls could fish between 123 and 143 days per year. Trawls or Danish seines could fish between 103 and 280 days per year. Gillnets could allowed to fish between 140 and 162 days per year. Trammel nets could fish between 140 and 205 days per year.

Several technical measures are applicable to the mixed fishery for flatfish species in the North Sea: mesh size regulations, minimum landing size, gear restrictions and a closed area (the plaice box).

Mesh size regulations for towed trawl gears require that vessels fishing North of 55°N (or 56°N east of 5°E, since January 2000) should have a minimum mesh size of 100 mm, while to the south of this limit, where the majority the sole fishery takes place, an 80 mm mesh is allowed. In the fishery with fixed gears a minimum mesh size of 100mm is required.

The minimum landing size of North Sea sole is 24 cm. The maximum aggregated beam length of beam trawlers is 24 m. In the 12 nautical mile zone and in the plaice box the maximum aggregated beam-length is 9m. A closed area has been in operation since 1989 (the plaice box). Since 1995 this area was closed in all quarters. The closed area applies to vessels using towed gears, but vessels smaller than 300 HP are exempted from the regulation.

A.3 Ecosystem aspects

Sole growth rates in relation to changes in environmental factors were analysed by Rijnsdorp *et al*. (2004). Based on market sampling data it was concluded that both length at age and condition factors of sole increased since the mid 1960s to a high point in the mid 1970s. Since the mid 1980s, length at age and conditions have been intermediate between the troughs (1960) and peaks (mid 1970s). Growth rates of the juvenile age groups were negatively affected by intra-specific competition. Length of 0-group fish in autumn showed a positive relationship with sea temperature in the 2nd and 3rd quarters, but for the older fish no temperature effect was detected. The overall pattern of the increase in growth and the later decline correlated with temporal patterns in eutrophication; in particular the discharge of dissolved phosphates from the Rhine. Trends in the stock indicators e.g. SSB and recruitment, did not coincide, however, with observed patterns in eutrophication.

In recent years no changes in the spatial distribution of juvenile and adult soles have been observed (Grift *et al*. 2004, Verver *et al*, 2001). The proportion of undersized sole (<24 cm) inside the Plaice Box did not change after its closure to large beamers and remained stable at a level of 60 – 70% (Grift *et al*., 2004). The different length groups showed different patterns in abundance. Sole of around 5 cm showed a decrease in abundance from 2000 onwards, while groups of 10 and 15 cm were stable. The largest groups showed a declining trend in abundance, which had already set in years before the closure.

Mollet *et al* (2007) used the reaction norm approach to investigate the change in maturation in North Sea sole and showed that age and size at first maturity signifi-cantly 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.

B.3 Surveys

There are 3 trawl surveys that could potentially be used as tuning indices for the assessment of North Sea sole.

- The BTS-ISIS (Beam Trawl Survey)
- The SNS (Sole Net Survey)
- The UK Corystes survey

The BTS-ISIS (Beam Trawl Survey) is carried out in the southern and south-eastern North Sea in August and September using an 8m beam trawl. The SNS (Sole Net Survey) is a coastal survey with a 6m beam trawl carried out in the 3rd quarter. In 2003 the SNS survey was carried out during the 2nd quarter and data from this year were. The research vessel survey time series have been revised by WGBEAM (ICES-WGBEAM, 2009). WKFLAT 2010 decided to use only the BTS-ISIS and the SNS surveys as tuning series, because of lack of information on the raising procedure and spatial coverage of the UK Corystes series. In the assessment, the BTS-ISIS and SNS indices, calculated by WGBEAM, are used for tuning the stock assessment.

B.4 Commercial LPUE

There is one commercial fleet available that can be used as a tuning series for the stock assessment, being the Dutch beam trawl fleet. This fleet takes more than 70% of the landings, and is relatively homogeneous in terms of size and engine power. The data from this commercial fleet can be estimated using two different methods. The first method uses the total landings, and creates the age distribution for these landings by segregating the total landings into market categories, with age distributions being known within market categories through market sampling. Effort for the Dutch commercial beam trawl fleet is expressed as total HP effort days. Effort nearly doubled between 1978 and 1994 and has declined since 1996. Effort during 2008 was <40% of the maximum (1994) in the series. A decline of circa 25% was recorded in 2008 following the decommissioning that took place during 2008.

Alternatively, the data for the Dutch beam trawl fleet can be raised as described by (WGNSSK 2008, WD1). This allows reviewing the LPUE trends in different areas of the North Sea. The data are based on various sources (WGNSSK 2008, WD1). There is a clear separation in LPUE between areas, with the southern area producing a substantially higher LPUE than the northern area. Average LPUE of a standardized NL beam trawler (1471 kW) over the period 1999 to 2007 was 266 kg day_{-1}, and the data have a significant (P<0.01) temporal trend of -6.1 kg day^{-1} $year^{-1}$.

The stock assessment uses the tuning index resulting from using the first method to calculate the commercial index. Owing to the strong changes in catchability in the in the first part of the time series, only the data from 1997 onwards is to be used in the assessment.

C Historical Stock Development

WKFLAT 2010 decided that XSA should be used for providing advice, while also using the SAM models concurrently. There are currently three methods that could be used to provide an assessment of North Sea sole, being XSA, the ANP model (Aarts and Poos, 2009), and the SAM model (WKROUND 2009, WD14). The XSA assumes the catch-at-age matrix is complete and without error. The Aarts and Poos method is a variety of statistical catch-at-age model, that uses splines to estimate the selectivity patterns in the surveys and for the catch-at-age matrix. WKFLAT tested an adaptation of the original ANP model, where the discards estimation procedures were not incorporated. The SAM model is a state-space assessment model, similar to TSA. The advantage of using ANP and SAM would be that they take into account (and show) the uncertainty of the assessment inputs and outputs. The disadvantage of using ANP is that it can only assess the stock status for those years where survey data is available. Once a new benchmark group decides that there is no problem with the operational aspects of using SAM for North Sea sole, we recommend replacing the use of XSA with SAM.

Model used as a basis for advice

The North Sea sole advice is based on the XSA stock assessment. Settings for the final assessment are given below:

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1- 10).
Tuning indices	BTS-Isis 1985-assessment year 1-9 SNS 1970[1]-assessment year 1-4 NL-beam trawl index 1997-assessment year 2-9
Plus group	10
First tuning year	1970[1]
Time series weights	No taper
Catchability dependent on stock size for age <	2
Catchability independent of ages for ages >=	7
Survivor estimates shrunk towards the mean F	5 ages / 5 years
s.e. of the mean for shrinkage	2.0
Minimum standard error for population estimates	0.3
Prior weighting	Not applied

[1] *The first year of tuning was erroneously listed as 1982 in the initial stock annex. It has been corrected following the 2011 WGNSSK meeting.*

The SAM model

Setting/Data	Values/source
Catch at age	Landings (since 1957, ages 1:10)
Tuning indices	BTS-Isis 1985-assessment year 1-9 SNS 1982-assessment year 1-4 NL-beam trawl index 1997-assessment year 2-9
Plus group	10
First tuning survey year	1982
Catchability independent of ages for ages >=	7
Prior weighting	Not applied

D Short-term Projection

Because the assessment on which the advice is based is currently a fully deterministic XSA, the short term projection can be done in FLR using FLSTF. Weight-at-age in the stock and weight-at-age in the catch are taken to be the mean of the last 3 years. The exploitation pattern is taken to be the mean value of the last three years, scaled to the last years F. Population numbers at ages 2 and older are XSA survivor estimates, unless there is consistent indication from the most recent recruitment surveys of a stronger or weaker year class. Numbers at age 1 and recruitment (age 0) are taken from the long-term geometric mean.

Management options are given for three different assumptions on the F values in the “intermediate” year; (A) F in the “intermediate” year is assumed to be equal to the average estimate for F of the last three assessment years scaled to the last years F; (B)

F2009 is 0.9 times the average estimate for F of the last three assessment years scaled to the last years F; and (C) F in the "intermediate" year is set such that the landings in the intermediate year equal the TAC of that year. ACOM in 2009 has decided to use option (A)

E Medium-Term Projections

Generally, no medium-term projections are done for this stock.

F Long-Term Projections

Generally, no long- term projections are done for this stock.

G Biological Reference Points

The current reference points were established by the WGNSSK in 1998. The current reference points are $\mathbf{B_{lim}}$= $\mathbf{B_{loss}}$= 25 000 t and $\mathbf{B_{pa}}$ is set at 35 000 t using the default multiplier of 1.4. $\mathbf{F_{pa}}$ was proposed to be set at 0.4 which is the 5th percentile of $\mathbf{F_{loss}}$ and gave a 50% probability that SSB is around $\mathbf{B_{pa}}$ in the medium term. Equilibrium analysis suggests that F of 0.4 is consistent with an SSB of around 35 000 t. Given that the assessment results in terms of historic biomass estimates did not change substantially following the updates in assessment methodology in WKFLAT2010, the estimates of these reference points are still valid.

	Type	Value	Technical basis
Precautionary approach	B_{lim}	25,000 t	B_{loss}
	B_{pa}	35,000 t	B_{pa}1.4 *B_{lim}
	F_{lim}	Not defined	
	F_{pa}	0.40	F_{pa} = 0.4 implies B_{eq} >B_{pa} and P(SSB_{MT} < B_{pa}) < 10%.
Targets	F_{mgt}	0.2	EU management plan

(unchanged since 1998, target added in 2008)

H Other Issues

None identified

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 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 2011
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.

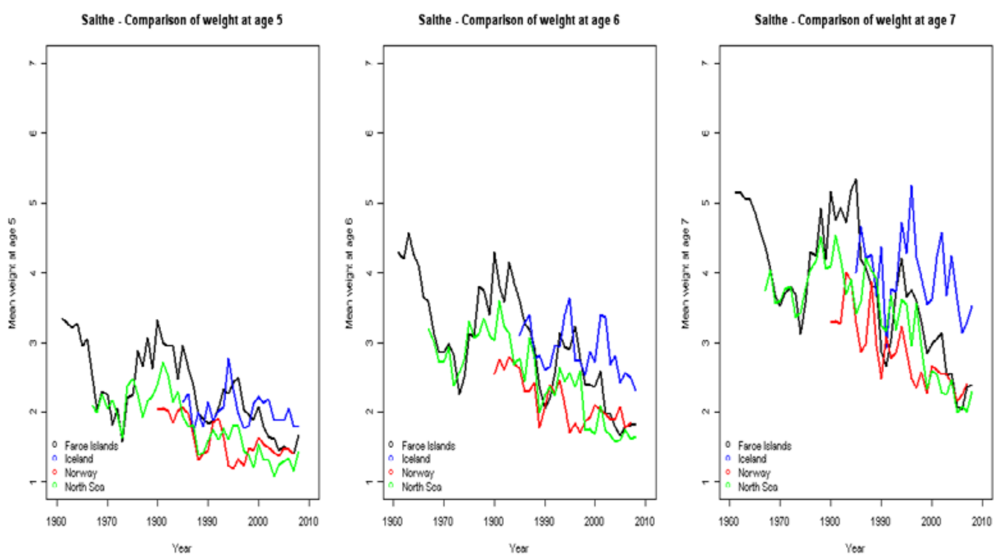


Figure 1. Weight at age by stock: The reduction of weight at age seems to be of importance for three out of four stocks, while one (Icelandic) does not show the same decline. (i Homrum, E. 2011, in prep).

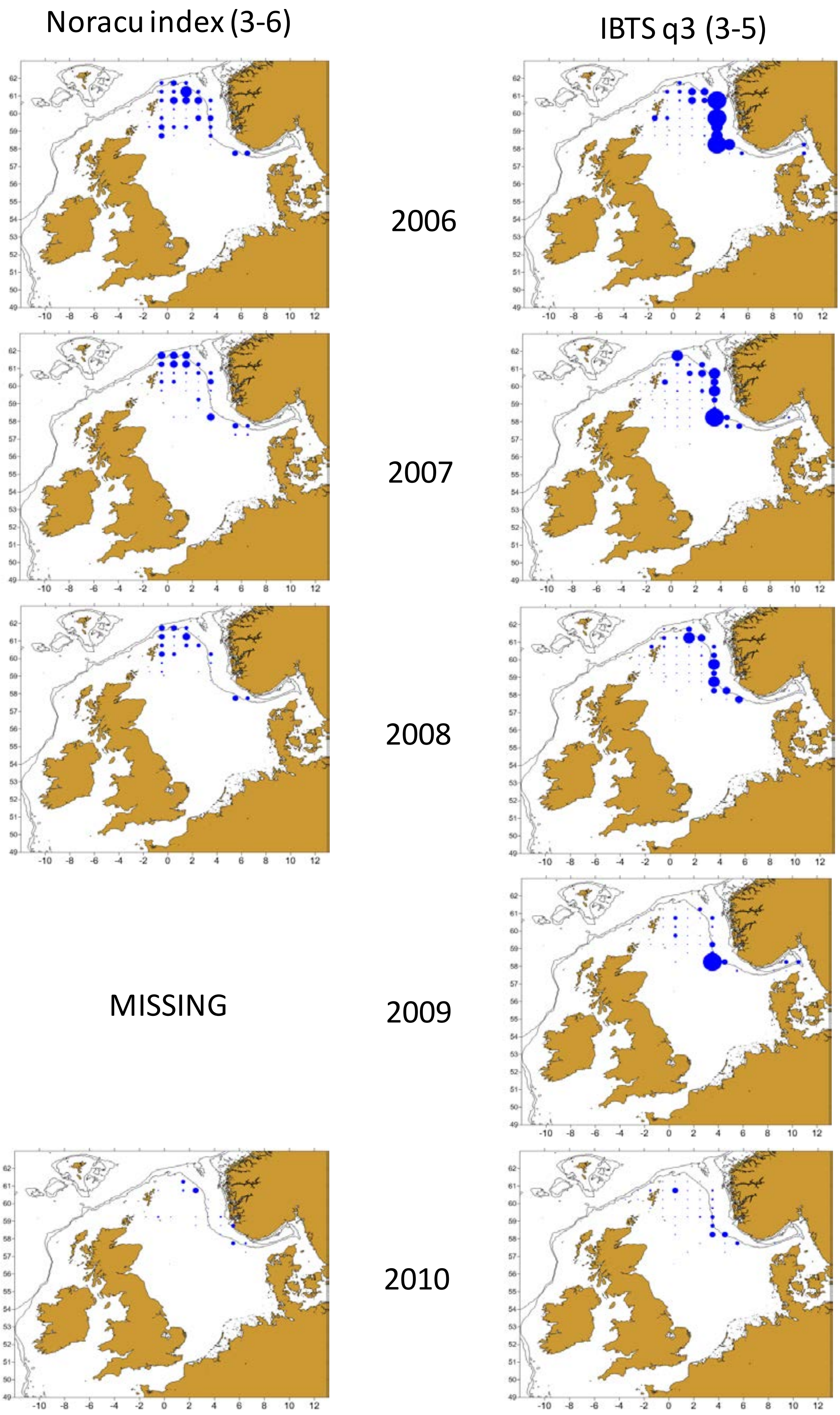


Figure 2. NORACU (left column) and IBTS Q3 (right column) indexes from 2006 to 2010

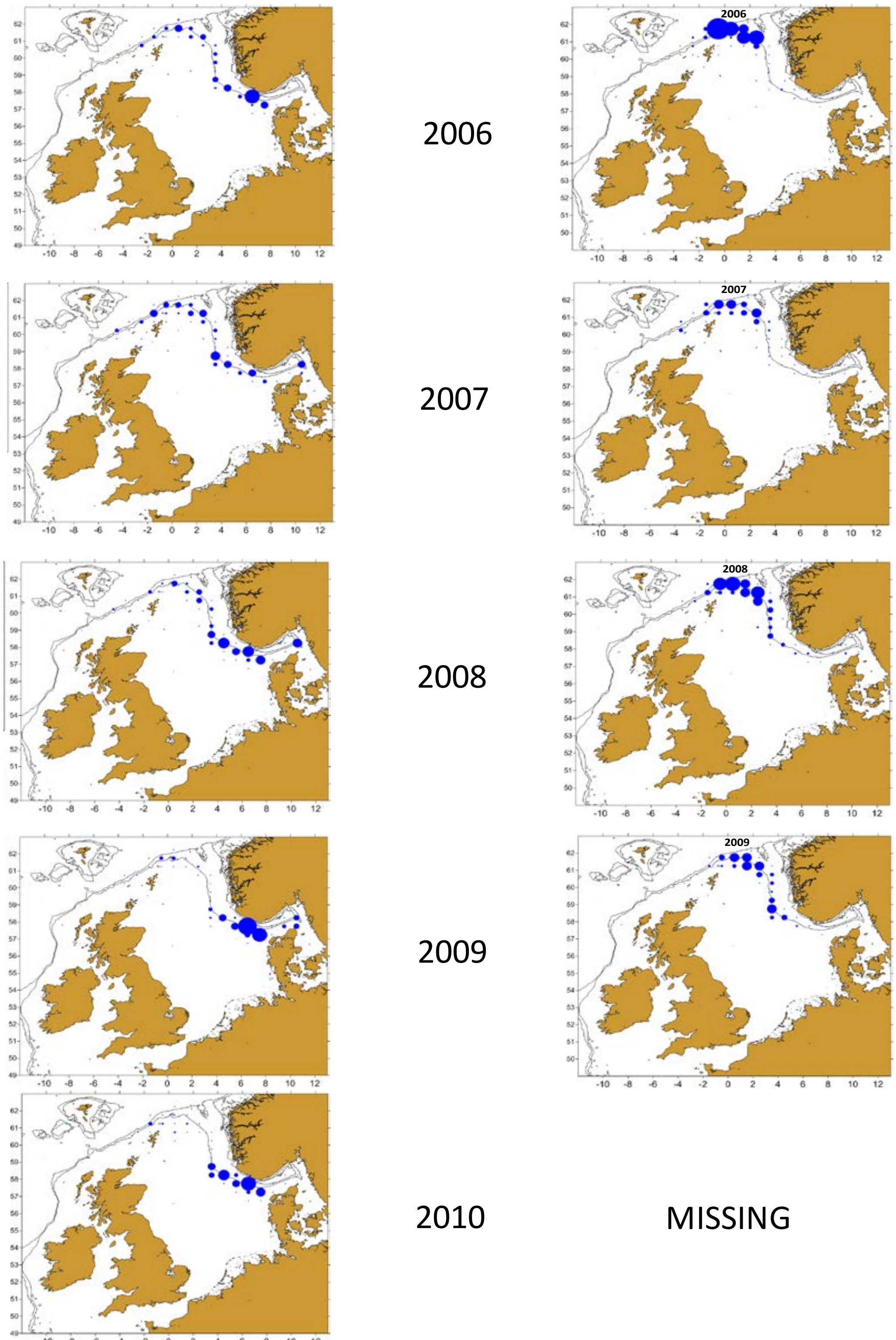


Figure 3. Spatial distribution of the catches for the GEROTR (left column) and NORTRL (right column) indexes from 2006 to 2010.

Stock Annex Whiting in Division IIIa

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Whiting IIIa
Working Group:	WGNSSK
Date:	(05/2011)
Revised by	(WGNSSK /Andrea Belgrano)

A. General

A.1. Stock definition

No new information was presented at the working group.

A.2. Fishery

The distribution of the landings for human consumption only between the areas IIIa N and IIIa S taking the average over the last three years showed that 69.3 % and 30.7 % were taken in IIIa N and IIIa S respectively, corresponding to an average of 72.32 tonnes in IIIaN and 32.06 tonnes in IIIa S. The average landings for the last three years, including both human consumption and industrial by-catch accounted for 37 % in IIIa N and 63 % in IIIa S corresponding to 116 and 197 tonnes respectively.

A.3. Ecosystem aspects

Understanding the complex mechanisms linked to the temporal and spatial distribution of fish abundances paly 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 between the 1920’s to 1970’s .

B. Data

B.1. Commercial catch

The new data available for this stock are too sparse to revise the advice from last year and therefore no assessment of this stock was undertaken. The commercial landings for this stock are available from 1975 to present, and estimate of discards from 2003.

The distribution of the landings for human consumption only between the areas IIIa N and IIIa S taking the average over the last three years showed that 69.3 % and 30.7 % were taken in IIIa N and IIIa S respectively, corresponding to an average of 72.32 tonnes in IIIaN and 32.06 tonnes in IIIa S. The average landings for the last three

years, including both human consumption and industrial by-catch accounted for 37 % in IIIa N and 63 % in IIIa S corresponding to 116 and 197 tonnes respectively.

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.

I. References

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

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

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:

13) *Every effort shall be made to maintain a minimum level of Spawning Stock Biomass greater than 100,000 tonnes (Blim).*

14) *For 2007 and subsequent years the Parties agreed to restrict their fishing on the basis of a TAC consistent with a fishing mortality rate of no more than 0.3 for appropriate age-groups, when the SSB in the end of the year in which the TAC is applied is estimated above 140,000 tonnes (Bpa).*

15) *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.*

16) *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.*

17) *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.*

18) *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.*

19) *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.*

20) *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:

1) Time-series of proportion of total catch discarded by age.

2) Log catch curves by cohort (total catch).

3) Negative gradients of log catches per cohort, averaged over mean *F* ages (total catch).

4) Bivariate correlations by cohort (total catch), with fitted regression lines. That is, catch numbers at age 0 are plotted against catch numbers at age 1 for each cohort, then age 0 against age 2, and so on for all age combinations.

5) Results of a separable VPA analysis, generated using either the Lowestoft VPA implementation (Darby and Flatman 1994) or the FLR equivalent.

B.2. Biological Information

Weight at age

Weights-at-age data are provided for the stock, total catch, landings, discards and human consumption. Values are derived from length sampling carried out by Denmark, Germany, Norway, Sweden and the UK (see table above), to which fixed weight-length relationships are then applied. Weights-at-age are also collected on the IBTS surveys, but these are not yet used directly in the assessment.

Maturity and natural mortality

The growth dynamics of haddock in the North Sea have changed considerably over time. WKBENCH (ICES-WKBENCH 2011) demonstrated that haddock are now growing more quickly when young but reaching a shorter eventual length than used to be the case. At the same time, survey-based sampling indicates that the maturation age has reduced, with the proportion mature of age-2 fish increasing from around 35% in the early 1970s to around 80% now. However, estimation of the effect of increasing maturity and changing growth on reproductive potential is not straightforward, as fecundity has also changed through time (see comments in ICES-WKBENCH 2011, and the section on “Biological Reference Points” below). The conclusion from WKBENCH was that:

- “WKBENCH recommends that refined maturity estimates should be developed before the next WGNSSK meeting in May 2011 and used in subsequent update assessments.”

WKBENCH also considered the issue of natural mortality *M*, which previously had been assumed to be fixed through time. Annual estimates of natural mortality are available from key runs of the SMS model, as reported by the ICES Working Group on Multispecies Assessment Methods (e.g. ICES-WGSAM 2008). The last key run was conducted in 2007, so estimates are constant for 2007-2009. In addition, it should be emphasised that the last year of comprehensive stomach-data collection was 1991, so the food-web definitions on which SMS runs are based are likely to be out of date to a certain extent. The effects of these time-varying estimates of natural mortality on both XSA and SAM assessment model runs were explored by WKBENCH. The new estimates are quite different from the fixed values used previously, with *M* for age-0 being lower and for ages 2 and above being higher, and that this is likely to have a substantial impact on assessments. The subsequent recommendation was:

- “WKBENCH recommends that time-varying natural mortality estimates from WGSAM should be used in the subsequent update assessments.“

Finally, WKBENCH carried out interim test assessments using the new estimates of maturity and natural mortality, and also produced interim estimates of corresponding biological reference points (which are considerably different to before). These need to be revisited before they can be considered as the basis for advice (see the section on “Biological Reference Points” below).

Recruitment

Recruitment to the North Sea haddock stock is very sporadic, and is characterised by occasional large year classes interspersed by several years of poor recruitment. The reasons for this are unknown. It is likely (see ICES-WKBENCH 2011) that larval haddock spawned to the West of Scotland (Division VIa) settle as demersal juveniles in the northern North Sea, before (possibly) returning west to spawn subsequently.

B.3. Surveys

Five survey series are used in the assessment of North Sea haddock. The survey data used in the 2010 assessment are summarised below:

Country	Fleet	Quarter	Code	Year range	Age range available	Age range used
Scotland	Groundfish survey	Q3	ScoGFS Aberdeen Q3	1982-1997	0-8	0-7
	Groundfish survey	Q3	ScoGFS Q3 GOV	1998-2009	0-8	0-7
England	Groundfish survey	Q3	EngGFS Q3 GRT	1977-1991	0-10+	0-7
	Groundfish survey	Q3	EngGFS Q3 GOV	1992-2009	0-10+	0-7
International	Groundfish survey	Q1	IBTS Q1 (backshifted)	1982-2010	1-5+	1-4

The Scottish and English groundfish survey time-series are both split, to reflect changes in the vessel and gear used which are thought to have substantially affected survey catchability. The collated IBTS Q3 time-series, to which both ScoGFS Q3 and EngGFS Q3 contribute, is also available for the assessment but has not been used to date: the principal reason is that it was historically not available in time for the assessment working group meeting in September, but it also has a shorter time series.

Data exploration

In recent assessments, exploratory data analysis using survey time-series has included:

1) Distribution plots by age and year.

2) Survey log CPUE by age.

3) Log survey catch curves by cohort.

4) Bivariate correlations of survey indices by cohort, with fitted regression lines. That is, indices at age 0 are plotted against indices at age 1 for each cohort, then age 0 against age 2, and so on for all age combinations.

5) Results of SURBA model fits (Needle 2003). These give estimated mean Z, relative SSB and relative recruitment trends, along with confidence intervals.

B.4. Commercial CPUE

Commercial CPUE (or LPUE) data are not used for tuning the final assessment. During preparations for the 2000 round of assessment WG meetings it became apparent that the 1999 effort data for the Scottish commercial fleets were not in accordance with the historical series and specific concerns were outlined in the 2000 report of WGNSSK (ICES-WGNSSK 2001). Effort recording is still not mandatory for these fleets, and concerns remain about the validity of the historical and current estimates of commercial CPUE. In addition, the LPUE indices from Scottish commercial fleets presented at previous WGs (ScoLtr and ScoSei) can no longer be generated in that form due to changes in EU definitions of fishery metiers.

B.5. Other relevant data

No other relevant data have been used in the assessment to date.

C. Historical stock development

Model used as a basis for advice

The advice is based on assessments carried out using the XSA model (Shepherd 1992, Darby and Flatman 1994) implemented as the FLXSA module of the FLR library of the R statistical package. WKBENCH recommended that exploratory runs of both the SAM (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 $\exp(\sigma^2)$, where $\sigma^2 \sim 0.34$ is intended to reflect the variability of the time-series concerned (B or F).**

In its report of January 2011, WKBENCH recommended that the biological reference points for North Sea haddock be revised in time for the 2011 advisory round: "If the proposed new assessment (with time-varying natural mortality and maturity estimates) is accepted for use in subsequent updates, WKBENCH recommends that biomass and fishing mortality reference points and management strategy evaluations be revisited and potentially updated." The use of revised maturity values without due consideration of concomitant changes in fecundity and reproductive potential could result in misleading advice, and WKBENCH concluded that reference points based on reproductive potential would probably serve the advisory process best. 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
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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:

a) expressing the total catch-at-age matrix as proportions-at-age, normalised over time, so that year classes making above-average contributions to the catches are shown as large positive residuals (and vice-versa for below-average contributions);

b) applying a separable VPA model in order to examine the structure of the catch numbers-at-age before they are used in catch-at-age analyses, in particular whether there are large and irregular residuals patterns that would lead to concerns about the way the recorded catch has been processed;

c) performing log-catch-curve analyses to examine data consistency, fishery selectivity and mortality trends over time – the negative slope of a regression fitted to ages down a cohort (e.g. ages 2-4) can be used as a proxy for total mortality.

B.2. Biological Information

Weight at age

Mean catch weight-at-age is a catch-number weighted average of individual catch weight-at-age, available by country, area and type (i.e. landings and discards). For ages 1-9 there have been short-term trends in mean weight at age throughout the time series with a decline over the recent decade at ages 3-5 that recently seems to have been reversed. The data also indicate a slight downward trend in mean weight for ages 3-6 during the 1980s and 1990s. Ages 1 and 2 show little absolute variation over the long-term.

Using weight-at-age from annual ICES assessments and International Bottom Trawl Surveys, Cook *et al*. (1999) developed a model that explained weight-at-age in terms of a von Bertalanffy growth curve and a year class effect. They found that the year class effect was correlated with total and spawning stock biomass, indicating density-dependent growth, possibly through competition. Further evidence for density-dependent growth had previously been found by others (Houghton and Flatman 1981, Macer 1983 and Alphen and Heessen 1984), although they pointed to different mechanisms (Rijnsdorp *et al*. 1991, ICES 2005). Results from Macer (1983) imply that juvenile cod compete strongly with adults, while the data from Alphen and Heessen (1984) suggest strong within-year class competition during the first three years of life.

Growth rate can be linked to temperature and prey availability (Hughes and Grand 2000, Blanchard *et al*. 2005). Growth parameters of North Sea cod given in ICES (1994) demonstrate that cod in the southern North Sea grow faster than those in the north, but reach a smaller maximum length (Oosthuizen and Daan 1974, ICES 2005). Furthermore, older and larger cod have lower optimal temperatures for growth (Björnsson and Steinarsson 2002), and distributions of cod are known to depend on the local depth and temperature (Ottersen *et al*. 1998, Swain 1999, Blanchard *et al*. 2005)

Differences in mean length by age and sex can also be found for mature vs. immature cod (ICES 2005). For example, Hislop (1984) found that within an age group, mature cod of each sex are, on average, larger than immature cod.

Maturity and natural mortality

In the historic assessments natural mortality for cod is assumed to be constant in time. However, calculations with the SMS key run (Stochastic Multi Species Model; Lewy and Vinther, 2004), carried out by the Working Group on Multi Species Assessment Methods (ICES WGSAM 2008), indicate that predation mortalities (M2) declined substantially over the last 30 years for age 1 and age 2 cod. In addition, calculations with the latest 4M key run (Vinther *et al*., 2002), carried out during the EU project BECAUSE (contract number SSP8 CT 2003 502482) in 2007, indicate a systematic increasing trend for older ages (3–6) of cod due to seal predation. A review of the WGSAM estimates was carried out at the 2009 WKROUND benchmark assessment of the North Sea cod (ICES-WKROUND 2009), and the variable time series of M, which include the major sources of predation on North Sea cod, was considered appropriate for use in future assessments. The natural mortality values shown in Table 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:

a) expressing the survey abundance indices (IBTSQ1 and IBTSQ3) in log-mean standardised form, both by year and cohort, to investigate whether there are any year effects, and the extent to which the surveys are able to track cohort signals;

b) performing log-catch-curve analyses on the abundance indices to examine data consistency and mortality trends over time – the negative slope of a regression fitted to ages down a cohort (e.g. ages 2-4) can be used as a proxy for total mortality;

c) performing within-survey consistency plots (correlation plots of a cohort at a given age against the same cohort one or more years later) to investigate self-consistency of a survey;

d) performing between-survey consistency plots (correlation plots of a given age for IBTSQ1 against the same age for IBTSQ3) to investigate the consistency between surveys;

e) applying a SURBA analysis to the survey data for comparison with models that include fishery-dependent data.

B.4. Commercial CPUE

Reliable, individual, disaggregated trip data were not available for the analysis of CPUE. Since the mid-to-late 1990s, changes to the method of recording data means that individual trip data are now more accessible than before; however, the recording of fishing effort as hours fished has become less reliable because it is not a mandatory field in the logbook data. Consequently, the effort data, as hours fished, are not considered to be representative of the fishing effort actually deployed.

The WG has previously argued that, although they are in general agreement with the survey information, commercial CPUE tuning series should not be used for the calibration of assessment models due to potential problems with effort recording and hyper-stability (ICES-WGNSSK 2001), and also changes in gear design and usage, as discussed by ICES-WGFTFB (2006, 2007). Therefore, although the commercial fleet series are available, only survey and commercial landings and discard information are analysed within the assessment presented.

B.5. Other relevant data

The annual North Sea Fishers' Survey presents fishers' perceptions of the state of several species including cod; the survey covers the years 2003-2008, (Laurenson, 2008). In addition, a number of collaborative research projects are reported to the WGNSSK each year. To date the studies providing time series of quantitative information have been relatively local, whereas those with wider coverage have been qualitative. The studies have therefore been used to corroborate assessment results and highlight differences in perception. The studies have proven useful in examining the dynamics of sub-stocks within the North Sea, for instance local recruitment, and thereby in the provision of advice to managers.

C. Historical Stock Development

Available stock assessment models

WKCOD (February 2011) considered two candidate assessment models for North Sea cod, B-Adapt and SAM, with a third model TSA used for exploratory analysis. B-Adapt is a VPA model used until 2010 as a basis for providing advice for North Sea cod, but was considered by WKCOD to be inappropriate for an effort management system that relies on the final year estimate of F, because it provides estimates of F that vary too widely from year to year. WKROUND (January 2009), recommended that SAM be run in parallel to B-Adapt, both models estimating catch multipliers from 1993 onwards to account for "unallocated mortality". WKCOD now recommends SAM, with correlated fishing mortality at age, and using the IBTS Q1 survey as the only tuning index (i.e. omitting the IBTS Q3 survey), as the most appropriate assessment model for North Sea cod for an interim period only. This is so that issues related to changes in survey catchability (the reason IBTS Q3 has been omitted) and discard modelling are further explored, and hopefully in future a more suitable model-data configuration for North Sea cod can be found. A full description of the SAM model can be found in the WKCOD report.

Model used as a basis for advice

The state-space models SAM offers a flexible way of describing the entire system, with relative few model parameters. It allows for objective estimation of important variance parameters, leaving out the need for subjective *ad-hoc* adjustment numbers, which is desirable when managing natural resources.

For North Sea Cod only one survey index (IBTS Q1) is used, for the time being, and the total catch-at-age data. No commercial fleets with effort information are used. The Beverton-Holt recruitment function is used, but there is no visual difference in the results if a Ricker curve, or simply a random walk recruitment is used in its place. Fishing mortality random walks are allowed to be correlated.

For North Sea Cod the model is extended to allow estimation of possible bias (positive or negative) in the reported total catches from 1993 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:

$$\vartheta = (Q_{a=1,2,3,4,5}^{(s=1)}, \sigma_R^2, \sigma_S^2, \sigma_F^2, \sigma_{\circ,a=1,2,3^+}^2, \sigma_{s=1,a=1,2^+}^2,$$
$$\tau_{1993}, \tau_{1994}, \ldots, \tau_{2009}, \alpha, \beta, \rho)$$

The Q parameters are catchabilities corresponding to the survey fleet. The three variance parameters σ_R^2, σ_S^2, and σ_F^2 are process variances for recruitment, survival, and development in fishing mortality respectively. The remaining σ^2 parameters are describing the variance of different observations divided into fleet and age classes. Finally the τ parameters are the scaling factors for the total catches, α and β are the parameters of the Beverton-Holt recruitment function, and ρ is the correlation parameter for the random walks on the fishing mortalities.

Model used: SAM (with correlated fishing mortality at age)

Software used: Source code and all scripts are freely available at http://www.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, Gadu*s 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

Annex 4 –Technical Minutes of the North Sea ecosystem Review Group

Review of ICES	**WGNSSK Report 2009**
Reviewers:	Gary Melvin (Canada, chair)
	Dorleta Garcia (Spain)
	Ciaran Kelly (Ireland)
	Anthony Wood (USA)
Chair WG:	Ewen Bell and Clara Ulrich Rescan
Secretariat:	Barbara Schoute

General

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak **(WGNSSK)** was one of 3 working group reports used by The North Sea Review Group (RGNS) to complete their review. The RGNS would like to acknowledge the effort expended by the working group to produce the report and the work required to complete their documentation in a timely manner.

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-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)
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)
sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall)
san-nsea	Sandeel in Subarea IV excluding the Shetland area
sol-eche	Sole in Division VIId (Eastern Channel)
sol-nsea	Sole in Sub-area IV (North Sea)
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:Short term forecast not presented due to 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)

5) Consistency: In ICES-WKCOD (2011) meeting it was decided to replace B-Adapt assessment model used up to 2010 by SAM. Furthermore, it was decided to use only IBTS Q1 as tuning index and not to use IBTS Q3.

6) Stock status: $B<B_{lim}$ since 1998, $F_{lim}<F<F_{pa}$ since 2005 with a decreasing trend and 95% confidence interval in 2010 below F_{pa}. R seems to be low in recent years but 2010 estimate is higher than the estimates in previous 3 years.

7) Man. Plan.: EU Plan Agreed in 2008: Effort management and a target fishing mortality of 0.4, reducing fishing mortality in a 75% in 2009, 65% in 2010 comparing with 2008 level, and applying successive decrements of 10% for the following years. Furthermore,

   a. If $SSB > B_{pa}$ => The TAC shall correspond with a fishing mortality Fy = 0.4.

   b. If $B_{lim} < SSB < B_{pa}$ => the TAC shall not exceed a fishing mortality Fy = $0.4-(0.2*(B_{pa} - SSB)/(B_{pa}-B_{lim}))$

   c. If $SSB < B_{lim}$ => the TAC shall not exceed a fishing mortality Fy = 0.2.

TAC levels for 2010 and subsequent years should not be 20% above or below the levels established the previous years.

General comments

SAM is a time-series model designed to be an alternative to the (semi) deterministic procedures (VPA, Adapt, XSA, ...) and the fully parametric statistical catch-at-age models (SCAA, SMS, ...). Compared to the deterministic procedures it solves the problem of falsely assuming catches-atage are known without errors, and in addition the problem of selecting appropriate so-called 'schrinkage', and in certain cases convergence problems in the final years. Compared to fully parametric statistical catch-at-age models SAM avoids the problem of fishing mortality being restricted to a parametric structure (e.g. multiplicative), and many problems related to having too many model parameters compared to the number of observations (e.g. borderline identification problems, convergence issues, asymptotic results, ...) (Taken from WKADSAM10 Report)

This was in general well documented, well ordered and considered section and easy to follow and interpret. But 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.

Downward trends in F from the high values in 2000 are observed and SSB is estimated to have increased for the second consecutive year, albeit from very low levels. The increase in SSB is largely derived from the relatively strong 2005 year class maturing. While these trends can be taken as 'green shoots' it is premature to state that 'the stock has began to recover' particularly given the historically low recruitment based on the Q1 IBTS 2009 survey and the very high levels of discarding being observed in the fishery. Even with a continued decline in F, the stock is well below B_{lim} and if recruitment continues to be impaired, the prognosis is still poor (relative to B_{pa}).

The high levels of discarding are particularly worrying and clearly demonstrate that TAC's are not constraining F sufficiently. The assessment output shows that F from discarding is now equal to or greater than F apportioned to landings. It appears that restrictive TAC's and available effort are mismatched and recovery is being constrained by discarding. Correction for unreported discards by a raising factor is a source of uncertainty.

There are a number of initiatives to reduce discards described, but based on the discard information presented; thus far these have been inadequate. A review of available mitigation options and their potential would be informative from a management perspective. There is a real need to improve the estimates of discards from all countries.

Technical comments

- 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 assessment shows a general tendency (Retrospective pattern) overestimate F, this could be problematic in a stock that is manage 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.
- 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.
- In section 14.7, 2010 must be replaced by 2011 in the following sentence, '… The first set (Basis A) assumes that F in 2010 follows…'.
- 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.
- 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.
- 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 reduce by a 10%.

- Basis A and B. The names in under “Rationale” column, 5th and 6th row, are incorrect, they should be ‘Status quo’ and ‘MSY’. In 7th and 8th instead of dividing ‘TAC’ and ‘Constraint’ I will used TAC constraint in both.

- 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.

Conclusions

The assessment has been performed correctly.

Suggestion for future benchmarks:

Re-estimate MSY and Biological Reference Points.

Apply the scaled factor, Say, multiplicatively to Fay in order to account for this ‘extra’ mortality.

Things to be done before ADG:

Check Table 14.12 Basis A. Is the 15% reduction in F correct or should be a 10% reduction?

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 with recruitment being assumed as the geometric mean of the five lowest values from 1994-2008 were performed. Long term forecasts were performed with an equilibrium age structured model in R to determine MSY.

4) Assessment model: FLXSA – tuning by 3 fleets (Scotland, England, International) compared to separable VPA,SAM, and SURBAR to corroborate update assessment.

5) Consistency: Error in FLXSA settings was corrected from last assessment which removed power model assumption for age-0. A linear growth model is now used to forecast weights at age. Retrospective analyses do not reveal any large patterns between annual assessments. Comparison with SURBAR and SAM assessment model fits have been made and trends in SSB, F and recruitment are similar.

6) Stock status: Stock has full reproductive capacity and is harvested sustainable. SSB (183,000 t) is above B_{pa} (140,000 t) and B_{lim} (100,000 t) though declining since 2002. F (0.23) is below F_{pa} (0.7) and F_{msy} (0.3) Recent recruitment has been low, but the 2009 year class was considerably high.

7) Man. Plan. Implemented in 2005 and evaluated by ICES in October 2007. Maintain a minimum level of SSB greater than 100,000t (B_{lim}) and restrict fishing on the basis of a TAC consistent with an F ≤ 0.30. Inter-annual TAC variability is also limited to ± 15%.

a. $SSB > B_{pa}$ => $Ftarget < 0.3$

b. $B_{lim} < SSB < B_{pa}$ => $Ftarget < 0.3-0.2*(B_{pa}-SSB)/(B_{pa}-Bl_{im})$

c. $B < B_{lim}$ => $Ftarget < 0.1$

General comments

This is a detailed and well written assessment report. The WG has devoted considerable effort to addressing all review comments and suggestions from both RGNS 2010 and WKBENCH 2011.

The implementation of CCS in 2008/2009 along with multiple real time closures and one net rule have likely impacted the exploitation patterns observed in recent years.

The RG agrees with the WG that a comparison between Intercatch and the spreadsheets used to collate catch in recent years needs to be carried out.

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."

It seems somewhat problematic that the main assessment model for this stock, FLXSA, is no longer being maintained.

There are no serious retrospective patterns in SSB or F.

Errata in the stock annex:

Page 9 Table: Agew 0 should read Age 0,

Page 11 Table Heading: cod should be North Sea haddock.

Technical comments:

The technical aspects of this report are strong. It is an update assessment that has gone through two recent extensive reviews (RGNS 2010 and WKBENCH) and the comments and suggestions of these reviews that have not been fully addressed still apply.

In page 673, under "ICES advice for 2011" paragraph, the text refers to Btrigger but it is not defined in the main text or stock annex.

Weight at age: Table 13.2.3.2-4 shows a declining trend in weight at age for older ages but a linear model is used to model weight at age in the forecast which is contradictory and could produce an overestimation of SSB. The effect of this should be evaluated or commented in the text.

It is not explained how is IBTS Q1backshifted. Are just ages and years reduced by one as said in the text? Should not be more appropriate to use the index as it is and not use the data for assessment year (2011)? I think more explanation on why this is done is needed.

In '13.3.1 Reviews of last year's assessment' I am not convinced with the answer to the question about log catchability residuals. The tuning fleets are surveys thus the catchability should not vary from year to year. And an increase in the catchability of commercial fleet should not affect, in principle, the residuals of the tuning fleets no the model fit.

In page 682, in the first paragraph of section 13.3.4, the comparison of FLXSA and SAM shows that SAM indicated that large 1967 cohort is unlikely. As the results are in general similar, maybe SAM is correcting downwards the total catch in 1967 and following years? In the following paragraph I think the affirmation "It is noticeable that the SURBAR SSB estimate follows the pattern of the SAM estimate rather than XSA" is not justified by the results as this fact is not clear and may be spurious.

Section 13.4 second paragraph, according to figure 13.4. fishing mortality is not fluctuating around the target. It decreases sharply after 2005 (implementation of the management plan) and in the last 3 years it establishes well below the target.

Section 135 the recruitments are taken over the period 1994-2008 and not 1994-2009.

Section 13.6, "forecast results" paragraph, second line, substitute 2010 by 2011.

In sections 13.10 and 13.11 it says that the SSB will increase in the near future but I think it should be make clear that the increase is predicted only for 2012, in fact for 2013 a decrease is predicted (Section 13.6 "forecast results").

Figure 13.3.2.10, SAM assessment run. It is confusing to have 5 plots for indices having only 3 for FLXSA run. A meaningful label in the plots would help to the comparison with FLXSA plots.

In the last part of the stock annex it explains the procedure to estimate Fmsy but the estimates are missing.

Conclusions

The assessment has been performed correctly. Emphasis should be made to address the concerns listed in the report that were to be addressed at WKBENCH. Those concerns centred on stock structure questions, XSA convergence issues, incorporating TEP information into the assessment, and utilizing the longer time-series of discard data.

Suggestions for future benchmarks:

Update of discards with UK revisions.

Compare previous and current methods of discards derivation.

Whiting in Division IIIa (Skagerrak – Kattegat) whg-kask

1) **Assessment type:** **Update Requested**
2) **Assessment**: not presented
3) **Forecast**: not presented
4) **Assessment model**: Exploratory SURBAR
5) **Consistency**:
6) **Stock status**: Unknown
7) **Man. Plan**

General comments

The WG states that the new data available for this stock are too sparse to revise the advice from last year and therefore no assessment of this stock was undertaken.

Reported landings 245.4t, WG estimated landings 291t

Technical comments

The Z from SURBAR analysis appears variable and without trend

Conclusions:

The RG agrees with the WG conclusion that the SURBAR analysis provided useful information based on the available IBTS indices for Q1 and Q3, however the estimates were uncertain based on the 90% CI.

Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel) whg-47d

1) Assessment type: Update

2) Assessment: analytical

3) Forecast:Short-term and medium term forecast presented

4) Assessment model: XSA + tuning by 2 surveys

5) Consistency: Last yr assess accepted – this years accepted. Retrospective analysis indicates large variations between annual assessments. Patterns are inconsistent; at times the model has both over estimated and under estimated the same stock parameters.

6) Stock status: Unknown due to lack of ref points, but expert judgement could be used to classify exploitation relative to likely MSY range. Perception is that the stock is at a historical low level relative to the period since 1990. Recent increase is due to an improved perception of recruitment.

7) Man. Plan.: There is a provisional long term management plan agreed at EU-Norway negotiations 2010 (not presented in the report nor the stock annex.). 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)

General comments

This was a well documented, well ordered and considered section. It was easy to follow and relatively easy to interpret. There are some differences in the way the assessment and forecast have been carried out by comparison with the stock annex, however the stock annex may not be correct.

Technical comments

Section 12.1.6 Table 12.2.1. is missing the catch by country for 2010

Section 12.1.7 paragraph 5 (bottom of P602) Table 12.2.5, should be Table 12.2.2?

Section 12.1.10 Figure 12.2.6, which way round should the axes be? I presumed ages 1-4+ top row to bottom, and 2006-2011 left to right columns

Section 12.2.4 Table suggests as to XSA outputs that ages 1-5 used for surveys, but stock annex says 1-6+. Is the catchability plateau the same as age at full selection? If so report says age 4 and annex says this is age 5. It would be useful to include the logfile of the XSA settings for the assessment, for a quick cross check with the stock annex. There is something odd in the assessment (aopolgies for the vague term). The exploitation pattern looks very dome shaped, is this okay given that M ogive is flat after age 3? It implies that the old fish are difficult to capture through some behavior? Is this really so? Given the mismatch between the numbers at age seen on the survey and subsequently at age 3 & 4 in the catches, this dome shaped selection becomes kinked by the most recent XSA fit. How real is the change in exploitation pattern? I think this is driving much of the results of the assessment.

Section 12.3 Figure 12.4 Mistake in legend, red and green lines are 2009 & 2010, not 2008 and 2008!

Section 12.4 2nd par. "It is the opinion of the WG that the stock is no longer in a regime of critically low recruitment". Given the failure of the WG to determine a B_{lim}, this is a pretty bold statement unless based on the observation of 2 recruitment estimates from the XSA which are reflected by a noisy survey. Given the data presented, I would wonder if there was ever a change in recruitment "*regime*", maybe just a series of low R's followed by some not so low. My point is this could be entirely random. In the next sentence based on this judgement the WG have decided to deviate from the stock annex, and this change in the WG opinion effectively doubles the R value for the forecast. Rather than flip flopping on methodology, maybe the WG should have stuck to the time series geomean and presented some low R scenarios?

Section 12.5 3rd para. Says that partial F was based on the mean prop over 2008-2010, but stock annex says proportions in the terminal year? 4th para, option is justified but different to annex.

Section 12.6 text says analyses presented in Section 16, but this section deals only with Plaice and Sole, so paragraph 2 is not supported.

Section 12.9 Given that F<0.4 for the past 10 years, and that the best estimates of Fmsy are in the range 0.33-0.4, there is some grounds for making an expert judgment that the stock is likely not greatly overexploited.

Conclusions

The assessment has been performed correctly, though it deviates somewhat from the annex. The putative change in catchability of the survey is a problem, and the combination of this with observed catch data and assumed M ogive given the model formulation (XSA with fixed q a age), gives rise to some odd metrics, which are difficult to logically rationalize. That said I think the WG could have gone further in concluding on a state of the stock, at least in terms of exploitation, which is likely not well above Fmsy. Just a note of caution for the ADG, that here we have a good effort to assess a stock, but it falls short of classifying its status relative to Fmsy. The primary client for advice on this stock has a policy which will apply a 25% cut in TAC in the absence of information in exploitation in relation to Fmsy. There is plenty of supporting information so it may be a good candidate to give an expert judgment on.

Suggestions for future benchmarks.

Explore alternative assessment models or XSA configurations to solve retrospective patterns.

Explore if really IBTS Q1 has changed catchability in recent years.

Plaice in Division IIIa (Skagerrak – Kattegat) ple-kask

1 **Assessment type:** **SALY**

2 **Assessment**: not presented

3 **Forecast**: not performed

4 **Assessment model**: FLXSA since 2006– data from 4 surveys and 2 tuning fleets available.

5 **Consistency**: na

6 **Stock status**: Unknown. Total landings in 2010 were 9,168t, an increase from 2009 landings of 6,692t and below the TAC of 11,641t. The perception from a North Sea fisher surveys is that the abundance is decreasing in Skarregat and Kattegat .

7 **Man. Plan.**: Landings in 2011 should not exceed 8000t, the average of landings over 2007-2009.

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.

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 2010 assessment. Retrospective patterns over the last 5 years are improving resulting in a slight underestimation of SSB and over-estimation of F.
6) **Stock status**: The stock is well within precautionary boundaries. F = 0.24 (Average last three years) which is close to Fmsy = 0.25 and well below F_{pa} = 0.60 (based on 5th percentile of Floss = 0.74). SSB= 461,000t 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 2011 the maximum TAC increase results in TAC of 73,400t. Fishing mortality in 2011 should not be more than F_{pa} (0.6) corresponding to landings less than 144,400t. SSB is expected to be above B_{pa} in 2012.

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?

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.

STF results indicate SBB will remain well above Bpa.

Minor corrections for report:

In figure 8.3.1 blue line is not described and red line is used in two cases.

Beare et al 2010 not in refs

Aarts and Poos 2009 not in refs

Figure locations in figures 8.2.2, 8.2.4, 8.2.10, 8.2.11, 8.4.2, do not reflect loca tions indicated in the figure descriptions. Eg. Figure 8.2.2 indicates a "left" and "right"plot when it should indicate "top" and "bottom."

In figure 8.4.1 it would be helpful to draw horizontal lines for F_{pa} and F_{lim}.

In first line of section 8.6 it says that FLCore is used to conduct short term forecast. FLCore does not provide any tool to conduct STF so I guess FLCOre should be replaced by FLSTF or Flash.

Minor corrections for Annex:

Paragraph 1, line 1: “ICES are IV” should read “ICES area IV”

Hunter *et al*. 2004 is not in the refs. Should this be Hoarau *et al*. 2004?

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.

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.

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.

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).

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. The exploratory runs were very interesting to give an idea of the effect of discards in perception of the stock and of the effect of possible change in catchability of tuning indices.

Plaice in Division VIId (Eastern Channel) ple-eche

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) < B_{lim} (5400t)<Bpa (8,000t) and F_{pa} (0.45) < Fbar (0.46) < F_{lim} (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 weight 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 ab undance 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?

Sole in Sub-area IV (North Sea) sol-nsea

1) Assessment type: Update

2) Assessment: analytical

3) Forecast: short-term forecast presented

4) Assessment model: XSA (FLXSA 2.0) 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. Previous retrospective pattern, especially with F, has been corrected by truncating the NL-BT survey analysis: F has been relatively stable for last 3 years. Recruitment estimates in recent year is noisy.

6) Stock status: F below F_{pa}, SSB at B_{pa}, strong year classes 2005 and possibly 2009, 2008 about average. F= 0.34 in 2010 which is below F_{pa} (0.4). The SSB 35 192 t in 2010 above both B_{lim} (25 000t) and B_{pa} (35 000 t). Stock is considered to be sustainably fished.

7) Man. Plan.: Biol. and MSY (proposed) reference points, EU management plan Target F of 0.2. Evaluated (ICES 2008).

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.

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.

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.

Sole in Division VIId (Eastern Channel) sol- eche

1) **Assessment type: Update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA– tuning by 2 comm + 3 surveys
5) **Consistency**: Last yr assess accepted – this years accepted,
6) **Stock status**: B>B_{pa} since 2000, F_{lim}>F>F_{pa}, R uncertain, but seems to be good 2008 recruitment. In the last 5 years fishing mortality has increased to values between F_{pa} (0.4) and F_{lim} (0.57). SSB for 2011 predicted to increase In 2011
7) **Man. Plan.**: None

General comments

This was a well documented, well ordered and considered section. It was easy to follow and interpret. The stock annex was difficult to locate, and it contains more (small) errors than the WG assessment report. For example the stock annex says to use average F scaled to the last year in the forecast, whereas the WG (correctly) does not scale to the final year as there is no trend in F.

Technical comments

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). The surveys could not estimate any trend in fishing mortality. The SSB and recruitment trends from both XSA and SURBA runs showed similar patterns.

Section 9.2 paragraph 2 line 2 should read 16% below and not above.

Section 9.2.4 Natural mortality is correct here but stock annex table on P8 says M = 0.2

Section 9.2.5 par 4 text says "until recently" referring to the period before 2005 but more than 5 years ago is not recent. Table 9.2.7 All the ages (2-15) are bolded, however only ages 2-10 are used in XSA assessment.

Section 9.3.2 Figure 9.3.2 the legend is not drawn large enough to interpret the detail in the plot.

Section 9.3.5 P461 par 2 2008 year class not 2008 year call

Section 9.4 par 2. Too much detail on the "*trends*" you could simply say F has been increasing since 2000.

Conclusions

The assessment has been performed correctly. The basis for the intermediate year catch in the forecast should be looked at carefully by the ADG. The forecast inputs were calculated correctly, according to the procedures outlined in the stock annex (with the exception that the WG decided (correctly) not to scale the average exploitation at age to the F in the final year. However as the SSB is increasing the use of *status quo* F as the basis for the intermediate catch, has the effect of amplifying the TAC overshoot in 2011. When the same basis was used for the intermediate year catch last year it overestimated the removals in 2010. i.e. the overshoot of the 2010 TAC (including misreporting estimates in 2010) was 4%. Because the stock is increasing using *status quo* F this year gives predicted removals in 2011 at 5,837 t this represents a 20% overshoot of the 2011 TAC. Unless you can justify an overshoot increase from 4-20% of the TAC, then the intermediate year removals being based on F*status quo* might be hard to justify. Essentially you are admitting that management by TAC is not fit to control the fishing mortality.

Saithe in Sub-areas IV (North Sea), VI West of Scotland), and Division IIIa (Skagerrak) sai – 3a46

1) **Assessment type: Update**
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: XSA + tunning: 3 comm + 3 surveys
5) **Consistency**: .Major changes from last assessment in 2009. Differences from earlier assessments include: exclusion of younger ages from the commercial CPUE indices; inclusion of Norwegian Acoustic young fish survey (NORASS); re-inclusion of Norwegian CPUE index (NORTRL). Model settings have not changed accept for SOP correction to catch. Consistent retrospective pattern underestimating F and overestimating SSB.
6) **Stock status**: SSB (197,327t) < B_{pa} (200000t), > B_{lim} (106 000t), and F(0.59)>F_{pa} (0.40) and <F_{lim}(0.60). B decreasing trend since 2004, F_{lim}<F (it increases sharply in recent years), R below average in last year classes. F (0.595) is currently at F_{lim} (0.6), double the target F of 0.3, and has been increasing since 2004.
7) **Man. Plan.**: Agreed in 2008: The objective is 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. There are differences in minimum landing size between EU and Norway.

Plan was evaluated by ICES in 2008. It concluded that "it is consistent with the precautionary approach in the short term conditional on the absence of major changes in productivity and the absence of measurement and implementation errors".

Given the current low recruitment and low growth rates in the stock a re-evaluation of the management plan reference points should be considered.

General comments

This was a well ordered and considered section. It was easy to follow and interpret.

Poor estimates of recruitment are a serious concern for this assessment.

Figure 11.3.10 layout does not match the Figure description (ie. Left/Right reference when the figure is Top/Bottom).

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.

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.

Technical comments

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.

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.

In Figure 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.

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.

In the section 11.5 "Recruitments Estimates" It is not clear which years use the geometric mean recruitment.

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.

Conclusions

The WG completed the assessment as agreed to by the benchmark WKBENCH 2011, however, there have been major changes in this assessment since the last review. From the information provided it is difficult to determine if the effects of these changes have been investigated thoroughly in the context of SSB, F, and recruitment. Consequently, although the assessment was preformed according to the request, there is still some uncertainty about the output. Caution is warranted in the interpretation of the assessment results.

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 varia tion in stock abundance.

Try to obtain reliable estimates of discards in order to incorporate them into the assessment.

Nephrops in Division IIIa (Skagerak Kattegat, (FU 3,4) nep-iiia

1 **Assessment type:** Update

2 **Assessment**: analytical/trends

3 **Forecast**: N/A

4 **Assessment model**: UWTV survey. based on UWTV survey, LPUE fluctuations (Denmark and Sweden Combined) and discard patterns.

5 **Consistency**: Large minimum legal size maintained

6 **Stock status**: Current levels of exploitation appear to be sustainable. Trends in survey abundance indicate no change in *Nephrop* density since 2007. Mean size is fluctuating without trend.

7 **Man. Plan**: No Biological Reference Points. F_{msy} proxies proposed by the working group in 2010 were F0.1, F_{max} and F35%Spr. Value are recommended for both males and females separately due to the strong differences between exploitation of the sexes. Suggested F_{msy} proxy is F_{max} (sexes combined) = 7.9. The mean HR for 2010 was slightly above at 8.2.

General comments

WG recommends that both FU 3 and 4 be merged into a single FU and the RG concurs..

There have been a number of improvements in the UWTV surveys in recent years including increase coverage, and better estimates of fishing area us VMS fleet distribution.

The high level of discards observed in recent years may indicate several years of good recruitment. Discards were slightly higher in 2010 than 2009 in FU4.

LPUE from the combined logbooks indicate an increasing trend with effort decreasing since about 2002. There was a slight decrease in LPUE in FU 3 in 2010 but the upward trend continues in FU4.

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

There are several source of bias in the TV surveys which cannot be easily estimated. The largest being the edge effect.

This is the first year *Nephrops* was assessed using the UWTV survey. The WG felt that the estimates from the survey are insufficient to draw conclusions regarding the stock trajectory given the changes in the survey. Regardless the harvest rates were relatively low.

Conclusions

Based on the indicators and the UWTV survey analysis this stock is being exploited sustainable. The RG agree with the WG recommendation to reduce the large amount of discards in this fishery

Nephrops in Division IVbc (Botney Gut – Silver Pit, (FU 5) nep-5

1) Assessment type: SALY
2) Assessment: trends
3) Forecast: not presented
4) Assessment model: LPUE data
5) Consistency: There was no reference to previous reviews.
6) Stock status: The status of the stock is uncertain, however, there are no indications that this stock is suffering from over-exploitation. Total landings consistently exceeded 1000t between 1997 and 2005, with a peak in 2005 of over 1400t. Since 2008 landings have dropped below 1000t, with a total of 959t landed in 2010.
7) Management Plan: Management is at the Sub-area level. The 2011 EC TAC for *Nephrops* in subarea IIa and IV was 23,454t in EC waters with 1200t in Norwegian waters.

General comments

The stock annex was unavailable for this FU.

Discard data were not presented.

A recommended research section may be appropriate for this stock. With the assessment of this stock shifting to UWTV reliable length frequency data will be needed. Also, growth information is currently assumed based on Scottish *Nephrops*. Collection of stock specific growth information as well as updated female size at maturity information could be a research focus moving forward.

Conclusions

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 (Farn Deeps, FU6) nep-6

1) **Assessment type:** Update
2) **Assessment**: UWTV
3) **Forecast**: Short term forecast presented.
4) **Assessment model**: Stock abundance is absolute number estimated from TV surveys.
5) **Consistency**: The methodology for calculating abundance from UWTV surveys has changed from previous years to account for greater sampling in high density areas
6) **Stock status**: In 2010 total landings were 1443t, a substantial decrease from the 2009 value of 2,703t, and at around half of the 10 year average. The TV survey indicates that stock status has improved. The current estimated abundance of 892 million individuals is above the 2009 estimate of 759 million individuals and above the MSY Btrigger value of 802 million individuals. The current estimate of stock abundance is above 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.

General comments

There seem to be some uncertainties regarding directed effort for this stock. Current effort is well below the effort in the mid 1990's but several changes throughout the time series complicate this trend: Changes in legislation in 2006, as a shift to multi-rig fishing gear, and restrictions on both quota and effort for directed finfish. The RG agrees with the WG that "further research is needed to better define directed fishing effort and thereby improve the [LPUE] series."

There is really no explanation given for the sharp decline in landings from 2009 to 2010.

Technical comments

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.

There are signs that the stock remains vulnerable as the dominance of large females (2009/10) suggests mating was less successful which may lead to poor recruitment in 2011 and 2012.

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: analytical
3) Forecast: presented
4) Assessment model: Abundance estimates based on TV surveys.
5) Consistency: Last year assessment was accepted. New procedures implemented for raising the Scottish commercial data in 2010.
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. In 2010 total landings were 12,825t, a decrease of about 500t from the 2009 value of 13,327t. The current estimated abundance of 5,224 million individuals is slightly below the 2009 estimate of 5,457 million individuals and almost double the MSY Btrigger value of 2,767 million individuals. The current estimate of stock abundance is above MSY Btrigger and ICES Fmsy framework dictates that the recommended F should be the current Fmsy proxy (F0.1 = 10.3%).
7) Man. Plan.: No Biological Reference Points defined for this stock. F2011 < Fmsy=F0.1.Management is at the Subarea level. The 2011 EC TAC for *Nephrops* in subarea IIa and IV was 23,454t in EC waters with 1,200t in Norwegian waters.

General comments

The report says "Information on ecosystem aspects can now be found in the Stock Annex." The Stock Annex Ecosystem Aspects section says "No information on the ecosystem aspects of this stock has been collated by the Working Group." Where is the ecosystem information?

Page 52 under commercial catch and effort data: "Total international landings (…) in 2009" should be 2010. Next line down 12,6900 should read 12,689 or 12,690 as a rounded total.

Page 55 under historical stock trends: The current stock size is estimated to be 5,224 million individuals, not 5,200 million. Table 3.3.7 should read 3.3.3.7

Assessment procedure and the procedure to calculate the MSY reference points were not explained in the report. The rest of the section was a well documented, well ordered and considered section.

The assessment procedure was not document in the report or stock annex. In the main text it says that the assessment procedure was described in Section 3.1 of last year's WG report but exactly the same was said in 2010 WG report. And exactly the same in 2009 WG report. In 2008 WG report it said that the procedure was the same used in 2006 WGNSSK but the report was not available online, thus it was not possible to get information on the assessment procedure of this stock.

Technical comments

The table with the yield per recruit reference points in the main text is difficult to interpret because it is not explained the meaning of M, F and T in row and columns. I guess the meaning is male, female and total but their role in rows and columns cannot be derived from the text.

The 'Survey Index' column in short term forecast table in the main text has the same value for all the rows. It is assumed to represent the fixed Index of number upon which landings are estimated for different harvest ratios. A better explanation of the table is required.

Conclusions

The assessment has been performed correctly.

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**: Absolute abundance from Underwater TV survey

5 **Consistency**: New approach has been used for the 2009 assessment

6 **Stock status**: TV survey information and stable mean sizes in length of smaller individuals over a long period of time suggest there is not overexploitation. In 2010 total landings were 1,871t, a decrease of about 800t from the 2009 value of 2,662t. The current estimated abundance of 682 million individuals is below the 2009 estimate of 732 million individuals and more than double the MSY Btrigger value of 292 million individuals. The current estimate of stock abundance is above MSY Btrigger and ICES Fmsy framework dictates that the recommended F should be the current Fmsy proxy (Fmax= 16.3%).

7 **Man. Plan.**: Based on EC TAC for Subarea IIa and IV of 23,454t. There is no agreed management plan for this stock. No biological reference points have been defined.

General comments

The report says "Information on ecosystem aspects can now be found in the Stock Annex." The Stock Annex Ecosystem Aspects section says "No information on the ecosystem aspects of this stock has been collated by the Working Group." Where is the ecosystem information?

High relative density observed in the UWTV survey and a long time series of stable landings suggest a productive stock. For these reasons F_{max} was chosen as the F_{msy} proxy.

Mean weight in 2010 landings is above average. Landings are down by about 800t. Overall survey abundance down slightly from peak in 2008. Discards have remained high in this FU at between 0.25 and 0.35 in recent years. The harvest ratio declined from 0.26 to 0.18 in 2010. There is no estimate of recruits for this stock

Technical comments

The RG is still concerned about the occurrence of *Nephrops* just outside the boundaries of FU 8. It is a matter of accounting and the possibility of bias in the landings. Are the *Nephrops* captured in this area taken by the same fleet and if so where are they reported? If the small fishery landings off Arboath are reported for another FU all is well.

A number of F_{msy} proxies have been identified for this stock from per-recruit analysis. The reduced effort and landings decreased the harvest ratio from 0.26 in 2009 to 0.18 in 2010 which is above F_{max}.

Conclusions

The assessment has been performed correctly with the limited available data..

The RG agrees with the WG view of the stock status and notes the continued concerns and regarding the inherent problems of managing this FU as part of a wider North Sea TAC. We also agree with the 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**: UWTV
3) **Forecast**: Short term forecast presented.
4) **Assessment model**: Stock abundance is estimated from TV surveys.
5) **Consistency**: New procedures implemented for raising the Scottish commercial data in 2010
6) **Stock status**: TV survey information suggest the stock is stable but at a lower level then seen from 2003-2005. In 2010 total landings were 1,032t, a decrease of 35t from the 2009 value of 1,067t. The current estimated abundance of 406 million individuals is slightly below the 2009 estimate of 415 million individuals and noticeably higher than the MSY Btrigger value of 262 million individuals. The current estimate of stock abundance is above MSY Btrigger and ICES F_{msy} framework dictates that the recommended F should be the current F_{msy} proxy (F35%SpR(T) = 11.8%).
7) **Management Plan**: Management is at the Sub-area level. The 2011 EC TAC for *Nephrops* in Subarea IIa and IV was 23,454t in EC waters with 1,200t in Norwegian waters.

General comments

The report says "Information on ecosystem aspects can now be found in the Stock Annex." The Stock Annex Ecosystem Aspects section says "No information on the ecosystem aspects of this stock has been collated by the Working Group." Where is the ecosystem information?

Landings declined again from 2009 to 2010 by ~4% which is less drastic when compared to the decline of the previous three years (40%).

The recommended F_{msy} proxy is $F_{35\%SPR(T)}$ as historic landings have been near this harvest rate and are thought to be sustainable. The estimated harvest ratio (11%) is below the value at F_{msy} proxy (11.8%).

Discards in 2010 have increased from 2009 which could indicate a higher recruitment for this year.

Technical comments

Factors affecting the high values of LPUE related to the incomplete databases between Marine Scotland Science and Marine Scotland Compliance need to be resolved.

Page 72, top: "Harvest ratios for 2009 and 2010 have been around F_{max}." I believe this should read Harvest ratios for 2009 and 2010 have been around F_{msy} proxy. The current harvest ratio of 11% is below F_{msy} proxy (F35%SpR(T) = 11.8%) which is 3% lower than F_{max}(T) = 14.9%.

There was no real change in the length composition suggesting sustainability exploitation

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 (Noup, (FU 10) nep-10

1 **Assessment type:** **SALY**

2 **Assessment**: N/A

3 **Forecast**: N/A

4 **Assessment model**: Underwater TV absolute abundance

5 **Consistency**: Surveys are sporadic with last occurring in 2007

6 **Stock status**: Unknown. Advice provided in 2010 is considered valid for 2011 and 2012. No reliable estimate for this stock due to the lack of data.

7 **Man. Plan.**: There is no agreed management plan for this stock. Precautionary reference points have not been defined. .

General comments

There is very limited data for this FU and the fishery is small. Landings for 2010 were 38t, the lowest reported since reporting started (1997).

Technical comments

Conclusions

No advice requested, virtually no data available, and no assessment undertaken

Nephrops in Division IVa (Norwegian Deeps, (FU 32) nep-32

1. **Assessment type:** SALY
2. **Assessment**: N/A
3. **Forecast**: N/A
4. **Assessment model**: No Analytical assessment model. Single survey (Norwegian shrimp trawl survey) but catches too small to be useful.
5. **Consistency**:
6. **Stock status**: No change from last year. Current fishery appears to be sustainable based on limited information.
7. **Man. Plan.**: Fishery occurs in the Norwegian zone of North Sea and managed by separate quota (TAC). No reference points have been defined for this stock. .

General comments

This stock is data poor. 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.

Technical comments

There is little evidence of a noticeable change in size and maximum size appears constant.

Conclusions

The RG agrees with the WG conclusion that the level of exploitation on this stock is sustainable based on very limited data and that catches should remain at the present level.

Nephrops in Division IVb (Off Horn Reef, FU33)

1) Assessment type: SALY
2) Assessment: not presented
3) Forecast:not presented
4) Assessment model: -
5) Consistency: -
6) Stock status:-
7) Man. Plan.: -

General comments

This is a data poor stock and the information on the report is also poor.

Only on Danish LPUE, thus highly uncertain. There may be some technology creep. Large (~50%) catch by Netherlands in 2008

Technical comments

-

Conclusions

No advice requested and no analysis presented

Try to improve the data available in order to be able to get signals on stock development.

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**: Last yr assessment accepted.
6) **Stock status**: $B>B_{pa}$ in the last 2 years, increasing trend since 2005 when $B<B_{lim}$. F increasing trend since 2007 (F2007 = 0) but below long-term average. The assessment predicts a very low recruitment in 2010. SSB is expected to decrease in 2011 to a level around B_{pa} = MSY Btrigger. Stock classified as at full reproductive capacity with SSB well above B_{pa} at the start of 2010 (up to 1st July 2011). Also, the most recent estimates of SSB (Q1 2011) show full reproductive capacity of the stock (SSB> MSY $B_{trigger} = B_{pa}$).
7) **Man. Plan.**: There is no Management Plan in place but the advice is given based on 3 management strategies already analysed by ICES (ICES 2007/ACFM:30,39,40). The strategies:
   a. Fixed fishing mortality (F = 0.35)
   b. Fixed TAC (50 000 t)
   c. Variable TAC escapement strategy,

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.

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.

Conclusions

The assessment has been performed correctly.

Suggestions for future benchmarks:

Revise maturity, natural mortality and weight at age parameters.

Revise commercial fleet standardization.

Investigate the pattern in the residuals of IBTS 3rd quarter survey. From 2002 all the residuals are lower than 0.

Pollack in ICES sub area IV and Division IIIa Pol-nsea

1) **Assessment type:** Collate data for new stock
2) **Assessment**: trends in landings data
3) **Forecast**: na
4) **Assessment model**: na
5) **Consistency**: New Stock
6) **Stock status**: Unknown. Landings in 2009 (1551t) were lower than 2008 (2294t) and around 300t lower than the past ten year average landings (1859t).
7) **Management Plan**: na

General comments

Some useful information here, nicely summarized.

Pollack is considered primarily a by-catch in other fisheries.

Missing data on life history parameters and age samples.

Conclusions

Analytical assessment would need an area specific time-series of age data.

Section 15.2 is a bit lacking in fisheries information. This could be presented without an analysis of the landings data, if information were gathered on what type of gears, and fisheries were catching the species. There is also no information on whether there is any biological sampling for this species. The only information on which to conclude any advice is trends in landings, and there is an assumption that these reflect the stock abundance which therefore by proxy is inferred as stable, for the past 10 years. But there is no possibility to make an expert judgement on whether the stock is likely overfished or not. With minimal information like length frequency data (from the commercial fisheries) augmented with a growth curve and a knife edge maturity ogive (available form fishbase) with a selection ogive and an M value, a simple YPR could be constructed. If this were presented with some sensitivity analyses, along with eyeballing the LF under equilibrium exploitation (which you could do in NFS Toolbox), you could make an expert judgement on whether the stock is likely overexploited or not.

Annex 5 Benchmark Planning and Data Problems by Stock

Part A

Benchmarks planning WGNSSK

Section X Benchmarks

X.1 Latest benchmark results

Haddock

Saithe

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 for an interim period (see comments)	Inter-benchmark in Feb 2011	Not currently	Proposal to ACOM	Future proposals for internal use	Consider re-instating IBTS Q3. Consider expanding SAM model to model landings and discards separately.
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-5						
nep-6						
nep-7	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No	2013		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-8	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No	2013		Fuller exploration of other input data (landings, discards, raising procedures, etc)

nep-9	OK	2009 WKNEPH - only benchmarked the UWTV survey process	No	2013		Fuller exploration of other input data (landings, discards, raising procedures, etc)
nep-10	No assessment/no advice		no	2013		
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	no	no		
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						
nop-34	OK		Benchmark planned 2012, see below			
ple-eche	Assessment only accepted for trends	2010	No but suggestion for a plaice Study Group	suggestion for a plaice Study Group	Unresolved stock identity, discard time sery too short to be used in the assessment	
ple-kask	Assessment not accepted	Never been benchmarked	No but suggestion for a plaice Study Group	Yes /or suggestion for a plaice Study Group	Unresolved stock identity. Age-based model not fully appropriate. Tuning fleets have changed	

ple-nsea	OK	2010	No, but suggestion for a plaice Study Group	No	-	Changes in catchability for indices of recruitment may need to be addressed again in a future benchmark
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	-	-
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		
Benchmark	Year:2012	
Stock coordinator	Name: J. Rasmus Nielsen, DTU Aqua, DK	Email: rn@aqua.dtu.dk
Stock assessor	Name: Internal: Ewen Bell, CEFAS, UK Coby Needle, MARLAB, UK-Scotland External: Beatrix Morales, IEO Mallorca, Spain Jacques Massé, IFREMER, France	Email:
Data contact	Name: J. Rasmus Nielsen, DTU Aqua, DK	Email: rn@aqua.dtu.dk

Issue	Problem/Aim	Work needed / possible direction of solution	Data needed to be able to do this: are these available / where should these come from?	External expertise needed at benchmark
Tuning series	Not to be evaluated in coming benchmark			Who, what type of expertise
Discards	Not relevant			
Biological Parameters	The primary aim of the benchmark will be to consider and change the values of a number of biological parameters (maturity, growth, natural mortality) based on new biological information from some work mainly in 2007-2008 and summarized in 2 scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.	The work needed is to include results from evaluation of new biological parameters performed in 2007-2008 and summarized in 2 scientific publications (one already published, one on its way) and then include those in the assessment and perform exploratory and comparative assessment runs as well as discuss the output of the assessments and finally to revise management reference points.	The needed data are available and analysed in peer reviewed publications and manuscripts. There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. It will for the benchmarking be relevant to have up-dated natural mortality information from a updated MSVPA model / SMS model run.	Expertise on population dynamics for short lived fish species and stock assessment expertise
Ecosystem/mixed fisheries considerations				
Assessment method	**Not to be evaluated in coming benchmark**			
Forecast method				

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
Biological Reference Points	Will need to be re-evaluated given change of the biological parameters in the assessment	Evaluate and estimate revised reference points based on the new biological input parameters in the assessment (B-MSY-Escapement and Blim)	Output data from revised assessment	**Assessment expertise and expertise on population dynamics on short lived fish species.**

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.	National data submitters, PGCCDBS, DCF, WKPULSE?
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.	Norwegian delegation
Saithe in Subarea IV, VI and Division IIIa	Only a short recruitment index time series	Establish ASSRI as standard survey	Norwegian delegation
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	Norwegian delegation
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	Norwegian delegation, German, French, and Scottish delegates, 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	PGCCDBS, DTU-Aqua. Or possibility to extend IBTS or BTS to the Western Skagerrak?

Stock	Data Problem	How to be addressed in	By who
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, DTU-Aqua, IMARES, IMR, CEFAS, IFREMER
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, French, UK and Belgiam delegations.
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	*PGCCBDS and the French authorised persons responsible for the French Young Fish survey*
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.	Scottish delegation

Stock	Data Problem	How to be addressed in	By who
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.	Scottish delegation
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	Norwegian WGNSSK members
Nep 32	Lack of Norwegian CPUE data. Lack of Norwegian sampling of commercial catches	Norwegian CPUE data require further investigation. The sampling issue seems to be solved as the Norwegian Coast Guard from now on will measure CL of Nephrops, not TL	Norwegian delegation

Appendix 1: **POTENTIAL DATA DEFICIENCIES REGARDING NORTH SEA DEMERSAL STOCKS**

Prepared by Clara Ulrich and Ewen Bell, WGNSSK Chairs, 30/03/2011.

Working Document prepared to WKDDRAC2 (2011) and completed with the comments from the WKDDRAC North Sea Sub-Group

1. Benchmark stocks 2012

1.1 Norway Pout

Norway Pout is the only WGNSSK stock that is to be benchmarked in 2012. The primary aim of the NOP benchmark will be to change the values of a number of biological parameters (natural mortality, maturity, growth etc), based on some work mainly performed in 2007 and summarized in 2 scientific publications (one already published, one on its way). This would have implications for the overall perception of the stock, as well as reference points and management targets. But there will likely not be inclusion of any new data or new methods.

There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. However the life cycle of this species can cause dramatic changes in the assessment between first and second semester.

However, some detailed information on distribution of different life stages will be very welcome. For example indication on spawning sites and spawning periods (i.e. observations of fish with running roe); information/data on detailed distribution changes of different size groups on the Fladen Ground (outer bank, inner bank; 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 is it 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.

2 Stocks without a full forecast

2.1 Plaice in VIId

This stock was benchmarked during ICES WKFLAT 2010. There is no forecast provided because the precise status of the stock is unknown due to large migration patterns to - and from the Eastern English Channel. ICES WKFLAT 2010 recommended that 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 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.

However, these hypotheses are based on limited tagging experiments, and it would be necessary to monitor these migration patterns more comprehensively.

Routine discard monitoring has recently begun following the introduction of the EU data collection regulations. Discards data from 2008 are available from France and UK, although sampling levels are not high. The percentage discarded per period, métier and country is highly variable but is considered substantial. However, the time series of discards is currently too short to be used in analytical assessment.

2.2 Plaice in IIIa

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.

These issues cannot be easily addressed through a standard benchmarking procedure and would require large-scale improvement in both commercial and survey sampling design. The WG considers that analytical assessment is not appropriate until these issues are solved.

In 2010, new projects have been launched, aiming at 1) providing a detailed analysis of the Danish commercial data (landings and harbor samples) looking for potential improvements of the catch-at-age estimates (DTU Aqua and DFA), and 2) mapping the genetic differences between plaice populations from the North Sea to the Baltic (IMR Sweden). These projects are still ongoing, and the preliminary results will be presented to WGNSSK meeting in May.

2.3 *Nephrops* in FU 3, 4, 5, 32, 33

Stocks in FUs 3 & 4 have been subject to a TV survey in recent years which will hopefully be considered robust enough within the next year. The stock in FU 5 was surveyed for the first time in 2010. Stocks 32 and 33 do not have an underwater TV survey, nor is it anticipated that they will in the near future. All these stocks are currently reliant upon commercial data in conjunction with catch samples for length frequencies. Given the complex behavior of *Nephrops* with regards to their burrowing habits coupled to the seasonality of the fisheries and the potential for efficiency creep, the use of commercial LPUE data as a proxy for stock abundance is only used with caution. The careful analysis of individual log-book data, including information regarding gear type, may allow for the development of more robust “sentinel” data series.

There are specific issues for the FU 32 related to deficient Norwegian data, including a different measurement scheme in the samples (TL instead of CL), no discards data from the Norwegian fishery (since discarding is prohibited in Norwegian waters and no vessel may discard *Nephrops* with observers onboard), and very poor Norwegian logbook data.

Catch sampling for length frequency is generally considered adequate (note FU 5 is not particularly well sampled) although discard sampling rates are typically low (as with most species). Growth data are scant and calls for new growth studies are repeatedly made by *Nephrops* groups.

3 Stocks with forecast

3.1 North Sea Cod

North Sea cod has just been into a benchmark process, see WKCOD 2011 report. A great part of the benchmark has dealt with data issues, and the main findings were as follows:

- The system used for raising Scottish sampled discard rates to fleet discard rates is currently under revision and improvement at Marine Scotland-Science (MSS).
- According to Marine Scotland-Compliance, the Scottish government department responsible for monitoring the Scottish fishing industry, detected and suspected unreported or otherwise illegal fish landings (known as "blackfish") has dropped has dropped as to be negligible (although not quite zero) and that trend has been consistent. While it has had an effect, it would be an oversimplification to suggest that the UK Registration of Buyers and Sellers (RBS) regulation was solely responsible for this behavioural change in the Scottish fleet. Other potential driving factors are 1) Two large-scale decommissioning schemes targeted on whitefish vessels run by Scottish Government, which between them removed over half of the demersal fleet, 2) The development of targeting and monitoring systems that has significantly increased the pressure on the fleet. WKCOD concluded that the incidence of underreporting in the landings in the Scottish fleet fishing for cod has declined significantly since 2003 and is likely to be extremely low since 2006.
- One of the biggest issues with misreporting is the so-called French line where catch composition rules mean that some species are misreported on either side of the line. That does affect overall catch stats of course but does undermine other aspects of fisheries management. The problem of misreporting persists but it is small compared with what existed before. It does occur for particular reasons such as monk and hake in the North Sea and various species in the Faroese zone but is considered to be neg-ligible for cod and haddock.
- On the Danish side, based on 6 different indicators, the Directorate of Fisheries does not estimate that there is placing on market of illegal fish on a big scale. Furthermore, Danish Fisheries Directorate has calculated the difference between the total quantity of cod registered in the logbooks and the cod registered in sales receipts for Danish vessels over ten meters per quarter over the period 2008–2010. It is demonstrated, that the difference (i.e. the misjudgement) varies between approx. 0.5% and 2.5%. The Danish Fisheries Directorate is therefore of the opinion, that there is no indication of lack of reporting of cod of any significance for vessels of ten meters and up.
- The size composition of landed cod from Danish trips with and without an observer on board was compared to investigate potential observer effects on discard estimates (e.g. less discard with an observer on board). However, it could not be concluded that the present discard estimates are biased.
- The conflict in the IBTS quarter 1 vs. quarter 3 surveys, an issue raised by the WGNSSK in 2010, was not fully resolved. The abundance indices in the quarter 1 survey were considered to more likely reflect stock trends in re-

cent years, because of suspected changes in catchability in the quarter 3 survey in relation to recent changes in the spatial distribution of fish in the latter part of the year. After deep considerations, it was agreed to use only the quarter 1 survey in the assessment for the time being.

Conclusions

WKCOD conclusions were that landings data are largely more reliable now than back in the past. A main source of uncertainty remains though within the amount of highgrading, which could bias the discards estimates. However, the benchmark assessment seems more robust than the WGNSSK 2010 assessment, which should allow ICES to give advice on the stock in 2011.

3.2 North Sea Haddock

The assessment is considered of high quality, and no major data deficiencies have been pointed out. North Sea haddock has just been benchmarked (ICES-WKBENCH 2011). No new catch or landings data were presented; neither were there any new survey CPUE tuning data.

Commercial CPUE tuning data have not been used in the assessment of North Sea haddock for several years, due to problems with reporting systems (see ICES-WGNSSK 2001). However, fishing-industry data from VMS and CCTV programs are available, and are being extensively used in evaluations of management strategies and systems. Work is also proceeding on ways to use these data more directly in stock assessments, as well as developments in estimates of natural mortality, maturity, and reproductive potential. It is intended that the use of these new estimates in management advice will be investigated closely during 2011.

3.3 North Sea Whiting

The current assessment is formally classified as an update assessment. A benchmark was held for this stock in January 2009. The conclusions from the benchmark were that the assessment was consistent since 1995 and offers a reliable basis for determining stock status, including estimation of current stock size and fishing mortality.

Main issues raised for whiting deal with spatial distribution and uncertain discards estimates.

- 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 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.
- However, scientific discards estimates point out that discards have decreased and are now the lowest in the series.
- Given the spatial structure of the whiting stock and of the fleets exploiting it, it is therefore 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. Discard information was supplied by France for 2003 – 2007 but was not supplied for 2008 or 2009.

- Survey information for VIId was not available in a form that could be used by the working group. 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.

3.4 North Sea saithe

Just missing to do...

3.5 North Sea flatfish

These stocks are treated together here as they are largely accounted for together with regards to data collection, due to the large predominance of the Dutch beam trawl fishery.

3.5.1 Sole

The stock has been benchmarked last year (WKFLAT 2010). There are no major data deficiencies regarding landings data. Overall, the samples are thought to be representative of around 85 % of the total landings in 2009. There are though some potential issues related to changes in sex ratio in the largest market sampling categories, which are much more female biased than they had been in the past. Explanations for this observation (sampling bias versus real biological effects) should be explored in detail.

The data available had too few immature individuals for a reliable estimate of long term trend in the proportion of mature fish in the population. Small individual sole sampled during the Belgian, German, Dutch, and British discarding programs (Quarter 1) should be sexed and staged so that a reliable time series can be constructed.

3.5.2 Plaice

This stock was benchmarked in 2009 (WKFLAT 2009). The assessment is considered to be highly uncertain most importantly because the different survey tuning series in different areas of the North Sea indicate different trends in the most recent development of the stock. This uncertainty is compounded by a relatively strong retrospective pattern, where this years' assessment result estimates higher SSBs and lower fishing mortalities for the most recent years. However, this retrospective pattern has been decreasing in recent years.

There is no major data deficiencies associated with commercial landings.

The discards time series used in the assessment was derived from Dutch, Danish, German and UK discards observations for 2000–2009. However, total sampling effort of the discards remains low, and data is sparse. Also, samples may not always be available from relevant fleets and fisheries within a country.

The Dutch discards data for 2009 were derived from a combination of the observer program that has been running since 2000, and a new self-sampling program. The estimates from both programs were combined to come up with an overall estimate of discarding by the Dutch beam trawl fleet.

Commercial LPUE series (consisting of an effort series and landings-at-age series) that can be used as tuning fleets are 1) The Dutch beam trawl fleet and 2) The UK beam trawl fleet excluding all flag vessels.

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 by area and fleet component, can be used as indication of stock development. In the benchmark assessment, first attempts were made to include the LPUE into the stock assessment. However, because other factors besides the spatial changes in fishing effort likely affect the catchability for plaice, the WKFLAT 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. This series has not been updated for 2009 due to discrepancies in the effort data for 2009.

3.5.3 Combined Dutch approach

There are several data issues with respect to NS plaice and sole that are already being dealt with together between IMARES and stakeholders in the Netherlands. There are stakeholders on board of research surveys, and the possibility of setting up a combined IMARES/industry survey for some of the flatfish species are being investigated (sole, plaice, but also turbot and brill). Further, comparisons of CPUE data to assessment input and output are being undertaken

The task force could potentially focus on is to collect data on those species that are poorly covered by the current surveys, or in periods of the year where there is no survey coverage. But that would imply careful planning with IMARES with regards to such additional data collection and analysis.

3.6 Sole in VIId

This stock was benchmarked in 2009.

There are no particular data deficiencies associated with the commercial data for this stock. Samples by country and quarter cover 100% of the landings.

Information available on discards for 2009 suggest, as in previous years, that discards are not substantial and therefore discards are not incorporated in the assessment. Discard information from French otter trawls suggest however that some discarding of 1 year old sole is taking place in the first two 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 main data issue for this stock relates to the fact that the UK component of the YFS index stopped in 2007, resulting in the unavailability of the combined YFS-index over the past few years. This combined index had previously estimated the incoming year class strength very consistently, hereby providing reliable estimates to the forecasts. Although results of using the YFS indices separately (YFS-FR for 1987-present and YFS-UK for 1987-2006), did not show apparent changes in retrospective patterns, it was noted that the lack of information from the UK YFS affects significantly the quality of the recruitment estimates and therefore the forecast.

Alternatively, a French commercial CPUE index could be useful.

3.7 *Nephrops* in FU 6 to 10

These stocks have time series of underwater TV surveys and are considered to be relatively robust assessments.

The models used in determining sustainable harvest rates are reliant upon growth parameters which are historic and not necessarily determined at the correct spatial scale. Calls for new growth studies are repeatedly made by *Nephrops* groups, however these are difficult and expensive to perform on crustaceans.

Length frequency data are generally considered to be good for the catches, discard sampling rates are typically quite low (as with other species).

With regards to consideration of industry-based data, same comments as for North Sea haddock are relevant here.

4. Stocks for which there is no advice (Category 11 stocks)

A number of commercially important species are not assessed by ICES, and no advice is therefore given. Under annual TAC negotiations, these stocks are therefore considered under the Category 11 of the EC Consultation on Fishing Opportunities ("Policy Paper"), which states that TAC should be adjusted towards recent real catches and that there should be no increase in fishing effort. In practice, this implies that the TAC can only be stable or decreasing, but can never increase.

There is therefore a clear desire from the industry side to improve the knowledge base for these stocks and allow some scientific advice to be given.

A number of these stocks were included in the previous MoU between ICES and the EC – and are being considered within the WGNEW assessment group. WGNEW has collected all existing data directly available within national labs but has been largely unable to complete analyses due to time constraint. Processing and analyzing old data is very time-demanding, and it is not a simple task to integrate sporadic and incomplete data sets into a standard stock assessment framework. Running a stock assessment on these new stocks requires therefore much time and also particular skills in stock assessment to implement non-standard assessment models. What is limiting now is therefore time for analysis and assessment rather than additional data collection.

According to Henk Heessen (former chair of WGNEW), the stocks for which an assessment could be further developed with the current data available are brill, turbot, lemon sole, dab, witch flounder and sea bass. The Task force discussed the possibilities for requiring and funding additional scientific work on these species.

A number of new species have been added in the 2011 MoU, and similar processes will have to be conducted on these. For the North Sea, this involves mainly Pollack, which will be looked at by WGNSSK in May 2011 for the first time.

5 Conclusions

Primary conclusion from the task force group. The main issue is lack of data analysis for category 11 stocks. It is important to first encourage further work for providing preliminary assessment with the data already existing, than to collect more data for the time being. On the basis of a preliminary assessment, recommendations for further data needs could be issued at a later stage. Lack of scientists' time seems to be the main issue, rather than funding itself.

On this basis the group sees no immediate need for establishing a permanent task force addressing data deficiencies in the North Sea. This doesn't exclude close cooperation between industry and scientists at a national level. The group recommends to pursue/extent the national data meetings that are already often taking place before assessment working groups meetings.

With regards to stocks currently assessed by WGNSSK :

The conclusions from this round are that to a large extent, North Sea demersal stock assessments do not suffer from very deficient data. Most stocks have a fairly sound basis for assessment, and for those which don't, the issues seem more related to biological uncertainty with regards to e.g. migration and growth, than to obvious deficiencies in commercial data.

Misreporting is being monitored to a higher extent, both by scientists and public authorities using VMS, and black landings are now considered of much less importance than in the past.

Indications about highgrading and discarding practices are still necessary and could be an obvious contribution of the task force.

The adequacy between biological sampling and commercial landings needs more careful monitoring, and we believe that some work is ongoing on this topic within national labs under the direction of PGCCDBS.

It is important that there is increased collaboration between scientists and public authorities to have ongoing monitoring of where the fishery is, so that the sampling program can be adapted. An example for this is the online access to VMS data granted to Danish scientists, which allows them to improve the spatial distribution of harbour sampling.

On a more general issue, the STECF SGMOS group on effort management and the ICES WGMIXFISH group noticed a number of discrepancies (not specifically related to the North Sea but across all regions) between the landings data used for the stock assessment and the landings data provided to STECF, and the difference can sometimes be very large. The task force could also work towards greater consistency and transparency between the various bodies providing data, so that no doubt can be left on the actual landings. Potential differences should be explained.

There are a number of initiatives going on to develop more robust commercial tuning indices. It could be discussed whether such approaches could be generalised to other stocks and be better integrated in assessment. Reference or sentinel fleets and industry surveys could also be considered; however, the issue of large spatial coverage over the whole stock distribution will always be an issue.

Finally, we encourage some methodological developments that could help integrating the annual Fishers Survey into a global quantitative index that could be potentially used in the assessment.

Annex 06 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	
As in 2009, the WGNSSK expressed major concerns that the current duration of the WG doesn't leave much room for additional ToRs. The WG members are keen in discussing new and relevant issues, and have certainly much knowledge to share. However, the new "last minute"ToRs added to the group this year again doesn't help progressing on the scientific issues they raise, because there is just not enough time for these. Experience shows that "update assessments" are not just "press-button" updates, there is an incompressible time needed for discussing new knowledge and regulations, reviewing data, running forecasts and writing texts and advice sheets, and with a large number of stocks (plus the new MoU stocks) to review, there is little time left for other investigations. There is a certain frustration in the WG for not being able to properly address the new ToRs. The WG recommends thus again that the amount of work required is better matched with the duration of the WG (and vice-versa)	ACOM, ICES Secretariat.
The assessment update procedure in October 2010 was fraught with timing difficulties induced by changes to IBTS indices, resulting in a delay of about a week in the delivery of Annex 02. These delays allowed the Sole Net Survey (SNS) to be finalised and incorporated into the Sole update forecast for the first time. The inclusion of this series had a significant impact upon the TAC forecast and is considered to have improved the robustness. WGNSSK 2011 therefore recommends that the deadline for updated forecasts in future years is postponed to the mid-October (14 October in 2011), to allow the IBTS index to be quality controlled before its release and also permit the SNS index to be finalised and incorporated.	ACOM, ICES Secretariat
A large number of WGNSSK Members are involved in the organisation of the 2012 World Fisheries Congress, which will take place in Edinburgh 7-11 May, as the same dates as the WGNSSK usually meets. WGNSSK wishes therefore to meet a week earlier than usual (27 april to 03 May 2012). However, this requires extra commitments from the National data Submitters, with a particular priority on providing IBTS data early enough to enable the indices to be ready on time.	ACOM, ICES secretariat, ICES Data Centre, National Data Submitters, WGIBTS
II. RECOMMENDATIONS DEALING WITH COMMERCIAL DATA	
As last year, the WG still feels that there are large gaps between the data collections programs and the metier-based sampling discussed in DCF and RCM in the one hand, and the way this is used for raising catch data for WGNSSK in the other hand (for both landings and discards). There is still unsufficient knowledge in the WG on how the data are raised before being provided to stock coordinators. Unsampled strata are still raised using age	PGCCDBS, RCM North Sea, WGMIXFISH, WGNSSK National Data Submitters, ICES Data Centre

distributions from other countries without any considerations of the metier used. The WG strongly recommends better communication between the various data forums in order to consider whether these current raising procedures are still appropriate, and whether metier-based age information could be provided. In particular, the WG recommends that these issues are addressed during the first days of WGMIXFISH (30 August), and recommends therefore that data submitters (landings and discards) from North Sea countries attend this workshop.	
Although it has increased, the use of InterCatch as a standard tool for collecting and raising catch data is still unsufficient. As part of the issue, the WGNSSK observes that many data submitters still do not submit their data directly into InterCatch, but rather send them to stock coordinators. WGNSSK requires that in the future, all national data are submitted to InterCatch in due time prior to the meeting.	National Data Submitters, ICES Data Centre
However, the WGNSSK has experienced significant design issues in InterCatch, concerning correction of erroneous data. Obviously, correction of previous data can only be done manually for each number, but a direct upload of a new file is not possible. The WGNSSK doesn't consider this a good database practice, and considers that file resubmission should absolutely be enabled, together with a proper version control. This is particularly important if countries start now providing data by regional metier standardised across stocks. Experience elsewhere indicates with certainty that mistakes occur and corrections are often required with such type of information.	ICES Data Centre
The WGNSSK experienced that the EC Data Tables were prone to differences in interpretations and lacked clear guidances on how to fill them. The categories proposed do often not reflect some common situations in data delivery. In particular, there should be a distinct category if a country has some minor stakes in a fishery and may therefore not be entitled to collect samples. The WG recommends then to to add a category E- no sampling due to minor landings in the fishery, and suggest also to split the category B – Relevant but not available to ICES into two sub-categories : B1=data available but not provided to ICES, B2= data relevant but not collected. Recommendations to revisit the data tables by correspondence before they are submitted to EC.	ICES Secretariat, EC
III. RECOMMENDATIONS DEALING WITH SURVEYS DATA	
WGNSSK has again experienced significant delays and issues regarding IBTS indices delivered from DATRAS. This year, these were 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 allowing information on which data changes have been submitted and why	ICES data Centre, National Data Submitters, WGIBTS
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, WKCOD recommended the establishement of a Working Group on improving the use of survey data for assessment and advice, that would look at such issues. The 2011 WGNSSK supports entirely this suggestion and recommends therefore that this group is established	WGIBTS, ICES secretariat, ACOM

In 2010, the WGNSSK recommended that the UK beam trawl and Belgian survey indices for sole and plaice should be published by WGBEAM, whose members should discuss them in the context of patterns and differences observed in the Dutch BTS (ISIS and Tridens) and SNS data. Large spatial changes in the distribution of plaice in the North Sea have occurred, viz. the migration of juvenile plaice out of the Plaice Box. WGBEAM should investigate spatial changes in the distribution of sole. These observations are still entirely valid in 2011, and therefore the WGNSSK reiterates its recommendation and hope to get more consistent Beam Trawl Surveys indices in the future.	WGBEAM
IV. RECOMMENDATIONS DEALING WITH WGNSSK CONTENT AND ToRS	
The provisional Fmsy reference points proposed last year have been reviewed, and there is now agreement on these for a number of stocks. However, there has been in most cases little operational progresses achieved on the estimation of MSY Btrigger, neither during WKFRAME 2 nor during WGNSSK. As last year, the WG still considers that the basis for chosing Bpa is inconsistent with the general MSY framework and recommends that further scientific discussions are undertaken for providing more consistent estimates.	ACOM
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. 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
As a new ToRs, the WGNSSK was asked to comment on the Strategic Initiatives on Marine Strategy and Marine Spatial Planning. The WG recommends increased collaboration between among others WGNSSK, WGMIXFISH, WGSAM, WGINOSE, SGIMM and WGECO to create synergies to best address the new ToRs and avoid duplicate work. The WGNSSK has also reviewed the possibility of including spatially resolved data on a more routine and integrated basis. The WG was aware of many initiatives, but not of any regular mapping of e.g. landings distribution by metier at the scale of the whole North Sea International data. In the case that such regular mapping cannot be found, and in the case of the establishement of the DCF Regional DataBases would be delayed beyond 2012, the WG suggests that the WGMIXFISH could be an appropriate temporary group for providing such maps. The WGNSSK recommends that this issue is discussed during the WGMIXFISH data workshop on 30th August 2011..	ACOM, ICES Secretariat, WGMIXFISH, WGSAM, WGINOSE, SGIMM, WGECO, STECF
There is a persistent issue in the definition and the estimation of the plaice stocks, since large-scale mixing occurs between the continuum of plaice stock units ranging from the English	ACOM, ICES secretariat, SIMWG

Channel (VIIe) to the Kattegat (IIIa). WKFLAT 2010 recommended that further investigations are done towards combined-areas assessment and management. As last year, WGNSSK endorses this recommendation, and have investigated the issues further during its 2011 meeting. WGNSSK requests the implementation of a dedicated Study Group similar to the SGHERWAY. The WG suggests that this meeting could take place 28 February to 01 March 2012 with the following ToRs : a) Provide an overview of the distribution and linkages between the various plaice populations b) explore the possibilities for combined assessments of some stocks and investigate their utility for advisory purposes; c) evaluate alternative management strategies for the combined populations maintaining each spawning component in a healthy state	

Annex 7 – Technical Minutes of the Sandeel Review Group

Review of ICES **Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, section Sandeel Assessment, Report 2011**

Dates:	4 - 10 May 2011
Reviewers:	Beatriz Roel (Cefas), Ellen Kenchington (DFO)
Chair WG:	Clara Ulrich, Denmark and Ewen Bell, UK
Secretariat:	Professional Secretary: Barbara Schoute
Secretary:	Diane Lindemann (diane@ices.dk)

General

The shift from a North Sea assessment to providing assessments at the area level is an improvement but in agreement with the 2010 review a full comparison between SMS-effort and SXSA still needs to be carried out.

The model assumes a linear relationship between F and fishing effort and this is providing stability to the assessment. Separable periods are assumed but no justification for the choice of periods is provided. Further, it is not clear from the stock annex how the "F, season effect" and the "F, age effects" or age catchability, are estimated.

References to the Stock Annex were appropriate but (initially) the Stock Annex was nowhere to be found. The data were used as specified in the Stock Annex. Generally, assessments and forecasts were conducted according to the Stock Annex.

There are small errors in the report (the text listed below is the correct one):

Figure 4.1.2, Management Areas should be shown overtop of ICES triangles

Section 4.1.5, Total landings in 2010 are not reported in the Annex and graphs there need to be updated?

Section 4.2.10, Short-term forecast (Area-1) it is 2011 TAC;

Section 4.3.5, tuning series, 2nd line: survey in area 2 was initiated in 2010.

Section 4.4.10, input, 1st line: is given in Table 4.4.10.

Figure 4.2.8 (caption). The assessment provides an estimate of 2010 recruitment (age 0 in 2010) why is it a random number?

NOTE that the neither the assessment nor the forecasts were carried out by this review.`

The Review Group considered the following stocks:

- Sandeel in IV: by area (Area-1 to Area-7).

And the following special requests:

- n/a

Sandeel in IV (WGNSSK Feb 2011))

The total sandeel stock is divided in several sub-populations. The North Sea is divided into seven sandeel assessment areas. Analytical assessments were only carried out for Areas -1 to 3.

Sandeel in Area-1

The SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2010. In the SMS model it is assumed that fishing mortality is proportional to fishing effort.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **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). Historic retrospective to assess consistency between this year's assessment and 2010 not presented.
6) **Stock status**: B>Bpa, there are no F reference points for this stock, estimated recruitment in 2010 is the second lowest in the time series.
7) **Man. Plan.**: There is no agreed Management Plan for this stock.

General comments

This section is clearly documented, references to figures and tables are appropriate.

Technical comments

The fit to the catch-at-age data is poor as noted in the report with clusters of negative and positive residuals. The residuals from the fit to the dredge survey also show some patterns and some of the residuals are quite large particularly for age 1. Given that the time-series is short at the very least we can say that the survey is probably very noisy. Plots of the observed and model predicted for both the catch-at-age and survey time-series would help to visualize how the model is fitting the data.

For the parameterization of F, the stock annex considers separable periods 1983-98 and 1999-2009 while this year's assessment uses 1983-88, 1989-98 and 1999-2010, reasons for the change should be provided.

Conclusions

The assessment and the short-term forecast appear to have been performed correctly. The assessment provides a sound basis for advice.

Sandeel in Area-2

The SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2010. The dredge survey in Area-2 is too short for assessment purposes. The catch rate indices of age group 0 from the dredge survey in Area-1 were used to calibrate the assessment of Area-2.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **Forecast**: presented

4) **Assessment model**: SMS-effort, dredge survey in area-1 used to tune the assessment.
5) **Consistency**: The assessment model is based on a recent benchmark (WKSAN, 2010). Historic retrospective to assess consistency between this year's assessment and 2010 not presented.
6) **Stock status**: $B>B_{pa}$, there are no F reference points for this stock, estimated recruitment in 2010 is around one quarter of the long term mean.
7) **Man. Plan.**: There is no agreed Management Plan for this stock.

General comments

This section is clearly documented and references to figures and tables are appropriate.

Technical comments

The residuals from the dredge survey are moderate and showing no patterns. However, the fit to the catch-at-age show very large residuals as well as clusters of negative and positive residuals particularly for season 2 suggesting violation of the separability assumptions. This could be biasing model estimates of SSB.

Uncertainty in SSB as reflected by the 95% confidence intervals is large in the most recent year and the lower interval is just above B_{lim}. This should be taken into account in the advice.

Sandeel in Area-3

The SMS-effort model was used to estimate fishing mortalities and stock numbers at age by half year, using data from 1983 to 2010. The dredge survey in Area-3 was used to calibrate the assessment. However, the survey only covers the southern part of area 3, implications for the assessment are not discussed.

1) **Assessment type:** update
2) **Assessment**: analytical
3) **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). Historic retrospective to assess consistency between this year's assessment and 2010 not presented.
6) **Stock status**: $B > B_{pa}$; no F reference points defined. Recruitment below the long term mean
7) **Man. Plan**: There is no agreed Management Plan for this stock.

General comments

This section is clearly documented and references to figures and tables are appropriate.

Technical comments

Reference to figure 4.4.4 related to internal consistency by age of the dredge survey is not clear, as R^2 is relatively similar for both regressions presented. The solid symbols may correspond to the most recent survey but that should be stated in the caption.

Showing both ages in the same plot makes visualization of the individual relationships difficult.

Very poor fit to the catch-at-age data with clusters of negative and positive residuals, separability assumptions seem violated. The CV corresponding to the dredge survey is very high for age 1 which suggests that the dredge survey may not be a good predictor of the incoming year class. The indication of the WG to continue using in-season monitoring in this area seems appropriate.

The confidence intervals about the recent SSB are very wide and include B_{lim}; the short-term forecast show that SSB in 2012 will be substantially below Bmsy trigger even in the case of zero catch.

Sandeel in Area-4

1) **Assessment type:** update
2) **Assessment**: effort and cpue trends presented; abundance indices by age group from dredge surveys. Robust estimates of the incoming year class not available.
3) **Forecast**: not presented
4) **Assessment model**: not carried out.
5) **Consistency**: not applicable
6) **Stock status:** unknown. The 2009 year class seemed strong but 2010 year class seems low (based on dredge survey cpue).
7) **Man. Plan**: There is no agreed Management Plan for this stock.

Dredge hauls covering the major sandeel banks were taken in 1999-2003 and 2008-2010. Sample sizes were low. A dedicated recruit survey was put in place in 2008 but data analysis has shown that the gear is unsuitable for estimating absolute numbers of 0-group. However, the regression of catch rates of age 0 and subsequent age 1 suggests consistency but the time-series is still too short for the results to be used for management.

The TAC advice of 5 to 10 thousand tonnes for area-4 seems much too high compared to recent ICES landings (Table 6.4.21.4.1).

Annex 8 – Technical Minutes of the North Sea ecosystem Review Group

Review of ICES **WGNSSK Report 2011 – November**

Reviewers:	Einar Hjörleifson (Iceland, chair)
	Dorleta Garcia (Spain)
Chair WG:	Ewen Bell and Clara Ulrich Rescan
Secretariat:	Barbara Schoute

General

The Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) ran the AGCREFA 2008 protocol to check for changes due to summer survey results. For Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI (West of Scotland and Rockall) it was concluded that the results merited reopening of the June advice.

The reviewers were notified at an early stage by the secretariat that some of the issues raised by the WGNNSK during what was supposed to be a simple prediction update may require some extraordinary work on behalf of the reviewer and the ADG group. The reviewers accepted the challenge and the documentation provided here is a reflection of the anticipation. The chronological order of this documentation follows to a large extent the chronological order of the process that took place during the review/advice process.

The three WGNSSK documents provided to the reviewers were (hereafter referred to as Document 1, 2 and 3):

http://groupnet.ices.dk/WGNSSK2011/Report%202011/Final%20Formatted%20Report/Annex%2002%20Update%20forecasts%20and%20assessments.doc

http://groupnet.ices.dk/WGNSSK2011/Report%202011/Draft%20Report/Annex%2002%20Update%20forecasts%20and%20assessments/Alternative%20assessment.docx

http://groupnet.ices.dk/WGNSSK2011/Report%202011/Draft%20Report/Annex%2002%20Update%20forecasts%20and%20assessments/Saithe%20assessment.docx

- Document 1 deals with RCT3 updates using the 2011 surveys.
- Document 2 deals with assessment and advice if the pre-benchmark settings were reinstated.
- Document 3 deals with detailed analysis of the current input data with some very productive suggestions with regards to the way forward.

In addition the reviewer visited the following documents:

http://www.ices.dk/reports/ACOM/2008/AGCREFA/AGCREFA_2008.pdf

http://www.ices.dk/reports/ACOM/2011/WKBENCH%202011/WKBENCH_2011.pdf

As a general comment is noted that no syntheses of the three numerated Documents were provided to the reviewers and they were as such be treated as separate entity. Document 1 and/or 2 lacked a comprehensible table of the 2011 survey results (single table, all years and ages). Document 2 lacked in the beginning of the review process a detail diagnostic, F and N output table of the assessment results as well as input table for the predictions. This was however promptly made available during the review process.

The fall update based on AGCREFA procedure

The reviewers concur that the 2011 surveys measurements merit a reopening of the June advice. However the following points with regards to the protocol specified in AGCREFA 2008 that were followed in Document 1 were noted:

1) The last two paragraphs in section 3 of the AGCREFA report state: "A key source of uncertainty in fisheries management advice is the size of recruiting year classes. It is common for the size of recruiting year classes to be assumed based on the size of previous year classes. As indicated in Table 1, summer surveys usually provide information (often the first information) that is relevant to the size of recruiting year classes. Therefore, the Group decided that the protocol for reopening advice should be based on the reliable new information on the size of recruiting year classes.

   The Group rejected the option of reopening advice based on an unexpected summer survey catch of year classes that were already recruited by 2008. Fisheries information and previous survey data on these year classes was available when spring advice was prepared. A summer survey that indicates that the size of recruited year classes is significantly different than had been expected usually means that there are inconsistencies in information. Resolving inconsistencies requires a more comprehensive and deliberate process than is practical in the time available. Typically, it requires waiting for the next survey to decide between conflicting sources of information."

2) The practical examples for ns Plaice and Sole provided in section 4 of the AGCREFA are not only dealing with recruiting age classes but also update of age classes "year classes that were already recruited".

Hence the framework (section 3) and the practical examples provided (section 4) within the AGCREFA report are contradictory.

It is the understanding of the reviewers that if section 3 of the AGCREFA were to be followed to the letter, only age 3 in 2011 (2008 year class) should have been considered. And as stated in Document 1, the 2011 survey measurements for that age do not merit any updates from the GM assumption made this spring. Given this understanding there would be no basis for opening the spring advice.

However by following the procedures suggested in section 4, i.e. by only updating the population numbers of age classes that already have recruited into the fishery in the assessment year (e.g. age 4 in 2011 as is the case for nsSaithe) results in that there is no longer a correspondence between the population numbers at younger age (age 3 in 2010 in the case for the nsSaithe), the fishing mortality (age 3 in 2010 in the case of the nsSaithe) and the actually observed catches already taken (age 3 in 2010 in the case of the nsSaithe). Given that the assessment is a VPA type, where catches are always treated without error, the stock estimates and the fishing mortality of the cohorts adjusted via an RCT3 procedure need at minimum to be updated back in time. In the case of the nsSaithe, the increase in the estimates of the 4 year olds based on the update procedure should result in higher recruitment estimates (via the analogy provided by Pope, were only M and C matters once the terminal N is "established") and hence lower F at age 3 (via the stock equation). These lower F estimates would then be taken forward in the prediction, given the nsSaithe setting.

Additionally the AGCREFA procedures as exemplified in section 4 does invite more than just updating only the 2 youngest age groups using the RCT3 procedure.

The reviewers had to grapple with the following questions:

- If the two last paragraph of section 3 in the AGCREFA are taken to the letter, the conclusion of the EG that an update is warranted is wrong. Because the update should only be applied to the recruiting year classes (age 3 in 2011).
- If the examples of nsPlaice and nsSole in section 4 in the AGCREFA are to be taken as the actual understanding of AGCREFA thinking back in 2008, then the upgrade of the 2007 year class as provided by the EG on the nsSaithe (Document 1) is according to protocol. But then one is left with that no protocol is provided with regards to solving the discrepancy that this creates with regards to N, F vs C back in time for the 2007 cohort.

Those minor details aside, the statistical basis (null hypothesis) taken by the AGCREFA with regards to criterion for opening up the advice can be questioned. The basis taken is that fisheries stock assessment is statistically analogous to a common garden experiment. I.e. where one confronts the alternative (is not GM) against a null hypothesis (is GM). Statistically speaking fisheries stock assessment falls under nothing but a common garden experiment. The base for reopening advice should hence be more akin to the likelihood. If that approach were to be adopted by ICES in the fall update procedure, all input new input data should be included.

Conclusion: For the specific case of saithe, the EG has carried out the work according to the specified protocol. The implication for the advice (which is based on the HCR), is that instead of requiring more than 15% reduction in TAC as was the result in the spring, no more than a 15% TAC reduction is needed.

Analysis of the recent survey signal

The contribution of the author of Document 3 was much appreciated. This was the only document that included all presently available information (measurements) and analyses in a single cohesive framework. An analysis on the survey indices showed that the signal in survey data seem to have changed from giving a prevalent cohort signal in the past towards being dominated by year effect in the last 3-4 years. No forecast was provided in document 3, but that is understandable given that the primary drive of the document was related to detecting and describing problems in the current modelling framework, not to be used necessarily as the basis for the fall 2011 advice.

The Benchmark 2011 did not have the most recent survey indices available at the time of the meeting (Table 6.2.3.1 in the report were the time series considered at the time of the meeting were: NORACU 1995-2008 IBTSq3 YFS 2006-2010. The issue raised in Document 3, which indicate that the marked year effect in the survey are a recent phenomena, may hence be not very apparent over the data time frame considered by the Benchmark 2011. In addition it shows that the marked negative year effect observed in some of the 2010 surveys is followed by a marked positive 2011 year effect in those same surveys.

The hypothesis in the Benchmark 2011 that there may be hyperstability in the commercial tuning indices is not supported by any rigorous analysis. E.g. by provision of a simple plot of the VPA estimates over the time period where convergence has occurred vs the cpue indices. Such a plot would of course only be valid for the period where the catch at age takes over any tuning signals (cumulative Z being around 1) but does not address potential recent hypothesis of fisheries developments.

In addition, the Benchmark 2011 explicitly recognized that the by increasing the influence of the survey indices in the assessment setup would result in increasing uncertainty in the assessment (overriding a potential cost of bias). This acknowledgment did however not materialize in any revaluation of the reference points. Finally, it is of interest to note that the Benchmark 2011 did not look at all into the established fall update procedure (which is supposed to be the primary focus of this document).

In general it seems that in the Benchmarks processes the emphasis is largely confined to analysis of the input values and performance testing of the historical assessment period. It could be argued that greater emphasis should be put on analysing the consequence of alternative settings on the basis of pa-reference points, predictions and advisory performance. Given the modern computer programs that are now commonly used carrying the assessment results forward should make this type of an analysis relatively straight forward.

Conclusion: The analysis in document 3, showing increases in year effects in the survey indices in recent years imply that their use in the tuning need to be re-evaluated and that in the interim period their influence should be reduced as much as possible. Given this a simple updating of the spring advice using the 2011 indices and following the AGCREFA protocol (as done in document 1), using the spring 2011 assessment results as a base may not be warranted.

The compromise

Document 2 as well as document 3 give the assessment and prediction results based on pre-Benchmark setup (commercial tuning series also used in the younger age groups (age 3-5). The data used in the assessment is up to and including those the year 2010. Although the survey indices still have influence in the assessment outcome their influence is much reduced. The historical trajectories are significantly different than that that resulting from the benchmark setting (e.g. F close to Fpa rather than Flim). Updating the pre-benchmark setup according to the AGCREFA protocol and the 2012 survey indices did not warrant a change in the predictions and advice. However, even if it did it is questionable if that process should have been undertaken, given the conclusion that the influence of the survey indices should be reduced as much as possible.

Some points for consideration in 2012

- Pre-benchmark settings used as a base.
- 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.

- 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.
- 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.
- Alternative modelling framework that may be able to handle transient year effect properly (e.g. TSA) may need to be explored.
- Analysis related to potential fall 2012 update be performed and procedures suggested (including potential scenario that it should not take place).
- Final setup used in the spring 2012 is determined by the EG, followed by a specific review process for that stock only.

Some additional generic comments

GENERAL COMMENTS ON OPERATING ENVIRONMENT PROVIDED BY ICES: For Linux users that do not operate in the "closed source" system provided by the Microsoft the ICES groupnet system is not usable. Although MS Word documents can be opened in the open source LibreOffice the fonts and page are not equivalent/retained. More importantly, the figures provided in the assessment and advisory documents are generally unreadable in LibreOffice. In addition, within the MS framework the groupnet system is also linked to the use of a specific browser. This is manifested in that when using Firefox the following message appears when 'Edit document in Microsoft Word' is selected: "Edit Document' requires a Windows SharePoint Services-compatible application and Microsoft Internet Explorer 6.0 or greater". The only remedy, if the above is not followed (installed) is to download and save the document, work on changes and then upload the document again. It is recommended that ICES evaluates its future strategy with regards to the default platform used (MS vs open-source). Although the prevalent base of the current users may be restricted to the MS environment, there are indication that future development/progress in the open-source environment may supersede that provided by the licensed based software. The recent developments within the R vs the Splus framework is a case in point.

GENERAL COMMENT ON THE AGCREFA 2008 PROCEDURE: Given the above, revisiting of the AGCREFA update procedure may be needed. At minimum the following should be considered:

- If terminal population numbers are estimated via RCT3, the corresponding historical F and N for the cohorts should be recalculated and the fishing pattern in the predictions adjusted accordingly.
- An upper cap on the number of age groups upon which the population number can be updated with the RCT3 procedure. As it is present there are no limits specified.